Southern Devices: Geology, Industry, and Atomic Testing in Mississippi's Piney Woods

by

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A dissertation submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

Auburn, Alabama
May 14, 2010

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Abstract

This work centers on the two underground atomic tests conducted in south central Mississippi on September 22, 1964, and December 3, 1966. The region, known as the "Piney Woods," hosted the two blasts, conducted by the United States Atomic Energy Commission, in a mammoth subterranean salt formation known as a "salt dome." These salt domes are common along the Gulf Coast from Texas to the Mississippi-Alabama border. The two tests, codenamed "Project Dribble" were part of a larger test series, "Vela Uniform," that sought to improve and create seismological methods to detect underground nuclear tests. The two nuclear tests were followed by two methane/oxygen blasts under "Project Miracle Play" to assess whether chemical explosions could simulate nuclear tests in an underground environment.

The atomic test program at the Tatum Dome was the result of a unique combination of geological and industrial factors. It succeeded in producing data considered crucial to nuclear weapons control negotiation and treaties, yet it failed to bring the nuclear industry into the Piney Woods. Furthermore, many of the desired economic benefits failed to materialize due to the federal reliance on outside contractors to perform tasks at the site. Unlike the long-term technological and cultural enthusiasm generated by federal projects such as NASA's facility in Huntsville, the Dribble program generated initial excitement, which eventually turned to resentment.

Citing a variety of archival materials, this work examines the development of Gulf Coast salt domes, the development of regional industry, and the relationship between Frank Tatum and the government, which sought to procure his land for the atomic tests. Once committed to the Tatum Salt Dome, the AEC faced numerous technical and weather-related problems, ultimately succeeding in carrying out its test program there. During this period, the Hattiesburg area, near the test site, sought to broaden its connection with the AEC by attracting a particle accelerator facility; an effort that ultimately failed. Following land remediation, the Dribble site played an important role in the debate over nuclear waste storage in Mississippi salt domes.

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Introduction

I Had No Idea

At ground-zero, some wag left a Confederate flag and a sign, "The South will rise again!" This it did by about 10 cm amidst a cloud of dust. Observers five km away heard a "whoomph" and felt a shock comparable to jumping off a street curb. However, the surface ground roll did not die down as quickly as expected, and later homeowners as far away as Hattiesburg asked to be reimbursed for cracked plaster.[1]

It happened on the morning of September 22, 1964. After years of careful planning and frustration, a nuclear device detonated below the wooded countryside in south central Mississippi. Unleashing a force roughly one-third that of the bomb that destroyed the Japanese city of Hiroshima in 1945, the explosion produced seismic waves that traveled outwards from the subterranean shot point. These were monitored from nearby stations and from around the world. This test was followed a little more than two years later by a second, much smaller device that hardly registered at all, and unlike its predecessor, caused no damage to any of the structures in the vicinity of the test site. The Atomic Energy Commission (AEC), for a complex of reasons, decided to bring their high technology to the Mississippi Piney Woods, instead of containing it at their Nevada Test Site near Las Vegas, or at one of their Pacific sites.

Residents around the site experienced the anxiety of atomic testing, a fear that their lives could be irreparably changed should something go wrong. For some, the damages were significant from the shock wave created by the first test, codenamed "Salmon." At least one home was rendered uninhabitable as the ground rolled and shook. For most, damages, if any, were inconsequential, and were offset by the knowledge that

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[1] Charles C. Bates, Thomas F. Gaskell, and Robert B. Rice, *Geophysics in the Affairs of Man: A Personalized History of Exploration Geophysics and Its Allied Sciences of Seismology and Oceanography* (New York: Pergamon Press, 1982), 204.

what the AEC was doing was of national and international significance. But as time went by, the appeal of the program waned, ultimately resulting in resentment. Even today, the topic is delicately approached by an outside researcher. As the author has experienced firsthand, people in the region are friendly and open to conversation, but when the atomic tests are mentioned, it seems that a ghost enters the room. Rumors persist about what took place at the rural test site and the results of the atomic activities there.

The title of this work, "Southern Devices: Geology, Industry, and Atomic Testing in Mississippi's Piney Woods" was not arrived at by accident, for it seeks to connect these three seemingly disparate entities, which intersected in the Piney Woods region in the 1960s. It began as a research paper written for a seminar conducted by Dr. Wayne Flynt on the history of the New South. It then became a product of several years of research and numerous trips to Hattiesburg and Purvis, the closest cities to the test site. During this time, the author had the opportunity to talk casually to a wide range of individuals. Most notably, there was a general sense of misunderstanding concerning what really happened. Some thought that the explosions in the massive subterranean salt plug – known as a "salt dome" – were weapons tests. To be sure, the program had a military component, but it was not intended to test weaponry. Indeed, the reason for the two tests was quite the opposite. They were part of a growing effort to control the worldwide development of nuclear weapons, and helped devise the systems used today to detect the nuclear tests conducted today by nations concealing their destructive aspirations from public scrutiny. But in researching the background of the atomic tests, this story quickly became far more complex than originally intended. It changed from a study confined to nuclear test and test detection technology to one of geology, southern industry, and aspirations to bring high technology to the region.

There are two groups of people regarding the history of these tests: those who have heard about them and those who have not. Most of those familiar with the tests either live in the area around the test site, have relatives who live around the test site, or were part of the test operations. Those who are unfamiliar with the tests generally fall into one of three subgroups: those who feel that the tests somehow explain what was wrong with Mississippi in the 1960s, those who feel that it was a good idea, and those who respond, "I had no idea."

What happened at the test site? This became the ultimate question when I began research around 2003. The author was ignorant of these atomic tests until viewing Peter Kuran's documentary, *Atomic Journeys: Welcome to Ground Zero*. Kuran's earlier *Trinity and Beyond: The Atomic Bomb Movie* is a well-worn item in the author's videotape collection, and led to the acquisition of *Atomic Journeys*. It was here that the existence of an atomic test site in southern Mississippi first was realized. Why had Mississippi been chosen for atomic tests, especially when it was widely regarded for its social backwardness during the 1960s? What led to these tests being conducted? What was gained from them, and why was there so little public knowledge of an atomic test program in the heart of the Deep South? Finally, what were the results of these tests on those living around the site and had they gained or lost anything because of them?[2]

The two atomic tests conducted at the Tatum Salt Dome site, codenamed "Dribble," are unique because of their location: they were the only ones conducted in the

[2] Peter Kuran, *Atomic Journeys: Welcome to Ground Zero*, VHS (Thousand Oaks, CA: Goldhill Video, 1999); Peter Kuran, *Trinity and Beyond: The Atomic Bomb Movie*, VHS (Thousand Oaks, CA: Goldhill Video, 1997).

continental United States east of the Mississippi River. Few books mention them; one of these, Charles Bates's *Geophysics in the Affairs of Man*, describes the events at the Tatum Salt Dome site in a page and a half. It is one of the longest treatments of these two tests to be found in any work. The most likely reason for this is that there was no fallout from the Mississippi tests, and no widespread damage. Despite localized contamination, there were no civilian contamination incidents as noted in Howard Ball's *Justice Downwind*, and numerous other works. This in itself is remarkable, for examination of a map clearly shows the Dribble site within 150 miles of several cities and large towns. No other American nuclear test site sits in such a highly populated area. Near the site is the Lamar county seat, Purvis, and within 35 miles is Hattiesburg. Within the 150-mile radius sits the state capital, Jackson, the coastal cities of Biloxi, Gulfport, and Pascagoula, Slidell and New Orleans in Louisiana, and Mobile, Alabama. By comparison, the most densely populated area near the Nevada Test Site is Las Vegas.[3]

The Dribble tests are little mentioned, as is the region where they were conducted. The first chapter, "Humble Origins," begins with the formation of the unique geological factors that resulted in the subsurface features of the Gulf Coast and Piney Woods. After evaporate deposition of thick layers of rock salt, which was then covered by sedimentary deposits, the massive salt domes rose from a deeply buried subterranean salt formation, or "bed." Salt domes rise upward several miles due to their buoyancy, and brought with them large petroleum and gas deposits close to the surface where they could be exploited. Their history then continues into the period of human occupation and early industry in south-central Mississippi, a region that has received precious little attention from

[3] Bates, Gaskell, and Rice, *Geophysics in the Affairs of Man*, 203-204; Howard Ball, *America's Atomic Testing Program in the 1950s* (New York: Oxford University Press, 1986).

historians when compared to the cotton-rich Yazoo Delta region to its north. It also introduces the Tatum family, who emigrated from Tennessee to seek their fortune in the rich timber land from which the Piney Woods takes its name.

The second chapter, "Timber, Oil, and Atoms," spans a much shorter period of time than the first. This is not a tale of the Cotton South; it is a story of the Timber South; the Oil and Gas South. The Tatum family expanded its timber and lumber operations in the Piney Woods. Southern Mississippi's wealth had always been in timber rather than cotton. The timber industry has generally been neglected by historians in favor of cotton. This is a serious omission, for as Gavin Wright pointed out in *Old South, New South*, between 1880 and 1920, the timber industry was the leading employer and contributor of value-added products to the southern economy, and lumber is a manufacturing industry. As he explained, its dependency on transient laborers, and its inherent transient nature due to the need to move facilities nearer to stands of trees, causes it to receive this diminished attention from historians because of a lack of cohesive identity among workers, unlike those working in cotton textile mills. Timber harvesting was a labor-intensive activity, and even though machinery was introduced near the turn of the twentieth century, it lost little of its hazardous nature.[4]

James Cobb charges the timber camps with widespread abuse, where timber camp workers were held captive by poverty and virtual imprisonment, policed by armed foremen. Citing wage slavery and peonage to the company store, he notes the activities of Florida's Osceola Log Company, which lured workers to their camps with promises of

[4] Gavin Wright, *Old South, New South: Revolutions in the Southern Economy Since the Civil War* (New York: Basic Books, Inc., 1986), 159-62.

reasonable wages, only to reveal later that substantial deductions were cut from their hourly pay for subsistence expenses such as room and board.[5]

Such charges are certainly true, but the widespread abuse does not seem to have been as evident in the Piney Woods of Mississippi, where the work was as hard as anywhere else. Historians neglect to mention such abuses there, and in fact, some note an unusual sense of racial harmony. Following the Civil War, members of Rankin Hickman's log rafting crews "ate out of the same pots, slept in close proximity around campfires, and joined in singing at night. Wages were equal and skin color was of little significance to those of both races, who were often neighbors and longtime friends." Such was the result of the close personal interaction that occurred in the region, which never saw widespread slavery, and was free of the cotton plantation system. This is not to deny racism and segregation in the Piney Woods, for it was present there as well as anywhere else in the South. But industry appears to have played a role in creating a regional lessening of the bitterest sentiments. Herman Clarence Nixon also noted that "industrialization has sprung up chiefly in sections that were only slightly touched by the pre-war plantation economy," and noted the importance of the timber and lumber industries that grew up "between the cotton fields and the coast," as well as a new source of southern income, petroleum.[6]

The Tatum family also pursued petroleum, beginning in the 1930s, on their growing landholdings. Mississippi's timber industry as a whole fluctuated as Wright

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[5] James C. Cobb, *Industrialization and Southern Society, 1877-1984* (Lexington: University Press of Kentucky, 1984), 69-71.

[6] Nollie W. Hickman, "Black Labor in Forest Industries of the Piney Woods, 1840-1933" in Noel Polk, ed., *Mississippi's Piney Woods: A Human Perspective* (Jackson: University Press of Mississippi, 1986), 82; Herman Clarence Nixon in Twelve Southerners, *I'll Take My Stand: The South and Agrarian Tradition, 6th ed*. (Baton Rouge: Louisiana State University Press, 1977), 192.

mentioned. The discovery of oil at the Spindletop Dome in Texas suggested a new set of opportunities. As Dudley Hughes notes, small lumber companies delinquent in paying their taxes often sold their harvested property cheaply to larger companies, or simply allowed the land to be seized by the state. Apparently worthless due to its denuded condition, the land held potential wealth in the form of their mineral rights, and was snapped up by larger timber companies. As Hughes further explains, the Gulf Coast oil boom resulted in widespread prospecting, with timber companies becoming the primary beneficiaries of any finds. Thus the timber industry was directly involved in bringing the petroleum industry into the South. The Tatums found no oil on their property and continued to harvest trees and manufacture lumber. While prospecting on their land, they discovered the great salt dome that bears their name, and that became the focus of later atomic testing activities.[7]

The oil industry brought new wealth and new expertise in drilling and excavation. It spurred southern universities to educate a new generation of trained geologists to look for the valuable substances hidden below the ground in reservoir formations and salt domes. But one must be careful to point out that although these individuals began to receive excellent training in geology, it was of a practical nature so that valuable resources could be better located. Other curricula, such as physics, lay concentrated outside the South. For example, Dr. Andrew Suttle, who is noted later in this work, was a native Mississippian, but he received his training in nuclear chemistry at the University of Chicago. Still, though overlooked by historians as the timber industry, the oil and gas industry in the South had far-reaching implications for the future atomic program.

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[7] Dudley J. Hughes, *Oil in the Deep South: A History of the Oil Business in Mississippi, Alabama, and Florida, 1859-1945* (Jackson: University Press of Mississippi, 1993), 37-38.

Certainly, industry in the Piney Woods was not limited to timber and oil, but these led directly to the Tatum Dome, and bear the most relevance to this study.[8]

Mississippi government officials were anxious to bring other industries into the state, beginning initially with the 1930s-era Balance Agriculture with Industry (BAWI) program, to later efforts to lure high-tech industries peripherally associated with the nuclear tests. Cobb notes that BAWI faced criticism for being socialistic, because it called for the state government to acquire land and facilities to lure outside manufacture into the region to check labor out-migration. Its successes, later amplified by the demand for manufactured goods caused by World War II, were deceptive because many of the manufacturers brought into the region were large enough in the prewar years to not need the program when most of the BAWI factories were established. This meant that the capital spent was wasted – if they had wanted to expand into Mississippi on their own, they could have done so on the strength of their own capital while exploiting the labor surplus in regions of the state impacted by the loss of agricultural jobs. BAWI "raised the curtain on an era of the competitive use of gifts and gimmickry to attract industry to the South."[9]

James Silver berated the continuing segregation in Mississippi following World War II, and charged that industrial leaders failed the state in allowing the "closed society" to continue. Governor Ross Barnett, he argues, was willfully ignorant in maintaining that northern manufacturers favored continued segregation because they located facilities in Mississippi. Citing Standard Oil's decision to build a refinery at Pascagoula, Silver noted that it was not due to a northern desire for a segregated work force, but because of the

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[8] Hughes, *Oil in the Deep South*, 49, 112-15.

[9] James C. Cobb, *The Selling of the South: The Southern Crusade for Industrial Development, 1936-1990* (Chicago: The University of Illinois Press, 1993), 14-34.

reliability of the work force as demonstrated in other industries of the area, local political diligence and leadership, and geography. Silver blames Barnett personally for the loss of industries, which rethought their Mississippi plans and relocated elsewhere because of the riots in Oxford during the James Meredith crisis of 1962.[10]

Like the space program, the AEC program in the Piney Woods was the product of outsiders. The AEC's need for a contained underground test site wherein it could analyze the physical and seismic effects of a nuclear blast in a salt dome led it to the South. Barnett's segregationist rhetoric did not deter Mississippi's selection as the state where the tests would be sited, as two salt domes there were deemed most acceptable for the proposed program. This was intentional, in part because of Barnett's refusal to integrate. The AEC program was fully committed to the Tatum Salt Dome site by 1962, the year of the riots at Ole Miss. Extrapolating historian Bruce Schulman's argument concerning federal defense programs and the economic leverage NASA's presence exerted in Huntsville, Alabama, to integrate the school system to the AEC program in Mississippi, it is not unreasonable to assume that it too was used to prod Barnett. In the case of Huntsville, white residents turned against Governor George Wallace, fearing the loss of the Marshall Space Flight Center. In Mississippi, Barnett attempted to negotiate with Attorney General Robert Kennedy a dramatic armed showdown between himself and federal marshals. At the end of this scripted drama, Barnett would capitulate to federal force and step aside to admit James Meredith to the university. This defiant last stand was never carried out, due to the enraged passions of pro-segregation Mississippians, and the threat of a gun battle where Barnett might have been shot. Several months after the

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[10] James W. Silver, *Mississippi: The Closed Society* (New York: Harcourt, Brace, and World, 1963), 71-77.

Ole Miss riots, another black student, Cleve McDowell, entered that institution's law school with no gubernatorial interference – indeed it appears to have been curiously uneventful. Clearly, something held Barnett at bay, for it was one thing to simply admit a black student to the Ole Miss, it was another to allow one to be trained there in the law. The evidence for this may lay somewhere in Barnett's personal papers, which have yet to be located.[11]

Schulman notes that quickly acquiescing to federal wishes had its benefits, which was evidenced by Barnett's successor, Paul Johnson. Known for a derogatory remark concerning the NAACP, and running as a segregationist successor to Barnett, he quickly ameliorated his tone upon his election. Refusing to oppose integration actively as his predecessor had done earlier, he assumed a more quiescent attitude. This was rewarded when Litton Industries built their "Shipyard of the Future" at Pascagoula in 1967, and several years later, the Research and Development Center, originally envisioned by Barnett in 1960, opened in Jackson.[12]

Chapter three, "The Road to Dribble," is an overview of nuclear test monitoring, technological problems, and innovation. Despite the radiological hazards presented by atmospheric nuclear testing, fallout from Soviet testing was a superior asset in analyzing their weapons development programs. Unfortunately for those engaged in this analysis, the international outcry over fallout forced the nuclear superpowers to consider moving

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[11]Bruce Joseph Schulman, "From Cotton Belt to Sunbelt: Federal Policy and Southern Economic Development, 1933-1980" (PhD diss., Stanford University, 1987), 333; Stephan D. Shaffer and Dale Krane in Dale Krane and Stephan D. Shaffer, *Mississippi Government and Politics: Modernizers Versus Traditionalists* (Lincoln: University of Nebraska Press, 1992), 39; Erle Johnston, *Mississippi's Defiant Years: 1953-1973* (Forest, MS: Lake Harbor Publishers, 1990), 200. In 2009, the author telephoned the Mississippi Department of Archives and History to inquire about the location of Barnett's personal papers. They replied that they had no knowledge of their status or location. It is likely that they are being held by the Barnett family.

[12] Schulman, "From Cotton Belt to Sun Belt," 358, 360.

their testing activities underground. "Project Dribble" was part of a larger test series, which was in turn part of an overarching program, called "Project Vela." Vela addressed covert Soviet atomic tests, deemed necessary as negotiations toward the Limited Test Ban Treaty progressed in the late 1950s and early 1960s. This treaty, which the United States, Great Britain, and the Soviet Union entered into in 1963, forbade nuclear testing in the atmosphere, in space, or underwater. Allan Winkler notes that this treaty, and the negotiations leading to it, was a means to de-escalate further from the 1962 Cuban Missile Crisis, while eliminating the health threat from global fallout created by atmospheric testing. Vela had three primary components, each to address covert testing through different means. "Vela Hotel" planned to use orbiting satellites to spot illicit detonations at high altitude and in space. "Vela Sierra" sought nuclear detonations much the same as Vela Hotel, but instead used ground-based stations. Vela Uniform, of which Project Dribble was a part, researched seismic means to detect and monitor underground nuclear testing, and whether such methods could be employed to fool such detection systems. Conceived during the Test Moratorium of 1958-1961, it was initially affected by the inability to conduct nuclear explosions, and instead relied on chemical explosive programs, although these could not provide the full range of data desired by the Department of Defense and the AEC.[13]

Chapter four, "Cowboy and the 'Big Hole' Theory," addresses the primary reason for the Dribble tests. The big hole theory offered a means whereby a nation could cheat the methods devised by the Vela program through exploding nuclear devices in pre-

[13] Allan M. Winkler, *Life Under A Cloud: American Anxiety About the Atom* (New York: Oxford University Press, 1993), 178-82; Harold Karan Jacobson and Eric Stein, *Diplomats, Scientists, and Politicians: The United States and the Nuclear Test Ban Negotiations* (Ann Arbor: University of Michigan Press, 1966), 178.

excavated underground chambers. This concern was raised because of the "Cowboy" series of high explosive tests previously mentioned. Cowboy suggested that this could be a problem for a detection system and begged the use of atomic device test verification. It also introduced a plan under the proposed "Plowshare" program, to employ nuclear devices in Mississippi to excavate the proposed Tennessee-Tombigbee waterway. Eventually ruled too hazardous to people living nearby, the idea of nuclear earthmoving appealed initially to the AEC's Nuclear Cratering Group, Governors Barnett and Johnson, and was championed by MITRC director Andrew Suttle. As Scott Kirsch notes, this realization was fortunate due to the excessive belief that nuclear earthmoving could be performed safely in the midst of a populated area, despite the use of some fifty "clean" nuclear charges, totaling 1.9 megatons.[14]

Chapter five, "MITRC, MCEC, and the Tatum Decision," focuses on the creation and aspirations of the Mississippi Industrial and Technological Research Committee, the engineering superfirm, the Mississippi Construction and Engineering Company (MCEC), and the final resolution of the question of the land and mineral rights owned by the Tatum Lumber Company. MITRC was initiated by Barnett during his inaugural speech in 1960 and was designed to spur interest in technologically-advanced industry and research in the state. MITRC was a successor to the BAWI program, which sought to bring manufacturing jobs to Mississippi. The MCEC was a privately-organized handmaiden to the MITRC, and sought to garner lucrative contracts from the AEC's presence in the state. Its resulting experience was a slap in the face for Mississippi's engineering community.

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[14] Scott Kirsch, *Proving Grounds: Project Plowshare and the Unrealized Dream of Nuclear Earthmoving* (New Jersey: Rutgers University Press, 2005), 163-68.

Gavin Wright observed another area where the South failed, which connects directly to the aspirations of the MITRC to attract a particle accelerator to the Hattiesburg area following the first atomic test. This is the failure of indigenous technological development, allowing what Cobb refers to as "economic colonialism" to continue. Wright notes the general employment of low-skilled workers utilizing imported technology near the turn of the century and afterward, preventing the South from gaining a reputation for technological innovation. Schulman noted that outsiders provided the technological acumen for high-tech industrial development in the South, and this was true at the Tatum Dome.[15]

Was it then a case of "atomic carpetbagging?" The term "carpetbagger" refers to northern opportunists who entered the South following the Civil War to exploit the devastated economy for their own personal benefit. The federal government brought the Dribble program to the Piney Woods, and it is a matter of debate whether anyone was actually exploited by it. Local residents were inconvenienced through repeated evacuation, but were compensated. Their property, when damaged, was generally compensated. In addition, the government brought many other programs to the South. The space program, for instance, was hailed as a means to develop the South's technical and technological potential. Politicians "envisioned NASA as the Moses that would lead the South to a High-tech promised land." Yet much of the technical know-how in rocketry depended on true outsiders in the form of imported German scientists. Still, regional universities benefited from the technical influx from the space program. Federal defense contracts supplied an ever-increasing economic resource, and were used as part

[15] Wright, *Old South, New South*, 62, 79: Schulman, 'From Cotton Belt to Sunbelt," 228-42.

of a “carrot and stick” relationship between the national and state governments. With the introduction of numerous contracts and projects after World War II, the federal government gained cultural leverage in areas it never previously held, such as in desegregation. Overall, this relationship was simple: once a state accepted and budgeted federal money from a contract, it was bound to obey federal wishes, lest the contract be jeopardized and the funding cancelled or reallocated. In this relationship, the federal government’s wishes held sway. Thus it was less an issue of carpetbagging than a paternalistic relationship.[16]

Chapter six, “Salmon Run,” addresses the final preparations for the initial nuclear test at the Dribble site. Following the end of the moratorium, Vela Uniform proceeded with its seven atomic tests. The AEC conducted them in several locations in order to assess seismic signal propagation through different types of media. Mississippi was only one of the extraordinary locations for these tests, as one was conducted near Fallon, Nevada, while the largest of the series was conducted near the end of the Aleutian Island chain in Alaska. The other four were detonated at the Nevada Test Site. They ranged in explosive yield, with the smallest, “Sterling,” detonated at the Dribble site registering little more than a third of a kiloton of force, to the Aleutian test, “Long Shot,” yielding 80 kilotons. Nearly eight years passed between the first shot of the series, “Shoal,” in October, 1963, and the final one, “Diamond Mine,” in July, 1971. The two Dribble tests occurred in 1964 and 1966.[17]

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[16] Schulman, “From Cotton Belt to Sunbelt,” 228-42, 257, 332-33.

[17] Thomas B. Cochran, William M. Arkin, Robert S. Norris, and Milton M. Hoenig, *Nuclear Weapons Databook Volume II: U. S. Nuclear Warhead Production* (Cambridge, MA: Ballinger Publishing Company, 1987), 164-69.

The Dribble program experienced numerous technical delays in conducting its first atomic test, "Salmon" at the salt dome site. During this period, it was most active with the public, providing frequent briefings, and a notable meeting at the Baxterville School. It was during this time that the Salmon test set an unenviable record: it was the most delayed atomic test ever conducted. The capricious nature of southeastern weather manifested itself beyond the expectations of anyone at the test site. Weather delays were preceded by engineering problems unique to the test site. In the end, a change in test procedures allowed the test to proceed.

Chapter seven, "Shoot That Damn Thing," is concerned with the effects and aftermath of the Salmon test. It also addresses the failed attempt by Hattiesburg to attract a particle accelerator research facility to the region, despite the best efforts of MITRC and local politicians. As Schulman pointed out, the ability for federal decision makers to choose where programs were allocated was well-known, although it was a bitter pill for Hattiesburg to swallow, especially in light of its previously demonstrated willingness to work with the AEC. But hope for Hattiesburg's future association with the AEC remained alive with the second test planned for the Dribble site, the more scientifically relevant test shot called "Sterling."[18]

Chapter eight, "A Silver Lining and a Miracle Play" addresses the Sterling atomic test and the subsequent use of the Salmon chamber for gas explosion tests. The Sterling explosion, conducted in December 1966, was the most scientifically important of the two atomic blasts at the Dribble site, for it explored the decoupling effect. Following Sterling, the AEC planned three methane/oxygen detonations for the chamber, of which two were carried out. Before the final test was executed, the AEC decided to end its

[18] Schulman, "From Cotton Belt to Sunbelt," 272.

activities at the Tatum Dome, remediate the land, and return it to its previous owners. The salt dome changed status from test site to nuclear waste repository, as contaminated earth and liquids were permanently entombed in the Salmon chamber.

Chapter nine, titled "Nuclear Waste," concerns further site remediation efforts and Dribble's role in the debate over nuclear waste storage in Mississippi's salt domes. Following the active test period and cleanup activities, biological sampling in 1979 indicated that the waste contained deep inside the salt dome was leaking. Compounded by laboratory errors, this led to a full evacuation of the area around the dome. This occurred while the Three Mile Island atomic power plant threatened Pennsylvania with a nightmare scenario of widespread radioactive contamination, and while the Department of Energy was looking again at Mississippi's salt domes as possible sites for nuclear waste repositories. Dribble was important to research, and its results led directly to the Threshold Test Ban Treaty, whereby no underground test could exceed 150 kilotons. Dribble's decoupling experiment allowed scientists to discern between coupled and decoupled shots, and in doing so provided a technical means to verify tests – the program's intended purpose. In order to thoroughly clean up the site, the Department of Energy bought the site from the Tatum family, and retains it to this day.

The events that took place in Mississippi's Piney Woods were greatly affected by geological and environmental forces, and human politics. Water and wind conspired to frustrate and delay one test at the Dribble site, and lightning served to accelerate another. Although the tests are interesting in themselves, what stands out are several threads that run through the entire work: the rise of local industry and its change as exemplified by the Tatum family, the trajectory of international events as they led to the Tatum Dome, the effort to bring nuclear technology fully into the Hattiesburg area much like NASA brought space technology to Huntsville, and the public sentiment of those living around the test site, who began their experience with the AEC with high hopes and some trepidation, and that later turned to resentment and fear that their very lives were threatened by the activities at the Dribble site. Finally, there is the land itself, that is currently being allowed to revert back to its pre-human activity condition. It deserves its rest.

Chapter One

Humble Origins

On October 22, 1964, the earth shook near the small town of Baxterville, a hamlet of about 150 people located in rural Lamar County in south-central Mississippi. The ground motion, though it was stronger than expected, was not a surprise. It had been caused by the long-planned and well-publicized detonation of a nuclear test device. There was no brilliant flash, nor was there a mushroom cloud rising dramatically over the rolling countryside and thick pine groves. The only thing out of the ordinary was the ground motion, which radiated out from the deep underground detonation point and caused dust to rise over the test site, throwing one man's refrigerator contents onto his kitchen floor, cracking numerous foundations, and rattling windows as far as Hattiesburg, some thirty miles away.

The atomic detonation in the verdant pine belt of south-central Mississippi was no random act designed to subdue the violent passions of Mississippi embroiled in the civil rights movement, nor was it the seemingly ubiquitous southern male tendency to blow something up just for the hell of it. The test, codenamed "Salmon" was a precisely planned and metered nuclear test conducted under unique surroundings and circumstances. The Salmon device yielded 5.3 kilotons of explosive force, which is roughly one-third that released by the bomb that had been dropped on Hiroshima near the end of World War II. The test was conducted at a depth of about 2,700 feet below the surrounding countryside, and was fully contained and monitored. Basically, Salmon was an unusually large outdoor laboratory experiment.

Salmon, and a subsequent atomic detonation codenamed “Sterling,” were the only two nuclear tests to be conducted in the continental United States east of the Mississippi River. Their purpose was to ascertain whether or not the United States and its allies would be able to enter into subsequent treaties placing controls on nuclear tests following the 1963 Limited Test Ban Treaty, which forbade atmospheric, undersea, and space tests with nuclear devices. With the growing desire to limit the size of nuclear weapons, it became clear that restricting test yields would be an important step – but underground testing presented unique limitations to verifying these yields. Seismology, a field rapidly gaining importance in disarmament efforts, would play a major role in test monitoring, yet its incorporation into a system of monitoring and observation raised questions. How did one distinguish an atomic test from an earthquake? What about the explosive eruption of volcanoes or other natural phenomena? How small a test could be detected? Even more to the point, could tests be intentionally hidden in an effort to evade treaty stipulations?

These questions were the focus of the “Vela Uniform” program, a series of seven nuclear detonations that were spread across several test programs. They were conducted in several locations: the Mississippi test site, which was known as “Dribble,” Fallon, Nevada, the Nevada Test Site, and Amchitka, Alaska, where the largest of the seven, an eighty-kiloton underground shot, was fired. Vela was intended also to answer the question of the effects of different soil and rock types and their effects on seismic signals. The various locations allowed for tests to be conducted in several different test environments.

Geologically, Mississippi had a unique role in this program. The choice of test site in that state was not accidental. In fact, the test location was many millions of years in the making. It was a remarkable geological structure that allowed not only for a fully enclosed and sealed shot location, but also presented an opportunity for assessing theories relating to the concealment of nuclear tests. This geological structure is a mammoth column of solid rock salt, some seven to eight miles in height, and well over a mile in circumference at its top, which is poised 1,500 feet below the earth's surface. Because of this enormous salt pillar Mississippi was chosen as a site for underground nuclear tests. The pillar, or salt dome, that was host to the atomic tests was large but not uniquely so. These enormous salt domes along and under the Gulf Coast and inland for several hundred miles were extruded upward from a thick subterranean salt formation known as the Louann Salt. This geologic formation formed during the Jurassic Period, and was up to 10,000 feet thick in some places. The Louann Salt, which is one of the basal formations within the northern Gulf Basin, ran (or "trended") in a large arc, starting in eastern Texas, with its northwestern maximum extent located just southeast of Shreveport, Louisiana. Then, it extended due east and north into Arkansas, where it joined another large salt formation located along the eastern half of the border between Louisiana and Arkansas. The Louann then spread into central Mississippi and curved southeast toward Mobile Bay. Interestingly, there was a salt-free zone between the Louann and another salt-bearing basin to its south, known as the Coastal Basin, which ran along the coast westward from southeastern Louisiana to the region of Galveston, Texas, where it then stretched north almost to the Oklahoma border.[1]

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[1] Donald H. Kupfer, "Mechanism of Intrusion of Gulf Coast Salt," *Proceedings of the Symposium on the Geology and Technology of Gulf Coast Salt: May 1-2, 1967* (Baton Rouge: Louisiana State

The origin of this bed likely lay within the formation of the Gulf of Mexico – itself created when the supercontinent of Pangaea fragmented and the North American, South American, and African tectonic plates split apart. What became the Gulf started as a shallow body of salt water. Repeated evaporative cycles allowed thick layers of salt to be deposited at its bottom. As the Gulf expanded through tectonic motion, the bulk of this deposited salt slid northward with the North American plate, as the Pacific plate pressed eastward. The Gulf basin enlarged and became a trap for alluvial and marine sedimentary deposits formed during the Cenozoic Era. These Cenozoic sediments buried the salt. Fluctuating global sea levels contributed to further salt deposition as rising and subsiding sea levels formed large shallow inland bodies of salt water that evaporated over time and allowed for various layers of salt to be laid down.[2]

Rock salt is a remarkable material. At the surface at room temperature, it is a hard crystalline substance like the table salt that is familiar to everyone. When it is subjected to intense pressure and heat, about 300 degrees C, as it is several miles below the surface, it behaves as a plastic material. Lighter in density than the surrounding and overlying sedimentary deposits, rock salt tends to rise under pressure, following fractures in the overlying strata. As long as the salt remains connected to the hot mother bed, it will continue to force its way upward hydraulically due to the geostatic pressure caused by the overlying burden. This process of deep subterranean plastic material rising through overlying material to shallower levels is known as "diapirism," and although similar to volcanism, it is defined by Gerald O'Brien as referring to low-temperature

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University Press, 1970), 25, 30.

[2] Jack L. Walper, "Tectonic Evolution of the Gulf of Mexico," in Rex H. Pilger, ed., *The Origin of the Gulf of Mexico and the Early Opening of the Central North Atlantic Ocean: Proceedings of a Symposium at Louisiana State University Baton Rouge, Louisiana March 3-4-5, 1980* (Baton Rouge: Louisiana State University Press, 1980), 87.

piercement of strata by sedimentary materials. These diapiric structures tend to remain buried, although in some instances, they do reach and exceed the surface level. The Darbast salt plug in Iran, for example, rises some 2,000 feet above the surrounding valley floor. Some of these salt mountains in Iran are enormous, being up to 1½ miles wide and 2-3 miles long and survive due to the dry climate. In his book, *Salt,* Mark Kurlansky discusses the growth and importance of the salt industry in Germany and Eastern Europe, which are other areas where salt diapirism was especially active. [3]

The origin of the Louann salt deposits and associated organic sediments was sea water. As is the case today, the seas of the Jurassic were full of life. Dead sea creatures, primarily microscopic organisms, fell to the bottom of these shallow waterways and were buried in prodigious quantities. The deep briny sea bottom provided an anoxic environment that partially preserved this organic material from decay. Specialized bacteria survived the alkaline and anoxic conditions, and slowly digested these enormous masses of biological material. This digesting mass was then buried with the salt to great depths. With the diapiric movement of the salt came the remnants of this ancient oceanic life.

In cross section, salt diapirs generally have a mushroom shape. This is because of a process that occurred while the salt progressed towards the surface, whereby the salt column generated an important feature known as a "caprock." The caprock generally isolated the salt from the overlying strata and was at the same time pressed upwards

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[3] William Carruthers Gussow, "Salt Diapirism: Importance of Temperature, and Energy Source of Emplacement," in Jules Braunstein and Gerald D. O'Brien, eds., *Diapirs and Diapirism: A Symposium, Including Papers Presented at the 50th Annual Meeting of the Association in New Orleans, Louisiana, April 26-29, 1965, and Some Others.* (Tulsa: The American Association of Petroleum Geologists, 1968), 21, 42-44; Gerald O'Brien, "Survey of Diapirs and Diapirism," in Braunstein and O'Brien eds., *Diapirs and Diapirism,* 1-2; Mark Kurlansky, *Salt: A World History* (New York: Walker and Company, 2002).

against the overburden with immense force. If one imagines a salt diapir as an active fluid convective column, with most of the convective activity occurring near the center, then it is easier to understand the process of caprock formation. The caprock was formed from the detritus left over from bacterial digestive processes and the insoluble residue from rock salt dissolution. Caprock is comprised of a calciferous material known as "anhydrite," as well as gypsum, sulfur, and some metallic deposits. Salt continually moved from great depths to the top of the salt column, where the caprock occurs, forming an ever thickening layer.[4]

Caprock was important as it increased the area over which the upthrusting salt diapir pressed against the upper layers of earth. Ground layers were faulted and displaced by the growth of the caprock and the upward progress of the diapir. If an aquifer were encountered that eroded the diapir and undercut the caprock, the resulting subsidence could also leave visible surface effects as it subsided. In short, the salt dome and its caprock affected the topography of a region, even when the caprock checked the progress of the salt diapir far below the surface. Rolling hills, valleys and other features that occurred along the north and northwestern Gulf of Mexico were sure signs of the presence of recent or active salt diapirism.

Caprock was not the only material transported or created by salt diapirs. The bacterial digestion of organic matter in an anoxic environment produced a material called kerogen. The hydrogen content in the kerogen determined whether it became oil or gas; hydrogen-rich marine kerogen more likely became crude oil, whereas kerogen from non-

[4] Roger Sassen, "Organic Geochemistry of Salt Dome Cap Rocks, Gulf Coast Salt Basin," in Ian Lerch and J. J. O'Brien, eds., *Dynamical Geology of Salt and Related Structures* (Orlando, Florida: Academic Press, Inc., 1987), 631-32.

marine sources tended to become gas.[5] These light materials were transported from the depths to pockets or reservoirs caused by upthrust or downthrust faulting; the disjointed strata acted as traps to hold the material. Salt domes played a crucial role in the development of oil and gas, for not only did they create faults that trapped and accumulated hydrocarbons, they also provided a crucial element for petrochemical formation: heat. As the hydrocarbons rose near a salt diapir, they were exposed to a "radiator effect" from the heat that was effectively conveyed from the mother salt bed up through the diapir. This heat helped to "cook" the petroleum and preserved it from further bacterial action and decay.[6] This effect would later make salt domes highly sought after for their petroleum reserves.

Periodically, a salt dome encountered an aquifer, where the water quickly eroded the salt, and occasionally the brine reached the surface as a spring. Salt is critically important to animal life: such salt springs attracted game animals and other wildlife. The salt and the ready availability of game in turn attracted humans to these hidden salt formations. Native Americans were more than aware of these precious brine springs in the inner Gulf Coast region, and they certainly knew that the salt attracted animal life.[7] Europeans were slower to realize the bounty of these resources as they first explored inland from the Gulf. One biographer of Spanish explorer Hernando De Soto noted that as he and his party trekked northwestward from the Alabama settlement of Mauvilia towards Tuscaloosa and then westward to the Mississippi River, they not only were

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[5] Ibid., 638.

[6] Douglas F. Williams and Ian Lerche, "Salt Domes, Organic-Rich Source Beds and Reservoirs in Intraslope Basins of the Gulf Coast Region," in Lerch and O'Brien, eds., *Dynamical Geology of Salt and Related Structures*, 751-52, 771.

[7] Kupfer, "Mechanism of Intrusion of Gulf Coast Salt," *The Geology and Technology of Gulf Coast Salt*, 27.

suffering from starvation, but they also suffered from salt deficiency.[8] De Soto's path roughly paralleled the outer reaches of the Louann bed; had his path been fifty to a hundred miles southward, at least one of his shortages might have been accommodated.

What De Soto missed was a region that has been known for some time as the "Piney Woods," or the Pine Belt of Mississippi. Underlain by numerous salt domes and the massive Louann Salt, this region today features a generally thin layer of soil that covers layer upon layer of clay and sand. The area is generally wet, with occasional swamps and streams. The major watercourse in the region, the Pearl River, flows southward to the Gulf of Mexico, and numerous smaller tributaries feed it as it gently runs to where Louisiana and Mississippi currently meet. The watershed, which covers the southern area of Mississippi, is heavily forested today; when the first humans reached the area it was densely covered with tall, longleaf yellow pine trees and various deciduous species. The proximity to the Gulf provided ample annual rainfall despite the occasional drought, and a mild climate, with the occasional hurricane cutting through the area. Winters were mild, with the occasional freeze, but the cold never lasted for an extended period of time. Summers were hot and humid, but as any visitor to the region knows, once in the forest or the surrounding swamps, the shade of the trees and the mysterious breezes that seem to come from nowhere cool the air and make it far more comfortable than areas closer to the coast. When the daytime heat and humidity reached a certain level, thunderstorms appeared from the thickened air, providing torrential downpours and vivid lightning. These storms also pushed inland with the sea breeze; a

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[8] Miguel Albornoz, *Hernando De Soto: Knight of the Americas, Translated from the Spanish by Bruce Boeglin* (New York: Franklin Watts, 1986), 321.

daily exhalation of cooler humid air from the Gulf that moved northward over the rapidly heating land resulted in towering storms that regularly soaked the land.

As it happened, De Soto did not travel through southeastern Mississippi, entering the state west of present-day Cuba, Alabama, although some of his escaped swine and cattle apparently did. They added to the game the Native Americans hunted in the fire-cleared forests. These peoples lived throughout the Piney Woods, subsisting on the land and its wildlife until the incursion of European settlers and traders in the eighteenth century. These newcomers, primarily French and Spanish colonists venturing from the larger settlements of Mobile and New Orleans, came northward to investigate the possibilities of rich lands farther inland. Southern *coureurs de bois* engaged the local Native Americans in the lucrative deerskin trade. The subsequent rapid decline of the native deer population and the extinction of the eastern bison were coupled with the ever-growing numbers of herd animals – primarily horses and cattle. Settlers also brought hogs into the area. These animals were allowed to roam the woodlands and were periodically rounded up and sold.[9]

The southernmost extent of the Piney Woods experienced the quick succession of national ownership that began in 1763, when the British claimed the territory from the French and named it West Florida; it was then ceded to the Spanish at the end of the American Revolution, and was finally made part of the United States after the War of 1812. In 1820, the Treaty of Doak's Stand surrendered five and a half million acres of Choctaw land in central and western Mississippi and effectively cleared the inland

[9] John H. Napier III, "Piney Woods Past: A Pastoral Elegy," in Noel Polk, ed., *Mississippi's Piney Woods: A Human Perspective* (Jackson: University Press of Mississippi, 1986), 12-13. *Coureurs de bois*, or "travelers in the woods" refers to European backwoodsmen, and more commonly refers to fur trappers and traders in the northeast.

regions for settlement by Americans. Although the bottom lands, watered and nourished by the alluvial deposits from the Pearl River, were highly valued for their fertility and ability to support cotton, many people remained within the Piney Woods, preferring a pastoral lifestyle within this pocket of frontier. This decision was likely due to the lower prevalence of diseases that were endemic in the lower regions, such as yellow fever and malaria. It was common in other locations, primarily on the Atlantic coast in places like Georgia and the Carolinas, for the wealthy to migrate annually to higher elevations to avoid these poorly understood maladies.[10]

In 1862, *Harper's New Monthly Magazine* published an account by J.F.H. Claiborne of his recent travels through the Pearl River watershed and into the Piney Woods. His priceless account of the land and its people provides one of the few descriptive passages from the period:

> Along the Gulf of Mexico, or what the United States Coast Survey styles the Mississippi Sound, extending across the State of Mississippi, with a depth in the interior of about one hundred miles, there lies a region of country usually denominated the Pine Woods. The soil is sandy and thin….But it sustains a magnificent pine forest, capable of supplying for centuries to come the navies of the world. The people are of primitive habits, and are chiefly lumbermen or herdsmen. Exempt from swamps and inundation, from the vegetable decomposition incidental to large agricultural districts, fanned by the sea-breeze and perfumed by the balsamic exhalations of the pine, it is one of the healthiest regions in the world….I have never seen so happy a people. Not afflicted with sickness or harassed by litigation; not demoralized by vice or tormented with the California fever; living in a state of equality, where none are rich and none in want; where the soil is too thin to accumulate wealth, and yet sufficiently productive to reward industry; manufacturing all that they wear; producing all

[10] Gideon Lincecum, "Life of Apushimitaha," in Marion Barnwell, ed., *A Place Called Mississippi: Collected Narratives* (Jackson: University Press of Mississippi, 1997), 16; Napier "Piney Woods Past: A Pastoral Elegy," in Noel Polk, ed., *Mississippi's Piney Woods,* 13-14; Regarding fears and behavior regarding the endemic nature of malaria and yellow fever, see Joyce E. Chaplin, *An Anxious Pursuit: Agricultural Innovation & Modernity in the Lower South, 1730-1815* (Chapel Hill: University of North Carolina Press), 93-100.

> they consume; and preserving, with primitive simplicity of manners, the domestic virtues of their sires….[11]

Claiborne described a Jeffersonian yeomanry, with minimal production of the crops commonly associated with large-scale slave agriculture: namely sugar cane, indigo, and cotton. That which was locally grown was intended for domestic use. The thin, sandy soil was much different from the rich alluvium that attracted cotton planters to the Mississippi and Yazoo River Delta region in the northwestern part of the state, as it differed from the Pearl River floodplain to its south. The terrain and the soil were inappropriate for the cultivation of plantation crops, as Claiborne asserted, "the country through which I am journeying is sparsely settled, and is only adapted to grazing."[12] Slavery, though not unknown, was not as prolific as it was in other areas of the state. The soil did allow the growth of trees, and slaves did work in the timber industry cutting trees and working in sawmills, though not in the numbers that one might imagine. Slaves never outnumbered whites in the Piney Woods counties, and beginning with the rise of timber operations in the 1840s were primarily used to fell, transport, and raft logs downstream to waiting lumber mills. They were also used in the mills for heavy manual tasks, although at least one operation employed its slaves in the manufacture of circular saws and steam engines. The 1850 and 1860 censuses show that the majority of the

[11] J. F. H. Claiborne, "Rough Riding Down South," in Marion Barnwell, ed., *A Place Called Mississippi*, 86-87. "California fever" refers to the frantic rush westward to the gold strikes first reported in 1849 at Sutter's Mill in California. The mad scramble for wealth benefited some, but for most it was a disappointment and resulted in overnight boom towns, saloons, and bordellos where the vices catering to wayward prospectors abounded.

[12] Ibid.

slaves in the region worked in "forest industries" and brick-making, with the forest industry standing at 200 slaves in 1850, and 400 in 1860.[13]

Along with the slaves, lower-class and landless whites provided manual labor. Despite the limited number of historical works directly addressing the Piney Woods region, there are studies of poor whites in northeastern Mississippi, including examples of illicit interactions and trade between slaves and poor whites. Evolving from the "triracial trade" among poor whites, Native Americans, and African slaves, the removal of the Native Americans from the state did little to stop this interaction. After all, the two races commonly worked together performing manual labor and other unsavory tasks. Their existence in close proximity would have interesting consequences later once the nation's question of the future of slavery was solved.[14]

The Piney Woods saw no great battles during the Civil War, nor did large armies march across the region despoiling all in their path. It was practically forgotten, save for the number of volunteers who enlisted in the Confederate cause. One wonders why these people of the lingering frontier went to fight. The historian John Napier offers two plausible answers: one, the white yeomen and poor whites feared economic competition and loss of their social status to emancipated slaves. Second, the Yankees represented modernity and outside change – something that the locals were happy to do without People of the Piney Woods preferred to determine their own course of existence, and to be left alone.[15]

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[13] Nollie W. Hickman, "Black Labor in Forest Industries of the Piney Woods, 1840-1933" in Polk, ed., *Mississippi's Piney Woods*, 79-80.

