SAVANNAH RIVER SITE COLD WAR HISTORIC PROPERTY DOCUMENTATION

NARRATIVE AND PHOTOGRAPHY

CMX AND TNX SAVANNAH RIVER'S PILOT PLANTS

Aiken County, South Carolina

NEW SOUTH ASSOCIATES
PROVIDING PERSPECTIVES ON THE PAST

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Aiken County, South Carolina

Report submitted to:

Westinghouse Savannah River Company • Aiken, SC

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ABSTRACT

This documentation was prepared in accordance with a Memorandum of Agreement (MOA) signed by the Department of Energy–Savannah River (DOE-SR) and the South Carolina Historic Preservation Office (SHPO) dated February 27, 2003, as well as the Consolidated MOA of August 2004. The MOA stipulated a thematic study and photographic documentation of 679-T and 678-T, known respectively as the CMX and TNX buildings. Initially, this area was called the CMX-TNX Area, and was only later identified as T Area or 600 Area (in the early years, the CMX and TNX buildings were simply listed in G Area, or the "general" area of the plant). This thematic study tells the story of these buildings, including: their beginnings; operational history and development; and closure. New South Associates prepared the narrative and Westinghouse Savannah River Company (WSRC) completed the photographic documentation. T Area (the CMX-TNX Area) was one of the very first operational facilities at Savannah River Plant. The CMX facility was constructed and started up in 1951, followed just months later by TNX.

After more than three decades of use, the successful completion of the mission to produce plutonium and tritium for national defense led to the closure of both pilot plants. CMX was the first to close in the early 1980s. This was followed by the closure of the TNX facilities in the late 1990s. Deactivation of the T Area facilities began soon after. Photographic documentation (large format photography, 35 mm black and white photography, and photo keys) was completed in 2003. The research and compilation of the narrative history were completed in 2005.

ACKNOWLEDGEMENTS

Many people were essential to the completion of this report. The most important were the six interviewees: Paul Dahlen, Claude Goodlett, David Honkonen, David Muhlbaier, Art Osborne, Al Peters, and David Ward, all of whom were interviewed in late 2004 and early 2005. The interviewees not only provided the vast majority of the information presented in the report, but also they unfailingly gave of their time. They also suffered through many repetitive questions. This report would simply not have been possible without their contributions.

Many employees of Westinghouse Savannah River must also be thanked. First and foremost is Linda Perry, who has worked closely with New South in recent years to further the cause of cultural resources management at Savannah River Site. Also essential to the work have been the personnel of the Photography Department, namely Tom Kotti, Byron Williams, Steve Ashe, and John Brecht. They were responsible for photographing the buildings at the CMX-TNX complex (T Area) before they were demolished between 2003 and 2005.

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ACRONYM LIST

ACHP	ADVISORY COUNCIL ON HISTORIC PRESERVATION
AMCP	ASSISTANT MANAGER FOR CLOSURE PROJECTS
AM&F	AMERICAN MACHINE AND FOUNDRY
AEC	ATOMIC ENERGY COMMISSION
AEC SROO	ATOMIC ENERGY COMMISSION SAVANNAH RIVER OPERATIONS OFFICE
AED	ATOMIC ENERGY DIVISION – DU PONT COMPANY
AOE	ASSESSMENT OF EFFECT
CAB	SAVANNAH RIVER SITE CITIZEN'S ADVISORY BOARD
CERCLA	COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT
CFR	CODE OF FEDERAL REGULATIONS
CNTA	CITIZENS FOR NUCLEAR TECHNOLOGY AWARENESS
COE	U. S. ARMY CORPS OF ENGINEERS
CRM	CULTURAL RESOURCE MANAGEMENT
CRMP	CULTURAL RESOURCE MANAGEMENT PLAN
CSRA	CENTRAL SAVANNAH RIVER AREA
DECP	DECOMMISSIONING PROJECT (DOE-SR)
D&D	DEACTIVATION AND DECOMMISSIONING
DOD	DEPARTMENT OF DEFENSE
DOE	U. S. DEPARTMENT OF ENERGY
DOE	DETERMINATION OF ELIGIBILITY
DOE FPO	U. S. DEPARTMENT OF ENERGY FEDERAL PRESERVATION OFFICER
DOE-SR	U. S. DEPARTMENT OF ENERGY SAVANNAH RIVER
DWPF	DEFENSE WASTE PROCESSING FACILITY
ECS	EMERGENCY COOLING SYSTEMS
EM	ENVIRONMENTAL MANAGEMENT
EOC	EMERGENCY OPERATIONS CENTER – SRS
EPA	U. S. ENVIRONMENTAL PROTECTION AGENCY
ERDA	ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FFA	FEDERAL FACILITIES AGREEMENT
FRA	FEDERAL RECORDS ACT
GS	GIRDLER SYSTEM
HABS	HISTORIC AMERICAN BUILDINGS SURVEY
HAER	HISTORIC AMERICAN ENGINEERING RECORD
HWCTR	HEAVY WATER COMPONENTS TEST REACTOR
INL	IDAHO NATIONAL LABORATORY
IRM	INFORMATION RESOURCE MANAGEMENT DEPARTMENT - SRS
JCAE	JOINT COMMITTEE ON ATOMIC ENERGY
LANL	LOS ALAMOS NATIONAL LABORATORY
LTBT	LIMITED TEST BAN TREATY
LTR	LATTICE TEST REACTOR
MED	MANHATTAN ENGINEERING DISTRICT
MOA	MEMORANDUM OF AGREEMENT
MPPF	MULTI-PURPOSE PROCESSING FACILITY
NARA	NATIONAL ARCHIVES RECORDS ADMINISTRATION
NASA	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

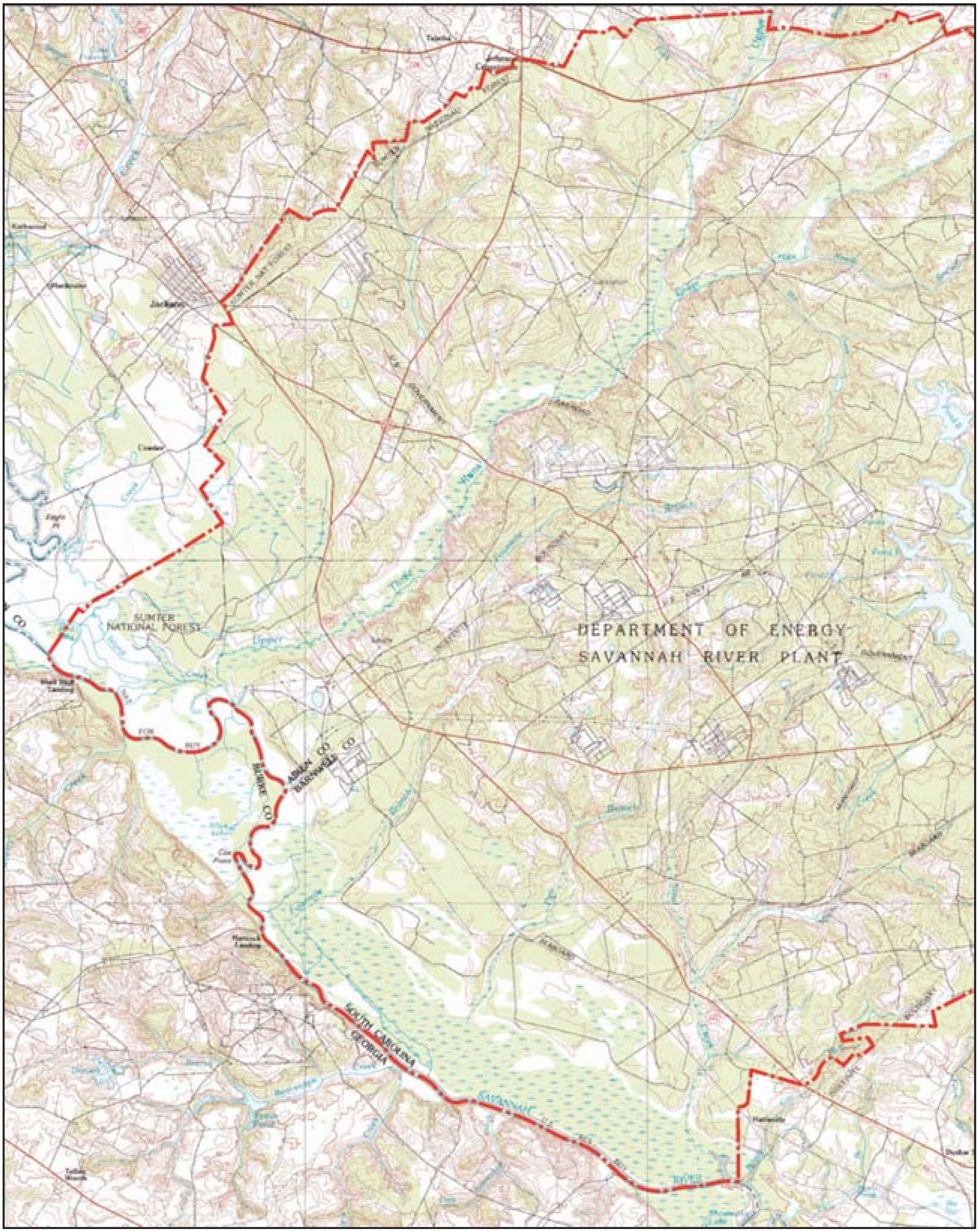
NEPA	NATIONAL ENVIRONMENTAL POLICY ACT
NHL	NATIONAL HISTORIC LANDMARK
NHPA	NATIONAL HISTORIC PRESERVATION ACT
NNSA	U. S. DEPARTMENT OF ENERGY NATIONAL NUCLEAR SECURITY ADMINISTRATION
NPS	NATIONAL PARK SERVICE
NPT	NON-PROLIFERATION TREATY
NRC	NUCLEAR REGULATORY COMMISSION
NRHP	NATIONAL REGISTER OF HISTORIC PLACES
NTG	NEUTRON TEST GAGE
NURE	NATIONAL URANIUM RESOURCES EVALUATION
NYX	NEW YORK SHIPBUILDING COMPANY
ORA	OPERATIONS RECREATION ASSOCIATION
ORNL	OAK RIDGE NATIONAL LABORATORY
PA	PROGRAMMATIC AGREEMENT
PDP	PROCESS DEVELOPMENT PILE
PSE	PRESSURIZED SUB-CRITICAL EXPERIMENT
RBOF	RECEIVING BASIN FOR OFFSITE FUEL
RTR	RESONANCE TEST REACTOR
SALT	STRATEGIC ARMS LIMITATION TREATY
SCDAH	SOUTH CAROLINA DEPARTMENT OF ARCHIVES AND HISTORY
SCDHEC	SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL
SCIAA	SOUTH CAROLINA INSTITUTE OF ARCHAEOLOGY AND ANTHROPOLOGY
SDI	STRATEGIC DEFENSE INITIATIVE
SE	SUB-CRITICAL EXPERIMENT (EXPONENTIAL TANK)
SHPO	STATE HISTORIC PRESERVATION OFFICE/OFFICER
SHRINE	SAVANNAH RIVER INFORMATION NETWORK ENVIRONMENT
SP	STANDARD PILE
SRARP	SAVANNAH RIVER ARCHAEOLOGICAL RESEARCH PROGRAM
SRI	SAVANNAH RIVER NATURAL RESOURCE MANAGEMENT AND RESEARCH INSTITUTE
SRL	SAVANNAH RIVER LABORATORY
SREL	SAVANNAH RIVER ECOLOGY LABORATORY
SRNL	SAVANNAH RIVER NATIONAL LABORATORY
SROO	SAVANNAH RIVER OPERATIONS OFFICE
SRP	SAVANNAH RIVER PLANT
SRS	SAVANNAH RIVER SITE
SRSO	U. S. DEPARTMENT OF ENERGY-SAVANNAH RIVER SITE OFFICE
SRSOC	SAVANNAH RIVER SITE OPERATIONS CENTER
SRTC	SAVANNAH RIVER TECHNOLOGY CENTER
STI	SCIENTIFIC AND TECHNOLOGICAL INFORMATION
TC	TEMPORARY CONSTRUCTION
TCAP	THERMAL CYCLING ABSORPTION PROCESS
TRAC	TRACKING ATMOSPHERIC RADIOACTIVE CONTAMINANTS
TTBT	THRESHOLD TEST BAN TREATY
UCNI	UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION
UGA	UNIVERSITY OF GEORGIA
USC	UNIVERSITY OF SOUTH CAROLINA
USFS	U. S. FOREST SERVICE
USH	UNIVERSAL SLEEVE HOUSING
VWF&S	VOORHEES, WALKER, FOLEY AND SMITH
WIND	WEATHER INFORMATION AND DISPLAY SYSTEM
WSRC	WESTINGHOUSE SAVANNAH RIVER COMPANY

I. INTRODUCTION

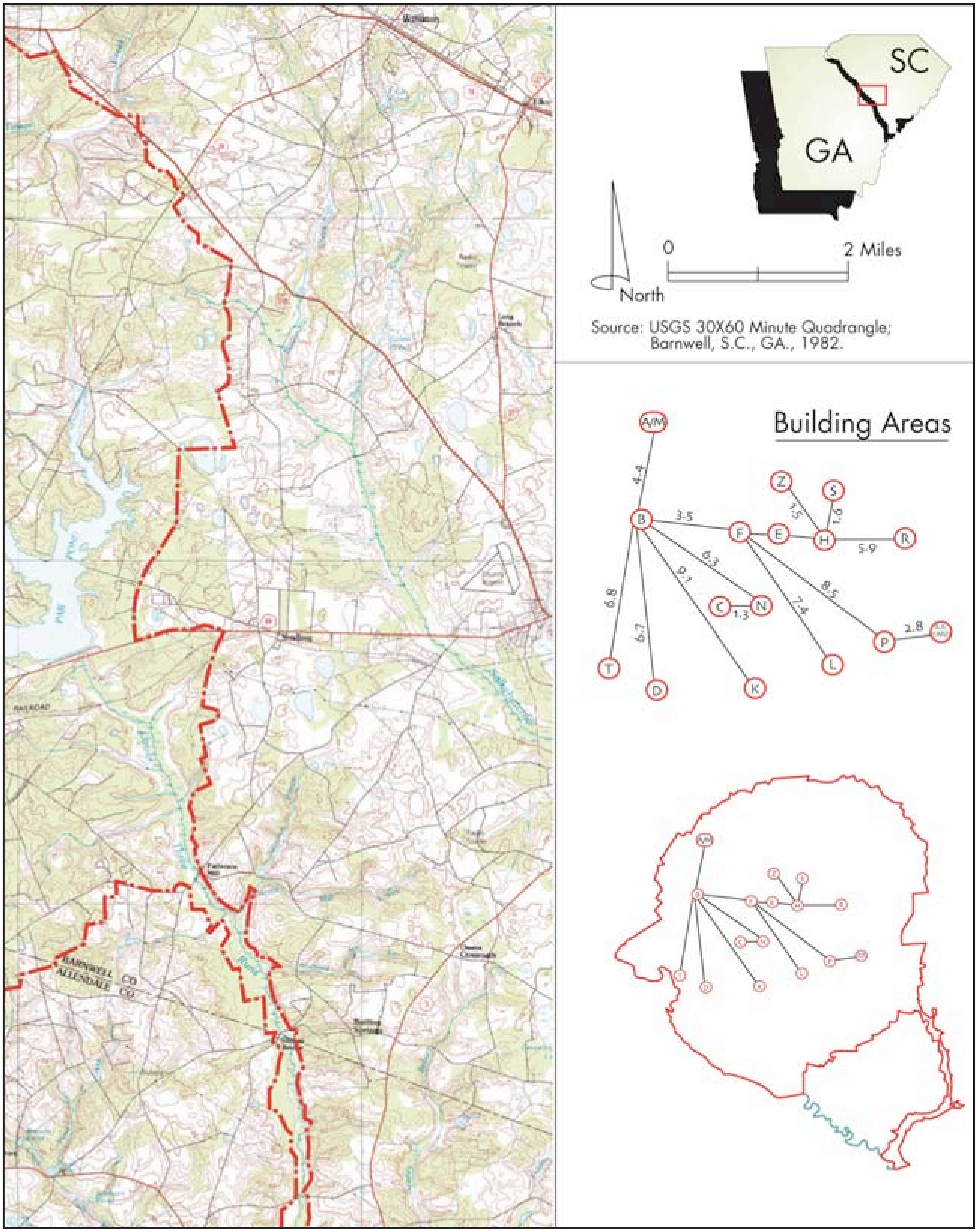
This documentation was prepared in accordance with a Memorandum of Agreement (MOA) signed by the Department of Energy–Savannah River (DOE-SR) and the South Carolina State Historic Preservation Office (SHPO) dated February 27, 2003, as well as the Consolidated MOA of August 2004. The agreements stipulated that a thematic study and photographic documentation be completed to record the history of Savannah River's pilot plants located in T Area. The core of T Area has always been the adjacent pilot plants, 679-T and 678-T, known as CMX and TNX, respectively. These two buildings, that are considered eligible for listing on the National Register of Historic Places as contributing resources to a proposed Savannah River Site Cold War Historic District. The agreements stipulated that a thematic study and photographic documentation be completed to record the history of Savannah River's pilot plants located in T Area. The core of T Area has always been the adjacent pilot plants, 679-T and 678-T, known as CMX and TNX, respectively. These two buildings, that are considered eligible for listing on the National Register of Historic Places as contributing resources to a proposed Savannah River Site Cold War Historic District, are the main subjects of our study.[1]

T Area, also know as the 600 Area, is the smallest of the building areas at the Savannah River Site. Originally known as the CMX-TNX Area, it contained two of the first operational facilities at the Site. Built and put into operation in 1951, CMX was instrumental in the successful use of Savannah River water to cool the nuclear reactors, located in the 100 Areas. TNX, built and put into operation later that same year, helped refine the PUREX process and other features of the large-scale separation process used to separate plutonium and uranium in the 200 Area. In the years that followed, both facilities broadened their range of operations to address new issues in the reactors and separations operations. Over time, the area surrounding the pilot plants was expanded to accommodate new buildings. Having served its purpose, CMX was closed in 1983. TNX was not closed until the 1990s, after the close of the Cold War, by which time "Savannah River Plant" (SRP) was renamed "Savannah River Site" (SRS) and the expanded CMX-TNX Area had been designated T Area. The impetus for this study was the decommissioning of T Area facilities between 2003 and 2005. Both pilot plants were demolished at that time.

SRS is located on 198,344 acres within Aiken, Barnwell, and Allendale counties in South Carolina. The Savannah River is its western border. The site comprises roughly one percent of the state of South Carolina and contains approximately 310-square miles within the upper coastal plain. Historically, the area that became the site was mostly agricultural, and its current physical setting remains largely rural. The seat of Aiken County, the city of Aiken, lies 12 miles to the north. Augusta, Georgia, lies 15 miles to the northwest. The towns of Jackson and New Ellenton are located beyond the site's northern perimeter. SRS is an integral part of the 18-county "Central Savannah River Area" (CSRA) adjoining the Savannah River in both South Carolina and Georgia.


DEPARTMENT OF ENERGY
SAVANNAH RIVER PLANT
SUMTER
NATIONAL FOREST
SOUTH CAROLINA
GEORGIA
AIKEN CO
BARNWELL CO
BURKE CO
Jackson
Hancock Landing
Hattieville
SAVANNAH RIVER

SRS Location Map



SRS COLD WAR HISTORIC DISTRICT AND ITS SIGNIFICANCE

The SRS is an exceptionally important historic resource containing information about our nation's Cold War history. It contains a well-preserved group of buildings and structures placed within a carefully defined site plan. All of these are linked historically, sharing a common designer and aesthetic. The site layout, predicated on an industrial process perfected by Du Pont, and informed by environmental and nuclear safety as conceived in 1950, is still intact. The site, its buildings, structures and layout, constitute a unique cultural landscape that possesses historical significance on a national, state, and local levels in the areas of engineering, military, industry, and social history. SRS is directly associated with the Cold War, a defining national historical event of the second half of twentieth century. This association satisfies National Register Criterion A, namely the association of a property with events that have made a significant contribution to the broad patterns of our history. The Site's process and research facilities were also used to further research for the peaceful uses of atomic energy. The Transplutonium Programs of the late 1960s, the discovery of the free neutrino, the production of plutonium-238 for heat sources, and the production of heavy water for research, were all notable achievements. The Cold War and the development of atomic energy for weapons and for peaceful purposes have received considerable scholarly attention as definitive factors in twentieth-century American history.

The proposed Cold War district also satisfies National Register Criterion C, since it embodies best practice principles of nuclear design and safety at the time of its construction. It represents the work of a master builder, in that Du Pont was the designer of the unique and unprecedented complex that required the simultaneous construction of five nuclear production reactors, two separation plants, an industrial size heavy water plant, and a fuel and target manufacturing plant. Du Pont was considered the single American firm with the ability to handle the enormous job entailed in the Site's construction and operation. While this facet of Criterion C is usually applied to an architect or architectural firm, it is appropriate here. Du Pont brought its corporate culture, management skills, adherence to flexible design and its World War II atomic energy experience to the job. A letter from President Truman to Du Pont requesting they take on the project underscores the fact that Du Pont was considered uniquely qualified to build and operate the Savannah River Site.

The historic district is also considered eligible under Criterion C. The construction methods involved flexible design, an innovative approach that was characteristic of Du Pont and its management style—an approach that directly contributed to the Site's success. The proposed district's buildings and structures reflect unique architectural and engineering attributes that were consonant with their mission. These include special construction materials, functional design, and special design criteria for radiological shielding, personnel safety, and the ability to sustain a military attack. The engineering required to bring the nine Savannah River plants online was innovative and was successfully completed under rigorous schedules unparalleled in our nation's twentieth-century history. For all the above reasons, the proposed Cold War District amply satisfies National Register Criterion C.

Savannah River Site's historic district may also fulfill National Register Criterion D, the potential to yield information in history. While this criterion is usually reserved for archaeological resources, it is also applicable here. Much of the historical data that elucidates Savannah River's full Cold War history is held as classified information. When these records are declassified and open to the American public, new information disclosed might yield important information about the Site's Cold War past that is unknown or imprudent to publicly release at this time.

While its national importance to the Cold War is evident, SRS also gains National Register standing for its impact on South Carolina as a whole and on the Central Savannah River Area (CSRA) as a region. The selection of the site along the Savannah River had a profound impact on the state. It shifted the image of South Carolina from rural agrarian, to one that was more progressive and industrialized. The training and inclusion of locals within the SRS workforce demonstrated the ability of Southerners to work in modern industrial facilities. Du Pont's management of this labor force, and the harmonious relations between races at the Site, further diminished northern concerns about establishing factories in the South. The presence of SRS, and the efforts of local politicians, would result in additional nuclear facilities coming to the region. Interstate and regional pacts on nuclear topics became models for interstate cooperation. The presence of SRS would begin to shift state university curricula from an agricultural focus to a new emphasis on engineering, raised the hopes and self esteem of its citizens, and placed the state at the forefront of the march to a New Age. No other single construction site or event would so affect South Carolina's history in the Cold War era, and the SRS derives National Register standing at the state level from this influence as well.

No other construction so dramatically altered the region as well. By its very construction, SRS rewrote the history of the CSRA. Communities like Ellenton and Dunbarton vanished in its wake, as did the rural areas around them. Other communities, like Aiken, changed almost overnight. As the first "open" nuclear site, SRS brought an influx of scientists and engineers the likes of which few regions in the nation would ever experience. It changed the housing stock and appearance of these local towns, changed the make-up of their schools, political parties, and other social organizations, and rewrote local history. If asked about local history, almost anyone within the CSRA would mention Savannah River Site before almost anything else. On any level, whether regional, state or national, SRS is extremely significant.

DOCUMENT ORGANIZATION

The MOA's stipulated that a written narrative should be developed based on primary sources to the greatest extent possible, including, but not limited to, oral history, archival history, and drawings. A companion documentation mitigation strategy was further stipulated - capturing the buildings and its interior process areas using large format photography when intact interiors were present, and 35 mm black and white photography for exterior photographic documentation and for interiors that had compromised historic integrity. New South Associates was responsible for the historical research, oral history and the compilation of a narrative. The oral history interviews were transcribed and the full texts are presented in Appendix A. Westinghouse Savannah River Company (WSRC) was responsible for the photographic documentation, its archival processing, and its compilation.

This narrative provides an overview of the historic processes carried out in T Area, as well as specific building descriptions and photographic documentation. It is part of a developing portfolio of similar studies that address the historic production mission of the Savannah River Site during the Cold War.

After this introduction (Chapter I) there are six additional chapters. Chapter II provides a Cold War context for the Site while the following chapters deal specifically with the history of Savannah River's pilot plants. Chapter III gives a history of the processes and problems that let to the development of CMX and TNX in 1951. The following chapter (VI) deals with the construction phase and focuses on the buildings. Chapter V describes the original missions of the buildings and the equipment installed in the buildings. An operational history, spanning the time from the mid-1950s to the 1990s, is presented in Chapter VI. The conclusions follow in Chapter VII.

CMX and TNX, the original two buildings, were always the focal point of T Area despite the presence of an additional 50 buildings by the 1990s. Both buildings were historically known by several names and building numbers. CMX was given the building number 679-G and TNX was assigned building number 678-G originally. These later changed to 678-T and 679-T respectively reflecting the new building area name. Neither CMX nor TNX are acronyms; the letters do not stand for anything. Even so, "CMX" has been called "Corrosion Mock-up Experimental" and "Corrosion Mechanical Experimental," as well as the "Corrosion Laboratory."[3] TNX also had

Aerial View of CMX and TNX Buildings, Looking to the East.

its share of nicknames, but was more generally known as the Separations Area Pilot Plant, or just simply the Pilot Plant. Both buildings were also known as the CMX or TNX "Semi-Works," in recognition of the important role both played in the transitional step between small-scale laboratory production and full-scale industrial production that was essential to the success of the Site's Cold War defense production goals. After this introduction, there are six additional chapters.

II. SAVANNAH RIVER SITE COLD WAR CONTEXT

The SRS, built by E. I. Du Pont de Nemours and Company for the U.S. Atomic Energy Commission, had its origins in the early years of the Cold War as a facility for the production of plutonium and tritium, materials essential to the nation's nuclear arsenal. From the beginning, its mission was military. It was designed primarily to produce tritium, and secondarily to produce plutonium and other special materials as directed by the Department of Energy (DOE) and its precursor organizations, the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA). Because of this mission, SRS has been an integral part of the nuclear weapons production complex. The production goal of the complex was to transform natural elements into explosive fissile materials, and to bring together fissile and non-fissile components in ways that would best meet the goal of Cold War deterrence. SRS provided most of the tritium and a large percentage of the plutonium needed for the production of fissile components from 1953 through 1988.

In addition to the Cold War defense mission, there was another, almost parallel, story of research and development using Site technologies and products for peaceful uses of atomic energy. Such government-sponsored research was strongly supported by the AEC, which was a civilian organization independent of military control. Although many of the non-defense programs conducted at SRS did not develop with the promise hoped for in the 1950s and 1960s, this was not for want of effort on the part of the AEC, Du Pont, or the scientists who helped operate SRS.

The two basic missions at SRS, nuclear materials production for defense, and production for non-defense programs, are explored in greater detail below. Both were considerable achievements. The defense mission produced much of the material required for the nuclear bombs and warheads constructed during the height of the Cold War. The non-defense programs generated new materials and increased the general knowledge of nuclear science.

COLD WAR DEFENSE MISSION

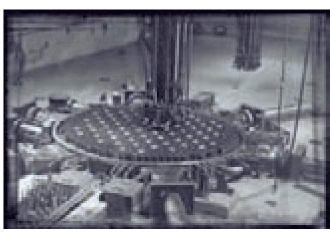
The defense mission of the SRP, as it was known prior to 1988, was an integral part of the AEC program to create weapons-grade plutonium and tritium for incorporation into fission and fusion bombs, known respectively as atomic and hydrogen bombs. The defense mission of SRP, and for that matter, the AEC, had its origins in the Manhattan Project, the World War II program that manufactured the world's first fission bombs, using both uranium and plutonium. It was the use of these devices against Japan in August 1945 that ended World War II, and ushered in the Atomic Age. The Manhattan Project, a vast and secret enterprise, set the tone for its successor, the AEC, even though the two were organized in different ways.

WE DON'T DIG URANIUM OUT OF THE GROUND, AND WE DON'T MAKE BOMBS, BUT WE DO NEARLY EVERYTHING IN BETWEEN.

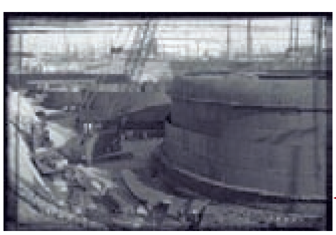
PLANT PROCESSES

FUEL AND TARGET FABRICATION

HEAVY WATER EXTRACTION



REACTOR IRRADIATION



WASTE MANAGEMENT

SEPARATIONS

PRODUCTS

PLUTONIUM-238

Produced by neutron irradiation of neptunium-237, a byproduct of uranium irradiation. Valuable for its heat generating capacity.

CURIUM-244

Properties and applications similar to plutonium-238.

PLUTONIUM-239

Used as a nuclear explosive, a breeder reactor fuel, or as the starting target material for production of heavier radioisotopes.

TRITIUM *(Hydrogen-3)*

A radioactive isotope of hydrogen, component of thermonuclear explosives, and a potential fuel for thermonuclear fusion power generation.

COBALT-60

Known radiation source and has long been used for radiotherapy.

CALIFORNIUM-252

One of the rarest man-made isotopes, has great potential value in medicine, industry, research, and education.

HEAVY WATER *(D_2O)*

Important nonradioactive product of the Savannah River Plant. It occurs at a concentration of 0.015% in natural water and must be concentrated to 99+% to be useful in reactors as a neutron moderator.

AND OTHER RADIOACTIVE ISOTOPES

Depiction of Plant Processes and Products Compiled from Savannah River Laboratory's Nucleonics of Tomorrow in the Making Here Today (Aiken, South Carolina: E. I. Du Pont de Nemours and Company, not dated).

The Manhattan Project

The Manhattan Project, formally known as the Manhattan Engineer District (MED), was established in August of 1942, more than half a year after Pearl Harbor.[1] Its mission was to beat the Germans in what was widely assumed to be a race for the atom bomb.[2] Unlike other Army Corps of Engineers districts, the MED had no specific geographical boundaries and virtually no budget limitations. General Leslie Groves was put in charge of the operation, and he was allowed enormous leeway. As Groves himself would state after the war, he had the role of an impresario in "a two billion dollar grand opera with thousands of temperamental stars in all walks of life."[3] In organizing the MED, Groves established a precedent that would carry over to the AEC: scientific personnel and resources would be culled from the major universities, but production techniques would be obtained from corporations familiar with the assembly line.[4] The Manhattan Project could not have succeeded without a willing army of brilliant physicists (many of whom were refugees from Hitler's Europe), the nation's huge industrial base of capital and personnel skills, and the leadership and construction skills provided by the Army Corps of Engineers.[5]

Commemorative Manhattan Project Button "A" Bomb Button. Courtesy of Oak Ridge National Laboratory.

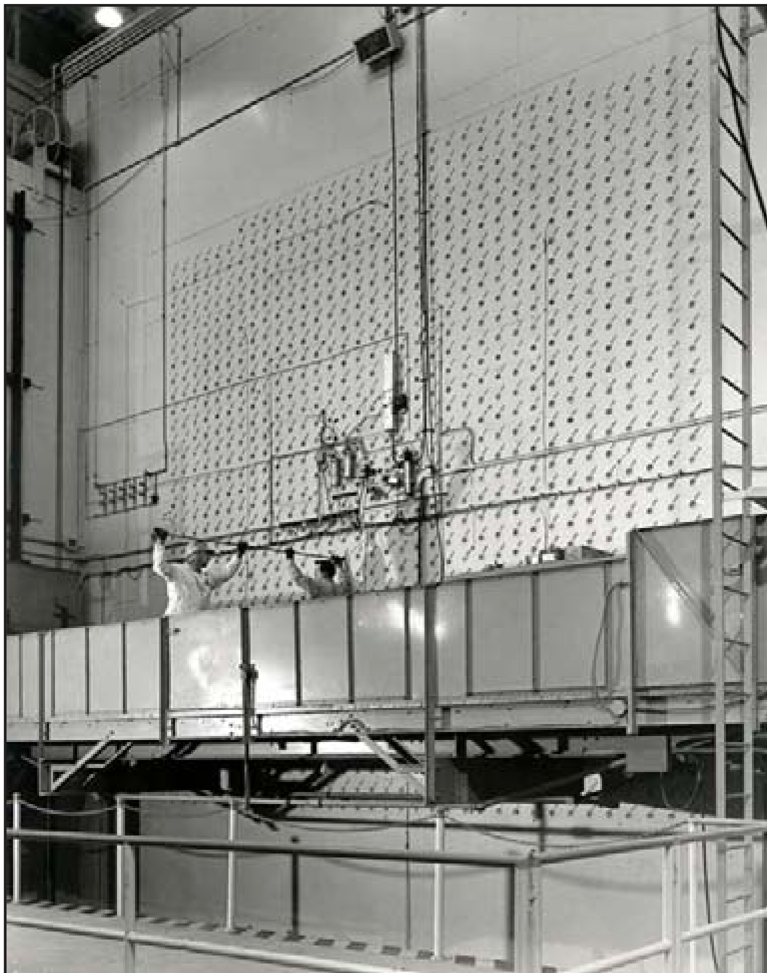
The last half of 1942 saw the groundwork laid for the development of the Manhattan Project. Groves and others selected the methods and sites to be used to produce the bomb. For both speed and economy, Groves wanted to concentrate on one single method for bomb production, but science would not oblige.[6] In the fall of 1942, there were a number of equally valid and equally untried methods for obtaining the fission material for an atomic bomb. There was even a choice of materials: uranium-235 and plutonium.

General Leslie Groves (left), Manhattan Engineer District Leader and Robert Oppenheimer (right), Scientist, Los Alamos.

The methods best known to the scientific community at the start of the Manhattan Project dealt with the collection of isotope uranium-235, which comprises only a very small percentage of natural uranium. There were at least four possible methods for removing uranium-235 from the matrix of natural uranium: the centrifuge method; thermal diffusion; gaseous diffusion; and electromagnetic separation.

To complicate matters, there was also a new method based on the production of a man-made element, plutonium, discovered and named by Glenn Seaborg and others in 1941. Plutonium could be produced by irradiating natural uranium in a pile or reactor, after which it could be separated from uranium chemically, something not possible with isotopes like uranium-235.[7]

By the end of 1942, the field was narrowed to three main methods in the race to produce nuclear materials: gaseous diffusion, electromagnetic separation, and plutonium production. In December 1942, when President Roosevelt gave his final approval for the all-out push, it was decided to proceed with all three.[8] The last of



X-10 Pile Constructed by E. I. Du Pont de Nemours & Co. at Oak Ridge, Tennessee, now designated as a National Historic Landmark. Courtesy of Oak Ridge National Laboratory

these methods certainly got a boost on December 2, 1942, when Italian refugee Enrico Fermi, working at the University of Chicago, created the world's first self-sustaining chain reaction in a graphite reactor.[9]

By this time, three huge test and production sites had been selected for MED's work. The first was Oak Ridge in Tennessee, then known as "Clinton Engineer Works," selected as the site for a full-scale electromagnetic plant (Y-12), a gaseous diffusion plant (K-25), and a plutonium pile semi-works (X-10).[10] Constructed in 1943, X-10 became the world's first production reactor when it went critical on November 4, 1943.[11] Hanford, in Washington State, was selected as the main plutonium production site, while Los Alamos in New Mexico, under the direction of Robert Oppenheimer, was chosen to be the nerve center of the project and the bomb assembly site.[12]

While Los Alamos may have been the center of the MED, Hanford was the key to the plutonium bomb, which required the new element in quantities unimaginable before the war. For the construction of the X-10 at Oak Ridge and the full-scale reactors to be built and operated at Hanford, Groves picked Du Pont. This was done not only because of Du Pont's history of explosives manufacture and its association with the U.S. military, but also because it was a large chemical firm that had the personnel, organization, and design capabilities required to do the job.[13] Most importantly, it had a tradition of translating scientific ideas and laboratory techniques into assembly line production.[14]

To do so in a field of endeavor in which they were not expert, Du Pont was to depend heavily upon the Metallurgical Laboratory of the University of Chicago for nuclear physics and radiochemistry experience. Du Pont's key technical employees were sent to Chicago and to Clinton to learn from the research scientists about problems that would bear on the design and operation of the semi-works and the full-scale production plants. This dialogue between the industrial engineers and the academic scientists would be the basis for the selection of processes, and the design of the equipment needed to carry them out, at both the semi-works and at Hanford.[15]

Hanford's three reactors (B, D, and F) and two separations buildings were constructed in 1943-1944. The reactors, water-cooled and graphite-moderated, went on line between September 1944 and February 1945.[16] One of the first crises in the plutonium program occurred shortly after the Hanford B reactor went critical in September 1944. The reactor would go critical and then shut down in a totally unexpected series of oscillations that threatened to ruin the production schedule. After frantic research, it was determined that the reaction had been killed by a periodic build-up of xenon that proved to be a huge neutron absorber with a nine-hour half-life.[17] An engineering feature added by Du Pont was instrumental in solving the problem of xenon poisoning. When scientists at the University of Chicago's Metallurgy Laboratory insisted that only 1500 tube openings were needed in the reactor face, Du Pont added an additional 500 openings as a precaution. This spare capacity, built into every Hanford reactor, made it possible to load the extra openings and simply overpower the effect of the xenon.[18]

By early 1945, Hanford was shipping plutonium to Los Alamos for bomb assembly work.[19] With a detonation device based on implosion, which was more complicated than that required for the uranium bomb, the plutonium bomb had to be tested near Alamogordo, New Mexico, in July 1945. One month later, a similar device was dropped on Nagasaki, only three days after the uranium bomb was dropped on Hiroshima.

The Manhattan Project had been a purely military undertaking, conceived and successfully concluded as a top-secret operation of the Second World War. In the year that followed the war, the project began to unravel as top scientists and others left the project to return to civilian life, and the government considered different proposals for dealing with the awesome power that had ended the war.

Onset of the Cold War

Relations between the United States and the Soviet Union, guarded during WWII, began to chill in the aftermath. The Cold War had its "official" beginnings in February and March of 1946, with three critical events. The first was Stalin's speech (February 9) to Communist Party stalwarts, reaffirming the Party's control over the Soviet Union, and promising more five-year plans and an arms race to overtake the capitalist powers. This was followed on February 22 by George Kennan's famous telegram describing the expansionist worldview of the Soviet leadership, and suggesting "containment" as the best solution. Last but certainly not least, on March 5, was Churchill's "Iron Curtain" speech at Fulton, Missouri.[20]

The beginnings of the Cold War in early 1946 quickly derailed initial talk of international control of atomic energy. By the time the AEC was created by Congress in the summer of 1946, atomic energy had become the cornerstone of the nation's defense against the Soviet Union's preponderance in conventional land forces. For this reason, President Truman was shocked to discover that when the AEC took over Los Alamos in early 1947, the United States did not possess a single assembled working bomb.[21]

Between 1947 and 1950, during the chairmanship of David Lilienthal, the main mission of the AEC was the re-establishment of the nation's nuclear arsenal. The AEC was created as an umbrella agency to control all of the nation's nuclear research and materials production. In this capacity, by early 1950 the AEC oversaw a virtual nuclear empire that not only included old MED facilities at Oak Ridge, Hanford, and Los Alamos, but also encompassed offices in Washington, D.C. and facilities at Argonne National Laboratory (Chicago); Schenectady, New York; Brookhaven National Laboratory, New York; and the University of California Radiation Laboratory at Berkeley, in addition to other small facilities around the country.[22]

During this same period, international events conspired to make the AEC's defense mission even more critical, as international relations slid further into the deep freeze. Concerned that a devastated postwar Europe might drift into the Communist camp, the U.S. government introduced the "European Recovery Program," first espoused by George Marshall in June of 1947. The "Marshall Plan," as it was commonly known, was worked out between the U.S. and various European nations months before it passed Congress in April of 1948. Although offered to all European nations, Stalin saw to it that his side refused to participate. When middle-of-the-road Czechoslovakia expressed interest in the plan, the local Communists, aided by the Red Army, staged a coup in February 1948. This move also gave the Soviets direct access to the rich Joachimstahl uranium mines, desperately needed by Stalin's nuclear program.[23]

Senator and Brigadier General in the U.S. Army Reserve Strom Thurmond, Representative Leroy Anderson and Captain Harry Peters, 1957. "Along the Iron Curtain, Looking into Communist East Germany from 11th Armored Cavalry Regiment Observation Post." Courtesy of the Special Collections, Clemson University Libraries, Clemson, South Carolina.