[14] Charles C. Bolton, *Poor Whites of the Antebellum South: Tenants and Laborers in Central North Carolina and Northeast Mississippi* (Durham: Duke University Press, 1994), 44, 107-108.

[15] Napier, "Piney Woods Past: A Pastoral Elegy," in Polk, ed., *Mississippi's Piney Woods*, 20.

Black and white workers commonly toiled together in the Piney Woods during and after Reconstruction, as the Southern timber industry grew quickly with the demand for lumber to repair the ravages of the war and to supply the requirements of the great migration westward to the Pacific Coast. Members of Rankin Hickman's log-rafting crews "ate out of the same pots, slept in close proximity around campfires, and joined in singing at night. Wages were equal and skin color was of little significance to those of both races, who were often neighbors and longtime friends."[16] Later though, in the 1880s, additional trouble arose as union organizers came to the Gulf Coast and its lumber mills to gather support among the work force. The Noble Knights of Labor (KoL) arrived to address working conditions in and around the sawmills along the Gulf Coast and won concessions on issues such as twelve-hour workdays and higher wages; but by 1900 the KoL's presence disappeared along the Mississippi Gulf Coast as its role was progressively overtaken by the American Federation of Labor. Unionization attempts occasionally occurred, and owners of forest industries within the Piney Woods became adept at using race as a means to discourage them. Although the timber industry still remained highly lucrative until the early twentieth century, competition for menial labor in the forest forced the races apart.[17]

In 1954, William Faulkner wrote an article for *Holiday* magazine, describing the changes that Mississippi had experienced over time. Regarding the woodlands of the state, he lamented that some time after the 1870s railroad lines had opened the interior of the state, allowing sinister forces entry:

[16] Hickman, "Black Labor in Forest Industries of the Piney Woods, 1840-1933," in Polk, ed., *Mississippi's Piney Woods*, 81-82.

[17] Ibid., 82-83.

> (A)ll the way from Chicago and the Northern cities where the cash, the money was….the rich Northerners could come down in comfort and open the land indeed: setting up with their Yankee dollars the vast lumbering plants and mills in the southern pine section, the little towns which had been hamlets without change or alteration for fifty years, booming and soaring into cities overnight above the stump-pocked barrens which should remain until in simple economic desperation people taught themselves to farm pine trees as in other sections they had already learned to farm corn and cotton.[18]

Faulkner's outrage at this influx of "Yankee dollars" and wasteful forestry practices overlooks an important point: before the intrusion of northern business into the Piney Woods, there was a surge of Upper-South capital and entrepreneurs, who had established themselves by the 1890s. One wealthy and ambitious Tennessean, Willie Sion Franklin Tatum, made his lasting mark on the Piney Woods. Born three years before the outbreak of the Civil War, Tatum and his family entered the mercantile business in Bethel Springs, Tennessee, when he was fifteen years old, and by 1881, despite his long moustache and beard (which his fiancée barely tolerated, and would later become his trademark) he had married and was operating the family business as "W.S.F. Tatum & Company." This changed in 1882, when his brother-in-law entered into partnership with him, and the business became known as "Tatum-O'Neal & Company." Among the machinery and goods that Tatum dealt in was pine lumber.[19]

Tatum developed a reputation for business acumen, intelligence, and diligence as a business operator. The lure of moving southward to investigate the potential of the longleaf pine timber industry in the Piney Woods of Mississippi drove him to travel there in 1891. Finding a promising tract in Forrest County located near Hattiesburg and

[18] William Faulkner, "Mississippi," in Barnwell, ed., *A Place Called Mississippi*, 103, 110.

[19] Gilbert H. Hoffman, *Steam Whistles in the Piney Woods: A History of the Sawmills and Logging Railroads of Forrest and Lamar Counties, Mississippi, Volume I – The Newman and Tatum Lumber Companies and the Mills at Lumberton* (Hattiesburg, MS: Longleaf Press, 1998), 106-108.

bordering a railway line, he bought the timber rights for 2,200 acres from a Michigan timber speculator for $27,125. A $9,000 down payment with a contract to satisfy the balance in two years was agreed upon, and in 1893, the Tatum family permanently moved to the small town of Hattiesburg, which had but some 700 residents. Before the Tatums had reached their new home, temporary milling equipment had been shipped to begin production of lumber for the new 160-acre lumber mill, to be sited at a location known as Bon Homme, some three miles south of Hattiesburg. Bon Homme was also on the New Orleans and Northeastern Railroad, critical for transporting the lumber.[20]

Tatum's dreams tied to the dense forests of longleaf yellow pine. He had no knowledge that his enterprise existed over the Louann salt bed, nor had he any notion that the rolling terrain that he would operate in was a direct consequence of salt domes welling up from deep below his feet. His primary concern was reaching the dense stands of old-growth forest, cutting trees, and moving them to the mill at Bon Homme. In doing this, he became notable for his energy and creativity in putting together one of the longest-lived timber operations in the Piney Woods. He could never envision the role that his land would play in local, state, national, or international politics, nor that it would become a critical laboratory of Cold War science. Beneath his feet, the product of millions of years of geologic change waited for discovery.

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[20] Gilbert H. Hoffman, *Steam Whistles in the Piney Woods*, 108-109; Joe F. Tatum, *W.S.F. Tatum: THIS IS A LIMITED BIOGRAPHICAL SKETCH OF A MAN WHO WAS BORN IN TENNESSEE AND MIGRATED TO MISSISSIPPI. HE WAS KNOWN BY ONE OF THE FOLLOWING NAMES: WILLIE SION FRANKLIN TATUM, WILL SION FRANKLIN TATUM, WILLIAM SAMUEL FRANKLIN TATUM, W.S.F. TATUM. Presented at the 235th meeting of the Ciceronean Circle at the home of Laurence H. and Kathleen Polk Mc Duff in Hattiesburg, Mississippi on May 29, 1991* AM91-47, Tatum Family Collection, McCain Archives, University of Southern Mississippi (hereafter referred to as MCAUSM).

Chapter Two

Timber, Oil, and Atoms

Industry drove the Piney Woods unlike any other region of Mississippi. Aided by the area's geology, several developed in succession and in parallel. Timber, transportation, and later, the oil and gas industries developed in the region, unlike the rest of the state. Despite the overwhelming segregationist sentiments in the state, the Piney Woods appears to have suffered less due to violence, which may attest to the nature of those who lived there. The land yielded its trees, and to the spirited, industrious, and wise, their gift was prolonged through extended harvesting. Later, the hidden salt domes offered the promise of vast wealth. By 1960, a geological formation that initially appeared worthless, gained an importance that surpassed the borders of Mississippi, and the United States itself.

Following Reconstruction, the timber industry began to increase in the Piney Woods region. Northern investors and timber speculators bought large woodland tracts and looked forward to leasing logging rights to lumber companies. The family of William Sion Franklin Tatum took advantage of this opportunity to carve a business empire out of the pine forests of Forrest and Lamar counties, while at the same time playing an increasing role in the development of the town (and later city) of Hattiesburg.

When the Tatum family stepped off the train from Bethel Springs, Tennessee, at 4:00 A.M. on January 5, 1893, they knew there were trying times ahead. Hattiesburg was a small town, nurtured by the railroads and the growing demand for timber. Family and friends were far away. W.S.F. ("Willie") Tatum, his wife Rebecca, and their son West, who was less than a year old, moved into a motel on Main Street. Willie Tatum's planning had been thorough in other respects, as even before he and his family had moved to Hattiesburg, the machinery needed at his Bon Homme mill site was delivered. Less than a week after the Tatums felt the predawn chill of that Mississippi winter morning, his workers finished the first house for mill employees. In all, twenty-two were constructed, as well as more commodious homes for Tatum's brother-in-law and partner M. Frank O'Neal, and for George W. Haynes, who supervised the operation of the temporary mills that manufactured the lumber to build the permanent mill. Willie Tatum's younger brother, Barca L. Tatum, also moved down from Tennessee to work at the new mill operation. By the middle of January, they had begun grading the roadbed for a spur line from the New Orleans and Northeastern Railroad, and two weeks later, they broke ground for the mill itself. By the end of June, the first load of rough timber had left the mill.[1]

Tatum designed his milling operation from the outset to utilize steam-powered machinery as much as possible. Several things made the Tatum – O'Neal lumber operation particularly noteworthy. Tatum understood the importance of railroads in getting his lumber to market, and he to access and extract timber from his forests. In its early form, logging in the Piney Woods relied on human and animal power to cut and move logs to streams and rivers to be rafted to mills. Loggers left substantial stands of trees uncut because they were too difficult to remove, or were not close enough to waterways that could move them. Rails could be laid into areas where no water was available, allowing men and animals, or steam winches and cranes, to lift the freshly cut trees onto logging cars for the trip to the mill. Tatum determined to avoid the waste of

[1] Hoffman, *Steam Whistles in the Piney Woods*, 108-109.

careless logging; he was not the forest industry operator of whom Faulkner wrote in 1954. Tatum knew that his wealth lay in trees and that only a fool would rip them out faster than they could be replenished.[2]

Bon Homme gave way to “Bonhomie” in 1893, a name that may have been given as a gesture of regard from transient workers who were happy for the employment Tatum provided them, although a biographical sketch implies that the site was already so titled. Still, despite an economic downturn, Tatum’s operation seems to have been designed to attend to the well being of his workers. Indicative of his nineteenth-century industrial paternalistic sentiments, a one-room schoolhouse was built near the mill in 1896 to save the children of mill workers from having to travel to Hattiesburg. The mill also featured a company store, stables, and a post office.[3]

Two years after Tatum’s logging railroad operation began in November 1894 the mill boasted about two miles of standard-gauge rail. About the same time, he constructed a planing mill on the site for the production of finished boards rather than rough-cut timbers, and a large drying kiln was begun in January 1895. In mid-February, the first three logging cars arrived at the mill, and by the end of September 1896, the mill’s first locomotive - a small four-wheel saddle-tank engine later named “Old Puss” – made its debut, and began a working career that lasted more than a generation. Despite the young entrepreneur’s eagerness to branch out into finished lumber and his use of powered machinery to manufacture it, financially the operation ran on a shoestring. The company quickly cleared out the land it was allotted in the initial contract with J. Henry Moores, a renowned timber speculator from Lansing, Michigan, from whom the timber rights were

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[2] Ibid,, 114-16, 125.
[3] Ibid., 109; Joe F. Tatum, *W.S.F. Tatum*, AM91-47, Tatum Family Collection, MCAUSM.

leased. As Tatum paid off percentages of the lease, additional tracts opened to logging, presumably to make sure the lumber would not be cleared from the entire 2,200 acres before the he paid Moores. The problem was an issue of increasing debt and diminishing timber. Despite a deal with Moores that kept the operation going, Tatum and O'Neal continued to struggle, and went as far as to borrow $5,000 from a Hattiesburg mercantile firm owner in 1895 to secure turpentine rights on some of the Moores land. Still, not until the end of 1897 did both the economy and the timber industry begin to improve, and Tatum pursued whatever extra logging rights he could secure on the lands around his mill complex.[4]

O'Neal left the firm in 1898, tiring of Mississippi and yearning to leave for Arkansas. Unable to buy out his interest in cash, Tatum promised him payment in three $5,500 installments, as well as the store in Bethel Springs. The business, renamed the "Tatum Lumber Company," surged on the upturn of the market, allowing Tatum a luxury that he had not had before: he began buying timber land rather than logging rights. Tatum bought 3,848 acres of land between 1897 and 1901, adding to his logging rights on the Moores tract. Interestingly, he bought the last block of 1,924 acres from another lumber speculator named McPherson, who like Moores, lived in Michigan. The increased size of his holdings, together with a flourishing economy, meant that the previous timber shortages were a worry of the past. Tatum Lumber products enjoyed a wide distribution throughout the major cities of the Midwest during the 1890s. At the turn of the twentieth century, the Tatum family, who added twin boys Will Sion and Frank Murry to their number in 1895, was doing well.[5]

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[4] Hoffman, *Steam Whistles in the Piney Woods*, 108-111.
[5] Ibid., 113-14.

Following a three-month family trip to Europe in 1904, during which time the mill had been closed, Tatum acquired more timber rights and land and also continued to expand the amount of standard-gauge track running through the Piney Woods. Lamar County was created that same year by the annexation of portions of Marion and Pearl River counties, and was named for the former senator, Secretary of the Interior, and Supreme Court Justice Lucius Quintus Cincinnatus Lamar.[6] The shutdown of the Bonhomie mill and the thorough logging of the mature trees on the lands that Tatum acquired before the turn of the century meant he held too little available timber to restart his operation economically. Tatum had determined earlier that simple clear-cutting was a waste of future profitable lumber and decided that only the trees with trunk diameters more than ten inches should be taken. In 1901, he conducted an experiment, ordering his crews to take only the younger pine trees whose trunks were less than ten inches in diameter, and to harvest enough to supply the mill with enough volume for thirty days. His experiment left him with a $500 deficit after that period. Larger trees contained more wood, and were therefore more cost-effective. He also forbade the use of log skidders on his property because of their destructive effect on the thin layer of topsoil on the timber tracts. With a partner, he bought nearly 14,000 acres of timberland for $325,000, known as the "Okahola Tract," as well as another tract that allowed him access to two important rail lines: the Gulf & Ship Island and the Mobile, Jackson, and Kansas City railroads.[7]

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[6] U. S. Department of Commerce, Bureau of the Census, *Thirteenth Census of the United States Taken in the Year 1910, Volume II: Population 1910; Reports by States With Statistics for Counties, Cities and Other Civil Divisions, Alabama-Montana.* (Washington, DC: Government Printing Office, 1913), 1031; Frank E. Smith and Audry Warren, *Mississippians All* (New Orleans: Pelican Publishing House, 1968), 59-74.

[7] Hoffman, *Steam Whistles in the Piney Woods*, 114-16, 125.

By 1907, Tatum was again fully immersed in the timber business with a new mill incorporating a doubled boiler capacity in the power plant for new machinery, and extended his logging railroads into his new holdings. In 1910, Tatum even incorporated one of his lines - the Bonhomie and Southwestern - to connect the towns of Columbia and Hattiesburg. A religious man, Tatum was adamant that the line would never operate passenger or freight service on Sundays, except in extreme situations "and the promotion of the Christian religion." This railroad never became a full reality and it fell several miles short of Columbia, although over the next several years people speculated that it would in fact be completed. The Okahola tract and other timber lands bought and worked by the Tatum company kept the mill in continuous operation until 1914, when work again ceased. Tatum's explanation was that the timber close to his rail lines had already been taken and that it would not be feasible to continue laying track towards the remaining stands of trees. The real reason was most likely due to a discovery that had been made in Texas just before he and his family moved to the Piney Woods. Willie Tatum's attention to his property had been confined above the ground to finding profitable stands of trees. Now he wanted to look beneath the surface to find oil.[8]

The Texas oil industry had begun in the early 1890s with accidental discoveries, such as in Corsicana, where drillers seeking life-sustaining water instead found oil in their wells. Petroleum was a resource that was quickly finding new uses, from lighting and lubrication to powering newly developed internal combustion engines. A Beaumont mechanic, Patillo Higgins, felt certain that a hill located on a flat plain near the town would yield oil and gas because of the presence of flammable gases he had encountered near it on Sunday school outings. Higgins called it "The Big Hill" while residents knew

[8] Ibid., 116-22.

it as Spindletop. Ridiculed for his beliefs by townspeople and geologists, he eventually received the attention and aid of Captain Anthony Lucas. Lucas and Higgins began exploratory drilling in 1899. These first efforts failed, driving the ridiculed prospectors to the wildcatter firm of Guffey and Galey in Pittsburgh.

Returning to Beaumont and Spindletop with Higgins, John Galey marked the spot of the next exploratory well near the gas springs that had first stirred Higgins's excitement. In late 1900, drilling began and slowly proceeded until it struck a modest amount of oil at 880 feet. Resuming drilling on January 1, 1901, the crews working the rig were shocked nine days later when the first Texas gusher blasted sand, drill pipe, oil and rocks hundreds of feet into the air. Higgins, the self-educated prospector, had been right after all and had been fortunate to become allied with Anthony Lucas, a successful mineral prospector who understood the properties of salt domes. Spindletop was a classic example of a Gulf Coast salt diapir that had reached close enough to the surface that its caprock had thrust a domelike hill in the midst of flat terrain.[9]

Even more important than the initial discovery of petroleum at Spindletop was the birth of understanding about the connection between salt diapirs and petroleum. All salt domes did not yield oil, but oil was commonly found in the presence of salt. Therefore it made sense to locate exploratory wells at salt domes. Even with the oil glut produced by the Texas fields, there was still sufficient financial incentive to continue prospecting along the Texas Gulf Coast, and then farther east towards Louisiana. In September 1901, Louisiana's oil industry began with a well drilled near a salt dome near the town of Jennings. In the spring of 1903, the first exploratory oil well in Mississippi was drilled at

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[9] Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, and Power* (New York: Free Press, 1991), 82-85.

Enterprise. As the timber industry began to decline in the early part of the twentieth century, the increasing importance of gas and oil to industry and transportation helped make up for up the overall financial shortfall. Natural gas proved abundant in the region, though oil initially proved elusive. Mississippi's first well to produce significant quantities of oil was completed in 1932, and was rapidly followed by others. The discovery of the first salt dome in Mississippi four years later by Sun Oil Company geologists was a major disappointment, yielding little if any gas and no oil.[10]

Mississippi's salt domes initially proved difficult to locate through seismic means. The sedimentary layers over the domes had the effect of damping seismic waves emanating from emplaced explosive charges as they radiated towards and reflected back from deep subterranean structures. There was little else to do but select likely sites, drill exploratory wells, and retrieve drill-core samples to locate salt domes and likely sedimentary beds where petroleum concentrated.[11]

Willie Tatum's pursuit of this new industry was expensive and time-consuming. Yet with characteristic determination, not only did he allow outside oil exploration teams on his land, but he actively urged his sons to enter the oil and gas business. In 1922, locals petitioned for Tatum to assume the unfilled term of Hattiesburg Mayor Thomas E. Batson, who had died on July 1.[12] With this mandate, he assumed the office and remained mayor for sixteen years, leaving office in 1938. While serving, he entered the natural gas supply business by fronting nearly half a million dollars to a natural gas enterprise, the Public Service Corporation of Hattiesburg, which sought to undercut the

[10] Dudley J. Hughes, *Oil in the Deep South: A History of the Oil Business in Mississippi, Alabama, and Florida, 1859-1945* (Jackson: University Press of Mississippi, 1993), 12, 23, 78, 103.
[11] Ibid., 175.
[12] Hoffman, *Steam Whistles in the Piney Woods*, 141.

existing manufactured gas system that already supplied Hattiesburg. Through questionable dealings including resolutions designed to thwart outside companies from providing the city with natural gas, Tatum secured a favorable deal for the Public Service Corporation. In doing so, he faced a lawsuit charging him with conflict of interest – the judge later exonerated him due to the court's opinion that Tatum performed a public service because of the much lower cost of natural gas as opposed to manufactured gas. Following this decision in 1932, Tatum bought the assets of his manufactured gas rival, who quickly went bankrupt, and also bought the property of the Public Service Corporation, which had also fallen on hard times and had declared bankruptcy in 1934. Shortly thereafter, he and his sons Frank and Will founded the Willmut Gas and Oil Company, which got its name from the first four letters of W.S.F. Tatum's first name and the last three letters of his last name in reverse.[13] In addition to his trees, Tatum was now in the oil business.

Northern and central Mississippi remained primarily agricultural regions while industry developed in southern portions of the state and along its Gulf Coast. Depression-era economic hardships led Mississippi's government to propose and endorse a larger program of industrialization for the state, known as the "Balance Agriculture With Industry," or BAWI, program in 1935. Credited to Democratic Governor Hugh L. White, a former lumberman, the program subsidized twelve new industrial operations in the state to shore up civic economies solely dependent on agricultural and timber production. Hattiesburg attracted a plant for the manufacture of silk hosiery, which changed to shirt manufacture during World War II. BAWI's other major effect in the region was the development of Ingalls Shipbuilding in Pascagoula, which continues to be

[13] Hughes, *Oil in the Deep South*, 93-95.

one of the largest shipbuilders in the country. Smarter lumbering practices forestalled, the collapse of the timber industry, and it remained a staple of the local economy for some time after the war. BAWI was important to the state at the time, but its relevance to the story at hand is that it presaged later developments. Mississippi was eager to attract as much industry as it could, as later programs ably demonstrated. BAWI was primarily intended for less industrialized areas of the state, and not so much in the Piney Woods, where timber and oil production provided most of the economic impetus. But BAWI was not the last program to bring industry to Mississippi. That came later, from an unlikely source.[14]

Despite the Great Depression, Willmut not only expanded its natural gas operation – with the purchase of the Public Service Corporation assets, it also assumed a respectable gas pipeline network – but also began prospecting on Tatum's extensive landholdings. Exploratory wells proved disappointing, although ironically Willmut did make a name for itself in Illinois oil production. In 1940, following a visit by a Sun Oil Company magnetometer crew, the Tatums drilled an exploratory well at a promising location on one of their Lamar County properties. The magnetic signal registered the signature of a substantial accumulation of iron, which usually indicated a salt dome caprock. Hoping for a geyser of oil, or at least the whoosh of a lucrative natural gas well, the survey team struck nothing more remarkable than calcite and salt. Willmut leased the sulfur rights to Freeport-Sulphur Company, and drilled deeper, to no avail. There was neither oil nor natural gas at the dome, now named for the Tatum family.[15]

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[14] Ernest J. Hopkins, *Mississippi's BAWI Plan: Balance Agriculture With Industry, An Experiment In Industrial Subsidization* (Atlanta: Federal Reserve Bank of Atlanta, 1944), 1-4, 11, 34, 42-3.

[15] Hughes, *Oil in the Deep South*, 144.

But there was plenty of salt. Although the depth of the base of the dome had yet to be determined, it was obvious that it was an enormous mushroom-shaped diapir that measured well over a mile in diameter, and whose uppermost surface was still more than twelve hundred feet below ground level. The Tatum Dome was born of the Louann Salt, yet it had no petroleum. This was an irony that would not be lost on Willie Tatum or his sons. In 1943, with World War II dominating the nation's fuel demands, Gulf Oil[16] began prospecting just a few miles west of Tatum's dry hole, near the small town of Baxterville, also located in Lamar County, and not far from Lumberton, Mississippi. This field eventually became the state's most productive one, yielding nearly a quarter billion barrels of oil and more than 400 billion cubic feet of gas between 1944 and 1990.[17] Through a twist of geological fate, the vast wealth of the Baxterville field had eluded Tatum. Yet it further focused the oil industry's attention on the Piney Woods and fueled dreams of more hidden oil bonanzas in the region.

Geological and petroleum journals reported the Tatum Dome's existence, and it was noted on surveyor's maps. The salt was deep, but it was technically recoverable should the world salt market's prices rise high enough to make it economically practicable. Much the same could be said for the sulfur that could be recovered from the gypsum-rich caprock, but sinking a shaft to mine the deep deposits at the Tatum Dome made no economic sense since much more easily accessed sources of sulfur existed. And

[16] Gulf Oil emerged from a deal between Spindletop prospectors Guffey, Galey, and Lucas, backed by Pittsburgh bankers Andrew and Richard Mellon. In May 1901, Guffey secured funding from the Mellons through the sale of 50,000 shares of stock, allowing him to buy out Galey and Lucas, creating the J. M. Guffey Company. Six years later, he merged his operation with the Gulf Refining Company, which later became the Gulf Oil Company. Shortly thereafter, Guffey was fired by the Mellons. See Neil McElwee, "Guffey and Galey – Some People Get Around." http://www.oil150.com/essays/2007/12/guffey-and-galey-some-people-get-around (accessed September 9, 2009)

[17] Hughes, *Oil in the Deep South,* 217-18.

so the salt and sulfur on Tatum's land remained buried and nearly forgotten. The land over the Tatum Dome was left to the trees and the wildlife, with occasional visits from hunters and picnickers.

In 1948, Willie Tatum died. He left behind a thriving city of nearly thirty thousand residents transformed from the small town of little more than a thousand persons when he first arrived. His sons, steeped in the timber and oil industry, inherited a business empire that encompassed much of the Piney Woods. Other industries had come to the region, in part due to the wartime needs of the shipyards of Biloxi, Pascagoula, and Mobile to the south and southeast, and also because of the availability of road and rail transportation. Nearly 700 people labored in the chemical industry – a new category not listed in previous census reports. Wood-based industries for Forrest County and Hattiesburg decreased from nearly a thousand in the 1930 census to about a third that number twenty years later.[18] Census and occupational data show that industry continued to thrive in the Piney Woods despite the employment decline.

The postwar and Cold War period fostered an increased atmosphere of social and racial tension in the South. African Americans who had fought for their country and had earned the respect of white comrades in combat returned to an atmosphere of racial inequality. Throughout Mississippi, racist groups including the Ku Klux Klan continued terror campaigns designed to cow local blacks and preserve the segregated status quo and

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[18] U. S. Department of Commerce, Bureau of the Census, *Fifteenth Census of the United States: 1930. Population, Volume III, Part 1;Reports By States, Showing the Composition and Characteristics of the Population for Counties, Cities, and Townships or Other Minor Civil Divisions; Alabama-Missouri.* (Washington, DC: Government Printing Office, 1932), 1301; U. S. Department of Commerce, Bureau of the Census, *A Report of the Seventeenth Decennial Census of the United States. Census of Population: 1950, Volume II, Characteristics of the Population; Number of Inhabitants, General and Detailed Characteristics of the Population, Part 24: Mississippi* (Washington, DC: Government Printing Office, 1952), 24-7, 24-46.

white supremacy. Interestingly, though, the number of the most violent of these terrorist actions, lynching, contrasted strongly between the numbers that took place in the state as a whole and those conducted in Forrest and Lamar counties, and indeed between the two counties themselves. Taking the figures from Julius E. Thompson's *Lynchings in Mississippi, A History, 1865-1965*, between 1890 and 2002, 617 people were lynched in the state, and of those, 14 were murdered in Forrest County and only one was lynched in Lamar County. Bearing in mind that Lamar County has been and is primarily rural with Purvis as its county seat, while Forrest County has the much larger Hattiesburg as its seat, this might indicate that this violence likely came as a result of cosmopolitan contact rather than the agrarian subordination and subjugation seen in Mississippi's Delta region. Part of the explanation for the relatively low numbers also comes from the racial makeup of the two counties: census data shows both to be primarily white. This agrees with the industrial history of the region, which was neither plantation-based nor primarily slave-driven.

This is not to say that even in the most urban settings in the Piney Woods that segregation was not observed: it was as surely a social mechanism of oppression there as it was anywhere else, but it does not seem to have been as violently enforced. Newspapers of the period, such as the *Hattiesburg American* and the *Laurel Leader-Post,* regularly ran news stories with titles referring to "Negroes," obituaries segregated into "White" and "Colored," and the occasional advertisement for a Klan rally, but much of the violence generally appeared to be happening elsewhere. Whether this was because of the feeling that *de facto* segregation was not as threatened, or from self-deception resulting from the lower level of violence, remains open to question.[19]

Mississippi itself remained a bastion of hard-line segregation. The 1947 decision by President Harry Truman to desegregate the military and incorporate changes that threatened the South's "peculiar institution" caused a reaction in Mississippi, where "segregation forever" became the battle cry among many whites. Following the 1954 election, the firebrand segregationist Ross Barnett won his first term as Mississippi's governor and represented a blatant rejection of federal power in his state. Ironically, he did not object to the intrusion of the atom into Mississippi. Although we cannot be certain, Barnett likely saw nuclear technology as a ready injection of cash into his state's economy.[20]

Politically, Mississippi was in flux. The year Willie Tatum died was the same year that many southern Democratic politicians, enraged by Truman's integrationist policies, left the party in protest to field their own Presidential candidate. Mississippi's delegation to the Democratic convention of 1947 was the first to defect, in what led to the formation of the States' Rights Party, commonly referred to as the "Dixiecrats." In many ways this was a return to the Redemptionist mindset following the years of Reconstruction. The titular head of the party that had originally been the political base of the segregationist system now threatened the social institutions that had become commonplace and accepted in the South. Refusing this new course, many Southern Democrats instead defected to the Dixiecrats and began the trajectory that eventually

[19] Julius E. Thompson, *Lynchings in Mississippi: A History, 1865-2002* (Jefferson, NC: McFarland & Company, Inc., 2007), 12, 36, 49, 65, 84, 98, 120, 142, 158-60, 182-83, 185.

[20] Ross Barnett's personal papers have not been archived; indeed no one knows where they are located. It is probable that they are being retained by the Barnett family.

made the South a conservative Republican stronghold, returning to the mantra of states' rights superseding national policies. At the 1948 Democratic National Convention, Mississippi's delegates led the secession from the Democrats to the States' Rights Party that later nominated South Carolina's Strom Thurmond as its presidential candidate, and their own Fielding Wright as the vice-presidential nominee.[21]

People of the Piney Woods certainly noticed this schism. Though the period between 1948 and 1960 were years of significant growth in terms of economy and population, they were marred by racist rhetoric and an avowed determination to keep Mississippi segregated. According to historian Erle Johnston, every major election during this period became a referendum on segregation, and in every one, the Piney Woods had a candidate running for the governor or lieutenant governor's office. In the 1955 gubernatorial election, Hattiesburg native Paul B. Johnson Jr. lost to Attorney General James P. Coleman and ran during the next election as Ross Barnett's lieutenant governor, finally reaching the governor's office in 1964. During the period before assuming the governorship, Johnson was an ardent segregationist, suggesting in the 1955 election that police power be used to maintain the state's "separate but equal" policies.[22]

Ross Barnett was an icon of segregationist political power. From his election in 1955 to his departure from politics in 1964, he always appeared to be at the forefront of racial division, actively denying James Meredith access to the University of Mississippi in 1962, and justifying white attacks on African-American bathers on Biloxi beaches. A model "states' rights" governor, Barnett never wasted an opportunity to stand against the

[21] Erle Johnston, *Mississippi's Defiant Years 1953-1973: An Interpretive Documentary with Personal Experiences* (Forest, MS: Lake Harbor Publishers, 1990), 28.

[22] Ibid., 31; Stephan D. Shaffer, "Party and Electoral Politics in Mississippi" in Dale Krane and Stephan D. Shaffer, eds., *Mississippi Government and Politics: Modernizers Versus Traditionalists* (Lincoln: University of Nebraska Press, 1992), 82-83.

rising national tide of desegregation. The election of John Kennedy signaled an important change in federal pressure on the South to alter its social institution. Barnett and the Kennedy Administration seemed to be natural antagonists, yet they found ways to work with each other. Barnett was a bigot, but he, Johnson, and John Stennis, who entered the United States Senate in 1947, were canny politicians who differed greatly from stereotypical "good old boys." Historians Stephan Shaffer and Dale Krane note that Barnett went so far as to discuss with Robert Kennedy a plan to enact a "symbolic surrender" at Ole Miss during the James Meredith crisis. Forced to accede to federal marshals at gunpoint, Barnett would save face in the eyes of his constituency while allowing Meredith into the university. The plan was cancelled for fear that state authorities might in turn draw their weapons on the federal marshals. Although publicly defying the Kennedy brothers on the Meredith issue, and capitulating in the face of force, Barnett also realized the change in national attitudes when Cleve McDowell, another African-American, applied to enter Ole Miss's Law School several months after the riots caused by Meredith's admission there. Barnett overrode actions to close the school, understanding there was little point in fighting the same battle again to the detriment of the school, its students, and the state.[23]

Nevertheless, Barnett was publicly committed to preserving the outdated social mores of Mississippi against the encroachment of federal plans to dismember and destroy it. He was not committed to excluding all federal influence, and correspondence indicates that he and his successor, Johnson, were both more than amenable to allowing atomic testing in the state. This was due to two things: prestige and money. Atomic

[23] Johnston, *Mississippi's Defiant Years*, 200; Stephan D. Shaffer and Dale Krane, "The Origins and Evolution of a Traditionalist Society" in Krane and Shaffer, eds., *Mississippi Government and Politics*, 83.

testing represented America's highest technology. As Mississippi was a poorer, primarily agricultural state, atomic testing could prove to be the ultimate pinnacle in the BAWI concept: the state had the potential to serve a base for the highest of high-tech defense industries. This was not as unreasonable as it may seem: neighboring Alabama was primarily agricultural before industry began to flow into the state as a result of outside economic sources following the Civil War. Over time, Alabama had become home to high-tech defense industries, such as the development of military aviation at Maxwell Air Force base and the concentration of ex-German rocket and missile engineers at Redstone Arsenal and the Marshall Space Flight Center in Huntsville. Mississippi was already home to a large army base at Camp Shelby, located in the heart of the Piney Woods. An influx of scientists and technicians could rehabilitate Mississippi's image. But unlike the original BAWI program, Mississippi did not have to sell itself to outside industry, and lure it with publicly-funded facilities. All it had to do was open the door to the federal government.

The most likely reason why Barnett was happy to welcome the Atomic Energy Commission's interest in his state was that with scientists and technicians, well-drillers and various support personnel, would also come a substantial amount of money. Initially, Hattiesburg's economy anticipated some $15-$20,000,000 from an atomic program, in stark contrast to Faulkner's dour impression of outside intrusion into the Piney Woods. The city would certainly be the center of operations as it was the largest transportation node in the area. There were also the structures necessary for the control, monitoring, and safety systems of the test site would have to be built, as well as infrastructure improvements to local runways and roads, all paid for again by the federal government.

The influx of federal capital was certainly welcome, and along with the millions to be spent on the test site and operations, there was a windfall when the salt dome was prepared for testing. As a byproduct of excavation and test site preparation deep into the salt dome, at least two million tons of salt, worth at least $16,000,000 would be brought to the surface.[24]

There may be another explanation for Barnett's puzzling attitude towards bringing the AEC into Mississippi. The atomic program was a carrot and social change was a stick. A common tactic in relations between the federal government and recalcitrant southern states, highway and airport development also served this aim. Local leaders received increased economic benefits and prestige in exchange for accepting growing federal influence. By the 1960s, the Department of Defense has assumed a primary role in this process, and the South emerged as a crucial region for military-related activities. Mississippi was no exception, and during the period between 1951 and 1976 saw an increase of more than twenty five times in the number of defense contracts awarded. To a great extent, these were rewards for acceptable behavior, with the unspoken threat that what the federal government granted, it could take away. To Barnett's credit, it appears that he was adept at playing both sides: negotiating with the Kennedy administration while continuing to appeal to his white power base.[25]

There were potentially serious drawbacks to any decision to carry out atomic testing in south Mississippi. Unlike the Nevada Test Site (NTS), there was no large reservation at the candidate salt domes to act as a buffer zone in case of an accidental

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[24] *Hattiesburg American*, Jan 21, Feb. 3, 1961.

[25] Charles S. Bullock III and Janna Deitz, "Transforming the South: The Role of the Federal Government" in Craig S. Pasoe, Karen Trahan Leathem and Andy Ambrose, eds., *The American South in the Twentieth Century* (Athens, The University of Georgia Press, 2005), p. 248; Schulman, "From Cotton Belt to Sunbelt," 228, 332, 360.

radiation release. In case of containment failure, radioactive materials would be in immediate contact with pasture and farmland. The Tatum site was located roughly 130 miles north of New Orleans, 100 miles northwest of Mobile, Alabama, 80 miles north of Biloxi and Gulfport, 25 miles southwest of Hattiesburg, and 12 miles west of Purvis, Mississippi. Winds had to be light, steady, and had to be from the right direction, ideally from the south blowing to the north. Such winds are common in the Piney Woods, and occur almost daily. As the ground heats up more quickly than the Gulf of Mexico to the south, the air over the ground rises more quickly than the air over the water. Air tends to flow inland from the Gulf - commonly called the "sea breeze." Along the Gulf Coast, much of the thunderstorm activity occurs when a strong moisture-laden sea breeze pushes inland as a "sea breeze front," and is then lifted by the warming effect of the ground. Preferably, there needed to be a high pressure region over the eastern Gulf or western Atlantic, pushing the air steadily over the Piney Woods from the south. This pattern is aided during the summer months as the "Bermuda High" pressure system builds up.

This weather pattern is also why the Gulf Coast is subjected to some of the most destructive weather on earth. The Bermuda High acts as an enormous steering system for tropical storms and hurricanes. It tends to push storms in the Atlantic southward towards Florida and the Keys, and once past the most powerful influence of the high, these weather patterns commonly travel north towards the coastlines of Florida, Alabama, Mississippi, Louisiana, and Texas. The threat of tropical storms and hurricanes had to be taken seriously, even a hundred miles inland from the coast. Tropical weather aside, every day brought the potential for heavy thunderstorms to suddenly materialize and pelt the site with torrential rains, lightning, heavy winds, hail, and the occasional tornado.

The Piney Woods had been blessed with ample stands of tall longleaf pine trees, and was later found to have substantial deposits of natural gas and oil. The salt that had proved twenty years earlier to be uneconomical to extract could be recovered as a byproduct of a far more lucrative operation than a salt and sulfur mine. Frank Tatum wrote to Senators John Stennis and James Eastland, as well as Congressman James Colmer on October 29, 1960, regarding an unusual visit by the representatives of the United States Army Corps of Engineers concerning the Tatum Dome: "These gentlemen came first with the request that they be allowed to go on the land. When we inquired why, they said they simply wanted to look it over. After a number of conferences with them, it finally developed that the Atomic Energy Commission wanted to do some atomic shooting in the salt dome."[26]

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[26] Tatum to Eastland, Stennis, and Colmer, Oct. 28, 1960, Subseries: Tatum Salt Dome T-2 1960-1961, folder 27, series 12 – Atomic Energy Commission, Stennis Collection, Mississippi State University Congressional and Political Research Center, Mitchell Memorial Library, Mississippi State University (hereafter documents will be cited by document, subseries file, Stennis Collection, MSUCPRC.)

Chapter Three

The Road to Dribble

The underground atomic tests conducted near Hattiesburg, Mississippi, were part of a larger series of tests, known as "Vela Uniform" (VU), which was itself part of an overarching program codenamed "Vela." The other two components of Vela, "Vela Hotel" and "Vela Sierra," were respectively tasked with detecting space-based and high-altitude tests. Vela was designed to increase the abilities of observers to detect covert and illicit nuclear testing, as well as to accurately assess the strength and properties of legitimate nuclear tests from long distances. Despite the agreement of the Soviet Union, Great Britain, and the United States to move testing underground by the beginning of the 1960s, these nations were still suspicious of each other and were not quite amenable to having observers from other countries present when they tested their most sophisticated military technology. Moreover, the impossibility of completely isolating such observers from test workers and civilians represented a perceptible security threat. Mechanical on-site observation stations were vulnerable to tampering or sabotage. What was most desperately needed were new, accurate means to observe the conduct of atomic tests over distances of hundreds or thousands of miles. The VU program, directed at underground test detection, was intended to address this need.

Atomic test monitoring can be traced back to the first test of an atomic bomb. Monitoring is only part of the challenge. It is far easier to do so when the planned time of a test is known. When it is not, the test must first be detected before it can be analyzed. From the first atomic test to the announcement of the Vela program, the United States tried and assessed several methods of remote nuclear test detection and monitoring. The increase in political momentum towards removing nuclear tests from the atmosphere caused some proven detection methods to be abandoned and replaced by others that were previously considered to be impractical.

The first nuclear test took place in the predawn hours of July 12, 1945, in an isolated area of desert near Alamogordo, New Mexico. Along with the scientific monitoring of the test was an unofficial experiment designed to rapidly evaluate the explosion and decide the winner of a betting pool set up among the new weapon's designers. Yield values ranging from zero (a dud) to 45 kilotons (45kt),[1] were established before the test, codenamed "Trinity." Each bet cost a dollar: Edward Teller bought the highest yield, while Los Alamos laboratory director J. Robert Oppenheimer bet on a modest 800-ton yield. Knowing it would take some time to evaluate the test thoroughly through radiochemical methods following the experiment (should it succeed), Italian physicist Enrico Fermi proposed a simpler means to settle the wager. He held scraps of paper in his hand and waited for the countdown to zero.[2]

Fermi had been primarily concerned with research into the bombardment of elements with neutrons and had presided over the first sustained atomic chain reaction in December 1942, when he oversaw the withdrawal of the control rods of the first atomic pile in the squash court beneath Stagg Field at the University of Chicago. Fermi had been responsible for crucial discoveries regarding nuclear materials development and atomic reactors, both vital steps towards development of the bomb. The Trinity test

[1] Explosive yields from nuclear weapons are expressed in terms of equivalent tonnage of TNT. The most common benchmark is the kiloton, or 1,000 tons of TNT. Later devices reached the megaton range, which is 1,000,000 tons of TNT, or 1,000 kilotons. All explosive yield data expressed in this work will be indicated by an Arabic numeral followed by the appropriate denotation kiloton (kt) or megaton (mt) where applicable.

[2] Edward Teller, with Judith Shoolery, *Memoirs: A Twentieth-Century Journey in Science and Politics* (Cambridge: Perseus Publishing, 2001), 211. Teller recalled the upper figure was 40 kt; Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon & Schuster, 1986), 656.

began the atomic age and led to an arms race; the paper in his hand would begin the process by which the technology and the arms competition would be restrained. Ten thousand yards from Ground Zero, he waited for the test to commence. At 5:30 AM, the area was instantly bathed in a blinding light reminiscent of the midday sun. As Fermi recalled, he opened his hand containing small bits of paper as the blast wave visibly raced towards him some forty seconds after the detonation: “I tried to estimate its strength by dropping from about six feet small pieces of paper before, during and after the passage of the blast wave. Since, at the time, there was no wind, I could observe very distinctly and actually measure the displacement of the pieces of paper that were in the process of falling while the blast was passing. The shift was about 2 ½ meters, which, at the time, I estimated to correspond to the blast that would be produced by ten thousand tons of T.N.T.” Fermi’s measurement was significantly conservative, being some 8kt under the actual yield, determined by later radiochemical analyses as 18.6kt. In what was the first known attempt to assess the power of an atomic test apart from an analytic measurement or official disclosure, Fermi had used simple barometric fluctuation in conjunction with a dynamic pressure wave to assess the explosive yield. Although the government had placed barometric and seismic monitoring equipment at distances of up to several miles from Ground Zero, these were considered less important for monitoring the test as they were for limiting damage claims to personal property that might be caused by the blast.[3]

The radiochemical analysis of the Trinity bomb was easy to accomplish – samples from the test were available and collected with relative ease. Yet it was a different story

[3] Rhodes, *Making of the Atomic Bomb*, 656, 674, 677. Physicist I. I. Rabi won the bet – Rhodes notes that due to his being last to enter the pool, the only remaining slot was for 18 kt – close to the actual yield; Charles A. Ziegler and David Jacobson, *Spying Without Spies: Origins of America’s Secret Nuclear Surveillance System* (Westport, CT: Praeger, 1995), 38.

when it came to the atomic bomb dropped over Hiroshima. Physicist and engineer Luis Alvarez flew on the Hiroshima mission aboard one of the accompanying B-29s.[4] Alvarez supervised the dropping of several parachute-borne detector packages that gave initial data on the detonation of the "Little Boy" weapon over Hiroshima. Incorporating microphones to measure the positive and negative dynamic pressures created by the blast, the detectors were developed by Alvarez in response to a request from Oppenheimer to develop a means to assess the performance of the untested gun-type uranium bomb. The detectors then sent telemetry data back to the raiding aircraft via a radio transmitter and delivered information on the barometric effects of the blast. Alvarez had in effect found a way to replicate Fermi's experiment and in the process invented the ancestor to the dropsondes that are used today by meteorologists to study hurricanes.[5]

Scientists discovered a second important means of test detection and monitoring. Knowing that volcanically-produced particulate matter rose high into the atmosphere, they suspected that the dust created by a nuclear bomb would also have quantifiable properties and could be collected as it floated in the stratosphere. Aircraft equipped with special filtration devices to sample the atmosphere flew carefully planned routes that intersected high-altitude air currents. After the airplane landed, the filters were analyzed with a special Geiger counter. Radioactive debris was readily detected in the upper

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[4] Contrary to popular belief, neither the Hiroshima nor the Nagasaki missions were flown by single airplanes, but were accompanied by camera-carrying and instrumented B-29s charged with collecting data on the attacks.

[5] Luis Alvarez, *Alvarez:Adventures of a Physicist* (New York: Basic Books, Inc., 1987), 139-41; Gregg Herken, *Brotherhood of the Bomb: The Tangled Lives and Loyalties of Robert Oppenheimer, Ernest Lawrence, and Edward Teller* (New York: Henry Holt and Company, 2002), 139. Dropsondes or radiosondes are used to collect information as they fall from an aircraft and transmit it telemetrically to a receiver. Many are specially outfitted to collect meteorological data such as temperature, humidity, barometric pressure, and wind speed, and are crucial tools in tropical weather forecasting and research.

atmosphere using this method. This became the primary means whereby the United States stood the best chance of detecting weapons development by unfriendly nations.[6]

The next atomic devices to be detonated were targeted on a fleet of warships moored in Bikini Atoll in the Pacific. The fleet consisted of vessels from the United States, Germany, and Japan, and represented nearly every class of naval combat vessel, from the aircraft carrier USS *Saratoga* to battleships, cruisers, and submarines. The test program, code-named "Crossroads," was initially to comprise three tests: the air-dropped shot, named "Able"; a shallow underwater shot, named "Baker"; and a deep underwater shot, named "Charlie." There was little concern that the bombs would not work. Shortly after the Able test bomb missed the target fleet, unmanned drone aircraft flew through the rising cloud; manned B-29s carrying special oil-coated paper filters were later flown through the debris cloud as it drifted away from the target area. Once the bombers landed, their filters were removed and placed against specially sensitized film. The radioactive particles produced spots on the film, and after it was developed it was used as a map for analysts to find individual specks of debris in the filters. These specks were then collected and analyzed to indicate how well the weapons performed.[7]

Acoustic monitoring and seismic detection were also investigated as ways to detect atomic blasts. These methods had been used during the Trinity test, and were again at Bikini in 1946. Pressure sensors and seismographs measured the intensity of shock waves on several islands of the lagoon with, and sensors were also placed on the floor of the lagoon. In regard to the acoustic method, the possibilities of blast detection

[6] Ziegler and Jacobson, *Spying Without Spies*, 38-39.

[7] Ibid., 46. The Charlie test was cancelled due to the unexpected radiation from the Baker test; Charles Ziegler, "Waiting for Joe-1: Decisions Leading to the Detection of Russia's First Atomic Bomb Test," *Social Studies of Science* 18 (May 1988): 213.

through the atmosphere came from a cataclysmic and unlikely source: the volcanic explosion of the island of Krakatoa in 1883, when sound waves from the blast reverberated back and forth numerous times across the globe. Although greater by orders of magnitude than the largest atomic bombs of the 1940s (it was estimated to have released some 500mt of energy), the blast's seven detectable atmospheric reverberations suggested the possibility that an anticipated Soviet test might be detected by ultra-sensitive barometers, or microbarographs. Barometers might be placed at likely antipodean locations on the opposite side of the globe from where a test was likely to take place. Scientists supposed that as the circular blast wave radiated away from the burst point, the shock front would expand radially outward, finally meeting on the opposite side of the globe. There it would be detected and analyzed for magnitude of yield. It was an intriguing idea – the only problem with it was that it did not work. Later experiments by the United States showed that numerous atmospheric factors occluded symmetrical shock wave propagation. The signal that reached the antipode would be too disrupted to be of use.[8]

The same uncertainties that made barometric and acoustic monitoring unfeasible made seismic monitoring inconceivable. Seismic equipment was unable to detect an atomic burst at any useful range; during the Yoke test, seismographs were unable to record the blast from 500 miles. Tectonic phenomena could be seismically detected at great distances, but there were numerous uncertainties as to how one might distinguish between an earthquake or volcanic eruption and an atomic bomb. Seismology promised

[8] Both acoustic and barometric means of monitoring nuclear tests are mentioned in reference to detection methods. The barometric methods utilized microbarographs and other sensitive equipment; the acoustic monitoring stations were literally a series of listening posts; Jonathan Weisgall, *Operation Crossroads: The Atomic Tests At Bikini Atoll* (Annapolis: Naval Institute Press, 1994), 119; Ziegler and Jacobson, *Spying without Spies*, 45, 103.

to be a more useful means of detecting atomic tests, but uncertainties as to what signal strength an above-ground detonation might create were an important concern in the creation of a practical test detection method. As it turned out, seismic methods of detecting atmospheric explosions would not work, unless the test device was detonated in close proximity to the ground. It appeared for the time being that the aerial sampling method – "sniffing" the atmosphere for fallout – was still the most fruitful of any proposed means of detecting a Soviet test.[9]

Atmospheric sampling methods were simple and used equipment that had already been developed. They allowed timely detection of tests owing to the fairly consistent wind patterns at higher altitudes. Soviet tests, should they occur, could be detected within a day or two, although this depended on whether the sampling mission flown by an individual aircraft penetrated the debris cloud. Samples found in the oil-soaked paper filters were chemically analyzed, allowing precise information to be collected regarding bomb design and yield. Those samples indicating a high ratio of plutonium to other radionuclides might indicate an inefficient design, wherein the reaction was not sufficient to consume the fission material; a sample with a high level of plutonium's fission product americium could indicate that plutonium fission had taken place efficiently. The inclusion of other materials in fission debris can suggest design elements as well. A large amount of beryllium could suggest an added neutron reflector within the device, and so on. The process of chemically analyzing bomb debris for data regarding bomb performance worked, but it depended solely on the collection of debris.

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[9] Ziegler and Jacobson, *Spying Without Spies*, 67, 102-103, 167.

Operation Sandstone consisted of three "shots" in April and May 1948 on the Pacific island of Enewetak.[10] Sandstone was a test program designed to evaluate new designs for deployable weapons. It was also an excellent opportunity to test detection methods. Two of the three important avenues of detection, acoustic and seismic detection, yielded poor data. But the air sampling method again worked well, and a serendipitous discovery further endorsed its use. Technicians at Tracerlab, a private Boston company that contracted with the government to analyze materials from atomic tests, analyzed the collection apparatus and noticed an interesting phenomenon – tiny spherules had mixed into the sampled dust and debris from the test. The lab quickly determined that these spherules were metallic, and were residue from the device itself. They not only stood out from the sandy debris from Enewetak, they also strongly suggested that even in a high-altitude test, bomb residue could be collected. [11]

One obvious drawback to relying on aerial sampling was that it could not provide information as to the exact moment of the detonation. Acoustic and seismic methods had failed to provide conclusive data during Sandstone. The largest device tested during Sandstone was a 49kt weapons-development shot code-named "Yoke" – well over twice the yield of the bomb dropped at Nagasaki. All of the tests were conducted on steel towers two hundred feet above the ground. Although the proximity to the ground was enough to generate large volumes of fallout, "Yoke," the largest device that the United States had tested to date, did not generate sufficient seismic energy to travel from

[10] There are evidently several ways to spell this name: Enewetak, Eniwetok, and Eniwetak. This is due to attempts to accommodate Western spelling with Pacific island languages.

[11] Thomas B. Cochran, William M. Arkin, Robert S. Norris, and Milton M. Hoenig, *Nuclear Weapons Databook Volume II: U. S. Nuclear Warhead Production* (Cambridge, MA: Ballinger Publishing Company, 1987), 151; Ziegler, "Waiting for Joe-1", 213, 215. Zeigler's article gives a detailed history of Tracerlab, and its importance to radiological analysis of atomic testing debris. ; Richard Pfau, *No Sacrifice Too Great: The Life of Lewis L. Strauss* (Charlottesville: University Press of Virginia, 1984), 96.

Enewetak in the Pacific to seismic recording stations in the United States; indeed it was undetectable 500 miles from the shot point. Instantaneous notification of any Soviet tests, though they were not immediately expected, required technology and methods not yet developed.[12]

Aerial sampling proved its importance on September 3, 1949. Noting elevated radioactivity during a routine sampling mission, the pilot, technicians, and crew of an air force Boeing WB-29 brought home incontrovertible evidence that the United States' nuclear monopoly had been lost. Despite the general attitude that the Soviet Union would not be able to test a bomb of their own for some time, the aerial sampling missions had been flown in the knowledge that one would eventually occur. Known in the West as Joe-1, the device was comparable to the first American test device – not surprising due to the aid provided to the Soviets courtesy of Klaus Fuchs and other agents operating within the nuclear weapons development complex. Still under a semi wartime footing under Joseph Stalin and his sadistic lieutenant, Lavrenti Beria, the Soviet atomic program rapidly escalated – the air force and Tracerlab were to be busy until the Limited Test Ban Treaty in 1963.[13]

Joe-1 was an eye-opener. Once it had been confirmed that the Soviets possessed a bomb, it was crucial to maintain vigilance over the development of their arsenal. It also became necessary to distinguish between American and Soviet material that had been collected. Espionage and high-altitude aerial sampling could ensure that most of the collected matter was of Soviet origin. Without advance notification, radiochemical

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[12] Cochran, et al., *Nuclear Weapons Databook*, 151; Ziegler and Jacobson, *Spying Without Spies*, 133.

[13] Richard Rhodes, *Dark Sun: The Making of the Hydrogen Bomb* (New York: Touchstone, 1995), 370-71.

analysis determined the date a particular test was conducted. Remarkably, the American aerial monitoring system was even able to assess the amount of plutonium being produced in the Soviet Union by sampling the atmosphere in several locations and analyzing the percentage of krypton-85, which is a byproduct of plutonium production and separation.[14]

From the detection of Joe-1 until the detonation of America's largest test, "Castle Bravo" in 1954 with a yield of 15mt, the United States tested thirty-seven devices; the Soviet Union tested seven. Despite the technological triumph and military significance of achieving increasingly larger fission, and later, fusion reactions, the residue from atmospheric testing quickly overshadowed any benefits these tests presented. The American nuclear arsenal promised to safeguard the country from communist aggression. But Americans themselves were not immune to the effects of fallout. In 1953, St. George, Utah, and surrounding areas were irradiated when unexpected device yields and wind patterns blew fallout from the nearby Nevada Test Site (NTS) over pastoral land. Mysterious illnesses and mass die-offs of sheep aroused fears about atomic testing in the continental United States, although most of this concern remained concealed from the general public. [15]

Nuclear tests quickly grew larger. Most of America's largest tests were conducted at remote locations in the Pacific Ocean. In just nine years, explosive yield had ballooned from Trinity's roughly 18kt to Bravo's 15mt; in essence the destructive power increased by a factor of over 825. Bravo's ash-like precipitation created an

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[14] Ziegler, "Waiting for Joe-1," 223-24.

[15] Pavel Podvig, ed., *Russian Strategic Nuclear Forces* (Cambridge, MA: MIT Press, 2001), 485. These devices included the first Soviet thermonuclear bomb, with a 400 kt yield; Howard Ball, *Justice Downwind: America's Atomic Testing Program in the 1950s* (New York: Oxford University Press, 1986), 56-71; Cochran, et al., *Nuclear Weapons Databook*, 152-54

international furor when accidental irradiation of civilians occurred, including the Japanese crew of the *Lucky Dragon* and Marshall Islanders. Like the irradiation of St. George, this was due to the unexpected yield of the weapon, and unpredictable wind patterns. Radiation effects were also found in the tuna caught in the area, causing fears about the safety of this Japanese dietary staple. The victims of America's military use of atomic weapons were now victimized further by American nuclear weapons program. [16]

Ironically, the earlier 1952 "Ivy Mike" test pointed the way towards the future of nuclear test detection and limitation. Banned from the test site due to his predilection for constantly changing aspects of site operations, Edward Teller nervously awaited the news of the test, and whether it had succeeded or failed. Teller felt slighted, because with Stanley Ulam he had finally managed to solve the problems inherent in achieving thermonuclear fusion – the key to the "Super" or hydrogen bomb. Using a seismic instrument at the University of California that recorded data on photographic paper, he watched a pinpoint of light from the machine in a darkened room. 15 minutes after the scheduled shot time, Teller thought that he saw a faint motion of the light. A check of the paper records confirmed his observation.[17]

Ivy Mike's seismic signal was detected primarily due to two factors: first, the device detonated at ground level. Not a weapon but a physics experiment, Mike was enormous, comprising a large building and refrigeration plant designed to keep its deuterium fuel, a type of hydrogen, liquefied. The explosive energy, 10.4mt, was transferred directly to the ground, with no air gap to attenuate the blast signal. Second,

[16] Rhodes, *Dark Sun*, 541-42. Castle Bravo was a weapon test, and led to deliverable bombs.

[17] It has been widely reported that Teller was a constant tinkerer, and that those involved in the tests were relieved that he would not be present – Teller claims differently that it was his involvement with the new Livermore Laboratory that prevented his attendance, despite the "kindly" invitation of Los Alamos Laboratory director Norris Bradbury to observe the test. Teller and Shoolery, *Memoirs*, 351- 52.

Mike's yield was at the time the largest explosion produced by humans. Teller had teleseismically monitored this nuclear test though oddly he later became a vocal opponent of seismology as a primary means of test detection. Teller noted in his memoirs that Livermore director Herbert York supported the growing call for an atomic testing moratorium and a ban on atmospheric testing and also believed that seismology would serve just as well for detection purposes in underground tests as aerial sampling had done for atmospheric tests.

Teller's opposition to relying on seismic detection methods lay more with his suspicion of Soviet intent than with his distrust of a relatively young science. The issue was not whether seismology could be made sensitive enough to detect underground tests, but whether a low-yield underground test could be effectively hidden among the background noise of earthquakes and volcanic eruptions. Underground testing in earthquake-prone areas might be simply misread, or could possibly be paired up with an earthquake, which could mask the test. As Teller later stated, as long as testing remained atmospheric, it was easily detectable – for him, a nuclear-armed Soviet Union was still the primary threat, despite "a few highly publicized liberal reforms in the period following Stalin's regime."[18] Underground testing presented difficulties in detection that Teller was certain were impossible to overcome and that problems with detection might lead to Soviet superiority in weapons design, whereas open-air tests allowed for the continued type of radiochemical analysis that the United States knew it could rely upon. Such sampling had revealed the Soviet first attempt at a thermonuclear bomb, the RDS-6, detonated on August 12, 1953. Radiological analysis of the test debris allowed physicist Hans Bethe in effect to "recreate" the bomb – later it was shown that his analysis had

[18] Ibid., 433.

been remarkably accurate. Underground testing would prevent releases of radioactive materials into the atmosphere that were crucial to determining the level of Soviet nuclear weapons development.[19]

America's atomic scientists believed that they should play a critical role in constraining nuclear weapons development. They belonged to an arcane fraternity – an international brother- and sisterhood that had transcended international boundaries before World War II. Not only did many dream of restoring this super-national correspondence as a way of overcoming the damage wrought by the war, they were encouraged by the administration of Dwight D. Eisenhower that they would be the perfect persons for the Conference on the Peaceful Uses of Atomic Energy to be held in 1955.[20] Although they could not deter nations from fighting, they could limit nuclear arsenals and help to prevent nations from using the weapons they had created. They would also become responsible for preparing the means to end the need for atmospheric testing, including developing new detection and monitoring methods. If the nuclear genie could not be forced back into his bottle, perhaps he could at least be forced underground, where he posed less of a threat.

The year 1955 was critical for atomic testing. The United States tested at least fourteen atomic devices, thirteen of which were in the atmosphere, detonated either on towers or on the ground; the majority of these tests were under 10kt, with many being of a 1kt yield. The Soviet Union detonated seven with a wide range of yield; from a single

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[19] Thomas Ott, *The American Experience: Race for the Superbomb* Produced and directed by Thomas Ott, 120 min., 51 Pegasi Pictures, Inc., 1999. Videocassette; Podvig, *Russian Strategic Nuclear Forces*, 443.

[20] Robert Gilpin, *American Scientists and Nuclear Weapons Policy* (Princeton, NJ: Princeton University Press, 1962), 152.

ton as part of a torpedo warhead test, to a 1.6mt yield as part of their first true two-stage thermonuclear bomb.[21]

Soviet weapons technology had made a leap forward, and so did their political leadership. Stalin's death in 1953 unleashed a spasm of uncertainty and chaos in the Soviet government. The most brutal totalitarian aspects of the government were controlled by Beria, the man who had overseen the crash program to build Joe-1. He rapidly assumed power, if only for a short period before being deposed and executed. His replacement was Georgi Malenkov, whose tenure was brief as well, before being forced out of power. In 1955, Nikita Khrushchev attained political supremacy. Although numerous differences existed between the two men, one was particularly important: Malenkov was convinced that the Soviet Union would be devastated in a nuclear war, while Khrushchev initially shared Stalin's sense of nuclear invulnerability.[22]

There was a temporary thaw in Cold War relations in 1955. The Soviet government offered a "major concession" in which they granted that inspection and on-site monitoring were necessary to advance general disarmament. Although they included unrealistic demands (such as eliminating all overseas United States military bases), it indicated that the Soviets would be willing after all to negotiate some form of nuclear control treaty. The Soviets also called for the cessation of all nuclear testing. The meeting between Eisenhower and Khrushchev in Geneva reached no further conclusions on the issue. The Soviet leader concluded,

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[21] Cochrane, et al., *Nuclear Weapons Databook* , 154-55; Podvig, *Russian Strategic Nuclear Forces*, 486-67.

[22] Edward Crankshaw and Strobe Talbot, translator and ed., *Khrushchev Remembers* (Boston: Little, Brown and Company, 1970), 342.

> We were encouraged, realizing now that our enemies probably feared us as much as we feared them. They rattled their sabers and tried to pressure us into agreements which were more profitable for them than for us because they were frightened of us….They now knew that they had to respect our borders and our rights, and that they couldn't get what they wanted by force or by blackmail. They realized that they would have to build their relations with us in new assumptions and new expectations if they really wanted peace.[23]

One of the issues Eisenhower raised with the Soviet delegation in Geneva was his proposal of an "Open Skies" policy. Concerned less with detecting tests than spotting the impending signs of a surprise attack, the Open Skies policy was a step on the road to more comprehensive nuclear weapons control policies. The Soviets remembered German reconnaissance aircraft over their airfields in the days and weeks before Hitler launched Operation Barbarossa in 1941, and rejected the proposal; the war was still too fresh in the minds of those making Soviet policy for them not to be skeptical of American motives. In retrospect, it seems almost ludicrous that Eisenhower proposed it, despite the later success of space-based reconnaissance, because the technologies had yet to be developed to make such activities possible.[24]

The United States tested a 1.7kt device at the Nevada Test Site during Operation "Plumbob" in 1957. Code named "Rainier," it was the first American attempt at fully containing an atomic test underground. The radioactive contamination remained isolated under a mountain ridge in the cavity created by the detonation and there was little or no surface disturbance. Aircraft or satellites might not be able to photograph underground tests below a certain size, or ones detonated at a depth where surface effects were not apparent. Radiochemical analysis of atmospheric testing debris would be useless – there

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[23] Gilpin, *American Scientists*, 144; Crankshaw and Talbot, *Khrushchev Remembers*, 400.
[24] Gilpin, *American Scientists*, 162-63.

simply would be none released unless there was a catastrophic accident that caused the test chamber to vent to the atmosphere. Finally, the ground where Rainier was conducted consisted of a volcanic material called tuff, and it dampened the seismic signal. [25]

The potential for cloaking future tests caused great concern in parts of the nuclear weapons community. Teller, an ardent anticommunist, suspected the Soviet Union of malfeasance at every turn. Beginning in 1957, he led one side of a debate that divided members of the scientific community for years to come: should nuclear weapons continue to be tested out in the open where they were more easily monitored, or should they be conducted underground where the contamination was contained? Teller supported the former, and as George Kistiakowsky noted, was particularly adept along with his lieutenants with devising numerous ways that the Soviets might circumvent a limited or comprehensive test ban. Kistiakowsky was a former Los Alamos scientist and member of the President's Science Advisory Committee (PSAC), later serving as the Special Assistant for Science and Technology. He had worked on the implosion system for the Trinity bomb and subsequently was well acquainted with most of the atomic scientists in the United States. He opposed the perpetually suspicious Teller, who believed that nuclear testing was an absolute necessity to the security of the West. Teller and several other scientists, notably Ernest O. Lawrence and Dr. Richard Latter from RAND,[26] were members of what was called the "infinite containment" school of thought, which imposed a monochromatic conditional system upon international affairs: either the nations of the

[25] Cochrane, et al., *Nuclear Weapons Databook*, 157; United States Congress, Office of Technical Assessment, *The Containment of Underground Nuclear Explosions. OTA-ISC-414* (Washington, DC: Government Printing Office, 1989), 31.

[26] The RAND (Research AND Development) corporation is a think tank begun in 1946 by the air force. Dr. John McLucas, Kenneth J. Alnwick and Lawrence R. Benson, *Reflections of a Technocrat: Managing Defense, Air, and Space Programs During the Cold War* (Maxwell Air Force Base, AL: Air University Press, 2006), 107.

world would have to be totally open with their military and scientific secrets in order to guarantee free and open inspection, or they would be forced to develop armaments of increasing power and capability for self-preservation. As principal motivation behind Teller's work on the hydrogen bomb, such a philosophy also justified his opposition to any treaty that would force atomic testing underground, thus limiting detectable efflux and ensuring increased secrecy. Those wishing to circumvent treaty stipulations would oppose developing any monitoring technology, ultimately rendering such detection systems obsolete. "In the contest between the bootlegger and the police, the bootlegger has a great advantage," Teller wrote.[27]

Nevertheless, Teller knew that from his own experience there were ways to detect underground tests. Eventually, all innovative military systems are countered; the countermeasure then requires further innovation to the original system or the adoption of a new system altogether to fulfill the operational requirements of the battlefield. This philosophy also held true for a system of underground test monitoring. If testing moved underground, it was more likely that the Soviets would cheat, and the fallout from their tests could no longer be used to assess the success of their weapons program. To counter this loss, a new method was required, though in actuality the method was not new at all. Teller recounted in his memoirs that he was impressed by the results of the Rainier test, observing that:

> Geologists, notified in advance of the test, gained many new insights by tracing the shock wave produced by the explosion through the mantle of the earth. The instrumentation designed to register the test information in a completely new

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[27] George Kistiakowsky, *A Scientist at the White House: The Private Diary of President Eisenhower's Special Assistant for Science and Technology* (Cambridge, MA: Harvard University Press, 1976), 5-6; Gilpin, *American Scientists*, 102-103, 178.

> manner worked well. Our questions were answered in the Rainier test – muffling does occur, and underground testing can yield information about weapon design and about the composition of the earth. This line of testing made possible the evolution of safer nuclear testing procedures. More important, the Rainier test was crucial to the upcoming negotiations with the Soviets. But by the time it was possible to continue testing underground, the test ban was a well-established popular movement.[28]

The generosity of time ameliorates Teller's earlier skepticism regarding underground nuclear testing. The apparent contradiction between his experience with teleseimic monitoring (the Mike test), his comments on the Rainier test and his beliefs about the effectiveness of newer monitoring methods are not mutually exclusive. Teller observed the Mike event because he knew when to look for it, and scientists were able to gather useful data from Rainier because they knew when it was going to be conducted. His argument was that seismology was not a useful system for observing unexpected events, or in discriminating between human-caused and geological phenomena. Teller, Latter, Doyle Northrup of the Department of Defense, and Harold Brown from the University of California Radiation Laboratory became concerned with the possibility that the Soviets would further engage in hiding their tests, and that muffling them through a process known as "decoupling" would be a primary means of doing so. Decoupling became a significant issue that drove later tests to determine the extent of its effect on seismic signal attenuation.

Hans Bethe opposed the Teller-Latter position and argued that decoupling would not pose an obstruction to underground test monitoring. Bethe believed that a future monitoring system could surmount any obstacles presented to it, given that it was carefully planned and extensively emplaced. A strong supporter of arms control, he

[28] Teller and Shoolery, *Memoirs*, 444.

consistently argued that the United States had tested its arsenal to the point that further experiments would yield little useful new data and while generating further antagonism towards the United States as global opposition to atmospheric nuclear testing increased.[29]

Yet decoupling remained troubling because it was theoretically easy to accomplish. In a typical underground nuclear test, a shaft is bored to a predetermined depth and the test device inserted with various instruments designed to measure aspects of the detonation. If the device was in close proximity to the walls of the shaft, it was said to be "tamped." The shaft was then filled with material, commonly a sand and gravel mix, in a process called "stemming." This filler trapped the expanding gases in the hole, ensuring that all of the energy from the blast was transmitted directly into the surrounding ground; it also served as an ablative plug, wherein the fill material quickly melted due to the tremendous heat and sealed the mechanical holes used to lay instrument cables. With no leakage of gasses from the chamber created by the blast, a seismic signal would be generated that could give important information about weapon design and strength.[30]

Teller argued that the Soviets wanted to avoid any sort of openness, and would attempt to attenuate the seismic signal. The easiest way to do this would be to decouple the test in a pre-excavated chamber. Once a large spherical chamber had been created, the test device could be suspended from the ceiling, or elevated on a scaffold sufficient to place it in the center of the chamber. At the moment of detonation, the spherical blast wave expanded, then dissipated to a degree dictated by the circumference of the chamber.

[29] Harold Karan Jacobson and Eric Stein, *Diplomats, Scientists, and Politicians: The United States and the Nuclear Test Ban Negotiations* (Ann Arbor: University of Michigan Press, 1966), 48, 73; Gilpin, *American Scientists*, 178-79.

[30] U. S. Congress, Office of Technology Assessment, *The Containment of Underground Nuclear Explosions*, 31-34.

A larger chamber would rationally under most circumstances have an increased attenuation effect. Theoretically, this diminished the seismic signal at its point of origin because the air gap between the device and the wall of the chamber lessened the blast wave. Instead of a direct coupling between the blast wave and the ground, it was decoupled. The telltale motion detected by a seismograph was therefore markedly smaller. In addition, there was a possibility that such a chamber could have further unknown effects that could fool mechanical means of test monitoring. By 1958, no decoupling experiments had been conducted, and both sides of the argument were using theoretical calculations without the benefit of empirical data. Teller noted in his memoirs that:

> Test-ban proponents claimed that underground tests could also be detected on seismographs because they cause effects similar to earthquakes. The tests could be distinguished from natural earthquakes by their sharply timed energy release and, of course, by their unusual location. Given the nature of muffling [decoupling], I thought those arguments incomplete.[31]

For those involved with nuclear test detection, 1958 was an eventful year. The United States conducted two tests designed to examine the safety of their nuclear devices at the Nevada Test Site in February and March. Less than a ton in yield, these tests, as well as two others detonated previously in December 1957 as part of Operation 58, were designed to verify the safety features of the devices to be detonated in the United States' largest nuclear test series to date, "Operation Hardtack." The experiments would be divided into two subseries, Hardtack I and Hardtack II, and include seventy-two

[31] Jacobson and Stein, *Diplomats, Scientists, and Politicians*, 74; Teller and Shoolery, *Memoirs*, 434.

individual tests, ranging from “slight” yields, to a massive 8.9mt blast at Enewetak in June. Hardtack was to begin near the end of April 1958.[32]

A month before the first Hardtack thermonuclear burst rose above the Pacific, the Soviets dropped a bombshell of their own. They had tested fifteen devices between January 1 and the end of March 1958, ranging from sub-kiloton yields to 1.5mt. At the conclusion of these tests, the Soviets announced a unilateral test moratorium beginning on March 31. It was a canny political move, for it was timed precisely to coincide with the beginning of Hardtack, as Bethe noted. Added to this was the admonition that if the United States did not join in the moratorium, the Soviets would feel free to resume testing. With a multimillion dollar test program in the offing, there was little the United States could do – it was unreasonable to cancel such a mass commitment of men and materiel. Hardtack proceeded as planned, and in the end the United States looked militarily aggressive. Eisenhower disregarded the Soviet moratorium, even though the world reacted with general approval; to him it was merely a publicity stunt, despite a letter from Khrushchev repeating his determination to end testing.[33]

If Khrushchev’s offer had any effect, it was to underscore further that a test moratorium had global support, despite the nuclear powers’ desire to continue testing. The Soviets won praise from the world community, and the Americans were left feeling outwitted. Teller felt a great deal of unease for, as he put it, “the Soviet Union had remained a tightly controlled, secretive, totalitarian state. The dangers of a treaty with such a nation were obvious to me, and I talked almost incessantly about the topic for many months.” The Soviet Union was clearly setting the diplomatic agenda, and the

[32] Cochrane, et al., *Nuclear Weapons Databook*, 157-59.

[33] Pavel Podvig, ed., *Soviet Stretegic Arsenal*, 490-91; Jacobson and Stein, *Diplomats, Scientists, and Politicians*, 45-46

West needed to regain the initiative; the solution was in engaging scientists as allies in the negotiations. The Eisenhower administration had suggested in January a scientifically-based conference on arms control measures. The resulting 1958 Geneva Conference of Experts represented an unprecedented meeting of Eastern and Western scientists to discuss methods whereby their respective governments could reach political agreements on the immensely technical topic of arms control.[34]

Meanwhile, Bethe had reported back to Eisenhower after the conclusion of the eponymous panel that he had chaired in order to discuss the feasibility of joining the Soviet moratorium and the ability to detect any violations of a test ban treaty. Interestingly, no seismologists were included on Bethe's panel, nor was seismology as a field represented on the PSAC, although seismologists were certainly available. These seem like unlikely omissions, although they may have been intentionally done as a political expedient, for there was no empirical data to confirm or discount any ability to identify nuclear tests through seismic means. In other words, to save risking a debate over unknown quantities that might stall discussions, excluding seismologists from the panel was an easier choice. Ultimately, the Bethe Panel suggested that the United States proceed with Hardtack and then work towards a moratorium agreement with the Soviet Union.[35]

The Conference of Experts began on July 1, 1958, as the Hardtack I tests continued at the Pacific Test Site. Dr. James B. Fisk, then a member of the PSAC and vice-president of Bell Laboratories, chaired the Western delegation, which also included

[34] Teller and Shoolery, *Memoirs*, 433; Jacobson and Stein, *Diplomats, Scientists, and Politicians*, 48, 53.

[35] Jacobson and Stein, *Diplomats, Scientists, and Politicians*, 47, 49.

Lawrence, substituting for Teller. Opposition to Teller stemmed from his outspoken nature and his work on hydrogen bomb development.[36]

Their counterparts from the Eastern delegation included Soviet scientific luminaries. Unbeknownst to the American delegation, however, the Soviets provided an expert diplomatic negotiator to support their scientists, while the Americans neglected to do so. This disappointed scientists who had high hopes of reaching a momentous breakthrough independent of the tensions of the international diplomatic arena. Their efforts did yield some results, though, in the form of the proposed "Geneva System": a land and sea-based seismic detection network designed to detect and monitor underground nuclear testing on a global scale and be able to discriminate between the vast majority of artificial and natural signals.

The Geneva System was the logical outcome of the impetus to move testing underground, but it drew objections due to several inherent flaws. First, there was the problem of small earthquakes and small bombs. Seismology in the 1950s was a rapidly changing and growing field of research and had reached nothing like the complexity and sophistication it has today: the immediate detection, identification, and location of seismic signals was far more difficult then than now. It was known that numerous small earthquakes occurred every year, and nuclear devices could be, and had been, tested with yields at or less than one kt. There was the distinct possibility that an unscrupulous nation might be able to carry on a rewarding test program using small devices and still maintain secrecy from both automated and manned stations. A 1961 congressional hearing into the seismic problems posed to the Geneva Conference concluded that even if the West received full concessions to a system of 160-180 land and sea-based stations

[36] Ibid., 55.

spread some 600 miles apart in seismically active areas, and 1,100 miles apart in non-seismically active areas, they could certainly pick up the signal from a one kt nuclear device or small earthquake, but they did not have the means to discriminate between the two. Added to this was the changing size and complexion of the Geneva System. Questions remained as to the amount of access granted to inspection teams, the degree to which remote monitoring stations might be tampered with, and the consequences of any such chicanery.[37]

The Geneva System was not built. Despite its flaws, it showed that science and diplomacy were able to interact to propose solutions to the arms control and testing problem. The United States continued to increase its seismic network through the United States Geologic Survey and geology departments in colleges and universities around the country. Heartened by the conference, Eisenhower and his administration announced that the United States would call upon the Soviet Union to join in a one-year moratorium on all nuclear and thermonuclear testing, beginning October 31, 1958, subject to extension should diplomatic efforts allow.[38]

Before the testing moratorium took effect there was a flurry of further atmospheric testing. The United States entered Phase II of the Hardtack series, which included tests of small-yield devices conducted almost exclusively at the Nevada Test Site. The Soviets also resumed testing, including megaton-yield thermonuclear weapons. Both sides wanted to "get their last licks in" before the moratorium. The Soviets even violated the test moratorium, testing two devices in November following the start of talks

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[37] U. S. Congress, Joint Committee on Atomic Energy, *Developments in the Field of Detection and Identification of Nuclear Explosions (Project Vela): Hearing Before the Joint Committee on Atomic Energy*, 87th Cong., 1st sess, (Washington, DC: Government Printing Office, 1961), 6.

[38] Herken, *Brotherhood of the Bomb*, 327.

between the United States and Soviet Union. This prompted the United States and Britain to renounce the moratorium, but as a sign of good faith, they retained their commitment not to conduct tests. The unofficial moratorium lasted until the Soviets resumed full-scale atmospheric testing in 1961.[39]

Perhaps it was the unofficial nature of the test ban that led the Eisenhower administration to conclude that it would eventually resume experiments. The political capital to be gained by moving tests underground was obvious, but the uncertainties concerning decoupling and other effects had to be addressed especially in order to quell some of the most ardent critics, namely Teller and his allies. The effects of nuclear decoupling would not be investigated until the Project Vela series began in 1963.[40] Begun in 1959 at the behest of the 1958 President's Panel on Seismic Improvements, Vela was a comprehensive program to determine the accuracy and feasibility of new detection systems for underground and covert high altitude and space tests.[41] In a sense, it was an extension of the International Geophysical Year's focus on the development of earth sciences, including seismology, which along with astrophysics stood to benefit the most from the large investment made by the Defense Advanced Research Projects Agency (DARPA) into Vela. Eisenhower's press office announced the project on May 7, 1960:

> The President today announced approval of a major expansion of the present research and development directed toward an improved capability to detect and identify underground nuclear explosions.…Known as Project VELA, the program calls for increased basic research in seismology; procurement of instruments for a world-wide seismic research program; development of improved seismic instruments; construction and operation of prototype seismic detection

[39] Podvig, ed., *Russian Strategic Nuclear Forces*, 446-47.
[40] Cochrane, et al., *Nuclear Weapons Databook*, 164.
[41] U. S. Congress, Joint Committee on Atomic Energy, *Developments in the Field of Detection and Identification of Nuclear Explosions*, 3.

> stations; and an experimental program of underground detonations encompassing both high explosive and where necessary nuclear explosions. The planned program provides for investigation of all aspects of improvement that are considered to be feasible.
>
> Such nuclear explosions as are essential to a full understanding of both the capabilities of the presently proposed detection system and the potential for improvements in this system would be carried out under fully contained conditions and would produce no radioactive fallout. In order to develop sufficient reliable data from the program, it is anticipated that it will be necessary to conduct a series of explosions of various sizes, in differing types of geologic formations.[42]

The announcement of this program, made during the middle of the voluntary test moratorium, might have made it possible to conduct the nuclear portion of the test program following special negotiations. The desire for positive global opinion forced the United States and Soviet Union to reconsider their weapons testing programs. While the test sites cooled off, the weapons laboratories continued feverishly with their work designing the next generation of bombs. Each side waited for the other to end the moratorium so that their arsenals could resume testing. Or at least that was how it appeared.

[42] James C. Hagerty, Press Secretary, announcement of Project VELA, May 7, 1960, Attached to correspondence from Hollingsworth to Stennis, November 28, 1960, Subseries: Tatum Salt Dome T-2 1960-1961, Stennis Collection, MSUCPRC.

Chapter Four

Cowboy and the Big Hole Theory

DARPA and the AEC had not been sitting on their hands between October 31, 1958, and September 1, 1961, while the test moratorium was effective. They were busily planning future weapons test series while exploring technical systems required for a detection and analytical capability to cope with the technical requirements of underground nuclear testing. Several test series utilizing high explosives determined the seismic characteristics of various underground environments. Authorized early in September 1959, Vela Uniform was publicly announced on May 7, 1960. DARPA was given the task of designing and implementing a three-phase program designed to detect and monitor subterranean, high altitude, and surface detonations. Decoupling gained enough credibility to warrant substantial field research. Geologists were beginning to understand the differences in seismic energy transmission through different materials and that a nuclear assay of underground structures needed to be made that approximated zones where the Soviets would most likely conduct subterranean tests. Two programs initially emerged, code-named "Cowboy" and "Concerto."[1]

Cowboy directly addressed the question of decoupling and the potential magnitude of its effect on camouflaging a test signal. Begun in December 1959 and lasting for three months, it was a non-nuclear test series utilizing high explosives. The experiments provided useful data while keeping faithful to the voluntary 1958 nuclear test moratorium. Begun at the end of 1958, the tests were both welcomed and resented in

[1] William E. Ogle, *An Account of the Return to Nuclear Weapons Testing by the United States after the Test Moratorium 1958-1961* (Las Vegas: U. S. Department of Energy Nevada Operations Office, 1985), 151.

the nuclear weapons community, who preferred continuing atomic tests. The work normally conducted at the Nevada and Pacific test sites screeched to a virtual halt once the two Hardtack test series concluded. While the threat of atmospheric fallout virtually disappeared, the existing concern directed towards the possibility of small covert nuclear tests that could be masked behind seismic background noise, providing the Soviet Union a tactical or strategic advantage in its arsenal development. There was another issue: the moratorium was voluntary, and thus subject to being broken without the international accountability that would come from violating a brokered treaty. The nuclear establishment felt it crucial to remain in a position to resume testing when the moratorium eventually ended, as many felt it would. High explosives provided an alternative to no testing at all and at least kept the people at the NTS working on something while the Pacific test site sat practically abandoned.

Cowboy was the first program to give solid baseline data on the difference in seismic energy between coupled (or tamped) shots and decoupled shots fired in a test chamber in a salt dome. The tests were conducted below the working area of the Carey Salt Mine near Winnfield, Louisiana, utilizing 1,000-pound high explosive charges. Control readings taken from shaft detonations were compared with decoupled shots in excavated twelve-foot and thirty-foot diameter spherical chambers. The United States Coast and Geodetic Survey carefully measured the explosive energy at thirteen sites ranging from ground zero to sixty-one miles from the shot point. Seismic monitoring crews took multi frequency readings at specialized sites up to eight miles from ground zero.[2]

[2] U. S. Department of Commerce, *Annual Report of the Director of the Coast and Geodetic Survey for the Fiscal Year Ended June 30, 1960* (Washington, DC: Government Printing Office, 1960), 37;

The paired tests produced good comparative data, proving that decoupling had a considerable effect on signal strength. Testifying before the Congressional Joint Committee on Atomic Energy (JCAE) in 1960, RAND Corporation scientist Dr. Albert Latter reported that the tamped shots fired during Cowboy yielded seismic signals that were 120 times stronger than the decoupled tests. His brother Richard, also employed by RAND, was another primary advocate of the possibility of using decoupling to hide underground tests. The Latter brothers enjoyed the support of Edward Teller, who had for some time anticipated Soviet chicanery. Teller's constant suspicion of the Soviet nuclear weapons complex and political/military leadership directed him to advocate the continuation of atmospheric testing. The Latter brothers' theories regarding decoupling suggested that atomic tests with a useful yield could be hidden. Albert Latter's testimony at the JCAE hearing led to his being credited with the "Latter big hole" theory. As he explained,

> (I)f the explosion occurs in a small hole – as is the case for a tamped explosion – the pressure which acts on the surrounding medium is very great, and the medium is not strong enough to stand the pressure. As a result, the hole must expand and this causes a large motion of the surrounding earth. It is this large motion, in the immediate neighborhood of the explosion which shows up at great distances as a tiny seismic signal….On the other hand, if the explosion is made in a big hole, the pressure which the surrounding medium experiences is not very great and the medium can stand the pressure. As a result, there is very little expansion of the hole and essentially no motion of the surrounding earth.[3]

Ogle, *An Account of the Return to Nuclear Weapons Testing*, 151; U. S. Congress, *Hearings Before the Special Subcommittee on Radiation and the Subcommittee on Research and Development of the Joint Committee on Atomic Energy Congress of the United States*, 86th Cong., 2nd sess. (Washington, DC: Government Printing Office, 1960),129.

[3] U. S. Congress, *Hearings Before the Special Subcommittee on Radiation*, 125, 129.

Latter also emphasized that it was not enough simply to excavate randomly-sized chambers to serve as covert test sites. There was an optimal volume to any chamber in relation to the device yield – to go beyond it could risk long-distance detection:

> " I want to mention a rather curious fact; namely that once a hole is big enough, the signal will not be further reduced by making the hole any bigger….Once it reaches the critical size, this happens because of an accidental cancellation of two opposing physical effects. One of these is that as the hole gets bigger, less energy goes into the earth's motion. This, of course, has a tendency to reduce the signal. On the other hand, it turns out that the energy which does go into the seismic wave is of a longer wavelength. As the hole gets bigger the wavelength increases. This longer wavelength is just the kind of a signal which can be propagated to great distances in the earth easily. The shorter wavelength signals tend to get filtered out by the earth. The net effect of these two opposite phenomena is that the seismic signal which occurs at a great distance from the scene of the explosion is independent of the size of the hole – provided the hole is big enough in the first place."

Latter believed that a decoupling factor of 300 could be achieved if the size of the test chamber was large enough. According to his calculations, a spherical chamber excavated to the dimensions dictated by a factor of 70,000 cubic meters per expected kiloton of device yield could achieve this maximum decoupling effect.[4]

The problem with this data was that it was practically applicable only to high explosives; nuclear devices were entirely another matter. It is difficult to compare nuclear detonations and those caused by high explosives. When nuclear charges are measured, it is in terms of tons of TNT (tri-nitro-toluene). Yet TNT comparatively "burns" much cooler and slower than a fissile mass. Also, high explosives do not produce the flood of X-rays, gamma radiation, and other exotic progeny that stem from nuclear fission and fusion. These various forms of electromagnetic energy posed

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[4] Ibid., 129.

unknown effects on the walls of a test chamber; the uncertainties were numerous enough to push for atomic testing in a salt environment as soon as possible once the moratorium was broken. Although it is the author's speculation, among the main areas of concern would have been the possibility of initial ablation of the cavity walls caused by the X-ray pulse from the detonation. Ionized plasma formed by X-rays striking the sodium chloride walls would move rapidly inwards towards the shot point just before the blast wave reached it. What effect, if any, this could have on the seismic signal was unknown. Until the moratorium ceased to be in effect, this and other questions would remain unanswered.

Concerto's area of investigation was different. This test series was to discern the seismic signals created by the detonation of low-yield (1/4kt to 5kt) devices in tuff (a relatively loose volcanic soil) at varying depths, as well as one low-yield shot that was to be conducted off NTS property, and one medium-sized detonation of 50kt, again fired in tuff. Of the seven proposed tests to be fired during Concerto, six were to be nuclear tests with one of the 1kt tests to be fired comparatively with a 1kt high explosive shot to gauge seismic effects between the two. Unfortunately for the scientists at Livermore Radiation Laboratory (LRL), who were to oversee the project, the moratorium proved to be too politically tenuous for them to proceed with anything but the high explosive shot, and preparatory excavation for a tamped underground 5kt nuclear shot code-named "Lollipop," which would be fired in a granite formation at NTS.[5]

The moratorium was not the only thing that retarded the Concerto series. The atomic testing budget for the Fiscal Year 1960 was $4,500,000. Between the Cowboy tests and the single Lollipop shot preparations, well over half this amount had been committed. Because of budgetary limitations, Teller recommended to army General

[5] Ogle, *An Account of the Return to Nuclear Weapons Testing*, 151, 156.

Alfred Starbird, director of the Division of Military Application (DMA), AEC, revision of a safety formula that dictated the minimum depth of test shafts. Starbird was amenable to reduced cost, but warned Teller that radiation containment was of paramount importance to any test series. Whatever radioactive contamination was produced had to be contained underground.[6] Despite the important role that nuclear testing occupied, it was still subject to a narrowing budget, and fiscal concerns continued to affect the configuration and process of atomic testing following the test moratorium's end. Any radiation release, even at the tightly-controlled Nevada Test Site, would most certainly result in negative publicity.

Assurances from military and technical spokesmen following lapses of containment no longer assumed the same credibility as they had earlier in the atomic age. The 1951 irradiation of St. George, Utah, was handled through official information and radio bulletins; indeed it appears that contamination in the town was light. The incident was considered so well-handled that a short film produced afterwards depicted the town's Rockwellian citizenry reacting promptly to alerts from official government sources and happily enduring the situation in the cause of a safer, more secure (and more radioactive) America. Yet the nature of fallout is such that it does not return to earth in a uniform pattern; it is sporadic, with some areas receiving a light dusting while other spots close by may be subjected to concentrations of material that is lethal to humans and other animals. Radioactivity posed an important health hazard to the public, who became increasingly conscious of the threat, and prepared to weather a rain of highly dangerous fallout following what many saw as the inevitable conflict between the Soviet Union and the United States. The decision to shave the safety margin later led to some of the large on-

[6] Ibid,, 95, 156.

site releases at NTS, including the Baneberry event in 1970, wherein a subterranean 10kt shot in tuff released a large quantity of fallout through a previously unknown fault. Baneberry's fallout traveled as far north as Canada, and public furor caused all testing activities to be suspended for seven months.[7]

Outrage and protest were one thing, the accidental irradiation of heavily populated areas was another. Should continental testing be moved offsite, it would be heavily constrained by population, possibly eliminating certain geological environments that were desirable for testing. Radiochemical containment had to be absolute, with no undue risk to those living in proximity to the test site. The overlying strata that were the primary shields against biological effects from testing had to maintain absolute integrity. Concerto would explore the capabilities possessed by different types of geologic material and their relative abilities to absorb the immense and sudden strain caused by a nuclear test, as well as their readiness to transmit seismic energy.

While Concerto was in its planning stage, another important program was pursued with increased vigor. The "Plowshare" program was an ambitious idea designed to put a useful face on atomic explosives. Ultimately totaling twenty-seven tests compared to VU's seven shots, Plowshare was publicly touted as a program dedicated to investigating the use of atomic devices for peaceful purposes. These included the stimulation of underground gas deposits, the excavation of canals and harbors and other large-scale earth-moving projects, isotope manufacture, subterranean storage chamber creation, and heat production. Plowshare, which took its name from a scriptural verse instructing people to turn their swords into plowshares, was always a sticking point in arms control negotiations between the United States and Soviet Union, the devices to be used were not

[7] Office of Technology Assessment, *The Containment of Underground Nuclear Explosions*, 32-33.

bombs – that is, they were not weaponized or militarized and did not incorporate such elements as a ballistic case or fuzing. As they were intended to be the nuclear equivalent of high explosives, the AEC made every effort to limit the amount of radioactive contamination caused by their detonation. Small, low-yield thermonuclear devices looked to be especially useful as they produced little radioactivity, with most of this coming primarily from the small atomic device used to spark the thermonuclear reaction. In this area, Plowshare sparked no small concern, for cloaked within the guise of a peaceful atomic program lay the need to develop these smaller, "cleaner" devices – a capability that potentially tied it to weapons development. Plowshare and VU were similar and different. Plowshare turned the military atom towards peaceful civilian purposes. Vela Uniform turned the military atom towards itself, ensuring continued peace through monitoring and detection methods. Nevertheless, they were commonly confused with each other.[8]

Enhancing this confusion, the first Plowshare test, "Gnome," was conducted during the first American test series following the end of the 1958 test moratorium. Lasting more than thirty months, the moratorium had been a period of uneasy peace between the superpowers without the frightful nuclear saber-rattling. In 1961, the Soviet Union broke the moratorium and resumed atmospheric testing. The experiments included the largest explosion in human history, a roughly 60mt blast over their test site at Novaya Zemlya. While American politicians and the world community railed against the resumption of testing on grounds of opposing added radioactive fallout and military

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[8] Jacobson and Stein, *Diplomats, Scientists, and Politicians*, 35-36. For further information on Project Plowshare's nuclear earthmoving program, see Scott Kirsch, *Proving Grounds: Project Plowshare and the Unrealized Dream of Nuclear Earthmoving* (New Jersey: Rutgers University Press, 2005).

destabilization, America's nuclear community got the green light to proceed with its own testing.[9]

The 1957 Rainier blast had shown that tests could be conducted underground with little or no surface disturbance or release of radioactivity while still providing useful data on the effects of the explosion. Gnome marked the first time that a nuclear device was tested in a subterranean salt bed, in this case near Carlsbad, New Mexico. The AEC sought to explore further the feasibility of constructing underground storage chambers, the production of useful heat energy for electrical generation, and the production of radioisotopes. Seismic monitoring stations included seismographs emplaced in Carlsbad Caverns and in a neighboring potash mine. The selection of the site was intended to allow the collection of data in a different medium from the volcanic tuff common at the NTS.[10]

The Gnome shot fired on December 10, 1961. Apart from the failure of some of the site equipment designed to prevent an accidental radiation release, little contamination was evident. The seismic damping that occurred due to the loose composition of tuff was absent in the salt bed. With little air space between it and the tunnel wall, the shot was tamped. The 3kt of force generated by the device traveled directly into the wall of the chamber. Monitoring personnel observed several interesting phenomena: first, the seismic travel times were not the same at stations located equidistant from the shot point, varying in delay times up to 9 seconds. This indicated

[9] Podvig, *Russian Strategic Nuclear Forces*, 498; Gilpin, *American Scientists and Nuclear Weapons Policy*, 253-56; Jacobson and Stein, *Diplomats, Scientists, and Politicians*, 280-82, 344.