Unwilling to cooperate with the Western allies in the postwar reorganization of Germany, Stalin initiated the Berlin Blockade, which began in the summer of 1948 and lasted almost a year. It was the first direct confrontation between the United States and the Soviet Union, and it led to the creation of the North Atlantic Treaty Organization (NATO) in 1949.[24] Other crises soon followed. In May of 1949, the Chinese Nationalists, still devastated from the Japanese invasion during World War II, collapsed before Mao's Communist insurgents. Even more ominous, on August 29, 1949, the Soviet Union detonated its first atomic bomb (a plutonium device), an achievement that Truman and most of the U.S. nuclear establishment thought would elude the Soviets for years to come.[25] At the end of 1949 and beginning of 1950, in the wake of the Soviet bomb, Truman and the AEC made plans for the development of the hydrogen bomb, the so-called "Super."[26] Almost simultaneously, Klaus Fuchs, a German émigré who had served in the British Mission to the Manhattan Project at the highest levels of plutonium bomb research, confessed to spying for the Soviets. This revelation in February 1950 sent shock waves through the nuclear community in both Britain and the United States, and seemed to reinforce the decision for both the Super and tighter security. Senator Joseph McCarthy began his accusations just days after news of Fuchs' confession, and four months later, on June 25, 1950, North Korea invaded South Korea.

During the Korean War (1950-1953), the AEC's defense mission was paramount, as witnessed by the explosion of the first H-Bomb in November 1952, and the growth of the nation's nuclear arsenal from 300 to 1000 bombs. The military mission remained strong long after the war, with the official U.S. policy of "massive retaliation" announced by Secretary of State John Foster Dulles in January 1954.[27] The centerpiece of the nation's nuclear arsenal was the H-Bomb, a thermonuclear device that relied on a complex combination of fission and fusion, with fission required to heat and fuse atoms of hydrogen isotopes like tritium to release the high-energy neutrons required for the blast. During the 1950s, a number of thermonuclear devices were detonated, first by the United

States and quickly followed by the Soviet Union. These new bombs required increased supplies of plutonium as well as tritium, which had a half-life of 12 to 13 years. The push for the hydrogen bomb led to the expansion or establishment of new AEC facilities, beginning in 1950. Foremost among these new or improved facilities were the Los Alamos Scientific Laboratory, the Lawrence Livermore Laboratory in California, and the SRP in South Carolina.[28] The SRP was first conceived to produce tritium, but was designed to be versatile in its production capacity, accommodating the production of both tritium and plutonium, in addition to other nuclear materials.

The first U.S. thermonuclear device, Mike I, was detonated in November 1952, before the completion of SRP. However, for at least a decade after the first SRP reactor went critical in December 1953, the main, if not overwhelming, mission of the Plant was the production of plutonium and tritium, in the percentages required by annual AEC quotas. SRP played a crucial role in the production of nuclear materials for both fission and fusion bombs, first for Air Force bombers, and finally for the long-range missiles that became prevalent in the late 1950s and early 1960s. During the period when the Cold War was at its peak, between the Korean War (1950-1953) and the Cuban Missile Crisis (1962), SRP was a main contributor to the AEC's defense mission.

Mike Shot. Courtesy of the Los Alamos National Laboratory

Savannah River Plant as Part of the Big Picture

Cold War nuclear weapons production in the United States can be divided into four phases: (1) a research phase, (2) a growth and production phase, (3) a stabilization phase, and (4) a second growth and production phase. The first research phase lasted from the end of World War II until 1955. The second phase witnessed a period of growth and production that lasted from about 1955 through approximately 1967. It was in preparation for this production that the Savannah River Plant was constructed, and this period approximates the more productive era of reactor operations at the site. The primary mission of the Savannah River Plant has been first to produce tritium, and second to produce plutonium and other special materials as directed by the Department of Energy and its precursor organizations.

Complex-wide, plutonium production reached its peak in the early 1960s. The third period was one of stability, during which the concentration of effort was on the improvement of performance and operations of the nuclear arsenal; this phase lasted from about 1967 until 1980. During this period, eight of the nine Hanford reactors were closed down, and the ninth reactor that remained in operation was used to produce fuel-grade plutonium. This left Savannah River as the primary source of weapons-grade plutonium during the period. The fourth phase was a second period of growth, which began in 1980 and saw the restart of L reactor at SRP and the return of Hanford's N reactor to weapons-grade plutonium production. In addition, SRP's C, K, and P reactors were used to produce super-grade plutonium that could be blended with excess fuel-grade plutonium that had been produced in the Hanford N reactor. This phase ended in 1988, when all plutonium production was halted.[29]

The following context, which is specific to Savannah River Site, is based generally on this chronological framework. The plant's construction (1950-1956) is treated as a separate phase in the Site's history, followed by a stable period of production and performance improvement that lasts through 1979. Between 1980 and 1989, SRS experienced dramatic change. The decade began with expansion but this was soon sharply curtailed by shifts in the public's perception of nuclear technology and the abbreviation of the Site's defense mission with the fall of the Iron Curtain.

SAVANNAH RIVER PROJECT, 1950-1955

The Soviet Union detonated its first atomic bomb on August 29, 1949. Labeled "Little Joe" by American journalists, the bomb's unpublicized detonation was confirmed through the AEC's program of sampling rainwater. As a consequence, production needs were increased by the Joint Chiefs of Staff who established new minimum requirements for the atomic stockpile. Programs that had been stalled were now begun with vigor. To accommodate the perceived production needs, new "production piles" were required and the Joint Committee on Atomic Energy (JCAE) decided to build new reactors rather than upgrade those at Hanford.

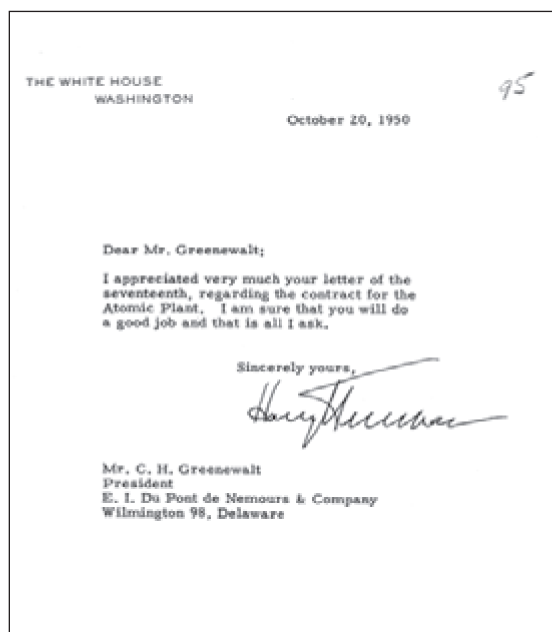
Enlarging the stockpile was the first response to the Soviet bomb. The second was the decision to produce a hydrogen bomb, a weapon many times more powerful than the uranium and plutonium devices dropped on Japan at the end of World War II. On January 31, 1950, Truman signed a presidential directive that directed the AEC to continue work on all forms of nuclear activity, including the development of the thermonuclear bomb, stating, "We have no other course."[30] A program jointly recommended by the AEC and the Department of Defense to produce materials for thermonuclear weapons in large quantities received presidential approval in June. The AEC had already estimated the construction costs for a new production center at approximately $250,000,000 and Sumner T. Pike, Acting Head of the AEC, immediately began negotiations with Crawford H. Greenewalt, president of E. I. Du Pont de Nemours & Co.[31] Truman requested funds from Congress for the construction of two heavy water reactors for the production of thermonuclear weapons on July 7 and shortly after the AEC drafted a letter contract framed in anticipation of Du Pont's acceptance of the project.[32]

Du Pont Signs On

With the passage of the appropriations bill in early 1950, the AEC opened negotiations with Du Pont to build and operate the new plant. Du Pont had built the X-10 reactor and semi-works for the separation of plutonium from irradiated fuel slug facility at Oak Ridge and had built and operated Hanford during World War II through 1946. Both ventures left an indelible print on the corporation headquartered in Wilmington, Delaware, and the success of both Du Pont efforts had left an equally indelible print in the minds of the MED's Leslie Groves and the AEC. In the field of atomic energy industry, they were seasoned players with a pennant under their belts. Crawford Greenewalt and his staff had participated in a period of intense creativity in which the labors of atomic scientists in their laboratories were duplicated on the production line under wartime conditions. Between 1942 and 1946, Du Pont's engineers and scientists had become experts within the atomic energy field. No other American firm could match Du Pont's expertise in the design and construction of production reactors and chemical processing facilities.[33]

AEC representatives visited Greenewalt formally in May of 1950 to apprise him of the proposed project and on June 8th the Wilmington firm was asked to complete the following: finish the site survey; design, construct, and operate a new reactor installation; and act in a review capacity for the technical aspects of the reactors and the processes for the production of heavy water.[34] The Commission also asked Du Pont to find a location that would not warrant the construction and management of a "company" town, a significant departure from previous military atomic energy plants established by the government.

Du Pont replied that it would consider the project if it had full responsibility for reactor design, construction, and initial operation. The "flexible" reactor design specified by the Commission called for a heavy water moderated and cooled reactor and Du Pont wanted to delay commitment to the project until they were able to review initial plans, particularly for heavy water production, and get a sense of proposed schedule. Greenewalt added a final proviso - that Truman himself request Du Pont's involvement in the project because of its urgency and its importance to the nation's security - which was done in a letter dated July 25, 1950.[35] Greenewalt's request was aimed at squelching any associations with the "merchants of death" label that lawyer Alger Hiss had leveled at the corporation in the 1934 U.S. Senate investigation of the munitions industry. Truman's letter, briefly written and to the point, would become an industrial icon for Du Pont. On July 26, Du Pont's Executive Committee adopted a resolution to undertake the project. The internal resolution also established the Atomic Energy Division (AED) within Du Pont's Explosives Department. The AED would be responsible for the new project.[36]


THE WHITE HOUSE
WASHINGTON

95

October 20, 1950

Dear Mr. Greenewalt:

I appreciated very much your letter of the seventeenth, regarding the contract for the Atomic Plant. I am sure that you will do a good job and that is all I ask.

Sincerely yours,

Mr. C. H. Greenewalt
President
E. I. Du Pont de Nemours & Company
Wilmington 98, Delaware

A letter contract, backdated to August 1, 1950, was signed between Du Pont and the AEC.[37] The letter, which would be superceded by a formal contract three years later, specified that there would be no "facility village" associated with the project and that Du Pont would not be held liable for any lawsuits that might result.[38] On October 18, Greenewalt wrote the company's stockholders that Du Pont would assume responsibility for the construction and operation of the new facility. As at Hanford, the government would pay all costs and receive any patents that might develop out of the work; Du Pont would get an annual fee of just one dollar.[39] Some of the contractual clauses that were first written into the Hanford contract and were duplicated in the SRP contract would become standard in operating contracts undertaken in the modern nuclear industry.[40]

At the time of the letter agreement, the AEC wanted Du Pont to build a tritium plant with two reactors, each to operate at an energy level of around 300 megawatts (MW). The AEC had selected the reactor type advanced by Argonne National Laboratory that was cooled and moderated with heavy water and Du Pont after review accepted the design. By 1950, heavy water reactors were considered more versatile than the graphite reactors Du Pont had built at Hanford and had better neutron economy.[41] As early as August of 1950, Du Pont's Atomic Energy Division had made preliminary improvements to the basic heavy water design proposed by Argonne and was on a pathway to construction.[42]

Site Selection

The proposed site, referred to as "Plant 124," was selected after a six-month investigation launched by Du Pont's Engineering Department and aided by the U.S. Army Corps of Engineers (COE). Truman had advised AEC's Gordon Dean not to brook any political pressure in the decision-making process and the selection process began on June 19, 1950.[43]

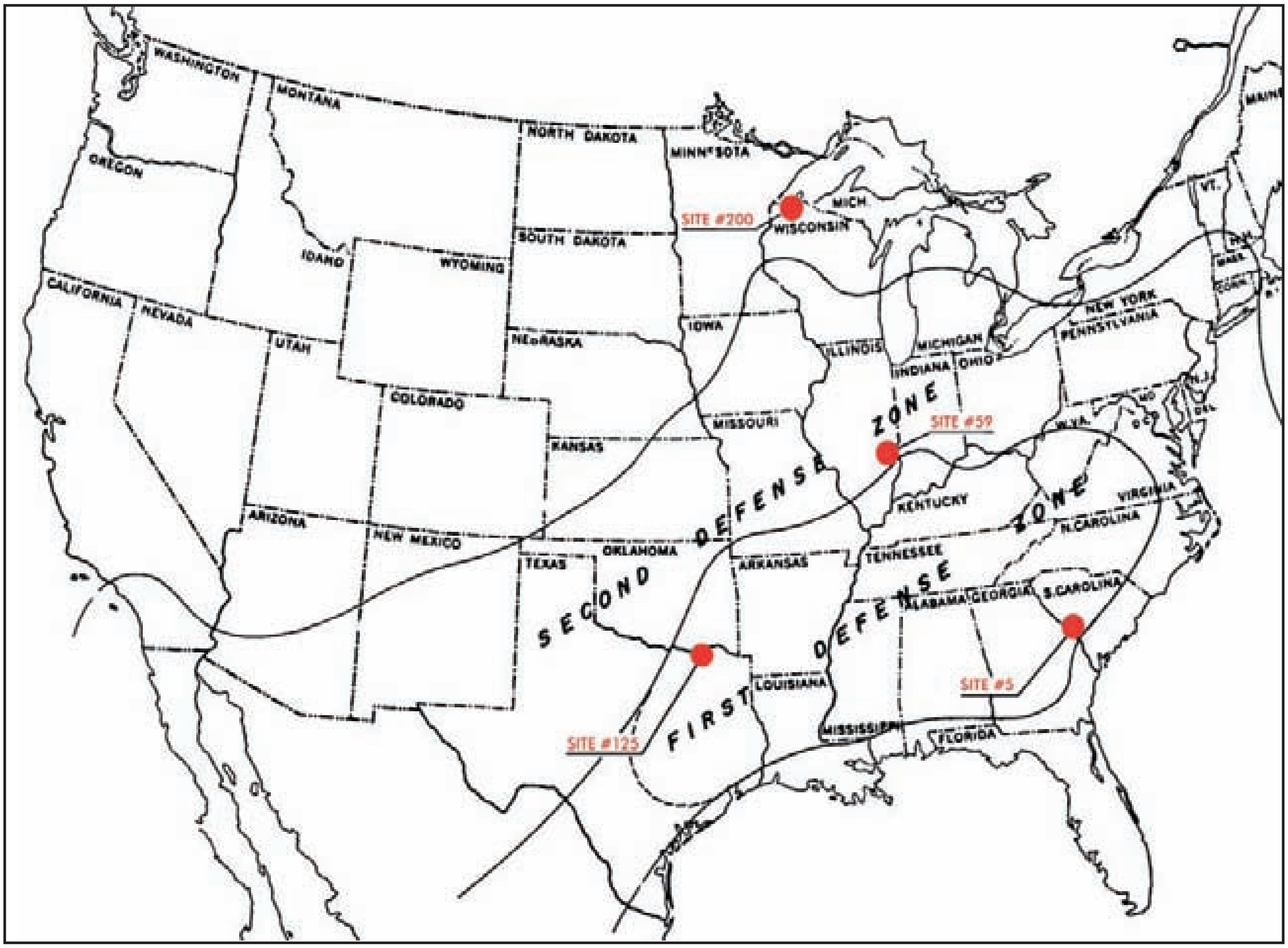
The AEC had first contacted the COE and asked them to prepare a list of sites including government-owned lands that might be suitable. This preliminary data was reviewed in the Cincinnati Corps Office of the Great Lakes Division but was found lacking in definition. The following methodology was agreed upon: all rivers with a recorded minimum flow of 200 cubic feet per second (c.f.s.) were marked on sectional maps prepared by the Corps and locations within 20 miles to a river were considered. Bands were drawn along selected rivers and potential sites were located within these bands. The preferred site would also be located in the "The First Defense Zone" for strategic reasons imposed by the Department of Defense. This zone encompassed area that stretched from Texas to Virginia and north to Illinois. Embracing the central portion of the Southeast, it included 84 candidate sites. A second band of area that stretched from Arizona to New Hampshire was considered the "Second Defense Zone." The latter had six candidate sites. C. H. Topping, Principal Architect and Civil Engineer within Du Pont's Design Division, further described the selection process that was guided by "basic site requirements" that were jointly arrived at by Du Pont and the AEC. The requirements were: a one-square mile manufacturing area; a 5.6-mile buffer zone enclosing the manufacturing area; a 10-mile distance to neighboring communities of 500 individuals and a 20-mile distance from communities with 10,000 individuals; presence of supporting populations to absorb the incoming workforce; ample water and power supplies; accessibility by rail and highways; favorable meteorology and geology; and positive conditions for construction and operating costs.[44]

Sixty-five sites were eliminated when progress in reactor design studies established that the minimum acceptable water supply was 400 c.f.s. By August 2, the list was pared down to seven sites. Members of the AEC, Army Corps of Engineers staff, and the Du Pont team, between August 6 and 17, chose these as candidates for a field inspection. Three local sites made it to this shortlist: two in South Carolina and one in Georgia. The site in Georgia was eliminated when it was learned that the Clark Hill reservoir would put a portion of the desired site under water and a site in northwestern South Carolina was considered too isolated. Site #5 in Aiken and Barnwell counties stayed in the running.

Changing water requirements also led to searches in colder climate areas both within and outside of the Second Defense Zone. These sites were put into the selection mix and similarly eliminated as the selection criteria were applied. In mid August, the requirement for the minimum water supply was increased to 600 c.f.s.[45] The Special Committee of the National Security Council on Atomic Energy had called for the construction of three additional reactors.[46]

A final evaluation of sites using the original and expanded criteria focused on four locations. These were Site #125, which was located along the Texas and Oklahoma border on the Red River; Site #59 which was located on the border of Illinois and Indiana on the Wabash River; Site #205 which was located on the shores of Lake Superior in Wisconsin; and Site #5 located in Aiken, Barnwell and Allendale counties on the Savannah River in South Carolina. Essentially, three factors were compared. The first was the availability of large quantities of reasonably pure water for process capability, the second was the presence of towns of sufficient population that could absorb the proposed labor force but were at a sufficient distance to minimize any impacts, and third, the presence of sufficient land that was suitable to the construction of production areas. During the week of August 24th, these sites were field checked by the AEC's Site Review Committee composed of five experts drawn from American engineering firms such as Black and Veatch, Sverdrup, etc., that were authorities on site selection.

Site #5, a rural site along the Savannah River in South Carolina, was recommended to the Site Review Committee on November 13, 1950 as the final selection. In the words of Du Pont Engineer, C. H. Topping, it "more nearly meets the requirements than do the others."[47] The Site Review Committee concurred with the recommendation and Site #5 was selected. The AEC formally confirmed the decision on November 28 and the public was notified by an AEC press release on the same day. AEC's Curtis A. Nelson was named as the plant first local manager in August. Nelson, a Nebraska born civil engineer and colonel in the Manhattan Project, was familiar with heavy water technology through his work as a liaison with Canada's Chalk River Plant. He also brought strong construction experience to the new project from his years in the Civilian Conservation Corps and as engineer in the Corps of Engineers where he had supervised the construction of the Joliet Illinois Ordnance Plants.[48] He was charged, along with Bob Mason, Du Pont's Field Manager for Construction, with moving the project off the Du Pont Company's and their subcontractor's drawing boards and placing nine industrial plants into the rural South Carolina landscape. Mason, a Hanford veteran, was assigned to the project on September 25.



Site Selection Map Showing Military Defense Zones and the Location of Candidate Sites. Site No. 5 is the future Savannah River Plant.

Announcement

The swiftness and military execution of the site selection announcement attests to the months of planning involved in its preparation. At 11 o'clock on Tuesday morning, November 28, 1950, the announcement was made simultaneously at press conferences held in Atlanta and Augusta in Georgia; at Columbia, Charleston, and Barnwell, in South Carolina; and to mayors, presidents of chambers of commerce, state, city, and county officials. During the day, teams representing both AEC and Du Pont called on city, county, and state officials in Atlanta, Columbia, Augusta, Aiken, Barnwell, Ellenton, Jackson, Dunbarton, Snelling, Williston, White Pond, Windsor, and Blackville. Later in the day further details were released concerning the project by the AEC in Washington, D.C. Teams gathered that evening in the office of the Du Pont Field Project Manager at the Richmond Hotel to compare notes.[49]

AEC Field Manager Curtis Nelson and Du Pont's Chief Engineer formally delivered the news to Governor Strom Thurmond and Governor-elect James F. Byrnes in Charleston, South Carolina, where they were attending the Southern Governors Conference. Governor Thurmond invited Georgia's Governor Herman Talmadge to join in the press conference prepared for the journalists covering the conference. The timing of the announcement for what could only be forecasted as a regional economic success story was excellent for both Thurmond and Talmadge. Byrnes was well versed in atomic energy development for military purposes. He had acted as Franklin Roosevelt's "Assistant President," running the country while FDR fought the war and he was Truman's Secretary of State.[50] All three men were major figures in national and Southern politics and it is unlikely they watched the site selection process unfold without knowledge or interest.


The Augusta Chronicle

$260,000,000 H-bomb material facilities will be constructed in S. C. near Augusta

Allies facing 'new war'

Grim note is voiced by Gen. MacArthur

Aiken-Barnwell site is selected for plant

Shocked officials seek urgent steps

Plant means big boom for Augusta

Ellenton's residents stunned, but accept news patriotically

Front page of *The Augusta Chronicle*, November 29, 1950, reported on the announcement from several angles reflecting the many meanings the new plant would have for the country, the CRSA, and for those displaced by the proposed land acquisition.

The public announcement of the project signaled a new era in which the American public's right to know was at least partially fulfilled. Previous military atomic energy undertakings had been done in total secrecy as part of a wartime defensive effort. The Savannah River Project was complex and atypical as it was to be constructed during peacetime, its mission still required secrecy, and a government town was not to be constructed. The latter meant that the surrounding communities, which were fairly settled, were to absorb the new workforce estimated in the thousands and to create the infrastructure and services needed for this population increase. Public disclosure was warranted and unavoidable. A straightforward approach was chosen in which public outreach and partnership initiatives were advocated. Public meetings, lectures, project managers working with community development and business leaders, and the airing of a movie called *The Du Pont Story* in Augusta for business leaders and new employees were just some parts of the AEC and Du Pont's well-orchestrated strategy for strong and positive public relations.

Site Description

With the site survey behind them, Du Pont moved forward with site definition and acquisition strategies. When acquired, the site would contain about 200,646 acres or 310 square miles within Aiken, Barnwell, and Allendale counties situated within two sub-divisions of the Atlantic Coastal plain: the Aiken Plateau and the Alluvial terraces that lie along the river. Eighty percent of the site was situated within the Aiken Plateau, where elevations ranged between 300 and 385 feet. The terraces are composed of three tiers of varying widths banding the river. From north to south, six streams dissected the tract: Upper Three Runs Creek, Four Mile Creek, Pen Creek, Steel Creek, Hattie Creek, and Lower Three Runs Creek. Five streams empty into the river in a southwesterly direction, the sixth, Lower Three Runs, flows to the southeast and drains the eastern portion of the proposed site. Although irregular in shape, the site measured roughly 22 miles in width and 22 miles in length.

The proposed site was rural but not isolated. The nearest large urban centers in Georgia were Augusta (20 miles northwest), Atlanta (155 miles west and north), Savannah (85 miles to the southeast) and in South Carolina, Columbia (65 miles northeast). In addition, data was gathered on towns with populations of over 1,000 individuals

Meeting at Ellenton Auditorium, December 6, 1950. The U.S. Corps of Engineers real estate officers responsible for the land acquisition called a public meeting in Ellenton. A representative from each family was asked to attend the question and answer session. Reportedly, over 500 individuals attended what appears to have been a segregated meeting with attendees, both black and white, spilling out of the main hall into the building entries and lobby. Courtesy of SRS Archives, negative 1221-1.

within a 50-mile radius to the site. The project area contained seven communities: Ellenton and Hawthorne in Aiken County, and Dunbarton, Meyers Mill, Robbins, Leigh, and Hattieville in Barnwell County. Ellenton, a post-Civil War railroad community and local trading center, was the largest with a population of 600. Dunbarton, also a railroad town, had a population of 231 individuals. The remaining communities were smaller. Meyers Mill possessed some stores and a cotton gin while Leigh was synonymous with a box and crate manufactory, the Leigh Banana Case Company, that operated at that site between 1904 and 1954, employing about 300 people in 1950.[51]

Camp Gordon, Oliver General Hospital and its annex, Daniel Field, and the Augusta Arsenal were military installations less than 26 miles from the proposed site and six airports, five municipal fields on which there was a recapture clause in case of war and one USAF inactive airfield, that were within 40 miles.[52] The existing road system was composed of state highways that intersected with U.S. highways and in addition, there was a well-defined network of unpaved "farm to market" dirt roads. Rail service was already in place. The Charleston and Western Carolina (CWC) Railroad paralleled the river, providing service from Savannah to Augusta and the Atlantic Coast Line Railroad ran from Barnwell to Robbins where it joined the CWC line. The CWC ran through Ellenton and Dunbarton and the smaller communities were railroad stops on the line.

Three companies provided power to area residents and businesses: the South Carolina Electric and Gas Company, the Aiken Electric Cooperative, and the Salkahatchie Electric Cooperative. Two phone companies, Southern Bell and Cassels Telephone Company, were communications providers as were telegraph offices in Ellenton and Dunbarton. U.S. post offices were located in Meyers Mill, Ellenton, and Dunbarton.[53]

The acquisition process was handled over an 18-month period by the South Atlantic Real Estate Division of the U.S. Army Corps of Engineers on behalf of the AEC. The process formally began the day after the announcement so that the government would have the necessary lands either by declaration of taking or through actual purchase by June 30, 1952. The acquisition process was staged to accommodate construction requirements. Priority zones were established, rights of entry obtained, and property transfers swiftly occurred. Ultimately, 123,100 acres situated in Barnwell County, 73,462 acres in Aiken County, and 4,084 acres in Allendale County were acquired. Boundary realignments occurred as the acquisition process progressed, eliminating two of the four communities (Jackson and Snelling) that were originally within the project area and adding on a 4,453 acre corridor of land on both sides of Lower Three Runs Creek in Barnwell and Allendale counties.

Six thousand individuals were evacuated from their homes and homesteads. Some displaced owners moved their homes, joined neighboring communities, and worked at the plant. Business owners relocated and new businesses were spawned by the influx of plant employees, particularly during construction. Others sold their properties and left the area viewing the change as an opportunity. While a sense of patriotism motivated most of the project area residents, it was difficult for all involved as government appraisals were guaranteed to fall short when values were attached to land that had generations of farming and family life invested in its soil.

Some residents preferred to move their homes to locations outside the new federal site. Du Pont designated a House Moving Coordinator to handle the moves. All land was acquired by June 30, 1952. Courtesy, SRS Archives.

Site Layout

SRP was originally organized into nine manufacturing areas, a central administration area, and two "service"-building building areas known as the Temporary Construction Area (TC Area) and Central Shops. Between building areas, buffer areas were forested, masking the earlier landscape and providing a sense of distance and isolation. The areas were linked by a well-designed transportation system that included 210 miles of surfaced highways, a cloverleaf that was the first constructed in the state, and 58 miles of railroad track. Previous road names were erased and letter designations, such as Road A, Road B, etc., were assigned.

Each area was given a number and a unique letter designation (Table 1). Function was reflected in the area numbers; letters identified site geography. This code-like system, used first at Hanford for the identification of building areas and their associated facilities, and the road lettering system heightened the anonymous and utilitarian character that evolved at the site.

1956 Basic Information Map- General Areas.

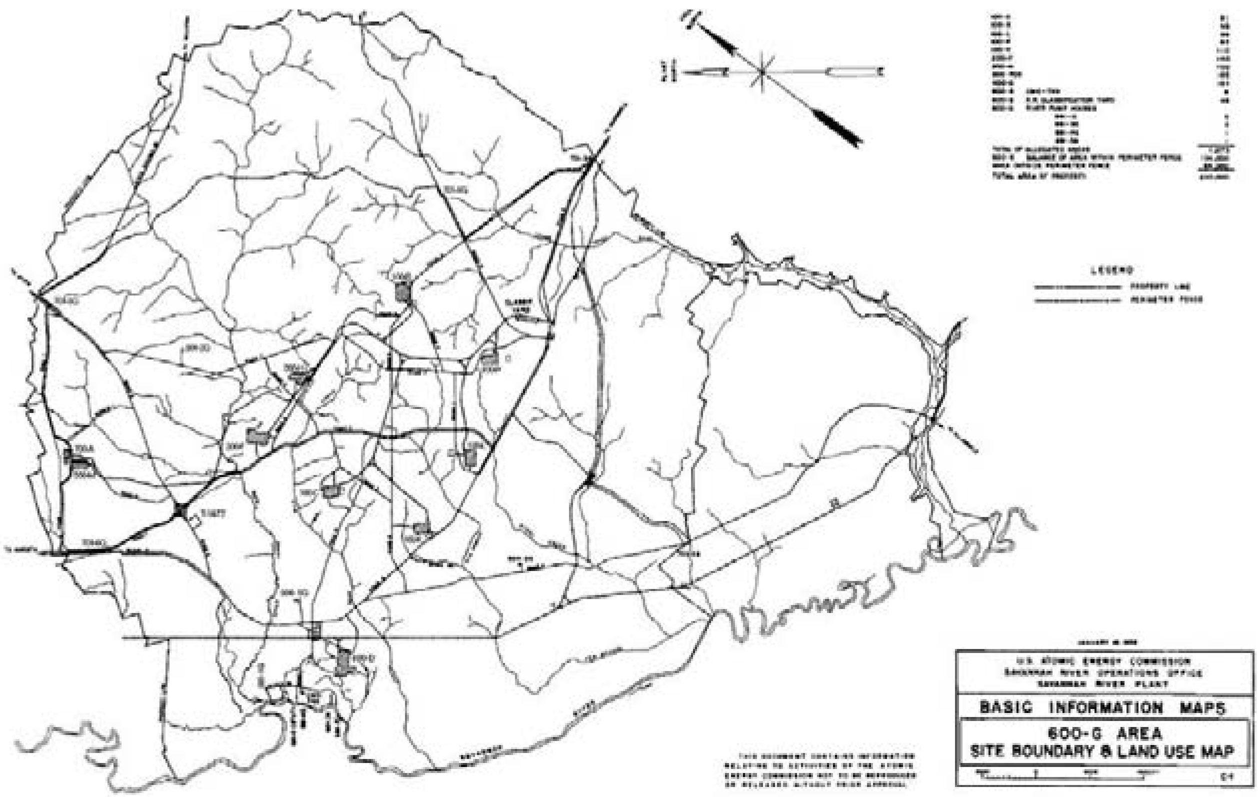


Table 1. Area Nomenclature

100 - Reactor Area	100-R, P, L, K, and C
200 - Separations Areas	200-F, H
300 - Fuel and Target Fabrication Area	300-M
400 - Heavy Water Production Area	400-D
500 - General (lighting, transmission lines, substations, etc)	500-G
600 - General	600-G
700 - Administration Area	700-A

Each 100 area, 100-R, 100-P, 100-L, 100-K, and 100-C, was situated within the manufacturing core in the central part of the site, aligned in an arc. After considerable discussion, the reactor areas were purposely dispersed at 2.5-mile intervals from each other and 6 miles from the site boundary to minimize the impact of an "atomic blast." Early maps show the site layout process and the reservation of space or alternative sites for future expansion. The *Engineering and Design History* notes that much discussion occurred between Du Pont and AEC consultants on where the process buildings should be located, however it was the U.S. Air Force that had the final word on their dispersal, suggesting that the pattern chosen had military ramifications.[54] Two river water pump houses, one at the mouth of Upper Three Runs Creek and a second two miles upstream from the first, supplied water to the 100 areas, primarily for cooling the heavy water coolant.

The 200 Areas, 200-F and 200-H, were also centrally located within the site's core area, approximately 2.5 miles from the closest reactor area and about 6 miles from the project area perimeter. The canyon buildings, massive concrete buildings, would dominate each separations area. F area contained four process buildings originally and was built to be self-sufficient. H Area did not contain the same process buildings but space was allotted for future expansion. Water to both 200 areas was supplied from deep wells.

The 400-D Area, located near the site's southwest perimeter approximately one mile from the river, housed heavy water production units and support buildings. Resembling an oil refinery, the 400 Area was characterized by three steel tall tower units, a flaretower, a finishing facility and other support buildings including a powerhouse. After SRP was closed to the public, this area was viewable from outside the site boundaries and the GS towers and flare tower was the visual image most area residents connected with SRP. A third river pump house supplied water to 400 Area.

The 300-M Area was situated near the northwest perimeter of the project area where it was laid out in a rectangle that adjoins the 700 Area. It contained testing and fabrication facilities for reactor fuel and targets. Two buildings, 305-M (now 305-A) and 777-M (now 777-10A), contained test reactors that were used to test the components manufactured in the 300 Area and to aid development and testing for SRP reactor design.

The 700-A Area was SRP's administrative and "service" center. It contained the main administration building noted in the excerpt above, the medical facility, communications facilities, patrol headquarters as well as a variety of maintenance and storage buildings. A Area also contained the Main Technical Laboratory, now Savannah River National Laboratory, in which plant processes were researched, designed, and tested, and other research facilities.

Finally, two pilot plant facilities, CMX and TNX, were located near the 400 Area. The former was designed to run corrosion tests on heat exchanger equipment installed in the reactors and to investigate what types of water treatment processes were needed for plant operations. A small pump house accompanied it. The latter was a pilot plant for processes completed in the 200 area canyons.

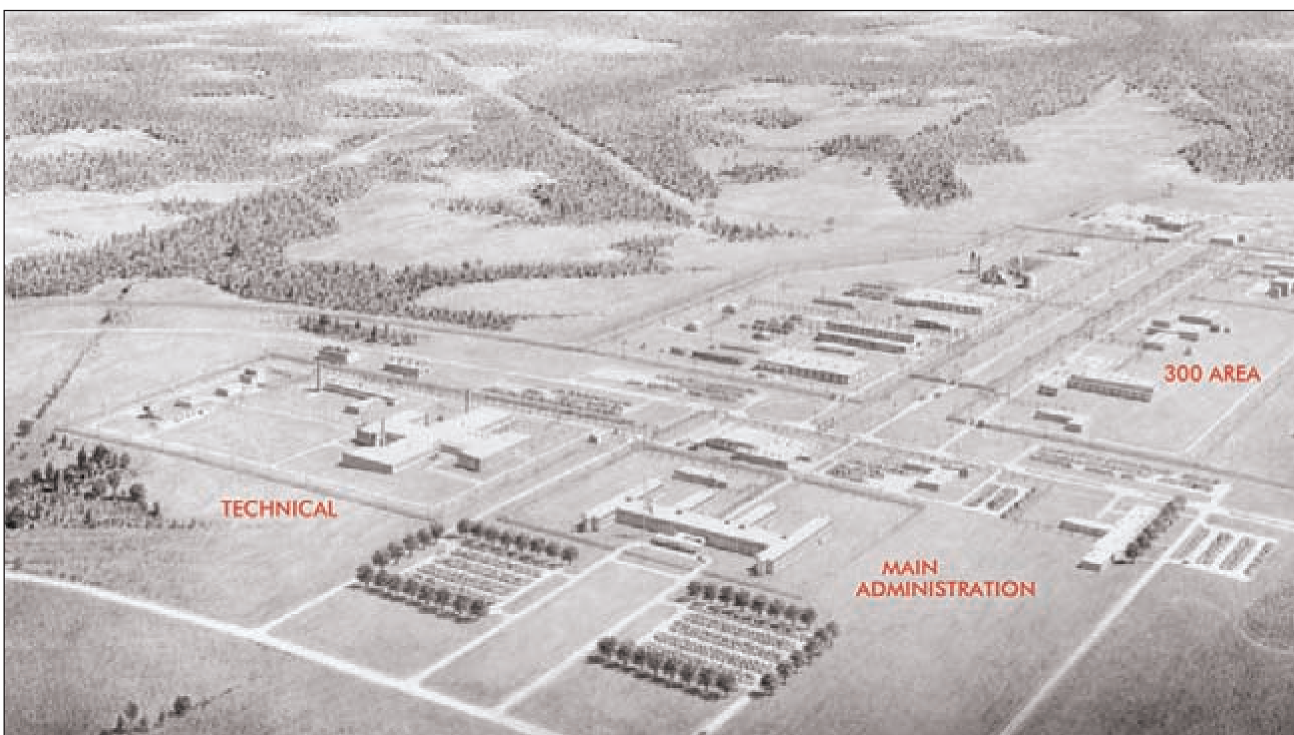
Nine coal-burning powerhouses located in the building areas supplied steam to the process areas and the overall site. The large pipes that carried the steam are above ground, arching over roadways where necessary and paralleling the road system. Outside the manufacturing and service building areas, general facilities needed for either process support or general site support included three-river water pump houses, a pilot plant, railroad classification yard, and burial ground for solid wastes.

The first generation of buildings at SRP was simply designed using a functional ethic. The AEC's specification that the project's buildings be spartan in their design was a done deal given the climate of American post-war industrial architecture. The choice of building materials, reinforced concrete and transite paneling, were mandated by the building code. Articulated in reinforced concrete or steel frame with transite panels, the majority were beige or gray boxes built for maximum flexibility and for government service. Their uniformity in color, their number and size, and their geometric forms create a harmonious grouping of buildings within an ordered industrial landscape where form reverberates function. This functional perspective is further emphasized by the placing of the Site utilities aboveground so that massive pipes parallel roads or arch over them. Economically motivated, this design feature has strong visual impact.

Subcontractors

It was recognized from the start that Du Pont Engineering Department would need supporting organizations to complete the project given its size and schedule. Temporary use was made of the Bush House located on Highway 19 as the Field Construction Office and a tenant farmer's dwelling was adapted for use as the Field Cost Office. The need for immediate construction buildings while Du Pont was organizing called for the hiring of a local architectural and engineering firm, Patchen and Zimmerman of Columbia, SC, to get things off the ground.[55] This firm's design work at the TC Area with its two massive cartwheel buildings and the adjacent cloverleaf created one of the most visually appealing layouts on site.

Engineering and design assistance to Du Pont was provided by the following subcontractors: American Machine and Foundry Company, Blaw-Knox, the Lummus Company, Gibbs & Hill, Inc, and Voorhees, Walker, Foley & Smith. Each of these firms had demonstrated experience in their respective areas and each made significant contributions to the equipment and SRP building stock.



Architectural Rendering of the Main Administrative Area (700-A) and the Fuel and Target Fabrication Area by Architects Voorhees, Walker, Foley & Smith, ca. 1951

Table 2. Subcontractors for Du Pont Project 8980.