[10] D. S. Carder, W. K. Cloud, W. V. Mickey, J. N. Jordan, and D. W. Gordon, *U. S. Atomic Energy Commission Plowshare Program: Project GNOME Carlsbad, New Mexico December 10, 1961 Final Report; Seismic Waves from an Underground Explosion in a Salt Bed. PNE-150-F* (Washington DC: Coast and Geodetic Survey, 1962), 3,7.

that previously unknown subterranean structures existed in the area and they had altered the travel time of the shock wave. Second, although no notable damage to nearby commercial or residential structures occurred, the shot had a substantially stronger signal than shot "Logan," a 5kt device detonated a little more than three years before at NTS. This was directly attributed to the unique characteristics of the in Nevada. Logan's seismic signal was comparable to a magnitude 4.5 earthquake while Gnome's signal was closer to a 4.6 to 5.0.[11]

Pointing the way to Vela, the report on Gnome's seismic program concluded: "it is recommended therefore that some consideration be given to conducting a future test in a shield area with the shot buried deep enough to be well coupled with the rock, and that the international seismological community be fully alerted. This would afford seismic measurements along continuous profiles in any direction, and afford a reverse profile for evaluation of clandestine events."[12] In short, naturally-occurring sources of signal attenuation were poorly understood. Interactions between geological formations directed and changed the strength of seismic energy, and could delay it as well. Understanding the manner of how shock energy passed through these structures was critical if any future seismic detection system was to work with a reliable degree of accuracy.

Nuclear tests were perfect for determining the composition and location of subterranean structures, because they produced a sharply-timed spike of energy and their detonation time, depth, and location were all known. They allowed the subterranean contours of the earth's crust to be precisely mapped. For the Plowshare and Vela series,

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[11] Carder, et al., *U. S. Atomic Energy Commission Plowshare Program: Project GNOME*, 35-38; Cochran, et. al., *Nuclear Weapons Databook*, 159.

[12] Carder, et al., *U. S. Atomic Energy Commission Plowshare Program: Project GNOME*, 38.

the United States Coast and Geodetic Survey (USCGS), provided the seismographs, and the AEC provided the nuclear charges.[13]

Gnome's revelation that salt was far more efficient at conducting seismic energy led to further interest in testing in salt environments. It is a crystalline substance, and in some respects salt is similar to media like granite in that it has a degree of a quality called "plasticity." Salt has the ability to flex or flow in response to dynamic heat and pressure. It is also much easier to excavate than granite or other rocks and therefore makes an ideal matrix for a test site. Methods practiced and perfected over hundreds of years of salt mining could easily be employed to create test locations. Testifying at the 1960 JCAE hearing, Lance P. Meade, manager of Phillips Petroleum's engineering department, offered several examples of storage chambers that had been mined in salt domes. At the time of his testimony, some 250 had been created, primarily for liquefied petroleum gas storage. These ranged from 140,000 cubic feet (4,000 cubic meters) to 5,600,000 cubic feet (160,000 cubic meters). Meade proposed mining a spherical 73 million-cubic-foot volume chamber approximately 516 feet in diameter – theoretically sufficient to decouple a 30kt explosion. The diameter and shape thus specified, the only question left was the expense of an excavation 13 times larger then any previous chambers. Meade provided two examples regarding the cost of excavation: one where the primary concern was expense and the other where time was the critical factor. The expense-critical (cheap) approach would last some forty-eight months and cost about $2,580,000 with a possible $500,000 to $1,000,000 in additional costs relating to site purchase and preparation, fresh

[13] Bruce Bolt, *Nuclear Explosions and Earthquakes: The Parted Veil* (San Francisco: W.H. Freeman and Co., 1976), 231-33.

water and brine disposal, and various other items. The time-critical (expensive) approach could be completed in twenty-eight months with a cost of $13,505,000.[14]

More questions needed to be answered regarding nuclear testing in a salt environment, especially concerning the types of residual materials created by the extreme heat and pressure of an atomic blast, and the feasibility of reusing such chambers for future tests. There were a limited number of sites that could host a large nuclear test in a salt dome in the high kiloton or megaton range. These sites would quickly be depleted in the course of a testing program if the plasticity of the salt could not tolerate the deformation and damage caused by a large nuclear blast.

By 1961, Project Clarion had been subsumed by the VU program. The two projects' goals were certainly similar, although the Vela program included a far greater number of chemical and atomic shots than Clarion. Lollipop, the granite shot, was never fired, at least not under that name. Instead, a test conducted on February 15, 1962, during Operation "Nougat," named "Hard Hat" was fired nearly 950 feet below ground at NTS in a "hard rock" structure. The 5.7kt yield and environmental similarity leads to the conclusion that it was the same test, renamed and included in a different test series.[15]

Re-designation was not unusual for test shots, test sites, and programs. The salt dome portion of the VU program was called "Ripple" during the survey phase and later changed to "Dribble" for the operational phase.[16] Six criteria were crucial to Ripple: the salt had to be pure and free of any rock intrusions or ledges; the top of the salt had to be

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[14] U. S. Congress, *Hearings Before the Special Subcommittee on Radiation*, 155-57.

[15] Cochran, et al., *Nuclear Weapons Databook*, 160.

[16] The nomenclature regarding the Dribble test series even remained ambiguous in government documents and the program was occasionally referred to as Ripple. Project Dribble began as Ripple, and it is likely that cold war security habits led to the change in the name although it was not a secret program. In this work, Dribble has multiple uses, and refers to the atomic test program conducted in Mississippi as well as the test site itself. It does not refer to any particular test.

less than 1,700 feet down; the population around the site had to be as minimal as possible, and within two miles of the site it had to be less than one hundred; within two miles of the test site there could be no "significant oil, gas, sulfur, salt, or other mineral production"; there could be "no town within five to ten miles of the site"; and initially there had to be "firm ground" for instrumentation purposes within thirty miles – later thirty kilometers – of the site at forty-five to sixty-degree radial intervals. In addition, if a leaching method was used to excavate the chamber, fifteen million barrels of water needed to be available "at a reasonable cost," and there had to be "an appropriate, economical method of disposing of the approximately fifteen million barrels of wash water during the approximately six months required to form the desired cavity."[17]

More than 200 sites looked promising for the salt dome shots, ranging from Texas to Mississippi. After further analysis, two Mississippi salt formations looked the most promising: the Bruinsburg Dome, some thirty miles south of Vicksburg, and the Tatum Dome. The ready availability of transportation by road, railroad, and air was a major advantage of the Tatum site, as was the absence of having to worry about potential effects on Mississippi River traffic. The general characteristics of both domes were well known, and deep sampling cores retrieved from them allowed further tests regarding their suitability. At the Tatum site, exploratory 2,700-foot-deep wells penetrated into the dome to determine the chemical and physical composition of the caprock and salt stock.[18]

When Frank Tatum wrote his elected representatives during the latter half of October 1960, and reported the AEC's desire to "do some atomic shooting in the salt

[17] U. S. Atomic Energy Commission, *Re-Evaluation of Salt Domes for Project Dribble, Particularly the Hockley Dome* (Albuquerque: Nevada Operations Office, 1964), 9. NTA accession no. NV0338573.

[18] *Hattiesburg American*, Mar. 4, 1961.

dome," he was disturbed that the dome in question was located in the middle of his family's extensive landholdings. A shrewd businessman like his father, Frank Tatum made an offer to the Corps of Engineers: he could agree to an open lease on the land with unlimited extension if needed, "with the proviso that they would pay an annual rental of at least equal to what we were getting from the land each year in turpentine rights and sale of the trees. They would not agree to a lease." Tatum attempted another bargain, offering to trade for an equal amount of nearby government land. This was denied, he being told that the piece of federal land in question belonged to different bureaus and could not be exchanged.[19]

This letter is misleading, for it portrays Tatum as a victim of federal action. He neglected to mention that a month and a half before he began his correspondence with Governor Barnett, Senators Eastland and Stennis, and Representative Colmer, the *Hattiesburg American* reported the possibility that Mississippi's salt domes might be used for atomic testing, and an editorial published on September 15 further detailed the scientific interest in the state's salt domes and the overwhelmingly cooperative attitude of the state's citizenry. The first media report mentioning government interest in a local salt dome appeared on October 7, and six days later, Tatum was named as a member of a ten-man committee to advise Mississippi state officials on issues concerning the possible test program. He was better prepared to look out for his interests than he would admit.[20]

Of particular interest is a *Hattiesburg American* article published on September 12, 1960, which coupled the idea of using nuclear devices in salt domes to "produce valuable radioactive materials and energy that would be useful for industrial purposes" to

[19] Tatum to Eastland, Stennis, and Colmer, Oct. 28, 1960, Subseries: Tatum Salt Dome T-2 1960-1961, Stennis Collection, MSUCPRC.

[20] *Hattiesburg American*, Sept. 12, 15, Oct. 7, 13, 1960.

the excavation of the Tennessee-Tombigbee Waterway project. The Tennessee-Tombigbee (commonly referred to as the Tenn-Tom) was to join the two river systems across northeastern Mississippi and northwest Alabama, create a water route to the Gulf of Mexico independent of the Mississippi River, and act as a major economic stimulus to the southeastern United States. The large canal that had to be excavated to link the two rivers had to cut through stone ridges, where conventional blasting and rock removal was the primary expense of the project. The Tenn-Tom seemed an ideal proving ground for Plowshare, where several nuclear small devices could open the necessary passage in the rock with a modicum of radioactivity. Ultimately, the waterway was constructed, but without the use of Plowshare explosives. There was no mention of Vela Uniform in the article.[21] Linking the two projects, plus the idea of isotope creation and industrial uses of atomic shots in salt domes further increased confusion about the programs.

As of October 1960, no firm decision was made to acquire the property over the Tatum Dome or the minerals within it. Tatum was determined to avoid being taken advantage of by the federal government and was primarily interested in seeing how the situation could be turned to his personal benefit. The Atomic Energy Commission sent representatives on October 29, 1960, to brief Tatum fully on the plans for the Ripple tests as then conceived, and the need to assess the Tatum Dome for suitability as a test site as compared with the Bruinsburg Dome:

> If the Tatum site is finally selected for these experiments it is expected that it will be necessary to acquire approximately 1400 acres. Whether this area will have to be purchased or whether a lesser interest, an easement or a leasehold, will be sufficient has not been finally determined. However, every effort will be made to interfere as little as possible with the use of the surface by the present owners. Because it is anticipated that dome salt in the immediate vicinity of the

[21] Ibid., Sept. 12.

> detonation area will be made unsuitable for further utilization due to the effects of the nuclear explosion, we would plan still to purchase the mineral rights underlying the approximately 1400 acres discussed above.[22]

This mention of buying the mineral rights in the salt dome would later become an important point of contention.

On October 31, 1960, Tatum wrote to Governor Ross Barnett, still in the first year of his administration:

> With further regard to the Atomic Energy Commission's program in South Mississippi on the salt domes, as you know South Mississippi is blessed with many creeks, streams, branches and springs, and practically all of our people have artesian water available. The question naturally arises as to the contamination and pollution that our streams and water resources may suffer.
>
> We have to take into consideration not only contamination but the effect or force of the explosion and then the terrific heat. These atomic explosions seem to have a chained reaction (sic) and I do not believe anyone knows what the result might be.
>
> I am informed by the Humble Oil & Refining Company, one of our largest producers of crude oil in Mississippi, who have interest in many of the oil fields, especially in South Mississippi, that there is a large salt dome located on government property in the New Augusta area and on the Camp Shelby property. This dome is farther away from the oil and gas production, is already owned by the government, and has been for many years, and it seems to me should be available to the government if they need it. Humble states that the salt dome now owned by the government under their property is about the same size and conformity and depth as the one they are looking at in Lamar County and they think, from looking at their structural maps and seismograph information, that it is equally as well located structurally and probably about the same depth.
>
> I am sure that we will immediately find our government, through its Forest Service, demanding that the Atomic Energy Commission get their land elsewhere and not interfere with the Forest Service's program, etc. As a citizen, I think they should use what they already have.[23]

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[22] AEC Chairman Hollingsworth to Stennis, Nov. 28, 1960, Subseries: Tatum Salt Dome T-2 1960-1961, Stennis Collection, MSUCPRC.

[23] Tatum to Barnett, Oct. 31, 1960, Subseries: Tatum Salt Dome T-1 1960, Stennis Collection, MSUCPRC. Perhaps most noteworthy is the environmentalist argument, predating Rachel Carson's book, *Silent Spring* by two years.

Tatum found an important ally in Frederick W. Mellen, one of the most eminent geologists in Mississippi, who discovered the Tinsley oilfield, one of the state's most productive, in 1939. Mellen had cultivated a reputation for honesty and integrity, which eventually led him to be appointed state geologist in 1962. He later resigned that position in 1965 due to his disgust with colleagues who illegally diverted government funds for their own purposes and attempted to pressure him to engage in the same activity. Following his resignation, he returned to the consulting business.[24] Mellen was deeply opposed to the idea of nuclear testing in Mississippi from the beginning, arguing that the potential for destruction of the state's natural resources was too great a risk to take. Following a presentation that was given by Dr. Andrew D. Suttle Jr., director of the newly created Mississippi Industrial and Technological Research Committee (MITRC), to the Oil Company Geophysicists Association, Mellen wrote a letter to Senator Stennis, dated November 22, 1961, criticizing Suttle and the AEC, and requested Stennis's intercession:

> I wrote you sometime ago, sending you a copy of a letter which appeared in one of the local papers opposing the underground nuclear testing in Mississippi. I am still just as opposed to it as I was at that time, although my reasons may have changed somewhat. I understand that you have given your tacit approval of the program, as contemplated by the Atomic Energy Commission and the Mississippi Industrial and Technical Research Board….Dr. Suttle did not give one definite assurance of any economic benefit of these explosions to the State except for the pump-priming effect of spending Government money in a local area.
>
> The most alarming thing to me is the coercive threat of Federal authority vested in the Atomic Energy Act and the fact that Dr. Suttle views these salt domes as more or less useless appendages to the mineral economy of the State. ….Dr. Suttle led us to believe that not one, but many explosions were in contemplation; that not one, but some indefinite number of salt domes would be used by the Government….

[24]Alan Cockrell, *Drilling Ahead: The Quest for Oil in the Deep South, 1945-2005* (Jackson: University Press of Mississippi, 2005), 101-102, 273.

> It is with deep regard and concern that I find myself in the position of having to sit back and watch the destruction of our native State by a Socialistic Government. I know that it is a matter of concern to you, as it is to every thinking Mississippian, and I sincerely trust that you will continue to look into this matter at every opportunity and help us to kill this snake before it destroys us.[25]

Mellen's "Statement of Personal Opinion," widely distributed via the editorial pages of the state's papers, raised concern in the AEC's public information office, which was unsure of Mellen's motives, and suspected that his actions were a result of professional animosity. The Mississippi Academy of Science, of which Mellen was a member, had not been consulted during the early planning of the Dribble test series. Spite or not, Mellen's name and reputation carried a great deal of weight in Mississippi, and the last thing that the AEC, MITRC, and its director Dr. Andrew Suttle needed was negative publicity.[26]

Yet, despite the drumbeat of criticism emanating from Tatum and Mellen's typewriters, Suttle's MITRC had a powerful ally in the man who first proposed it, Governor Barnett, and the contracting firms in Mississippi, who hoped to benefit from its creation. MITRC, spiritual descendant of the earlier BAWI program, intended to bring high-tech industry into the Piney Woods.

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[25] Mellen to Stennis, Nov. 22, 1960, Subseries: Tatum Salt Dome T-1 1960, Stennis Collection, MSUCPRC. His misidentification of the MITRC as the "Board" is not explained.

[26] Memo, James Cannon, Office of Public Information, USAEC, to George Dennis, Office of Information, Albuquerque Operations Office (ALOO), April. 25, 1961, United States Department of Energy Nuclear Testing Archive (hereafter cited as NTA), accession no. NV018673.

Chapter Five

MITRC, MCEC, and the Tatum Decision

Frederick Mellen's efforts to stop the tests in Mississippi involved criticizing one of the state's newest administrative entities. The Mississippi Industrial and Technological Research Committee originated in 1960 in response to newly elected Governor Ross Barnett's inaugural address. Barnett reaffirmed his commitment to segregation, a legacy of the state's racist past. Yet for the future he saw himself in a unique position in Mississippi history, and advocated the introduction of high technology for his state. Noting "the urgency for this administration to direct its every effort toward raising the living standard of all our people," Barnett recommended the creation of a "Mississippi industrial and technological research center" in addition to programs designed to increase tourism, attract industry, and improve education. This initiative was similar in some respects to Governor White's earlier BAWI program except that it would not merely focus on the attraction of heavy industry to accompany agricultural development; instead, it would attempt to draw scientific and technological research to the state. Electronic, chemical, and nuclear industries were aggressively pursued. Barnett envisioned a large research park administered by highly qualified professionals – not politicians – as the anchor of this endeavor. This concentration on industrial and scientific expertise versus political appointees was remarkable for its ambition, especially in a Deep South state. To overcome the poverty and violence in the state's Delta region, and to spur development in other parts of the state, Barnett sought to attract high-tech industry. The legislature was willing to comply, and MITRC was established shortly after Barnett's inauguration.[1]

Such an organization required the stewardship of a gifted administrator. Despite Mellen's misgivings, Dr. Andrew D. Suttle, named first director of MITRC, proved to be an inspired choice. A Mississippi native, having been born in West Point in 1926, Suttle attended school in Starkville, where he later obtained a bachelor's degree from Mississippi State University, majoring in chemistry and mathematics with a minor field concentration in physics. Following his service in the Naval Reserve during the last two years of World War II as an aviation radio technician, he returned to work as a research assistant at Mississippi State's chemistry laboratories before he received an AEC fellowship at the University of Chicago in 1949. He earned his doctorate there in 1952, concentrating most of his attention on radiochemistry, and shortly thereafter worked for the Humble Oil Company. He continued as Humble's senior research scientist while serving as MITRC director. Suttle energetically promoted MITRC and wrote numerous reports for the state's industries.[2]

Tatum and Mellen's letters to government representatives complemented each other. Mellen feared the devaluation of Mississippi's salt domes to worthless sites for testing nuclear devices; these concerns reprised roughly a decade and a half later. His main assertion was that despite the depth of the Tatum salt (and that of the Bruinsburg Dome as well), they represented the top of a slippery slope. Once Mississippi's domes were judged disposable, the state would simply become another test site, dependent primarily on the federal dole, and unable to support itself through its own mineral and resource wealth, except by selling its salt domes as radioactive dump sites. Despite the

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[1] *Hattiesburg American*, Jan. 19, 1960.

[2] Ibid., Dec. 1, 1960; *Texas A&M News, University Information from Britt Martin VI 6-4919,* undated, Cushing Memorial Library and Archives, Texas A&M University, College Station, TX.

potential benefit to the world situation by stabilizing the nuclear balance of power, Mellen was highly suspicious of the AEC's interest in the region, and continued to protest the use of any of Mississippi's salt domes for atomic tests.

Mellen was in contact with Dr. Linus Pauling, a well-known scientist and opponent of nuclear testing, who feared that the proposed Vela program might harbor more sinister intentions. In a December 20, 1960, letter to Mellen, Pauling wrote:

> I agree with you that much of the destruction of our natural resources that is now going on is unwarranted. In particular, I too am strongly opposed to the use of Mississippi salt domes for detonation of nuclear explosions.
>
> Our military men may want to use even the peace-time experiments for tests of nuclear weapons, and I think that the only way to be sure that a misuse of the nuclear explosives is not being carried out is to have all peace-time applications of nuclear explosives in the hands of the United Nations. Also, I feel that very careful thought must be given to any proposed peace-time use of nuclear explosives, because I fear that the radioactivity will damage human beings so greatly and will damage our natural resources also to such a great extent that the explosions cannot be considered justified.
>
> I am pleased that you are active in your work along these lines, and I hope that you will continue.[3]

Tatum also expressed concern regarding environmental effects. In a letter to Eastland, Stennis, and Colmer, he spoke of Mississippi's environmental value as compared to the desert southwest: "This letter is not written necessarily as a property owner but as a Citizen of Mississippi. South Mississippi enjoys many water resources in its creeks, branches, springs, and artesian wells, many grasses, plants, and growing trees, both pine and hardwood. We have vast sections in the United States that are deserts and are covered by lava rock in the western states, no water, no grasses, no trees. I have seen a great deal of these lands in two trips west and seemingly all they produce, outside of the

[3] Pauling to Mellen, Dec. 20, 1960, Subseries: Tatum Salt Dome T-3 1961, Stennis Collection, MSUCPRC.

enormous amount of lava rock, is rattlesnakes, frogs, and lizards."[4] At times, he feared that the test program that was being considered for his salt dome would ultimately be used for more nefarious purposes than "military men" merely co-opting peacetime tests to develop weapons. Writing to Senator Eastland on Nov. 9, 1960, he stated his concern:

> The Atomic Energy folks tell us the project now contemplated is what they call Project Vela, that it is a project for the United Nations Commission. The A.E.C. is undertaking this project to settle the question raised by the United Nations Commission who have been studying the ban of nuclear explosions and the detection of such explosions. The United Nations Commission has raised the question as to whether it is possible to set off underground nuclear explosions so they cannot be detected by our enemies or others….They think by shooting off the explosions in the salt domes that the salt will so distort the shock waves that you could not tell whether it was an atomic explosion or an earthquake; that the salt mass will distort the waves of tremor and cause a different type of chart recording or a different type of wiggle or waggle….
>
> I am not ready for a one-world government and, personally, I would like to see United Nations put on a distant island and all Russians and Communists deported. I think this Nation could well stand on its own feet and tell the others to support themselves. I have never had fear of outside invasion, but I feel we will have rot from within.

Concluding his letter, Tatum added: "with best regards and congratulations on another term. We are certainly going to need you with Kennedy elected."[5]

The Kennedy administration had few white supporters in Mississippi. Tatum was definitely not a fan of John F. Kennedy, who along with his brother Robert, the attorney general, was the focus of his anger regarding the racial conflict that took place in Mississippi. Tatum certainly supported the idea, if not the fact, of maintaining segregation as a means of maintaining social status. A June 27, 1961, letter to Barnett

[4] Tatum to Eastland, Stennis, and Colmer, Oct. 28, 1960, Subseries: Tatum Salt Dome T-2 1960, Stennis Collection, MSUCPRC.

[5] Tatum to Eastland, Nov. 9, 1960, Subseries: Tatum Salt Dome T-1 1960, Stennis Collection, MSUCPRC. Emphasis in document.

and Tatum's congressional representatives illustrates his sentiments of states' rights and white supremacy:

> It seems that the Kennedy brothers have gotten together with the NAACP and similar organizations and issued new orders and directives regarding the letting of government contracts….
>
> As you remember, you invited the AEC to Mississippi. We agreed for them to work on our land as a matter of patriotism and not otherwise, as we do not believe they will accomplish any good for the State, except a waste of taxpayers' money. I believe, however, if we are going to go through this sort of thing we should see that the money is spent under Mississippi law, and not under Mr. Kennedy's law or Supreme Court law.
>
> We are having enough trouble regarding the Negro invasion now, and probably we are going to have the same sort of troublemakers invade the State by the thousands coming from the West coast, New York, Chicago, etc., and eventually we may have to meet them at the State line. We don't need further to be bringing into Mississippi organizations who will agree to these government demands, to get the government money and contracts. It's a good time to call a halt to the whole thing and let them know that you, as the head of the State of Mississippi, are not going to put up with it….
>
> As a private citizen, my position would be until we get rid of the Kennedy brothers, no government money for any purpose. I wouldn't want their projects and I would get them out of the State if I could. Untold harm is already being done to our way of life by government installations such as Keesler Field, where they [black and white servicemen] sleep and eat together.[6]

Despite his avowed opposition to the test program as a loyal American resisting UN pressure and the whims of scientific excess, Tatum wrote another letter on November 11, 1961, to Barnett, Stennis, Eastland, and Representative William M. Colmer making a case that had little to do with the environment, the threat of an internationalist government, or miscegenation. Now the issue was money:

> The Atomic Energy Commission, I believe, now agrees with us that they can lease the land on a ten year lease, year-to-year basis. However, they still think they will have to have possession of the salt mass. When you think of a huge mass standing 40,000 to 50,000 feet high and more than a mile in diameter, you are thinking about twenty to thirty cubic miles of salt, billions or trillions of

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[6] Tatum to Barnett, Eastland, Stennis, Colmer and Williams, June 27, 1961, Subseries: Tatum Salt Dome T-4 1961, Stennis Collection, MSUCPRC.

> tons all of which may be useful to us as property owners, as storage basins, for the extraction of salt and for industrial purposes.
>
> We see no reason why the government could not also lease the salt mass for the period of time necessary, paying thereon a lease rental and royalty for the salt removed (1/8th of the value of whatever it may be). If the AEC and Dr. Suttle know what they are talking about, only a small portion of this mass will be used or contaminated by the project….
>
> Our family has spent more time, money and energy in the conservation of our natural resources than, I believe, any other group….
>
> We do not want to lose this salt mass and have it turned over to the Bureaucrats, large corporations, promoters and opportunists, etc. We see no reason why a reasonable form of lease cannot be worked out where we can retain possession and the Government still do their work.[7]

Herein lay Tatum's primary argument with the federal government. Despite the salt mass being at a depth where it was commercially unfeasible to mine, it had potential value that he did not want to lose. Noting that his family had invested considerable time and money locating the dome, he felt due compensation was in order. He would happily lease the land above the salt dome, but should any of the mineral wealth be destroyed, he wanted to be reimbursed. The federal government could either buy the portion that would be affected by the tests, or they could buy the whole thing. He did not care; he wanted the money. The government saw the situation differently. It wanted to preserve as much latitude as possible when it came to contractual obligations with Tatum or the landholders over any other salt dome that might be chosen for the tests. As the choice was narrowed to the two domes in Mississippi, the federal government pursued an aggressive course towards acquiring land for the test site.

Sensing the likelihood of a major government program in the state, directors from several of the state's most prominent engineering firms formed a single entity near the end of November 1960, the Mississippi Construction and Engineering Company

[7] Tatum to Barnett, Stennis, Eastland, and Colmer, Nov. 23, 1960, Subseries: Tatum Salt Dome T-1 1960, Stennis Collection, MSUCPRC.

(MCEC). This new superfirm drew upon $10 million worth of assets and benefited from local expertise and international support, as many of the firms represented on its board of directors had international affiliations. One of the first things that the new company did was alert Stennis's office of its existence. In a letter to Stennis's aide, Marx Huff, MCEC's vice-president of public relations, Jack Stuart, threw MCEC's hat squarely into the ring: "Our company was formed in order to be large enough to handle any projects which might come to Mississippi and, to our knowledge, this is the first time so many of the large contractors have united in any single effort." The superfirm actively competed for primary, secondary, and support contracts, and hoped that with Stennis's political clout they would be able to secure the most important and lucrative arrangements with the government.[8]

Meanwhile, Mellen continued his campaign against the program. Whereas Tatum's approach could be likened to a shotgun, where the shot scatters broadly, Mellen's approach was more akin to a rifle aimed at governmental impropriety and material waste. He made new accusations to Stennis, arguing that the tests were the means through which Edward Teller's desire to end the nuclear test moratorium could be justified, and that Ben Hilburn and Andrew Suttle, the two most prominent officials in MITRC, were sycophantic co-conspirators. Furthermore, MITRC had refused to hire a fully-trained geologist, preferring instead to utilize a graduate student who was allowed the use of state-owned equipment in pursuit of his masters degree in return for his "rubber stamp" on all geological reports pertaining to the Dribble surveys. Calling for science to be "creative but at the same time conservative," Mellen concluded that "most

[8] Jack N. Stuart to Marx Huff, Jan.3, 1961, Subseries: Tatum Salt Dome T-2 1960, Stennis Collection, MSUCPRC.

scientists will agree that Project Vela Uniform is ultra-liberal."[9] Just a month and a half earlier, on February 6, 1961 Mellen had written that "destruction of mineral resources is tantamount to the destruction of life," and included Humble Oil, the AEC, and the state of Mississippi in Suttle's and MITRC's treacherous intentions. He also feared that thermonuclear devices would be detonated in the state's salt domes. As far as Mellen was concerned, a conspiracy was growing wherein several complementary schemes were working in concert to bring a destructive program to Mississippi.[10]

Mellen was not alone in his concern for the state's role in the proposed test program. Retired air force Lt. Col. James Marsalis also wrote to Stennis, fearing a veritable environmental apocalypse for the state:

> I would like to bring to your attention the $16,000,000 being spent here in the State of Mississippi blowing up salt domes, by the Atomic Energy Commission.
>
> Senator, an investigation of this activity will make your hair stand on end. Ruined forest and crops --- salt forming desert waste as far as the wind blows. Natural rescources [sic] destroyed. Can Mississippi stand such an act? No, not when we are on our way to becoming[sic] a manufacturing and agricultural paradise. There are other places to detonate these expremintal(sic) explosions, with little harm to man or beast.
>
> You have heard of Fred Mellen, who discovered oil at Tinsley. He is a product of our own State and is recognized as one of the foremost scientest(sic) in the United States. It would be amazing for you to hear him.[11]

Marsalis's letter is similar in tone to Mellen's "Statement of Personal Opinion," which had raised the AEC's concerns about Mellen's influence. But what Marsalis and Tatum alluded to was not environmental at all. Tatum's earlier letters, portraying

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[9] Mellen to Stennis, March 28, 1961, Subseries: Tatum Salt Dome T-3 1961, Stennis Collection, MSUCPRC.

[10] Mellen to Stennis, Feb. 6, 1961, Subseries: Tatum Salt Dome T-3 1961, Stennis Collection, MSUCPRC.

[11] William I. Marsalis to Stennis, April 11, 1961, Subseries: Tatum Salt Dome T-3 1961, Stennis Collection, MSUCPRC.

Mississippi as an unspoiled region, and Marsalis's letter referred to salt, which lay beneath the surface. It is possible that Marsalis was referring to plans to bring salt to the surface during excavation, and the potential from that, but his argument that Mississippi was approaching a state of paradise was far from accurate. Still, it indicates the reach of Mellen's opposition to atomic testing in the state.

Mellen's animosity toward Suttle continued. While the MITRC director continued to try to bring atomic energy to Mississippi, Mellen continued to rail at Dribble in general, and Suttle in particular, as when he wrote Stennis on April 12, 1961:

> I may be naïve in not suspecting that the Defense Department had no more than a casual interest in the outcome of Project Vela Uniform, a sub-project of Project Plow Share [sic], supposedly set up for peaceful uses of atomic energy. You will note that the Clarion Ledger article of April 29 stated that the detonation in the Tatum dome and, or in the Bruinsburg dome will be conducted by the Defense department. In other words, the Defense department is more than a cooperative agent in this undertaking, although Dr. Suttle has told us that the present testing was part of Project Plow Share. If there were any evidence that a decoupled nuclear shot would be of any aid in development of scientific detecting instruments, the project might be a little understandable. It still appears to most of the people that I know over the State of Mississippi that Drew Suttle simply wants to start setting off some nuclear firecrackers just for the sake of seeing what happens, irrespective of the adverse effects, the moral implications and the financial drain on a weak economy.[12]

For his part, Suttle was engaged in several important pursuits during the first half of 1961. He was determined to bring Dribble to Mississippi and wanted to prepare the ground as much as possible to prevent last-moment relocation to another state. He also wanted to increase the benefits of the Dribble tests beyond seismic detection to experiments regarding the production of isotopes and heat for electrical power generation. Suttle's interest in radioisotope generation is unsurprising, as this was his

[12] Mellen to Stennis, April 12, 1961, Subseries: Tatum Salt Dome T-4 1961, Stennis Collection, MSUCPRC.

area of expertise. In essence, he wanted to engage in a program similar to what Gnome ultimately became: a combined Plowshare/Vela test wherein materials of industrial importance might be produced. More important, Suttle believed that hydrocarbon and petrochemical experimentation valuable to state industry could be performed in combination with the AEC program. To Suttle, it only made sense to utilize the tests to their utmost economic potential. Certainly he could not still every disapproving tongue, but a financial windfall for the state and the region would with the MITRC converts from the ranks of its less-committed detractors.[13]

His other ambition focused on the Tenn-Tom Plowshare project. Noting a $25 million cost savings on the proposed waterway, he pointed out that the size of the waterway itself could be enlarged with the use of nuclear explosives, upgrading it from a unidirectional channel with periodic expansions along its course to allow opposing river traffic to pass to a true bidirectional watercourse. He wrote to Stennis:

> At the present time….it is the feeling of the most competent physicists in the United States that devices which are relatively free of fissile fuels can be constructed and operated with good efficiency and great economy. Unfortunately, misguided individuals have delayed the testing and further improvement of these units by confusing their development with the military program. I am the last person to speak out against the most vigorous program of armament and believe that we have been derelict in our responsibilities by failing to test nuclear weapons. But I would also emphasize that the peaceful utilization of nuclear explosives is a separate and distinct activity which, I believe, should be completely divorced from the weapons development program and regardless of the decisions reached in that field, that this peaceful utilization should move forward without delay.[14]

[13] Suttle to W. F. Libby, April 12, 1961, Subseries: Tatum Salt Dome T-4 1961, Stennis Collection, MSUCPRC.

[14] Suttle to Stennis, April 14, 1961, Subseries: Tatum Salt Dome T-4 1961, Stennis Collection, MSUCPRC.

Depending upon one's point of view, the news concerning Dribble was promising for the Piney Woods, or a looming disaster. On January 1, 1961, a ten-year lease went into effect for the land above the Tatum Dome, with annual extensions negotiable among the AEC, Frank Tatum, and the Bass family.[15] Tatum believed that the agreement was obtained under duress: "Some time ago I had a letter from Senator Stennis in which he stated he thought we were in favor of the Atomic Energy Commission's experiments in Mississippi….We did lease to the AEC 1430 acres of land for the experiments, as we were told they would probably condemn it if we didn't."[16] Tatum received $7,344 per year, and additional one-time $7,500 payment for expected tree and growth damage at the site. The Bass family, who grew paper-shell pecans on 100 acres that were in close proximity to the dome, leased a parcel of their land to the AEC, receiving $650 per year. In all, this amounted to 1,470 acres.[17]

A February 8 newspaper story reported that AEC engineer and Mississippi project engineer Ray C. Emens stated that the Tatum Dome fully met the technical requirements for the Dribble tests. A week later, Nevada Test Site director James E. Reeves visited the area. Addressing a joint civic club meeting in Hattiesburg, he outlined the AEC's past experience with underground testing, telling the assembled group that the only injury caused so far by underground tests had been due to a large kettle of soup overturning and scalding a person at the Nevada site. During the meeting, one waggish reporter asked Reeves whether anyone had considered detonating the subterranean shots beneath the

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[15] Frank Tatum recounted in a letter to his representatives that this date was actually Feb. 18, 1961.

[16] Tatum to Stennis and Eastland, May 26, 1961, Subseries: Tatum Salt Dome T-4 1961, Stennis Collection, MSUCPRC; Atomic Energy Commisssion, *Site Disposal Report Tatum Salt Dome Test Site*, 14, 16. NTA accession no. NV0338578.

United States Supreme Court building, to which Reeves replied, "that's a heck of a thing to ask a Yankee."[18]

At the Tatum Dome site, once the lease was concluded, roughnecks began drilling into the caprock and the salt below. At one particular location, twenty-four men employed by Texas Water Wells operated a derrick engaged in drilling exploratory holes and retrieving core samples. Only four of the men at the site were from the company headquarters in Houston, while the rest came from the oilfields of southern Mississippi. It was the same type of hole that many of them had dug several times before, but as one of the drillers remarked, "It's the first time I ever worked on one where everybody, from the start, hoped and prayed that it was a dry hole." For the men on the platforms, it was more work in a dwindling oil region. Mississippi's big strikes were playing out, and oilfield work was welcome even though they were fairly certain that they would not strike oil.[19] Ironically, an oil strike could have eliminated the Tatum Dome from the list of possible sites as listed in the Ripple criteria.

What the men on the derricks especially did not want to hit was high-pressure water. At various depths, sedimentary layers contained large aquifers that could prove to be problematic for the program. The region's aquifers had been utilized for a long time as a water supply for people and livestock. Despite standard drilling procedures that lined the drill holes with an impermeable casing as the hole extended downward, water might travel down along the casing to the salt, creating a brine that might contaminate several aquifer layers. Also, there were concerns about the release of radioactive

[18] U. S. Congress, Joint Committee on Atomic Energy, *Developments in Technical Capabilities for Detecting and Identifying Nuclear Weapons Tests: Hearing Before the Joint Committee on Atomic Energy* 88th Cong., 1st sess., (Washington, DC: Government Printing Office,1963), 501; *Hattiesburg American*, Feb. 8, 1961, Feb. 15, 1961.

[19] *Hattiesburg American*, March 4, 1961.

materials. Although the depth of the shots would eliminate the possibility of an atmospheric release, water could scour its way into the test chamber along the casing and convey highly radioactive materials away from the test site and into public contact. Water was trouble.

Operation Concerto had been planned to employ six atomic test shots in different locations and environmental conditions. Dribble would test at one location. The Concerto devices would have ranged in yield from 250 tons to 50 kt. Because of the two primary candidate locations for Dribble, the device sizes would not range as widely in yield. From July 25-27, 1961, a special JCAE hearing took place wherein the VU program was first addressed as a whole, and the Dribble component fully defined. VU's program manager, Theodore A. George, outlined a six-shot test program. The devices were codenamed "Record," at 100 tons yield, "Hayride," at 500 tons yield, "Hermit," at 100 tons yield, "Gaucho," at 5kt, the highest yield shot, "Greenbean," at 25kt, and "Tipsy" at 5kt. "These tests will furnish us with information on the effectiveness of concealment of an underground explosion by decoupling," George wrote. "All of these tests will be conducted at a depth of 2,500 feet."

> First we have three small underground nuclear explosions. Record is to be fired in the center of an underground cavity which will provide for complete decoupling. It will be followed by Hayride having a yield five times as much as Record, but fired in the same cavity. This will provide data on the effects of partial decoupling. Both of these shots will then be compared with Hermit with the same yield as Record, but fully tamped. These three events are expected to take place in the Tatum Salt Dome in Mississippi.
>
> The next three events are also intended to furnish data on decoupling but at a much higher yield level. Here we have Gaucho a 5-kiloton event completely decoupled; Greenbean a 25-kiloton event partially decoupled; and Tipsy the comparison shot of 5 kilotons, tamped.[20]

[20] U. S. Congress, *Hearings Before the Joint Committee on Atomic Energy Congress of the United States,* 87th Cong.; 1st sess. *on the Developments in the Field of Detection and Identification of*

The Dribble site, which George noted was likely to be located in the Tatum Dome, would require several test locations. At least two chambers would need to be excavated, with a corresponding pair of test tunnels for the two tamped shots. Fortunately, the Tatum Dome was large enough to accommodate this, despite the high-yield series having an explosive force 50 times greater than the low-yield series. Reflecting on one of the questions raised by Cowboy, no one knew what the effects of even a small atomic test in salt would have – specifically whether the test chamber would be reusable as it would have to be during the Dribble series. Nor did anyone know how the walls of a pre-excavated chamber reacted, or if the salt might fissure and allow high-temperature gases to escape. The first shots in the two series were decoupled, and there would be blast effects on the chamber walls. Furthermore, the second shot in each series would seismically overload, or "overdrive" the test chambers with explosive energies five times as powerful as the decoupled shots. Overdriving the chambers would explore insufficiently decoupled devices in shot-created cavities. The chambers had to be structurally sound enough to withstand the stress, and five months would pass from the time of the hearings before Gnome gave any indication as to how salt held up to an atomic blast.[21]

World events caused VU and Dribble to quickly regain international importance. On September 1, 1961, the Soviet Union broke the voluntary test moratorium that had been in effect since the end of October 1958 with a 16kt atmospheric test of a tactical missile warhead. In September alone, the USSR conducted twenty-six atomic and

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Nuclear Explosions (Project Vela), July 25, 26, and 27, 1961 (Washington, DC: Government Printing Office, 1962), 130, 132-33.

[21] Ibid., 130-33.

thermonuclear tests ranging from subkiloton to multimegaton yields. In all, the Soviet Union conducted fifty-nine tests from September 1 until November 4, 1961, including the awesome *Tsar Bomba* on October 30, with an estimated yield of 50-60mt. On several dates, up to three tests were conducted during a single day; on one day, four devices were detonated. In many cases, these multiple tests were fired at the same test site.[22]

The American nuclear testing program had been dormant for the thirty-four months the moratorium lasted, but on September 15 it roared to life, first at NTS, and later at several sites in the Pacific. Until November 4, 1962, the majority of the American nuclear testing program had been conducted in the atmosphere. The final Soviet atmospheric test was held on December 25, 1962. Between the two superpowers, this fourteen-month spasm of tests resulted in 100 tests by the United States, and 141 by the Soviet Union above and below ground, under water, and at high altitude, before the end of atmospheric testing. These tests were carried out regardless of delicate international events, and included seven American and at least four Soviet detonations during the Cuban Missile Crisis.[23]

At the beginning of October 1961, the AEC and DARPA selected the Tatum Dome as the site for Dribble, removing the Bruinsburg site from contention. The criteria having been met, field activity was put on a standby status, and the Dribble program further refined.[24] The biggest battle between Tatum and the AEC was beginning to take shape, over the salt dome itself.

[22] Podvig, ed., *Russian Strategic Nuclear Forces*, 493-99.

[23] Cochran, et. al., *Nuclear Weapons Databook*, 159-63; Podvig, *Russian Strategic Nuclear Forces*, 493-506.

[24] "Significant Events In the Dribble Program," undated, NTA accession no. NV16661.

Beginning earlier in the year, Tatum had started to feel that his correspondence to Barnett and others was making the rounds of the AEC. They seemed to know too much about his objections concerning the way the operations on his land were proceeding. For instance, in a letter to Mellen on March 31, 1961, he not only railed against the United Nations: “we are not for world government or world court and had thought that the United Nations should be moved to some distant point beneath the ocean,” but requested that his correspondence be limited in exposure: “one thing we have found out is, everytime we write, the letter always ends up with the Atomic Energy Commission.” Ironically, this letter did end up with Stennis with a penned notation at the bottom, reading, “Senator: I thought you might want to take note of this – Fred M.”[25] This request from Tatum became increasingly common in his correspondence to his elected representatives. His paranoia was warranted: his letters were indeed shared by their recipients with the AEC.

Tatum understood he was agreeing to a lease on the land and that the mineral rights question had yet to be addressed. For nearly a year since its decision to locate Dribble at the Tatum Dome, the AEC believed that a fight with Tatum was inevitable, and it would be over the salt. Earlier letters from Tatum and Mellen had argued the importance and value of the large salt deposit to the future of the state of Mississippi, and by extension, to the United States. Tatum was not going to mine it, as it would be economically foolish to retrieve. But that did not mean that he would allow it to be devalued. If the salt was going to be used or ruined by the AEC, he wanted fair

[25] Tatum to Mellen, March 31, 1961, Subseries: Tatum Salt Dome T-3 1961, Stennis Collection, MSUCPRC.

compensation for the material, and offered to accept one-eighth market value for any salt used or destroyed.[26]

The AEC's position was twofold. First, they asserted that only a portion of the salt was likely to be made radioactive, but a large quantity of salt was going to be mined during the creation of the two enormous test chambers 2,700 feet underground. This salt was going to be excavated either by brine mining, where water washed away the unwanted salt and the resulting brine was pumped to the surface for storage and removal, or by mechanical means. Either way, there would be hundreds of thousands, if not more than a million, cubic meters of salt brought to the surface by contractors employed by the AEC and not by Frank Tatum. Paying Tatum for the salt would amount to undue enrichment at taxpayers' expense. Second, several large shafts would have to be drilled into the salt dome for equipment insertion and salt extraction. These were also regarded as undue enrichment, as they would open the Tatum Dome's resources to easier mining, again at the taxpayers' expense. There would be no investment by Tatum, yet he wanted the salt, or to be paid for it. Tatum replied that would accept condemnation of two to three percent of the salt mass and all the shafts excavated by the government. Still, this was unacceptable to the AEC.[27]

The effect of the Tatum salt on the global market was another element in this conflict. Tatum recounted a visit from a worried Morton International Salt Company representative early in 1961 who inquired as to what was to be done with the enormous amount of salt, estimated at two million tons, which would be brought to the surface.

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[26] Tatum to Stennis, Dec. 2, 1960. Subseries: Tatum Salt Dome T-2 1960-61, Stennis Collection, MSUCPRC.

[27] Tatum to Seaborg, undated. Subseries: Tatum Salt Dome T-7 1963, Stennis Collection, MSUCPRC.

Tatum had his own ideas, while NTS director James Reeves offered another possibility: trucking it south and dumping it into the Gulf of Mexico. Estimates of $16 million for the salt were bandied about, although Tatum considered the figure far too conservative. Before any talk of cavernous excavations and atomic testing, the salt had been considered practically worthless to Tatum because it held no oil or gas. Ironically, it was extremely valuable to the world salt market only if it remained there undisturbed, for if it was suddenly made available, salt prices would plummet.[28]

The standby period at the Dribble site stretched for nearly a year. Livermore Radiation Laboratory (LRL) announced on August 15, 1962, that it was ready to take over control of the activities at the Dribble test site, as well as the responsibility for appointing a technical manager. Most important, during the standby the configuration of the test program had drastically changed. The number of test shots was halved, from six to three: a 5kt tamped shot, named "Salmon;" a 100-ton decoupled shot that would be fired in a fully excavated test chamber named "Sand;" and a control shot, a 100-ton tamped blast, named "Tar."[29] The proposed test program was expected to last a year, beginning in May 1963 and ending in May 1964. The months between October and April were considered unfeasible because of a seasonal increase in seismic noise, due to atmospheric storms and wave noise from the Gulf of Mexico. The newly configured program would require only one small chamber to be excavated, saving on construction and salt disposal costs.[30]

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[28] *Hattiesburg American*, Jan. 21, Feb. 15, 1961.

[29] U. S. Atomic Energy Commission, *Re-Evaluation of Salt Domes*, 7, NTA accession number NV0338573.

[30] John S. Foster, Jr., LRL, to Brig. Gen. A. W. Betts, AEC, Aug. 15, 1962, NTA accession no. NV00313001.