American Machine and Foundry (AM&F) - This firm was charged with the design and fabrication of special mechanical equipment for use in the 100, 200, 300, and 400 area process facilities. AM&F described their firm as manufacturers of machines for industry. In 1950 they were considered the world's largest manufacturer of cigarette and cigar making equipment.[56]

The Lummus Company - This firm was requested to design and partially procure six "GS" units (towers 116' in height) including the DW and finishing plants for the 400 area heavy water production facilities. This firm brought strong petroleum, petrochemical, and chemical experience to the project. Self described as a network of men, minds, and machines that were dedicated to transforming ideas and capital into profit earning processes and equipment, the Lummus Company, international in scope and headquartered in New York, were expert in the design of distillation processes.[57] The 400-area design benefited from an agreement between the Girdler Corporation, which had designed the Dana Plant, and the Lummus Company for the exchange of technological information gained from the Dana Plant that could be applied at SRP.[58]

Blaw-Knox Company - Design of process buildings and equipment required in 200 area facilities, general area facilities (600 area) related to 200 area processes.

Gibbs & Hill, Inc. - Design of steam, water, and electrical facilities for process areas and overall plant. This engineering firm based in New York was subsumed by Dravo Corp of Pittsburgh in 1965 then later sold to Hill International, a New Jersey based firm.

Voorhees, Walker, Foley & Smith - This New York architectural/engineering firm was responsible for the design for all "service" buildings including laboratories and general facilities including roads, walks, fences, and parking areas; the manufacturing buildings in the 300 area; laboratories; some design work for 200 areas and overall site clearance at SRP. It was also responsible for Du Pont's Experimental Station in Wilmington, the MED laboratories at Columbia University and Argonne National Laboratory.[59]

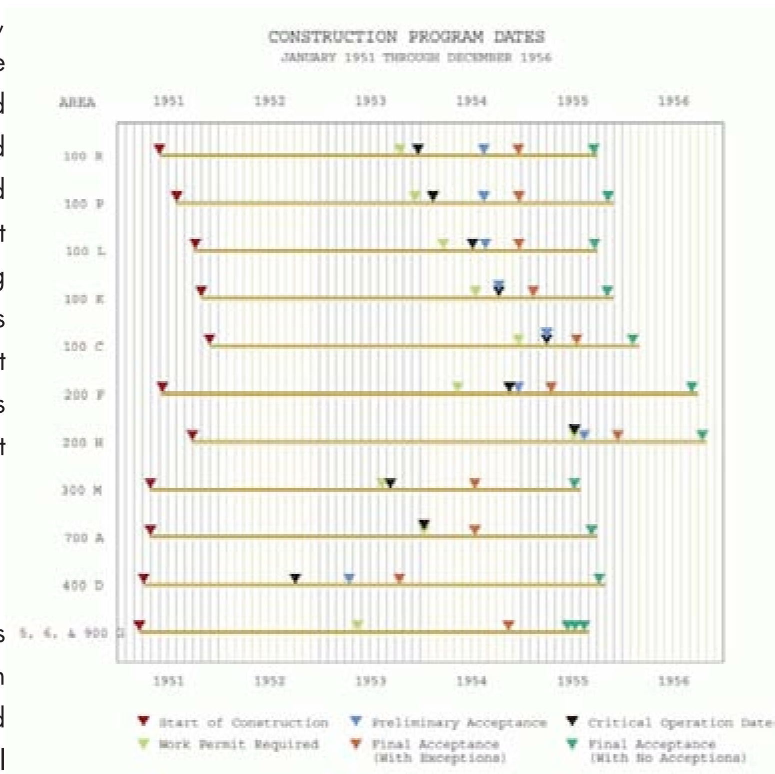
New York Shipbuilding - This firm was responsible for fabricating the five reactor vessels that were transported by barge to the South Carolina site. Known as the NYX Program, this effort produced the cover plate of the reactor vessels known as the "plenum" (a laminated steel plate 19 feet in diameter, four feet thick, weighing about 100 tons, and drilled with 500-4-inch tubes), the reactor vessels, and the primary piping.[60] Organized in 1899, New York Shipbuilding was located on the banks of the Delaware River in South Camden, New Jersey. The firm brought its experience in the fabrication of heavy industrial equipment and machinery to the task. A company history notes that the firm had taken on projects as "a public service where the facilities of the Yard provided the only available means for constructing unusual items. Its location on tidal waters, with weight handling equipment up to 300 tons, makes it possible to load assemblies which may be beyond the size or weight limitations for shipment by rail."[61] These qualities were probably well known to Du Pont who also had a plant in the Camden area.

Unfolding Scope of Work and Flexible Design

By Hanford standards, the 38 months from start of construction to operation for C reactor at Savannah River was quite slow. However, by the standards of a later generation of nuclear engineers, such a pace would appear incredibly rapid. The placing of R reactor in operation in December 1953, when the conceptual design had only been sketched out in December 1950, seemed to later nuclear specialists a remarkable achievement in engineering and management.[62]

The scale, shape, and funding of the Savannah River Project and the mix of plutonium, tritium, and other radioisotopes to be produced in its reactors was determined by the AEC. The schedule was set by world events. Du Pont's design team, in association with their primary subcontractors, was responsible for translating the larger conceptual design outline by the AEC into reality within an atmosphere of "urgency and commitment."[63] Du Pont designers accomplished their goals using a "flexible design" approach. This approach operated at two levels: the first entailed postponing design decisions until the best design could be determined by research or through consultation, and the second was to build in the potential for future design options should AEC policy change.

In the first scenario, Du Pont designers based some design decisions on their experience from previous atomic energy plant construction projects and from scientific research completed at the AEC's national laboratories. This allowed them to move forward with production in some areas while alternative design choices were researched for others. In the second scenario, postponement of design was necessary as part of the current and future client-contractor relationship. AEC directives, based on Department of Defense guidance on what product or product mix was needed for its weapons program, directly translated into design decisions. Du Pont recognized this as an integral feature of their contract and responded with aplomb to an evolving scope of work. Their ability to do so was characteristic of the firm's management that had an internal set of departmental checks and balances and well-honed procurement strategies.[64]



Bar Graph showing the construction schedule and the milestones reached. Source: Engineering Department, E. I. Du Pont de Nemours & Co., Savannah River Plant Construction History, Volume I, DPES 1403, 1957.

SRP Operations, 1955 - 1989

As an integral part of the nuclear weapons production complex, SRP's primary mission has been first to produce tritium, and second to produce plutonium and other special materials as directed by DOE and its precursor organizations.[65] Its role was not one that can be described as one step along a linear process, but rather as one of the hubs of material movement through the complex. Table 3 shows how the site was integrated into the overall nuclear weapons complex and the direction of material flow that established the relationship.

Table 3. Direction of Flow of Materials into and from the Savannah River Site to other Sites Within the National Nuclear Weapons Production Complex

Other Sites Within Complex	Direction of material flow	SRP Area	Type of Material
FMPC and Weldon	To	300 Area	**Raw Materials:** natural and low enriched uranium for fuel and target manufacture
Oak Ridge Site Y-12 Plant	To	300 Area	**Isotope enrichment:** highly enriched uranium for fuel and target manufacture
Oak Ridge Site Y-12 Plant	To	300 Area	**Isotope enrichment:** Lithium for target manufacture
Oak Ridge Site Y-12 Plant	From	400 Area	**Isotope enrichment:** Heavy Water for deuterium production and deuterium gas
Dana Plant	To	100 Area	**Isotope enrichment:** Heavy Water for moderator and coolant
FMPC and Reactive Metals, Inc.	From	300 Area	**Fuel and Target Fabrication:** depleted uranium for fuel
Weldon Spring Plant, FMPC, Oak Ridge Site K-25 Plant, and Paducah Gaseous Diffusion Plant	From	200 Areas	**Separations** (for raw materials recycle): low enriched uranium for recycle
Oak Ridge Site Y-12 Plant	From	200 Areas	**Separations** (for raw materials recycle): highly enriched uranium for recycle
Rocky Flats	From	200 Areas	**Separations:** plutonium metal buttons for pit production
Mound Plant	To	200 H Area	**Separations/component manufacture:** recovered tritium for purification and reuse
Pantex Plant and Iowa Army Ammunition Plant	From	200 H Area	**Separations/component manufacture:** filled tritium reservoirs ready for assembly

Source: USDOE Office of Environmental Management, *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to their Environmental Consequences* (Washington, DC: USDOE Office of Strategic Planning and Analysis, 1997), 18-19, 154-155.

Heavy Water Production and Rework

The Heavy Water plant at SRP (the D Area) used the Girdler Sulfide (GS) process of hydrogen sulfide-water exchange. This portion of the plant, completed in 1952, included 144 process towers ranging from 6.5 to 12 feet in diameter, each 120 feet tall.[66] Between 1952 and 1957, the D Area plant and the heavy water plant at Dana, Indiana, supplied most of the heavy water for the nuclear weapons production complex. A sufficient stockpile of heavy water had been accumulated by 1957 to allow the closure of Dana and of two-thirds of the Savannah River units. The remaining units continued to operate until 1982, primarily to reconcentrate heavy water that became diluted during reactor operations. During its 30 years of operation, D Area produced over 6,000 tons of heavy water.[67]

In the spring of 1953 a small plant was constructed in D Area to produce deuterium gas from heavy water by electrolysis. Some of this deuterium was used at Savannah River in the Tritium facility (tritium reservoirs were actually filled with a mixture of tritium and deuterium), and some was sent to the Oak Ridge Site to be converted to the lithium deuteride used in the secondary assemblies of thermonuclear weapons. A second, larger deuterium plant was constructed in D Area in 1954.[68]

Fuel and Target Fabrication

The manufacture of early reactor fuel elements, or slugs, was fairly straightforward. Although there had been problems in the early fabrication process at Hanford, the lessons learned there allowed SRP production in the M Area to proceed with relatively few problems. The slugs were solid natural uranium rods about one inch in diameter and eight inches long, clad in aluminum. The uranium rods were fabricated by the FMPC and shipped to Savannah River. The metallurgical structure of the uranium rods was adjusted (first at Savannah River, later at FMPC prior to shipment); the slugs were then sealed in aluminum.

Lithium target slugs were also needed for the production of tritium, and for use as control rods in the reactors. Lithium was sent from the Oak Ridge Site to Savannah River Building 320-M, where it was alloyed with aluminum, cast into billets, extruded to the proper diameter, cut to the required length, and canned in aluminum. The lithium-aluminum slugs were also encased in aluminum sheaths, called raincoats. At Savannah River, tritium was initially produced as a reactor byproduct in the lithium-aluminum control rods. As AEC requirements for tritium increased, reactor elements specifically designed for tritium production were needed. Driver, or fuel, elements of highly enriched uranium were used to provide the neutrons for irradiating the lithium-aluminum target elements. Enriched uranium drivers were extruded in 320-M until 1957, after which they were produced in the newly constructed 321-M, built specifically for this process.[69]

The M Area at Savannah River continued to produce most of its own fuel and target assemblies until the end of the Cold War. Revisions and upgrades were made to the facilities, as needed, one of the most important being the change from solid slugs to tubular elements. The production of solid slugs ended late in 1957. Production in the M Area increased and decreased with the needs of the reactors. The last large increase was in 1983, when the operations in 321-M went to 24 hours a day. Operations fell off as the reactors closed, and for the most part have ceased altogether since 1989, when the last reactor was taken off line.[70] This report provides a more detailed account of SRP's 300/M Area's genesis and operations history in the following chapters.

Reactor Operations

There were five production reactors operating at the Savannah River Plant during the Cold War, identified as C, K, L, P, and R reactors. The first SRP reactor to go online was the R reactor, which was tested for integrity and operability during the fall of 1953 and brought to criticality in December. The first few months of operation were problematic because instruments triggered frequent automatic power reductions and "scrams," or unscheduled emergency shutdowns. Improvements to the instrumentation and signal systems mitigated these problems, and the number of scrams, one a day in February 1954, fell to an average of one in three days in May. P reactor was the second to go critical, the event occurring on February 20, 1954. The first irradiated fuel was discharged from R reactor the following June, and all five reactors were operating by the end of March 1955.[71]

Changes were quickly made to both how the reactors operated and to the reactors themselves. Although Savannah River was originally intended as a tritium production site, the lithium-aluminum slugs from which tritium was produced were at first used only as control rods, and tritium was produced as essentially a byproduct of plutonium production. However, AEC requirements for tritium production had increased by 1955, and that year the reactors were loaded in configurations specifically meant to produce tritium. As operators found they could increase the power levels at which the reactors operated, they began adding extra heat exchangers to eliminate the increased heat. C reactor had 12 heat exchangers, but the other four reactors only had six, a necessary shortcoming due to limited supplies of heavy water and vender production capabilities during the construction period. The number of heat exchangers was increased to 12 on all reactors in 1956, and the original power output of 378 megawatts was increased to 2,250 megawatts.[72] A megawatt, as used in reference to production reactors, is not a measure of electrical generation but of thermal output, a convenient measure of the operation of a reactor.

To further increase the capabilities of the cooling system, a large retention lake was created. Heavy water was used to remove heat from the reactors, and light water from the Savannah River was used to remove heat from the heavy water. The increase in the amount of heat being removed via the heavy water meant a concurrent increase needed to be made in the amount of heat being removed by the light water. Unlike the heavy water, the light water was returned to the river, so a means of dissipating its heat before returning the light water to the environment was necessary. The 2,600-acre P and R (PAR) Pond was constructed for this purpose, and was integrated into the cooling system in 1958. All the cooling water from R reactor then was routed to Par Pond, and a portion of P reactor water was sent out via Par Pond. The new reservoir not only served as a means of cooling water, it also created an additional source of cooling water for P and R reactors, which produced savings in pumping costs. Since they would then be drawing less water from the Savannah River, more would be available for the other three reactors. This and further improvements in the light water circulating system allowed C reactor to be brought to a power level of 2,575 megawatts in 1960, and to eventually reach its all-time peak of 2,915 in 1967.[73]

Another major change in reactor operations came with the use of computers. Computers were first used to monitor the 3,600 reactor process sensors on an experimental basis in K reactor beginning in 1964. The experiment was successful, and the system was added to the three other then-operating reactors (R reactor had been placed on standby in 1964) by the end of 1966. In 1970, a closed loop control system began trial operation at K reactor.

Computers were used to assess information from the sensors, and to make adjustments to groups of control rods based on that information. Using computers to do this was another means of optimizing reactor performance. In the late 1970s, new computer systems were installed to provide safety functions and to monitor and add additional control over reactor operations.[74]

By 1970, the heyday of reactor operations had passed. R reactor was shut down in 1964 due to a lack of demand for reactor-produced products, and L reactor was placed on standby status in 1968 for the same reason. C, K, and P reactors continued to produce tritium, plutonium, and other isotopic elements as directed by the AEC in pursuit of both military and non-military programs.

Separations

Operations at the Savannah River Plant included two main types of separations: combined plutonium and uranium extraction, and tritium extraction. The former was conducted primarily in the canyons in F and H areas. The F Canyon went into operation in November 1954, and the H Canyon was online the following July. In these two buildings, the fuel elements that came from the reactors were dissolved in acid to separate the uranium and plutonium from waste fission products by chemical extraction in solution. Tritium separations took place in two much smaller areas. Slugs irradiated to produce tritium were initially sent to a building in the F Area, which started operating in October 1955, where the slugs were melted, instead of dissolved, to release the gaseous tritium. After melting, the tritium was purified by a process known as thermal diffusion. Tritium extraction was moved to its current location in H Area a few years later.[75]

The two canyons were originally designed to operate using the Purex process by remote operation and maintenance—which meant that the process areas were not designed to be entered by personnel on a routine basis. During the first year of operation, the F Canyon attained its designed throughput level of three metric tons of uranium per day. Modifications to the H Canyon by applying lessons from early operations in F Canyon allowed H Area operations to see a throughput of seven tons per day.[76]

In early 1957, the F Area canyon was closed down so that substantially larger equipment could be installed to increase throughput, and so that a new facility to convert the plutonium to metal could be built on the canyon roof. This would more than double the capacity of the canyon. The modifications took two years to complete, and the F Canyon went back into operations in March 1959, with a capacity to process 14 tons of uranium each day.[77] As soon as F Area was back in operation, H Area was shut down for conversion to a modified Purex process designed to safely recover enriched uranium from target elements then beginning to be used in the SRP reactors, a change that took only three months. H Canyon was back in operation by June.[78] Many more minor modifications of the canyons followed over the years to allow products other than uranium and plutonium to be recovered, but the fundamental processes for extracting plutonium and uranium remained essentially the same throughout the Cold War.

The first tritium facility was located in Building 232-F. A 232 building was also constructed in the H Area, but it was not completed during the initial phase of construction. The H Area tritium building was outfitted for production in 1956, and by the end of the year two lines were operating. Tritium was originally shipped elsewhere for placement in the reservoirs, but by 1957 this was completed in Building 234-H. In August of the following year, tritium began being recycled in this facility as well. Tritium processing capacity in the H Area facilities was doubled in 1958, and the F area 232 facility was closed that autumn. A new facility, the Replacement Tritium Facility, went into operation in 1993, and it continues to perform the tritium mission today.[79]

Waste Management

In general, the waste facilities at Savannah River were modeled on those at Hanford but modified somewhat since the radioactivity of the high-level wastes would be greater than those at Hanford. The original tanks each had a capacity of 750,000 gallons, were supported by internal columns, set on top of a steel pan to catch any leaks, and encased in concrete. Separate tanks were provided for high- and low-level wastes, and the high-level units were provided with cooling coils to remove heat generated during the decay of the wastes (cooling coils were added to all these tanks in 1955). Waste evaporation facilities were also provided as a means of reducing waste volume.[80]

Eight such tanks were originally built in the F Area, and four in the H Area (with space for four additional tanks set aside), each buried under at least 9 feet of soil. Four more tanks were approved for H Area in 1954, due to expected increases in the throughput of H Canyon. These four tanks were larger, each having a capacity of 1.07 million gallons, but other details of design were essentially the same as that of the original 12 tanks. They were constructed in 1955 and 1956. By June 1955, the first high-level waste tank was already full, prompting efforts to reduce the volume of waste sent to storage.[81]

Four single-wall tanks for low-heat high-level wastes were constructed in the F Area in 1958, and four in the H Area in 1962. These tanks have caused numerous problems due to leakage through fine cracks caused by the reactions of the solutions stored there with the materials in the tank walls. However, only one of the original 12 tanks has leaked substantially. Four others have deposits on the outside of the tank walls that may indicate leakage, but no leaks have been found. An additional 27 tanks, each with a capacity of 1.3 million gallons, have been constructed since 1962. These are all similar in design to the initial tanks, except the catch pans extend the full height of the tanks, rather than only five feet, as with the initial design.[82]

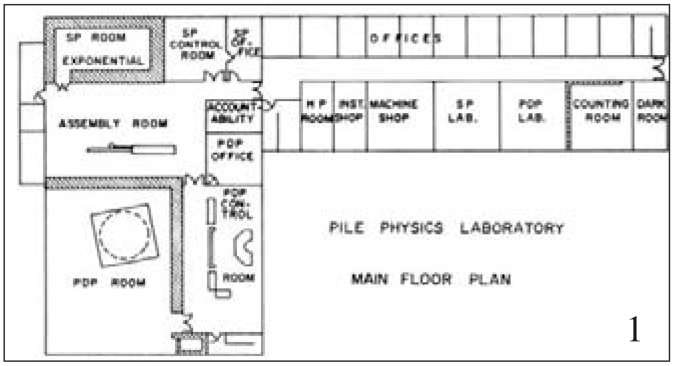
Two burial grounds serve as the disposal site for solid wastes. The original burial ground occupied about 76 acres and was used from 1953 until 1972. The second, larger burial ground has been used since 1972; it covers approximately 119 acres. Solid low-level waste from all plant areas were buried there, with special areas set aside for items with higher levels of radiation or with plutonium fission products. The TRU solid wastes were buried in designated sections of the burial ground early on but, by the early 1980s, they were being stored on concrete pads in containers that allowed for later retrieval.[83]

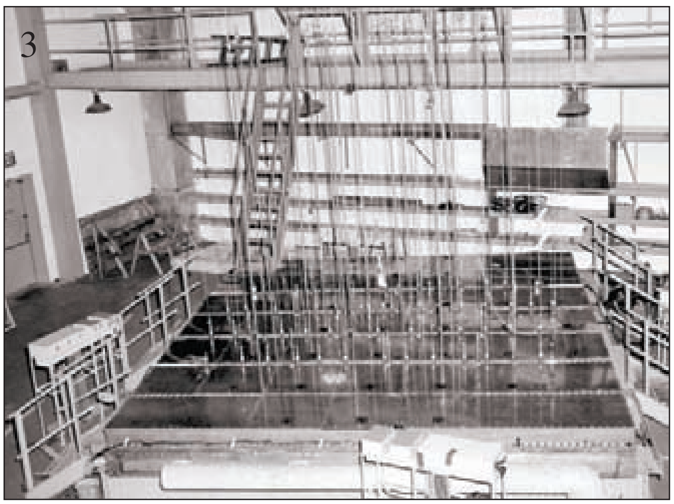
Research, Development, and Testing

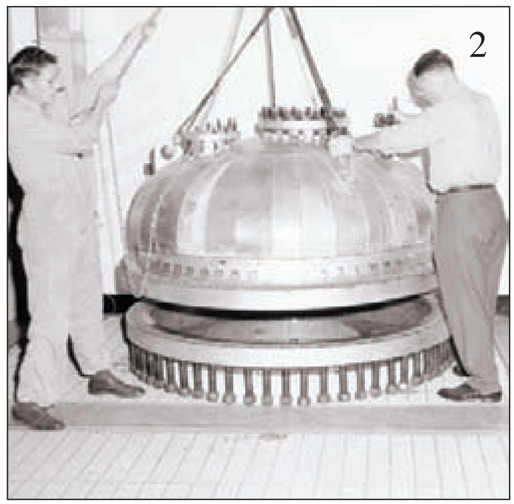
The scientists and researchers at the Savannah River Laboratory (SRL) were responsible for research and improvements in process design in support of SRP's operations. From the beginning, it was noted that neither heavy-water moderated reactors, nor the Purex process, had ever been operated on an industrial scale.[84] Also,

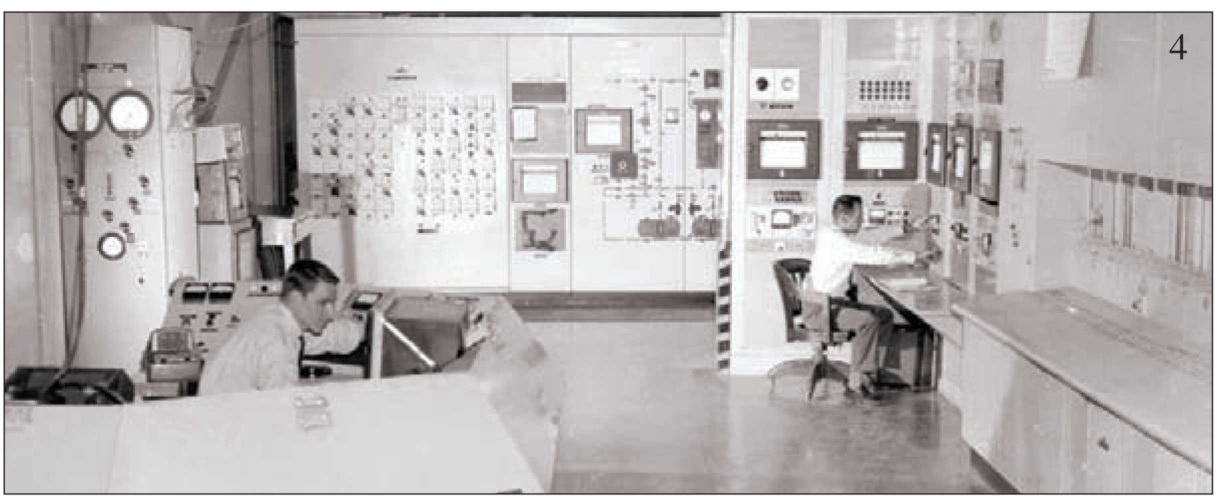
Savannah River's Test Reactors

1. Pile Physics Laboratory floor plan. This facility housed three test reactors used by SRL researchers. The reactors were placed under the high-hat area of the building. Courtesy of SRS Archives, negative DPSTF-83. 2. Pressurized Subcritical Experiment (SE) test reactor in Pile Physics Laboratory that was used to measure nuclear parameters at high pressures and high temperatures. When built, it was the first of its kind. Courtesy of SRS Archives. The Standard Pile (SP) was designed and constructed by the General Electric Company and was similar to the Thermal Test Reactor at Knolls Atomic Power Laboratory. (Not shown). 3. Fuel elements were placed in the Process Development Pile (PDP), a zero-power test reactor used for physics research. Courtesy of SRS Archives, negatives DPSTF 1-2613, 1-2536. 4. PDP control room. Courtesy of SRS Archives, negative DPSPF-8929-13.



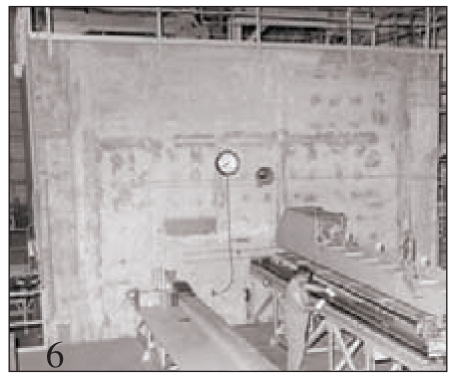






People, Research and Development

5. Graphite Test Pile control room in 305-M. Courtesy of SRS Archives, negative 2023. 6. Face of Graphite Test Pile, Courtesy of SRS Archives, negative 38887-1. 7. Interior of Heavy Water Components Test Reactor. Courtesy of SRS Archives, negative DPSTF-6027. 8. Aerial of Heavy Water Components Test Reactor (HWCTR). This test reactor facility was decommissioned in 1997. Courtesy of SRS Archives, negative 7885-G.



the versatility of the reactors called for the development of new fuel and target elements. The need to explore the safety and process issues involved called for the installation of laboratory facilities that were fully equipped to allow research and experimentation on a laboratory or micro scale of the processes that were writ large in the process buildings. Consequently, the general laboratory area that was established in A Area was fitted out with sand filter systems and waste treatment facilities. The main research facilities were: the main laboratory; 777-M (later 777-10A), an experimental physics laboratory; process pilot plant facilities CMX and TNX (also referred to as semiworks); 735-A, the Health Physics Laboratory; and 723-A, the Equipment Engineering laboratory.

SRL, the main laboratory, was the focus of separations technology studies, metallurgical research and development, heat transfer studies, and radiation monitoring. Its "High Level Caves" allowed chemical and metallurgical equipment studies on highly radioactive materials behind heavy shielding windows and the Isotopes Process Development Laboratory allowed radionuclides to be encapsulated for use as targets.[85] After 1983, the testing of new fuel and target elements was moved from CMX to SRL. The TNX Semiworks Facility, a pilot plant, was equipped with instrumentation and stainless steel equipment for "cold" processing for chemical engineering studies on a larger scale afforded by the main laboratory facilities.

777-M, later designated 777-10A, the Physics Laboratory, contained three test reactors: the Process Development Pile, the Standard Pile, and the Subcritical Experiment. These test reactors allowed scientists to provide experimental measurements needed to test reactor charge design. While computers would eliminate the need for these test reactors in the 1980s, they were integral to the safe and successful operation of SRP's five reactors, as reactor charges were first tried out in the laboratory environment prior to their use in reactor operation. The reactor designers who used the test reactors in 777-10A used slide rules, mathematical tables, and desk top calculators to make the calculations that would later be generated by computers.

In addition to the central mission of supporting plant operations, a second laboratory system was established at SRP devoted to environmental studies. Savannah River Ecology Laboratory (SREL) was first housed in the Forest Service area but was given a new building in 1977 in A Area where it is surrounded by a complement of environmental laboratory facilities that range from duck pens to greenhouses. SREL and a consortium of other research programs conducted by the Savannah River Forest Station (SRFS), Savannah River Archaeological Research Program (SRARP) and Du Pont conduct research on disparate ecological topics that range from reptile studies, aquatic insects, restoration of degraded habitats, reintroduction of endangered species, and investigations into the Site's cultural history. SRS was designated as the first National Environmental Research Park (NERP) in 1972 as a result of the National Environmental Policy Act (NEPA), the Energy Reorganization Act and the Non Nuclear Energy Research and Development Act. Under these acts, the Site area became an outdoor laboratory set aside for national environmental goals in ecological research, research into the effects of nuclear energy on the environment, and finally, the disposition of this area is reportable to the public.

DEVELOPMENT OF PEACEFUL USE OF ATOMIC ENERGY, AND ITS IMPACT ON SRP

The tug-of-war between military and non-military applications of atomic energy was present at the inception of the AEC. Senator Brien McMahon of Connecticut championed civilian control over atomic power, and his bill, which became the Atomic Energy Act of 1946, barely beat out others that championed direct Army control.[86] Congress passed the McMahon Bill in July, and Truman signed it into law the following month. According to this act, the AEC was to become effective December 31, 1946/January 1, 1947.

After advice or directives had filtered through the Commission, the Office of the General Manager carried out the directives, with work divided into various divisions, such as Production, Raw Materials, Military Application, Research, Engineering, Biology and Medicine, and Administrative Operations.[87] Even though the AEC's main mission was defense-related (peaceful use of the atom was not even a formal part of the Atomic Energy Act of 1946), civilian control meant that there was always a push at the AEC to justify atomic energy use for non-military purposes.

The early leadership of the AEC certainly demonstrated this interest in the non-defense mission. David Lilienthal, appointed as the first chairman of the AEC by Truman in October 1946, was himself a strong proponent of the peaceful use of atomic energy, taking his case to the public in a number of articles that tried to correct the popular perception that nuclear energy was just for bombs.[88] Among the peaceful uses of the atom listed by Lilienthal were the control of disease, new knowledge of plants and the workings of the natural world, and even incredibly cheap electricity provided by nuclear power plants.[89]

During the Korean War, 1950-1953, little was heard about the peaceful use of the atom. With the close of that conflict, however, President Eisenhower reopened this potential with his "Atoms for Peace" address at the United Nations on December 8, 1953.[90] In direct response to this initiative, Congress passed a new Atomic Energy Act in 1954 that essentially amended the original act to allow for international cooperation in the development of atomic energy and in the civilian use of atomic energy. This allowed domestic utility companies to build and operate nuclear power plants.[91] The 1954 Atomic Energy Act not only broadened the scope of the AEC, but also allowed nuclear energy to be used outside of its purview. While peaceful uses of the atom had always been an interest of the AEC, it was now an official part of its charter.[92]

Purely scientific studies, like the neutrino research conducted at SRP in 1955-1956, were just the beginning of the non-defense mission conducted at AEC facilities. In addition to the Oak Ridge School of Reactor Technology, established in 1950, the AEC sponsored a five-year reactor development program in the mid-1950s, designed to test five experimental reactors for potential use.[93] Out of this work came two broad agendas: the breeder reactor program, which was largely for the Navy, which was keenly interested in nuclear power for ships and submarines; and power reactor research for civilian use.

The use of nuclear power for the production of electricity was first done in December 1951 at the National Reactor Testing Station (later, the Idaho National Engineering Laboratory). In 1955, this capability was expanded to

Arco, Idaho, the first U.S. town to be powered by nuclear energy.[94] The development of commercial power reactors soon spread to selected spots throughout the country, using reactor types that varied from the heavy-water cooled and moderated variety found at SRP and favored by the AEC, to the light-water reactors favored by the Navy. Other reactors, like Hanford's N-Reactor, were dual purpose, capable of both nuclear materials production and power.

The AEC favored the development of heavy-water power reactors, and the SRP was closely involved in the AEC plans to provide this technology to commercial utilities throughout the country. By the late 1950s, heavy-water power reactor studies were commonly produced at the Savannah River Laboratory, and these studies culminated in the design and construction of the Heavy Water Components Test Reactor (HWCTR), built and operated at SRP in the early 1960s.[95] During this same period, and drawing on technical data obtained from HWCTR, the Carolinas-Virginia Tube Reactor, near Columbia, South Carolina, became the first heavy-water moderated power reactor in the U.S.[96]

Despite AEC efforts to push heavy-water power reactors, the example of HWCTR and the Carolinas-Virginia Tube Reactor was not generally emulated in the United States (HWCTR itself was closed down in 1964).[97] As early as 1962 U.S. utility companies showed a clear preference for light-water reactors.[98] These reactors, using pressurized light water, were based on research that came out of the U.S. Navy's reactors program, especially the Navy's light-water reactor at Shippingport. Ironically, the AEC "Atoms for Peace" program, which provided partially enriched uranium to commercial reactors, worked against the AEC heavy-water reactor program: heavy-water reactors might have been more popular if utility companies had been forced to use natural uranium.[99]

Speaking in 1963, Lilienthal described Eisenhower's "Atoms for Peace" initiative as "still alive, but in a wheelchair."[100] While almost surely in reference to the international aspect of that initiative, Lilienthal's comment could be said to apply to the AEC's program to spread heavy-water power reactor technology to U.S. utility companies. Despite considerable research and achievements, the program simply did not progress in the direction intended.

With the reduction of the AEC's military mission in 1964, the stage was set for another series of programs to further develop the peaceful use of the atom. These new initiatives were two-fold: provide isotopic heat sources for the U.S. space program, then becoming a major national concern; and contribute to the transplutonium programs that were pushed by Glenn Seaborg, one of the discoverers of plutonium and chairman of the AEC from 1961 to 1971.

Among the isotopic heat sources produced for the space program was cobalt-60, desirable because it did not produce a decay gas.[101] Another isotopic heat source requested of the AEC was curium, and the production of this material dovetailed with the transplutonium program.[102]

The heavy-water reactors at SRP were pivotal to the transplutonium campaigns, which began with the production of curium during the Curium I program (May-December 1964). The successful attempts to produce curium and other heavier nuclides led to a succession of programs conducted at SRP and coordinated throughout AEC facilities nationwide. These programs included the High Neutron Flux program, both at SRP and at Oak Ridge, where the High Flux Isotope Reactor (HFIR) began operation in 1965.[103] Curium II (1965-1967) completed the required production of curium, and provided a start for the most ambitious of the transplutonium campaigns: the production of californium. The Californium I program (1969-1970) was designed to produce enough californium to make the isotope available to industry and private sector interests.

The production of californium went hand-in-hand with the Californium Loan Program, sponsored by the AEC to help create a potential industrial and medical market for this powerful neutron source.[104] Despite the best of intentions, however, most of this work was in vain. Even though samples of californium were distributed to willing participants throughout the country and elsewhere in the 1970s, no viable market developed for what was still an expensive isotope with a relatively limited application.

The problems inherent in the Californium Loan Program were ones that plagued other potential applications of atomic energy for non-military use: the expense was simply more than the limited market would bear. The transplutonium programs, while wildly successful as scientific endeavors, failed to take up the slack left by the reduction in the defense mission. In the case of SRP, the production reactors were just too expensive to maintain and operate for the production of non-defense nuclear materials.

When the defense mission went into eclipse in the late 1980s, the non-defense mission, especially that for production reactors, went into decline as well. The close of the Cold War in 1989 solidified the forecast for Savannah River and the other production sites. The rise of environmentalism in the 1970s had already made inroads into nuclear progress, changing American attitudes about the safety of nuclear production plants and nuclear power plants. The promise of nuclear energy was increasingly called into question and new regulators and environmental regulations were placed into effect. While the ramp up of military might under Reagan characterized the start of the decade, by its close, world affairs and changing public opinion created new missions related to environmental clean-up and restoration rather than nuclear materials production.

ENVIRONMENTALISM, EXPANSION, AND CHANGE AT SAVANNAH RIVER

At the end of the Carter Administration and throughout the Reagan years (1980-1988), there was a resurgence in the production of nuclear weapons materials. This reaffirmation of the nuclear weapons complex was opposed by the environmental movement and then halted by the end of the Cold War. All of this led to conflicting changes at Savannah River Plant, especially in the 1980s. The decade opened with new requirements set by the Department of Defense for plutonium and tritium that directly translated into physical change for the plant. New construction occurred in the process and administration areas to house new programs and personnel, worn facilities were repaired, and technical upgrades were made to operating systems and equipment. Updated security provisions and other physical changes were made with the installation of Wackenhut Services Inc. as the on-site security force.

While SRP expansion was gaining momentum, the environmental movement was also becoming a force that ultimately changed the nature of how the expansion would take place. The accident at Three Mile Island in 1979 drew national attention to the nuclear power industry and reactor safety. The environmental movement hastened change but it was the end of the Cold War in 1989 that shaped new missions for the Savannah River Site.

Rise of Environmentalism

In December of 1974, the Environmental Protection Agency issued the first sanitary NPDES permit for the Savannah River.[105] While this was largely pro forma, it was a harbinger of things to come. In subsequent years, there would be an increase in environmental regulation on federal lands, and Savannah River was not exempt from this trend. In 1976, the Resource Conservation and Recovery Act (RCRA) gave the EPA authority to enforce environmental laws on all Department of Energy weapons-production sites. As a result, regulatory agencies began to weigh in on the previously "closed" controversy over the relative merits of confinement and containment at nuclear reactors, as well as the need for towers to cool reactor effluent water, a feature that was already standard for commercial power reactors.

Despite a promising collaboration in the early 1970s, environmental regulation and the nuclear community did not have the same agenda, and this became clear during the mid- to late-1970s. Environmental regulators soon moved beyond a balanced concern for the environment and the search for new energy sources, and began to micromanage commercial and DOE facilities solely for the benefit of the environment. The nuclear community, long sustained by public awe of atomic power, now began to find itself under attack by a public that increasingly feared the atom and its residual effects. By the late 1970s, the average environmentalist was antinuclear and environmental regulators were responsive to that shift.

Carter, an "environmental president," was the first to promote alternative sources of energy, such as solar and wind power. The exploration of such avenues was in fact one of the main reasons for the establishment of the Department of Energy in 1977. This exploration did not extend to the nuclear industry. In addition to banning the reprocessing of spent nuclear fuels for commercial reactors, Carter put a stop to the breeder-reactor demonstration program started by Nixon.

In the early 1980s, President Reagan would attempt to revive both the commercial reprocessing of spent fuels and the breeder reactor program, but by this time interest had flagged both in Congress and within the U.S. commercial nuclear industry. The demonstrated abundance of natural uranium certainly played a role in this shift of opinion, but the biggest change would be the accident at Three Mile Island. Even though it was the worst accident to befall the U.S. nuclear industry, its most disastrous impact was in public relations.[106]

The impact within the industry was great. Many of the energy concerns and conservation programs conceived in the early 1970s were simply abandoned by the late 1970s and early 1980s. Due to environmental regulations and a lessening demand for nuclear energy that was apparent even in 1979, there was less concern about the uranium supply or the discovery of new uranium sources. This spelled the end of projects like NURE, and effectively put an end to any real demand for the reprocessing of spent nuclear fuels for commercial reactors.

Three Mile Island also had an impact on the nation's production reactors. Up to that point, reactor safety had concentrated on the prevention of major accidents, with an acceptance of certain low-level risks as a requirement of the job. In the wake of Three Mile Island, however, more thought was given to low-probability accidents, and to ways of reducing reactor power levels as well as levels of radioactivity. With this new emphasis, "Loss of Coolant Accidents" (LOCA) became a major concern of the 1980s.[107] With LOCA raised to greater significance, there was a corresponding rise in the importance of Emergency Cooling Systems or ECS. The idea behind the Emergency Cooling System was that even after shutdown, the ECS could still supply cooling water to a reactor in the event of an emergency. Throughout the nuclear industry, and certainly at Savannah River, Emergency Cooling Systems were added to reactors or were augmented in the years after 1979.[108]

At the other end of the nuclear process, Three Mile Island also focused attention on the problem of radioactive waste, a dilemma that had never been permanently resolved. There were two types of radioactive waste, low-level and high-level, and both had their unique problems and potential solutions. The Low-Level Radioactive Waste Policy Act of 1980 made every state responsible for the low-level waste produced within its borders. Even though the solution to most low-level waste involved burial, progress in implementing this law was so slow that Congress was forced to amend the act to give several states more time to comply.[109]

The problems associated with high-level waste, especially those of the defense industry, were greater and more intractable. Here, simple burial was not adequate, even though the idea of "geological disposal" of high-level waste had been proposed in underground salt deposits and at Yucca Mountain, Nevada, since at least 1957. Storage in high-level radioactive waste tanks was the preferred method of disposal, but this was recognized to be a temporary solution, and never more so than when the first serious leaks began to compromise the tanks in the early 1970s.[110] By the end of the decade, it was acknowledged that there would have to be some sort of "Defense Waste Processing Facility" to provide a more permanent solution to the problems of storage.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, also known as the "Superfund" legislation, helped provide the resources to clean up radioactive waste sites around the country. The money came with strings attached. The EPA and the states under authority delegated by the EPA, were given more authority to regulate DOE weapons production sites. The Nuclear Waste Policy Act of 1982, which President Reagan signed into law in January 1983, followed this law two years later. Robert Morgan, manager of Savannah River Operations Office (SROO) between 1980 and 1988, played a significant role in carrying out this act, which required the Department of Energy to establish a long-term site for the permanent disposal of the waste generated by nuclear power plants.

Reactor Upgrades, L-Restart, 700 Area Expansion, and Close of Heavy Water Facilities

Only four of the nation's production reactors were in operation in 1980: SRP's P, K, and C and Hanford's N reactor. Plutonium irradiated in N reactor had a high concentration of plutonium-240 that was unsuitable for weapons grade material. This shortcoming could be corrected by blending it with plutonium that had a lower concentration of plutonium-240 and SRP was directed to produce the proper plutonium for blending. A program to recover scrap plutonium at Rocky Flats in particular also had ramifications for SRP Operations. In order to comply with the change in product needs, SRP was compelled to upgrade and modernize its three operating reactors to allow them to attain higher power levels within shorter cycles. In 1980, one assessment cited the following problems: one-quarter of the reactor heat exchangers were irreparable due to wear and aging; plant facilities had obsolete and worn out instruments and controls, not only in the reactors but in other plant areas as well; that the needed parts could seldom be replaced in kind; and finally there were too few engineers available to design modern equivalents.

To begin to refurbish the Site's facilities, a five-year Restoration Program was established and funded at $350 million dollars, which was to be dovetailed with a $300 million dollar Productivity Retention Program by Du Pont. The Restoration Program did not include capital funds needed for new construction such as the Defense Waste Processing Facility (DWPF) discussed below but was the source of funding for L-restart and other upgrades.

The L Reactor Startup Team was the first management group to be placed under Du Pont's "program management" organizational philosophy. The program management structure was applied plant-wide in 1982. Courtesy of SRS Archives, negative 34872-3.

By 1983, SRP's engineers were successful in this endeavor as the reactors reached the needed power levels, exceeding expectations. In addition, Du Pont was directed in 1981 to reactivate L reactor, a project that, when completed in 1984, brought L reactor to a safety and dependability level comparable to that of the three reactors that had remained in operation and had been continually upgraded. Employees in the 300 Area worked a seven-day workweek to keep up with the pace the higher power level in the reactors warranted and in anticipation of L reactor startup.[111] This was a major initiative budgeted at $214 million, employing a peak workforce of 800 for the renovation efforts, and projected to employ an operating workforce of 400 to run the reactor. It was also the first time that a reactor on standby had ever been refurbished and restarted after being out of service for more than a decade. The reactor was refurbished with new heat exchangers, replacement piping, removal of aluminum-nitrate from the reactor tank and nozzles, and the addition of safety upgrades. The challenges for the Restart Program stemmed from environmental rather than technological challenges.

DOE had completed an internal study of all associated environmental issues involved with the restart program, but chose not to follow the Environmental Impact Statement (EIS) procedure that provides for public hearings. This choice, characteristic of an agency committed to the "need to know" ethic, led to great controversy as local and national environmental groups called for action. Senator Strom Thurmond held local hearings in response as part of the Armed Service Committee's responsibilities that demonstrated the controversy production reactors could evoke by the 1980s.[112] By the close of 1983, it was recognized a lake would have to be constructed, not to impound cooling water, but to cool effluent water leaving the reactor before it would enter the Savannah River Swamp. L Reactor was finally re-started in 1985. It operated less than three years before it was shut down again. During its period of operation, its output was often constrained by the environmental requirement to limit the temperature in L Lake to 90 degrees F in the summer months.

"When we started using these reactors down here, the commercial nuclear business hadn't been invented yet. We had five reactors going—and commercial power reactors were just a gleam in the scientist's eye. So everything we did was pioneering—there was no real road map for us."

- Gerry Merz

Source: "Reacting to Change," *The Augusta Chronicle*, November 6, 2000.

(Above) Aerial View of P Reactor, 1989. Courtesy of SRS Archives, negative 89-2074-7

(Right) Detailed Aerial View of P Reactor.

(Below) At the close of the decade all five of Savannah River's reactors were shut down. P Reactor had earned the designation of "World's Safest Production Reactor" with its impeccable safety record spanning almost three decades.

The process areas were not the only focus of upgrades and new construction in the 1980s. The main Administration area was expanded under a long-range building program that aimed at replacing trailers with administrative facilities.[113] Between 1980 and 1989, nine buildings were added to the Upper 700 Area to ameliorate working conditions. Others were also added to F and H areas. The design and building materials used in this construction was based on obtaining the most space for the available money. The buildings were considered "Local Practice Commercial Standard Office Buildings" and were let to bid as "Design-Build" projects.

Another change in the 1980s was the closure of the last of the Heavy Water production units in 1982. The area was in operation for slightly over 29 years, and had produced a sufficient amount for the needs of the Site's three operating reactors. Heavy water produced at SRP was sold to foreign countries and domestic consumers for a variety of uses and it, along with timber, was a revenue producer for SRP. For example, the AEC negotiated the sale of 450 tons of heavy water valued at $42 million dollars in 1969.[114] Over 6,000 tons were produced during D Area's years of operation.[115]

Defense Waste Processing Facility (DWPF) and Naval Fuels Program

Two additional programs were also started in the 1980s concurrent with the restoration program further exacerbating financial and manpower deficiencies. The DWPF got underway as did the Naval Fuels Program.

Aerial View of DWPF Building 1977. Courtesy of SRS Archives, Negative 97-1527-1.

The long term problem of defense wastes was tackled in the early 1970s when scientists began to research for a solid waste form and a process by which defense wastes could be converted and stored in that form. Glass was selected after much research. The converted waste once vitrified would be encased in stainless steel canisters for permanent storage. Radioactive materials in the waste tanks were separated from nonradioactive materials through chemical separation processes that allowed the remaining sludge of radioactive materials to be sent to the DWPF Building, a monumental reinforced concrete building about 360 feet in length, 115 feet in width and 90 feet in height, for vitrification. Modeled after the canyons, most of the process work that occurs in this facility is conducted remotely behind heavy shielding. The salt that remains after the separation process is dissolved in water, cesium-137 and strontium-90 are precipitated and filtered then sent over to DWPF as a slurry for vitrification. The remainder, a salt solution, is hardened into a cement-like substance by mixing it with fly ash, furnace slag, and Portland cement. The final product called "saltstone" is placed in long concrete enclosures in Z Area. Construction began in 1984 but would be hampered by a lack of funding. The facility was complete in 1989 and actual vitrification began in 1996.[116]

The Naval Fuels program was aimed at converting uranium feedstock into useable fuel in support of the Navy's nuclear propulsion program. Facility 247-F housed the processes involved in this conversion; it was constructed and deactivated before it went into operation.

The scale of the needed repairs and the new construction engendered by the Naval Fuels and the DWPF facilities was prodigious. Moreover, the timing was awkward. In historian Bebbington's words, all of these programs were coincident with the first generation of SRP employees reaching retirement age, compelling Du Pont to hire and train a new workforce that was in size and in scope comparable to that of 1950. The major departure in the 1980s from the 1950s was the hiring of outside contractors to fill the needed gaps in the Du Pont team.

A second large change in staffing came about in 1984 when DOE requested that a specialized security force be designated for plant protection that would be able to respond to the changing world order. Prior to 1984, Du Pont handled site security. The Du Pont security force was disbanded and security of the plant was transferred to Wackenhut Services, Inc. in 1984. At this time, physical barriers protecting restricted areas were enhanced and security measures were updated.[117]

Reactor Shutdowns and Du Pont's Departure

In 1986, a coolant system assessment indicated a situation could arise in which insufficient amounts of cooling water would be available to the reactors in an emergency situation. The power levels of the reactors were decreased by 25 percent in November of that year. Then, in early 1987, a special panel of the National Academy of Science set maximum reactor power levels to about 50 percent of normal full-power operations.

By this time, Du Pont was clearly interested in pulling out of the atomic energy business. In October 1987, Du Pont formally announced that it would not seek to renew its contract with the Department of Energy, scheduled to expire in early 1989. The rationale for their departure was first that the government no longer appeared willing to guarantee the work and that Du Pont was no longer uniquely qualified to do it. Following almost immediately, there were safety hearings before a House subcommittee.[118] Since the mid 1980s, DOE and its contractors had been under examination in Congress for allegations of poor safety practices at federal nuclear facilities. In hearings before the Subcommittee on Oversight and Investigations of the House Committee on Energy and Commerce, Savannah River was noted for its poor fire prevention procedures. Congress wanted sprinkler systems installed in the reactor buildings, and this was a government expenditure that SROO and Du Pont management had resisted for the simple reason that the all-concrete reactor buildings could not burn.

The concern over fire prevention was eclipsed by a news story reported on the front page of *The New York Times* in 1988. A report, "SRP Reactor Incidents of Greatest Significance" compiled three years before, which detailed and categorized 30 significant incidents in the history of the five Savannah River reactors, was released to the public. Most of the incidents in the 1985 report had been summarized in an earlier ERDA document. An internal memorandum initially, the report's purpose was to show that the serious reactor incidents at the Savannah River Plant were largely confined to the early years of operation, and that the safety precautions of later decades had greatly reduced the incidence of error. The 1988 report was released in an effort to show that nuclear work was in fact becoming safer. This was not how the information was received, and the national media immediately interpreted 30 "incidents" as "accidents." The outcry over the disclosure led to further congressional hearings over perceived problems at Savannah River. Media attention reached a peak in late 1988.

Responding to ever-tougher safety regulations and a relatively large stockpile of nuclear materials, the Department of Energy shutdown the three remaining reactors, P, K, and L in 1988. The fact that the Savannah River reactors had all been shut down was almost lost in the public debate. Although this shut down was initially intended to be temporary, it soon became permanent. In March 1987, administrative limits were placed on the power levels at K, L, and P reactors due to lingering uncertainties over the Emergency Cooling System (ECS). The following year, all three were shut down due to continuing concerns over the ECS, as well as the possibility of a "loss of pumping accident" or a "loss of coolant accident." K reactor was the first to go, in April 1988, followed in rapid succession by L in June and P in August. The ripple effect of these shutdowns passed through other areas of Savannah River as well. The production of fuel tubes ceased in Building 321-M that same year.

When Westinghouse assumed Du Pont's mantle in April 1989, all the reactors were shut down, and the U.S. had ceased the production of weapons-grade fissionable material altogether. The Site was officially included on the National Priority List and became regulated by the Environmental Protection Agency. In the same year, the Department of Energy formally announced that its primary mission had changed from weapons production to a comprehensive program of environmental compliance and cleanup. In a signal that it was making a break with the past, the facility's name was changed from the Savannah River Plant to the Savannah River Site.

Later attempts to use the reactors for further production were half-hearted. Even though L Reactor was selected as a backup for tritium production (1990), and K Reactor was restarted for power ascension tests (1992), the Department of Energy ordered both reactors shutdown with no capacity for restart in 1993.[119] While the work of nuclear processing continues in the Separations Areas and other places on-site, the SRS reactors themselves are now used to warehouse discarded radioactive materials.

End of Cold War

The controversy over "Star Wars," not to mention conflicts in Afghanistan and Nicaragua, kept the Cold War fairly warm in the early 1980s. There was also a confrontation over missile deployment in Europe. It was in this context that the L Reactor Restart program was initiated and completed. By the mid-1980s, however, Soviet society was beginning what would turn out to be a permanent thaw. Yury Andropov, Brezhnev's successor, died in 1984 after only a couple of years in power, and was eventually succeeded by Mikhail Gorbachev in 1985. Within a year, Gorbachev became the first Soviet leader to openly admit the weakness of his country's planned economy. More remarkably, he was the first Soviet leader to admit that elements of the old Communist doctrine were wrong or, at the best, outdated.[120] By the late 1980s, Gorbachev was well into the programs now associated with his name: *glasnost* (openness) and *perestroika* (economic and political restructuring of the old Soviet system).

The nuclear accident at Chernobyl played a role in this development. After first denying the accident, Soviet authorities soon made a complete turn-around, with relatively open disclosure of the problem and solicitations for foreign assistance. The approach to Chernobyl paved the way for new approaches to other problems. In December of 1987, the U.S. and Soviet authorities signed an agreement to eliminate all land-based intermediate range nuclear missiles from Europe. More was to follow in almost dizzying succession. In the fall of 1989, the Berlin Wall, symbol of the Cold War in Europe, was dismantled, permitting a rapid reunification of Germany. Communist regimes collapsed throughout Eastern Europe. Within two years, in 1991, the Soviet Union itself would collapse, leaving the former giant split into its various constituent republics. Gorbachev, now jobless, was forced to bow out to Boris Yeltsin, the president of Russia.

In the decade that followed, there would be additional problems with Russia as its economy continued downward, but there would no longer be the threat of an ideologically fueled nuclear war between the two great superpowers of the Second World War. Now it was the time to take stock of the vast nuclear arsenals in both countries, and initiate a general clean up of forty years of nuclear production. Savannah River Site, under the aegis of the Westinghouse Savannah River Company, was already poised to head in that direction.

This chapter has provided a context for Savannah River's Cold War history from a national and complex-wide perspective to provide background for the narrative that follows. The next chapters deal specifically with the history of CMX and TNX, Savannah River's Pilot Plants.

III. SRS ANTECEDENTS

Because of the enormous amount of heat created, any large-scale nuclear reactor must be situated beside a large body of water, preferably a river. This water is then run directly through the reactors or through the reactor's heat exchangers, to remove the excess heat. This was certainly the case with the world's first large-scale reactors, operated by Du Pont at Hanford, in Washington State, during World War II. The Hanford reactors were different from those that would be established 10 years later at Savannah River. The Hanford reactors used graphite as the moderator, and the cooling water, pulled from the Columbia River, was run directly through the reactors before returning to the river. At SRS, the reactors used heavy water as the moderator. Heavy water is a rare but naturally occurring isotope of regular water (also known as "light water"). The acquisition of heavy water requires culling of this isotope from vast quantities of natural water, or by means of the Girdler sulphide process that was performed at Savannah River in D Area. The heavy water obtained from D Area was used in all of the Savannah River reactors. When the reactors were in use, heavy water from the reactors was run through a series of heat exchangers, where river water was used to remove the excess heat. The volume of river water going through the heat exchangers was immense, and had to be pushed through the system as fast as possible, using the most powerful pumps available. Any problems with this cooling water—too much silt or mineral deposits which might corrode the pipes—had to be known in advance to insure the proper working of the entire system.

As a result, Du Pont established an experimental station at Hanford to test the status of the Columbia River water that was used to cool the Hanford reactors. Like almost everything at Hanford, which was a top-secret facility, this station was given a code name, in this case "CMX." The designation, assigned by Du Pont's Engineering Department, did not stand for anything, but was simply a code. According to Paul Dahlen, who headed up Hanford's CMX, "some people said that CMX meant 'Corrosion Mock-up Experiment,' but that was just talk." Most people working at CMX did not even know why they were testing the river water. [1]

Paul Dahlen, who ran the CMX operation at Hanford and later was the first CMX chief at Savannah River Plant, is the best authority on the importance of CMX. Born in Minneapolis in 1913, Dahlen received a Technical Engineering degree from the University of Minnesota in 1936, and a Master's of Science in Chemical Engineering from the same school three years later. Hired by Du Pont right afterwards, he worked on the production of nylon in the Ammonia Department at the company's headquarters in Wilmington, Delaware. After the United States entered the Second World War, he transferred to Du Pont's Explosives Department, and began work on the atomic bomb project in April of 1943. He was transferred to Hanford in August of 1943, where he received the very first badge issued at that installation:

> At Hanford, we pumped the river water directly through the reactor and the only thing that separated the stainless steel nozzles on the face of the reactor from the aluminum tubes going through the reactors, was the gasket, and they thought there might be electrolytic corrosion between those two metals. That's why they decided to have a CMX at Hanford, [to test that corrosion]. [At CMX] we had a mock-up of some reactor tubes and we pumped river water through the tubes and the dummy [uranium] slugs were heated

> with steam. Back during World War II, there was a shortage of some equipment and that so instead of having a conventional boiler to supply the heat for heating the water going through the tubes; they used five steam locomotives. This was back at the time when the railroads were converted from steam engines to diesels and so old locomotives were available. They hooked up five locomotives, side-by-side, and we hired some retired railroad engineers to operate that steam source and it worked out beautifully for us.
>
> We ran the [river] water through the tubes and that we soon found out very quickly there was an increase in the pressure drop of the water going through the tubes, so we shut down and tried to find out what was causing it. [We] didn't see anything wrong so we started up again, did that several times. Finally we decided, "Okay, let's get the water in the tubes when we shut down and examine it then." [That's when] we found that there was a build-up of a gelatinous material or film on the dummy slugs, and that's what caused the pressure drop. We took our thumbnails and scraped on that and could see this gelatinous film; analyzed it and found out it was a hydrated silicate film. [As a result,] our attention shifted from corrosion to film formation and how to prevent that film from forming. [We discovered that] it formed from material in the river water. The Columbia River water looked beautiful, clear, and cold, but it contained some silicate and due to what they call the streaming potential there was a difference in charge between the silicate particles and the walls of the tubes, and this attracted the silicate particles to the tubes.
>
> Du Pont being a large company with many specialists, we were able to get a fellow from the Chemical Department who was a specialist in silicate; [he] came as a consultant to us at CMX. We got a fellow from the experimental station who knew how to set up experiments so we could get the electronic charge going back and forth. After a time we were able to determine the charge of these particles and eventually found that the proper chemical balance could essentially eliminate the formation of the silicate film. We also found another way to remove the film was to add Dichromate to the river water.
>
> This was extremely important because if we had not found this out before starting up the reactors, we would have started and eventually the pressure drop would have been such that we could not have continued operating. [Worse,] we wouldn't have been able to analyze the problem because the tubes would have been radioactive from the nuclear reaction. At CMX, we could handle it [safely] and find a solution.[2]

As a result of this critical work at Hanford, Du Pont decided early on that they would also have a CMX facility at Savannah River Plant. Paul Dahlen himself was the main connection between the two operations. As he stated years later:

> I worked at CMX for the Hanford Project and it proved to be extremely beneficial for the overall success of the reactors there. [As a result,] when Du Pont was asked to do the so-called Hydrogen Bomb Project at Savannah River they immediately decided that we'd better have another CMX; and as much as I had worked on CMX at Hanford, I was asked to head up CMX at Savannah River.[3]

The antecedents for CMX at Savannah River are particularly clear and direct. This is less the case with TNX. There was a TNX at Hanford, but the direct connections, in both process and personnel, are lacking.[4] The main reason for this was the difference in the separation processes used at Hanford and at Savannah River. Historically, there have been three main methods for the extraction of plutonium from the irradiated fuel and target elements that come from the reactor. The first and oldest was the bismuth phosphate process, which was a batch process. It was relatively primitive and could only extract plutonium from the irradiated materials, not uranium. This was the method first used at Hanford. The second method was the REDOX Process, which was later installed at Hanford. REDOX was the first countercurrent, continuous flow process that allowed for the recovery of both plutonium and uranium.[5] The third method was known as the PUREX Process. This was the method used at Savannah River.

Both REDOX (at Hanford) and PUREX (at Savannah River) used the continuous process preferred by Du Pont in its chemical assembly lines. In both cases, slugs of irradiated uranium/plutonium, went into one end of a massive process line known as a "canyon," and left the building at the opposite end as purified plutonium and uranium metal. The big difference in the canyon buildings at Hanford and Savannah River, was that Savannah River had two parallel process lines rather than one—the hot and warm canyons.[6] There were other differences as well. The heart of the REDOX process was the use of a series of "pulse columns" to drive the process. At Savannah River, the PUREX method used "mixer-settlers."[7] The PUREX method used a solvent with a higher flash point than that used in the REDOX process, which was an important safety feature. It also produced less radioactive waste that had to be sent to the waste storage tanks.[8]

The PUREX process, created at the AEC's Ames Laboratory, was based on a solution of tributyl phosphate in a kerosene-like hydrocarbon. This was used to remove both plutonium and uranium from a nitric acid solution that contained the irradiated uranium. In order to achieve this removal, the solutions were blended in multi-stage mixer-settlers, and then allowed to settle and separate. At Savannah River, this process was done in two huge separations buildings or "canyons," 221-F and 221-H. The first cycle was performed in the "hot" canyon, with the second cycle done in the "warm" canyon.[9]

Even though the PUREX method was known when Du Pont began construction of SRP, it had never been tried on an industrial scale. There were bound to be problems that would be difficult to work out in the canyons themselves. For this reason, Du Pont decided to establish a pilot plant for the Separations process like those already planned for the reactors. The Separations pilot plant would be called TNX.

IV. PILOT PLANT CONSTRUCTION

Voorhees, Walker, Foley & Smith, headquartered at 101 Park Avenue, New York City, was chosen as the plant's over-all architectural and engineering firm for its experience in industrial architecture, particularly laboratory design. The firm was also noted for its work in the early 1940s in the renovation of Columbia University's laboratories for atomic energy research. Perry Coke Smith was the firm's lead architect on the Savannah River project.[1] Voorhees, Walker, Foley & Smith designed the CMX building, 679-G, in March of 1951, making this one of the first structures designed for the entire plant.

Another company, Blaw Knox Corporation, did much of the design and engineering work in the Separations Areas, including the tritium areas, located in Separations. Blaw Knox designed the TNX building in March and April of 1951, basically just days after the work was done for CMX.

CMX/TNX LAYOUT

Despite the fact that CMX and TNX served different purposes and were designed by different firms, they were situated side-by-side adjacent to the Savannah River, in an area removed from what would soon be the industrial core of the SRP complex. There were solid reasons for putting the two pilot plants together, and putting them where they did, and this section will explore those reasons.

CMX was the earliest of all the pilot plants and it had to be located along the river because of its water requirements. If it was going to test any possible corrosion or silt problems associated with the river water, it had to run a volume of water through its test facilities comparable to what would later take place within the reactor systems. In early 1951, when CMX was designed and built, this demanded a site close to the river, since the enormous piping system that would later supply the reactors with river water had not yet been constructed. The location along the river also had the advantage of being far from the SRP industrial core, which would soon be humming with construction activity. There were other SRP facilities placed close to the river, often for the same reasons. One of these was the Heavy Water Area (400/D Area). Naturally, the river pump houses that would supply water to the 100 Area reactors, were also placed along the river, just downstream from the CMX-TNX Area. The river was also the focus of other early work at SRP. The first environmental study of the plant site, conducted by the Philadelphia Academy of Natural Sciences, was concentrated along the river. It was even important as a transportation artery. The reactors themselves were brought to the site by means of barges.[2]

There was another logistical reason for the location of CMX - proximity to the town of Ellenton, less than a mile away. SRP would eventually displace all of the small towns and settlements within the project area, but this process did not happen immediately. Ellenton was not removed until later in 1952, and during 1951, the critical first year of work at CMX, proximity to Ellenton provided electricity, supplies, roads, and rail facilities.[3]

After the location was determined for CMX, it was a relatively simple matter to put TNX beside it. The TNX facility also needed a relatively high volume of water, and for simple logistical reasons it was decided to place the two together. Both would share the same water facilities, electrical facilities, guard station, and parking lot. Access to Ellenton was important to both.

The general layout of T Area indicates the early importance of CMX. The 679 building, and the tank facilities around it, are located close to the river. All subsequent construction was situated south or east of CMX, away from the river. The TNX building, 678, was located immediately south of CMX. In the first couple of years of operation, this was virtually all there was to the T Area. Later, as the mission of both CMX and TNX expanded and diversified, other buildings and facilities were added to the area, until there were around 50 by the early 1990s.[4]

CONSTRUCTION PARAMETERS

At an early date, the Atomic Energy Commission (AEC) informed Du Pont of its preference for Spartan simplicity in building design. This policy required Du Pont and its subcontractors to design facilities with maximum economy consistent with functional requirements and to standardize designs and specifications for buildings and associated facilities to achieve uniformity.[5] Standardization of design for the CMX-TNX Area was not necessary since these two buildings were unique constructions. However support facilities such as guardhouses would follow standardized plans. All Savannah River construction would follow what was known as Du Pont's design philosophy, called "the Hanford Philosophy." These included five general categories: reliability and safety, simplicity, interchangeability, standardization, and flexibility.[6]

Design meetings between the AEC, Du Pont, and other subconsultants were ongoing as early as November and December of 1950. Drexel Institute of Technology's Professor H. L. Bowman and Du Pont engineers tackled the building criteria needed to protect the proposed facilities from atomic blast and to allow it either wholly or in part to operate in the face of such an attack. Three types of construction were developed and this classification system was codified and placed into a supplement to the Uniform Building Code published in January 1, 1946 that was adopted for plant construction use.

Class I buildings were described as massive, reinforced concrete, monolithic structures with a static live load of 1,000 lbs. per square foot.[7] Their exterior walls and roof were to be poured, reinforced concrete with a supporting frame of reinforced concrete or structural steel. Critical process buildings were to be constructed of blast proof materials throughout. Reinforced concrete construction was selected for its ability to take stress, the protection it affords from alpha and gamma rays and intense heat, and the speed and economy it would lend to construction.

Class II buildings were considered to be of friable construction with a structural frame of reinforced concrete or structural steel and expendable wall materials. If bombed, the structural frame remained intact while the exterior walls were considered expendable. Fifty percent of a building's exterior wall area had to be covered with friable materials to suit this class of construction. Roofs were poured concrete and designed for a live load of 150 pounds per square foot; all floors were of poured reinforced concrete. If equipment or areas in these buildings required further protection concrete blast-resistant walls were added or floor levels were placed below grade.

Extensive tests were undertaken at Sandia National Laboratory in New Mexico to identify possible friable wall materials by exposing the candidate materials to TNT explosions that simulated atomic bomb blasts. After analysis, Transite™, a short fiber, cement-asbestos siding material, was chosen because it broke into small pieces on impact.[8]

Transite™ was sold in the form of flat and corrugated sheets made of asbestos-reinforced cement.[9] As an exterior sheathing it reduced the load bearing factor considerably from 120 to 20 pounds per square foot when compared to masonry walls and it was further desirable as it did not rot, rust, or burn and was impervious to insects and rodents.[10] Advertised as smart, modern, and economical in period advertisements, Transite boards became the primary building material for exterior wall sheathing between 1950 and 1956 at SRP. The presence of the smooth, natural cement color exterior board is the hallmark of the Site's first generation of buildings for this class of construction.

Class III construction was considered normal construction carried out under the building code. Class III buildings would not have blast resistant features. They would generally be made of corrugated asbestos or metal siding.[11] This included all service buildings, shops, and change houses, all of which were considered expendable. This category included a plethora of prefabricated metal buildings manufactured by Butler, Hudson, Mesker, and other firms.

The facilities at CMX-TNX fell into the category of Class III. The CMX and TNX buildings were considered normal construction. Transite was not used on the exterior walls, nor was there any special concrete reinforcement, aside from that was required for the tasks at hand. The building stock in T Area was always considered expendable in the event of a conventional or nuclear attack.

PILOT PLANT BUILDINGS

The following discussion deals with the construction of the 679-T and 678-T buildings, their architectural description as-built, and the design criteria employed in their construction.

679-T CMX BUILDING

As early as January 10, 1951, there were meetings about the importance of the CMX project. At that time, it was given the highest priority rating within the entire Savannah River complex. After topographic studies done by Aero Service, the site of the CMX area was proposed on January 22, 1951. Discussions about the river intakes for CMX were held the following day. The CMX location was approved on February 2, and the CMX area layout was assigned to VWF&S just three days later.

The beginnings of the CMX building, now identified as 679-T, are closely tied with VWF&S, the architectural design firm for the Savannah River Project, and the return of Paul Dahlen to the CMX Mission. The first working plans for CMX were created in February by VWF&S, and by that time, the "material and equipment list" was well underway. The original designation, "CMX-679," was changed to 679-G, on March 2. Shortly afterward, the first purchase order for Building 679 was issued, specifying the purchase of the first pumps.[12] In late March and early April, permits were obtained from the Army Corps of Engineers for the river pump house that would be needed for CMX.[13] All of this work was very early in the life of the Savannah River project. To provide perspective, during this same period, project roads were being laid out on maps, and there were discussions about where to locate the river pump houses, Central Shops, and the manufacturing area (300 Area) and the administration-laboratory area (700 area). No other construction was yet planned in final form, much less on-going.

Knowing the importance of the CMX project to the original Hanford work, Du Pont transferred Paul Dahlen from the Plastics Department, to the Savannah River Project, at the end of 1950. In February of 1951, Dahlen made his first visit to the CMX-TNX Area, to help with site selection.[14] After that, he worked with Du Pont and VWF&S on the design of the facility, and this work processed very rapidly. The final building plans were inked in early March of 1951.[15] Construction in the CMX area began on March 19, before the building plans even met with final approval in April. Construction began on the building itself that same month. The CMX building vies with Central Shops as some of the very first constructions inaugurated at SRP.[16]

By the time Dahlen returned to the plant in July of 1951, the CMX facility was nearing completion. Start-up officially began in September of that year. When the facility was formally turned over to Operations on September 27, 1951, it was identified as Building 679-G, and was noted to be the first completed facility at Savannah River Plant.[17]

If "form followed function" at SRP, as remarked upon earlier, then it is important to establish the original purpose of the CMX building. Its sole purpose, at least in the beginning, was to test the Savannah River water for any unexpected problems that might arise in the reactors as a result of corrosion, or film-build up, as a result of the condition of the water itself. If problems were found, CMX was expected to come up with solutions.[18] At Hanford, the river water had been run directly through the reactors and then back into the river. At SRP, the process was different. Since the reactors were moderated with heavy water and not graphite, river water would be run through a series of heat exchangers, and it was there that the business end of the cooling process would take place. As Dahlen stated:

> The Hanford project was different from the Savannah River with respect to cooling water in that at Hanford the river water, which was the cooling water, went directly through the reactor and then exited back into the river. At the Savannah River Plant, because we had heavy water as a moderator, the cooling water went through heat exchangers. The moderator, the heavy water, picked up the heat in the

reactor and was cooled by the river water in heat exchangers. Our job was to determine what degree of treatment was necessary for the river water [that would go into the heat exchangers].[19]

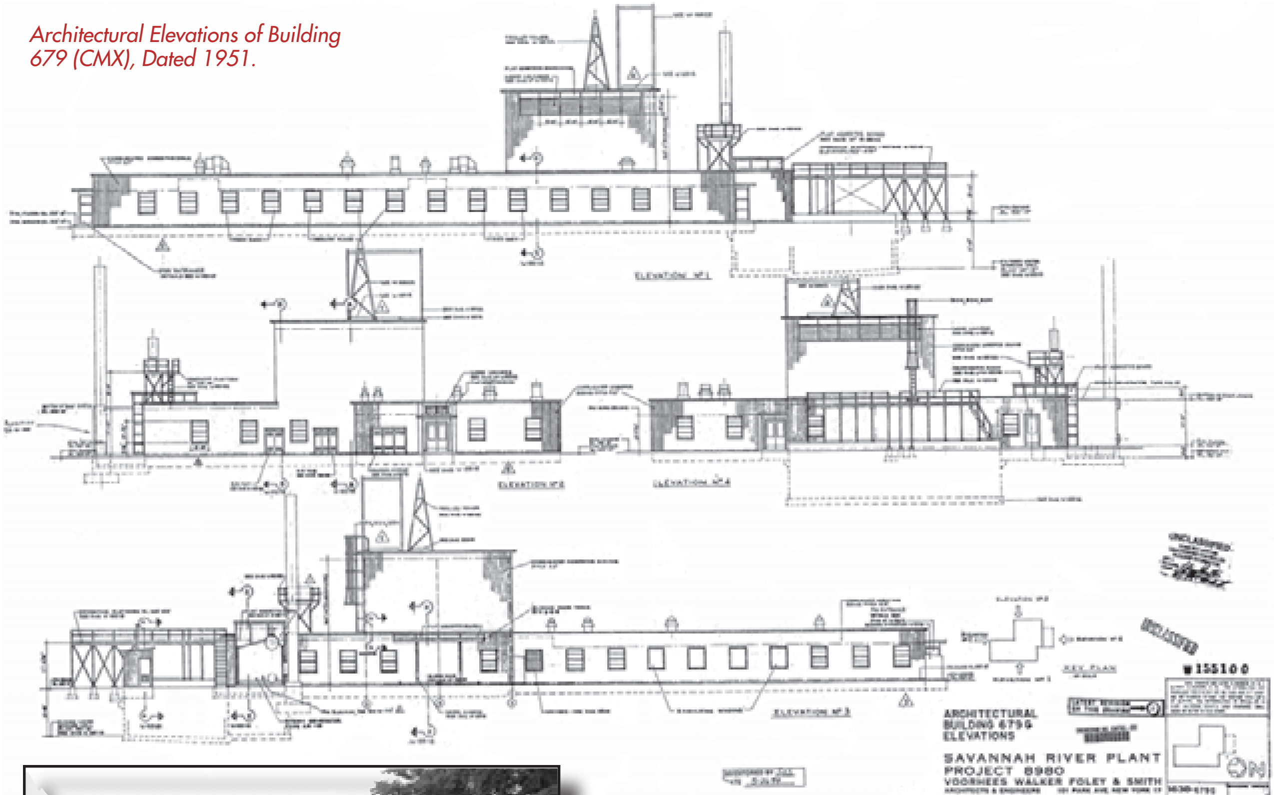
CMX was designed in some haste, and was constructed in the same spirit. There are only three original engineering drawings, all produced under the label of VWF&S, detailing the CMX floor plan, elevations, and equipment layout for 679-G. In plan, the building was shaped like an "L," with the long arm of the "L" oriented north-south. The small arm of the "L" came out of the north end and pointed west, towards the river, and covered an area 69 feet, 4 inches, by 51 feet, 2 inches. The longer of the two arms covered an area that was 155 feet, 2 inches, by 49 feet, 10 inches. The longer arm was one story, with a height of 11 feet. The western-most part of the small arm contained the "tower" or "pilot room," which housed the equipment needed to test the river water. This part of the small arm covered an area 35 feet by 35 feet, and rose 20 feet, 10 inches, above the level of the main roof slab. The whole building rested on a reinforced concrete slab foundation, with spread footings. The building frame was constructed of both steel and wood—steel used for the tower, and wood used elsewhere. The wood frame was fashioned with 2 by 4 inch studs on a 4 by 4 inch shoe. The exterior siding was corrugated asbestos siding, and there was built-up roofing. The interior walls were formed with 3/8-inch gypsum boards. The toilet room walls were fashioned with concrete block to a height of four feet behind the toilets, slop-sinks, and urinals; with cement asbestos above the four-foot level. The ceilings were lined with 3/8-inch gypsum board, except for the pilot room and the utility rooms, where the construction was left exposed. The doors were wood and the windows were a number of different types: double-hung, fixed sash, and insulating glass. The interior floors were concrete in the vicinity of the tower, and asphalt tile in the long arm of the building.[20]

View of Water Clarification Facilities for Building 679 (CMX), Seen in the Background. Photograph Taken 1951, Looking South (SRS Negative #6-158).

View of Building 679 (CMX), Two Story Pilot Area, in the Center of Photograph, with River Water Clarification Tanks to the Left, and Building 678 (TMX) in Background to the Right. Photograph taken 1951, Looking Southwest (SRS Negative # 6-158).

View of Building 679 (CMX), 1951, Looking North-northeast (SRS Negative #6-158).

Architectural Elevations of Building 679 (CMX), Dated 1951.

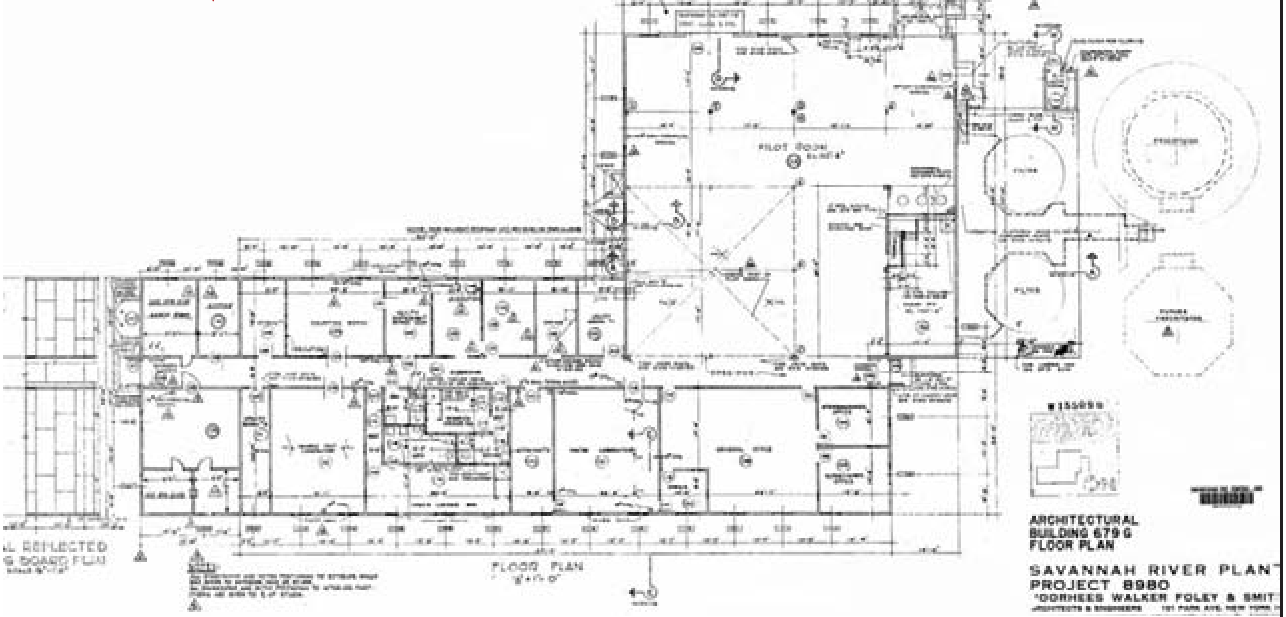


View of Joist Construction of Building 679 (CMX), 1951 (SRS Neagative # 6-121).

Within the CMX building, there were three basic components: the Water Laboratory, Health Physics, and Building Services. The Water Laboratory included the facilities in the tower and the various lab facilities in the long arm of the building. Also included here were the boiler and the water treatment plant, located outside, but adjacent to, the north side of the pilot room. Health Physics was only housed in the CMX building until its own facilities could be constructed. The function of Health Physics was to determine the base radioactivity levels across the site, which were determined by sampling and analyzing earth, air, water, and plant and animal life. This was conducted in the sample preparation room and counting room. Other facilities for Health Physics included a dark room for film development, instrument storage and repair rooms, and office space for personnel. In order to protect the equipment, many of these facilities had to be air-conditioned. Building Services included the change rooms, lockers, showers, and bathrooms—altogether providing facilities for 35 men and 10 women.[21] The Water Laboratory had sole use of the tower area; all three components shared the long arm of the building.