In September 1962, the AEC made its move, filing to acquire the mineral rights in the Tatum Dome through condemnation. A letter from AEC general manager Maj. Gen. Alvin R. Luedecke to Senator Stennis explained the government's reason for initiating condemnation proceedings, including the need to control the area around the region where the radioactive debris would be contained, and possible damage to surrounding mineral deposits due to tunnels, shafts, and the emplacement of experiments. In addition:

> ownership of a large part of the mineral interests in the land is in dispute, and several parties have indicated that each owns, and will claim title to, the same salt mass within the Tatum Dome. The time required for legal action to clear title to the mineral interests would be incompatible with the current schedule for execution of the series. For this and other reasons, it is the opinion of the Corps of Engineers, acting for the AEC in this matter, that condemnation will be necessary to obtain some or all of the mineral interests.[31]

Frank Tatum was outraged. The claimants to the mineral rights were Tatum, the Bass family, and the Hibernia National Bank in New Orleans. The relationship was complicated: Tatum and Bass lay claim to the surface land, which they acknowledged they had leased to the AEC, but this did not extend to mineral rights; nor could it, because Tatum bought the land over the salt dome in 1937 from Hibernia, and the bank retained the mineral rights. But, as Tatum wrote, "our attorneys and we, ourselves, have always construed this as it is written to mean Hibernia retained only the oil and gas minerals and that the salt mass belongs to us. We drilled the land and discovered the salt mass after extensive seismographic operation.…"[32] Luedecke realized that this Gordian

[31] It is unclear what the exact role of the Corps of Engineers was in the condemnation decision, except that it was easier for the Corps to condemn property for government use than the AEC, which was technically a civilian entity. Alvin R. Luedecke to Stennis, Sep. 26, 1962, Subseries: Tatum Salt Dome T-5 1962, Stennis Collection, MSUCPRC.

[32] Tatum to Stennis, Eastland, Colmer and Williams, Sep. 26, 1962, Subseries: Tatum Salt Dome T-5 1962, Stennis Collection, MSUCPRC.

knot needed to be severed quickly, or else the Dribble site would likely remain in limbo for years as the lawsuits dragged on. Tatum was a headstrong man from a powerful family, and such suits would be fought on his home turf to his advantage. As distasteful as condemnation was, it would mean that Tatum would at least be minimally compensated for mineral resources he had no plans to exploit, the surface lease would function as signed, and later the land would be returned. The salt would belong to the government. Of course, Tatum saw this as further government intrusion into an area where it was not wanted. As usual, he blamed the Kennedy administration and their efforts to build "facilities in South Mississippi where the negro and white will have to eat, sleep, bathe, etc., together."[33] Tatum favored a mineral lease, and continued to demand from the government terms he found more favorable than condemnation.

On October 15, 1962, a memo went out naming Dominic Magnetti as the temporary Project Officer for Project Dribble. Magnetti, normally an Operations Officer at the Nevada Operations Office (NVOO) was transferred to the Hattiesburg Project Office at 1485 West Pine Street, and from there began to prepare for the bidding process that would soon begin as the AEC's primary contractor, Holmes & Narver, Inc. (H&N) sought subcontractors to carry out the work at the Dribble site. Magnetti only held his post for a single month before being replaced by Leonard J. Yelinek, who would be the permanent manager of the Dribble site. Yelinek had been employed at NTS in 1956 as a project engineer, and in January 1962 was Area Engineer for Pacific Operations in Honolulu. His duties were primarily administrative, while others such as Jim Reeves

[33] Ibid.

bore much of the publicity work, traveling from NTS to answer occasional questions from local residents at civic meetings.[34]

In late October, Holmes & Narver issued a notice to mining and engineering firms for bids to excavate the underground chamber to be used in the decoupling test at Dribble. This was the most lucrative of all of the contracts at the site, and five firms ultimately submitted their proposals to Holmes and Narver: the Dravo Corporation, Pittsburgh; Kerr-McGee Oil Industries, Inc., Oklahoma City; Brown and Root, Houston; Camay Drilling Co. – Patrick Harrison, Inc., Los Angeles and Golden, Colorado; and the Mississippi Construction and Engineering Company.[35] This contract was the reason that MCEC was formed, and it would keep much of the project money in Mississippi while acting to further Barnett's promotion of the state's technical development. Stennis went to work immediately to promote the superfirm's bid, telegraphing Reeves in the middle of November and meeting with Mike Manatos on John Kennedy's staff at the end of the month to agitate for their cause. Stennis claimed that he was not seeking special favor for the group, but "with everything being like equal, this Company is entitled to a break and that is the reason for the Senator's call."[36] Certainly, this was not true: Stennis took a strong personal interest in the success of the MCEC and continued to lobby on their behalf.

In the end, it was not enough. The first notification of the decision came on the evening of Monday, December 3. Reeves called Stennis's office in De Kalb, Mississippi, to notify him that not only was the MCEC's bid not chosen, it was "low on the list."

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[34] Press release HP-62-3, Nov. 15, 1962, NTA accession no. NVO326733.

[35] Betts to Stennis, Dec. 14, 1962, Subseries: Tatum Salt Dome T-5 1962, Stennis Collection, MSUCPRC.

[36] James Reeves to Stennis, Nov. 16, 1962; minutes from meeting between Mike Manatos and Stennis, Nov. 30, 1962, both in Subseries: Tatum Salt Dome T-6 1962, Stennis Collection, MSUCPRC.

Reeves acknowledged Stennis's lobbying efforts and said that "if Senator wanted to take it up higher in Washington, of course he could." [37] Defeated, the MCEC waited for the opportunity to bid on future contracts. Despite the proximity of the member firms, their apparent familiarity with the region and their international affiliates, MCEC lost to the Camay-Patrick Harrison (CPH) partnership. Camay had established itself as a competent drilling firm and prior to the contract had been busy working for the Pan American Petroleum Corporation, prospecting for oil in Utah. Little is known of Patrick Harrison, Inc., except that it was also engaged in mine and tunnel work.[38] CPH prepared to excavate the ninety-five-foot-diameter spherical test chamber, as well as a vertical forty-two-inch-diameter shaft drilled next to the location of the chamber and connected by an "uphill drift," or inclined connecting tunnel, that would allow mined salt to be removed for surface storage. Other ventilation and auxiliary shafts, drilled to the test chamber approximately 2,000 feet below the surface would also be excavated by the CPH. It would later prove to be a pyrrhic victory for CPH; it was a lump of Christmas coal for the MCEC.[39]

A little more than a month later, an important contract was issued to another outside firm. Six ten-inch diameter shafts, ranging from 1,000 to 4,000 feet deep, needed to be drilled at the site, and oilfield veteran Big Chief Drilling Company from Oklahoma City won with their bid. In business since the mid-1930s, the company had created a reputation for achieving previously unheard-of depths in the Oklahoma oil fields; in

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[37] "L.L." to "Eph," Dec. 12, 1962, Subseries: Tatum Salt Dome T-6 1962, Stennis Collection, MSUCPRC. There is no available explanation why the MCEC bid was "low on the list."

[38] http://oilgas.ogm.utah.gov/Data_Center/LiveData_Search/view_pdf.php?file=4303710864.pdf, 16; Frontier-Kemper Constructors, Inc. "Crosscut" Vol. 16, Issue 2, http://www.frontier-kemper.com/crosscut/ccyearend07.pdf (accessed Feb. 9, 2010).

[39] Press release attached to Betts to Stennis, Dec. 14, 1962, Subseries: Tatum Salt Dome T-6 1962, Stennis Collection, MSUCPRC.

1956, one of their wells reached a depth of 16,000 feet. Beating out seven competitors, Big Chief was tasked to create the deep holes required by the two tamped tests, and the accompanying shafts for monitoring equipment. Big Chief increasingly became an important subcontractor at the site.[40]

One bright spot for Mississippi industry in relation to Dribble came on March 9, 1963, when a firm from Laurel, the Studdard Workover Company, contracted with Reynolds Electrical and Engineering (RE&E) to rework five instrument holes at the site to prepare them for use in the tests. RE&E had long been associated with America's atomic testing program. Like Holmes & Narver, it was a primary contractor for the AEC; H&N assumed responsibility for the physical preparation of the test sites, while RE&E and another firm, Edgerton, Germeshausen and Grier (EG&G) took care of the electrical and electronic tasks, respectively. The co-founder of this firm, Dr. Harold Edgerton, developed remarkably synchronous timing and firing circuitry for both atomic devices and recording equipment.[41] Studdard Workover's contract with Reynolds was an encouraging development; it was important work, and though unrelated to device emplacement or chamber excavation, refurbishing the previously-drilled instrumentation holes saved the Dribble program money and put a Mississippi drilling firm to work at the site.[42]

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[40] Oklahoma Energy Resources Board. "Oklahoma: Where Energy Reigns." http://www.oerb.com/Portals/0/docs/ForEducators/Oklahoma_Book_LR.pdf, p. 117 (accessed Feb. 9, 2010); Bulletin HA-63-5, U. S. Atomic Energy Commission Hattiesburg Project Office Hattiesburg, Mississippi, Jan. 18, 1963. NTA accession no. NVO326728.

[41] Edgerton was also responsible for the development of ultra-high speed photography. Slow-motion images of expanding atomic fireballs made within hundred-thousandths of a second, and fascinating movies of rifle bullets penetrating apples and cutting playing cards were the result of Edgerton's efforts.

[42] Bulletin HA-63-10, U. S. Atomic Energy Commission Hattiesburg Project Office Hattiesburg, Mississippi, Mar. 9, 1963, NTA accession no. NVO326728.

The MCEC might have been defeated, but Frank Tatum was not. His next destination was the Chancery Court in Lamar County, where he conceded the oil rights at the Tatum Dome, but claimed that the salt was discovered three years after he bought the land. Thus, as discoverer of the salt, it was completely and totally his. Furthermore, he charged that the government condemnation was an expedient wholly designed to avoid a hearing on the matter. The AEC had Civil Action 1765 in the United States District Court that would allow them to obtain all of the mineral rights in the salt dome for $32,235.00. Tatum countered that according to his estimates his family had spent some $125,000 in the process of discovering the salt dome; furthermore, of this $32,235.00 would have to be divided between Tatum and the Hibernia Bank with Tatum estimating that he would receive between $1,400.00 and $1,500.00.[43]

The federal court in Jackson, Mississippi issued the Order of Possession on December 21, 1962, condemning the salt dome.[44] Tatum still attempted to ameliorate his losses by arguing that only part of the salt should be condemned – the portion that contained the tests, and if it would satisfy AEC chairman Glenn Seaborg, Tatum's political representatives, and his attorneys, this could also include any shafts, excavations, or anything else that could constitute undue enrichment. This, too, was rejected by the AEC, which felt that an all-or-nothing approach was preferable to partial condemnation, thus removing the possibility of further wrangling over the salt. By April 1963, the issue was largely decided, and Tatum would have little to do with further proceedings at the Dribble site while it remained under government control. His

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[43] Tatum to Eastland, Stennis, Colmer, and Williams, dated Dec. 18 and 31, 1962. Subseries: Tatum Salt Dome T-6 1962, Stennis Collection, MSUCPRC.

[44] U. S. Atomic Energy Commission and U. S. Department of Defense, *Project Dribble* (Las Vegas: Nevada Operations Office, 1964), 10, NTA accession no. NVO0321724.

compensation exceeded that which he initially expected, as the AEC paid him $142,164.25 for the mineral rights in the salt dome. The land was leased, the salt belonged to the government, and that was that.[45]

[45] Tatum to Eastland, Stennis, Colmer, and Williams, March 6-April 1, 1963, Subseries: Tatum Salt Dome T-7 1963. Stennis Collection, MSUCPRC; U. S. Atomic Energy Commisssion Nevada Operations Office, *Site Disposal Report Tatum Salt Dome Test Site (Dribble/Hattiesburg) Lamar County, Mississippi NVO-88* (February, 1971), 16, NTA accession no. NV0338578.

Chapter Six

Salmon Run

While the salt under the Dribble site was contested in the courts, Hattiesburg began feeling the effects of the impending test program. Well drillers, necessary for site surveying and sampling, had been active since late 1960, sinking shafts into the caprock, salt, and surrounding soil to chart the location of aquifers and sedimentary strata. The Dribble program's schedule had the first nuclear shot set for May 1963. This gave the contractor, Camay-Patrick Harris barely five months from the award of the contract to complete the job of excavating the ninety-five foot diameter decoupling chamber. The wells through the caprock and deep into the salt dome had to penetrate numerous layers of sand, clay, and gravel. Within some of these layers were aquifers, with some containing fresh water and some containing brine. Like underground rivers, these aquifers generally flowed at constant rates. Farmers and residents of the region knew these aquifers well, and had for many years tapped these sources of fresh water for their use, as well as for their livestock. Eventually, water would lead to a reappraisal of the whole Dribble site, and for a time it appeared that the AEC might have to leave Mississippi prematurely.

The flip side of this dilemma was a benefit to Hattiesburg, because the longer the crews worked at the site the longer they stayed in the city and contributed to its economy. Despite the hubbub raised by Tatum over the condemnation of the mineral rights, the city was eager to do business with the federal government. Hattiesburg had been an intersection of road and rail lines, and it had a commercial airport. Southern Airways and Delta Airlines operated regularly out of Hattiesburg, and with the need to transport equipment and personnel to and from the test site, the air force anticipated operating from there as well. To do this, the air force needed to be able to fly its mainstay transport aircraft, the Lockheed C-130 Hercules, from the Hattiesburg airport. The Hercules was designed for relatively short take offs and landings. Its six-wheel undercarriage maximized the aircraft's "footprint," or weight distribution. Still, the Hattiesburg public works commissioner, C.B. "Pat" Patterson,[1] and air force personnel were concerned whether the city's existing strip could handle the large transports. The aircraft were attached to the Air Force Technical Applications Command (AFTAC), which had been created long before Vela as the primary military department dedicated to atomic test detection. In addition to transporting equipment and personnel, AFTAC aircraft would observe the Dribble tests from the air, the Hercules's long range and endurance being a benefit for extended loiter-time observation.

In mid-May 1963, AFTAC notified Patterson of its desire to operate from the Hattiesburg airport. AFTAC sent a package of information including a pilot's manual for the C-130A to provide operational and technical specifications as well as loading tables that showed the Hercules's weight distribution similar to the older and familiar C-47. Patterson replied that consultation with airport engineers led to some concerns that would be diminished by drier weather, because wet soil beneath the runway could lead to damage from heavily laden airplanes.[2] AFTAC was certainly welcome to operate from the Hattiesburg airport, but: "we would grant our permission for landing your aircraft on the condition that if any damage is done to the runways, we would expect your agency to

[1] Thus his name is recorded by the Hattiesburg city office. His wife, who also worked for the city, is recorded as being known as "Mrs. C.B. Patterson."

[2] The question regarding suitability of the Hattiesburg airport was directly connected to weight, not length of the runway, for it was at least 5,000 feet long, and currently is over 6,000 feet long.

reimburse the City for the cost of repairs." In the end, wishing to simplify operations and lessen the growing expense of the Dribble operations, AFTAC opened an operations office in Hattiesburg on May 27, but on June 3 notified Patterson that it would stage its aircraft from Brookley Field in Mobile, Alabama. This removed any possibility that AFTAC could be held liable for damage to the Hattiesburg airport, particularly if it was not caused by the AFTAC airplanes but by normal wear and tear on the facilities.[3]

The dates of the airport correspondence reveal the official decision to push the date for the first test, the 5kt Salmon, back from May to the week of July 8, 1963. Still within the one-year window, the extra two months gave the excavation crews precious additional time, especially considering the fickle nature of spring and summer weather in the South. Other important work had already been conducted in relation to the Dribble tests. Between April 1 and 10, some twenty chemical high explosive tests were conducted within a 120-mile radius around the test site. Ranging from 500 to 4,000 pounds, the blasts were conducted to investigate further seismic anomalies that could affect the shock wave from the nuclear tests and to calibrate recording equipment.[4]

While AFTAC and the airport were negotiating the use of the Hattiesburg airport, nine single-story structures were erected at distances varying from 3/5 to 3 ½ miles from the Dribble test site. Two of these were cement block buildings, while the other two were frame construction. They were arrayed along two axes: one towards Baxterville to the south, and one towards Purvis to the east. These structures were instrumented and used

[3] Capt. S.E. McGrew, Deputy Commander AFTAC, to C. B. Patterson, Hattiesburg Public Works Commissioner, May 13, 14, June 13, 1963; Patterson to McGrew, May 21, 1963, folder 9, box 133: Commissioner C.B. Patterson: Atomic Energy Commission – Project Dribble (1963-1964) - M208 Hattiesburg Municipal Records, Records of City Commissioners, McCain Archives, University of Southern Mississippi Manuscript Collections, MCAUSM (hereafter cited as M208 MCAUSM).

[4] McGrew to Patterson, May 17, 1963, folder 9, box 133: Commissioner C.B. Patterson: U. S. Atomic Energy Commission – Project Dribble (1963-1964) M208 MCAUSM; Richard X. Donovan to Stennis, Mar. 21, 1963, Subseries: Tatum Salt Dome T-7 1963, Stennis Collection, MSUCPRC.

to assess the ground movement from the 5kt Salmon test. Although noted as an experimental program in their own right, test buildings had less to do with the scientific observation of ground motion from a test in a salt dome and more to do with indemnification of the AEC, which knew that many of the structures in the area were vulnerable to damage or collapse. The experimental buildings would act as controls when the expected claims came rolling in after the Salmon test. In conjunction with safeguarding the citizens from their activities, the AEC was determined to reduce its own liabilities.[5]

An April 5 memo from Alvin Luedecke to General Austin W. Betts, director of the AEC's Department of Military Applications (DMA) following Starbird, noted that the Dribble program was on schedule, and that it had "now reached the point where it is considered essential to initiate a rather intensive public information program in order to assure continuing public acceptance of the program and to initiate actions required so that the proposed mid-summer detonation schedule for the initial shot may be met." Part of this call to action was an area-wide structural survey to be conducted by Holmes & Narver engineers, contacts between local residents and United States Public Health Service (USPHS) representatives attached to the Dribble program, and drafting of form letters to local residents who would either have to evacuate the area or be asked to be outside their houses during the test. Timetables were created specifying certain points of contact with Governor Barnett, local officials, and the AEC. As it ultimately turned out,

[5] Bulletin HA:63-15, U. S. Atomic Energy Commission, Hattiesburg Project Office, Hattiesburg, Mississippi May 15, 1963, NTA accession no. NV0326716.

this schedule was wildly optimistic, but in April and May 1963, a July date for Salmon looked possible.[6]

As Frank Tatum had previously explained to Governor Barnett, the region around the Tatum Salt dome "is blessed with many creeks, streams, branches and springs, and practically all of our people have artesian water available." That water proved difficult to drill through. The sites where CPH had begun operations struck water on the way down to their target depth. This was not unexpected, as core samples revealed the existence of several aquifer layers between the surface and the top of the caprock. Oil drillers were experts at keeping overlying water from flowing into oil wells. The most common method was to line the hole with a metal casing extending to the bottom of the well and puncturing it at levels where desirable materials – natural gas and oil – were located by core sample analysis. The contractors drilling at the salt dome found it excessively difficult to prevent the water from entering their boreholes because of the large diameters of the wells. This threatened the most important test at the Dribble site: the decoupling test. In order for the ninety-five-foot-diameter chamber to be excavated at a 2,000-foot depth, some 1,200 feet of overlying soil, clay, sand, aquifers, and caprock had to be penetrated before even reaching the salt, and then the hole had to continue for almost 800 feet before reaching the excavation site. Furthermore, there had to be at least two such holes, and they had to be absolutely watertight to ensure the safety of those excavating the chamber. In one scenario, a water leak into the chamber would hamper the excavation; in a worst-case scenario a catastrophic leak could kill an excavation crew hollowing out the subterranean cavity and ruining the salt dome beyond further use.

[6] Luedecke to Betts, "Project Dribble Progress Report," April. 5, 1963, NTA accession no. NV0075301.

Water posed another threat to the test itself. If any was present in the test chamber, it would immediately flash into steam when the decoupled shot was fired, adding mechanical energy to the test and potentially affecting the data. Steam caused by a tamped test could work its way through fissures that occurred naturally in the dome, or were caused by the detonation of the test device. It could also blast the plug of concrete and gravel into the atmosphere like a giant cannon. The water had to be contained or another option had to be found. The vent shaft to the chamber, penetrating to 2,000 feet, cased with thirty-inch-diameter pipe 150 feet into the dome and sealed with cement grout and other materials defied all efforts at waterproofing and caused months of delay. Although it was pumped dry on November 1, 1963, eighteen days later it was found to be filled with water that reached "within several hundred feet from the top." The thirty-inch diameter ventilation shaft was the smallest of the three that were needed for the cavity excavation; the seventy-inch production shaft that was begun had been abandoned at 950 feet because of casing failure.[7]

James Reeves, Nevada Operations Office Manager, stayed up to date on the bad news. Despite the best efforts of the engineers, drillers, and hydrologists, all three shafts were constantly flooded by pressurized water that forced its way past the grouting materials and casing. Ordering a "thorough study by highly qualified authorities in the country of the engineering problems that have been encountered in construction work at the Project Dribble site," Reeves cut back the operations at the site "to a status of minimal activity" in December. In short, the Dribble tests would not be conducted

[7] Bulletin HA:63-22, U. S. Atomic Energy Commission, Hattiesburg Project Office, Hattiesburg, Mississippi, Nov. 18, 1963, NTA accession no. NV0326711; U. S. Atomic Energy Commission, *Project Manager's Report: Project Dribble (Salmon Event), NVO-24* (July 1966), 111, NTA accession no. NV0004351.

anytime soon, if at all. The year 1963 ended with Dribble again in limbo, while the AEC and its consultants scratched their heads. It was cold comfort that environmental factors would only allow for the testing window to open again in April 1964, when accurate seismic data could again be recorded.[8]

The problems at the Dribble site did not stop the overall progress of the VU program. On October 26, 1963, the first atomic test of the series was fired at Fallon, Nevada. Yielding 12kt, the device, codenamed "Shoal," was a tamped shot detonated 1,200 feet below ground in a shaft. Shoal was a fully contained seismic experiment, and though it was initially planned to follow the first Dribble test, there was no reason to hold it up – especially in light of increasing competition for funding. Already Vela had been reduced in size, and potentially could be further dismembered by the accountant's axe. By proceeding with the series, the AEC could show some return for the money and planning that had been spent on Vela and the doomed Concerto series.

The flooding problem at the Dribble site condemned the shafts for the excavation of the chamber for the decoupling test. This experiment was one of the primary reasons for choosing the Tatum Dome; the other was that it could accommodate both phases of the originally proposed series. If it could not be used for the decoupling tests, they would have to be moved elsewhere. During the lull in activities at the test site, several other salt domes that had originally been considered for the Ripple/Dribble program were reappraised. Environmental conditions limited the time period when seismic data could be clearly received, basically from April until November, when weather-related and other seismic noise was relatively low. This pause in activities at the site gave engineers time

[8] Bulletin HA:63-23, U. S. Atomic Energy Commission, Hattiesburg Project Office, Hattiesburg, Mississippi, Dec. 20, 1963, NTA accession no. NV0326710.

to examine what course should be followed. Salmon was a less troublesome shaft to drill, and due to its yield, it needed to be detonated where it would have a lesser effect on the surrounding population. Sand and Tar were much smaller, and could be staged in a greater variety of locations. The Dribble program started with six atomic tests, then it was three; the growing likelihood was that the Tatum Dome would be the site of only one shot.

Ross Barnett had actively encouraged high tech industry into Mississippi, and the maintenance of segregation during his administration. The 1963 gubernatorial campaign was the beginning of the end of Barnett's political career, and resulted in Paul Johnson Jr.'s ascension to the governor's office. Formerly Barnett's lieutenant governor, and son of former governor Paul Johnson Sr., the younger Johnson ran with a segregationist tone that accorded with Barnett's rhetoric, but upon his inauguration, his tone changed dramatically. Despite his efforts to keep James Meredith out of the University of Mississippi, and his gubernatorial tenure being tarred by the disappearance of civil rights workers, Johnson was a man of conscience, realizing that Mississippi would never progress if gross racial inequalities were permitted to continue. Johnson managed to anger just about everyone during his tenure as governor because he actively refused to segregate or desegregate Mississippi. Most important, he did not stand in the way of the changing social situation in his state. Johnson would not oppose change, preferring a *laissez faire* approach coupled with continuing efforts to bring in technologically-advanced industry into the state. It proved to be a wise choice, as demonstrated when Litton Industries decided to locate its "Shipyard of the Future" in Pascagoula in 1967. The challenge to Southern governors in the age of expanding federal defense contracts was to maintain a connection to the old ways while changing their tone enough to satisfy Washington.[9]

While weather and budgetary threats loomed, construction at the site resumed in earnest in April 1964, as a second shaft for the Salmon device was begun. Designated Site 1A, this new 17 ½-inch-diameter hole progressed steadily as new methods of grouting the casing avoided the water problem from the previous year. The target depth for Site 1A was 2,700 feet. The first 2,200 feet would be cased with steel, with the final 500 feet excavated directly into the salt stock. This uncased portion of the hole was to eliminate the casing from the region where the maximum predicted "chimney" area would be located. The chimney was expected to develop where the material fractured and loosened by the detonation collapsed into the blast cavity. Because the salt was rigid, and the upper limit of it was buried 1,469 feet below caprock and overlying strata, a subsidence crater would not form. Instead, a spherical chamber would initially be created by the blast, and shortly thereafter molten and fractured salt would drop to the bottom of the chamber, making the expected cavity have a shape roughly similar to that of an egg, with the lower part partially filled with this melted and crumbled debris. The prediction of the chimney's maximum height was 435 feet. The absence of the steel casing enhanced the blast's ability to help stem the emplacement hole as fractured materials were blasted upwards toward the surface. This worked in concert with the materials poured from the surface down the hole, a mixture of pea gravel and concrete, added shortly after the device was emplaced. In addition, were the casing to extend into the

[9] Schulman, "From Cotton Belt to Sunbelt," 358.

chimney region, it would likely be seriously damaged and would complicate or completely frustrate any efforts to utilize the Site 1A shaft for chamber reentry.[10]

In addition to Site 1A, numerous other shafts were sunk into the salt dome. Along with reopened and reworked instrumentation holes, several new shafts for instrumentation and water sampling were drilled at various locations around the 1,750-acre site. The depths varied greatly for the instrumentation holes, ranging from near-surface emplacements to ones below the Salmon emplacement depth. All of the holes within an 1,100-foot radius of the detonation point were stemmed in the same fashion as the Salmon emplacement hole, using gravel and concrete to block the escape of highly-pressurized gases from the detonation. The sampling wells were drilled to the depth of their respective aquifers, with several wells assigned to each aquifer to detect the quantity, direction, and speed of any radioactive contamination if it was released.[11]

Satisfactory progress also continued at the Dribble site where NVOO manager Reeves issued more timetables and technical information to the parties involved with the test. Along with enhanced safety procedures and concerns regarding nearby oil and water wells, Salmon finally was assigned an official operational period, beginning on July 10, 1964, and indefinitely continuing into the postshot period. In addition, a second test phase was planned for 1966. Salmon was projected to be ready for early September 1964.[12]

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[10] Dribble Public Safety Meeting, July13, 1964, 4, NTA accession no. NV0096095; Atomic Energy Commission, *Salmon Event – Project Dribble* (July 17, 1964), 30, 43, NTA accession no. NV0075308.

[11] Atomic Energy Commission, *Salmon Event of Project Dribble: Report to the General Manager by the Director of Military Application* (July 17, 1964), 8, NTA accession no. NV0075308.

[12] *Operation Order NV-OPO-5-64* (July 10, 1964), 7-8, 170, NTA accession no. NV0096218.

Still, there was the question of the other two Dribble shots, Sand and Tar. Salmon's emplacement was comparatively simple because keeping the water out of Station 1A was proving effective, but the larger holes needed for chamber excavation were not technically feasible in the wet environment over the dome. Thirty-nine salt domes were originally considered as candidates for the Ripple/Dribble program. Of these, eight domes in Texas and Louisiana were reappraised for the decoupling test. The resulting report pointed to the Hockley Dome, thirty-five miles northwest of Houston, Texas. Because it was a salt mine, it had a large sixteen-by-sixteen foot shaft that ran 1,650 feet deep into the dome. It had lift and hoist equipment to handle the large quantities of salt that would need to be removed, and was fully ventilated. Originally it had been approved for the Phase I low-yield tests of the Ripple/Dribble program. Excavation and instrumentation of a decoupling chamber could be accomplished relatively quickly. The main piercement points at Hockley were free of aquifers so water intrusion would not be a problem. The tamped Tar shot would require a shaft similar to Salmon's, about 2,000 feet deep into the Hockley Dome. The Sand cavity could be excavated from within the mine, requiring about 2,500 feet of new shafts. Hockley would be cheaper than the Tatum Dome, estimated to cost $13,195,000 versus $13,860,260 at the Mississippi site. Strangely, this figure did not include the cost of buying the actual site. The tradeoffs included the proximity to a major metropolitan area (not considered to be a hazard due to the very low yield, but problematic in terms of public opinion and support), and the effect on the seismic program caused by the use of two test sites for Dribble. Program managers recommended continuing the investigation into relocating the two small shots to Texas.[13]

[13] U. S. Atomic Energy Commission, *Re-Evaluation of Salt Domes*, 3, 4, 7 13, 16, 18, 23, 25-27,

Back in Mississippi, ground motion surveys and predictions led to the delineation of a 1.6-mile radius around the test site, where an additional force equal to gravity (1G) was expected. Some sixty people lived within this area; James Reeves returned to the site in July and August to address the residents around the Dribble site. As part of the site preparations, H&N surveyed private residences and other structures and prepared detailed drawings of each to brace them against the expected shock. The USPHS ordered pads and blankets to protect furniture, and packing materials were procured, allowing residents to safeguard their delicate possessions. Propane tanks in the area were braced and secured, and ten house trailers were set aside as emergency housing in case of homes being damaged beyond the limits of habitation. An ample amount of water was contained in tanks and trucks to supply thirty-two of the sixty-two families in the two nearest zones to the detonation and their livestock, as well as ten 3-5-kilowatt generators to supply electricity in case of power line damage.[14]

The preshot evacuation plan was complicated by the wind. Before the test, some residents would be asked to evacuate the area, while in others they would be advised to remain outside their homes until the test was concluded. Three areas were identified around the test site, designated A, B, and C. Zone A was described as being "irregularly shaped" and covered all homes out to 1.6 miles from ground zero. These people would evacuate the area; their proximity to the site not only left them vulnerable to the shock of the blast, but accidental failure of the stemming could lead to their being fatally irradiated. Zone B extended from the outer boundary of Zone A to 2.6 miles of ground zero. These people would be allowed to remain on their property, but were advised to

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NTA accession no. NV0338573.

[14] *Pre-Shot and Standby Support for Residents Vicinity of Project Dribble – Salmon Event*, undated, NTA accession no. NV0096064.

remain outdoors until told otherwise, in order that they not sustain injury should their house or chimney collapse. Ground motion analyses by the Roland F. Beers firm suggested that the region should receive a sharp jolt. Although the intensity would be milder than the shock expected in Zone A, it could be more than enough to turn shelf contents and wall decorations into missiles. Zone C was the downwind sector, and would be determined on the day of the shot by the meteorologists. It incorporated part of Zone B and would be extended outward as dictated by wind speed. Like Zone A, Zone C would have to evacuate until it was determined that the stemming had held and radioactive leakage was unlikely.[15]

Securing the test site and the surrounding area was the responsibility of private and public safety officials. Private security guards patrolled the site itself, while local and state police were slated to man roadblocks and safeguard the homes in the region. Radiation safety (rad safety) officers whose job it was to detect and monitor any radiation release from the test provided perhaps the most important security service. Fanning out over the area before and after the shot, these personnel were crucial to the safety of the site, and could quickly evacuate any endangered civilians in the path of an atmospheric release. The rad safety personnel also monitored the wells and aquifers in the area, taking preshot baseline radiation readings for comparison with the postshot conditions. Naturally occurring radioactive substances are commonly found in well water in minute quantities. Knowing what already was present would help allay public fears and would allow precise detection of any radioactive leakage into these underground water sources, should it occur.

[15] *Operation Order NV-OPO-5-64*, 36-37, NTA accession no. NV0096218.

With the holes for device emplacement and instrumentation nearing completion, final site preparation began in July. Further delayed by a couple of weeks, Salmon was scheduled for September 22, 1964, at 10:00 AM. Before it could be fired, several auxiliary and support structures had to be constructed. Outside of a 1.7-mile perimeter from the Salmon surface ground zero (SGZ), a control point (CP) was established, and at a distance of a mile from Site 1A, the Technical Director's Manned Station (TDMS) was constructed. The detonation party and site reentry teams would be stationed at this latter location during the test, and access would be highly restricted during the maximum security phase of the test program. This phase of operations was designated by the arrival of the test device at the site, ideally five days before the shot date, and was expected to last for three days after the detonation. This maximum security period could be extended as needed. An observer area 3 ¼ miles from the shot was developed for media, interested civilians, and personnel not essential at the CP or TDMS. A 150-foot radio repeater tower would also be located at the observer's area along with a support trailer. An electrical facility, under the control of Reynolds Electrical and Engineering Company (REECO) was constructed at the site, including a transformer and distribution station.[16]

Not far from Site 1A, the assembly area, which was large enough for a trailer, was graded, leveled, and surrounded by a security fence. Here, the Salmon device would be prepared following its transportation from LRL. Nearby were several earth berms erected for high explosives handling and assembly for the immediate preshot high

[16] *Operation Order NV-OPO-5-64*, 17, 23-24, NTA accession no. NV0096218; U. S. Atomic Energy Commission. *Project Dribble* (Aug. 1, 1964), 18, NTA accession no. NVO0003295.

explosive test series. These areas were tightly controlled, and during the maximum security phase would be the most inaccessible parts of the site.[17]

Near the Salmon emplacement hole, a "bleeddown" plant was built. This facility was crucial to the chamber reentry phase of the operations at the site, which was scheduled to begin within several days of the shot. The bleeddown facility would be connected to the well head as the reentry hole was drilled. Once the shot point was reached, any pressurized gases produced by the blast would be diverted to a large condensation and holding tank, called a "blooie tank" at the facility. The gases would then be cooled and scrubbed of as much radioactive material as possible, diluted with air, and the resultant efflux released into the atmosphere. Once pressure had been equalized, air would then be injected into the cavity to remove the remainder of the gases, which would likewise be scrubbed at the bleeddown plant, diluted, and released. Air monitors surrounded the test site, and any spike in radiation would be immediately noticed. The radioactive contaminants collected in the condensation tanks would then be disposed of. Depending on the levels of radioactivity, the waste might be stored onsite or shipped to a disposal facility such as Oak Ridge, Tennessee. After the cavity was purged of hot radioactive gas, cameras and sampling equipment could then be lowered into the resultant cavity. One of the goals of the original Dribble program was to find out whether the cavity created by a 5kt test could be reused to decouple a 25kt shot. Reentry and inspection of the cavity would suggest whether or not this would indeed be possible.[18]

On August 6, the nineteenth anniversary of the atomic bombing of Hiroshima, James Reeves, director of AEC public information Henry Vermillion, Hattiesburg office

[17] U. S. Atomic Energy Commission, *Appendices "A", "B", &"C" to AEC 1029/30 – Salmon Event – Project Dribble* (July 20, 1964), 227, NTA accession no. NV0075315.

[18] U. S. Atomic Energy Commission, *Project Dribble*, 18, NTA accession no. NV0003295.

director Leonard "Buck" Yelinek, Lawrence Radiation Laboratory project director Dr. Phillip Randolph, director of AEC project operations William W. Allaire, and Mississippi Research and Development Commission director Dr. Robert Dye convened a public information meeting at the Baxterville School. Also at the meeting were Phil Allen of the Meteorological Service, Joseph Lang of the USGS, Mel Carter, director of the United States Public Health Laboratory in Montgomery, Alabama, Roland F. Beers, and Tom McCormick from H&N. The shot date was a month and a half away, and despite the increasing pace of preparations on and offsite, the project administrators displayed a relaxed, easygoing attitude during the meeting. Following Vermillion's introduction, Reeves declined to revisit project information reported by the *Hattiesburg American* and other news sources, deciding instead to concentrate on the impending actions that were planned for the area. He believed that the delay in the Salmon test was ultimately a positive situation, and that because of the extra time spent trying to solve the engineering and construction problems encountered at the Dribble site, the test would be far safer than it might have been otherwise. Still, the two causes for concern were accidental radiation release and ground motion. Admitting that they expected "some damage to structures, cracked plaster, broken windows, or maybe a chimney or two will fall down," Reeves noted that damage claims would be settled either by repairing the damages or by monetary settlements.

Allaire arrived late to the meeting, having gotten lost en route to the school. Reeves jovially remarked that he was certain that Allaire had either gotten lost or had run afoul of the local police. Allaire's sense of direction might have been wanting, but his timing was perfect, as he was to brief the assembled residents on the evacuation plans for the forthcoming test. The plan for September 22 was to evacuate all residents within the 1.6-mile radius of the test, Zone A, at 7:30 AM. They were expected to be away from their homes for most of shot day, as were those who lived in the downwind sector Zone C, which was assumed to be the northern quadrant of the B Zone extending out to five miles from SGZ. The downwind sector would not be specified until the day before the test. All residents would be allowed back as soon as monitoring personnel were certain that no radioactive leakage had occurred. While the evacuation was in effect, helicopters would patrol the area in order to detect unauthorized persons and emergency situations, like fires. For their inconvenience, each adult who evacuated these sectors would be paid $10, and each child under twelve years old would receive $5.

The people in the B Zone who were not in the downwind sector would be asked to remain outdoors during the shot, but would then be allowed back into their homes. Allaire added a suggestion that people who lived in an area from the outside perimeter of the B Zone, 2.6 miles, to a farther distance of 4.6 miles, might also want to remain outdoors to avoid falling objects indoors; although it was not felt to be necessary, he added that it was "just an extra precaution."

Once the all-clear was given, probably in mid-afternoon, public health personnel would escort heads of household to their properties to check that their homes were sound. Damage would be radioed to the CP, and assessors would be dispatched to survey the damage and compare it with preshot surveys that had been made by Holmes & Narver of all the dwellings and buildings in the area. The General Adjustment Bureau, a "professional claims adjustment group," would then handle the paperwork and expedite the claims. The $5,000 limit on individual damage claims was set by the Atomic Energy

Act, and Allaire doubted that any damage would reach that amount. One of the reasons for this was the preparations for structural bracing made by H&N. Structures in the A and B zones were slated for an aggressive bracing program. Tom McCormack of H&N noted the concern for bracing "foundations and chimneys and porches and anything that's susceptible to ground motion." The residents of the area within a 4.6-mile radius were divided into five groups in respect to their distance from the shot point; following the meeting they were invited to see the bracing suggestions and plans that H&N had created for each structure. Further contact would be made by H&N with each homeowner before the bracing of their homes and other structures. Finally, Vermillion advised that a public observation area had been established at the Dawson Johnson farm located between Baxterville and the Tatum Dome with the cryptic statement: "I don't think anybody is going to see anything because I don't think there will be anything to see; but nevertheless, there will be a place from which you could see something if there were anything to see at all."

The presentation concluded, and residents were invited to ask questions. Some were expected. Emergency water for humans and animals would be available nearby if needed; livestock was not expected to be heavily affected because the evacuation was of short duration; structural bracing would be paid for by the AEC and would not be mandatory but was strongly advised; and packing materials would be provided, but it would primarily be up to the homeowners to safeguard their household possessions. Plastered walls and ceilings could suffer damage, and the AEC would fix or pay for any damages. Structural changes made since the original H&N surveys would be accounted for and new surveys made so that buildings could be correctly braced.

Several questions were surprising. One concerned the ability of telephones and televisions in the area around the site to pick up AEC radio transmissions. A REECO engineer at the meeting explained that the problem was more likely related to the televisions rather than the AEC's equipment. The REECO engineer was at a loss to explain the telephone interference, referring the frustrated resident to the phone company. The unnamed resident replied that the phone company was of no help, and that the reception of AEC radio traffic was especially annoying during expensive long-distance telephone conversations.

Another question, involving ground motion, prompted a response from Roland Beers, whose firm had consulted for the AEC for years and was widely recognized for its experience in ground motion prediction and analysis. Noting a large map of the area, he estimated the shock effects in terms of units of gravity (Gs), and the relationship between shock forces equivalent to fractional amounts of gravity and damage. The area within the 1.6-mile radius was expected to experience forces equivalent to an additional 1 G, if not slightly more. At 4.5 miles, the shock was expected to be 0.1 G, and the shock would likely not produce any damage. Beers was then asked to "describe in words people would understand about how much the ground would shake." Beers responded that "everyone within this radius of four and one half miles will get a tingling in the toes. It won't hurt you. It may be fun." For those closer to the test, within 1.6 miles, they "would get a jolt which would be comparable to jumping off a curbstone, for example. You could, of course, jump off a curbstone and turn your ankle so that it would hurt, but that is about the extent of it. If you landed squarely on your feet, the force of gravity would not hurt you, and if you translate this feeling on or into what your house might do, perhaps you would have an understanding of how we feel about the predictions."

Vermillion also fielded a question regarding future activities at the Dribble site. He noted that two "much considerably smaller" tests were scheduled for the program, and that it was not certain they would be fired at the salt dome; if it were to happen, it would be much later, and again, they would be far smaller than Salmon. Once the question and answer session ended, those attending were broken down into their groups and invited to look over the H&N bracing plans for their structures.[19]

A plethora of scientific recording instruments was scheduled for emplacement during the Salmon test. Four deep instrumented holes surrounding Site 1A contained some seventy-one instruments belonging to Sandia Corporation designed to record subsurface and surface motion. Vertical accelerometers emplaced at 1,000 and 1,900 feet in seven different holes were the responsibility of the Stanford Research Institute. LRL, the stewards of the Salmon device, would also be monitoring crystal pressure gauges emplaced within the salt to measure the stresses on the salt from the blast. The United States Coast and Geodetic Survey was responsible for several seismic stations. Linear seismograph arrays stretched east and south from the shot point, consisting of six recorders at distances ranging between ¾ and 4 miles. Other stations in the area were located at the Baxterville oilfield some five miles to the southwest, the Pontiac Eastern Refinery three miles north of Purvis, and one each at Purvis, Wiggins, Ellisville, Beaumont Prentiss, and Tylertown. Another station was located at Bogalusa, Louisiana. Several other stations were operated by the USCGS about seventy-five miles from the

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[19] *Transcript of Dribble Public Safety Meeting, 7:30 PM, August 6, 1964, Baxterville School, Baxterville Mississippi,* NTA accession no. NV0017777.

shot point, and one of their research ships operated a submarine seismograph off the coast of the Yucatan Peninsula to record the Salmon shot.

The USGS operated three seismic stations at a range of seventy-five miles from the SGZ. DARPA operated five seismic stations that would actively monitor the Salmon test, and included Vernal, Utah, Fort Sill, Oklahoma, McMinnville, Tennessee, Baker, Oregon, and Payson, Arizona. Geotech Corporation, acting under the supervision of AFTAC, operated some forty seismic stations located more than 1,200 miles from the Dribble site. Although seismological development was the primary goal of Salmon, other nonseismological programs would be conducted with Salmon, including detection of any visual and photographic effects of the shot, electromagnetic research, piezoelectric and solid state changes in rock strata, and seismic noise research.[20]

In addition to these programs, many others were interested in monitoring Salmon. Seismographic stations from around the world anxiously awaited the shot, including several within the Soviet Union. Newspapers openly reported the proposed shot date and time, as well as the device yield, depth of emplacement, and precise geographical location. In a surprising break from typical atomic testing secrecy, Salmon was a public spectacle – at least as public as an underground test could be.

Seismic departments at colleges and universities around the globe looked forward to the test. Instead of waiting for unpredictable earthquakes, an expected seismic source of a known magnitude would allow further calibration and synchronization between stations. One of these independent stations was located some 100 miles from Dribble at Spring Hill College in Mobile, Alabama. The small Jesuit college had benefited from the order's attention to seismology after the 1906 San Francisco earthquake as a service to

[20] U. S. Atomic Energy Commission, *Project Dribble*, 12-13, NTA accession no. NV0003295.

humanity; it also benefited from the presence of its one-man seismology department and innovator, Father Louis Eisele. Eisele's contributions to the field included the development of an electronically-coupled seismograph that recorded on paper and an ink that would not clog the recording pen due to fungal growth. This replaced the standard method of using mechanical seismographs that recorded on photographic paper. In 1962, Spring Hill College joined the World Wide Network of Standard Seismic Systems (WWNSSS), adding six more machines for Eisele to care for; they were of the older photographic type that Eisele had replaced with his development in 1952 of paper and ink machines. Eisele was the first to report to the world the tremendous magnitude 8.6 earthquake in Prince William Sound in Alaska on March 27, 1964; the event was so strong it nearly broke his recording equipment. As a technologically advanced seismic station, the data recorded at Spring Hill College would be particularly valuable – especially as the Louann Salt that spawned the Tatum Dome extended deep beneath the college.[21]

During August, invitations went out to local officials and media personnel to witness the Salmon shot. A press brief from the AEC to news reporters and editors cautioned: "news media representatives should be aware that they probably will not see any effects of the detonation at shot time. It is probable that there will be noticeable ground motion at the observer area which is located about three and one-half miles from

[21] Spring Hill College (Mobile, AL), "*News Release*," Obituary notice for Fr. Louis Eisele, SJ, died Oct. 3, 1988, Spring Hill College Archives, Faculty folder – Eisele, Fr. S.J.; *Times-Picayune* (New Orleans, LA), Oct. 31, 1976; Everett Larguier, S.J., ed., *Seismology at Spring Hill College* (Mobile, AL: Spring Hill College Press, 1990), 4-7. All in Spring Hill College Archives.

the explosion point." The brief also mentioned the evacuation and compensation of local residents and the structural bracing and damage compensation plans.[22]

Hattiesburg mayor Claude F. Pittman and city engineer Pat Patterson received identical letters from Jim Reeves:

> As you know, the Advanced Research Projects Agency of the Department of Defense and the United States Atomic Energy Commission are scheduled to detonate a nuclear device deep underground at the Commission's Project Dribble site near Hattiesburg on Tuesday, September 22. We would like to take this opportunity to invite you to participate in Project Dribble as an official observer.
>
> We would like you to be aware, however, that we do not anticipate any visual effects to result from the detonation. It is also possible that there will be delays on an hour-to-hour or day-to-day basis due to unfavorable weather conditions, technical considerations, or for other reasons. We will inform you in advance of any delay in the schedule if time permits, though this may not be possible in the case of last minute changes.
>
> A Vela Uniform Program-Project Dribble briefing has been scheduled for official observers and news media representatives on Monday, September 21, beginning at 7:30 p.m. ...At that time representatives of the Department of Defense, the Atomic Energy Commission, the Lawrence Radiation Laboratory, and associated agencies will discuss various aspects of Project Dribble and its relationship to the Vela Uniform Program.
>
> Transportation from Hattiesburg to the Project Dribble site on September 22 will be by chartered bus.…The time of departure will be announced at the Monday briefing. Operational considerations do not permit the use of private vehicles.
>
> We hope that your schedule will permit you to participate in Project Dribble, and we would appreciate hearing from you by September 4 if you plan to attend, or if you will not be able to attend….[23]

Senator Stennis received his personal invitation from AEC Chairman Glenn Seaborg on August 28:

[22] Press briefing statement, Aug. 7, 1964, Subseries: Tatum Salt Dome T-8 1963-67, Stennis Collection, MSUCPRC.

[23] James E. Reeves to Claude F. Pittman and C. B. Patterson, Aug. 12, 1964, folder 9, box 133: Commissioner C.B. Patterson: Atomic Energy Commission – Project Dribble (1963-1964). M208 MCAUSM.

> As you have been informed by advance copies of the press releases, the SALMON event of Project DRIBBLE has been scheduled for September 22, 1964. This experiment is a 5-KT nuclear detonation at a depth of 2700 feet in the Tatum Salt Dome near Hattiesburg, Mississippi.
>
> Since this event is an unclassified Department of Defense-Atomic Energy Commission seismic experiment, appropriate public information activities and announcements are planned before and after the detonation. News media representatives and local residents will be invited to observe the surface effects of the detonation from a designated observer area.
>
> Although venting of radioactive debris is not expected, safety considerations require precautions against this possibility. The wind must be steady and from a direction which would carry any radioactive release toward a closely prescribed, previously evacuated sector. A delay of several days is possible in obtaining the desired conditions for your optimum safety.
>
> I would like to invite you to observe this event on September 22 or as soon thereafter as weather conditions permit….[24]

As experts stated, there would be little to see because of the Salmon test. Persons looking for the effects of the detonation might see a toppled chimney or two. Looking elsewhere, as Winfred Montcreif did, one would see the effects all around the region. A photographer for the *Hattiesburg American*, Montcreif compiled a collection of photographs of the events. Now housed at the Mississippi Department of Archives and History in Jackson, the photos offer a window into the events at the site and around the area. In one photograph, Martha Saul, four years old at the time, peeks around a heavy timber bracing the chimney on her house. Additional lumber propped up the timber, and was firmly anchored in place. Heavy wire further secured the bracing to the chimney and the house. In other photographs, Martha appears beside her mother, who is carrying her younger brother. The sturdiness of the bracing work added by H&N contrasts with the

[24] Glenn Seaborg to Stennis, Aug. 28, 1964, Subseries: Tatum Salt Dome T-8 1963-67, Stennis Collection, MSUCPRC.

braces on the boy's legs – he may have suffered from polio or another disease. The family looks otherwise robust and well-kept.[25]

Though no record is immediately available, some time in early or middle September, a convoy from LRL made its way down the narrow roads to the test site. Within the convoy was a truck carrying the Salmon device. It parked at the assembly area and technicians inspected the device after its transit from the stockpile to its ultimate destination.[26] Diagnostic equipment was attached to test whether the sensitive components in the device were functional, and the nuclear components were further checked. Salmon was a complex machine; despite Jim Reeves's feelings about extra time equaling extra safety, it also meant extra money. Salmon was to be emplaced at the bottom of a 2,700-foot-deep shaft that would then be back-filled with pea gravel and concrete – if it failed to function when the firing switch was triggered, it would be practically irretrievable, and would then represent a significant waste of material and money. Once Salmon was thoroughly examined, it was attached to the lifting equipment and lowered to the bottom of Station 1A.

Salmon's pedigree is still top-secret. It was not a weapon – although at one time it may well have been. It was an oversized seismic charge, much the same as bundles of dynamite were used as seismic charges before newer high explosives became common. At the heart of the Salmon device was a core of radioactive material, either plutonium or highly enriched uranium. There was no assembly line for nuclear test devices, only

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[25] Winfred Montcreif Photograph Collection, PI/94.0005.0195, PI/94.0005.0199, PI/94.0005.0200, Mississippi Department of Archives and History, Jackson, Mississippi (hereafter cited as MDAH).

[26] This most likely occurred on September 11 or 12, although no specific information on the transportation is available at present. A 1966 report on Salmon notes that device emplacement began on September 13. See U. S. Atomic Energy Commission. *Project Manager's Report, Project Dribble (Salmon Event)* (Las Vegas: Nevada Operations Office, July 1966), 33, NTA accession no. NV0004351.

weapons were produced in quantities. In April 1960, the AEC realized that the testing moratorium would not become permanent, and that it was important to have devices on hand to resume testing immediately upon its cessation. This led to an examination of America's nuclear stockpile for older weapons that could be converted to test devices. Two fit the requirements: the Mark VI and Mark VII fission weapons. The Mark VI was thirty-nine inches in diameter and operationally yielded 30-60kt. It remained in the United States stockpile from 1951 until it was phased out in 1962.

The Mark VII was twenty-seven inches in diameter, and was America's first truly multipurpose warhead. It could be configured in several ways by varying the high explosive detonators and nuclear cores. The interchangeability of different critical components gave it a wide range of yields, from 1 to 70kt. Although it remained in the stockpile from 1952 until 1967 and was still an active weapon in the inventory, older models of the Mk VII had been withdrawn from active service before 1964. The 17 ½-inch diameter of the Station 1A hole seems problematic when compared to the 27-inch diameter of the Mk VII; although this is speculation, it is probable that much of this 10-inch difference would be accommodated by the size of the smaller of the interchangeable pits and explosive assemblies, and the ballistic casing, fins, and other components necessary in weapons system would be unnecessary in a seismic test device. Therefore the Salmon device was most likely an older Mk VII tactical nuclear bomb, stripped of its weapons components and recycled into an atomic seismic charge.[27]

Whereas a bomb relies on internal barometric switches, radar altimeter triggers, or impact switches to detonate the high explosive lenses that initiate the compression and

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[27] Ogle, *Return to Testing*, 173; Chuck Hansen, *U. S. Nuclear Weapons: The Secret History* (Arlington: Aerofax, 1988), 131-38.

fission processes, the Salmon device would be dependent on a system designed by EG&G to fire the bomb accurately. The detonation signal would be sent via cables from the surface, and the firing station itself would be triggered by radio, allowing the firing party to be a safe distance from SGZ. The device required a strong shell, as it would be topped with tons of gravel and concrete; it was encased in a 2.32 meter (7.6 feet) long, 40 centimeter (15.75 inch) diameter cylinder.[28]

On September 13, 1964, Salmon was hoisted from its truck and lowered into the Station 1A hole. Slowly dropped down the shaft, the device was constantly subjected to diagnostic tests via its attached cables when, at a depth of 1,200 feet, the device registered an undisclosed malfunction. It was retrieved to the surface for analysis. The shot date, September 22, was scrapped, and a new shot date was set for September 28. The Salmon device was fully lowered to the bottom of the shaft on September 21, and was finally emplaced and the shaft stemmed with 600 feet of concrete poured on top of the device, and the rest of the hole filled with pea gravel. Despite the apparent safety of the stemming procedures, the *Hattiesburg American* questioned whether the Dribble site might become an enormous shotgun if the force of the blast could not be contained.[29]

Salmon was the first atomic test to be conducted east of the Mississippi River. This was not its only distinction: Salmon became the most postponed nuclear shot in the history of American nuclear testing. The delay caused by the diagnostic readings during the canister's descent to the bottom of the emplacement hole merely added a few days to

[28] U. S. Atomic Energy Commission, *NVO 24 Project Manager's Report, Project Dribble (Salmon Event.)* (Las Vegas, Nevada Operations Office, 1966), 31, NTA accession number NV0018934.

[29] U. S. Atomic Energy Commission, *Salmon Event – Project Dribble AEC 1029/30* (July 17, 1964), 2, NTA accession no. NV0075308; *Hattiesburg American*, Sept.11, 1964, from subject file Tatum Salt Dome, McCain Archives, University of Southern Mississippi (hereafter referred to as TSD-MCAUSM).

the schedule. It was late summer in Mississippi, and the predictable wind patterns failed to materialize. Time after time, Salmon was postponed because of unfavorable winds. One of the main problems lay in the method used to predict the winds – the forecasts originated almost a full twenty-four hours before the conditions were expected. The AEC still clung to September 28 as the date for Salmon. But September 28 came and went, as did the next attempt, September 30. The winds refused to cooperate.

Far from the Dribble site, well into the Gulf of Mexico, towering cumulonimbus clouds formed and sustained themselves on a diet of warm water and high pressure aloft. Growing in strength, they reached hurricane force by September 30; its given name was Hilda. She intensified rapidly, almost doubling her wind speed over twenty-four hours from 80 miles per hour to 150 miles per hour on October 1, 1964. Sparking an evacuation of more than 50,000 people along the Gulf coast, Hilda eschewed the Texas coast in favor of central Louisiana, making landfall near Morgan City. Within a week, Hilda claimed at least thirty-eight lives, twenty-one resulting from a single tornado that hit La Rose, Louisiana. As she died out, Hilda hugged the Georgia-Florida border, flooding the region. But in her wake, disturbed winds continued to plague Salmon.[30]

Hilda was a catastrophe for the residents of the central Gulf Coast and the planners of the Salmon test – and just as soon as Hilda exited the scene, there was another tropical storm to contend with. On October 13, Tropical Storm Isbell was reported to be threatening Cuba; ironically American hurricane tracking aircraft were prohibited from close monitoring of the storm because of the deterioration of American/Cuban relations. Despite Isbell's distance from Mississippi, she stirred the atmosphere over the southeast. Furthermore, the unpredictable nature of tropical weather meant that it was possible that

[30] *Laurel* (Mississippi) *Leader-Call*, Sept. 30-Oct. 5, 1964.

Isbell could suddenly make a beeline for the test site. As far as the seismic teams were concerned, Hilda and Isbell were noisemakers. The large waves generated by the storms pounding on the beach created a seismic cacophony that prevented a clear reading of the signals generated by the test. Disturbed winds and high waves meant that the test would have to be delayed.[31]

Salmon's firing date was delayed six days because of the technical problems with the device. Then it was a wind delay. On September 30, another wind delay. Then October 2 – a wind delay. Then the fifth, the sixth and eighth - postponements followed frustrating postponements. Salmon passed the previous record for test delays – twenty-nine days – on October 19. Twelve shot days had come and gone by Monday, October 19. Eleven times, the Weather Bureau forecast that the winds would cooperate and blow south to north at around five miles per hour. Twice, the Mississippi Highway Patrol set up their barricades, and the residents of the area were prompted to leave their homes. Twice they were given reimbursement chits, and twice they were paid. A one-shot, one-evacuation test program was promising to become a healthy windfall for some larger families. Meanwhile, men in hardhats and khakis lounged in the sun around the observation points, eating Eskimo pies, sandwiches, and Honey Buns, and consuming coffee and cold drinks. On October 8 and 11, the observation areas were populated, and people left muttering. News reporters with television cameras waited, and nothing newsworthy happened.[32]

Tuesday, October 20, was again unsuitable for the shot – the wind was coming from the wrong direction. It was still refusing to come out of the south around the big

[31] Ibid., Oct. 13-14, 1964; *Hattiesburg American*, Sept. 30, 1964, TSD-MCAUSM.
[32] *Hattiesburg American*, Oct. 9, 1964, TSD-MCAUSM.

Bermuda High, instead consistently blowing in the opposite direction: north to south. In a decision reminiscent of Teller's and Starbird's decision to save money at NTS by carrying out shallower tests in order to spare the atomic testing budget, the meteorologists quickly put together a plan that would assume a north wind. Instead of the residents in the northern sector of the B zone being evacuated, it would be the corresponding southern sector. There was a problem though: to the south of Dribble lay Biloxi and Gulfport. Should the worst happen at Dribble, those populated areas could be irradiated. If a contaminated plume rose high enough and did a quick turn to the south-southwest, Slidell and New Orleans could be affected. On the other hand, the device would not remain viable forever. The AEC and LRL did not want to leave an expensive 5kt device at the bottom of a hole, but the testing budget only allowed for certain expenditures for personnel, materiel, and compensation for local residents. Developing a new set of protocols for the experiment was the expedient solution, and it worked.[33] The rest of the week looked increasingly favorable. The new Zone C was designated on Wednesday, and was prepared for evacuation the following morning. At 7:30 AM on the morning of Thursday, October 22, for the third time the evacuation of Zones A and C began. Aerial patrols took off to secure the region, and were joined by sampling and observation aircraft. Rad safety personnel took up their stations, ready to sound the alarm if necessary. Around the world, seismographs awaited the first motion of Mississippi's premiere atomic blast.

SGZ was deserted, of course, although the signs of human presence were everywhere. The ground was crossed in several directions by cables connecting buried

[33] Public information statement, Project Dribble Joint Office of Information, Oct. 20, 1964, NTA accession no. NV0326663.

and surface instruments to recording trailers and telemetry equipment. Temporary plank walkways spared shoes and socks from summer mud, and a sign warned of an explosive hazard 2,700 feet below. A large Confederate flag flew overhead, beneath which an unknown airman had reenlisted several days before. The flag was not raised by locals, but by the imported Dribble personnel, in part as a good-natured joke, and as a salute to the local people, upon whose hospitality they had come to depend. Other souvenirs marked Site 1A, including a sign bearing a defiant Southern slogan left "by an AEC wag." Just before 10:00 AM, the countdown began, and for the first time, did not stop. At 10:00 AM on October 22, 1964, keeping in spirit with the flag and the sign, at the Dribble test site near Purvis, Mississippi, the South did rise again, by approximately four inches.[34]

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[34] *Hattiesburg American*, Oct. 9, 1964, TSD-MCAUSM; *Mississippi Press-Register*, Oct. 23, 1964; Bates, Gaskell, Rice, *Geophysics in the Affairs of Man*, 203-204.

Chapter Seven

"Shoot That Damn Thing"

Claudette Ezell is laughing in the photographs, obviously enjoying the attention of the photographer and reporter. The October 1, 1964, story in the *Hattiesburg American* focused on the preparations for the Salmon test, already postponed three times. Mrs. Ezell recounted her concern for the safety of her plaster of Paris plaques – a hobby she began after undergoing cancer surgery. More than a thousand hand-painted plaster plaques, many with religious motifs, hung on the walls of her house, in her father's corn crib, and on the walls of the Gulf Café and Service Station in Baxterville, which she operated. Residing a little less than three miles from SGZ, she was determined to leave the area when shot day eventually came, despite there being no official need for her to evacuate. She simply figured that her business would be nonexistent that day. She showed the reporter the chemically-treated cloth patches that the AEC distributed to area residents; a heavy dose of radiation would turn them purple. As she explained, her laughter masked fear of the unknown results of the impending test. One mile closer to the test site, Martha Saul's mother waited for the activity at the site to conclude so that her husband would hook up her new electric clothes dryer. Her fragile possessions were packed in padded crates, and she accepted the frequent visits from monitoring personnel sampling water from her well: "we're used to being pestered."[1]

A resident of Lamar County invited to join the group of official observers located close to the test at the Saucier farm demurred, saying: "If it comes off as quietly as the

[1] *Hattiesburg American*, Oct. 1, 1964, TSD-MCAUSM.

AEC says it will, there won't be anything to see, and if it doesn't work that way I don't want to be around."[2]

Others eager to see what they could see were repeatedly disappointed. One mother was overheard saying "they're not going to shoot that damn thing," as she rounded up her brood and loaded them into her car. Her identity unknown, she was likely one of the many evacuees who left their homes early on shot day, and returned once the test was cancelled. Sunburns and large nests of fire ants were the immediate hazards at the observation area, where reporters and civil defense personnel mingled, families picnicked, and the AEC-run canteen experienced a curious lack of interest in their barbecue beef sandwiches. Before the wind protocol change was approved on October 20, it seemed that they would never "shoot that damn thing."[3]

Mrs. Clifford Jones wrote from Philadelphia, Pennsylvania, to Hattiesburg Mayor Paul Grady to inquire about the status of the tests, and expressing her outrage:

> I read in Closer Up – (a small periodical from Florida) that our U. S. Government had made an announcement of the decision to explode a nuclear bomb near Hattiesburg Miss on Sept. 22, 1964.
>
> Not one word of this have I read in any of our newspapers or the Wall St. Journal or N.Y. Tribune.
>
> I am curious to see if it was done. Do you mind answering and let me know?
>
> Never have I heard of such a thing and I am furious. What are we coming to on this earth?....
>
> Our actions now are worse than the Carpet Baggers times. That [?] Amendment is not part of the U. S. Constitution…
>
> I want to God to bless you [sic] all thru this trying experience which Washington has thrust on you….[4]

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[2] *Hattiesburg American*, Oct. 8, 1964, TSD-MCAUSM.

[3] *Hattiesburg American*, Oct. 13, 1964, TSD-MCAUSM.

[4] Mrs. Clifford B. Jones to Mayor Paul Grady, Sep. 23, 1964, folder 1, box 29: Mayor Paul Grady. This letter was damaged by a flood at the USM Archives, and though it was photocopied as quickly as possible, it had deteriorated to the point where it was barely legible in most areas, and completely illegible in others.: Atomic Energy Commission (1962-1972; undated), M208 MCAUSM.

Mrs. Jones's connection to Hattiesburg is unknown, although it reveals her lack of contact with the area, where newspaper stories kept close tabs on the development of the Salmon test. Despite the general illegibility of her letter due to the ravages of a flood in the archives where it was kept, she saw the federal government's presence at the Dribble site as an outside intrusion, and a crime against the people in the region. Her outrage is notable for the contrast with the sentiments of those living in the affected area near the test site.

The general consensus among locals concerning the Salmon test was the desire to get it over with. Despite the holiday mood at the observation stations, the fear of the unknown continued among those living around the test site. For many of them, their lives were on hold until the test took place. Metaphorically, it was like hearing the distant thunder of a slowly approaching violent storm, and anxiously waiting to see what debris needed to cleaned up afterwards – except that this particular storm had been thundering for a month, and the first raindrop had yet to fall. It was annoying.

Flooding, a hurricane, device problems, and uncooperative winds had stalled Salmon for thirty days from its planned shot date; given more time, the fire ants might have found their way onto this list. The AEC sought to control them with the same amount of success they had with conducting the test. There was nothing in the air that marked October 22 as "the day" – apart from favorable winds. Evacuees and the still curious assembled once again at the observation station that Thursday morning. Advised by loudspeaker that the countdown continued and that conditions remained favorable, news cameramen reexamined their equipment, official observers and evacuees left the precious shade of trees, and all focused their attention on the test site three and a half miles away. The countdown reached zero, and a cloud of dust rose into the air over the Dribble site.

The energy equivalent of 5,300 tons of TNT exploded at the bottom of Station 1A. The intense heat instantly converted a large mass of salt into ionized plasma, while a shock wave formed and propagated outward. The shock hammered the cement stemming plug, which held, causing a spherical cavity to form in less than a second. The ground bounded upward and then fell back, ending up roughly four inches above where it had been. More important, the shock wave shook the entire salt dome. As the blast forced the ground upward, it also pushed the enormous finger of salt downwards, and because it was not at the radial center of the dome, it caused the enormous saline protuberance to vibrate. Within a few seconds of detonation, the plasma cooled to form salt vapor. Fractured and molten material fell to the bottom of the chamber, forming a rubble pile of vaporized device components and molten salt.

All over and around the test site, seismographs recorded the motion and were promptly knocked over. Wooden housings for the sensitive USCGS recorders leaned forward precariously, threatening to dump thousands of dollars worth of machinery onto the ground. At least one was saved by its bulk, wedging it into place so that it stuck precariously out of its box. At the zero point, anything not staked into the ground was thrown up into the air - the vertical surface displacement was thirty centimeters, or 11.8 inches - falling to earth shortly afterward. The expected acceleration at SGZ was 10G, while later measurements recorded acceleration almost three times as strong: 28 G. Dust filled the air.[5]

The dust was the only thing to see, until the ground shock reached the manned positions and the observation area. Several noticeable ground waves propagated outward, lasting for nearly three minutes. Cars rocked on their springs and equipment trailers shook. The vibrations raced out in all directions: "three good tremors" rocked Purvis; the *Hattiesburg American* building swayed; numerous other locations also reported the ground motion. Clearly the "tingle in the toes" that was expected several miles away from the blast was far more perceptible than first thought.[6]

Twenty-five seconds after the blast, the shock wave reached Father Eisele's seismographs at Spring Hill College. Examining the data, Eisele said that Salmon "recorded comparably to a major earthquake." Seconds later, the shock wave reached the University of Michigan's experimental seismic stations: at the university's Botanical Gardens the blast registered a 6.0 on the Richter scale; at its Fulton county station in Ohio it registered as a 5.8. Salmon was far stronger than anyone had expected; its effects were unanticipated. Later radiochemical analysis of chamber debris verified that the device performed as specified with the expected yield, but shook the earth like a larger device. The reason this occurred was because of the unique geology that allowed the Tatum Dome to form. Recalling the process of diapirism, the hot, fluid salt forced its way towards the surface from several miles below. If one mentally removes the surrounding strata from above the Louann salt bed and around the dome, one is left with a long, inverted teardrop-shaped finger of salt, connected to the Louann bed. The top

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[5] U. S. Atomic Energy Commission. *NVO 24 Project Manager's Report, Project Dribble (Salmon Event.)* (Las Vegas, Nevada Operations Office, 1966), 28, NTA accession no. NV0018934.

[6] *Hattiesburg American*, Oct. 22, 1964, TSD-MCAUSM.

mushrooms out, though not dramatically. The sedimentary strata pierced by the salt diapir are not rigid like stone, but are more like pudding. If one sticks a finger in water, gelatin, or pudding, and wiggles it quickly, the wave effect will readily be seen. At the immediate area, a vertical bound and several rebounds were recorded. But the diapir also vibrated horizontally, causing a sympathetic "sloshing" of the surrounding ground that amplified the seismic effects.[7]

No underground radioactivity escaped from the Salmon explosion. The chamber created by the blast contained all of the fission products deep underground. Still, safety protocols dictated that a full sampling sweep be conducted to make certain that an unknown fissure somewhere was not spewing radioactive gases into the atmosphere. Fifteen minutes after the shot, a helicopter transported personnel back to SGZ, to take readings from several devices emplaced there. At noon, USPHS personnel began escorting residents from the evacuated areas to their homes to check for damage.

Claudette Ezelle received good news: her treasured plaques survived. More than three miles from the shot, her home and business were subjected to a strong shock, but her plaques remained where she had left them. On the other extreme, two miles from Station 1A, Horace Burge returned to a mess. Burge, a fifty-one-year-old tung tree farmer, his severely asthmatic wife, and four children lived in a three-room frame house. For all intents and purposes, it was uninhabitable – the fireplace and chimney were destroyed, his refrigerator jolted open, dumping food from the shelves, and bricks and debris littered the floors. In addition, his pipes burst, spewing water all over the kitchen

[7] David E. Willis and Phillip L. Jackson, *Collection and Analysis of Seismic Wave Propagation Data: Final Report* (Ann Arbor: University of Michigan, 1966), 47; *Hattiesburg American*, Oct. 22, 1964, TSD-MCAUSM.

floor. Winfred Montcreif's photographs for the *Hattiesburg American* show a crew-cut Burge clad in shirt and striped overalls dejectedly surveying the damage in his home.[8]

Most of the damage around the site was slight, with cracked masonry and plaster most commonly reported. Damage complaints flooded into the AEC's Hattiesburg office; within three days, 205 had been lodged. By November 17, some 700 complaints were reported and 267 claims filed.[9] At the beginning of December, the AEC officially reported that the Hattiesburg office recorded 835 complaints, and 358 claims for damages were filed. Of these, 97 had already been settled. Because the process was slower than some would have liked, residents of the affected area, which spread well beyond the five-mile radius initially predicted, were rapidly growing impatient with the AEC. Along with their anxiety over being paid in a timely fashion, they were critical of the AEC's "clamming up." Before the Salmon test, news and announcements were issued almost constantly from the Hattiesburg Joint Information Office; after the test, information was simply not as forthcoming. Official announcements concerning damage complaints and claims were not forthcoming until December 1, almost six weeks after the test, and then a week later on December 8. The next AEC announcements related to the reentry operations at the site. By March 25, 1966, 1,189 claims were filed for damages from distances as far away from the site as twenty-five miles. These claims totaled $2,178,713.78. Of these claims, the majority, 1,018, were settled for a total amount of $547,498.03. Four claims, well in excess of the $5,000 limit, required approval by

[8] *Hattiesburg American*, Oct. 22, 23, TSD-MCAUSM.

[9] The difference between complaints and claims was that a complaint would typically be telephoned in for investigation as to whether the damage was pre-existing or had been caused by the test. A claim involved paperwork and was considered for reimbursement.

Congress for a total of $44,288.73.[10]

The disparity between the amounts claimed and settled was appreciable: roughly 25 percent. Despite the H&N's structural surveys and bracing, certain aspects of the area's structures could not be thoroughly inspected. Buildings that seemed solid could actually have been on the verge of collapse due to a number of factors, including termite or other insect damage, weak foundations, or poor construction, and regardless of the severity of the shock, the structure would suffer damage. In some cases, complaints and claims were filed for questionable reasons. Lavern P. Smith wrote a complaint to the AEC concerning a strange event:

> I think that you all want to know everything that happened during the explosion so just think you should know this. My wife and I were sitting in the car listening to the radio, and as soon as the blast was over & the car stopped shaking we shut the radio off and I stepped on the starter and all of the water in my battery just boiled all over the place and the battery was dead as it could be. Please don't think I want a battery because I don't as I already have one. I don't know what could of [sic] happened because it was an almost new battery. I just thought you would want to know.

Frank Ingram's reply from the Joint Office of Information was polite, but insisted that the battery trouble was a coincidence, and not directly linked to the Salmon test.[11]

The AEC and Roland Beers clearly erred in their predictions of ground motion caused by the test. The shock wave was stronger and propagated farther outward than anticipated. Following the test, some residents were optimistic that test damage could benefit them. The *Hattiesburg American* reported that a Baxterville woman said of her

[10] *Hattiesburg American*, Oct. 26, Nov. 17, Dec. 1, 1964, TSD-MCAUSM; U.S Atomic Energy Commission. *NVO 24 Project Manager's Report, Project Dribble (Salmon Event)*, 54, 128, NTA accession no. NV0018934.

[192] Lavern P. Smith to AEC, Oct. 22, 1962, NTA accession no. NV0016539; Frank L. Ingram to Lavern P. Smith, Oct. 28, 1964, NTA accession no. NV0016538.

house, "I was hoping the whole thing would fall down."[12] A $5,000 house could be an improvement over an older structure, especially in 1964 dollars. As 1965 began, the presence of an atomic test site in the Piney Woods became increasingly considered a nuisance. Patriotic or not, the residents of the area felt growing resentment towards government agencies that had the power to dislocate them at will, threaten their homes and lives, and delay payment on legitimate damages to private property. The initial excitement was wearing off, the metaphoric storm had passed, and the aftermath was frustrating and tedious.

While adjusters worked over the mass of claims following the Salmon test, personnel at the site began working towards reentering the shot cavity. With shots Sand and Tar on indefinite hold, efforts concentrated on the long and hazardous process of investigating the products of the 5.3kt blast. Initially the plan was to begin reentry a day or two after the shot. This was soon discarded, as there was no way to know the pressure of the gases in the chamber, although it was certain that they would still be extremely hot. Salt retains heat – a property that allowed the salt diapirs to form. By opening up the cavity, hot, pressurized radioactive gas could conceivably overwhelm the bleeddown facility and escape into the atmosphere. This would be an environmental disaster, requiring an emergency evacuation of people living around the dome. All of the radioactive materials created by the test were trapped deep within the dome, and they were not going anywhere. Rad safety monitoring continued all around the site, and by holding the known contaminated gasses and materials in the dome, radiation leak detection would be far more accurate. Chamber reentry would bring contaminated matter to the surface, potentially affecting readings.

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[12] *Hattiesburg American*, Oct. 22, 1964, TSD-MCAUSM.

A work order issued on January 3, 1965 named REECO and the Oklahoma firm Fenix and Scisson (F&S) to perform new tasks at Station 1A, with REECO assuming the duty of radiation monitoring. Almost a quarter million dollars in contracts was allocated for private firms, with $175,000 dollars available immediately and intended for the actual chamber reentry, rad safety, and "Contingency Engineering and Construction." Once again, Big Chief Incorporated, also from Oklahoma, drilled into the salt dome. Contracted before Salmon, the firm's workers began the task of drilling a hole called Postshot 1 parallel to and thirty feet distant from Station 1A. The work was slow, despite Big Chief's experience with the Tatum Dome, due to radiation safety concerns. Initiation of a second hole, Postshot 2, began in February about 105 feet away from Postshot 1, in order to allow a different method of material assessment. The second hole was planned to be sunk to 2,900 feet, where sample cores could then be retrieved. The hole would then be filled to the 2,200-foot level and an angled shaft dug from that depth at twenty-five degrees to enter the top of the chamber, allowing further sample collection from the area near the top of the void. Angled drilling, or "whipstocking," was a procedure perfected in the oilfields that allowed drilling rigs to explore promising pockets of oil and gas that were not accessible by drilling straight down.[13]

Postshot 1 drilling started, or was "spudded in," on January 2, 1965. Carefully checking for leaks in the new casing via television cameras lowered periodically into the hole, the Big Chief drilling team slowly closed the distance to their target. At 2,655 feet, drillers detected radioactivity, and at a foot deeper, high levels of gamma radiation

[13] U. S. Atomic Energy Commission, *NVO 24 Project Manager's Report, Project Dribble (Salmon Event.)* (Las Vegas, Nevada Operations Office, 1966), 55-56, NTA accession no. NV0018934; James E. Reeves, *Work Authorization Number 1 – Station 1A Re-entry, Project Dribble PPB:NLP-2062* (Jan. 3, 1966), NTA accession no. NV0096068.

showed that the cavity was close. Drilling at a speed of roughly a foot every half hour, they reached the Salmon chamber on March 4, at a depth of 2,660 feet. Remote probing showed that Salmon had created an alien world, resembling Venus more than Earth. Nearly four and a half months had passed since the blast, yet the chamber temperature was a nearly uniform 400 degrees Fahrenheit. Highly acidic fluid accumulated in the bottom of the shaft where it met the chamber; a boiling concoction of concentrated hydrochloric acid, brine, and ferric chloride. This delayed the chamber interior survey with a television camera until the fluid could be removed.

Despite the temperature, a partial vacuum existed in the chamber; the bleeddown plant kept the pressure at a steady level, 310 millibars, while the monitoring technicians performed a cavity gas sampling operation. Radiation levels averaged 100 milliroentgens per hour, with higher levels encountered at the bottom of the chamber and in a layer some three feet into the salt. Put into perspective, this meant that every hour, an exposed human would receive a little less than one third of the annual exposure average of 360 milliroentgens. The corrosive atmosphere in the chamber required that air be introduced to dilute the mixture and flush it from the cavity. During this process, calculations of the volume of the chamber showed it to be in the vicinity of 380,000 cubic feet. On March 7-8, a television camera was lowered into the chamber. The cavity created by Salmon measured about 120 feet in diameter, was spherical, and had a flat floor. The video from the camera was telling: still hot as an oven inside the chamber, wisps of smoke appeared on the television monitors as paint burned off the camera casing. Following the television survey, the platform crew installed a device called a “bridge plug” in the Postshot 1 hole at the chamber intersection to guide the drilling tools that would reach down into the layer of slag and debris at the bottom of the cavity and penetrate deeper to sample the salt below the chamber.[14]

The sampling operations were extremely complicated, relying on technology and equipment developed in the oilfields. Onsite innovation, a hallmark of the petroleum industry, also became a hallmark of the operations at the Dribble site. The actual work done in the cavity was performed by roughnecks and engineers a half mile away from the action, connected only by a thin metal pipe. Any mistake required a tedious removal of tools through the drill casing, slightly less than nine inches in diameter. The drilling pipe, or "thread," accessed the bottom of the cavity by a bridge casing connected to the bridge plug. The bridge casing was crucial to add rigidity to the drilling thread as it crossed the chamber from top to bottom. Without it, the drilling thread with its attached coring tool would flex and whip around as it was sunk into the material at the bottom of the chamber. A simple analogy would be to feed a plumber's snake into a drain from several feet above it, except that with the snake, the shaft lashes back and forth and will not break; in the case of drilling thread, the heavy steel tubing would flex beyond its maximum stress point and snap off, losing the tool and the important samples located therein. One sample core hole through the bottom of the chamber reached a depth of 2,908 feet, more than 200 feet beneath the zero point of the Salmon test. In order to obtain further seismic readings below the chamber, technicians added, or "spotted," brine in the hole to allow seismic

[14] U. S. Atomic Energy Commission, *NVO 24 Project Manager's Report, Project Dribble (Salmon Event.)*, 35. NTA accession no. NV0018934; Donald H. Kupfer, ed. *Geology and Technology of Gulf Coast Salt*, 104; http://www.epa.gov/rpdweb00/understand/calculate.html (accessed Sep. 15, 2009); handwritten memo: *Drillback to the Salmon Cavity, Project Dribble* (undated), 45-47, NTA accession no. NV0105416.

energy to be transmitted through the material below the cavity when an explosive charge was detonated.[15]

Two documentary sources report an incident that followed this sampling and spotting operation. One is a project manager's report published almost two years after the Salmon test; the other is an undated, handwritten draft report that has been partially "sanitized." The two suggest that an accident occurred at the site on March 22 during a coring operation – in fact, it may have been the deep penetration below the cavity floor. On that date, at 4:15 A.M., the crew retrieved a core sample from the dome. Once the sample cleared the hole, Postshot 1 became a man-made geyser of water and steam. For seven minutes, the geyser reached an estimated forty feet into the air before the blooie line could be attached; for five hours the efflux diverted into the bleeddown plant. Fourteen men were near the hole when it blew, and two of them were drenched by the water from the chamber. All affected personnel proceeded with decontamination at the onsite facilities; clothing was handled by a specialized laundry at the Dribble site that functioned as part of the decontamination facility. The director's report mentions nothing of this event – but it does note that the bridge casing broke away from the bridge plug at some date, requiring twenty-two days to retrieve.

The incident occurred as a result of a steam event in the chamber – the pressure in the chamber as the core sample was taken indicated approximately 1 pound per square inch (psi) above atmospheric pressure (approximately 15psi); this was estimated to have risen to 12-13psi above atmospheric pressure when the water flashed over to steam. The water could only have come from one of two places: either from the brine injected into

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[15] U. S. Atomic Energy Commission, *NVO 24 Project Manager's Report, Project Dribble (Salmon Event)*, 35, NTA accession no. NV0018934.

the hole bored beneath the chamber floor; or an aquifer somehow leaked through a section of damaged well casing and poured into the salt dome, flashing into steam as it encountered the hot salt. This second possibility seems unlikely because there are no reports of this problem being repeated, as it would have been with a leaking casing. Either way, Postshot 1 was rendered unusable for some time as the workmen plugged the hole with cement for later redrilling, while additional casing was inserted down the hole to replace the damaged casing that required drilling out and removal.[16]

This event is made significant by its omission from the manager's report. It was an uncontrolled release of radioactive material at the site. Although several people were exposed and mildly contaminated, what was reported appeared to be a routine radiation release. The report notes that there was no radioactivity evident 1,000 feet from Postshot 1, but until the crew diverted the efflux through the well head to the blooie line and tank, the water and steam blew into the atmosphere and collected on the ground. Fortunately for those in the vicinity of the well, previous ventilation with compressed air allowed the processing of the corrosive vapors through the bleeddown plant. Samples of water from the blooie tank showed minimal radiation. Two important radiological readings emerged from the contaminated water around Postshot 1 and from the blooie system, showing a mystery isotope whose identity has been erased from the handwritten memo. The concentration of this isotope, 65.6 microcuries per milliliter of water, existed in the ground sample, and 3.85 microcuries per milliliter was present in the blooie tank. Once

[16] Handwritten memo: *Drillback to the Salmon Cavity, Project Dribble* (undated), 47-48, NTA accession no. NV0105416; U. S. Atomic Energy Commission, *NVO 24 Project Manager's Report, Project Dribble (Salmon Event.),* 35, 75-76, NTA accession no. NV0018934.

the ground water sampling was complete, it was washed into a collection pond and later collected and disposed of as radioactive waste.[17]

What was the mystery substance? Although its identity does not appear in the handwritten report, several clues point the way to a logical conclusion. The fission device that created the cavity was efficient – that is to say that the fissile material reacted in such a manner that it was consumed in the reaction with little residue remaining from the detonation. Forcibly injected into the salt by the blast, the metallic bomb residue and fission products existed as a rind around the cavity embedded a few feet deep into the salt. Although such material could exit the chamber in a steam plume, widespread dispersal was not felt to be a threat. Also, fissile materials are severe inhalation hazards, and were recognized as such even in 1964. There was a localized evacuation of the drilling rig at Postshot 1, but there was no site-wide evacuation, so it may be concluded that the material was considered to be of a lesser hazard. Therefore, plutonium or uranium, their heavier "daughter" elements, and device casing debris were not likely to have been the materials deleted from the report.

The Salmon test did produce a radioactive and water soluble substance in quantity that did pose a health risk, an isotope of hydrogen called tritium. Possessing a half life[18] of a little more than eleven years, it emits beta radiation, which can penetrate skin and cause burns. It has several industrial applications, and is widely used in rifle scopes as the illuminated pipper and reticle. The steam eruption would have brought substantial quantities of tritium to the surface in the hot water and steam. Despite tritium's radioactivity, it could be easily washed from clothing and skin as the report noted before

[17] Handwritten memo, *Drillback to the Salmon Cavity, Project Dribble* (undated), 47-53, NTA accession no. NV0105416.

[18] "Half life" refers to the amount of time for an isotope to lose half its radioactivity.

the contaminated water was directed into disposal pits. With all the creeks and aquifers in the region, the water solubility of tritium posed the greatest contamination hazard. If any material could migrate offsite, tritium was the most likely culprit. The Salmon test caused no detectable contamination to the environment beyond the perimeter fence, but the drillback operations produced a sizeable quantity of contaminated drilling fluids, "chips" or solid debris, and released additional tritium onto the site.

Upon resolution of the steam incident, further investigation of the chamber continued. The Salmon device had excavated a chamber slightly larger than the one CPH contracted to excavate. It did not need ninety-inch shafts for access and excavation. Additionally it required no additional site negotiations, nor would it require relocating personnel to Texas. The Salmon chamber looked to be a promising site for the decoupling test. Sand and Tar were indefinitely suspended, although the AEC and DARPA still wanted them conducted. The primary problem facing their execution at the Dribble site was size: the Salmon cavity was some 30 feet greater in diameter than the chamber planned for the 100-ton Sand test. Tar could be conducted as easily as Salmon had, because it was slated to be a tamped test. Further analysis showed that device sizes were inappropriate to study the magnitude of the decoupling effect because of the chamber volume. Sand and Tar remained in limbo, but plans for reutilizing the cavity continued to develop.

With the successful test of the Salmon device, Mississippi still hoped to become a center for nuclear research. The seismic detection program was important, but it also achieved one of the goals of Plowshare – a potentially useful salt cavity had been excavated in less than a second through the use of an atomic explosive. But it was not the only nuclear research program that interested the state in 1965. Upon his inauguration, President Lyndon Johnson had issued a "Policy for National Action in the Field of High Energy Physics," authorizing construction of a 200-billion-electron-volt (Bev) proton accelerator facility. Having a nuclear test site in the state and enjoying a short-term financial boost was one thing, but gaining an advanced scientific facility located in the Piney Woods, possibly close to Hattiesburg, was quite another. It would result in a long-term financial benefit to the region and be the ultimate reward for MITRC's efforts to champion Mississippi's technical and scientific potential. Dr. Andrew Suttle was no longer the director of MITRC. In 1962, he joined Texas A&M University as vice president for research before leaving to work with Dr. Harold Brown in Washington. Dr. Robert F. Dye assumed MITRC directorship, having been with the organization since its formation. Winning such an accelerator facility would vindicate Suttle and Dye's work to bring high technology to the region. Suttle's close ties to the AEC and its chairman Glenn Seaborg, developed during his work in Washington, D.C. between 1962 and 1964, and appeared to be a further advantage. By mid-1965, forty-five of the forty-eight contiguous states vied for the contract; near the end of the year, the list had shrunk to forty-three states, with Mississippi suggesting locations near Jackson, Scott County, and Perry/Forest County. The latter location was close to Hattiesburg.[19]

The requirements listed by the AEC and the National Academy of Sciences (NAS) were broad in nature. At least 3,000 acres were necessary, and preferably already

[19] Undated lists, "State-by-State Applicants for AEC's Accelerator Laboratory," and "United States Atomic Energy Commission Proposals Identified by AEC for Further Consideration by NAS Committee." Also, "Enclosure I," document unknown, April 24, 1965. folder 1, box 29: Mayor Paul Grady: Atomic Energy Commission (1962-1972; Undated) M208 MCAUSM; *Texas A&M University News, VI 6-4919*, undated, Cushing Memorial Library and Archives, Texas A&M University; Jon Sven Knudson, "Beam On: The Development of the Texas A&M Cyclotron Institute" (master's thesis, College Station: Texas A&M University Press, 1982), 27-33.

owned by the federal government, or easily procured. The soil had to be firm enough to provide a solid foundation for the one-mile-diameter apparatus, and preferably would be fairly level to avoid serious earth moving operations.[20] Furthermore, the suitable location needed to be free of faults and seismic activity. Several hundred megawatts of electricity needed to be available, and though not a deal-breaker, a ready supply of fresh water for the facility was preferred. The site needed to be near a major airport, as well as having access to highways and railroads for material and personnel transportation. In addition, the AEC desired a commercial industrial center to be located nearby for easier access to specialized technical personnel, including research facilities that would allow for "opportunities for desirable interaction of scientific and engineering personnel," suitable housing for several thousand people who would form the permanent staff at the facility, and finally "proximity to a cultural center that includes a large university will provide intellectual and cultural opportunities attractive for staff and families." Always desiring to save money, the AEC was conscious of "regional wage and cost variations as well as labor surplus areas" in its decision-making process. This might insinuate that the South, with its traditionally anti-union sentiment and large number of under-employed skilled laborers, appealed to the selection committee.[21]

By these specifications, the Hattiesburg area contended strongly, and the city fathers knew it. Though small, the University of Southern Mississippi was in Hattiesburg, Camp Shelby just to the southeast, fresh water abounded, and thanks to the Salmon test, the entire area was more seismologically and geologically surveyed than

[20] Opelika, Alabama was on the list of prospective locations, as was New Orleans, despite its swampy nature.

[21] AEC bulletin H-94, *AEC-NAS Enter Agreement On Evaluating Sites for a Proposed New National Accelerator Laboratory* (Apr. 28, 1965), folder 1, box 29: Mayor Paul Grady: Atomic Energy Commission (1962-1972; Undated), M208 MCAUSM.

practically any other location on the planet. Although AFTAC had demurred on using Hattiesburg's airport, it received moderate commercial traffic, and if necessary could be enlarged to a more suitable size. Road and rail traffic, the reason for Hattiesburg's nickname "Hub City," were more than sufficient. Cultural activities, if unavailable in Hattiesburg, could be found in New Orleans, Mobile, or the state capital in Jackson, all within 120 miles. The Gulf Coast's beaches were a ready diversion located only an hour or so away. At the Tatum Dome, air compressors cooled the atmosphere in the Salmon chamber while in Hattiesburg and Jackson, excitement heated up.

Dreams of advanced research facilities and further activities at the Tatum Dome were dampened when the hurricane season presented the Gulf Coast with another deadly storm. From September 1, 1965, to its landfall on the night of September 9-10, Hurricane Betsy carved a path of destruction that confounded meteorologists because of its refusal to follow a consistent track. In the Atlantic, Betsy made two complete loops before hitting the tip of Florida and entering the Gulf. From there, it headed steadily toward Louisiana, striking the mouth of the Mississippi River and charging inland, passing to the southwest of New Orleans. In the worst hurricane to hit New Orleans up to that time, the waters of Lake Ponchartrain inundated neighborhoods throughout the city. Forty years later, the same neighborhoods were similarly drowned, though Betsy's death toll barely exceeded eighty persons.[22] The effects of the storm occasioned a sharp criticism from Edward Teller, who was addressing a meeting of the Louisiana-Arkansas Division of the Mid-Continent Oil Association. In words that would resound two generations later, he asked, "Why weren't the people of the inundated areas evacuated?….Your city had hours

[22] "New Orleans Hurricane History" accessed via http://web.mit.edu/12.000/www/m2010/teams/neworleans1/hurricane%20history.htm (accessed Feb. 14, 2010).

of warning. Why wasn't it anticipated that the levee of the Industrial Canal might break? In any storm the size of Betsy, tidal wave action can be anticipated." Understandably, New Orleans mayor Vic Schiro was less than cordial in receiving this criticism. Furthermore, the scope of the devastation eliminated the city from consideration for the particle accelerator.[23]

Still, Mississippi remained guardedly optimistic that it had a chance of landing the particle accelerator. Things proceeded well at the Dribble site, too. One of the problems that the testing program encountered was how to deal with the hundreds of thousands of gallons of liquid waste generated by the reentry program, and by the incident caused by the steam and water release. Considering collection and transportation of these wastes too expensive and hazardous, project management deemed an onsite disposal method necessary. An uncontrolled release of radioactive substances into the aquifers around the site raised serious concern at the Dribble site because the surrounding residents and their livestock depended on well water. But there were aquifers that locals did not use because they contained nothing but brine. Project engineers realized that the fifth aquifer layer below the surface, which lay at an average depth of 2,500 feet, was isolated between heavy clay layers and consisted of brine. Liquid injection from the drillback operations into the brine aquifer through the HT-2 well isolated the waste. Monitoring stations ensured that the waste remained where it belonged until its radioactivity decayed.[24]

In the meantime, an extensive program of water, air, and milk sampling took place to track any entry of radioactive materials into the environment. The USPHS office in Montgomery, Alabama, constantly monitored calcium (Ca), potassium (K), strontium

[23] *Hattiesburg American*, Sept. 15, 1965.
[24] W. W. Allaire to AEC NVOO, March 11, 1965, NTA accession no. NV0096077.