The long arm of 679-G contained a series of laboratories, lockers, and offices, connected by a corridor that extended the length of the arm. In addition to these facilities, the CMX supervisor's office was located at the northeast corner, and a lunch room was located in the southwest corner. The diagram for the equipment layout

Architectural Floor Plan of Building 679 (CMX), Showing Offices, Pilot Room, and Various Architectural Details, Dated 1951.

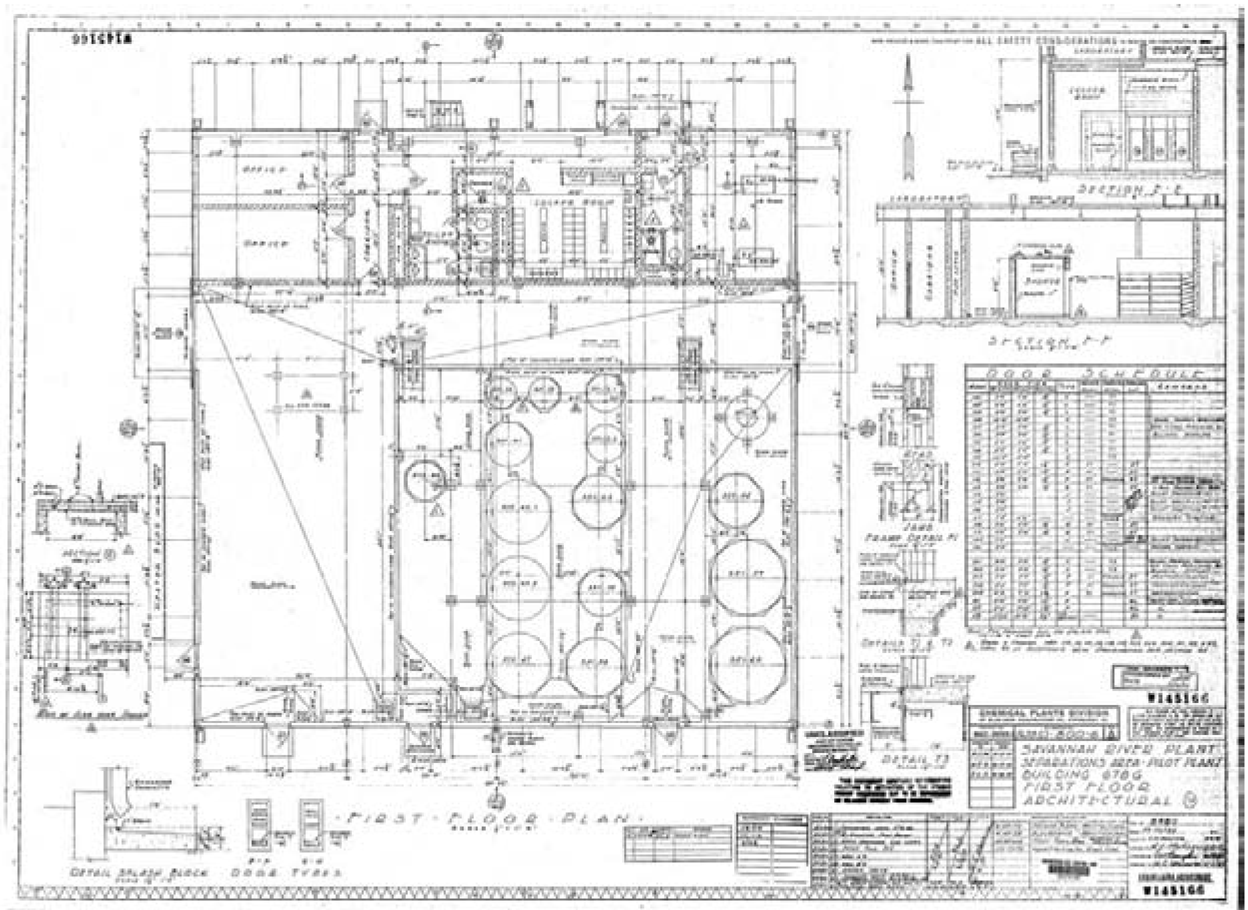


was devoted primarily to the tables, desks, and other rather general equipment to be employed in the lab and office wing of the CMX building.[22]

Changes appear to have been made to the design of the building, even during the construction period. On April 24, 1951, the number of operating personnel was bumped up from 30 to 60, which required changes in the septic tank design. In late May, it was requested that the service lines be adjusted to allow for future building expansion. The division engineer for CMX reported back that it was too late to make that adjustment, due to the advanced stage of construction.[23]

The pilot room or tower was also referred to as the "high-rise." This high-rise housed the heat exchanger mock-ups and adjacent equipment that formed the core of the initial work at CMX. The ceiling was roughly 30 feet high. In addition to the heat exchangers, it housed a mock reactor. The arrangement was described by David Ward, an engineer who worked at CMX in the early days:

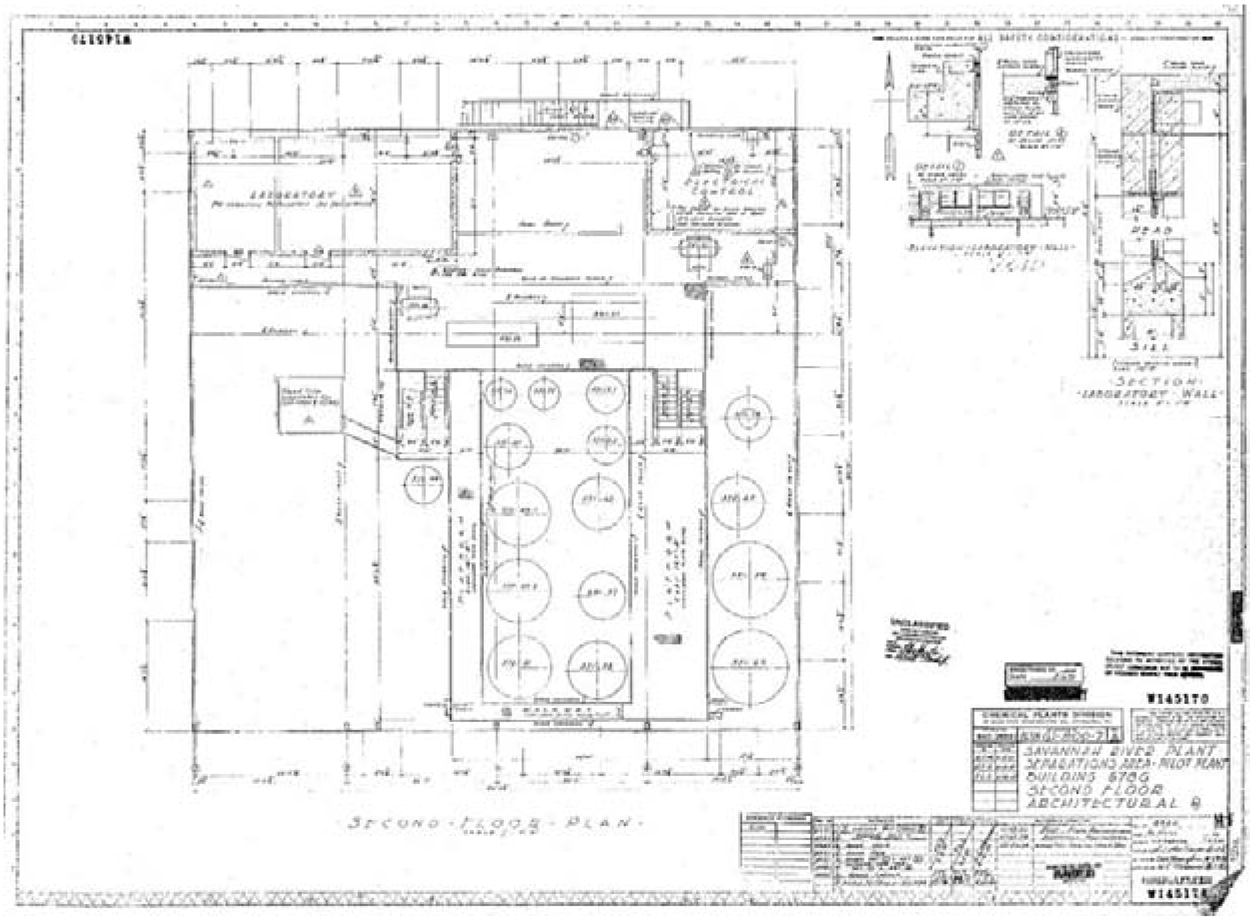
> [Within the high rise] was a reactor model called a converter. I don't know why it was called the converter but it was full height, and then [there were] the heat exchangers… seems like there were four. There were [also] a couple of big pumps [that] pumped water into the heat exchangers. [Other pumps sent water] into the top of the reactor and came out the bottom back into the pumps. These pumps… just pumped ionized natural water through our simulated reactor. [In the reactors themselves] this would have been heavy water but heavy water is very expensive to make. [At CMX] we didn't have any heavy



Floor Plan of Building 678 (TNX), First Floor, Showing Offices, Locker Room, and Process Tanks, Dated 1951.

> water at all, but… simulated [it] with ionized water because the heat transfer and fouling characteristics would be similar.
>
> These pumps had fairly well advanced mechanical seals, which were similar to the mechanical seals on the much larger pumps that were going to be run in the reactor areas– and the pumps were part of what was being tested too. We would then have valves in the system and again, in the detailed side it was very important that the valves would be leak-proof…. Typical valves have packing around the stem so when it goes up and down the water doesn't leak out. Well that wasn't good enough for heavy water, it had to have more elaborated systems in the bellows and we would end up testing a lot of stuff up there.
>
> [Along the north side of the building] was a boiler, it sort of stuck out the back and then there was a big water treatment plant– big precipitators and big filters [just north of the building]. Then there were… pumps in the river; they pumped the water up to the building.[24]

Somewhat later, there would be the addition of Andale Heat Exchangers. Less than one foot in diameter, these small heat exchangers were used to conduct small-scale testing.[25]



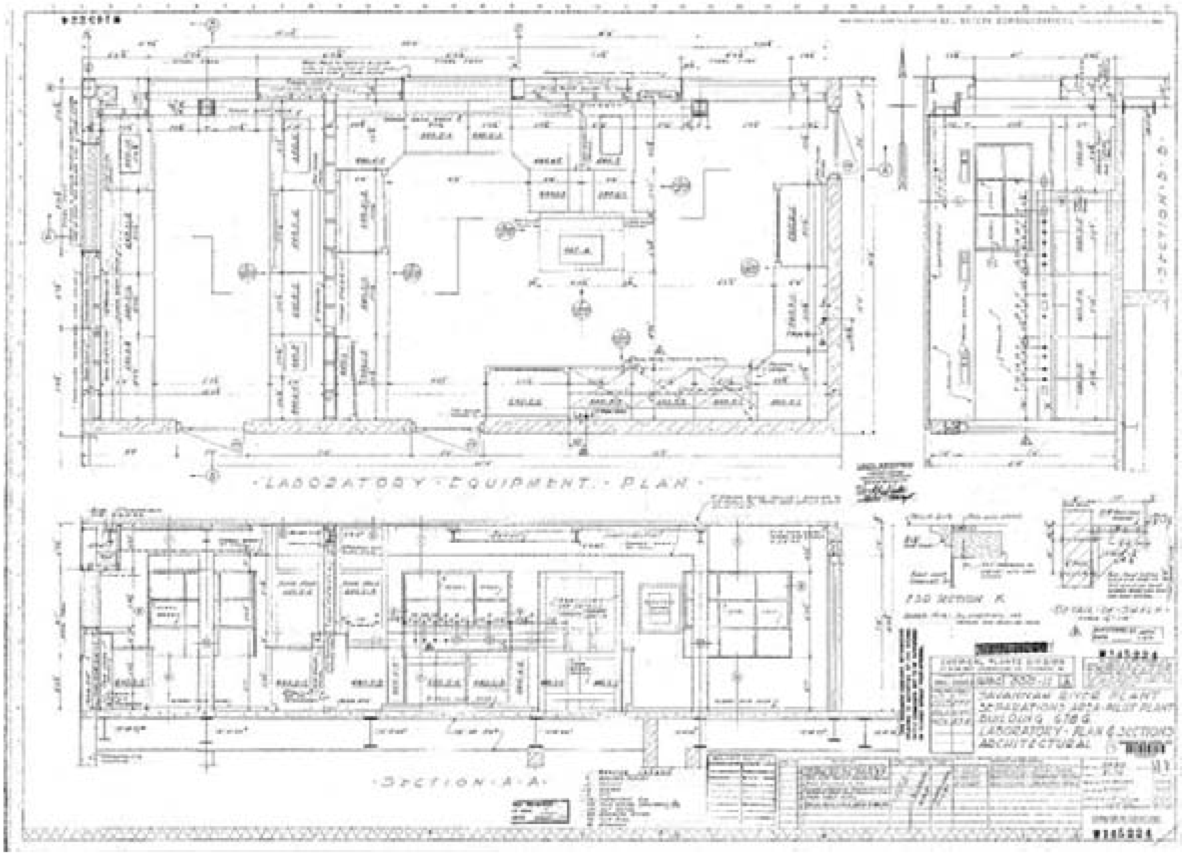
Floor Plan of Building 678 (TNX), Second Floor, Showing Laboratory, Electrical Control Room, and Process Tanks, Dated 1951.

Other original equipment associated with the CMX building were the water treatment facilities, various equipment needed for hydraulic testing, associated with the CMX "Analytical Laboratory," pumping and heating equipment, including boilers, even equipment for conducting health physics experiments.[26] Out of all of the original equipment, however, the most critical elements were the heat exchangers.

According to Dahlen:

> At Savannah River Site the water going through the reactor was heavy water and the heat that was [generated] in the reactor was removed by heat exchangers. Those heat exchangers were large. Each one was the size of a railroad tank car, and each reactor eventually had 12 of them. The heavy water flowed through the tubes [of the heat exchangers] and the river water, to remove the heat, flowed outside of the tubes in the shell of the big heat exchangers.[27]

It was this process that had to work, and work well, for the reactors to function at anything like normal activity. If there were any problems with the water flow in the heat exchangers, it had to be found before the first reactor start up. This would be the critical first mission of the CMX project at Savannah River.



Floor Plan of Building 678 (TNX), Showing Sections for Laboratory, Dated 1951.

678-T TNX BUILDING

The function of the TNX building, originally assigned the number 678-G, was neither as specific nor as urgent as that of CMX, but it was essential all the same. Its overall function was to study the problems associated with the separations process as planned for SRP. Primarily, this meant a study of the PUREX process, which had never before been tried at the level of industrial-scale production. While the process was basically understood, it was recognized that there could be problems with certain aspects of the process when conducted on a massive scale. There could also be problems associated with the equipment needed for the process—and testing equipment that would go into the 200 Area Separations was an essential part of the mission.[28] It was for this reason that TNX, more so than CMX, was known as the "Pilot Plant," or more specifically the Separations Pilot Plant, a miniature version of the plutonium and uranium separations operation in the 200 Area.

The TNX building, like most of the 200 Area, was designed by the architect-engineering firm of Blaw-Knox Construction Company, which entered into a letter agreement with Du Pont in the fall of 1950. Blaw-Knox began its research on mixer-settlers for the PUREX process as early as December of 1950. While much of this work was naturally geared toward the development of the 200 Areas, it also had repercussions for the Separations Pilot Plant. Blaw-Knox was authorized to start the design and procurement work associated with the pilot plant in late February 1951.[29] This began a series of regular meetings between Du Pont and Blaw-Knox to design and provision the Pilot Plant.

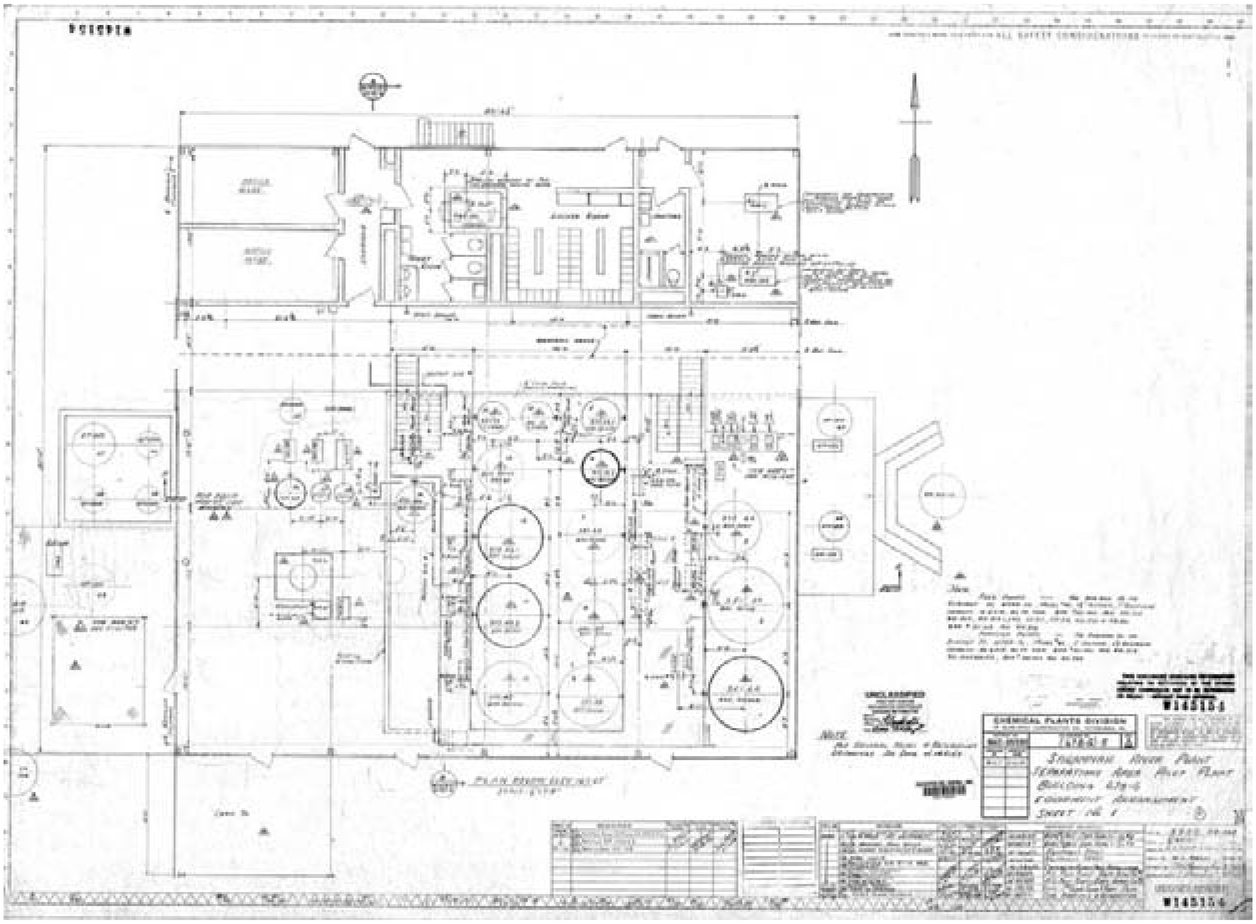
Based on these meetings, Blaw-Knox prepared a final series of eight drawings detailing the plans, elevations, and other features of the TNX building, all dated to March and early April of 1951. These plans worked around the needs of the mixer-settlers, which were the core of the TNX building. The first design called for a simple 40 foot by 80-foot building, with the tanks located outside. Monitoring needs soon dictated that the tanks be covered. This led to two 40 by 80-foot buildings: one for the offices and labs and another for the tanks, and then finally just one big building for both tanks and offices and labs. That building was 80 by 80 feet, and 24 feet high.[30] The north end of the building would be divided into two stories, and it was here that there would be offices, labs, and locker rooms.[31]

By early March, it was also determined that TNX would be situated in the CMX Area; VWF&S, the designers of CMX, were told on March 14 to make accommodation for TNX in all subsequent plans.[32] By the time construction began, the TNX building was sited 50 feet south of CMX. Construction began in the TNX area on April 23rd, before some of the later plans were approved in May. Construction of the building itself began in earnest in May of 1951, and was basically complete by the first of November 1951. Operators were in the building as early as July of that year.[33] The first laboratory people were assigned to TNX in early September, before construction was complete. The glassware and other equipment were installed in October, and the first study of raw river water for use in the PUREX process began in late October. At that time there were four chemists and three analysts working at the facility. The place was in full operation before the end of the year. The equipment included two banks of mixer-settlers, which were the essential features of the PUREX process to be used in the Canyons. These were served by evaporators, as well as an assortment of pumps and tanks.[34]

View of Steel Frame Construction for Building 678 (TNX), 1951 Looking Northwest (SRS Negative # 6-260).

View of Building 678 (TNX), looking West-Northwest, 1953 (SRS Negative #6-260).

As it was finally constructed, the TNX building was a Class III construction that measured 80 by 80 feet, and rose to an elevation of 24 feet. The foundation was a 6-inch thick reinforced

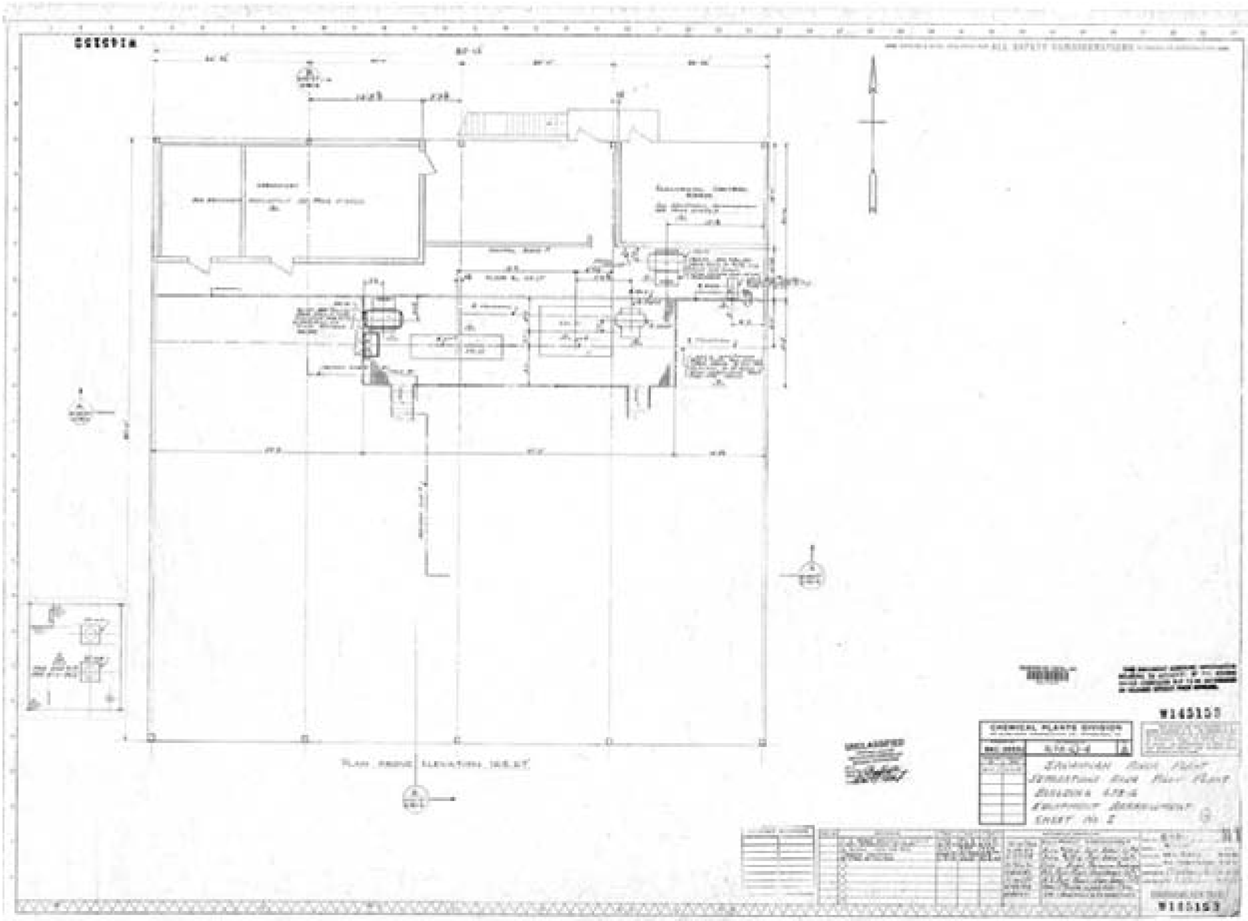


Floor Plan of Building 678 (TNX), First Floor, Showing Equipment Arrangement, Dated 1951

concrete slab on piers. The frame was of prefabricated steel, with a trussed roof. The exterior was covered with corrugated galvanized metal siding and roofing. The floors were concrete. The north end of the building was divided into two stories for the inclusion of offices, labs, and other facilities, but the rest of the building was open for the inclusion of mixer-settlers and other equipment. Built at roughly the same time was a concrete block heater building, 15 by 27 feet, located on the west side of TNX but separate from the main building. Another addition was a one-story lean-to (17 by 21 feet), added to the side of TNX in April of 1952.[35]

The heater building, 15 by 27 feet and 18 feet high, contained two direct oil-fired unit heaters that supplied heat to the TNX building. This was a safety feature, since it was considered too dangerous to have a heater inside the building with the tanks. The oil storage for this heater building came from an underground tank, 8 feet in diameter and 7 feet in length. Originally, it had been planned to heat the TNX building with steam heat from CMX, but this was found to be too taxing on the utilities already installed at CMX. For this reason, the heater building was added slightly later than the TNX building.[36]

Inside, the TNX building was a mostly an open "process area" that held around 16 tanks of various sizes. Many of the tanks rose to fill the inside of the two-story space. The tanks at the east end of the building were feed pumps and transfer pumps. Most of the tanks were set up on concrete pads, and there were four overhead



Floor Plan of Building 678 (TNX), Second Floor, Showing Equipment Arrangement, Dated 1951

platforms used to monitor the various vessels. Since ventilation was a potential problem, four large fan vents were installed on the roof line to vent the facility. Only on the north third of the interior space was devoted to offices, laboratories, toilets, locker rooms, and electrical control. The offices, toilet facilities, locker room, air compressor, and instrument air dryer, were located on the first floor. The laboratory, control board, and electrical room were situated on the second.[37]

The laboratory on the second floor was an analytical lab with fume hoods and other standard equipment. All of this would be added to over time. The core of the TNX building, however, was the experimental mixer-settlers, the crucial element in the entire PUREX process.[38] The first tests done in the building were on the 14 stage 1A size mixer-settlers, to simulate the eight-hour continuous operation of the 1A and 1B flow rates to be used in the separations canyons. This was followed by tests on the 3 stage 1C mixer-settlers. All of this testing was done with slightly radioactive natural uranium, rather than the plutonium and irradiated uranium that would be found in the canyons.[39]

Blaw-Knox came back to add additional facilities in 1952. These included decanters, agitators, and centrifuges. The decanter, which was added above the tanks, was part of the solvent recovery system that would be used in the 200 Areas. The decanter was designed to separate the heavy aqueous solution from the lighter organic solution containing reclaimable solvent (tributyl phosphate and "kerosene"). The agitator, an impeller and shaft, was added to assist in the solvent recovery process. Steam and air jets, used throughout the 200 Area processes, were also installed, and this required the installation of additional piping on the south wall for the jets. Last but not least was the centrifuge, a three to four-foot diameter machine designed to remove plutonium and uranium with the liquid solution. The remaining "cake," the solids left behind on the walls of the centrifuge, were cut and removed with high pressure sprays. The addition of the centrifuge required re-doing part of the floor on the open side of the process room to allow for a concrete pit for the liquid from the centrifuge to be collected by gravity flow.[40]

V. EARLY OPERATIONS

The early operations at both CMX and TNX were hectic and exciting, as scientists and engineers struggled to iron out the kinks in a series of problems. In the case of CMX, the first problems to be solved dealt with the water quality of the Savannah River water to be used to cool the reactors; only afterwards was there concern about other aspects of fluid-mechanics associated with the reactors. In the case of TNX, the problems to be resolved were those associated with the PUREX process scheduled to take place in the Separations Area. CMX will be treated first, if only because it was finished first and its mission was the most urgent. This will then be followed by a similar discussion of the original work at TNX, followed by a more general discussion of life and work at the CMX-TNX Area during the mid-1950s, the critical first years of the plant.

START UP AND EARLY WORK AT CMX

The proposed operation of the reactors at SRP was extremely complicated, and it required three different "pilot plants" or semi-works to nail down the technology, both mechanical and nuclear, needed to make them work. The PDP test pile, and two other smaller test piles, in Building 777-M (now 777-10A) were designed to study the nuclear configuration within the reactors. The 305 test pile in Building 305-M, was designed to test the fuel and target elements that would go into the reactors. The CMX was designed to test the hydraulic features of the entire system. Again, because of the need for vast amounts of water, CMX was not put in M Area with the others, but was situated beside the river itself.[1] Of these three semi-works, CMX was the first to begin operation.

The completion date for CMX was originally scheduled for July 1, 1951, but the necessary materials proved difficult to obtain and completion was postponed until September. Even so, the first CMX personnel arrived at the site beginning on July 5.[2] That summer, the CMX-TNX Area had about 12 Du Pont engineers and chemists already at work, even though the facilities were not yet complete.[3] Foremost among these was Paul Dahlen, who returned to the area in July and moved his wife and family to Aiken in August. To underscore the urgency of his work at CMX, Dahlen, who had badge number 1 at Hanford, had badge number 5 at Savannah River. That summer, Dahlen's office was in the plant's first construction headquarters, housed in the two star-shaped buildings (TC-1 and TC-2) that used to be in B Area. Some of the others who worked for Dahlen had their offices in old buildings at or near the CMX site. Since the CMX building was not complete, the first task of Dahlen's crew was to write the CMX operating procedures, and it was a miserable job since there was no air conditioning that summer. Some of Dahlen's main assistants that first year were Dan Wingard, Ray Good, and Earl Nelson.[4]

CMX was not turned over to Operations until September 27, 1951, but the first analysis of the river water began on September 1. This work began with one supervisor (Dahlen), two chemists, and five technicians. In those days, CMX worked around the clock, with three shifts in a 24-hour day. This usually entailed two engineers, two chemists, and two "works engineering" people for the evening and night shift. There could be as many of 10 or 15 people for the day shift.[5]

During this period, beginning in August of 1951, CMX was operated under the aegis of the Technical Division. It was not transferred to the Laboratory Section of the Works Technical Department until May of 1952.[6] This was for the simple reason that the main laboratory for SRP, located in the 700 Area, had not yet been completed. CMX virtually operated on its own during its first year. Of this period, Dahlen recalled that, "every morning I gave a verbal report by telephone directly to Wilmington as to what was going on." The man he reported to was Dale Babcock in Du Pont's Explosives Department. For direct meetings, Dahlen took the train:

> Back in the early days, I made quite a few trips up to Wilmington to report what we were designing. I'd jump on the train there in the old town of Ellenton around 5:30 or so in the afternoon and I'd get up to Wilmington, Delaware, about 7:00 in the morning, get off of the train, put in a full day's work and come back just the reverse. It was very convenient.[7]

And in those days the problems were many, and one of the biggest was the existing power grid. SRP did not yet have its own power system, and the local utility company was not always capable of providing reliable power.

> In the early days before the plant utilities, the electric power for the area was frequently interrupted by electrical storms; and there wasn't much heavy industry. Apparently, people tolerated the [interruptions]. When we started up CMX, we ran into some of that and it would ruin our experiments. If we lost power the water flow would stop, things would be all upset. We had a deal with the electrical utilities to get them to upgrade their switch gear and so forth so it wouldn't be sensitive to lightning. The initial attitude was, "Oh, so what, the power was [only] out for a couple of minutes." Later it got much better.[8]

In addition to the electric company, there were other interactions with the local community that first year. There was a field canteen opened for the CMX construction people as early as June of 1951, but there was never a local cafeteria.[9] Most workers just brought their lunch, but many went to Cassell's, the largest general store in Ellenton. When management came from Wilmington to tour CMX, lunch break included Cassell's.

> That was an interesting experience. A lot of construction people would go there for lunch. They had a big long counter. At the head of that counter you'd tear off a piece of butcher paper, you'd go down the counter, you'd take a couple of slices of bread, you'd put on some meat or cheese or tomato or lettuce, whatever you wanted, and maybe pick up some milk or coffee. Then you'd go to the end of the line and they'd look at that and they'd say okay, that's $2.25. You'd pay for that and you'd go eat your lunch in the car. That was a real country store. They had everything: clothing, harnesses for horses, all kinds of food supplies, fertilizer.[10]

Once work began at CMX, it was the condition of the river water, and how it might impact the heat exchangers, that received the most attention. This work was initially complicated, but eventually benefited by the completion of the Clarks Hill Dam, upstream from SRP. This dam helped stabilize the seasonal variations in the Savannah River. It also helped lower the water temperature of the river, since water was released from the base of the dam. All of these things were beneficial for the running of the reactors at SRP.[11] The big question, however, was the presence of silica, silt, or other properties in the water that might gum up or otherwise clog the heat exchangers. Since this sort of fouling had been such a problem at Hanford on the clear Columbia River, it was naturally assumed that the more turbid Savannah River would present even greater problems.[12] The early tests that were run on the river water have been described by David Ward and Al Peters, both of whom worked at CMX and remembered the experiment.

> The heat exchangers were very large stainless steel tubing shells the size of a giant railroad car. [At CMX] some prototypes made of those heat exchangers, much smaller, with the same basic design and of stainless steel. A boiler provided hot water at one side, and the other side was cooled by Savannah River water. Over a period of weeks and months, and I guess extended on into years, the degree of fouling from the river water was measured, with the idea that this would predict the fouling that would occur in the large reactors.[13] CMX had a very large water clarification plant to remove all of that silt and turbidity and so we ran side by side comparisons with clarified water, which we called treated water, and raw water, right out of the river.[14]

After several months of testing, it was determined that raw river water was perfectly adequate for the heat exchangers. By then, it was clear that the river water carried enough abrasive particles to keep the heat exchanger tube surfaces scoured. No significant amount of fouling occurred; what little that did occur could be treated with oxalic acid.[15] This discovery, which was determined by early 1952, was perhaps the biggest and most important of the early successes at CMX.[16] This discovery came too late to alter the construction of R Reactor. The first of the five reactors to be designed and constructed, R Reactor was equipped with all the requisite clarification features that might be required. The discovery halted the clarification work that was already underway at P Reactor, the second of the five, and it permitted the complete elimination of all major clarification facilities at the last three, K, L, and C. This represented an estimated saving of some $25 million. As Al Peters commented, as a result of this alone, CMX "paid for itself in spades."[17] In the end, the river water that was pumped through all the heat exchangers remained unfiltered. The only thing that was added was a low treatment of chlorine to keep down the algae.[18]

Just months after this discovery, in late 1952, Paul Dahlen was transferred out of CMX. In his subsequent career at SRP, he went from a chief supervisor of Reactor Technology, to become superintendent of the Reactor Department, and finally the Heavy Water Department. He retired from SRP in 1977, but during all those years never worked again at CMX.[19]

One interesting feature of the initial work at CMX was the complete lack of heavy water. It was too scarce and expensive in the first year to have been used for the experiment, especially when ionized water was similar enough to be used in its stead. This led to a tradition and eventually a policy to keep radioactive elements to a bare minimum in the CMX building, and this policy was extended to TNX as well. There, it would be a more difficult proposition, since the processes that TNX had to study were themselves highly radioactive.

INITIAL WORK AT TNX

The Separations Area Pilot Plant, 678-G, which was set up to deal with problems in the PUREX process, was not as urgent an issue as CMX. For this reason, it was constructed slightly later than CMX, and the original building was smaller.[20] Even so, the initial work at TNX was very important.

To understand the TNX work, it is necessary to discuss at least briefly, the range of the entire PUREX process. PUREX was designed to recover plutonium and uranium in separate cycles by using organic solvents. The solvents recovered the plutonium and uranium by mixing with the irradiated materials in a counter-current flow within large boxes known as mixer-settlers. Specifically, the irradiated material brought from the reactors was first exposed to nitric acid, and was then exposed to the organic solvent. The plutonium and uranium were turned into nitrates, which could be removed with the organic solvents. The other fission materials remained behind and were removed from the system in the aqueous phase. The plutonium and uranium were then concentrated in the organic solvent. The solvent was removed, leaving plutonium nitrate and uranium nitrate.[21]

The crucial step in the process, was the mixing of the irradiated material with the nitric acid and the organic solvent, and this process was done in mixer-settlers developed by the Knolls Atomic Power Laboratory. The earliest work at TNX was testing various aspects of the mixer-settlers for use in the canyons.

Another integral part of the PUREX process was the concentration of plutonium, to prepare it for the B-Line processing in the canyons. This entailed removing the excess nitric acid, and this was done in large evaporators, designed by Blaw-Knox. Another means of doing the same thing was through ion-exchangers, but these were not used initially at SRP.[22]

All of these aspects of the PUREX process were tested at TNX, as was other equipment to be used in the canyons. However, they were tested using solutions of non-irradiated uranium, in order to keep radiation levels to a minimum. The radioactive testing required for the process was done by Du Pont scientists at other national laboratories, working on a smaller scale of production.[23] This was in line with the earlier decision to keep the problems associated with radiological shielding out of the CMX-TNX Area.

As TNX work ratcheted up, a one-shift work cycle was replaced by two shifts, from 8 to 4 and from 4 to 12 midnight. This was done on November 6, 1951. The first batch of uranium arrived at TNX in the middle of that same month. The change to three shifts, around-the-clock work, began on December 10, 1951. A "standard rotating shift" schedule was briefly implemented in September of 1952, but was shifted back to three-shift work before the end of October of that year. By this time, the TNX personnel, originally assigned to the Technical Division, had been transferred to the Works Technical Department.[24]

TNX work also spread to Ellenton, which was in the process of being removed in 1952. A temporary organization, the "Equipment and Method Development Group," took up residence in the Ellenton School Shop (the Manual Training Building). There they developed prototypes of equipment that would be used by labs in working with radioactive materials—equipment such as junior caves and gloves boxes. There was even a temporary glass blowing facility. This group was later shifted and transferred to other areas, as SRP neared completion.[25]

Perhaps the most significant single event that occurred at TNX happened on January 12, 1953. On that day, during the 4 to 12 shift, one of the building's evaporators exploded. Not only was the evaporator destroyed and the adjacent siding blown away, but the area was contaminated with uranyl nitrate dust. Fortunately, no one was injured by the blast. Even though the uranium contamination was mild, the building clean-up required TNX to switch to a two-shift schedule for about a month. Work ceased on the decanter, jets, and the centrifuge. Since part of the building siding had been blown out, Blaw-Knox was assigned to do the repair work. A replacement evaporator was back in operation by May of that year. As a safety measure, this one was placed outside, surrounded by a concrete wall.[26]

As a result of the explosion, it was discovered that the evaporation of uranyl nitrate solution had an explosive potential under certain conditions. It was learned that the explosion was caused by the spontaneous oxidation of the organic solvent by nitrogen dioxide in the vapor phase of evaporation. This had not been previously considered possible. The solution was found to reduce steam pressures throughout the system and add instrumentation for greater safety. Fortunately, the accident occurred before either of the two canyon buildings were up and running. The original evaporators were reconfigured and the steam pressure was reduced to forestall any repeat of the explosion in TNX.[27]

This explosion, however, had repercussions that went far beyond the confines of SRP. Claude Goodlett, who worked at TNX, called it "the explosion heard around the nuclear world." Up to that point, no one knew that waste from the solvent extraction could have contained organics capable of explosion. At the SRP canyons, the evaporators (often called "reactors" but not to be confused with the nuclear reactors in the 100 Areas) were removed from inside the canyon building and were segregated outside in a special tank farm around the A-Line Processing Building.[28]

The discoveries made as a result of the January 1953 explosion made TNX as valuable to the entire SRP mission as the CMX was for its contribution to the river water clarification issue. As a result of the work done at TNX, the SRP canyons began operations in 1954 and 1955. Specifically, 221-F began operation in November 1954, followed by 221-H in July 1955.[29]

One of the last of the early features added to the TNX area was the 678-G Seepage Basin, which was installed in early 1954, on the east side of the CMX-TNX area.[30] This feature was required by the continued work done at TNX that generated mildly radioactive waste or other forms of industrial waste that required disposal.

ENVIRONMENTAL AND HEALTH PHYSICS WORK AT CMX-TNX

In addition to the regular work of CMX and TNX, the area was also the site of the first environmental work conducted at SRP. In 1950-51, Du Pont decided to conduct the first environmental study of a proposed nuclear

Views of the TNX Building after the Evaporator Explosion, January 12, 1953.

facility, to establish a base line from which to judge all future and possible radiological releases into the atmosphere and local river systems. This environmental survey was conducted by what was called the "Site Survey Group," under C. M. Patterson. There were other scientists as well. Dr. Ruth Patrick headed up a group of scientists from Philadelphia's Academy of Natural Sciences. This group studied the river and compiled a list of plant and animal species found there. There was also a more local and permanent team under Dr. Eugene Odum of the University of Georgia. All of this environmental work became the basis for what later evolved into the Savannah River Ecology Laboratory in 1962. In the summer of 1951, these groups operated out of the CMX-TNX Area, largely because it was conveniently situated beside Ellenton and the river. Dr. Odum's long-term terrestrial studies began in what was then a local "barn."[31]

The summer of 1951 also saw the establishment of the first Health Physics Area Monitoring Group, which was headquartered in the TNX building. This group was established to monitor the first radioactive materials sent to SRP, usually low level uranium. By early 1952, this group was monitoring all radioactive materials coming and going from SRP. By this time, the group had its own Monitoring Building (614-G). Later, Health Physics headquarters was relocated to the 700 Area Laboratory.[32] There were other groups as well. The Instrument Development Division evaluated instruments to be used for radiation monitoring. Located in CMX, the division helped Health Physics set up its environmental monitoring stations.[33] There was also the Film Badge Service, first set up in the CMX area by September of 1951, and extended a couple of months later to TNX. This Service established SRP's first radioautograph program, and was initially run by Oak Ridge National Laboratory. By March of 1952, the work was transferred to CMX, moving the following month to the Ellenton School. Finally, in September of 1952, these facilities were relocated to 735-A. There was also the Bio-Assay Group. Although this group was placed in the 700 Area, there were tentative plans to locate the facilities in CMX. After the January 1953 explosion at TNX, the Bio-Assay Group checked the local area for contamination, and checked urine samples of possibly contaminated workers.[34]

CMX-TNX STABILIZATION

The initial era of an independent CMX and even TNX, managed from Du Pont headquarters in Wilmington, lasted only a short while. By the mid-1950s, before most of the reactors and separations buildings started, both CMX and TNX were placed under the wing of the SRP Laboratory (700 Area). This was true for the other pilot plants around the plant as well.[35] This guaranteed that both CMX and TNX would be closely tied to the wide range of programs that would soon be conducted at SRP—programs that went beyond the stated mission of producing plutonium and tritium. In fact, all of the basic phases of work at SRP, from the mid-1950s to the 1990s, were represented in T Area. This included Start-Up (1951-55); Power Ascension (1955-1964); Stabilization and Special Products (1964-1972); and the era of Safety and Waste Management (1970s-1980s).

All of this meant that there had to be security at CMX-TNX. This might not have been such a burning consideration in the early days of CMX, since the river water tests were hardly classified information. Such was not the case, however, with TNX, where every aspect of the PUREX process was considered a secret operation. Of course in later years, the work at CMX was classified as well. Only many years later, toward the end of T Area's usefulness, was security largely eliminated. Al Peters remembered that in the early days:

> [CMX-TNX] was a fenced off area with guards. As that work became declassified with time, they eliminated the security. But in my day down there you had to have an a Q clearance. We couldn't do our work without detailed knowledge of the engineering and physics characteristics and the operating conditions [of the plant], which was all top secret at that time. But as that became more and more declassified with time, my recollection is they had the guardhouse and they had a gate but they eliminated the guard. I'm guessing that was maybe late 1970s or early 1980s.[36]

One standard feature of life at CMX-TNX was on-site training. Since the work at CMX and TNX was generally experimental in nature, it was a hands-on laboratory.[37] It became one of the secondary functions of the area to provide training for future heads of the reactor and separations work at SRP. As Al Peters recalled:

> CMX and TNX provided hands-on [training for the plant] with much smaller scale and comparable equipment…. So while the plant was being built, [that was] another purpose of the CMX facilities, to utilize the technical people, get them familiar with the nuclear technology, and then transfer them into the plant. They all went into either Reactor Technology or Separations Technology. Subsequently, like myself, we ended up in production in the plant.[38]

Not all was work at CMX and TNX, especially after the first era of stablization. In addition to regular monthly safety meetings with engineers sent over by the SR Laboratory, there were plant-wide softball games, sponsored by Operations Recreation Association (ORA). Teams were formed on the basis of where you worked at the plant. The CMX-TNX team was known as the "River Rats" or "Swamp Rats," and was active for at least much of the 1950s.[39]

VI. OPERATIONS HISTORY

The history of operations at CMX and TNX, from the mid-1950s to the 1980s, is a close reflection of the larger trends occurring at SRP. Much of what was done in the reactor areas and within separations– the core of the plant– was done first at either CMX or TNX. To complicate matters, one program or test would have implications for other programs, running concurrently or overlapping. Even so, the work at both CMX and TNX prefigured or mirrored the work being done in the reactor and separations areas. And that work can be divided into definite periods. The first was Power Ascension, which had an immediate impact on both reactors and separations areas (1955-1964). Here, the effort was on increasing capacity for the production of nuclear materials, plutonium and tritium, required from the AEC by the Department of Defense. The second period was Special Programs (1964-1970)– the creation of new transplutonium elements championed by the head of the AEC, Glenn Seaborg. This program was made possible by the earlier program of Power Ascension. The third period (1970-1980s) saw a combination of three interrelated concerns: a final stabilization of plutonium and tritium production; a greater concern for safety; and a growing interest in the treatment of the radioactive wastes generated by years of nuclear production. The CMX-TNX Area, played a role in all of these arenas.

POWER ASCENSION AND SPECIAL PROGRAMS AT CMX (C. 1955-1970)

Power ascension in the reactors, an integral part of production increase, began almost immediately after the reactors went on line and finally reached its peak in the late 1960s. Later wrapped into this program were the Special Programs, which required high power and high reactor flux. The increase in power required for this work necessitated a host of changes in the reactors to allow them to bear the extra load, and most of these changes were first tested in CMX.

One of the most prominent people to work at CMX during this period was Albert H. Peters, Jr., who was born in Summerville, South Carolina in 1929, and began working at CMX in late January of 1953, shortly after receiving a Chemical Engineering degree from Clemson College. Peters worked at CMX for the next 16 years, leaving only in 1969. His tenure at CMX brackets this era almost perfectly. There were many others who worked here as well. Among them were David Ward, David Muhlbaier, Fred Apple, Fred Welty, Bob Kirkland, Kurt Rohr, Jerry Beck, and Dave Palmer.[1]

Depending on the work, there could be as many as 12 engineers at CMX, or there could be two or three. In addition to the foreman, there were also a number of technicians and operators. Their numbers also fluctuated, from around four to 12. Technicians were paid weekly, but the operators were usually hourly staff. The operators usually did carryover work in the late shift, and were not allowed to change any of the settings. There was also a Maintenance Crew, which was shared with TNX. At its height, there were around 50 people who worked at CMX. Due to the length of the tests that had to be run, it was normal to operate around the clock, with three shifts.[2] Regular reports had to be made to the SR Laboratory in 700 Area. Even with this schedule, though, the work was more informal than at the SR Laboratory:

> There was a lot of camaraderie [at CMX] and we were kind of isolated from… the rest of the plant and laboratory, which was good and bad, but we had an opportunity to do a lot of practical things, working with mechanics. For example, if you wanted to build something, there wasn't a lot of red tape to go through to get approvals…. You could just go over and talk to a mechanic and say, "Let's put this over here and so forth." There were a lot of more informal arrangements for doing things. I still have very fond memories of the people I worked with, not just the engineers but the mechanics and operators. [CMX] was a nice place to start my engineering career.[3]

After the tests were completed on the river water, which had been CMX's initial mission, the main emphasis shifted to long-term flow testing for fuel and target elements.[4] This began with water flow tests on the solid core uranium slugs, the first fuel and target elements put into the SRP reactors. As reactor power increased, fuel and target elements were increasingly improved for greater productivity and efficiency. The first fuel slugs were tested in the "converter," which was the reactor mock-up within the CMX building. As a standard procedure, they would be tested for signs of corrosion or water wear, with enough lead-time to identify and solve the problem before they were used in the reactors.[5] As early as 1954-55, new flow facilities were added to the CMX building for the testing of reactor components. These included the installation of two converter units, or fuel element test vessels, with revised top plenum design, and an A-frame to handle the reactor components.[6]

CMX also dealt with a wide range of potential problems associated with fluid mechanics in the reactors. This even extended to work on mechanical seals, which required special attention due to the high pressure of the heavy water moderator in the reactors.[7] The CMX work on mechanical seals, as well as monitor pins within and around the reactors, has been described by David Ward.

> It was very important that the valves be leak-proof. A typical valve has packing around the stem so when it comes up and down the water doesn't leak out. Well, that wasn't good enough for heavy water, it had to have more elaborated systems in the bellows and we would end up testing a lot of stuff up there. Another technical area that CMX got into was monitor pins. Under each one of the 600 fuel element positions [in the reactors], there were what we called the monitor pins sticking up in the bottom of the reactor. Each pin had four thermocouples in it. [The reason for this was that] the reactor fuel elements were sensitive to any disturbance. They were clad with aluminum but uranium is very corrosive even in pure water so the aluminum had to be very good quality and if there was any leak through a crack or anything, the uranium would start to corrode badly and swell up, and that could have been very damaging to the reactor. In order to detect any swelling or anything abnormal in the fuel elements, these monitor pins with the four thermocouples required a lot of design work, so that they could be very sensitive to the sampling efficiency of the temperature coming out of the fuel.[8]

To study vibration wear on the fuel and target elements, the slugs were placed in the long-term flow testing facility. It was essential to test the earliest slugs here, since they were solid and there was limited clearance for the water to flow around these in the reactor quatrefoils. These tests might be run for months in order to simulate the kind of wear patterns that might be obtained in the actual reactors.[9] This sort of testing was extended to the new fuel and target elements as they became available from the Manufacturing Area. First the slugs were made hollow, and then they were fashioned into tubes for greater cooling potential. The first experimental co-extruded fuel tubes were produced at SRP in September 1956. Many more followed when Building 321-M was completed in 1957 for the express purpose of making tubes.[10]

Another critical test for the new fuel and target elements was the heating test that determined the temperature at which the elements began to burn. This work was begun by Fred Welty around 1955 and was continued by many others.[11] If power was to be raised in the reactors, it was essential to learn the maximum temperature at which the fuel and target elements would begin to burn. This test was usually conducted by bringing the tube to heat in the "converter" (reactor mock-up), and then lowering the cooling water flow until the element either melted or corroded.[12]

> There was a heat transfer lab in [Building] 773 that did most of the heat transfer work, originally under Sam Mershak in the [Savannah River] Laboratory. Sam got promoted and that all came under me when I was transferred up there. But some heat transfer work was done at CMX by the same individual, Sam Mershak. It never was assigned to CMX but there in the early stages we had the utilities and the facilities to do this work and this was work done to determine, from the safety standpoint, what we call the limitation of flow down the fuel element due to excessive heat generated by the fuel. In this case there was an electrical tube, and our concept was to have what they call, "boiling disease" protection.
>
> For this boiling disease protection, we had restricting orifices at the top of these fuel elements. So if the flow decreased a little bit and decreased pressure dropped across the orifices and let more flow come back in. Now why would the flow decrease? Because of a blister on the cladding [known as] boiling; so that was to prevent boiling disease. At the bottom of the fuel elements, there was a monitoring configuration we put over the monitor pins in the reactors and they had a pressure tab for monitoring and a pressure differential as fuel elements and full thermocouples. Even before our reactors achieved their initial design power, which was a few hundred megawatts, a drop in the bucket compared to what we ultimately achieved, the reactors were sitting there idling at just beyond critical station, at very low power, because we had a problem in the monitoring efficiency. In other words, we wanted to be able to detect pluggage in the sub-channel [by way of the] monitor pin, and that would allow you to shut the reactor down and take that element out. It turns out the very first initial experimental work on our monitoring was done on our Engineering Research Laboratories in Wilmington, Delaware. All of that work we took over at CMX… in late 1954 and 1955. We started an extensive program on that and Fred Welty was the initial guy in CMX doing that work. In fairly short order, we configured changes in the bottom fitting that would improve the mixing. We made those changes in the reactors, also gave them calibration, so they would know what they were looking for and allowed them to proceed to full power at that time. It was lots of work done in the 1950s and 1960s.[13]

It was these sorts of tests that determined the success or failure of any prospective fuel and target element, and there were scores of these designed and built at SRP. One of the first of the new elements was Mark III, an element formed from plates rather than tubes. When it failed the round of tests at CMX, it was scrapped as unworkable. Soon there was a great deal of design work that went back and forth between the Savannah River Laboratory and CMX.[14]

CMX even conducted tests for the Heavy Water Component Test Reactor (HWCTR), which was an experiment conducted by the AEC in the late 1950s and early 1960s to test the possibilities of a heavy-water moderated power reactor.[15] In this regard, CMX tested magnesium as a possible cladding for fuel and target elements. The failure of magnesium to withstand the abrasion of the water flow was probably a factor in the final cancellation of the project.[16]

With the increase in reactor power, and the redesign of the fuel and target elements, it was essential to check the flow of the heavy water moderator inside the reactor tank and make sure it was performing at its optimum. This work was done in the first major building addition to the CMX-TNX Area. This was 677-G, later known as the Reactor Mock-Up Building or Cross Flow Tank Building, constructed in 1955.[17] David Ward and Al Peters helped design the equipment that went into this building and later did much of the work there.[18]

Building 677-G, was constructed from March to October of 1955. Beginning in 1954, new building projects, outside the bounds of the original contract with Du Pont and its subcontractors, were conducted as "S" Projects, which were specific work orders and requests. All "S" Projects over an estimated amount of $20,000 had to be approved by the AEC. The construction of 677-G was covered by Project S8-1015. It was a two-story structure, with a one-story side addition. Ironically, the new building was constructed to reclaim thorium, then known by its secret code designation, "88." The thorium program, one of the first of the new programs at SRP, showed a lot of promise as a fissionable material in the early 1950s. As problems arose, however, the thorium program was cancelled, as was Project S8-1015. The final design of the thorium pilot plant equipment was put aside, but the building itself had already been completed.[20]

Building 677-G was located south of both CMX and TNX, and was approximately 300 feet southeast of the CMX building.[21] The main part of 677-G was the two-story construction, which measured 50 by 170 feet. Much of this building was constructed from the 17 bays of the former temporary construction building, 8300-D. In the early days, it appears that 677-G was used by TNX as well as CMX. In 1956, a new retort furnace, or extraction furnace, was installed in the building to test the new extraction furnaces contemplated for tritium extraction in 232-H. At that time, the existing furnace, which was 25 inches long and 11 inches in diameter, would not take the long target tubes, unless they were cut into smaller pieces. The new long furnace was installed on the west side of Building 677-G.[22] A year later, in late 1957 and early 1958, a 30 by 50-foot single-story addition added to the east side of the building to accommodate new lab facilities, a lunch room, and a semi-works office.[23] Only later was the building modified to include the Cross Flow Tank.

The Cross Flow Tank, designed for hydraulic studies, was a scale model of one-sixth of a normal SRP reactor. This new construction was required because of the great increase in water flow needed to cool the reactors, now running at much greater power than before. The tank was designed to isolate reactor tank "hot spots," any areas with poor circulation within the reactor tank itself. One wall of the cross flow tank was designed to allow visual observation of the tank flow, which could be highlighted with dyes. This work resulted in the design and installation of jet-tube spargers to improve circulation within the tank. This entailed the use of nozzles at various elevations along the length of the fuel and target assemblies.[24]

David Ward described the need for the cross flow tank as a result of the reactor power increases:

> The [SRP] reactors were large tanks, about sixteen (16') feet in diameter, about sixteen (16') feet high. They are filled with about 600 fuel elements. Heavy water ran down the inside and up around the outside where it acted as a moderator. As we kept doing things to increase the power of the reactors, we had to increase the flow through the reactors. At one point we put in more exchangers in the reactors, bigger pumps and everything. So again there was concern about the vibration of this water crossing over the fuel elements. Anyway, we were concerned about that and so we built this [cross flow] tank, which was a full size 16 feet tall, but just a one-sixth pie segment of the reactor tank. We just pumped flow through that and observed vibration and what we could do about the design of the fuel tubes to make them less resistant to vibrations. I did a lot of experimental work on the cross-flow [problem].[25]

Later in the 1960s, the cross flow tank was modified to add a new, full-scale mock-up of a reactor plenum. This was the shield that went over the top of the reactor and directed the water flow into the tank. By the late 1960s, with SRP reactors engaged in Glenn Seaborg's Transplutonium program, there was call for greater and greater reactor power, and high-flux within the reactor. During this period, in 1967, reactor power peaked at 2915 megawatts, seven times greater than the original rating.[26] The plenum added to the reactor tank was done to help test the high-neutron flux charges, which required an even greater flow through the plenum than before.[27]

> When we did that testing for the Californium program [part of Glenn Seaborg's Transplutonium program], we had to modify the plenum on the [CMX] reactor, so that we had the same design characteristics as the real reactor before we could begin that program of evaluating what was going on. The plenum in the SRP reactors was something like 8 inches deep. It was twice that or so in the CMX model. It was originally set up to look at moderator circulation patterns so that you had no hot spots in the moderator. And there was designed a jet tube, which would sit within the lattice of the reactor, take up one position of the reactor tubes. This jet tube would take very high flow from the plenum and discharge the water along the length of that jet tube and in fact, it would discharge it upward, and it would help accelerate the water in the moderator and it would cause that up flow and it would help prevent any dead spaces.... It was developed in order to insure adequate circulation patterns in the reactor and prevent those dead spots where you could get overheating in the moderator. [28]

By the time of the Californium and High-Flux programs in the late 1960s, CMX was probably at its height, in terms of experiments, number of personnel, and relative importance to the Plant. This period was captured by an in-house document detailing the facilities and equipment found at the CMX "Reactor Engineering Semiworks." [29] The run-down of equipment available at that time should be reiterated here.

Among the general equipment listed at that time, there was a river water treatment plant that could provide clarified and filtered water to a 100,000 gallon storage tank. Three pumps provided water from the tank to the experimental facilities. There was also a steam boiler, and the electrical capacity for 2250 KVA (kilovolt ampere). Under the heading "special equipment," there were a number of facilities, only the most important of which are listed here:

- Pressure vessel facility for continuous flow testing of power reactor fuel elements (for HWCTR). This would take assemblies up to 17 feet in length and had a flow capacity of 2800 gallons per minute. The loop operated at 1000 pounds per square inch gauge (psig) internal pressure.
- "A" converter facility for continuous flow testing of fuel elements from a common plenum;
- "B" converter facility for continuous flow testing of fuel elements with individually controlled flows;
- Hydraulic test facility for studies of fuel element hydraulics (for fuel elements up to 15 feet long);
- Vibration study facility with water coolant flow (to study the vibration of fuel and target elements);
- Two monitoring loops for studying components used to monitor coolant flow;
- Mixing study facility; and a
- Cross flow tank facility for study of water moderator circulation.

This was the heyday of CMX. It was a time when the reactors were operating at peak performance, yet there were still issues and potential problems to be addressed. In the coming years, when the reactor process was stabilized, and finally, the reactors began to shut down, CMX went into decline.

POWER ASCENSION AND SPECIAL PROGRAMS AT TNX (C. 1955-1970)

During this period, TNX generally operated with a smaller staff than CMX. Through most of the 1960s, it had around four to five engineers or other technical personnel, five operators per shift; five to six instrument people; eight mechanics to construct new facilities, and various maintenance people—in all, around 30 people. Among the better known individuals from this era, were Claude Goodlett, Al Kishbaugh, Al Jennings, John Webster, William Model, and Vince Caraciolo. Just as at CMX next door, the work at TNX was closely coordinated with similar work conducted at the Savannah River Laboratory and at Du Pont headquarters in Wilmington.[30]

The purpose of TNX remained largely unchanged during this period. It was to aid in the development work for the 200 Area, in particular the process of fuel element solvent extraction. The F Area canyon was the first to be up and running, followed by H Area, then followed by F Area again, as improvements were made to the separations process, and new equipment was designed and installed. During this period, constant improvements were being made to the large evaporators used in the PUREX process. TNX also designed equipment for handling enriched uranium, when that began to be processed in the canyons. It also did work on "steam jets or steam abductors, to transfer solutions from one tank to another; to feed solvent to extraction facilities. These all originally were developed at TNX." Much of this work was done by Ed River, known as E. "Jets" River. Even so, TNX was best known for its improvements to the mixer-settlers and evaporators placed into the canyons.[31]

The first improvements to the mixer-settlers were completed in the mid-1950s. Project S8-1006, dated to late 1954 and early 1955, allowed for the testing of different mixer-settler designs for possible future use in the 200 Areas.[32] This work led to the development and installation of the Jumbo Mixer-Settlers in the late 1950s and early 1960s. Like the original mixer-settlers installed in the canyons, these new jumbos used gravity to mix the solutions. They were designed to be the largest that could be installed in the canyons.[33]

Views of Mixer-Settlers Brought to Building 678 (TNX), Circa 1955.

At least some of the jumbo mixer-settlers remained in service throughout the active life of the canyons, but they were soon joined by other types. Small critically-safe mixer-settlers were installed in the mid-1960s in order to process loads of enriched uranium. About the same time, centrifugal mixer-settlers (also called centrifugal contactors) were installed as well, and these partially replaced the earlier gravity mixer-settlers. In addition to being more efficient, the 18-stage centrifugal mixer settlers were an improvement for another reason—they exposed workers to less radiation. This was one of the great achievements of the TNX team, and this work was spearheaded by Al Jennings, Al Kishbaugh, and John Webster.[34]

Another achievement of the TNX team was co-dissolution of uranium and aluminum in the PUREX process. The original fuel and target slugs were comprised of a metal uranium core, jacketed by aluminum. Originally, these two metals had to be dissolved in two separate operations, aluminum first (then to be discarded), followed by uranium.

> A development that came out of TNX was the co-dissolution of uranium and aluminum. Originally the fuel elements were aluminum jacket on a metal uranium core, so you dissolved the aluminum jacket in a caustic solution, which did not dissolve uranium metal. Then you went in with an acid dissolution of the uranium metal. You threw the aluminum jackets with the caustic solution away as a coating waste. It was a lower-level type waste. Then the uranium metal went through a solvent extraction as a nitrate. The plutonium… was then purified through a couple of cycles and sent to "B" line where it was converted to plutonium metal.

> The uranium went out to what we called the "A" line in those days and converted to UO-3 and stored as UO-3 in 55-gallon drums, and shipped off-plant. Later, we started enriched uranium processing, which used the drivers in the reactor. It was a matrix of uranium aluminum in an aluminum jacket. [Now the aluminum could not be thrown away.] Eventually we found that if you added mercury as a catalyst then you could dissolve the aluminum jackets and uranium aluminum alloy core at the same time using the mercury catalyst.[35]

In addition to extraction work on uranium and plutonium, there was also work on the tritium process, which was also located in the 200 Areas. We have already seen how some of this early work was done in Building 677-G. Most of this work was done, however, in TNX. One of the biggest of the tritium programs, and one of the earliest, was work on the thermal diffusion column for the 232 buildings. Du Pont began the development program in January of 1954, and a decision was made to install a prototype of the thermal diffusion column at TNX in June of that same year.[36] The column was tested there, to the degree that was possible for a facility that was still basically non-radioactive. Some of the first pinch-welding research was done at TNX and at Du Pont's Mechanical Development Laboratory in Wilmington, in 1956. By October of that year, this work was transferred to the Weld Development Group of the Engineering Assistance Section in Building 723-A.[37] Pinch welding soon became the hallmark of tritium reservoir loading done in Building 234-H.

TNX also did work for the Special Products Transplutonium program that was a part of the SRP mission in the late 1960s. Much design work was done on the Multi-Purpose Processing Facility (MPPF) that was eventually installed in the High-Level Caves of the 773 Laboratory building. This facility was essential for the recovery of neptunium and californium, some of the final products of the Transplutonium program. The facility was also used to handle plutonium-238, a heat source used in space satellites.[38] TNX even did metallurgy work on the Naval Fuels program, a program that was later aborted.[39]

By this time, the TNX building contained a number of facilities and equipment for the "cold" (non radiological) processing of 200 Area materials. These included: an ion exchange column, electrolytic dissolvers, chemical dissolvers, mixer-settlers, centrifugal contactors, centrifuges, evaporators, and containment glove-boxes.[40]

CMX AND TNX IN AN ERA OF STABILIZATION AND WASTE MANAGEMENT

By the early 1970s, Savannah River Plant had reached a production plateau, or period of stabilization. The great problems that had plagued early operation of the reactors and the separations areas, had largely been solved, and the need for fissile materials leveled off. By 1972, the optimum fuel and target elements for the production of plutonium and tritium were well established, and there were no serious plans for new arrangements in the process. All of this had a profound impact on work at both CMX and TNX. Both shifted gears, moving away from their original purpose toward new missions. CMX began its slow decline, while TNX found new life in research for the Defense Waste Processing Facility (DWPF). The story of CMX in this period will be presented first, followed by TNX.

By the early 1970s, general reactor operation had become routine. Reactor power limits had been reached, fuel and target arrangements had been standardized. Also, after two decades of production, the demand for nuclear materials, particularly plutonium, began to level off and then decline. During this period, the gravest danger to the heat exchangers and the general hydraulic system was an infestation of river clams—and this problem was treated in the Laboratory, not at CMX. Since the hydraulic workings of the reactors had long been established, this more relaxed environment made it possible for personnel at CMX to work on other issues, and the main new issue was safety.[41]

Safety, of course, had always been of concern to Du Pont in its operation of the SRP. By the standards of the day, Du Pont ran one of the safest industrial facilities around, and probably ran the safest of all the nuclear facilities administered by the AEC. Beginning in the 1960s, and continuing throughout the 1970s and beyond, there was a more heightened environmental concern about nuclear materials and processes, both within the nuclear community and in the nation at large. As a result, safety became increasingly important, eventually eclipsing the original mission of the plant. By the late 1960s and early 1970s, a greater emphasis was placed on preventing possible accidents, no matter how unlikely, and this opened up a new arena of work at CMX.

Safety analysis work had always been a part of hydraulic testing at CMX. Even in the 1950s, there was work done on the mechanical seals of reactor pumps, as well as monitor pins in the thermocouples found at the base of the reactor tanks. This work clearly had a safety component, as did everything else at SRP, but it was also closely tied to the demands of production. By the 1970s, however, there was room for safety research that was not directly tied to production.

One such program was the "Starved Pump Test" from the late 1960s and early 1970s. This tested water flow and re-circulation in the instance of pump failure during the operation of the reactor, which was characterized as a "loss of coolant accident" (LOCA). This became a matter of great concern given that the reactors now operated at much higher power than they did in the mid-1950s.[42] Dave Muhlbaier, who worked on this test, described it this way:

> Starved pump test [sought to find] what would happen if you had a line break and you pumped all the moderator out onto the floor of the reactor. [At that point] the light water injection system would come on and inject water inside to keep the reactor cool. What they wanted to know was how would the [reactor] pumps perform under those conditions. So we did a number of tests at CMX to look at small-scale pumps and how they performed when they were in a starved condition. When I say starved what it means is the suction line is open to the atmosphere. You've got water flowing into it, but you can suck air in too. And so we characterized pump performance under those conditions at CMX, and then went to the reactors and actually did testing, where we lowered the moderator so far that it was flowing by gravity into the pumps so that air was going into the pumps as well as the water. And that was a major reactor test. When we ran that, it sounded like rocks going through the piping system and it was pumping the air and water and it was flowing through there, the pipes moving around. It was incredible. But, you know, it all hung together well and it showed that you would get significant cooling, not just from the light water going in, but from the re-circulation of those pumps that continued to operate. It reduced the impact of an accident significantly.[43]

Muhlbaier later went on to address the problems of reactor containment, which became a big concern in the 1970s. Before the 1960s, radioactive releases were simply vented out the tall stacks adjacent to the reactors. Later, efforts were made to contain such releases, and this offered a wide range of new work. In this particular instance, Muhlbaier, George Priggy, and Al Peters worked on the carbon beds designed for the air filtration system. The carbon bed system was designed to catch radioactive particles as well as radioactive iodine, which was a vapor. The entire thing had to have misters to take out the radioactive steam, particulate filters to remove the air-borne particles, and the carbon beds themselves to take out the iodine vapors. In the tests, freon was used as a substitute for the radioactive iodine. The system that was finally worked out for this level of reactor release containment soon became a standard within the nuclear industry.[44]

TNX also went through a transitional period during the early 1970s. By that time, most of the basic problems associated with the operation of the 200 Areas had been satisfactorily resolved. With a lessening demand for plutonium and tritium, greater emphasis was shown on safety issues. The overriding safety issue for TNX and the Separations Areas was the disposition and treatment of the nuclear waste. This concern eventually led to the initial work on the Defense Waste Processing Facility, which was tasked with the permanent curation of nuclear waste.

One of the first people to work on waste management at TNX was Claude Goodlett. When he began work on this topic, in the 1960s, it was not a high profile job. It was also not a job that was designed to come up with a permanent solution to the nuclear waste problem; it was more local. Most of the early work revolved around sealing leaks in the huge waste tanks in F and H areas, and perfecting the pumps needed to move the waste from one tank to another. This was still a large task, since these tanks ranged in size from 750,000 gallons, to 3.3 million gallons.[45]

By the 1970s, as safety and nuclear clean-up became of greater interest to the public, this sort of work became high-profile. Waste tank pumps were perfected, and more was learned about how to pump waste through pipes from one tank field to another. Within the tanks, work was conducted on converting the liquid waste into a more solid form through evaporation. This reduced the volume of the waste by a factor of three or four. A sluicing method was perfected by both Goodlett and Art Hill to get waste out of the tanks. To further study this, a one-half mock-up of a typical waste tank was constructed so they could study the movement of sludge. [46]

As Goodlett described the process:

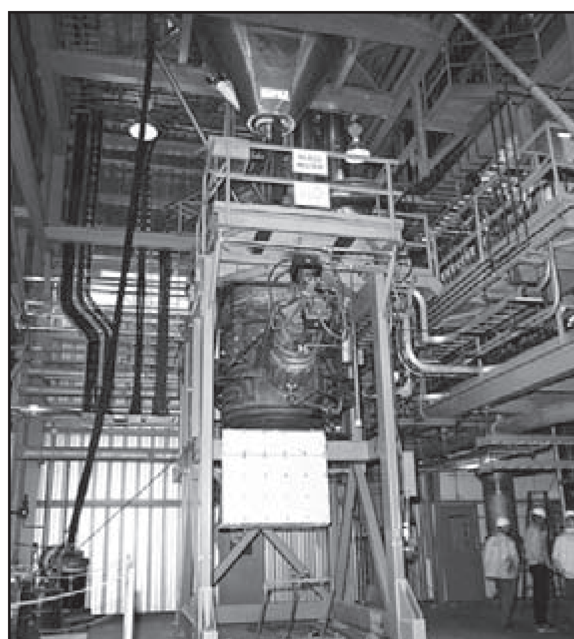
> We brought oil well people in [to TNX] and set up a simulated sludge, which I kind of developed.... We built a half mock-up of a waste tank. We built the high pressure put pumps in and we sprayed it and found out we could indeed remove this simulated waste out of the tanks. The only trouble with that was it took fresh water. So the idea was, "Is there some way we can keep from adding all this extra water to the tanks?" One, it's corrosive and, two, you've got to get rid of it sooner or later. So we were having a meeting one day and we said, "Well, we can get about 60 pounds of pressure from a centrifugal pump, that's about all you can get. These may be running 2000-3000 pounds. So we came up with the idea that we'd get a centrifugal pump. Then the fellow I worked with, Mike Mobley, found a report, which

> was actually written by a Du Pont person, which gave the cleaning radius or the amount of distance a jet stream would go. So we found that we could put these centrifugal pumps in by controlling the nozzle or the flow through the nozzle, we could actually clean the waste for the same distance we'd use in the weight of the liquids that were already in the tank. So that's where the "sludge removal pumps" they have out there now came from.
>
> I made a list of large pump manufacturers that we decided could do this kind of work for us and visited them. It turns out that most of these pump companies are on the West Coast. We went to B & Ryman, which was in Portland, Oregon. And so, with… engineering department help, we in the experimental group designed and told them how we wanted this pump built and they winded up building these things. They were like a million dollars to copy some five or six years ago. That development and those sludge removal pumps came out of TNX. We built the facility and then we came up with an idea that you can get longer cleaning radius because you're limited in the number of holes in a tank that you can put a pump in. There were eight or so in a tank and then we learned to get longer distances, cleaning distances. So, we came up with this equation that somebody had and it worked! And so we were able to use … not add water, use a lower pressure system and to clean the waste from the tank using these prototypes and then what we were putting into the plants. All that work was done at TNX.[47]

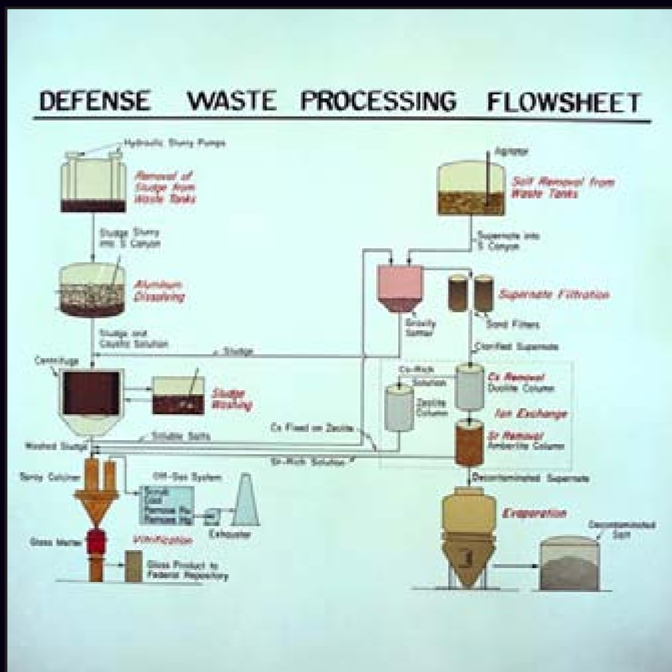
As for reducing the volume within the waste tanks:

> [After the waste in the tanks] settles out, you've got maybe a five, ten percent volume of sludge and then you've got the remainder of liquid. So, when I was doing the concentration, I actually took the liquid, boiled it down to a series of evaporations; and you've got some reasons why you have to do this because of chemistry, the certain carbonating sulfates are not affected by temperature insolubility. And so you concentrate waste and take it back to the tank and cool it and some of that crystallizes out as salt; sort of like the salt that you use on the table. Then we take the liquid back and concentrate it and put it back in the tank and that's how you can get this volume reduction to about a factor of three to four. It saved many billions of dollars in building tanks.[48]

All of this contributed to the research that went into the Defense Waste Processing Facility, or DWPF. The idea behind the DWPF was to find a permanent solution to the problem of nuclear waste belonging to the Defense Department. This research began in the late 1970s and went right on through the 1980s. Even though Du Pont broke ground on the DWPF as early as 1983, persistent problems in the process of turning the liquid waste into a solid, inert form, prevented the facility from going on line until the



Full View of Glass Melter in Building 675-G (TNX).

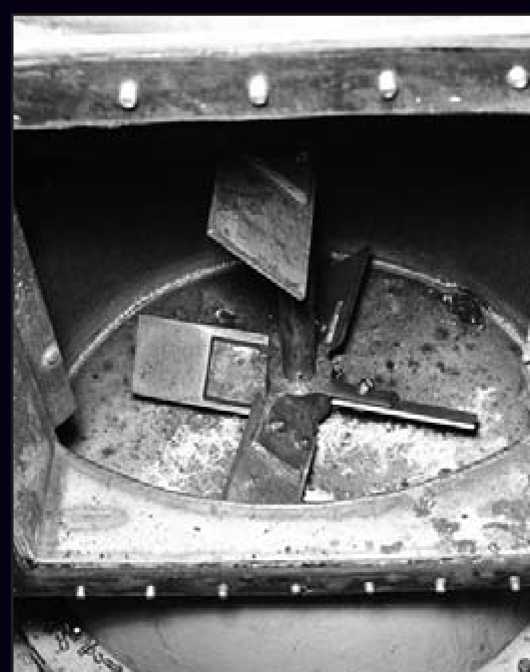


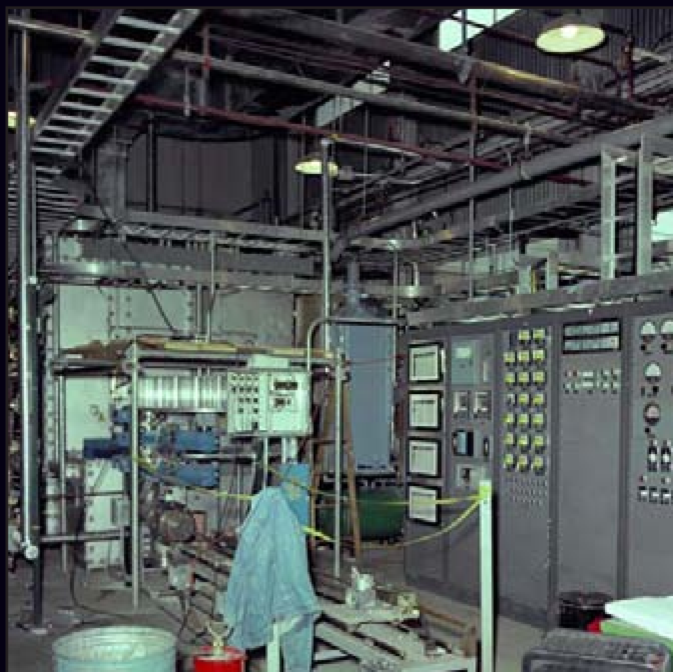
Defense Waste Processing Flow Sheet

Large Tank and Platform (Melter Complex)

Slurry Tank (F-5)

Impeller in Slurry Tank

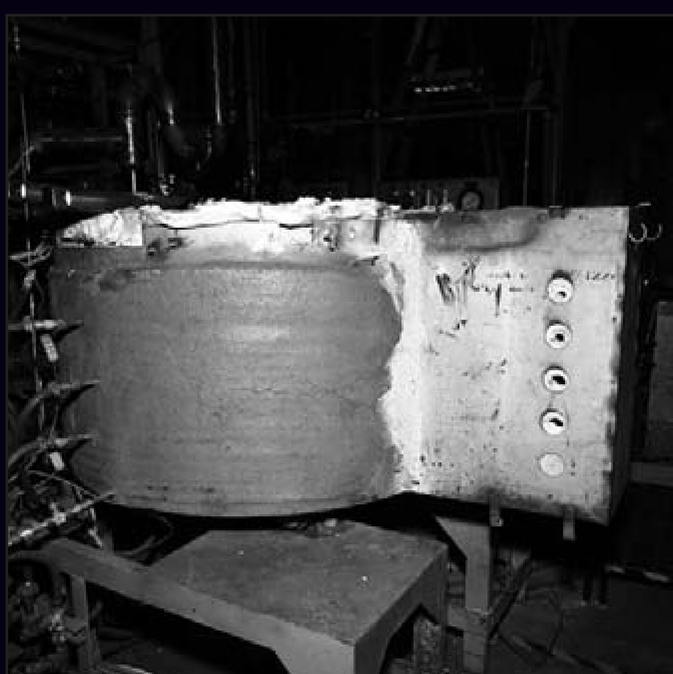




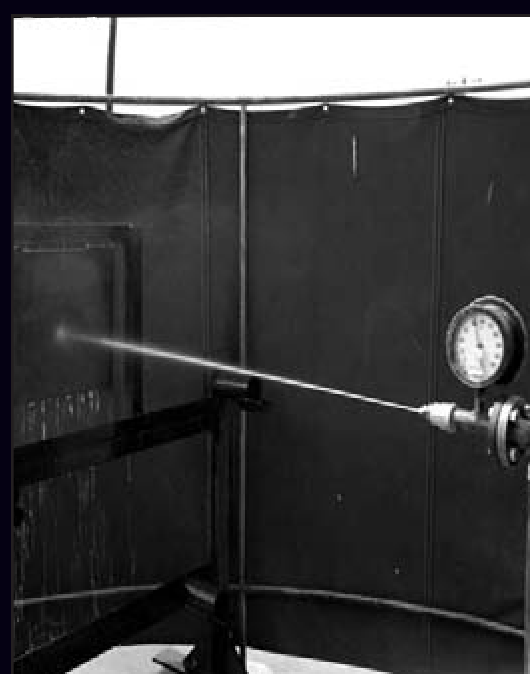
Control Panels for the Melter System

Workman Examining Melter Equipment

Melter Associated with the Melter System



Jet Test for Slurry Tank



Detail Views of Glass Melter in Building 675-G (TNX).

middle of the 1990s. By then, it was recognized that the best means of solidifying and stabilizing the waste was to use the vitrification method preferred by the French, turning high-level waste into "glass logs." This required efficient glass melters, and several half-scale pilot melters were installed at TNX.[49] These included in-can melters, also known as continuous melters.[50]

TNX virtually became the semi-works for the DWPF, which became an important new mission at SRP. As a result, TNX went through a considerable expansion, adding new buildings and facilities around the old campus. There was even an addition added to the south side of the TNX Building itself, constructed in 1978. Much of this TNX area expansion contained equipment for the study of the vitrification process, and included a calciner and the prototype glass melter. The first large demonstration of the glass melter was done in 1982, and work continued on this project throughout the 1980s.[51]

By this time, TNX had definitely eclipsed CMX as the focal point of T Area. The staff at CMX had long scaled back to just one shift a day, while TNX continued to work around the clock. TNX also took over many of the offices and other facilities in the administration wing of the CMX building[52]

VII. CLOSING ERA

Even though the 1980s proved to be a busy time for the personnel at TNX, it was also an era of closing. CMX, its various missions completed, was the first to go, in 1983. It was during this period that the formal designation of the area shifted from CMX-TNX, to T Area. Other changes followed. By the end of the decade, the reactors were shut down, as were most of the Separations facilities. Almost simultaneously, Du Pont bowed out of the operation of Savannah River Plant, and Westinghouse Savannah River Company became the Site operator. Savannah River Plant was renamed Savannah River Site.