(Sr) isotopes Sr-89 and Sr-90, an isotope of iodine (I-131), an isotope of cesium (Cs-137), and an isotope of barium (Ba-140) in milk samples from 1963 onward. These isotopes presented special health hazards, and because they were direct fission products they would indicate a serious problem at the site linked directly to the Salmon explosion. The most serious threats, Strontium, cesium, and iodine-131 were the basis of the international demand to stop atmospheric testing. These substances were especially dangerous if consumed by children, as the body processed strontium like calcium, storing it in the bones where the radiation killed and weakened bone cells. In large enough doses it could cause tumors and cancer. Cesium concentrates in muscle tissue, and iodine-131 mimicked beneficial iodine and concentrated in the thyroid gland. Cesium and iodine are water-soluble; surface water and milk were constantly checked for the presence of these substances. From the beginning, all sites reported the presence of these materials in minute quantities, the legacy of nearly twenty years of atmospheric nuclear testing.[25]

The public safety program considered water well monitoring crucial. Utilizing purpose-drilled wells and private wells, monitoring personnel periodically took samples and transported them to Montgomery for testing. The water wells were a source of concern to local residents because along with the sporadic damage to their homes, the well water was a visible sign that something had happened at the salt dome. One hundred fourteen sites within thirty miles of the Dribble site reported water quality issues – in most cases the water had been agitated deep in the aquifer by the shock caused by the test and had picked up sediment. The shock also affected the filter screening of some pumps,

[25] Environmental Protection Agency, *Project Dribble Data*, April 21, 1971, NTA accession no. NV0037113. This file is a cumulative collection of air, water, and dairy sampling at the site; for further information on radionucleid health threats, see Allan M. Winkler, *Life Under a Cloud: American Anxiety About the Atom* (New York: Oxford University Press, 1993), and Richard L. Miller, *Under the Cloud: The Decades of Nuclear Testing* (New York: The Free Press, 1986).

leading to clogging with sediment or rust. None of these complaints were considered serious, except by those affected. Still, the water looked different, and the Hazleton Nuclear Science Corporation (HNSC) conducted constant monitoring to make certain that cavity materials had not contaminated the water supply, and to reassure local residents.[26]

On the anniversary of the Salmon test, the *Hattiesburg American* reported noticeable changes on and around the test site. Government vehicles were no longer omnipresent on the roads around the site, and human activity was minimal. Compressors continued to cycle air through the chamber, but from all indications, things were on hold. Unknown to the reporter, estimates were already submitted for the purpose of reopening the Station 1A hole, and putting the Dribble site back on a nuclear test footing. The chamber was too big for the paired Sand and Tar decoupling/baseline tests; instead a reverse extrapolation suggested an appropriately increased device yield for the cavity volume. The first step to a return to testing was to reopen Station 1A, as it was larger than the postshot holes and led directly down into the Salmon chamber. A second device would be lowered into the chamber and suspended in the exact center of the void. The cost of reopening Station 1A was estimated at $300,000 and with a sixty-one day timetable. Furthermore, there was no guarantee that the casing had held against the aquifers when Salmon detonated: engineers estimated only a 25 percent chance that the shaft was dry to a depth of 2,200 feet. If they reached that depth and the shaft was dry, they raised their estimate to a 75 percent chance that they could then extend their reopening operations into the chamber. The Tatum Dome had stymied them before, and

[26] U. S. Atomic Energy Commission, *NVO 24 Project Manager's Report, Project Dribble (Salmon Event.)*, 95-96, NTA accession no. NV0018934.

no one was betting that it would not do so again. Finally, on January 3, 1966, the AEC issued a work order to reopen Station 1A.[27]

A week after the anniversary of Salmon, the third and largest VU test was conducted. Called "Long Shot," the 80kt shot exploded in an excavated shaft 2,300 feet below the remote island of Amchitka in the Aleutian chain. The reason for conducting the test in that location was because of regional seismic activity, and because of the isolation of the site. Long Shot was the first nuclear test at Amchitka, which would see two thermonuclear tests: 1mt "Milrow" in 1969; and the largest underground test ever conducted by the United States, 5mt "Cannikin" in 1971.[28]

Meanwhile, the news regarding the particle accelerator became less than optimistic. Having thus far survived a process of elimination, the Piney Woods received official visitors on December 1 as a party of four AEC advisors arrived, and were feted throughout the day. Their morning arrival in Hattiesburg was quickly followed by a press conference, a country club luncheon with most of the Chamber of Commerce in attendance, a tour of two possible sites for the facility, followed by a dinner reception at the Hattiesburg Holiday Inn. The local paper whipped up enthusiasm for the visit, and editorials espoused the importance of bringing further research and development assets into the area. Beginning in September, the *American* regularly featured items arguing that Hattiesburg should ride the crest of high-tech industrial development. Mayor Paul Grady determined to bring the facility to the region: "Anything this big could smash

[27] *Hattiesburg American*, Oct. 22, 1965; Robert E. Miller to V. F. Denton, Oct. 12, 1965, NTA accession no. NV0096074; James E. Reeves, "Work Authorization Number 1 – Station 1A Re-Entry, Project Dribble; PPB:NLP-2062" (Jan. 3, 1966), NTA accession no. NV0096068.

[28] Cochran, et. al., *Nuclear Weapons Databook*, 166, 168-9; Dean W. Kolhoff, *Amchitka and the Bomb: Nuclear Testing in Alaska.* (Seattle: University of Washington Press, 2002), 56-61, 105-06. Cannikin is notable for the environmental outrage it generated, and for the attempts by Sierra Club members to stop it by sailing the ship *Greenpeace* to the area; this action, motivated by the Milrow test and funded by an anti-testing benefit rock concert spawned the Greenpeace organization.

many of our problems, it would be a magnificent development for the entire trade area. We're keeping our fingers crossed." Others advised caution. The chairman of Mississippi Power Company's industrial development department, Les Wood, was not "overly optimistic."[29]

Following the visit, came the exchange of obligatory thank you notes. The AEC team wrote to Mayor Grady on December 27, after finishing their tour of possible sites; Grady's response followed more than a month later, still arguing Hattiesburg's case. He contended that an easily arranged plan for temporarily housing workers at Camp Shelby offset the shortage of housing noted by the AEC visitors. Road improvements had progressed substantially since construction workers had been stationed there during World War II when Hattiesburg had little public housing. Grady pointed out that before the war "there was only a two-lane highway that carried the traffic from Hattiesburg to Camp Shelby. Now there is a beautiful four-lane highway, separated by a wooded median strip which provides for faster, safer, and more effective movement of traffic from Hattiesburg to either of the two sites we visited with your team." It was no use. The AEC wanted its particle accelerator, but it was part of a financially burdened government faced with the rapidly growing expense of the Vietnam war. Then there was the political problem: Mississippi continued to defy the national Democratic Party, and gave Barry Goldwater and overwhelming 87.1 percent of the vote over his opponent, Lyndon Johnson, during the 1964 Presidential election. As Bruce Schulman pointed out, acting against the will of the federal power structure bore the potential consequence of losing federal programs. Citing Hubert Humphrey, he noted the power that bureaucrats held

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[29] *Hattiesburg American*, Sept. 14-15, 1965; Hattiesburg Chamber of Commerce to Mayor Paul Grady, Nov. 24, 1965, box 29, folder 1 – Mayor Paul Grady: Atomic Energy Commission (1962-1972; Undated). M208 MCAUSM.

when locating federally funded research programs at universities, "making a vast intellectual wasteland out of America by having R&D contracts concentrated as they are in limited geographical areas." [30]

Ultimately, a 200-Bev particle accelerator was constructed at Texas A&M University (TAMU) in College Station. AEC chairman Seaborg told Suttle that he wanted TAMU to become a center for chemistry and physics research despite competition from other institutions, and this certainly influenced the selection process. The new particle accelerator became known as the Texas A&M Variable Energy Cyclotron, or TAMVEC. In the end, Suttle continued as assistant director of research at TAMU until 1971, when deposed from his post as director of the cyclotron institute. TAMVEC began operations in 1967, narrowly missing the contraction of the AEC's largesse in funding particle accelerator research that occurred in the 1970s.[31]

The particle accelerator project sought by sites across the nation almost certainly became the TAMVEC; Seaborg's wishes were evident before the official site selection began. TAMU entered into a contract with the AEC on April 24, 1964 to develop a particle physics facility. The inescapable conclusion is that the selection process was a mere formality and that despite their hopes, Hattiesburg never stood a chance.[32]

Still, another nuclear test was likely at the Dribble site – a consolation prize to be certain, but it promised more activity for the region. The program had changed again. A decoupling test would be conducted at the Tatum Dome, but it would be different from

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[30] Dr. Spofford G. English to Mayor Paul Grady, Dec. 27, 1965; Mayor Paul Grady to Dr. Spofford G.English, Jan. 31, 1966, folder 1, box 29: Mayor Paul Grady: Atomic Energy Commission (1962-1972; undated). M208 MCAUSM; *Hattiesburg American*, Dec. 1, Dec. 22, 1965; Schulman, "From Cotton Belt to Sunbelt," 272, 332, 353.

[31] Knudson, "Beam On," 33, 38, 67-71.

[32] Ibid., 38.

the proposed and now cancelled Sand test. First, the device yield would be increased, from 100 tons to more than 300 tons yield to compensate for the larger diameter of the cavity. Second, there was the issue of the chamber, which was blast-formed instead of having been excavated. Finally, the shot was redesignated “Sterling.”

Chapter Eight

A Silver Lining and a Miracle Play

Project Dribble underwent several configuration changes since it had been first announced in 1961. As originally conceived, it incorporated two phases of operation at the Tatum Dome. The series lost its higher yield tests in 1962. This was a fortunate change, for if the 5kt Salmon shot shook houses in the region, the planned 25kt detonation would likely have leveled them and caused damage far beyond Purvis and Hattiesburg. Instead, the 5kt shot and the two 100-ton decoupling tests, Sand and Tar, remained on the active shot list until water problems forced DARPA and the AEC to reconsider whether to execute the two smaller tests elsewhere. They remained in limbo, and eventually died there. Sterling simply replaced them. As far as the question of decoupling was concerned, it was the more important test; Sterling would be detonated in the chamber Salmon had created. Though Sterling was in effect a consolation prize to the Dribble program managers because it was not the program that was originally desired, it still addressed the important aspect of decoupling in underground test concealment.

The high-explosive Cowboy tests had clearly shown that the decoupling effect could be significant when an explosive detonated in an excavated chamber. One of VU's primary tasks was addressing the problem of detecting large decoupled nuclear tests to when their seismic signals dropped below the generally detectable threshold of 5kt. Below that yield it became unlikely that an underground shot would reliably be detected because of the masking effect of natural seismic noise. In a large enough salt formation, decoupling chambers could be excavated that would allow such large weapons to be secretly tested while generating seismic signals that remained below levels that would betray their origin. In other words, salt could allow an unfriendly country to hide its weapons tests. Should a treaty be signed between nuclear nations creating a threshold yield for underground tests, one side could violate it with impunity. This was the problem faced by scientists and diplomats alike.

Originally, the ideal decoupling chamber was to be mined in the Tatum Dome as part of Project Dribble – in fact, there would be two chambers: one for each phase of the operation. But water control problems quashed any possibility that the large diameter shafts needed by the excavation crews could be successfully sunk into the salt. So the Salmon emplacement by a narrower shaft was far easier to seal against water intrusion, and the resulting void appeared to meet the needs of a slightly larger decoupling test.

In fact, Sterling was far more practical and ideal than anyone initially realized. Plowshare, the "peaceful atom" program, used nuclear charges for excavation and earthmoving. As Salmon demonstrated when the chamber was reentered in March 1965, a nuclear device was useful for creating a sizeable, dimensionally uniform void in solid salt. On top of that, there was no salt to dispose of, which could reveal excavation efforts. This made secret testing feasible for several reasons. There was no threshold limit for underground tests, thus any sized device could be employed to create a test chamber that could be used to hide later tests. By 1966, the Soviet Union conducted several underground tests that created underground cavities. In addition, a country that wanted to be truly devious could cloak their tests behind diplomatically acceptable means. A country could announce an internationally acceptable Plowshare-type test, detonate the device, and end up with a ready-made decoupling chamber with the size of the void being determined simply by the device yield. The seismic signal thus explained as an acceptable detonation, no repercussions from the creation of the test chamber followed.

The real problem lay in the properties of salt once it had been exposed to the effects of an atomic blast. In a mined chamber, the cavity walls are smooth. The only cracks or fissures present are the ones that have occurred naturally as the salt pushed upwards from deep within the earth. If brine-mining is used, the solution can actually fill any small cracks; the chamber would have a perfectly uniform surface almost like glass or marble. In salt mines, striations and ripples are clearly visible in the ceiling and walls of the excavations, allowing geologists to track where smaller upwellings in the overall diapir have occurred over time.[1]

The Salmon chamber was a different story. The device created a hellish environment, with heavily fractured cavity walls. The heat released by the test remained trapped in the void for months before reentry and ventilation cooled it down. Sample cores drilled into and nearby the void revealed that three distinctive salt conditions were present after the test, layered like a hollow onion. The cavity radius was some 17 meters, or about 55 feet. The innermost layer started at the wall of the chamber and extended out to about 20 meters, or a little more than 65 feet. The second shell or layer extended from 20 meters to 60 meters, nearly 200 feet from the cavity center. The third distinct layer extended from 60 meters to 120 meters, or nearly 400 feet. The innermost layer was highly distressed and deformed. The blast shattered and melted the salt immediately surrounding the Salmon device and heaved it outward. Radioactive gases injected into natural and newly-created fissures. The intense heat caused the shattered mass to remain

[1] Donald H. Kupfer, "Relationship of Internal to External Structure of Salt Domes," in Braunstein and O'Brien, eds., *Diapirism and Diapirs*, 81.

viscous, and as it slowly cooled material fell to the bottom of the chamber, forming the flat floor. Large and small fractures in the salt existed throughout this layer.[2]

The second layer consisted of micro-fractured salt, created by the mechanical action of the chamber's creation. When Salmon detonated, a void formed where solid salt once existed, and during its creation there was an immediate period of expansion followed quickly by a rebound of the cavity walls. This mechanical action shattered the crystal structure of this second layer. The third or outermost layer was partially micro-fractured, and transitioned into the natural salt stock that made up the dome.[3]

The fracturing, micro-fracturing, and gas injection were serious. They did not affect the structural integrity of the chamber, which though heavily deformed, was sound, but they did affect the transmission of seismic energy. Estimates varied as to how much the shot-formed cavity would decouple blast energy from a nuclear test, the consensus emerging that it would diminish the decoupling effect. This seems illogical, for the chamber was surrounded by a loosened layer of salt that would allow the chamber to flex when a subsequent device exploded, and would dampen the shock before it traveled farther into the salt dome and into the surrounding earth. Most desirable was a uniform salt body with no micro-fractures that would flex uniformly, distributing the blast wave evenly along the walls of the chamber in all directions. The Salmon chamber was spherical except for the floor, formed from an aggregate of melted material and device debris. The floor was flat and would not allow blast shock to expand uniformly. Also, the heavily distressed chamber walls concealed mechanically created weaknesses that

[2] "Unclassified Excerpt From Technical Concept, Project Sterling" (July 7, 1966), 6, NTA accession no. NV0096497.

[3] Ibid.

could allow blast energy to find an easier transmission to the more solid salt. No one knew. Estimates of the decoupling effect ranged from a factor of 160 to a factor of 20.[4]

Sterling was to be the second nuclear shot at the Dribble site. A third shot was also being considered: a decoupling shot detonated in a mined cavity to compare with the Salmon/Sterling data. Despite the problems with water control in the shafts leading to the mined chamber site, engineers felt that innovations would eventually allow the mined chamber to be created with a thirty-six-inch-diameter shaft to a depth of 2,700 feet. Called "Payette," the 5-10kt shot would explore the possibility of fully decoupling a 5kt blast and reusing a mined test chamber. Unlike the Sand shot, Payette's chamber-mining operation was not set on a rigid timetable, and the program was expected to proceed at a much slower pace. Long before Payette, Sterling would test the reusability of the Salmon cavity, with an estimated 350-ton yield.[5]

Sterling's pedigree is not as easy to estimate as Salmon's. What seems certain is that Salmon was a militarily obsolete device; this certainly does not apply readily to Sterling. Subkiloton devices have existed in the United States' nuclear arsenal only for specialized functions. Before advanced designs allowed small-diameter thermonuclear weapons with megaton yields, device size corresponded with device yield. Thus if one wanted a big explosion, one had to deliver a big bomb. For specialized uses, such as the Davy Crockett recoilless rifle or the nuclear-armed version of the Falcon air-to-air missile, the small weapon size corresponded with a small device yield. The same could be said for the new Small Atomic Demolitions Munition, or SADM. All three of these

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[4] Ibid., 10.

[5] Dean Warner, "Project Payette" (Aug. 19, 1966), pp. 4-6, U. S. Department of Energy, Department Office of Scientific and Technical Information (hereafter cited as OSTI), reference number 434320. Accessible via www.osti.gov. Last accessed April 22, 2010.

devices shared a common warhead based on the W-54 design that allowed for a yield between 0.02 and 1kt, depending on the weapon configuration. Also common between these weapons is that they were all actively in the stockpile in 1966. In fact, the W-54 was a relatively new design. Sterling most probably used the fissile core of an active weapon and thus was far closer to a weapon test than Salmon, which made sense for a decoupling experiment. The other alternative is that Sterling was the fission primary from a retired thermonuclear weapon. This is almost impossible to discern, because all pertinent information regarding the Sterling device has been sanitized from the project documentation.[6]

Beginning on October 8, 1966, United States Public Health Service personnel began contacting residents around the test site. Concentrating primarily in a five-mile radius around the test site, they collected pertinent information regarding the residents of the area so as to create a viable evacuation program. Despite Sterling's comparatively puny yield compared to Salmon, no one could predict the amount of decoupling that would occur – or whether the chamber's integrity would fail and allow a radioactive leak into the surrounding countryside. Like Salmon, evacuation procedures would be followed, as would some other interesting measures. A November 17 meeting at Baxterville school informed residents of the upcoming test, and asked whether those within the two-mile radius of the test site would again leave their homes. Senator John Stennis kept abreast of the developments as well, and was advised that the AEC had

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[6] Hansen, *U. S. Nuclear Weapons: The Secret History*, 107; James Norris Gibson, *The History of the U. S. Nuclear Arsenal* (Greenwich: Brompton Books, 1989), 79, 179, 187.

determined a shot date of November 29, 1966, at 6:00 AM.[7]

The early timing of the Sterling shot presented different challenges than the Salmon test. For the latter, a 10:00 AM shot time allowed area residents to leave in the morning and wait for the all-clear signal. The early shot time for Sterling led USPHS workers to advise those residents within the two-mile radius of the test leave the night before. Of the thirty-one families in the area, comprising 127 persons, all agreed to follow the recommendation save for one family who ran a poultry farm. They elected to leave at 3:00 AM on shot day in order to tend to their chickens. Instead of paying each adult and child a daily compensatory amount for evacuating the area, the AEC based the payments on four-hour blocks of time: every adult would receive $6.00 for every four hours they were dislocated, and every child would receive $2.00.[8]

The reason for pushing the schedule up was seismic noise. Sterling was a small device, and the chamber was expected to decouple its seismic signal and make it hard to detect. Six o'clock AM was about dawn, when the area stirred and began the day. Commuters added significantly to seismic background noise because of the unique nature of the regional geology. Father Eisele at Spring Hill College noted the inability of his relatively sophisticated seismographs to collect accurate seismic data due to the traffic in Mobile during daylight hours: "a problem in the operation of sensitive instruments in this Gulf Coast region is the absence of solid rock upon which to mount the seismographs…. It is so easy to vibrate this kind of sediment that the local traffic patterns of Mobile are clearly recorded on our records. In fact, from about 6 a.m. to 6 p.m. our records are

[7] U. S. Public Health Service, "Vela Uniform Program, Sterling Event: Off-Site Surveillance," VUF-1036 (May 24, 1968), 6; John J. Burke to Stennis, Nov. 14, 1966, Subseries: Tatum Salt Dome T-8 1963-67, Stennis Collection, MSUCPRC.

[8] U. S. Public Health Service, "Vela Uniform Program, Sterling Event: Off-Site Surveillance," VUF-1036, (May 24, 1968), 9-10, 14; *Mobile* (AL) *Press-Register*, Dec. 4, 1966.

almost useless because all we are recording are 'wiggles' caused by commuting Mobilians." In order to diminish the possibility that road and rail traffic would affect the ability of distant recording stations to detect Sterling, the early test time helped avoid noise generated by the morning commute. Road and rail traffic would be temporarily halted in the area around the test site on the morning of shot day. Newspaper reporters, granted full access to the progress of the Sterling operation, gave it the sobriquet "the sneak test."[9]

The only thing to sneak past anyone on November 29 was the Sterling test itself. In what must have been a depressing reminder of Salmon's month of weather delays, program managers rescheduled the shot for December 5. Whether the device was retrieved following the aborted test and re-emplaced or was allowed to remain in the decoupling chamber is unknown. What is certain is that something went wrong between November 28 and December 2. A coolant system designed to regulate the device temperature while it was suspended in the still-warm chamber began to fail. Nuclear devices seem infinitely powerful, as they are capable of wiping out targets in less than a second. Yet, they are also delicate, relying on precise mechanical geometry that ensures the proper progression of the shock wave from the high explosives that compresses the fissile pit. The pit itself must be kept within a certain temperature range so that fission propagates properly through the fissile mass: the warmer the pit, the greater the distance between atoms, making them harder to hit with neutrons. The physical distance seems small but on the atomic scale, this spread can mean the difference between a full fission reaction and a partial reaction, or "fizzle." Temperature readings coming from the

[9] "'Hill' Professor Does Something About Quakes," undated, publisher unknown, reference number 2006.002.4, Father Louis Eisele subject folder, Spring Hill College Archives; *Mobile Press-Register*, Dec. 4, 1966.

Sterling device indicated that the cooling system was not functioning, and that the temperature of the device was not being maintained. Instead of delaying the test to retrieve the device and repair the cooling system, a decision made on December 2 began evacuation procedures for the area around the Dribble site in preparation for firing the following morning.[10]

Local law enforcement and the state patrol policed the area that night while USPHS caseworkers tallied the residents as they departed. At 3:00 AM, the AEC took over control of the roadblocks. Alerted by radio, a Southern Railways freight train on the Picayune to Purvis mainline stopped. The last family left the area just before 3:00 AM; the roads around the test site were empty, save for other law enforcement and government vehicles transporting detection teams and rad safety personnel. At 6:15 AM on the morning of December 3, 1966, Sterling's firing circuit closed. The control personnel stationed a mile from the epicenter of the test reported a rumble; cattle grazing near the area also likely felt a mild tremor. Reporters stationed at the observation location debated whether they had felt anything at all. The only people who were certain that anything had happened were monitoring seismographic instruments, and they clearly saw that the blast had occurred. Sterling was later found to have exceeded its planned yield by the equivalent of 30 tons of TNT, for a total yield of 380 tons, or 0.38kt.[11]

Sterling's seismic signal was decoupled by the Salmon chamber. Despite the uncertainty over the effect that the distorted and distressed salt surrounding the chamber

[10] James E. Reeves to Governor Paul Johnson, Jr., Jan. 10, 1967, box 48: Correspondence, Alphabetical A-Be, folder 6, Correspondence: Alphabetical: At-Ay, M191: Johnson Family Papers. MCAUSM.

[11]U. S. Public Health Service, "Vela Uniform Program, Sterling Event: Off-Site Surveillance," VUF-1036 (May 24, 1968), 13-14. Accessed via the Defense Technical Information Center (DTIC), http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA382680&Location=U2&doc=GetTRDoc.pdf (accessed Sept. 30, 2009); *Mobile Press-Register*, Dec. 4, 1966.

would have on the shock wave, its effect on Sterling was substantial. The postshot assessment found that the decoupling effect was roughly a factor of 70, which was exactly in the middle of the range predicted before the test. In other words, in a shot-created cavity of appropriate size that had been excavated by a nuclear blast, a 70kt blast could register as yielding as little as 1kt. Though far lower than the predicted effect of a mined chamber due to the inelastic nature of the micro-fractured salt layers, this was a significant reduction in signal strength. The other important finding with Sterling was the seismic frequency range produced by the test in relation to Salmon. Sterling, and a high explosive shot fired in a shaft in the salt at the same depth, produced longer-lasting high-frequency seismic waves, whereas Salmon's seismic energy concentrated in lower frequencies; it was the difference between a "boom" and a "bang," but it likely pointed the way to the ability of a seismic detection network to determine whether a shot was coupled or decoupled. Furthermore, the floor of the chamber improved the elasticity of the salt in that portion of the chamber and possibly added to the decoupling effect.[12]

Shot-generated decoupling chambers clearly offered an effective means to attenuate seismic signal strength. Mathematically, the Salmon chamber was appropriately sized for a shot in the 200-ton range, but as the margin of safety in Albert Latter's decoupling figures was a factor of two, a 325 and later 350-ton yield device was approved. As Sterling fell precisely in the middle of the expected range for the decoupling effect, it suggested that mathematical scaling laws and other means of extrapolation were adequate to explore the size of a shot-created decoupling chamber

[12] D. Springer, et al., "The Sterling Experiment: Decoupling of Seismic Waves by a Shot-Generated Cavity," *Journal of Geophysical Research* 73 (Sept. 15, 1968): 5995-96, 6000-02, 6009-10.

needed to hide a 5kt blast from detection. As technicians behind the Iron Curtain would later discover, duplicating the effect that Sterling produced was difficult.[13]

Sterling benefited from the extensive seismic monitoring program that was emplaced for Salmon. Seismometers placed in deep holes around the site augmented surface stations radiating outward from the test site to a distance of roughly twenty-five miles. The reuse of equipment was cost-efficient and logical. Without the extra expense of drilling and emplacing new devices, the program could remain closer to the overall budget, and reusing the same devices also allowed those monitoring the data the ability to correlate the readings from the test site that had passed through a common filter. This simple expedient further aided the employment of scaling laws to model different-sized decoupling effects.

There were no plans to reenter the Salmon cavity for at least eight months after Sterling. In the meantime, the recording equipment was recovered, USPHS personnel monitored the wells and the milk produced in the area around the test site, and local residents returned to business as usual. But there was a difference: the excitement surrounding the Dribble site was increasingly replaced by feelings of resentment. The Sterling test required little extra work from contractors, so the money that the Salmon test produced was less. In addition, further talk of Project Payette made people nervous. Salmon, at 5kt had caused damage over a greater area than had been anticipated, although most of it was minor. Payette was planned to be 5-10kt, despite it being planned for an excavated decoupling cavity. To the people living around the Tatum Dome, it seemed that all the AEC wanted to do was to set off devices in the salt dome while they still had

[13] "Unclassified Excerpt From Technical Concept, Project Sterling," (Jul. 7, 1966), 6, NTA accession no. NV0096497.

it. Science or no science, and future treaties be damned, they were getting tired of the inconvenience and wary of the likely damage from future tests.

By May 1967, Payette had Frederick Mellen and Frank Tatum fully riled. Letters from both criticized the AEC's further exploration of the salt dome for the test. Tatum argued that the drilling could be performed by private companies from Louisiana or Mississippi for far less than the $275,000 dollars that the *Jackson Clarion-Ledger* reported at the beginning of the month was to be paid to Fenix and Scisson from Oklahoma. Citing the vast experience such local firms had gained by creating underground storage chambers for hydrocarbons and petroleum, Tatum was thoroughly convinced that the activities at the salt dome were nothing more than outlandish federal waste:

> On every hand, where there is a government project, you see an enormous waste of material, time and effort. As an example, the AEC has paid $150,000 to $300,000 to get a well drilled 2500' into the salt mass at the Tatum Salt Dome and I am sure private industry could have done it for $25,000 to $40,000. As a matter of fact I drilled the first well into the Tatum Salt Dome with a small drilling rig from the Jackson Gas field and drilled 600' into the salt at a cost of about $15,000.[14]

Mellen was concerned with more than government waste. Writing to Senator George Murphy concerning the AEC's activities at the Dribble site, he argued:

> Never in the history of the United States of America has an agency been given such broad sweeping authority and such unlimited funding with which to carry out its direct and lateral objectives. This authority is abused (1) in the unwarranted seizure of private property under eminent domain procedure; and (2) in distorting true scientific objectivity of other agencies and contractors through liberal funding of these groups. Thus, the U. S. Geological Survey, for example, receives much direct funding through the AEC, a procedure which Congress should never permit, consciously.

[14] Tatum to Mellen, May 15, 1967, Subseries: Tatum Salt Dome T-8 1963-67, Stennis Collection, MSUCPRC.

Damages from the 1964 Salmon test had not been fully settled in some cases, he protested, and like Tatum, he wanted local firms to work at the site: "there are many competent people in Mississippi who might perform this study [the assessment of the Tatum Dome regarding Payette] objectively – but it is obvious that objective evaluations are not sought." Furthermore, Mellen was aware of what he feared was an all too cozy relationship between F&S and the AEC, and worried that F&S were working on a method of salt cavity excavation while under a government contract that they would later patent and use to monopolize the subterranean salt dome storage chamber industry. Mellen urged Murphy to conduct a Senate hearing on the AEC's conduct in Mississippi and whether there had indeed been misappropriations or abuse of federal money concerning the Dribble program.[15]

Payette would also force the lease the AEC had signed with Tatum to last longer than originally planned. It was estimated that from the issuance of the order to begin site preparation to the actual shot would take four years. Two years' time was budgeted for excavation of the cavity alone. It called for the creation of a deeper chamber than that created by the Salmon test and deeper than the planned Sand chamber. Also, intensive surveys had to find entry paths to the salt dome that would avoid as many aquifer layers as possible. Payette called for a substantial investment in simply creating the test site, and Mississippi would reap little benefit from the program.[16]

Thanks to events several thousand miles away, Payette was ultimately stillborn. The escalating hostilities in Vietnam drew billions of dollars away from the defense budget, including money intended for nuclear testing. While America's conventional

[15] Mellen to George Murphy, May 15, 1967, Subseries: Tatum Salt Dome T-8 1963-6, Stennis Collection, MSUCPRC.
[16] Dean Warner, "Project Payette" (August 19, 1966), 4, OSTI reference no. 434320.

forces fought in a futile attempt to quell the communist insurgency in that nation, the fiscal burden was such that expensive programs were delayed and later terminated. Payette was also a victim of advanced mathematics. Seeing that Sterling behaved exactly as predicted, and that it correlated with data collected from the excavated chamber high-explosive tests during the Cowboy series, it became less necessary to fire decoupled shots in an excavated salt chamber. The Piney Woods would experience no further nuclear tests. Activities at the Dribble site, however, were far from over.

More than a year after Sterling, in January 1968, the AEC solicited bids to reopen the Salmon chamber to inspect the effects of the Sterling test. This was not the only activity related to the VU program, as the fifth test of the series, 6kt shot "Scroll," exploded in a shallow shaft at NTS on April 23, 1968. No more VU tests were planned for Mississippi, but that did not mean that the AEC was ready to surrender the Tatum Dome. The Salmon cavity proved useable for future tests, but due to the expense and safety concerns attached to nuclear shots, more atomic testing there was immediately dismissed. A data set regarding a nuclear test in a shot cavity had been created, and duplicating the results of Sterling with another nuclear shot was unnecessary. Suspending several hundred tons of high explosives in the chamber center to simulate the blast generated from a Sterling sized device was also impractical. If a means were discovered that correlated to the Sterling blast wave, using conventional explosives, accurate decoupling tests could be conducted in areas unsuited for the risk of accidental radioactive release. The AEC decided upon a simple explosive mixture of methane and oxygen that could be accurately measured and administered into the shot chamber with little or no chance of a radioactive release if something went wrong.[17]

The AEC announced the new test program for the Dribble site on November 25, 1968, called "Miracle Play." It would consist of two, and possibly three, methane-oxygen detonations to be conducted in the Salmon chamber. The program configuration was well defined from the beginning, unlike the previous atomic tests. The plans called for the two initial tests to yield 315 tons, with the third yielding just short of a kiloton, at 890 tons. This third test was optional, and depended on whether the chamber was sufficiently strong enough to handle the blast following the first two shots. The AEC codenamed the Miracle Play tests "Diode Tube," "Humid Water," and "Dinar Coin."[18]

Using methane/oxygen for the explosive mixture had advantages and drawbacks. The components were relatively cheap and a simple manifold allowed easy piping of the gases into the test chamber. Ignited from a central point, the blast wave raced through the mixture, applying a nearly symmetrical shock wave to the chamber walls. The amount of stemming needed to guarantee safety for a nuclear test was unnecessary with gas explosions. A plug of cement grout and sand sufficed to prevent the gas detonation from reaching the surface. The Salmon cavity became a combustion chamber. The drawback to the methane/oxygen mixture was that the reaction generated water, which could eventually further degrade the salt walls. Diode Tube was a straightforward test of the chamber and gas handling apparatus; Humid Water, as its name implies, investigated the deleterious effects that water had on the chamber and on the decoupled seismic signal. If all went well, Dinar Coin would partially overdrive the chamber, generating energy too

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[17] Cochran, et. al., *Nuclear Weapons Databook*, 168.

[18] O'Neill to Stennis, Nov. 25, 1968. Subseries: Tatum Salt Dome T-9 1968-70, Stennis Collection, MSUCPRC.

large for the cavity to fully decouple. This could generate unexpected seismic noise, and would give test monitors certain parameters to determine whether a foreign test had been unsuccessfully decoupled.

Like they had done with Salmon and Sterling, the AEC convened a public meeting to inform the public about the new program that was to be conducted in their area. Unlike the previous two meetings, AEC officials met with some outward resentment. On December 17, 1968, about sixty people attended the meeting held at the Baxterville School. The AEC laid out its case for the test program and its location at the Tatum site. Because of the prior tests at the site, the gas tests had an excellent baseline with which to compare the data. As with the Sterling test, reuse of instrumentation holes, combined with the cheaper gas detonations made the Miracle Play program extremely cost-efficient.

That was not enough to placate residents in the area who felt that the nuclear testing program's issues had not yet been resolved. Since the Sterling meeting little more than two years before, people reported subsidence in the area that resulted in several buildings sustaining serious damage. The AEC cannily applied a one-year limit on damage claims – in other words, the AEC was ready to settle on acute damages, but chronic damage caused by factors like subsidence were excluded. Obviously, the AEC felt that subsidence was not its problem. However, the excessive ground motion from Salmon revealed the water-laden quality of the soil and underlying layers. Should an aquifer have been diverted by the test so that its hydrostatic pressure did not aid in supporting the overlying strata, the resulting subsidence could have been attributable to the AEC's activities. In order to investigate this, more exploratory wells were needed, and wells cost money. William Allaire, now deputy test manager, Nevada Operations Office, promised engineers to investigate the subsidence. With the one-year limit, it was an empty promise. One attendee at the meeting finally asked why the AEC still remained in the area, and wanted to know why they could not conduct their tests at NTS instead of in the Piney Woods. David Miller of the NVOO public affairs office explained that there were no salt domes at the Nevada site – at least none approaching the size of the Tatum Dome. If the AEC had similar formations in Nevada, they would use them, because it would be far cheaper; this invited the retort: "It would be cheaper for us too." It is probable that this sentiment was a key to why the AEC increased their isolation from those around the test site. Atomic testing bore certain responsibilities, but gas explosions did not. The Miracle Play tests were small, they were non-nuclear, and there was no reason to embark on a public relations crusade among a population growing tired of the AEC's presence.[19]

Diode Tube, the first test of the Miracle Play series, was scheduled for January 6, 1969. To no one's surprise, it did not take place. Equipment delays and changing construction requirements pushed the date back a week; then two, then three. The valves for the piping system that injected the gases into the chamber arrived late to the site. For increased safety, the cement grout plug increased in depth from 65 feet to 400 feet. Originally the sand backfill extended upwards 345 feet from the top of the grout plug. This was increased as well, to reach ground level. Problems with the firing circuitry caused Diode Tube further delays. The mixed gas stayed sealed in the chamber while technicians traced the wiring faults. No one expected any perceptible motion from the

[19] "Summary of Dec. 17, 1968, meeting at the Baxterville school," attached to Stradinger to Overby, Jan. 8, 1969, Subseries: Tatum Salt Dome T-9 1968-70, Stennis Collection, MSUCPRC.

detonation, just as the experts had predicted before Sterling. But not all were reassured: Talmadge Saucier, circuit clerk for the city of Purvis, circulated a petition to stop the tests, citing safety concerns and the problem with building subsidence in the area. This petition, in addition to several letters, was not enough to halt Miracle Play, but they underscored the growing resentment of the AEC at the Tatum Dome.[20]

At 7:15 AM, February 2, 1969, the test finally took place. Like the Sterling shot, observers nearly a mile from Station 1A felt a slight motion, while the real proof of success was recorded on paper by a battery of seismographs placed around the site. As expected, Diode Tube yielded about 315 tons of explosive energy, and thanks to its low yield, non-radioactive nature, and integrity of the salt dome, the test was conducted without the need for costly evacuations or roadblocks. Ironically, this likely added to the growing antipathy of the local population. During Salmon and Sterling, the residents were at least active (and paid) participants. Despite Salmon's repeated delays, it was a cause for picnics and trips to the observation points; it was an opportunity to mingle, enjoy cold drinks and meet news reporters. Salmon was a big story, important to the world, and thus the people around the test site felt important. They had their pictures in the newspapers. Some of them had their very lives opened up to the world. People read about Claudette Ezell and her plaster plaques and Mrs. Jones's new clothes dryer, waiting until Salmon was finished to have it connected. There was the Saul family, anticipating the results of the shot, and the mess on Horace Burge's floor. This was missing from Diode Tube. There was little local participation, and what happened at the site had little to do with the people around it. Scientists and technical personnel were now intruders,

[20] "AEC Bulletin HA 68-9," Jan. 16, 1969; O'Neill to Stennis, Jan. 27, 1969; petition and letters from Talmadge S. Saucier to Stennis Dec. 23, 1968, AEC bulletins, Jan. 31, 1969 and Feb. 1, 1969, Subseries: Tatum Salt Dome T-9 1968-70, Stennis Collection, MSUCPRC.

conducting further tests on an enclosed site, and having little effect on those around it. As Schulman notes, the majority of personnel involved in defense work were imported from elsewhere, with locals occupying “manual and custodial positions.” Although the Dribble site employed local drillers during its construction, later site operations relied on non-Mississippians. The outsiders may as well have been tinkering in a secret laboratory somewhere. The benefits of an AEC presence in the Piney Woods were growing more questionable by the day. Diode Tube was done. Humid Water was scheduled to quickly follow it, and if feasible, Dinar Coin. This third shot bore the only possibility that people living around the site would need to prepare or evacuate.[21]

Humid Water, the second Miracle Play test, was originally planned for mid-February. A month-long delay stretched to well over a year, with the test finally being scheduled for April 21, 1970, following reentry, ventilation, and inspection of the cavity. The bleeddown facility handled the waste gases and whatever radioactive materials freed by the Diode Tube explosion, and site personnel recharged the cavity with its explosive mixture. Once again nature stepped in to influence the test program. The Dribble site was originally selected for its geology, not its weather. Hurricanes, tropical storms, and unfavorable winds had all delayed the tests at the Tatum Dome, but this time the weather accelerated the pace of testing. On April 19, two days before the planned test, a particularly violent spring thunderstorm blew up over the test site, replete with high winds, heavy rain, and at least one unfortunate bolt of lightning. Immediately after the flash, security guards at the site felt a low rumble under their feet. The lightning had discharged into the chamber and ignited the mixture. Fortunately some of the

[21] AEC Bulletin HA:68-13, Feb. 2, 1969, Subseries: Tatum Salt Dome T-9 1968-70, Stennis Collection, MSUCPRC; Schulman, ”From Cotton Belt to Sunbelt,” 257.

seismographic equipment was operating and managed to catch the shock waves from the blast, allowing the AEC to confirm that Humid Water had indeed detonated. But it quickly became clear that lightning posed a threat to any gas detonations, and lightning is common throughout the area all year long. An expensive war, a declining national economy, and a growing desire to move operations to a centralized location caused the AEC to reassess their offsite testing. Save for Plowshare tests and the two tests conducted in Alaska, America's atomic testing program retreated to NTS, where the AEC conducted the sixth VU test, Diamond Dust, on May 12. There, the relative ease in conducting actual nuclear tests rather than relying on gas detonations rendered Dinar Coin unnecessary. The AEC released news of its cancellation on June 23, 1970.[22]

The fate of the Dribble site had actually been determined before the Diode Tube test, when the DMA notified the Defense Atomic Support Agency (DASA) and NVOO on January 31, 1969, that DARPA would have no further use for the Tatum site following the conclusion of Miracle Play. Decommissioning and disposal procedures outlined well in advance would begin following either Humid Water or Dinar Coin. These were intended to bring the site back to a condition where it could safely be returned to the Tatum and Bass families. The AEC lease on the 1,430 acres over the Tatum Dome was set to expire on June 30, 1971, although it was subsequently extended for a year. The AEC planted trees and other vegetation to control erosion around the site. They also removed or dismantled most of the buildings on the site, and removed excess machinery and hardware to be reused or sold as surplus. Foundation slabs roads on the site were left in place. Clean-up personnel incinerated or buried non-radioactive trash and debris.

[22] AEC bulletin from O'Neill to Stennis, Apr. 22, 1970; O'Neill to Stennis, Jun. 23, 1970; both in Subseries: Tatum Salt Dome T-9 1968-70, Stennis Collection, MSUCPRC; Cochran, et. al., *Nuclear Weapons Databook*, 169.

Once they were finished at the Tatum Dome, the AEC had no desire to leave much tangible evidence of its presence.[23]

As for the other evidence of their activities at the Dribble site, the AEC noted several locations where radioactive materials were present. As all of the contaminated materials had resulted solely through drillback operations, AEC personnel disassembled all of the contaminated drilling equipment, storage tanks, piping, and valves. These items were partially decontaminated and sent to NTS for storage. Low-level radioactive waste, including rags, coveralls, contaminated paper, and other debris were packed in drums and likewise removed to NTS. The real problem resided in the quantity of contaminated soil, mud, and water. The latter was primarily disposed of by pumping it into the HT-2 well and injecting it into the deep brine aquifer that had served as a receptacle for drilling wastes from the Baxterville oilfield. Whether collected in the drilling sump, bleeddown tank, or the blooie tank, contaminated water was relatively easy to handle. But it also collected in a large storage pond. In addition, the large "slush pits" used to hold spent drilling fluids and other debris were unlined. This created contaminated mud that migrated slightly into the surrounding clay.[24]

Drillback activities and the 1965 water/steam incident contaminated the soil at surface ground zero. Slight contamination in the soil around the decontamination pad was detected. Soil materials were not as easy to dispose of as the waste water. Most of the heavily contaminated material generated by the tests remained encased in the melted salt at the bottom of the Salmon chamber. Like the convenient brine aquifer, the test

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[23]U. S. Atomic Energy Commisssion *Site Disposal Report Tatum Salt Dome Test Site*, 1-2, 10, 40, NTA accession no. NV0338578.

[24] Ibid., 25; U. S. Department of Energy Nevada Operations Office. *Special Study Tatum Dome Test Site Lamar County, Mississippi Final Report*. NVO-200 (Washington, DC: Government Printing Office,1978), 23-28.

chamber itself became a waste repository. The AEC simply dumped the more heavily contaminated materials and soil down the Station 1A hole. The storage pond and holding pits were filled with uncontaminated soil once they were pumped dry and emptied of their radioactive burden. After the last of the radioactive debris entered the chamber, the Station 1A hole was plugged for the last time and a granite marker and plaque placed at the site. By April 1, 1972, the Atomic Energy Commission was ready to hand the land over the salt dome back to the original owners, with the agreement that United States Environmental Protection Agency (EPA) personnel be allowed to visit the site regularly to monitor it for any radioactivity. No future excavations would be permitted at the site, thus insuring the integrity of the chamber and isolating the radioactive wastes.[25]

Along with the notification that the AEC was returning the site to the original owners came the news that it was terminating its presence in Hattiesburg, save perhaps for one or two personnel. This laid off at least a dozen people; the drilling firms that played such a critical role in the program were long gone. All in all, Mayor Paul Grady managed to put a happy face on the situation in a letter to AEC manager Robert Miller:

> Thank you for your nice letter informing us of the complete closeout and cleanup of the Tatum Salt Dome operation near Baxterville. Working with your people during this project was most enjoyable and they were all good citizens while in our community.
>
> You are to be commended for the type of personnel you must have especially screened for this project. Please convey to them that our community is a richer place by having shared this portion of their life with them.
>
> Should we be able to work with you in the future, in any matter, please inform us accordingly. Warm personal regards.[26]

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[25]U. S. Atomic Energy Commisssion *Site Disposal Report Tatum Salt Dome Test Site*, 31, 36, 40, NTA accession no. NV0338578; Robert E. Miller to Mayor Paul Grady, Mar. 31, 1972, folder 1, box 29: Mayor Paul Grady: Atomic Energy Commission (1962-1972; Undated). M208 MCAUSM.

[26] Miller to Mayor Paul Grady, Mar. 31, 1972; Grady to Miller, dated Apr. 11, 1972, both in Records, folder 1, box 29: Mayor Paul Grady: Atomic Energy Commission (1962-1972; Undated), M208 MCAUSM.

VU was finished too. The DARPA program that began in 1960 ended on July 1, 1971, in an 875-foot-deep shaft at NTS. The test, noted like the two previous VU shots, is listed as being less than 20kt. It had been a period of unprecedented seismic research that led the way to the 1975 Threshold Test Ban Treaty (TTBT), limiting all underground tests to no more than 150kt. Despite the end of the VU program, the sealed Salmon chamber at the Tatum Dome would play a crucial role in another important debate.[27]

[27] Cochran, et. al., *Nuclear Weapons Databook*, 169.

Chapter Nine

Nuclear Waste

By the time of its decommissioning, the Dribble test site changed from an enormous laboratory to a massive liability. Slated for six nuclear detonations, it saw only two. It was then to host three methane-oxygen detonations, of which only two actually occurred. The cavity excavated by the Salmon shot of 1964 proved reusable, yet it showed deterioration after the second Miracle Play shot. When the methane was oxidized in the chamber, it produced water vapor, which worked its way into the cracks and microfractures in the cavity walls. As a result, the blast and water-weakened walls threatened to crumble. This did not affect the overall integrity of the Tatum Dome, because compared to the size of the overall diapir, the Salmon cavity was tiny and buried deep within the dome. It did mean that the chamber was useless for further research, and unless the AEC intended to excavate another cavity by means that had already proved useless, or through detonating another device and risking further damage claims from the already annoyed residents around the test site, the agency would only extend the lease over the salt dome for as long as it took to perform the cleanup and remediation activities.

Radioactive contamination first reached the surface during the 1965 reentry of the Salmon chamber. Salt from the immediate vicinity of the chamber was radioactive, which was one way the work crews knew that they were reaching their target. Drilling fluid, or “mud,” an oily material containing clays and other minerals, cooled and lubricated the drilling head. Mud also played a critical role in drilling because it constantly washed away the cuttings created by the drilling head. The mud then flowed back to the surface through the shaft, filtered to remove the spoil, and then reused if needed. Radioactive mud was a different story, because it could not be reused. It was collected in large storage pits near the drilling derrick. Because it was not intensely radioactive, storing it in the large pits seemed safe. But the unlined pits were not the most secure means to store these fluids, despite their being excavated in thick clay. In addition the Piney Woods region experiences occasional heavy downpours. The test site had several creeks on it and ponds not far from surface ground zero. Surface and underground water was plentiful, and water-soluble radioisotopes were plentiful as well. It would be analogous to locating a maximum security prison next to a mass transportation station. Security is generally very good, but once the convict is out, there are numerous routes of evasion and escape; returning the convict to his cell becomes difficult, if not impossible.[1]

In order to combat the possibility that radionucleides could escape containment, the AEC initiated a large cleanup beginning in May 1971 that quickly outstripped its estimates. Soil, water, and vegetation analyses indicated that the primary contaminants at the site were tritium (3H) and radioactive antimony-125 (Sb-125). An onsite monitoring laboratory staffed by eight personnel constantly assessed samples collected from different locations and soil depths to identify where more active decontamination measures needed to be taken. Initially, the AEC thought that 1,400 cubic yards of soil would require removal and disposal; in actuality more than 11,000 cubic yards of soil were taken from the surface and the disposal pits and fed through a shaft into the Salmon chamber. Large clods of earth that were too big to fit down the shaft required breaking by hand. The process was expensive, costing roughly $40 per cubic yard to remove and dispose. The

[1] U. S. Department of Energy Nevada Operations Office. *Special Study Tatum Dome Test Site Lamar County, Mississippi Final Report*. NVO-200 (Washington, DC: Government Printing Office,1978), 23-28.