When CMX was closed in 1983, the remaining active test facilities were removed to the Savannah River Laboratory.[1] The historic equipment was removed around that time, and the building was totally altered internally to create office space.[2] The other CMX structures were not altered, with the exception of removing the equipment. The CMX buildings would remain in place for another 20 years or so. Even TNX was affected during this period; in 1980 and 1984, the low-level waste burial ground at TNX was dug up and reburied closer to the center of the Plant.[3]

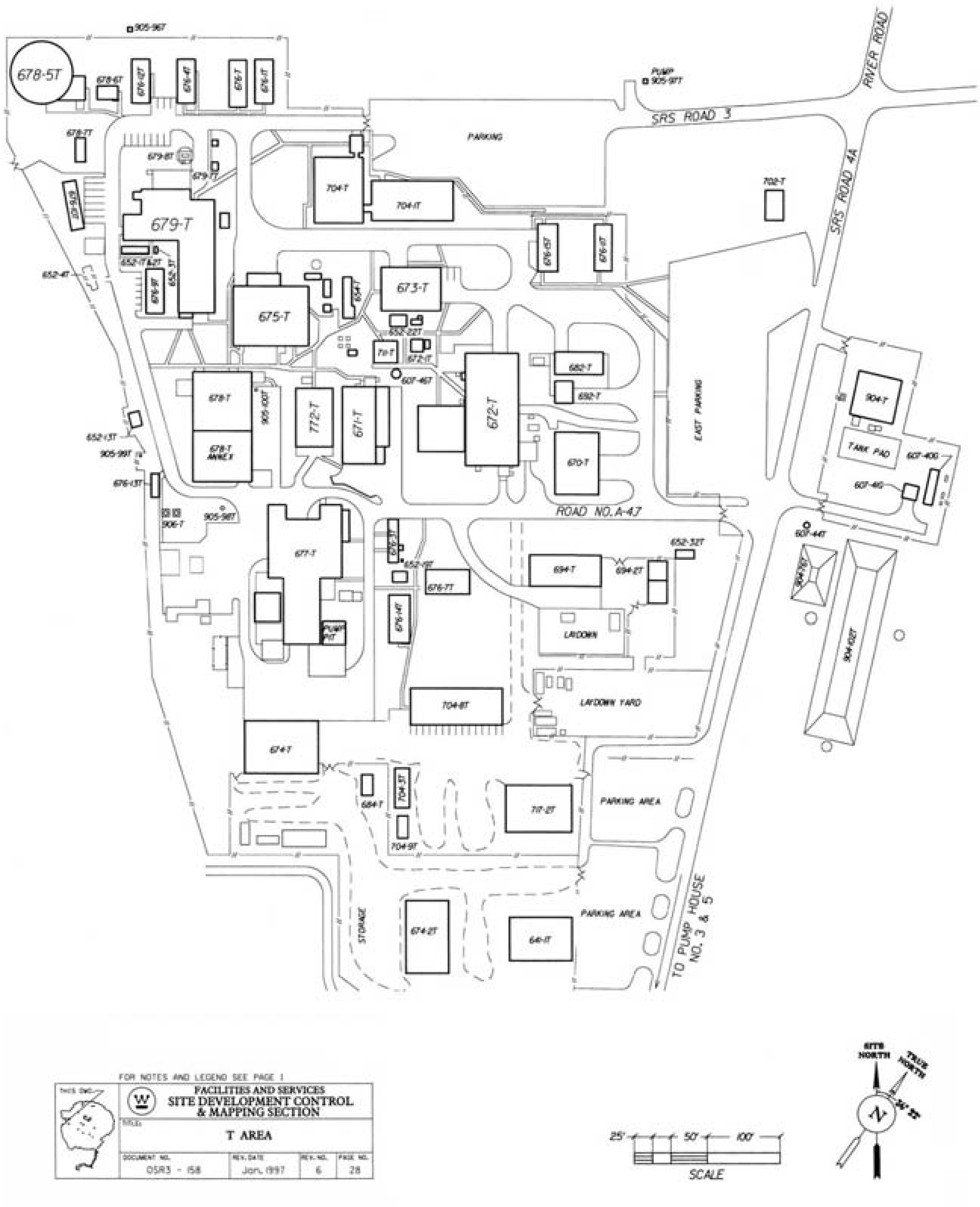
During the 1980s, TNX entered a period of florescence, since it served as the semi-works for the Defense Waste Processing Facility, or DWPF. Groundbreaking for the DWPF occurred in 1983, construction began the following year, and was completed in 1989. Due to problems with the process, radioactive start-up was delayed until March of 1996. By that time, the DWPF was the world's largest nuclear waste vitrification plant, turning high-level waste sludge into borosilicate glass.[4]

As DWPF grew, so did its semi-works, TNX. A number of buildings were added to the area in the years after 1980, including the 1941 Melter Building (this refers to a type of melter, not a year), a canister testing building, a new administration building, and a number of miscellaneous storage shelters and other buildings.[5]

Some of the biggest problems associated with the DWPF concerned the melters for the high level waste. Much of the work done at TNX on this problem revolved around the in-can melters, the continuous melters, and the 1941 melters, all of which had to be studied to determine which one provided the best results. As a result of this work, the in-can melters were eventually abandoned and the 1941 melters, based on a continuous melt and pour technique, became the process used today. In this regard, Jim Kelly and Sam Mirshak did a considerable amount of work on perfecting the glass technique used in the melting process.[6]

Another problem area was in the nozzle of the "can" used to seal the glass in the stainless-steel tank.[7] The tests on how best to seal the plug of the cannisters were done in the cannister testing building. Eventually, it was discovered that the cans were best sealed with high electrical charges.[8]

By 1996, when the DWPF went on line, most of the problems inherent in the process had been worked out satisfactorily. By 2000, there was little need for the semi-works facilities at TNX, and the area went into rapid decline.


678-5T
679-T
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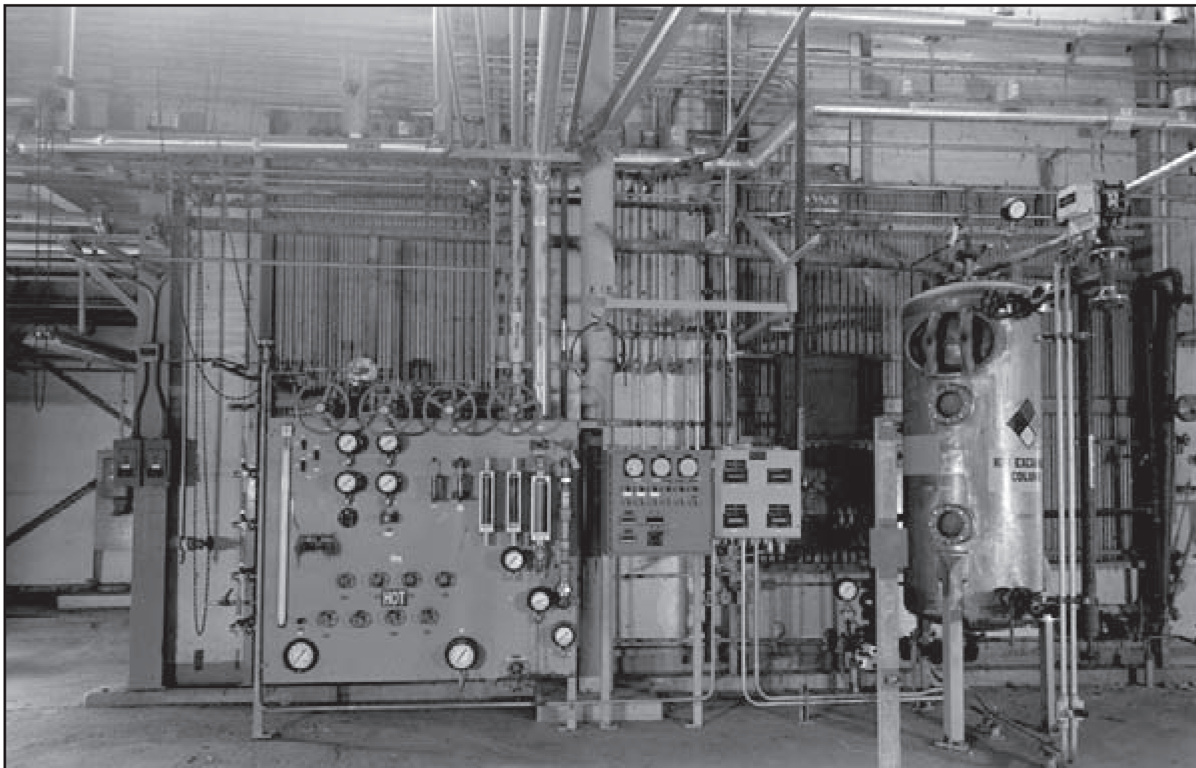
772-T
674-T
704-T
704-1T
670-T
682-T
694-T
904-T
PARKING
SRS ROAD 3
RIVER ROAD
SRS ROAD 4A
EAST PARKING
TANK PAD
ROAD NO. A-4.7
LAYDOWN
LAYDOWN YARD
704-8T
717-2T
674-2T
641-1T
PARKING AREA
STORAGE
TO PUMP HOUSE NO. 3 & 5
PUMP PIT
PUMP 905-97T
FOR NOTES AND LEGEND SEE PAGE 1
FACILITIES AND SERVICES
SITE DEVELOPMENT CONTROL
& MAPPING SECTION
T AREA
OSR3 - 158
Jan. 1997
6
28
SCALE
25'
50'
100'
SITE NORTH
TRUE NORTH

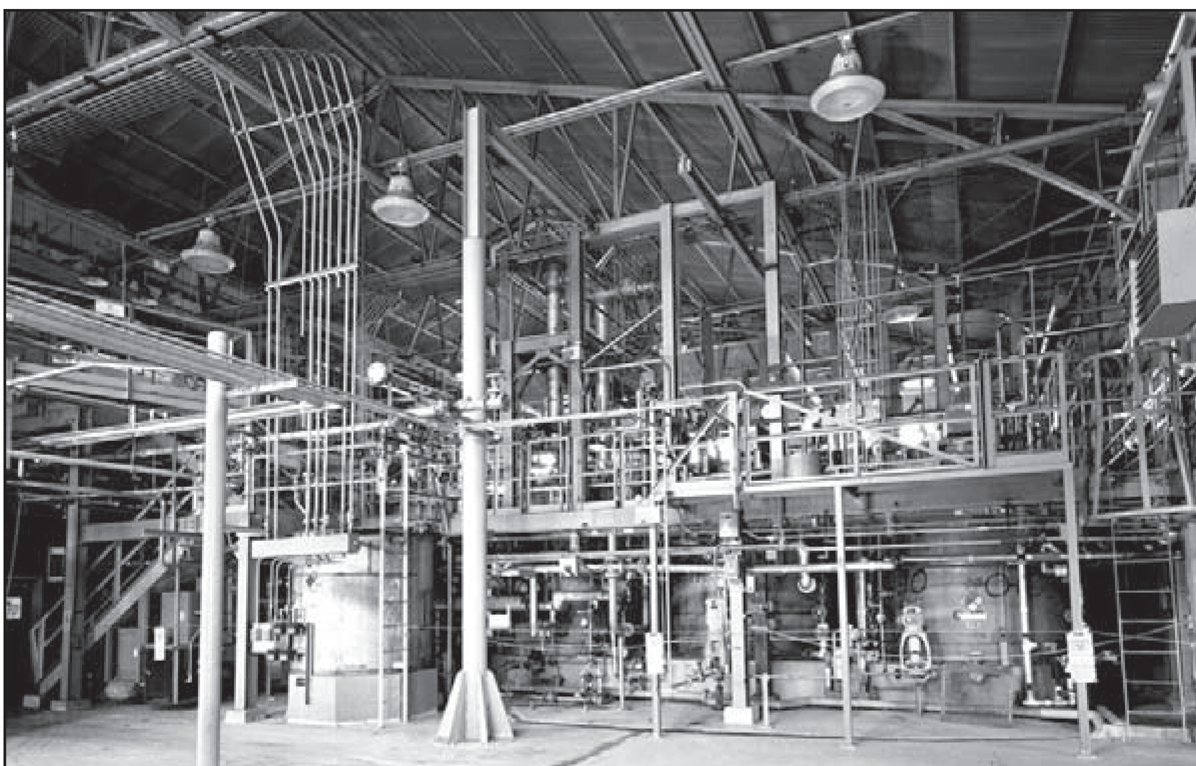
Interior view of 678-T, TNX building, showing Pilot System Tanks for Separations.

At that time, at the turn of the century, almost all the buildings that had ever been constructed at T Area were still standing. This included the main T Area buildings—679-T, 678-T (and the 678 Annex), and 677-T. In addition, there were a host of other buildings and facilities that served these basic buildings, mostly to the south and east, as well as office buildings. The new construction was mostly functional in character and typically featured metal panel buildings with the exception of a brick veneered office building. The building area had grown in the 1980s and 1990s as a product of the waste management programs, principally SWPF production processes. To an extent, it afforded office space to a growing SRS workforce. CMX's adaptation into office space in the early 1980s is indicative of this need. However when DWPF went into operation and the production areas were shutdown, T Area went into decline. TNX's complement of installed equipment was removed over time. When visited in 2003, fragments of equipment were still present for photographic documentation including the CIF Pilot Facility, the pilot system tanks for Separations, a control panel with ion exchange, an ion exchange resin test facility, the OCTF System, and a multi-tank pilot system.

T Area's potential reuse as a research campus for associated industries was unsuccessfully explored by the Department of Energy in the late 1990s. This lack of success and the growing move within the Department of Energy toward reconfiguring the Site and decommissioning obsolete facilities made T Area a candidate for D&D activities. By 2005, these buildings were all gone, razed to their concrete pads.



Control Panel with Ion Exchange in building 678-T, TNX.



CIF Pilot Facility in building 678-T, TNX.

The importance of T Area, better known as the CMX-TNX Area, cannot be overestimated. An enormous amount of testing and hard work had to be done to contribute to the success of the mission of Savannah River Plant– later Savannah River Site– and this work had its beginnings at CMX and TNX. As pilot plants for the Reactors and the Separations Areas, much of what was created for the process was tested in T Area. And this testing was absolutely essential. In an era before powerful computers, large calculations like those needed for even relatively mundane work in the nuclear field were difficult to perform, and the end results were difficult to predict. For these reasons it was essential to have pilot plants, where experiments could be done at relatively low cost on a trial and error basis.[9] There it could be learned whether things that worked in the laboratory would also work on an industrial scale. The pilot plant was the only viable intermediary between the laboratory and full-scale production. There is no doubt that full production could never have occurred at SRP without this step.

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GLOSSARY

A

Alpha Particle
A positively-charged particle from the nucleus of an atom, emitted during radioactive decay.

Atom
A particle of matter which cannot be broken up by chemical means. Atoms have a nucleus consisting of positively-charged protons and uncharged neutrons of the same mass. The positive charges on the protons are balanced by a number of negatively-charged electrons in motion around the nucleus.

Atomic Bomb
An explosive device whose energy comes from the fission of heavy elements such as uranium or plutonium.

B

Becquerel (Bq)
A unit of radiation equal to one disintegration per second.

Beta Particle
A particle emitted from an atom during radioactive decay.

Biological Shield
A mass of absorbing material (e.g., thick concrete walls) placed around a reactor or radioactive material to reduce the radiation (especially neutrons and gamma rays respectively) to a level safe for humans.

Breed
To form fissile nuclei, usually as a result of neutron capture, possibly followed by radioactive decay.

C

Chain Reaction
A reaction that stimulates its own repetition, in particular where the neutrons originating from nuclear fission cause an ongoing series of fission reactions.

Containment Building
A containment building houses the reactor, pressurizer, reactor coolant pumps, steam generator and other equipment or piping containing reactor coolant. The containment building is an airtight structure made of steel-reinforced concrete. The base slab is approximately 9 feet thick; the vertical walls are 3 3/4 feet thick; and the dome is 3 feet thick.

Control Rods
Devices to absorb neutrons so that the chain reaction in a reactor core may be slowed or stopped.

Coolant
This is a fluid, usually water, circulated through the core of a nuclear power reactor to remove and transfer heat energy.

Core
The central part of a nuclear reactor containing the fuel elements and any moderator.

Critical Mass
The smallest mass of fissile material that will support a self-sustaining chain reaction under specified conditions.

Curie (Ci)
A unit of radiation measurement, equal to 3.7x1010 disintegrations per second.

D

Decay
Decrease in activity of a radioactive substance due to the disintegration of an atomic nucleus resulting in the release of alpha or beta particles or gamma radiation.

Decommissioning
Removal of a facility (e.g., reactor) from service, also the subsequent actions of safe storage, dismantling and and making the site available for unrestricted use.

Depleted Uranium
Uranium having less than the natural 0.7% U-235. As a by-product of enrichment in the fuel cycle it generally has 0.25-0.30% U-235, the rest being U-238. Can be blended with highly-enriched uranium (e.g., from weapons) to make reactor fuel.

Deuterium
"Heavy Hydrogen", an isotope having one proton and one neutron in the nucleus. It occurs in nature as 1 atom to 6,500 atoms of normal hydrogen, (Hydrogen atoms contain one proton and no neutrons).

Dose Equivalent
The absolute measurement of exposure to a dose of ionising radiation depends upon the type of particle and the body tissue with which it interacts - hence the conversion to dose equivalent, which has units of rem. Rads are converted to rems by multiplying by a factor that depends upon the type of ionising radiation and it's biological effect. For example, with gamma radiation the factor is 1 and a rad is equal to a rem.

E

Element
A chemical substance that cannot be divided into simple substances by chemical means; atomic species with same number of protons.

Enriched Uranium
Uranium in which the proportion of U-235 (to U-238) has been increased above the natural 0.7%. Reactor-grade uranium is usually enriched to about 3.5% U-235, weapons-grade uranium is more than 90% U-235.

Enrichment
Physical process of increasing the proportion of U-235 to U-238.

F

Fast Breeder Reactor (FBR)
A fast neutron reactor (qv) configured to produce more fissile material than it consumes, using fertile material such as depleted uranium.

Fast Neutron Reactor (FNR)
A reactor with little or no moderator and hence utilising fast neutrons and able to utilise fertile material such as depleted uranium.

Fertile (of an isotope)
Capable of becoming fissile, by capturing one or more neutrons, possibly followed by radioactive decay. U-238 is an example.

Fissile (of an isotope)
Capable of capturing a neutron and undergoing nuclear fission, e.g., U-235, Pu-239.

Fission
The splitting of a heavy nucleus into two, accompanied by the release of a relatively large amount of heat and generally one or more neutrons. It may be spontaneous but usually is due to a nucleus absorbing a neutron.

Fission Products
Daughter nuclei resulting either from the fission of heavy elements such as uranium, or the radioactive decay of those primary daughters. Usually highly radioactive.

Fuel Assemblies
These are a group of fuel rods.

Fuel Fabrication
Making reactor fuel elements.

G

Gamma Rays
High energy electro-magnetic radiation.

Graphite
A form of carbon used in a very pure form as a reactor moderator.

H

Half-Life
The period required for half of the atoms of a particular radioactive isotope to decay and become an isotope of another element.

Heavy Water
Water containing an elevated concentration of molecules with deuterium ("heavy hydrogen") atoms.

Heavy Water Reactor (HWR)
A reactor which uses heavy water as its moderator.

High-Level Wastes
Extremely radioactive fission products and transuranic elements (usually other than plutonium) separated as a result of reprocessing spent nuclear fuel.

Highly (or High)-Enriched Uranium (HEU)
Uranium enriched to at least 20% U-235. Uranium in weapons is about 90% U-235.

I

Isotope
An atomic form of an element having a particular number of neutrons. Different isotopes of an element have the same number of protons but different numbers of neutrons and hence different atomic masses, e.g., U-235, U-238.

J

Joule
A unit of energy.

K

KeV
One thousand electron-volts. An electronvolt (symbol: eV) is the amount of energy gained by a single unbound electron when it falls through an electrostatic potential difference of one volt. This is a very small amount of energy.

Kilowatt
A Kilowatt is a unit of electric energy equal to 1,000 watts.

Kilowatt-Hour
This is a unit of energy consumption that equals 1,000 watts used for one hour. For example, ten 100-watt light bulbs burned for one hour use one kilowatt-hour of electricity.

L

Lattice
Structural configuration in a reactor organizing positioning of fuel rods, control rods, and safety rods.

Light Water
Ordinary water (H20) as distinct from heavy water.

Light Water Reactor (LWR)
A common nuclear reactor cooled and usually moderated by ordinary water.

Low-Enriched Uranium (LEU)
Uranium enriched to less than 20% U-235. Uranium in power reactors is about 3.5% U-235.

M

Megawatt (MW)
A unit of power, = 106 Watts. MWe refers to electric output from a generator, MWt to thermal output from a reactor or heat source (e.g., the gross heat output of a reactor itself, typically three times the MWe figure).

Metal Fuels
Natural uranium metal as used in a gas-cooled reactor.

Micro
One millionth of a unit (e.g., microsievert is one millionth of a Sv).

Millirem
This is a measurement of the biological effects of different types of radiation equaling 1/1000th of a REM.

Mixed Oxide Fuel (MOX)
Reactor fuel which consists of both uranium and plutonium oxides, usually with about 5% Pu.

Moderator
A material such as light or heavy water or graphite used in a reactor to slow down fast neutrons so as to expedite further fission.

N

Natural Uranium
Uranium with an isotopic composition as found in nature, containing 99.3% U-238, 0.7% U-235 and a trace of U-234.

Neutron
An uncharged elementary particle found in the nucleus of every atom except hydrogen. Solitary mobile neutrons travelling at various speeds originate from fission reactions. Slow neutrons can in turn readily cause fission in atoms of some isotopes, e.g., U-235, and fast neutrons can readily cause fission in atoms of others, e.g., Pu-239. Sometimes atomic nuclei simply capture neutrons.

Nuclear Reactor
A device in which a nuclear fission chain reaction occurs under controlled conditions so that the heat yield can be harnessed or the neutron beams utilised. All commercial reactors are thermal reactors, using a moderator to slow down the neutrons.

O

Oxide Fuels
Enriched or natural uranium in the form of the oxide U02, used in many types of reactor.

P

Plutonium
A transuranic element, formed in a nuclear reactor by neutron capture. It has several isotopes, some of which are fissile and some of which undergo spontaneous fission, releasing neutrons. Weapons-grade plutonium is produced with >90% Pu-239, reactor-grade plutonium contains about 30% non-fissile isotopes.

Pressurised Water Reactor (PWR)
The most common type of light water reactor (LWR).

R

Radiation
The emission and propagation of energy by means of electromagnetic waves or sub-atomic particles.

Radioactivity
The spontaneous decay of an unstable atomic nucleus, giving rise to the emission of radiation.

Radionuclide
A radioactive isotope of an element.

Radiotoxicity
The adverse health effect of a radionuclide due to its radioactivity.

Rads
A unit to measure the absorption of radiation by the body. A rad is equivalent to 100 ergs of energy from ionising radiation absorbed per gram of soft tissue.

Reactor Vessel
It is the steel pressure vessel that holds the fuel elements in a reactor.

rem (Roentgen Equivalent Man)
REM is the common unit for measuring human radiation doses, usually in millirems (1,000 millirems = 1 rem).

Reprocessing
Chemical treatment of spent reactor fuel to separate uranium and plutonium from the small quantitiy of fission products (and from each other), leaving a much reduced quantity of high-level waste.

S

Shielding
Material, such as lead or concrete, that is used around a nuclear reactor to prevent the escape of radiation and to protect workers and equipment.

Spent Fuel
This is used nuclear fuel awaiting disposal.

Stable
Incapable of spontaneous radioactive decay.

T

Thermal Reactor
A reactor in which the fission chain reaction is sustained primarily by slow neutrons (as distinct from Fast Neutron Reactor).

Transuranic Element
A very heavy element formed artificially by neutron capture and subsequent beta decay(s). Has a higher atomic number than uranium (92). All are radioactive. Neptunium, plutonium and americium are the best-known.

U

Uranium
A mildly radioactive element with two isotopes which are fissile (U-235 and U-233) and two which are fertile (U-238 and U-234). Uranium is the basic raw material of nuclear energy.

Uranium Oxide Concentrate (U308)
The mixture of uranium oxides produced after milling uranium ore from a mine. Sometimes loosely called yellowcake. It is khaki in colour and is usually represented by the empirical formula U308. Uranium is exported from Australia in this form.

V

Vitrification
The incorporation of high-level wastes into borosilicate glass, to make up about 14% of the product by mass.

W

Waste
High-level waste (HLW) is highly radioactive material arising from nuclear fission. It is recovered from reprocessing spent fuel, though some countries regard spent fuel itself as HLW and plan to dispose of it in that form. It requires very careful handling, storage and disposal.

Waste
Low-level waste is mildly radioactive material usually disposed of by incineration and burial.

Y

Yellowcake
Ammonium diuranate, the penultimate uranium compound in U308 production, but the form in which mine product was sold until about 1970.

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APPENDIX A
ORAL HISTORY TRANSCRIPTIONS

Oral History Interview – Paul Dahlen

Paul Dahlen was born on March 22, 1913, in Minneapolis, Minnesota. He obtained a Bachelor of Technical Engineering from the University of Minnesota in 1936, and for the three years that followed, worked with the Northwest Research Foundation while obtaining his Masters of Science degree, awarded in 1939. That same year, Dahlen began working with Du Pont, in the Ammonia Department at the experimental station in Wilmington, Delaware. In 1940, after the outbreak of World War II, he transferred to Du Pont's Explosives Department, and worked for a while in Childersburg, Alabama.

In 1943, he became one of the first people transferred to the Hanford Engineering Works, in Washington State. There, he worked at Hanford's CMX works, dedicated to a study of the Columbia River water, which would be needed to cool Hanford's nuclear reactors. Dahlen remained at Hanford until the end of the war.

In the late 1940s, Dahlen transferred to Du Pont's Plastics Department, based in Arlington, New Jersey. In 1950, when it was clear that Du Pont would be tapped to build and operate the nation's new "Hydrogen Bomb" plant at Savannah River, Dahlen began working in Du Pont's Atomic Energy Division. He was selected to head up the CMX pilot plant at Savannah River in early 1951, and oversaw that work during the plant's crucial first two years. By 1953, with the main function of CMX fulfilled, Dahlen was shifted to Reactor Technology, where he was chief supervisor for engineering studies, later becoming chief supervisor for plant assistance. In 1961, he was transferred again to the Reactor Department, where he was area supervisor for the K Area reactor. Dahlen retired from Du Pont and the Savannah River Plant in 1977, and still lives in Aiken, South Carolina.

Interviewee: Paul Dahlen
Interviewer: Mark Swanson, New South Associates
Date of Interview: September 13, 1999

Mark Swanson: This is an interview with Paul Dahlen [interviewer is Mark Swanson].

Paul Dahlen: Dahlen (sounds like Dahlen, accent on last syllable)

MS: Dahlen, okay, conducted by Mark Swanson, Historian with New South Associates being conducted on 13 September 1999 at the home of Mr. Dahlen. This interview is being conducted as part of a Savannah River Site history project, which is documenting the fifty (50) year history of Savannah River Site and its impact on the surrounding area and the people who have lived in that area. Mr. Dahlen is being interviewed because of his long tenure at SRP and as a normal rule … what we try to do next is to actually get your age and if you would say your name the way you pronounce it, Dahlen, Paul Dahlen.

PD: Okay. Paul Dahlen, I'm 86-years-old.

MS: Uh-huh. And place of birth?

PD: Minneapolis, Minnesota.

MS: Uh-huh. And your relationship to Savannah River Site?

PD: Well, I started in very early 1951 and I was asked to head up the CMX group. CMX was a co-designation for work to be done on determining the treatment of the cooling water for the reactors for the Savannah River Plant. Should I just continue talking?

MS: Sure if you want to, yeah, sure...

PD: The reason they decided to have a CMX project is that there had been a CMX project for the Hanford job and it proved to be extremely valuable. The Hanford project was different from the Savannah River with respect to cooling water in that at Hanford the river water, which was the cooling water, went directly through the reactor and then exited back into the river. At the Savannah River Plant, because we have heavy water as a moderator, the cooling water went through heat exchangers. The moderator, the heavy water, picked up the heat in the reactor and it in turn was cooled then by the river water in heat exchanges; so our job was to determine what degree of treatment was necessary for the river water.

MS: Okay, great, that was … what year was that that you were doing that work?

PD: Starting in fifty-one ('51). I moved to the site here in August of '51 and CMX was the first operating facility to go into operation at the site. This facility was located near the Savannah River, maybe a quarter of a mile from the river and that site is still there.

MS: Okay, great. Let's see … how did you first find out about the Savannah River Site project?

PD: Well, when Du Pont was asked to get into the production of the so-called hydrogen bomb, that became public information and we knew that there were several sites under consideration and this Savannah River Site was selected and that was announced in November of 1950.

MS: Okay, let's see, where did you come from when you came here … I know you'd been working at Du Pont, did you come from Wilmington?

PD: I was originally with … I started with Du Pont in thirty-nine ('39) and that was with the old ammonia department at the experimental station in Wilmington. Then when we got involved with the defense program back in 1940-41, I had a low draft number and just starting out in the defense program Du Pont didn't know whether or not they could get a deferment for me in the work that I was doing. At that time, Du Pont was asked to get into a very large defense program producing the smokeless powder and other explosive material for the United States government. Du Pont was going to have to design, construct and operate a number of defense plans throughout the United States so they asked if I would consider going into that program; they were sure that I would get a draft deferment in that program so I agreed to that and went into training in 19 … late 1950 or early 1951 initially at Eastern Laboratory, Gipstown, New Jersey. After four (4) or five (5) months of training there, I then went to the Alabama ordinance works in Childersburg, Alabama where Du Pont was operating a military explosives plant. Then in 1952 … no it was 1953, April of 1953 I was transferred from Alabama to Wilmington to work on the design of the reactors that were to be built at Hanford. I then …

MS: You mean 1943, right?

PD: … forty-three ('43) yeah, excuse me, 1943; I then was assigned to the CMX group and was in the first operating group at Hanford. I went out there in August of 1943 and as an aside, I had badge number one (1) at Hanford; and incidentally, I had badge number five (5) at Savannah River site.

MS: How did they work that out, was it strictly whoever …?

PD: Uh, the order in which you came into it. Now the reason I had number one (1) at Hanford is there were some operating people out there prior to my arrival, but they knew that a group was coming there for this CMX so at the time I was being badged out there, they decided, "Gee, we'd better set up a new badge system for the operating people." The initial badging system was set up for the construction people, so okay we needed a new one for the operating people. I was the first one to go through and happened to get number one (1).

MS: That's pretty good, that's pretty good. I don't suppose you would have that badge do you?

PD: Oh no, we don't keep them.

MS: Okay.

PD: No, they're turned in.

MS: Yeah, that's pretty good. When you came here …

PD: After Hanford, many of the … Du Pont transferred the operation of the plant over to General Electric and Du Pont could take the employees that they wanted to keep from Hanford and use them in their normal work and so, a relatively small percent of the people from Hanford were transferred back to Du Pont work. I was transferred to the Plastics Department and initially worked in Arlington, New Jersey in a research group there and in 1950 there was this research group was transferred to the experimental station in Wilmington, Delaware, where new research facilities had been constructed after World War II. I was there in the fall of 1950 when Du Pont was asked to get involved with the so-called Hydrogen Bomb Project and I was asked to come back into the atomic work. I transferred from the Plastic Department in Wilmington to the work for this Savannah River Plant.

MS: Right, right, hmmm, that's pretty good. What was your impression when you came to this area?

PD: Well, I first visited the plant in February of 1950 to look over the site where we were going to have our CMX facility and I guess there wasn't anything that was particularly surprising. I had worked in the

Alabama Site … worked in the South, I've done a lot of traveling all of my life so there weren't any big surprises coming here.

MS: Right. Was work at the plant considered attractive to those that came in from outside of the Southeast?

PD: Well, it depends on the individual. Some people adapt to that pretty easily, some people who have not moved around a lot and a new location is a bit difficult for some people. Maybe in some respects it is more difficult for the spouse. This was not a real progressive area socially or educationally and so … and there was some reluctance on the part of the local people to have all of these strangers come in and kind of flaunt their little town like Aiken; so it was understandable that was a little bit of resentment on the part of the locals but I think we overcame that rather quickly because they could see that it was a interesting group of people that came down here. The people were well educated, we got involved in civic activities, joined churches, participated in the improvement of the schools, the public schools and so that initial resentment was overcome fairly quickly.

MS: Right, right. You were a Du Pont employee before you came to Savannah Plant …

PD: Yeah.

MS: … what was the difference in the kind of work that you were required to do earlier … you went into a little bit of like what was going on at Hanford, what was the difference between what you did earlier and what you had to do here at Savannah River Plant?

PD: Well, what we did at Savannah River and CMX was quite similar to what we did in CMX at Hanford. Now how that differs from normal Du Pont research work that I had been doing, of course, the nature of the work was very different. Security was a big factor here but I had the previous experience at Hanford; interesting thing about Hanford, was that very few of the people working out there knew what the project was all about. That included most of the people working on the plant site, they didn't know what we were producing … what it was for and of course we couldn't discuss it with our spouses or our friends and as an example, the day the first atomic bomb was dropped in Hiroshima, Japan, my wife was at the beauty parlor and, this was before the days of TV, it came on over the radio that an atomic bomb had been dropped on Hiroshima in Japan and that the material for the bomb had been produced at Hanford. That was the first she knew of what was going on there at Hanford. But then here it was announced in the press and everything before the plant was ever started that we were going to build an atomic facility there at the Savannah River Site, so the security was different in that respect.

Hi! This is my wife Marie.

Marie Dahlen: Hello.

PD: This is Mark Swanson.

Marie: Mark Swanson? That's a good Scandinavian name.

MS: [laughs]

PD: He claims he isn't though.

Marie: He isn't?

MS: I'm afraid not, afraid not [laughs].

PD: His beard is getting blonde though.

MS: No, I'm afraid it's gray.

PD: [laughs]

MS: You were talking about security differences, did it make … did it make a difference in how you got badges and things like that?

PD: Not particularly, no.

MS: Okay, right, so that kind of security implementation was the same?

PD: Yeah, pretty much the same. Uh-hum.

MS: Okay. How had the previous experience; you said you worked with, if I remember correctly, the Ammonia Department?

PD: Initially.

MS: Initially, right? Did that have any impact on your work or was it sort of like you went into something totally different when you started doing ….?

PD: Well, the previous experience was beneficial in that I got experience operating equipment, developing research programs and so-forth and so in that respect there was a similarity but the type of work was entirely different.

MS: Uh-huh, right, yeah, uh-hum. I guess … did people understand what the mission of the plant was when they first started working here?

PD: At Savannah they did; at Hanford, no.

MS: Yeah, probably didn't have any idea. You mentioned your first job assignment was, correct me if I'm wrong, was at CMX?

PD: Yeah.

MS: Here?

PD: Here.

MS: And we talked about the differences between that and what you did at Hanford at CMX.
Tell me, if you wouldn't mind, after you started working at Savannah River Site, I know that you had a number of different positions, if you wouldn't mind addressing that to some degree.

PD: Well, the initial assignment at CMX was interesting in that we ended up determining that very minimal treatment of the Savannah River water was required to go through the heat exchangers to cool the reactors, in fact, we gave it a low treatment of chlorine and that was all. We didn't even have to filter the water that went through the heat exchangers and of course, that resulted in a tremendous savings. We didn't have to build the filter plants for each of the five (5) reactors. Didn't have to operate those plants so there were millions and millions of dollars that was actually saved as a result of that. Towards the end of the CMX program to determine the treatment of the water required to cool the reactors, I was then transferred to Reactor Technology; which was a section of the works technical department of the plant and I was assigned as a Chief Supervisor. At that time we had three (3) chief supervisors in Reactor Technology, one (1) for physics studies, one (1) for engineering studies and one (1) for plant assistance. I was initially Chief Supervisor for engineering studies and subsequently was chief supervisor for plant assistance. Our assignment was to assist the Operating Department and the Reactor Department with the technical problems, procedures and so forth that developed during the initial operation of the reactors. I continued in reactor technology until 1961 when I was transferred to the Reactor Department, the Operating Department and I was Area Superintendent of K area, in charge of the operation … the K Reactor.

MS: Oh, okay, so you were in charge of K Reactor?

PD: Initially.

MS: Uh-huh, right, uh-huh; did you later work in L Reactor as well or …?

PD: Well, I … after about a year I was promoted to Assistant Department Superintendent and was then located in the 700 Area and was responsible for all five (5) reactors.