AEC likewise underestimated the volume of liquid wastes and contaminated water: originally estimating 77,000 gallons, ultimately more than 1,300,000 gallons poured into the Salmon chamber. In part, this increased volume of material was due to the stringent decontamination standards imposed by the AEC, and it was also due to cross-contamination of previously cleared sites which then required further excavation. Ultimately site remediation workers filled these excavations with clean soil and leveled them with the surrounding soil. On occasion, workers were mildly contaminated due to soil and fluid contact occurred, requiring little more than soap and water to remove the materials from their skin.[2]

In other areas of the site, personnel prepared larger objects from Dribble for transportation, including contaminated drilling equipment and chemically jelled liquid wastes, for rail shipment to Oak Ridge National Laboratory (ORNL) in Tennessee for disposal.[3] The preparation of these materials included beating the scale and rust off the metal parts and spraying them with a protective material to keep the surface isolated from the environment during transportation. Pipes and tubing had end caps attached to ensure that no contaminants escaped. ORNL's ability to handle contaminated materials from Dribble became limited due to the quantity of wastes it received from other sources. The AEC then considered the Savannah River site in South Carolina for permanent storage of the coated drilling threads, contaminated casings, derrick components, valves, tanks, and other miscellaneous objects. In the end, the effect on public opinion nullified this plan. The sight of trucks bearing the black and yellow radiation hazard markings hauling

[2] Bruce W. Church, "Nevada Operations Overview" and Arden E. Bicker, "Site Decontamination" in George A Cristy and Helen C. Jernigan, eds., *Environmental Decontamination: Proceedings of the Workshop December 4-5, 1979 Oak Ridge Tennessee* (Oak Ridge, Oak Ridge National Laboratory, 1981), 62, 91-95, OSTI no. 6529387. Obtained through www.osti.gov (accessed Sept. 30, 2009).

[3] This would have been liquids other than tritium-contaminated water.

contaminated loads over public highways was not desirable. In addition, the AEC had to consider the risks of barging the contaminated steel through the Intracoastal Waterway, around Florida and up the East Coast to Savannah River, an estimated journey of nine days. A sunken barge would quickly amount to both a navigation and an environmental hazard. Ultimately, contaminated materials from the Dribble site arrived at NTS via eighteen railroad flatcars, a low-visibility alternative that allowed the AEC to sequester these artifacts for long-term desert storage with a minimum of risk. As far as the AEC was concerned, it was a case of "out of sight, out of mind." Overall, the 1971 decontamination effort in Mississippi cost $1,080,000.[4]

Radioactivity was only part of the problem for the crews working to restore the test site. It had hosted numerous ground vehicles in addition to a number of helicopters when test operations were active. Vehicles and machines required fuel and lubricants, and occasionally they broke down and needed to be repaired. Field equipment required cleaning with powerful degreasers and solvents. There was an electrical substation at the test site; when transformer equipment failed or cracked, the oils contained inside could leak into the soil. The oils contained high levels of poly-chlorinated biphenyls, or PCBs, considered to be a health risk. Generators at the site used diesel oil, and the cabling contained copper and chemicals in its insulation. While teams sought radioactive decontamination at the Dribble site, they frequently instead came across more conventional types of chemical pollution. Many of the contaminants were known by the

[4] Memo, Donald H. Edwards to William D. Smith Jr., re: Disposal of Liquid Radioactive Waste. OSB:JRM-1829, Dec. 15, 1966, NTA accession no. NV0095861; memo Otto H. Roehlk to W. W. Allaire, re: Contaminated Liquid – Project Dribble OSB:WRB-446, April 14, 1966, NTA accession no. NV0096184; U. S. Atomic Energy Commission. *Status and Alternative Plans for Cleanup Preparatory to Disposition of Tatum Salt Dome Test Site (Dribble/Hattiesburg), Report to the Assistant General Manager for Military Application by the Manager, Nevada Operations Office (NVOO)*, undated (written after May 1970), NTA accession no. NV0095768; Church, "Nevada Operations Overview" and Bicker, "Site Decontamination,"in Cristy and Jernigan, eds. *Environmental Decontamination*, 62, 94, OSTI no. 6529387.

Environmental Protection Agency to be carcinogenic as well as being water-soluble. Radiation was not the only hazard at the Tatum Dome; industrial chemicals presented their own threats to the environment at the site.[5]

The Dribble atomic tests answered many American questions regarding decoupling. But theirs were not the only questions that required address. A little more than half a year after the AEC began its remediation activities at the Tatum Dome, the Soviet Union embarked on its own decoupling experiment utilizing a large salt dome. On December 22, 1971, they fired a fully-tamped device yielding 64kt in a salt formation at Bolshoy Azgir in Kazakhstan at a depth of 987 meters, or 3,238 feet. The result of this shot, designated A-III, was similar, but on a larger scale, to the Salmon shot conducted seven years earlier; the blast formed a nearly spherical chamber 36 meters (119 feet) in diameter. A-III was part of a series of tests, designed to explore the capability of nuclear devices to create useable subterranean storage cavities. Comprising ten tests in total, this program was notable in that six tests were conducted in a shot-generated cavity created by the detonation of the 27kt A-II test that had been fired in 1968. Once the cavity was filled with water, the six later shots were used to test methods of isotope generation. The chamber created by A-X, the last of the series detonated in 1979, was ultimately put to use as a nuclear waste receptacle, like the Salmon chamber.[6]

On March 29, 1976, Soviet researchers initiated a decoupling test designated A-III-2. At 8kt, the blast was one-eighth the yield of the shot that created the A-III chamber, and detonated at the center of the void as Sterling had been in 1966. In

[5] U. S. Department of Energy, *Salmon Site Remedial Investigation Report, Volume I –DOE/NV—494-Vol. I/Rev.1* (Washington, D.C.: Government Printing Office, 1999), 1-10-1-12.

[6] L.A. Glenn, "Comparing U. S. and Russian Experience with Cavity Decoupling In Salt," *Geophysical Research Letters*, 20 (May 1993): 919; Podvig, ed., *Russian Strategic Nuclear Forces*, 476-77,512, 541.

contrast, the Sterling test at the Tatum Dome yielded 380 tons, not quite a fourteenth of the 5.2kt that created the Salmon cavity. The results could not have been more different. Where the Salmon/Sterling decoupling test produced a decoupling effect of 72, the larger Soviet decoupling test produced an observed decoupling effect of 11.7. Theories as to why this discrepancy was so pronounced centered on the thermal effects caused by the larger yield of A-III. Its blast would have caused the same microfracturing as seen in the Salmon chamber, but the overall heat released by the blast was far greater, and it remained in the chamber far longer. Thus the chamber walls were hotter when A-III-2 was detonated. This had the effect of allowing the seismic energy from the 8kt shot to radiate outward more efficiently, overriding the chamber's ability to decouple the seismic signal. Clearly, shot-generated cavities behaved unpredictably; the only way to raise the likelihood of full decoupling was to excavate the shot chamber, and that would produce detectable evidence.[7]

The A-III-2 decoupling test may have been preplanned or it may have been driven by diplomatic developments: the TTBT was a direct result of the research conducted during the VU program and bolstered by the Soviet tests at Azgir. Representatives of the United States and Soviet Union signed the treaty on July 3, 1974 and submitted to Congress a little more than two years later. VU assumed critical importance with the diplomatic efforts to create the 1963 LTBT. VU developed methods so that seismic signals from underground Soviet tests could be detected and analyzed for technical development and prevent hiding of nuclear tests. Technical means created and tested during the VU series led directly to supporting the TTBT, creating the ability to create

[7] Glenn, "Comparing U. S. and Russian Experience with Cavity Decoupling In Salt," 919, 921. Glenn cited an 8kt yield; Podvig lists the shot as being 10kt. As the comparative decoupling effects come from Glenn's article, his lower yield is used.

and enforce treaties limiting the yields of underground testing. When testing moved underground in 1963, there were no yield limits. Megaton-size underground shots were uncommon, but both sides conducted them. Primarily, these consisted of weapons tests: America's largest underground test, the 5mt Cannikin shot in November 1971 at the Amchitka, Alaska, site, tested a warhead for the proposed Spartan antiballistic missile system. The largest underground Soviet nuclear tests on record were likely twice this yield. The TTBT put a ceiling of 150kt on all testing, although combined device tests were allowed a 1.5mt yield limit.[8]

Such was the desire to cooperate in limiting their arsenals and testing programs that the treaty signatories obeyed the TTBT provisions even though they did not take full effect until 1990. The Soviet Union's last test officially to exceed 150kt was at the end of October 1975; the last American test to do so was at the end of March 1976. The reason the TTBT's provisions were prematurely honored was twofold: first, the Soviet decoupling experiment showed that shot- generated cavity decoupling was unreliable. The vast difference between American and Soviet results showed that cheating was far too risky. Though poorly decoupled, the 8kt Soviet test produced certain frequencies that indicated a probable decoupling attempt, despite the apparent success of the Sterling test in decoupling the device signal. A detected low yield test accompanied by those particular signals would tip off the other side that something covert was going on. Consequently, the international uproar caused by solid evidence of such cheating would

[8] Podvig notes at least three underground Soviet tests listed in the range of "1,500-10,000"kt. They were conducted on Sept. 12, 1973, Oct. 27, 1973, and Nov. 27, 1974. All three were weapons development tests conducted at the Novaya Zemlya range. Pavel Podvig, ed., *Russian Strategic Nuclear Forces*, 454, 522-25. The provision for combined device tests was related to Plowshare and Peaceful Nuclear Explosions (PNE) where large excavation and earth moving projects utilized several nuclear devices detonated in concert. The total yield could not exceed 1.5mt, which was the equivalent of ten devices at the TTBT limit of 150kt.

result in the sort of negative public relations exposure that neither side wanted to risk, especially while both superpowers continued to align developing nations towards their respective blocs.[9]

The second reason for the success of the TTBT before its official enforcement was that warhead size was shrinking due to the dramatic increase in accuracy of ballistic missiles between 1964 and 1976. Initially, yields for intercontinental ballistic missile (ICBMs) warheads were in the high kiloton or megaton range. This was a function of accuracy, or rather inaccuracy. To destroy a city or a military installation with a missile that likely would not strike closer than a mile from the target required an enormous yield. This was a wasteful way to conduct a nuclear war because it meant area destruction instead of target destruction. In addition, it could not guarantee target destruction if the target was sufficiently hardened against weapon effects, or located underground. Missile guidance improvements and development of multiple individually-targeted reentry vehicles (MIRV) moved both nations away from the brute force approach. The 1972 Strategic Arms Limitation Treaty (SALT) limited the number of delivery vehicles, not warheads. Thus it was possible to increase a nation's nuclear warhead count while maintaining or lowering the actual number of missiles by the simple expedient of putting multiple warheads on each missile. In order to do this, the warhead weights needed to be lowered. Guidance improvements, which allowed individual MIRVs to impact much closer to their targets, aided the process. Militarily, it is foolish to expend a megaton on a target that can be destroyed by a 100kt warhead. Accuracy and MIRVs led to smaller, lighter, and lower-yield warheads; large weapons did not need further testing to prove

[9] Glenn, "Comparing U. S. and Russian Experience with Cavity Decoupling In Salt," 919, 921.

that they worked, but the newer and smaller ones were the products of innovative weapons designs and needed testing. High-yield single-warhead ICBMs remained in smaller numbers in both arsenals for use against special targets, such as the North American Air Defense (NORAD) command center in Cheyenne Mountain, Colorado. Paradoxically, the increase of smaller weapons made nuclear war more dangerous and more likely. But it also meant that there was little reason to test anything above 150kt.[10]

While the superpowers cautiously worked towards the TTBT, the Dribble site slowly returned to its pre-test condition. The return of the land over the Tatum Dome to its original owners was not without special provisions. There were quarterly visits from the EPA and the USPHS for well water sampling and annual radiation monitoring. The land reverted to its original state once the fences came down. Deer and other wildlife roamed freely, and curiosity seekers and hunters walked across the former center of the AEC's attentions. Except for the granite marker and bronze plaque at the site that occasionally caught a hunter's bullet and signs indicating the locations of monitoring wells, the Tatum land began to look like it once had. EPA monitoring noted the presence of tritium and other contaminants at the site, but nothing raised much concern; the majority of the radiological pollution was interred in the Salmon chamber and the remainder was staying safely onsite. But the Tatum Dome itself had become a radioactive waste site, and by the late 1970s it became possible that some of Mississippi's other salt domes could join it. Less than a decade after the Tatum family had regained possession of their land, radiation fears thrust the salt dome back into public debate. The

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[10] For further information on the development of increasingly accurate ballistic missiles and MIRV technology, see Donald MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*, (Cambridge: Massachusetts Institute of Technology Press, 2001). Tables on 428-29 show the comparative improvements in missile accuracy between the United States and Soviet land based and submarine-launched missiles.

rush to build nuclear power plants in the 1950s and 1960s led to a rapid buildup of nuclear reactor waste by the 1970s, and there was no place to dispose of it permanently. The massive salt diapirs along the Gulf Coast, which proved effective for natural gas and petroleum storage, offered an environment where reactor waste could be stored indefinitely. The growing environmentalist movement sought to restrict locations where nuclear waste could be stored. The Tatum Dome ultimately became an unlikely battlefield where science and public opinion clashed over the usefulness of Mississippi's salt domes as nuclear waste repositories.[11]

America's nuclear industry generates copious amounts of radioactive waste. Foremost are the residues from nuclear weapons material production and spent fuel assemblies from reactors. Highly radioactive and corrosive, these are some of the most dangerous human-produced substances on the planet, but they are not the only source of radioactive pollution. Everything that was contaminated, from paper towels used to wipe up small radioactive spills to contaminated coveralls, shoe covers, air filters, steel tubing, machinery, vehicles, and decommissioned reactor components had to be specially disposed of. Low and mid-level wastes were occasionally packed into marked fifty-five-gallon steel drums and dumped into landfills or into the open ocean. High-level wastes were either stored at nationally-run repositories such as ORNL, Hanford, Washington, or NTS. Spent reactor fuel rods were generally stored onsite at the plant that had used them for producing electricity. The growing focus on indiscriminate nuclear waste dumping during the 1970s caused the DOE and the Nuclear Regulatory Commission (NRC),

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[11]Stone and Webster Engineering Corporation. *Final Report on Decommissioning Boreholes and Wellsite Restoration, Gulf Coast Interior Salt Domes of Mississippi, Revision 0. Report Number DOE/CH/10285—T1* (1989), 6, OSTI no. 10122492.

successors to the AEC, to evaluate numerous and varied geologic formations for their suitability as long-term nuclear waste repositories. Several factors involved in the process of selecting such candidate sites, such as geologic isolation, stability, the possibility of water intrusion, and the likelihood of tectonic activity, excluded many locations. But salt domes looked promising for waste isolation purposes. Ideally, an older, stable and moderately-deep salt dome could contain a repository for thousands if not tens of thousands of years. Eight salt domes along the Gulf Coast region were selected in 1978 for special study; three of these domes were located in Mississippi: the Cypress Creek Dome, the Lampton Dome, and the Richton Dome. The DOE further investigated the Cypress Creek and Richton Domes through sample core and water well drillings. Quarterly monitoring of the water wells indicated the flow rate and direction of local aquifers, in order to avoid the problems encountered at the Tatum Dome.[12]

Public reaction to the program was not overly positive. The most favorable location, Richton Dome, was two miles from the center of the town of Richton, Mississippi, which would have been within the security exclusion area for the waste site. The same pitch was delivered to the citizens surrounding the salt domes as had been given to the residents of Lamar and Forrest counties, that a government installation meant jobs and income. But the AEC and the other organizations at the Dribble site wore out their welcome by becoming quiescent after the first test, and it was unlikely that periodic bulletins would accurately report the classified contents and their status in a salt dome repository. Except in case of an accident, the chosen site would become a black hole, as the Dribble site became during the Miracle Play series.

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[12] Ibid.

Two events within days of one another in March 1979 virtually killed the initiative to build a waste repository in Mississippi's salt domes. One was a little-reported incident involving *Bufo terrestris*, or the Southern toad, while the other was America's worst nuclear reactor accident at the Three Mile Island power plant near Harrisburg, Pennsylvania. On March 22, Dr. Edmund Keiser from the University of Mississippi's biology department reported finding disturbing evidence that all was not well at the Tatum Salt Dome. Part of the remediation at the former test site involved collecting and analyzing biological specimens, especially those with a high propensity for environmental contaminant absorption, from various locations around the area in conjunction with well monitoring and soil analysis. Small fish and minnows, low on the food chain, effectively concentrated any contaminants found in surface waters. Farther up the food chain, amphibians such as frogs, toads, and salamanders, not only accumulated toxins found in the water but also soil-borne contaminants. They absorbed these chemicals primarily through their diets as well as their skin. In essence, they were canaries in the coal mine; these living biological alarms reflected any slight change in their environment. Any contaminants that were present would concentrate in their livers. Keiser and his assistants collected several specimens that week around the Tatum Dome, noting what looked to be skin irritation and a few cases of toads with deformed feet. When they returned with their collection to the biology department, they got a major shock. One of the toads was dangerously radioactive, containing what initially appeared to be americium, which is formed when plutonium atoms capture extra neutrons without fissioning. Like plutonium, americium does not occur in nature.[13]

[13] *Jackson Clarion-Ledger*, March 22, 1979; *Jackson Daily News*, (Jackson, MS) Jun. 1, 1979, Subject File: Tatum Salt Dome, Mississippi Department of Archives and History (hereafter referred to as

Tritium was known to exist at the test site, and finding it there would have surprised no one. Radioactive antimony-125 was also noted at the site. Commonly used as an industrial tracer, it was easy to detect. Americium was an entirely different matter. All of the radioactive contaminants at the Dribble site originated in the test chamber. That chamber had been reentered after each test shot for analysis and sample collection. Anything on the ground or in the water that issued radiation beyond background levels came from the two nuclear tests. Except for the steam event following the Salmon test, contaminated solids and liquids produced during reentry drilling proceeded through the bleeddown plant for processing and storage. Technicians retrieving samples from the Salmon chamber knew those materials to be radioactive, and handled them carefully. For americium to be present in a toad's liver, it had to come from the test chamber – an extremely unlikely source. Americium production is the result of slow neutron bombardment, such as in a reactor. It is not the result of intense high-energy neutron bombardment, such as one finds in a nuclear explosion. In addition, the level of radioactive emission coming from the specimen was intense, 1,000 times the allowable level set by federal guidelines for environmental samples. Something critical had gone wrong at the Tatum Dome and it was leaking heavily contaminated material into the environment. Somehow, somewhere, a seam or fissure had developed from the test chamber 2,700 feet below, or more likely, one of the well casings or plugs had failed. It appeared the Tatum site was venting radioactive contamination into the environment.[14]

Keiser and his graduate student assistants found the samples shocking. As members of the environmentalist group Sierra Club, parent organization of Greenpeace,

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TSD-MDAH.)

[14] *Jackson Clarion-Ledger*, March 22, 1979; *Jackson Daily News*, June 1, 1979, TSD-MDAH.

they passed the word to fellow members, including Ron Lewis, noted as one of the leading antinuclear activists in Mississippi. Lewis then spoke to Keiser to confirm the findings. Once confirmed, Keiser requested that Lewis not publicize the information until further analyses could be performed on the contaminated frog. Lewis ignored him and passed the information all the way up to Governor Cliff Finch, who eventually sounded a general alarm. At 3 A.M. on May 26, Lamar County sheriff's deputies evacuated the residents around the test site. Finch declared the area off-limits. Despite the later realization that the radiation was coming not from americium, but from a highly radioactive isotope of sodium, called sodium-22, the samples continued to emit dangerously high levels of radiation.[15]

Less than a week after Keiser reported his radioactive samples, on March 28, 1979, the Three Mile Island (TMI) nuclear power station near Harrisburg, Pennsylvania, generated the greatest domestic nuclear hysteria since the Cuban Missile Crisis.[16] The accident in the number two reactor seemed to spiral further out of control with every news bulletin. Due to gross lack of oversight, the plant operated with equipment that had failed numerous times before in other plants, and possessed severely limited communications with the outside world. After the accident occurred, it took hours to contact technicians to help with the situation. The radiation release from the accident primarily remained onsite, although some radioactive gases entered the atmosphere, prompting Governor Richard Thornburgh to recommend a partial evacuation of children and pregnant women from the surrounding area. The plant's operator, Metropolitan

[15] *Jackson Clarion-Ledger,* March 22, 1979, May 26, 1979, TSD-MDAH.

[16] Ironically, less than two weeks before the accident, *The China Syndrome,* a film starring Jack Lemmon, Jane Fonda, and Michael Douglas, opened nationally and was treated as antinuclear hysteria. One line in the film referred to an area the size of Pennsylvania being in danger of contamination from the fictional Ventana Power Plant in California.

Edison Electric Company, frustrated state and local officials with a lack of timely and important information, while the NRC looked incompetent in dealing with the looming disaster that slowly evolved over a period of several days.[17]

TMI held the national attention for months because it was precisely the sort of event that the DOE and NRC insisted could never happen. But it did happen: plant workers erroneously switched off safety systems and misread important gauges. Before the first twenty-four hours had passed, a sizeable percentage of reactor number two's core lay at the bottom of the pressure vessel. The results of the accident were severe for the nuclear power industry: orders for new plants came to a screeching halt, and the emboldened antinuclear lobby seized upon the incident as further evidence that nuclear power was far too dangerous while operating under the vigilance of an untrustworthy government regulatory body. Nuclear power in America has yet to recover from the black eye it received from TMI.

On the same day that the news about the reactor accident broke from Harrisburg, the *Jackson Clarion Ledger* printed a letter to the editor expressing one resident's concern for the future of the state:

> I see that the U. S. Department of Energy has approved plans for further tests to determine if salt domes in Perry and Marion counties can be used for nuclear waste dump sites. DOE officials also met with Mississippi state officials, and the group reviewed the plans and found no reason why the field geologic tests should not be carried out.
>
> Well, you don't have to be a genius to know that after the tests are carried out the group will determine that Mississippi salt domes will be just great for nuclear waste dump sites.
>
> The U. S. Energy Department is an agency of the same government that used the Tatum Dome as a nuclear testing site and then walked away leaving Tatum Dome radioactive for maybe the next 10,000 years.

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[17] Chana Gazit, *Meltdown At Three Mile Island* , VHS (Alexandria,VA: PBS Video, 1999).

From now on you don't have to call us the "Great State of Mississippi" and you don't have to call us the "State of Mississippi" and you don't have to call us "Mississippi," just call us the "Radioactive Waste Dump for the U. S. A."[18]

This letter expressed the growing sentiments of many in Mississippi, who feared the federal effort to emplace dangerous materials in salt domes. Especially poignant is the perception of the DOE's efforts at the Tatum Dome. Site remediation reports, though available, did not warrant front page news. As far as most citizens knew, the site was still heavily contaminated, despite the work to safely inter the volume of waste and monitor the site for further contaminants. The contribution to global nuclear arms control being ignored or forgotten, the Dribble publicly remained a scar on Mississippi's image. Discovery of the contaminated toad further underscored the threat from nuclear waste.

Something did not seem quite right though, especially at the DOE office in Las Vegas. Troy Wade, Deputy Director of the Nevada Operations Office, found the readings puzzling. Noting that the toad situation at the Tatum Dome was unlike anything previously reported, he visited the site in order to collect more information and assist in the investigation of the contaminated animals.[19] At the same time, Frank Tatum offered his opinion, in a newspaper interview, of the land he again owned:

We got lots of contamination down there," he said, pausing for a mock dramatic effect, "of salt. S-A-L-T. You know what that is? And that's it.

"Cattle have been grazing on it. Hunters have been hunting over it all the time. You can't keep fences up. Animals keep going in there to get that salt," he said. "If something was wrong, we'd have known by now.[20]

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[18] *Jackson Clarion-Ledger*, March 28, 1979, TSD-MDAH.

[19] Many years later, at a reception at the National Atomic Testing Museum in Las Vegas, Nevada, Wade related to the author that the first indication that something was amiss with the radiation reports was when DOE personnel calculated that to concentrate and emit the levels of radioactivity that was being given off by the toad liver samples, the animal would have had to have weighed over 400 pounds.

[20] *Jackson Clarion-Ledger*, June 18, 1979, TSD-MDAH.

Tom Humphrey, a geologist working for the DOE, was also unconcerned by the radioactivity that he encountered at the site. Noting that the highest tritium levels his team had discovered were about a quarter of the allowable maximum for drinking water, he offered a novel solution he and his colleagues had developed for clearing out any accumulation of the isotope in their bodies: "People working at the test site occasionally get minor doses of the tritium and our treatment is to drink as much beer as possible – this simply flushes it out of the system."[21]

Nothing seemed to add up; more puzzling were the results when other portions of the toad were analyzed – they showed only trace amounts of radioactivity. Yet several scientists at the University of Mississippi laboratory and an FDA facility verified the radiation levels from the liver samples. The discrepancy between the radiation levels in the liver and other organs revealed the error. The toad itself contained no sodium-22, but the sample dish did. The liver had been transported to various facilities and subjected to measurement by several instruments, all indicating strong levels of radioactivity. The liver remained on the same dish during the whole time, confusing the readings. At least one journalist had a hearty laugh at the expense of Keiser and the Ole Miss biology department; Keiser asserted that left to their own devices the error would have ultimately been discovered. But under media and political pressure, they had missed it entirely. The incident made Keiser and those tasked with monitoring the former test site look incompetent.[22]

Worse, and apparently not investigated, was the likelihood that the contamination was intentional. Sodium is one half of the molecule that makes up salt. Sodium-22 is a

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[21] Ibid, Aug. 15, 1979, TSD-MDAH.
[22] *Jackson Daily News*, June 1, 1979, TSD-MDAH.

highly radioactive isotope, and it made sense that radioactive sodium might be found at a salt dome test site. The animal tissues were not appreciably radioactive, so that once discovered it could easily be explained away as a simple case of laboratory equipment contamination. Many of the graduate students in the laboratory associated with antinuclear activist Lewis, who ignored Keiser's request to allow the laboratory thoroughly to confirm its findings. Finally, it made a case that everyone opposed to the nuclear waste repositories in the salt domes could support: salt domes leak. The *Jackson Daily News* story that finally revealed the errors noted that it may have been a "college prank," but if it was, it frightened the people around the Tatum Dome, and it undermined any trust in scientific monitoring at the site. If it was a deliberate environmentalist action, the perpetrators ultimately saw their cause succeed, for in 1986 the Department of Energy removed the salt domes from consideration as waste depositories and instead concentrated on Yucca Mountain in Nevada.[23]

Yet another crisis developing around the test site was purely human. Despite assurances that the test site was safe, the government did admit that there was a certain amount of radioactive contamination at the surface and in the HT-5 injection well. Further studies revealed that tritium had indeed migrated into some of the subsurface water, but that it all remained securely located at the test site. In the late 1970s and early 1980s, a group of plaintiffs who lived downwind of the Nevada Test Site (known as "downwinders") and military veterans who had taken part in atmospheric atomic maneuvers finally won their battle to get documents declassified supporting their claims that the excessive amount of radiation to which they had been exposed had severely

[23] Ibid.; Stone and Webster Engineering Corporation. *Final Report on Decommissioning Boreholes and Wellsite Restoration,* 6, OSTI no. 10122492.

affected their health. During the period of atmospheric testing in the 1950s and 1960s, some downwinders tried to take pictures of the mushroom clouds as they passed near their farms, only to have the intense radiation fog the film and render it nearly useless. Animals like sheep, cattle, and deer died after nuclear tests, killed by unknown means. Previously healthy livestock miscarried or gave birth to hideously mutated stillborn young. And people living in the southwestern corner of Utah, who were repeatedly irradiated by fallout borne by the prevailing winds, started to show skin burns, bleeding gums, gastrointestinal problems, and leukemia. They displayed clear symptoms of heavy radiation exposure but the federal government denied them any compensation because the evidence of the excessive fallout was classified for at least twenty-five years; in some cases it took repeated requests under the Freedom of Information Act to acquire the necessary documentation to file claims against the government.[24]

In the area around the Tatum Dome, people also got sick, although the cause was not as evident as it was in Nevada and Utah. Many of them wondered whether their condition was due to the tests that had been conducted nearly two decades before. Repeated monitoring at the Dribble site showed that no contamination was moving offsite and that the tritium levels were rapidly falling off due to natural decay. Still, with the scare caused by the 1979 toad incident and the horror stories reported in the news of governmental abuse and denial of radiation injuries, many began to wonder whether the same thing was occurring in the Piney Woods. Because radioactivity is intangible,

[24] For more information on the downwinders and their efforts to gain compensation from the government for radiation injuries, see Philip L. Fradkin, *Fallout: An American Tragedy* (Tucson: University of Arizona Press, 1989); John G. Fuller, *The Day We Bombed Utah: America's Most Lethal Secret* (New York: New American Library, 1984); Thomas H. Saffer and Orville E. Kelley, *Countdown Zero* (New York: G.P. Putnam's Sons, 1982); and Howard Ball, *Justice Downwind: America's Atomic Testing Program in the 1950s* (New York: Oxford University Press, 1986).

except with measuring devices, explainable illnesses prompted fears that radiation was the culprit.[25]

More troubling was that the DOE was not forthcoming with information. The AEC had certainly been deceptive when dealing with the people living around NTS. The agency cloaked information with excuses that the issues concerning peoples' lives were matters of national security and could not be discussed. Periodic briefings and meetings would have allowed Tatum Dome area residents to address their concerns directly to the DOE, and provided them updates on monitoring results and an opportunity to speak personally to an official representative. Ironically, the AEC held such meetings before conducting tests. A grassroots demand for answers emerged in the Piney Woods, primarily as a result of the efforts of Hewie Gipson, a Lamar County resident living close to the test site. Gipson tirelessly agitated for government attention and collected whatever documentation he could about site remediation. According to him, "dozens" of his friends and neighbors who lived near the test site had developed cancer. In 1990 the DOE finally ordered further remediation studies to evaluate the site itself as well as a cancer survey of the area to determine whether there was a greater incidence of disease – particularly leukemia - in the region. The initial survey showed no anomalous disease levels when compared to the national average. Nor did the comprehensive analysis performed by the Mississippi Department of Environmental Quality's Division of Radiological Health. As noted in the 1995 Baseline Ecological Risk Assessment (BERA), it also found cancer rates in accordance with the national average.[26]

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[25] *Hattiesburg American*, Nov. 2, 1990; *Jackson Clarion-Ledger*, April 20, 1993, TSD-MDAH

[26] *Jackson Clarion-Ledger*, April 20, 1993, TSD-MDAH; IT Corporation, *Baseline Ecological Risk Assessment: Salmon Site Lamar County, Mississippi DOE/NV—394 UC-700* (Las Vegas: NVOO, 1995), 34, OSTI no. 64136.

One might wonder why a rural area would have a cancer average approaching or surpassing the national average. Lamar County does have a Superfund site listed on the EPA National Priorities List, but it is not the Dribble site. The Davis Timber Company was a lumber mill and processing facility that began operating in 1972 and declared bankruptcy in the late 1980s. Located west of Hattiesburg, the factory used several chemicals in their processing facility that are known carcinogens, including dioxin, furan compounds, and pentachlorophenol. These were present in discharged waste water, causing fish kills in a nearby lake as early as 1974. Granted, the Davis operation is at least twenty-five miles from the Tatum Dome, but it also was not the only source of industrial chemical pollutants. Historically, Lamar County depended on the timber and lumber industries. In addition, chemicals released from other factories, diesel fuel, oilfield contaminants such as heavy metals from drilling mud, and pesticides all contributed to the wider environmental pollution in the region. Mercury releases have been recently reported in several instances in Lamar County, requiring hazardous materials teams to respond and clean up the sites. The region around the Tatum Dome looks pristine, but in reality it bears the invisible marks of industrial activity.[27]

In this respect, Lamar County and the Tatum Dome area tragically resemble much of the more agricultural regions of the South. Industrial chemicals and pesticides have been recorded there in hazardous quantities since the end of WWII, when the chemical industry manufactured substances to control the spread of agricultural pests. Left to the caprices of the wind and water, these chemicals, insidious as radioactive fallout, spread beyond their intended areas of application, contaminating the environment. Like fallout,

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[27] The information on the Davis Timber Company and the mercury leaks both come from the EPA website: http://www.epa.gov/region4/waste/npl/nplms/davtimms.htm (accessed Sept. 30, 2009).

these chemicals, especially chlorinated hydrocarbons, remained deadly for a very long time. Affecting the liver, skin, and nervous system, these chemicals caused illness and death among those sufficiently exposed. Poorly regulated, such chemicals found their way into household use in the form of domestic insecticide products. In addition to these contaminants, the aforementioned industrial chemicals created a background “witches’ brew” of exotic toxins, as difficult to ascertain in their effects as atomic radiation.[28]

The 1995 BERA of the site concluded that radioactive materials were still present, but that their concentrations were low enough not to present an immediate threat to the surrounding environment. Analyses conducted in several ecological “pathways” for contamination proved to be mostly inconclusive. The DOE and EPA sampled bodies of onsite water, including Half Moon Creek and Beaver Pond, for water and sedimentary contamination. Their biota were likewise sampled and analyzed. Benthic life, which includes organisms that live in the creek and pond bottoms and sediments appeared to be affected by something, but it was impossible to determine whether it was due to contaminants. In fact, the report noted that apart from elevated aluminum and manganese levels in the water, contaminants were absent. The tritium dosage absorbed by the fish taken onsite was determined to be far below levels that could warrant concern. The tritium quantities were so low as not to pose a threat to the population of great blue heron in the area that subsists almost entirely on fish. Barium and manganese occurred in substantial levels in sediment samples, but were not considered hazardous.[29]

On land, the situation was different, where three identifiable areas emitted substantial radiation: a Clean Burn Pit not far from Station 1A to the northeast; an

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[28] Pete Daniel, *Toxic Drift: Pesticides and Health in the Post-World War II South* (Baton Rouge, Louisiana State University Press, 2005), 1, 3, 78, 130, 145-50, 169.

[29] IT Corporation, *Baseline Ecological Risk Assessment*, 149-50, OSTI no. 64136.

electrical substation at the western side of the test site; and the area around the HT-2 injection wells as a result of pumping contaminated waste water into the brine aquifer. Also, the area around the substation tested positive for high levels of copper. These areas were not considered to threaten human or animal life, and awaited more thorough investigation when the DOE was able to further disturb the land; that measure had to wait until the department bought the land from the Tatum and Bass families. The DOE initiated the purchase in 1994; by the time the 1995 BERA appeared, the government owned the land it had once leased from Frank Tatum.[30]

Not only did the DOE determine the Dribble site to be of no threat to those living around it, but by 1999, it concentrated on the hazards the contaminants at the site posed to those hiking, working, or even living there. Once the DOE owned the property over the salt dome, it engaged in cleanup activities of the identified areas of further concern. Attention was diverted towards the mud storage pit close to surface ground zero. The DOE detected quantities of tritium and trichloroethane (TCE) below ground level, but excavations near the pit failed to show similar concentrations. This indicated that the mud pit was successfully containing the contaminants. Furthermore, despite the identification of several isotopes of lead, antimony, radium, and uranium, and the presence of arsenic on the site, concentrations of radioactive material were statistically low, and the arsenic, radium, and uranium were naturally occurring elements. The scenarios analyzed during the 1999 Remedial Investigation included the potential cancer risks from radiological and chemical contaminants to park rangers working at the site, hikers and backpackers, and residents, especially young children who were more likely to eat dirt than adults, and thus consume possibly carcinogenic materials. The report

[30] Ibid.

concluded that little risk existed.[31] Considering water from onsite wells to be the most likely vector for radioactive contamination for those working or living onsite, in 1999 the DOE began installing a water system to service the homes in the Tatum Dome area; it could be easily extended onsite if future occupation looked likely and thereby relieved any dependence on well water. Generally seen as a step to assuage the local population, the report pointed toward the Tatum Dome's future. EPA monitoring would continue for an indefinite period while the land reverted to its condition before the AEC came to the Piney Woods, or even before any member of the Tatum family first cut a tree in its forests. By the turn of the millennium, it was felt that in the near future the former test site would serve as a working demonstration forest and wildlife refuge, and would eventually be returned to the state of Mississippi. In a little more than a hundred years of heavy human activity, the area over the Tatum Dome had almost come full circle.[32]

[31] Cancer risk is difficult to ascertain, and is based upon complicated statistical analyses. Similarly, cancer causation is also difficult to determine in many cases. The acceptable levels at the Dribble site for carcinogens was low – indeed in the matter of some radionucleides the allowable dose onsite was less than was generally found elsewhere due to the fallout deposited during atmospheric testing. The microdoses of industrial chemicals were likewise extremely low. Still, they constituted a statistical risk.

[32] U. S. Department of Energy, *Nevada Environmental Restoration Project*, 201-12, OSTI no. 14966.

Conclusion

Costly Success

In the latter part of 2008, the author visited the front gate at the Dribble site. It was surrounded by tall fences and signs warning unauthorized personnel that they were being monitored. Faded, barely legible signs from the time of test activity still clung to posts near the front gate. A flatbed trailer sat in the tall grass in an adjacent field, apparently abandoned. The road through the padlocked gate looked long unused, although with the recent heavy rainfall and the reddish, gravelly soil, it was hard to tell. On the DOE's side of the fence, row after row of pine trees grew, contrasting with the brownish grass on the public side, making it look artificial. Ironically, the Cold War laboratory had so many trees, one could not see much beyond the fence, while the surrounding area looked comparatively bare, and practically despoiled. Then it became obvious: the trees looked unnatural, because trees do not grow in rows, and the ones there looked young – perhaps planted in the late 1970s or 1980s. It is hard to tell the age of pine trees by simple observation because they grow very quickly.

The Dribble site is not a state park, and it is uncertain whether it ever will be, or should be. Local people still claim that cancer rates are high around the Tatum Dome, despite official reports. It may be that the fences will stay up until people forget why they are there, and eventually they will be taken down. Occasionally newspaper articles and television news reporters revisit the activity at the site. They are almost always wrong in failing to discern between "bomb" tests and "device" tests. No one tested bombs at the

Dribble site; they tested seismometers and theories. And they tested the people who lived there, and their collective patience.[1]

What were the results of the activities at the test site? Internationally, they were crucial. The LTBT was hampered without a scientific means to verify distant underground tests and their magnitudes. The ability to detect possible cheating by using decoupling to mask seismic signals was a further development that further reinforced the LTBT. Subsequently, the TTBT was inconceivable without teleseismic monitoring and the scientific accuracy that allowed such a treaty to be enforced with the trust of both major superpowers. Science, bolstering diplomacy, gave the superpowers a reason to trust each other. They negotiated, and perhaps as a result, we did not enter into a thermonuclear war. This is one of the major legacies of the Dribble tests.

The technology developed during the Vela Uniform program led to improved seismic detection networks. Despite the cessation of the United States testing program in 1992, and the end of Soviet testing before the dissolution of the USSR in 1991, other nations have since joined the "nuclear club" and tested their own devices. Pakistan conducted a five-detonation underground series in 1998 on May 28, and a further test on May 30, with yields ranging from "sub kiloton" (likely a partial or unsuccessful reaction, or "fizzle") to an estimated 12kt. North Korea tested its first nuclear device on October 16, 2006, with a yield estimated at less than one kt. Seismic detection, coupled with air sampling, provided the conclusive evidence. This indicated that the North Koreans accidentally or intentionally released radioisotopes into the atmosphere during their test. America still retains the ability to conduct atmospheric sampling, the originally

[1] WLOX-TV, a Biloxi television station produced a two-part television report on the Dribble site in 2007. It is accessible at www.wlox.com/Global/story.asp?S=7836706 (accessed Feb. 21, 2010); In addition, several years ago a newspaper widely appeared discussing the activities at the Dribble site.

preferable method of assessing foreign tests. It also shows a remarkable ability to detect and assess underground nuclear blasts with very low yields.[2]

Part of the nuclear test detection story is the civilian benefit. One of the ways to ascertain whether a seismic event is an atomic test is to know where it has occurred, and how large it is. The ability to quickly pinpoint the location, depth, and magnitude of an earthquake can save countless lives. Despite the high death toll in the "Christmas tsunami" on Dec. 26, 2004, the seismological systems functioned perfectly; people died because of poor communications and lack of local tsunami warning systems that would have saved tens of thousands of lives. Monitoring personnel knew where the earthquake was and the likelihood of tsunami generation. They were finally able to communicate with embassy personnel in countries in East Africa, to warn them of the impending danger, which did save lives.

What did Mississippi gain from the Dribble and Miracle Play tests? Initially, it benefited, and some local firms found work at the site. The MITRC was founded to further the state's appeal to heavy and high-tech industry, and was not created solely to reap benefits from the Dribble program. As a new state office, it sought to secure further benefits from the AEC program, either from contracts directly related to the tests, or from other programs. This could have led to further embedding of nuclear technologies into the Piney Woods, resulting perhaps in the sort of technical, educational, and cultural effects that federal programs created in other southern states. But as previously discussed, most of the valuable contracts went to outside firms. The MCEC bid, held to be low on the list of bidders, was rejected with no apparent explanation. There are

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[2] This information comes from the Federation of American Scientists website. http://www.fas.org/nuke/guide/pakistan/nuke/index.html; http://www.fas.org/nuke/guide/dprk/nuke/index.html (accessed Oct. 2,2009)

several reasons that this may have happened. It may not have been the most competitive bid, or there may have been back room deals involved. It may have been a political decision, for as noted, the relationship between state and federal governments in the case of defense contracts was not equitable. The federal government controlled the purse. It determined who was awarded prime contracts, and awarded them as it pleased.

Sadly, this extended to the particle accelerator program. It appears that despite Hattiesburg's eager presentation, and its willingness to accede to the AEC's desire to conduct the atomic test program, it did not attract the facility, nor did it seem to have ever stood a chance to bring it to the Piney Woods. The evidence strongly suggests that the decision was made in advance before the selection program began to award it to Texas A&M University. Ultimately, the Dribble program achieved what the government wanted, and failed the residents of Lamar and Forrest counties.

The residents of the area were initially engaged in the program. Most appear to have been tolerant of, or even excited by, the test program, and few expressed some worry, but the test dates when locals were evacuated and went to the viewing areas had a festival atmosphere. Once the Salmon test was concluded and damage claims began rolling in to the Hattiesburg AEC office, the AEC became less forthcoming. They could have employed more local firms at the site, retaining at the very least a working relationship with some local residents, allowing a tangible benefit to the community. They failed to do this, and instead small articles appeared in the *Hattiesburg American* regarding the number of damage claims. To be sure, the AEC felt it had to protect itself against unwarranted claims – it is impossible to imagine what liabilities such a test program would generate in today's litigious society – although in 1964, such opportunism appears to have been much more restricted.

By the Sterling shot, the number of local residents actively participating in the program through evacuation had fallen considerably. By the time Miracle Play was announced, public resentment was openly evident. Local people were shut out of the activities at the site, and those conducting the gas detonations were simply outsiders. When the news of the downwinders became public after 1980, it took the NRC and the DOE years to address the worries and fears expressed by those living in the area. These were people who had been frightened by the news reports from Three Mile Island in 1979, and later roused from their beds thanks to environmental activists and a panicked governor; it took the DOE twenty years to install a public drinking water system in the area that removed the primary fear of aquifer contamination from local residents' minds.

At the time of this writing, it has been a little more than forty-five years since the Salmon test. Most of the tritium has decayed into stable isotopes of hydrogen, and the most dangerous materials are safely contained deep within the Tatum Salt Dome. Except for the fences and signs at the gate, nothing hints at what occurred there. There is a plaque on the granite marker at SGZ. On the back side, it reads:

"NO EXCAVATION, DRILLING AND / OR REMOVAL OF MATERIALS IS PERMITTED WITHOUT U. S. GOVERNMENT PERMISSION TO PENETRATE BELOW MEAN SEA LEVEL ON THE 1470 ACRE TRACT SITUATED WITHIN SECTIONS 11, 12, 13, AND 14, T2N, R16W, ST. STEPHENS MERIDIAN, MISSISSIPPI."

On the front, it bears a more descriptive plaque:

UNITED STATES

DEPARTMENT OF DEFENSE

ADVANCED RESEARCH PROJECTS AGENCY

DR. E. RECTIN DIRECTOR

PROJECTS DRIBBLE AND MIRACLE PLAY

EXPERIMENTS IN THE VELA UNIFORM PROGRAM SPONSORED JOINTLY BY THE DEPARTMENT OF DEFENSE AND THE ATOMIC ENERGY COMMISSION WERE CONDUCTED BELOW THIS SPOT AT A DEPTH OF 2700 AND 2715 FEET IN SALT. A 5.3 KILOTON NUCLEAR DEVICE WAS DETONATED ON OCTOBER 22, 1964, KNOWN AS THE SALMON EVENT WHICH WAS THE FIRST OF THE DRIBBLE SERIES TO EVALUATE THE DECOUPLING PRINCIPLE AND TO STUDY SEISMIC WAVE PROPAGATION IN THE SOUTHEAST UNITED STATES. A 380-TON NUCLEAR DEVICE WAS DETONATED ON DECEMBER 3, 1966, KNOWN AS THE STERLING EVENT. OBJECTIVE OF THIS EXPERIMENT WAS TO DETERMINE THE EXTENT OF DECOUPLING OF A CAVITY IN SALT AND THE ACCURACY OF DECOUPLING CALCULATIONS.

THE MIRACLE PLAY SERIES CONSISTED OF TWO GAS EXPLOSIONS WHICH WERE CONDUCTED IN THE CAVITY ON FEBRUARY 2, 1969, AND APRIL 19, 1970. THE OBJECTIVE OF THESE EXPERIMENTS WERE TO DETERMINE THE DECOUPLING EFFECT OF EXPLOSIONS IN AN OPEN CAVITY AND THE REDUCTION IN DECOUPLING CAUSED BY OVERDRIVING.

It is hidden by the trees.[3]

[3] "Salmon and Sterling Nuclear Detonation Test Site, Tatum Salt Dome, Baxterville, Mississippi, Mens et Manus.Net, 2006 October." Accessed at http://www.mensetmanus.net/salmon-sterling-site/ (last accessed Feb. 21, 2010).

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