MS: Okay, but when you were like the Area Superintendent, you were in K area right?

PD: Yeah, uh-hum.

MS: Let's see, since we brought up reactors, let's talk some about difference there. Why was heavy water chosen over graphite or natural water like the use in Hanford to cool the reactors?

PD: It is more efficient, it utilizes the neutrons more efficiently than graphite.

MS: Is there any safety factor involved in that as well or is that just sort of like in your …?

PD: Not really, not really?

MS: Not really?

PD: Now Hanford couldn't choose heavy water because heavy water wasn't available. They were just developing a process to produce heavy water and it really lacked the development of the process for the reactor itself, so heavy water wasn't an option for Hanford so that's why they had to use graphite.

MS: Uh-hum, right, right.

PD: But by the time Savannah River was being considered, why, the process had been developed sufficiently for heavy water so that we could use it and therefore it was more efficient than the graphite moderated reactors.

MS: And you were not … you weren't working like uh, in K Reactor at the time when it first went critical?

PD: No uh, in Reactor technology the … we were headquartered in C area, the Reactor Technology, the bulk of the people; but as each reactor uh, was completed, the construction completed and ready to start operation, why we were all at that reactor doing what was necessary to get it critical the first time, keep it operating successfully, get through the startup headaches and so forth so we started with R and then six (6) months later was P Area and then L, K and C. I was involved with all five (5) reactors of the startup

MS: What was it like when the reactor went critical?

PD: Well, it went critical over a period of time. It was a number of shifts as we would approach a criticality, why problems would develop that would have to be worked out that would have to be worked out, that would delay things, instrument problems and so forth so it went over a period of several days before we finally achieve criticality; and then we had to make sure all of the instruments were working as they should be working before we could go up in power level to significant power and so that dragged on for a few days and so it wasn't one big moment and that was it but it dragged over a period of time.

MS: Right. You mentioned power ascension. I know they did that in like the fifties ('50s) and sixties ('60s). What were the problems that … what was it like when they did do the power ascensions and the reactors, were there any problems with that or fairly smooth?

PD: It was fairly smooth but it took a lot of planning and so forth and, of course, initially the reactors each had six (6) heat exchangers but the design was such that we could put another six (6) heat exchangers in and so that was done, which in affect doubled the power level that the reactors could be operated at but that went smoothly because lots of good engineering and planning right from day one (1) of the design.

MS: And one (1) question of interest is what was the atmosphere like at the plant when they shut the reactors down? You may have already retired, you know, before that happened.

PD: We had shut down one (1) or two (2) before I left; placed in standby; but at that time we thought that they might start up again … didn't know, but I retired in February of 1977.

MS: What was it like when they shut the power reactor down? I guess that was in 1964?

PD: Well there … I supposed you wonder about what affect on [inaudible] and so forth, there wasn't too great an affect because there wasn't a reduction of force, we still kept a nucleus of people there and the other people were reassigned in the plant and so it wasn't a reduction of force so we didn't have that morale problem that they were faced with later.

MS: Right. What was the next reactor to be shut down, was it like … one that …?

PD: Well, we had problems with C area; problems with cracks in the tank and so forth so we had to shut down and do work on that. We had also done work on our area, which took some months to do and took a lot of planning and mockup work and so for the to develop just how the reactors could be patched and fixed so that they could be operated again. Those instances took several months each.

MS: In doing the job of like taking care of the reactors, what aspects of your job did you like the most and what aspects did you like the least? If we could get into that.

PD: No, that's all right. I guess the aspect I liked the most was the challenge. We worked during a period when there was a great demand for what we were producing and so there was a lot of incentive to produce more and more and so that was a good atmosphere to work in. The aspect that I liked the least probably was, and this probably should be censored, was working with AEC and the government representatives. They were continually trying to get into what we were doing and having to explain to those people, many of them who were not well trained and having to answer to them was frustrating.

MS: Right, we talk a little bit about the different designs and the reactors that you mentioned, C reactor for example I know was designed a little bit differently from the other reactors.

PD: Yeah, yeah.

MS: Were there any like major differences between and the operations of the different reactors beside from lets say C or …?

PD: No, not as far as the reactors themselves were concerned, but our program required that we make different products, so the operations of the reactors … there were times when we had five (5) different reactors running and they were all running differently so that was a big challenge to … for instance, get a call at 2 o'clock in the morning that one (1) of the reactors had shut down and to come out of a sleep and to realize, okay this reactor is on this particular program and because of that program you could start up this quickly or take that long to start up and so forth. One really had to stay on top of things to handle that efficiently.

MS: Right. You mentioned like some of the special products that were made … what were some of those?

PD: Well, Plutonium, Tritium, Californium, Cobalt (radioactive cobalt) and then some other special products, but those were the main ones.

MS: How successful was the Californium project?

PD: The production of Californium, I think, was very successful. How it was utilized in health problems and so forth I don't know, somebody else would have to answer that, somebody working on that.

MS: Right. What about Cobalt … Cobalt sixty (60).

PD: That was satisfactory. Of course, one of the uses that they were talking about was the irradiation of food and that didn't seem to materialize but I've seen within the past year in the news that there's still some consideration being given to irradiation of food using radioactive cobalt.

MS: Yeah, uh, over time, while you were working with the reactors, what was done to make them better or more versatile, if that was even necessary?

PD: Well, we had different fuels. The fuels were designed differently; initially the fuels were individual slugs in columns, in quatrafoils. A quatrafoil is four (4) tubes joined together as a single unit with slugs in each one (1) of these tubes. We then went to tubular fuel and we, of course, had natural uranium as fuel and then had enriched uranium as fuel and then there was a big development as to the types of target material was in the reactor. Initially the targets were in control rods and then later they were separate elements in the reactors as specific targets so that was quite a developed program.

MS: What about uh … were there any, I mean, aside from the need from different fuels, targets and the production of plutonium on the one hand and tritium on the other, were there any other special considerations that had to be given to, lets say, the production of tritium?

PD: I don't think there was anything special along that line that I can think of, no.

MS: Okay, were there any production programs that were particularly interesting that you got a chance to work on … that you remember in particular?

PD: They were all mighty interesting. We ran into some special problems on the heat exchangers where each tube in the heat exchanger had what we called a coil rod; that was a rod that was in there to take up space in the tubes to reduce the inventory of heavy water that we had to have in each reactor complex and also to increase the heat transfer capability of the heat exchangers. Those coil rods, some of them, tended to vibrate a little bit and that would cause some wear on some of the tubes and that could lead to loss of heavy water and also increase radioactivity of cooling water that exited the heat exchangers, which ultimately went back to the Savannah River so that was undesirable so we had to work on ways of minimizing that. I talked about the additional heat exchangers, then there were studies made as to our vulnerability with respect to earthquakes and so we had a program that was the Du Pont Engineering Department made a study as to what pieces of equipment would have to be more securely anchored so that in case of an earthquake a heat exchanger wouldn't break lose and result in the tremendous leak of heavy water with the subsequent release of radioactivity. That was a pretty big program that we had.

MS: When was that?

PD: When was it? Oh, I'd say in the late fifties ('50s); mid to late fifties ('50s).

MS: Did any of the reactors develop a particular reputation or be better at producing certain products?

PD: No, they were identical except for C area, which had slight modification and C area could produce a little more than the other four (4) but otherwise they were identical … and one (1) was not favored over another with respect of making certain materials.

MS: I came across a term of "pilot reactors," which was explained to me as a … let's say a new product was being produced and they were tried out in one reactor first and used in the other reactors, how did they normally work that out?

PD: I believe what you're referring to is that they had, if you want to call it a pilot reactor, in the 300 area that was operated primarily by the Technical Division, the Savannah River laboratory people. Norm Bauman, on your list there would be the fellow to get into that.

MS: Oh are you talking about the Process Development Pilot?

PD: Yeah, PDP.

MS: Right, uh-huh, right. Was that considered the Pilot Reactor?

PD: Well, it was a process development to test out new types of fuel elements and changes in target material and the hydraulics and so forth was tested. But there was no pilot reactor in the reactor areas, they were all production reactors.

MS: Okay. How did security concerns affect the operations of reactors, or did they?

PD: Not really, it was understood that that was the way that we did our business and we could cope with that satisfactorily.

MS: Now this is kind of a … was there any competition between like the personnel and different reactors? Was there ever any kind of contest to see who could make the best?

PD: No, Du Pont doesn't permit that kind of stuff. It was great cooperation. A team! The Reactor Department was a team, it wasn't one (1) reactor against another; now there were minor things such as say the safety record of one area against another possibly, but that was minor. But as far as how we did our business, why it was all complete cooperation.

MS: Sort of on the same lines, was their any rivalry between different shifts operating the reactor?

PD: No.

MS: Du Pont just worked to get rid of that altogether.

PD: Yep, yep.

MS: How did reactor cycles change over time?

PD: Oh, they changed greatly. Depending on what we were producing; when we were making Californium there … some of the cycles were less than a day long. When we were making other material some of the cycles would be more than three (3) months longs.

MS: Was it in a general sense … did they become shorter over time?

PD: No, they got shorter as the power level increased; we could make … reach a certain level of product quicker at a higher power level so in that respect it shortened but otherwise the cycle was determined by what we were producing and what we reached our goal in production of that material. That determines the cycle link.

MS: Hmmm, okay.

PD: Now, maybe what you're thinking about a little bit is shut-down cycles. What we shut the reactor down to discharge fuel and charge new fuel in that as we became more proficient the shut down time decreased a bit.

MS: All right. We talked about power ascension; how it affected operations. How did it affect the safety procedures that Du Pont had in place?

PD: Du Pont puts great emphasis on procedures. Before the reactors were ever started up the operating procedures were developed by senior people, people who had had experience at Hanford. Then before we ever started up the reactors, we had developed emergency procedures; what do we do if this happens, an earthquake, thought up things way out. We had developed a procedure, "What do we do when that happens?" and similarly with respect to the power ascension going up that was very thoroughly analyzed by the technical division people, by the reactor technology people, by the Reactor Department people and so forth. Procedures written to handle those situations and all of that went very smoothly.

MS: What about the … I know that Du Pont got a lot of bad publicity with the so-called "dirty thirty" (30) incidents …

PD: What? What incident?

MS: I think it was like the thirty (30) worse nuclear incidents …

PD: Oh, okay, yeah.

MS: … they weren't really accidents as I understand they were just …

PD: We had a practice, which was developed jointly between Reactor Technology and the Reactor Department to investigate everything that went wrong, everything that was abnormal. Anything that was out of the routine and they were called nuclear incidents. Now that connotation in itself frightens a lot of people who weren't thoroughly familiar with this but whenever these incidents arose, we would investigate them and we had the people that could contribute most to determining what went wrong, why, what could we do to avoid that in the future. Some of the investigations were just a few Reactor Department people and Reactor Technology people. Sometimes if it was an instrument, we had the Instrument people, sometimes electrical people, sometimes Technical Division people, sometimes people from Wilmington that had an expertise in a certain type of work, they'd be down, and we'd have a formal meeting and determine, "Okay, just what went wrong – what are we going to do to avoid that happening in the future." and a report was issued. Now what you're referring to is that back some time ago, somebody was assigned the job of going through all of these incidents and picking out the worse ones. That got publicity and so forth. Now that was way after I left the Savannah River Site so I know nothing about that except the little bit I saw in the paper.

MS: Right, right. What, in general, were some of the health protection measures taken at SRP to provide safe working conditions?

PD: Well, I guess number one (1) is to keep all radioactivity contained. So, great emphasis was made in the design of the equipment and in the operating procedures to minimize the release of radioactivity. Then should some be released the design was to keep it confined to as small an area as possible through design and procedures and if it's necessary to go into those areas, the people wore protective clothing or wore fill bags to monitor how much radioactivity they were subjected to and using hand and foot counters and things like that that you determined if there was any radioactivity was on your shoes or any place on your person and, of course, had a big Health Physics Department that's … who's sole responsibility was to monitor that type thing. And again, team work and cooperation was emphasized throughout.

MS: Right, right. One question I had was how would you go about operating, let's say, a department at Du Pont?

PD: Du Pont has a lot of experience in engineering, designing, constructing and operating complex chemical facilities. They have within the Du Pont Company dozens of manufacturing plants. And some of these are complicated plants, dealing with very difficult technical problem, difficult physical problems, high pressures and so forth. In addition, Du Pont had the experience in designing, building and operating the military explosives plants for the United States Government and so in starting up a facility such as Hanford or Savannah River facility, we followed those same principles with respect to organization and operation. I mentioned previously about procedures being a big part of how we operate facilities. Another thing is Du Pont's emphasis on providing as much technical know-how as possible to the operating group and I mentioned Reactor Technology, how it cooperated with the Reactor Department in the operation of the reactors. That is a method that Du Pont has used in its commercial plants for many years; that type of thing, so when Du Pont starts up a new plant they have a lot of technical people there to assist. As the startup bugs gets worked out and things are running more smoothly, the number of technical people at the plant site is reduced, transferred elsewhere or transferred to other operations of the same plant and I think that's one of the keys to Du Pont's success in starting up new plants is the fact that it puts a lot of expertise into the startup. That way they can overcome some of the startup problems that are bound to happen.

MS: Uh-hum, right, right. How many people were working at Savannah River Plant back in the fifties ('50s)?

PD: Oh about eight thousand (8000).

MS: Was that pretty much standard, like say fifties ('50s), sixties ('60s) and in the seventies ('70s)?

PD: Yeah, it was fairly steady. Of course it went up in twenty some thousand (20,000) later.

MS: Yeah, that's what I heard.

PD: Without as many facilities in operation.

MS: Right. What was it like working … going back in time here to the Atomic Energy Division at Du Pont?

PD: Yep.

MS: You worked there beginning in 1950 right, for about a year before you started … before you went back to Savannah Plant or before you went to Savannah River Plant?

PD: Well, yeah it was more like eight (8) months.

MS: Oh, okay, right. What was it like to work up there?

PD: Interesting. I was primarily concerned with the design of the CMX facility and getting the personnel that would be required for the operating of the CMX facility, engineers and chemists that would work with me on that to form the team that we had there.

MS: Right. I don't guess you had any … did you have any contact with the NYX Program?

PD: Yeah. I didn't work there, I visited there several times and we exchanged information with those people. That was another excellent program to test out the hydraulics of the system before we ever installed it down here. Of course, the location of NYX was where it was because the reactors were built there at a New York Ship Building Company and they were transferred by water down the Atlantic Coast to the mouth of the Savannah River up the river to a special dock that was built there to the banks of the river to unload them and then hauled by truck to the reactor sites.

MS: How did they get from the dock to the sites?

PD: Truck.

MS: By truck?

PD: Uh-hum. There were no bridges that they had to go over or under; that was planned. Of course, they could control the roadways and everything and eliminate all traffic.

MS: Wow! Wow! Did they use the river a lot back in the early days?

PD: For the site or in general?

MS: For the site.

PD: No not too much. Just the reactor tanks and the shields for the reactors.

MS: Everything else came by …?

PD: Rail or truck.

MS: Okay, uh …

PD: The heat exchangers are like a big tank car, they're on trucks in the reactor building. But they can be removed; if a heat exchanger failed or something, it could be removed from the reactor building and replaced with a new one. That gives you and idea to the size of the heat exchangers.

MS: Uh-huh, right. Let's see, going back to the differences between Hanford and Savannah River Plant what would you say was the biggest operating difference between the two?

PD: Well, Savannah River Site, the instrumentation for the reactors is more sophisticated and the charging and discharging of the fuel elements is done by remote controlled machines at Savannah River Site. At reactor, it was almost done manually by pushing in the new elements in the final reactor, the irradiated elements exiting in the back.

MS: You mean Hanford instead of reactor, right?

PD: Hanford, yes.

MS: Talking of instrumentation, how did that change at the reactors here in Savannah River Plant. I know they had like computers when you came here …

PD: Yep.

MS: … starting out with safety computers. How did that affect the operation of the plant?

PD: The Reactor Technology people developed the computers to be used in the operation of the reactors and the computers were built to the specifications of the Reactor Technology people. We didn't go to the computer companies and have them come in and tell us what we needed, we went to the computer companies and told them what they had to build to fulfill our needs. We had these Reactor Technology people were holding the operating people's hand as we were learning how to operate the reactors with computers. The computers permitted us to go to significantly higher power levels than we would have felt we could do without the computers because of the speed of response of the control rods and so forth with the computers and our knowledge of what was going on in the reactor was soon proved with the computer that we felt safer.

MS: Right.

PD: But the computers in the reactors were really state of the art.

MS: When did the first computers come in?

PD: I'd say around 1970, but one person you probably should talk to would be Kris Gimmy. K-R-I-S G-I-M-M-Y, he was the computer expert for the reactors. He worked in Reactor Technology. He lives in Aiken.

MS: Okay.

PD: K. L. Gimmy; if you want to pursue this further, he would certainly be the best contact.

MS: Okay. How was it different when you were working in the Reactor Technology Section … oh I know, let me ask this, you worked briefly at the Savannah River Laboratory …

PD: Well initially when I came to head up CMX I reported to the Technical Division; actually, I reported to the Technical Division in Wilmington. But on the organization chart it showed that I went through the laboratory to the Technical Division.

MS: What was the difference between working in, like, the Reactor and Technology Section and then being an actual superintendent in K area?

PD: Well I had been so closely involved with the reactors at Hanford and here at Savannah River that it wasn't a big change for me.

MS: Let's see, thinking on a more like day-to-day level what time of day did you normally go to work? How long of a day did you have to put in?

PD: The normal was … started work at 7:45 and quit work at 4:15 but both when I was in Reactor Technology but particularly in the Reactor Department, why, we put in a lot of overtime.

MS: Right.

PD: When ever a reactor was started up with a new charge, we were out there and whenever anything abnormal happened, we got a phone call and frequently when I was in the Reactor Department, I would consult with the superintendent of Reactor Technology Section on technical problems. Sometimes it wasn't technical, sometimes it would be mechanical or instrument or something else so I consulted with other people. But that phone was busy. One weekend, one that was particularly sticky at the plant after the weekend, I reconstructed, I was on the phone more than sixty (60) times; either receiving a phone call or mAikeng a phone call, one weekend.

MS: Well you were kind of busy. This may seem like a foolish question but were the reactors … were any part of the reactors air conditioned … or did they need to be?

PD: The control room is air conditioned. That's done primarily to protect the instrumentation.

MS: And the rest of the building?

PD: No.

MS: No?

PD: Oh, I think some of the offices were air conditioned, but the bulk of the operating area was not air conditioned, just the control room.

MS: Right. What was the schedule like for the people that had to work in the control room?

PD: Eight (8) hour shifts. Rotating shifts.

MS: What does that mean?

PD: Well they'd work about a week say from 8 o'clock to 4 o'clock; then they'd have a couple of days off, then they'd work on the 4 o'clock to 12 o'clock shift for a bout a week, had a couple of days off and the twelve 12 o'clock to 8 o'clock shift; 12 midnight to 8 a.m. shift for about a week, couple of days off, just rotated.

MS: Was that done in the reactor control rooms or was that done throughout the operation?

PD: Throughout the operation.

MS: Throughout the operation, okay.

PD: Supervisors and the [inaudible] people both.

MS: Right, okay. What was it like when you had to work overtime, were there certain hours that you had to work or was it just depending on the job?

PD: Just depended on the job … what had to be done. Sometimes we'd be out there a couple of days straight without going home.

MS: Uh-huh. I imagine that was good money.

PD: No, we didn't get paid overtime, not supervisors.

MS: Oh, you didn't? Oh okay. Who did get paid overtime?

PD: Hourly people.

MS: What was it like to work for Du Pont?

PD: Real fine. It's a wonderful company to work for. They try to do right with their employees and hourly people as well as supervisors, that's one reason there isn't a union at the plant. The hourly people don't feel they need a union. They can deal directly with their supervisors or with the company and that they'll be treated fairly.

MS: Was there any serious attempts to establish a union?

PD: Yep, several.

MS: When was this?

PD: Back in the fifties ('50s).

MS: And they were, I guess, voted down?

PD: Oh yeah.

MS: Okay, try to think of some other questions that I can get you off on a good tangent on.
What about when they started … was there any difference in the whole feel of the plant in the seventies ('70s) versus the way it was in the fifties ('50s) and sixties ('60s) especially with the more heightened environmental concerns.

PD: Oh there was a little bit more, but throughout pretty much the time that I worked there, uh, there still was a great desire to make more product and … but I had to be done consistent with safety.

MS: What kind of … what kind of things did Du Pont do to help instill the whole safety culture they had up there.

PD: Well, safety is preached to the employers whether they're supervisors or hourly people from day one. Of course, Safety First, is a slogan that used many places but with Du Pont they really mean it and so all of the people attend a safety meeting each week and as we had discussed earlier about reactor incidents and problems that develop in operation similarly with respect to safety. Any incident that develops with respect to safety is thoroughly investigated and how can we make sure it doesn't happen again. It's branded in the people from day one (1) as long as they work with Du Pont.

MS: Right. I know that they've got a number of films that date to the like 1950s, 1960s; was it required to see safety films?

PD: Yeah, yep.

MS: Was this done in the meeting that you were talking about?

PD: Yep, uh-huh.

MS: How long would those meetings last?

PD: About a half hour as a rule.

MS: Was there any particular day they usually happen on?

PD: No. Well, each shift would have it at a certain time each week as a rule unless sometimes conditions dictated that it be a different time but normally they'd have a set time each week for a safety meeting.

MS: Who did the safety meeting?

PD: Normally the head of that shift, supervisor of the shift.

MS: Okay. Was there any other like, procedures that Du Pont normally did to help instill the safety aspect?

PD: No, uh, one other thing that we had were security meetings, which would be devoted exclusively to security.

MS: How long would those be?

PD: Oh they'd be fifteen (15) to thirty (30) minutes each usually once a week.

MS: And who did those?

PD: The shift supervisor in charge of the shift.

MS: What kinds of concerns were they dealing with in security?

PD: Storage of the classified information and how you treat your security badge and …

MS: What was the big difference in the plant between the time that you first came here [inaudible – coughing] and by the time that you retired in 1977.

PD: Well, when I first came here construction was just; well I guess it was probably at its peak then. Like I said, we were the only operating group to start with and then of course, by the time I left we had a small construction force but it was very small in comparison and things were at a normal operation so there was that big change.

MS: In the operation of the reactors did they have construction going on all of the time for small things or …?

PD: No, normally maintenance handled that type thing and normal project type work would be handled by the Maintenance Department but there were always on a plant as large as Savannah River Plant, there were always some construction type projects going on and occasionally major alterations like when we installed the initial heat exchangers, when we retrofitted the reactors for the earthquake resistance and things like that; they would have construction people there.

MS: Uh-huh, right.
What about "Hector" [HWCTR or Heavy Water Component Test reactor]? Did you have anything to do with Hector?

PD: No, I really didn't, no.

MS: Uh-huh okay, uh-huh.

PD: But one big advantage of a company like Du Pont, and I'm sure that advantage probably doesn't hold true today to the extent that it did fifty (50) years ago, is that where we had our own design and construction people and engineering people all working for the same company, it was much easier to be able to handle big emergencies than it would be if the engineering people were one company, design people were another company, construction people were another company and you'd have to try to get all of these people together and work out the logistics as to how do you pay them and who can talk to whom. With one company the way Du Pont was then and I don't think they are today to that same extent. They farm out more design work and construction work and that and I think they lose some of that advantage because of that. There were occasions where we'd have a big problem come up and we'd get the design people from Wilmington down the next morning, we'd have the Engineering Department top guys down the next day and we'd work together just like we'd been working together all of our lives and we could solve problems, handle situations and it was a great benefit.

MS: Yeah I imagine that would have been pretty nice. Do you think that Du Pont did any outsourcing in later years or was that not something that Du Pont dealt with?

PD: A little bit but not much. They didn't practice that.

MS: What about the day-to-day operation of the reactors did you have to deal with, let's say, atomic energy decisions that Du Pont, or a regular basis, or …?

PD: Yeah they came in every morning to see what was going on.

MS: Oh really?

What about the Atomic Energy Commission people?

PD: Some. They'd pay visits and we'd have to tour them around.

MS: How often did they normally …?

PD: Well that was intermittent. Depending somewhat on who was on the commission at the time.

MS: Just out of curiosity, did you ever run across Glenn Seaborg [head of the AEC in 1960s]?

PD: Yes.

MS: Did he come to Savannah River?

PD: Oh yeah.

MS: How often did he come?

PD: Oh, two (2) or three (3) times a year, maybe.

MS: Did he have like … I've heard that he had special input into the … like the special programs that they had like Californium and things like that.

PD: Yeah, he had a special interest in that because he discovered Californium so that was his baby. Yeah.

MS: What was it like when he came to tour?

PD: Oh nothing dramatic, we had a lot of VIPs touring and Du Pont people and other people and so we were used to that but we'd frequently have to make special presentations to some of these people depending on if they has some special interest that they wanted to check into on that particular visit, we'd prepare presentations for them to satisfy their interest. We worked with Enrico Fermi, up in Wilmington before the Hanford project. He was a stimulating fellow to work with.

MS: Tell me more about yeah, Fermi.

PD: Well, you know he was that Italian nuclear physicist and he was married to a Jewish woman and so when the Nazis and the Fascists were starting to pick on the Jewish people he and his wife wanted to leave Italy so they ended up in the United States and of course he had a great reputation by the time he came to the United States and so it was in 1939 that the physicists discovered the fact that under certain conditions the uranium atom could absorb a neutron and split and form two (2) approximately equal parts with the release of a great amount of the energy and that interested the military people and the engineers because that was what we were getting involved in the European conflict and the fact that you could release a great amount of energy, that got their attention. So, when he came they then started trying to learn what they could from him; of course, in those days the only nuclear physicists were in academic positions, they weren't in commercial industry so the initial work was done in laboratories such

	as Columbia University, Chicago University, Princeton and so forth. Then they got the attention of Einstein … is it all right, I'm rambling like this?
MS:	Oh, that's fine. Yeah, yeah, we've got plenty of tape I just have to make sure I turn it over when …
PD:	Yeah. Got the attention of Einstein, he then wrote the letter to President Roosevelt. Said that he thought from a national defense standpoint, the country had better start looking into this nuclear business. So he got a team together to consult with him and it developed from that until finally in 1939 they decided that they better get a little more serious about this and they and so they got some top engineers, a few Du Pont top engineers and others and the academic people to make a study that eventually produced what they call the feasibility report. Would it be feasible to develop an atomic bomb and their conclusion was, "Yes". Well the work had been done under the United States Army and General Groves had been designated the man to head up this work. Well, as it expanded he realized that the Army cannot handle all of that, that they'd better get some industrial organizations in. So they then were figuring who could best handle this and so it was decided that the Du Pont company was far and above the rest of the companies with respect to being able to engineer, design, construct and operate a complex facility like this. That's when Roosevelt wrote a letter to Mr. Carpenter, the President of Du Pont Company, asked that Du Pont get involved in this. Carpenter consulted with some of his top people, they said that they'd be willing to do this under two (2) conditions.

Side Two

MS:	Okay. Yeah.
PD:	That Du Pont not be paid over and above their expenses to do the work and secondly that all the patent rights go to the government. Du Pont would get no patent rights and then when Du Pont signed the contract they also asked that Du Pont could pull out of the work one (1) year after the end of the war or after the emergency was over. So that's why Du Pont pulled out of the Hanford project one (1) year after World War II was over, and the government then turned it over to the General Electric.
MS:	Right. Let me ask you a question about … that just brought to mind, you talking about you getting there at Hanford, of course, the whole problem with Xenon poisoning was a big issue with the first reactors there …
PD:	Yep.
MS:	Didn't they have a similar … not similar but some kind of a problem at SRP with Xenon poisoning?
PD:	Well, Xenon poisoning is a fact of life. You have to live with it but we had to work out how to cope with it, which we did.
MS:	What normal … what things had to be taken care of in order to keep the Xenon poisoning …
PD:	Well, Xenon decays so if for instance the reactor was operating and we had to shut the reactor down, either it was shut down automatically or we shut it down manually depending on where we were in the cycle we had to determine what the Xenon poison stats was and in some cases we could start up right away; other cases we'd have to wait until the Xenon decayed sufficiently so that we then could overcome that and start up the reactor.

MS: Was that a problem … was that matter taken care of over time or was it not seen as a problem?

PD: Well we improved our efficiency with respect to calculating that and how to cope with it with experience, yeah.

MS: Right, okay. Out of curiosity, when they were moving, let's say a few of the targets that would go into the reactor, how did they transport those from the manufacturing area?

PD: Well the un-irradiated material would just be shipped by truck, like you'd handle a box full of slugs, ordinary slugs or some tubes. If they were un-irradiated, no problem with respect to handling. When we discharged it from the reactor it was discharged into a water basin and stored in the water basin. If it was slugs they would be disassembled under water and put into buckets and the buckets then would be stored for such a length of time to get over the initial high radiation and then transferred into casks that were water-filled casks and hauled by railroad to the 200 area where they would be processed. If it was tubes, why then they'd be transferred into special shipping containers and so forth shipped by rail to the 200 area.

MS: When did they start pulling up the railroads? Some of them are still there obviously, but some of them are gone.

PD: I don't know, they hadn't started any of that while I was there.

MS: Uh-hum, okay. Any other points you'd like to make?

PD: I've probably rambled long enough!

MS: Well, I don't know, I imagine we could come up with some more stuff.

PD: [laughs]

MS: Let me go back through this real quick, make sure I've got all of the uh … we've already gone into what it was like when you arrived here and attitudes from a local standpoint. As far as some these questions here for … we talked about very briefly the nature of labor relations and great demands for labor unions and so on.

PD: Yep.

MS: Talk if you would, just a little bit about what … how they dealt with labor … why was labor relations relatively good at Savannah River Plant.

PD: Well, I think it was primarily because of the relationship between the supervisor and the hourly worker that again, team work, and the respect that the company had for the hourly people. For instance, we didn't have time cards on the plant … they didn't have to punch in or punch out, they knew when they were supposed to be there to start work and what time they were supposed to leave and that was expected of them and they obeyed that and didn't have a problem. I think it was that they were treated well and the company respected the worker and the worker respected their supervisor.

MS: Right, yes. What happened if somebody didn't show up for work on time on a regular basis.

PD: Well, it would be reprimanded and if it continued he wouldn't be working there.

MS: Yeah, all right. One thing they talk about in … and I know I've seen some of these models at Savannah River Site now … Du Pont worked with models when they were coming up with a new construction idea; it was introduced with blue prints and models. Did you ever have any dealings with that?

PD: I was aware of it and that but I didn't work directly with it. But, that evolved during the early days of the Savannah River Site. I don't believe we had any models for anything when we first built the plant but over the next ten (10) years or so they started developing that and worked from that and computer pictures of things rather than blueprints.

MS: Right.

PD: Yeah, that evolved during the fifties ('50s) and sixties ('60s).

MS: Yeah.

PD: But you're talking to an old fellow.

MS: You were talking about in the early days of big generators, what about in … like in working at the Hanford Site for example, what was that like … I mean this is really not related to Savannah River Plant but it would be interesting nonetheless.

PD: It was a unique experience. Should I just ramble?

MS: Sure, we've got plenty of tape.

PD: Okay and you can edit and you can throw away a lot.

We went out there, the CMX group, in August of forty three ('43) and the housing for people in the Village of Richland was under construction but not ready to be occupied; so we lived in Pasco, that's where the rail terminal was at that time and so we went from Hanford to … or from Wilmington to the Hanford project by train, not flying and got off there at Pasco and the guy that headed up CMX for the Hanford project had preceded us a little bit and he had arranged for our housing. There were eight (8) of us that slept in the basement of a private home. they had army cots there, our bath facilities were … we washed our hands and face and that in a laundry tub in the basement. They had a shower, which was a circular shower curtain with a shower head above it above a drain in the floor, that's where we showered so that was our housing for the first weeks that we were out there. We traveled to the Hanford site, which was about thirty five (35) miles away in a government vehicle, kind of a station wagon, and we then followed the finishing construction of our facility out there. It was interesting … what we were doing, as I explained before, trying to determine what kind of treatment for water required for cooling the reactors. So to simulate the heat that was generated in the reactor, we needed steam boilers to heat the water. This was during World War II or the preparation for it and it was difficult to get some materials, some equipment, so instead of going on the market and trying to get a boiler we got five (5) steam boilers from railroads. This was at a time when the railroads were converting to steam engines to diesel engines; so there were excess steam engines around so we got five (5) steam engines, locomotive steam engines, and hired then locomotive engineers to operate the steam locomotive engines for us to produce the heat for our reactors. We … when we got to the point when we could operate the facility at CMX we went on shifts and there were a couple of engineers and a couple of chemists, probably about three (3) hourly operators and we had assigned to us some people that were nominally maintenance type people but we didn't have a maintenance department there; they were construction people. But we'd have a mill right probably and a pipe fitter and maybe an instrument man on each shift to handle the problems that would develop in our facility there. It was a very interesting operation in that we had simulated the tubes that would be in the reactor and we'd force the water through these tubes and we were going to study what corrosion there might be and any other problems from the water. Shortly after we started operating we found … are you an engineer?

MS: No.

PD: We found that a pressure drop developed through the life of the tube … and because the pressure increased for the water going through the tube, that decreased the flow of water. We couldn't figure out what caused that, so we shut down, opened up the tubes, shut off the steam, shut off the water, looked in the tubes and couldn't see anything … reassembled start up again the flow would be normal and it would start decreasing again. That happened a number of times, finally we were wise enough to … when we shut down we kept it wet and the slugs we had in the tube, we discharged them under water and we found that a gelatinous material had built up on the surface of the slug and in the tube; you could take your thumbnail and rub along there and it … you could peel off the gelatinous material. When we discharged it previously hot and in the air, that gelatinous thing dried up and because the gelatinous material was ninety-five (95) percent water, when the water disappeared we couldn't see the film. So we found that instead of corrosion or something like that being a problem with respect to the water of the Columbia River it was film formation. Now if we had not had a CMX, if we had tried to start up the reactor and we would have run into this, it would be like the Xenon problem. We'd have to shut down, what do we do? Well here the reactor would be radioactive; we couldn't go in there and peel off a film with our thumbnail because we couldn't get to it.

MS: Right.

PD: We would have been stymied, it would have been a big problem for a long time, but learning this at CMX we finally found out that by treating the water with certain … well first of all we had to add Dichromate, then we had to add sodium silicate to the water, just small amounts we could control the formation of that film and we also worked out a method where we could remove the film once it's developed if that was necessary and that … we only did that once in the operating reactors. But, we had it in our hip pocket as to what to do in case a film developed. So, learning that for the Hanford project is why Du Pont decided, "Boy, we'd better have a CMX for Savannah River, we don't want to encounter some unusual problem there."

MS: What does CMX stand for?

PD: It was just a code name that the Engineering Department used. It was setup by the Engineering Department before the operating people really got into it in Wilmington, Delaware.

MS: Right. Also just for my records here if you would explain again, exactly or more concisely that I could probably be able to do, what is CMX?

PD: It was a water treating facility to study what treatment was necessary for the cooling water for the reactors at Savannah River.

MS: That's pretty interesting, I didn't realize that there was any kind of a problem with the gelatinous material of the heat exchangers at Hanford but I can see why they would definitely have that at Savannah River Site.

PD: Yep.

MS: While you're looking for that I'm going to turn the recorder off.

PD: That bottom paragraph on the right.

MS: Oh, okay. I'll just read this into the tape recorder.

Among the first installations to be put into operation at Hanford was the water study laboratory. In order to simulate the tremendous quantities of heat released by the reactors, five (5) steam locomotives were set up on the banks of the Columbia River. They were stripped of wheels, they were manned by regular locomotive firemen and could generate enough steam to simulate temperatures that the future reactors were expected to produce. It was a strange site to see five (5) steaming roaring locomotives standing still in a dessert plateau; but the forty-five thousand (45,000) people working at Hanford site were getting used to seeing peculiar things and not asking questions. This is from a book entitled, "Manhattan Project, the Untold Story of Making of the Atomic Bomb," by Stephanie Groueff. Thank you very much.

PD: I was just going to show you some pictures here.

MS: Oh, okay.

PD: At Hanford the construction camp had sixty thousand (60,000) people in it. At that time it was the fourth largest city in the State of Washington.

MS: Wow!

PD: Out in the middle of the desert.

MS: Right.

PD: This was the construction camp [showing Mark photographs].

MS: Right. I was just looking at some pictures here entitled, "Atomic Energy by …

PD: Smythe.

MS: Is it Smythe? Is that it? This is the one that came out right after the war was over, right?

PD: Yep, uh-huh.

Marie: Mr. Swanson, can you stay for lunch?

MS: Uh, well I can … I'd better shut this off.

Marie: You can?

MS: [Turns tape back on] I'm just trying to think of any additional questions I can come up with that … and yet frankly, if you want to reminisce more about the early days at Hanford? One question that I did have though, going back to what I was thinking about when you were talking about the other stuff early and the housing problems at Hanford. What was the housing situation like at Hanford versus here at the early days of Savannah River Plant.

PD: The big difference between Hanford and Savannah River was that at Hanford the government owned everything. The residential village; the government owned our houses, the stores, the churches, everything. Here they didn't want to get into that – that's one of the reasons they chose this site, which is fairly close to Augusta and Aiken so that they could expand those cities and absorb the people and so there I was single when I went out to Hanford; Marie and I were engaged. When we got engaged, is that thing on?

MS: Yes. Want me to turn it off? [laughs]

PD: Yeah.

MS: [Turned tape back on] Talking about working in Richland in their early days in Hanford.

PD: One thing different about Richland and Savannah River is that at Richland, we didn't drive to work, we went to a bus depot in the outskirts of the town of Richland and got on buses. They had buses that went to all of the operating areas and so that bus would take us out to work at the start of the shift and it would take the people that were being relieved from their shift out in the area back to town to the bus depot again. It just went back and forth every shift doing this.

MS: So most people didn't drive private cars at all?

PD: Not to work, you couldn't. You weren't permitted to drive on the reservation.

MS: Okay. So that would definitely be a big difference between there and here at Savannah River Plant.

PD: Right, and the housing. Here for instance, when I came in Augusta in fifty one ('51), I had to find a place to live so … and a lot of other people were trying to find a place to live at that time. We found a little place that was just being completed on the other side of town, which I rented and moved the family down here then and shortly thereafter, a month or two (2) after, we bought this lot and then started building this home about a month or two (2) after and moved in here in April of fifty two ('52).

MS: Hmmm, okay so you've been here since then?

PD: Been here ever since. At the time we had built a home in Wilmington and I was kind of reluctant to leave that brand new house because I recall stories that some people that had homes in Wilmington for the Hanford project moved to Hanford, lived there for a couple of years and in a few instances moved back to Wilmington and bought the same house as they had sold but had to pay twice as much as they got for it. So I was reluctant to sell our house in Wilmington. But the closer we got to my moving down here, the more I realized it was impractical to own a home in Wilmington and rent a house down here so we sold the home in Wilmington and built down here, but at that time I thought I'd probably be transferring back to Wilmington in two (2) or three (3) years.

MS: Uh-hum, uh-hum, right.

PD: I never dreamt that I'd still be here.

MS: [laughs] Yeah that's true, that would be a change. So you were in Wilmington, I guess …

PD: Forty-six ('46) to fifty-one ('51).

MS: Okay, right, right.

PD: Five (5) years.

MS: What was it like when you had to work up here as far as working for Du Pont?

PD: Well it was different in that we worked in an office building with thousands of others in there but it was good … good experience.

MS: Yeah.

PD: One little thing, maybe with respect to when the Du Pont turned over the operation of Hanford to General Electric; the office date was September 1, 1946 and they had a big ceremony in the public park in the City of Richland there where the President of Du Pont Company, Carpenter, turned it over to the President of General Electric Company, and of course the Atomic Energy Commission people were there and everything and the bulk of the people that worked for Du Pont stayed there and worked for General Electric. There had been a few people that Du Pont had transferred from Hanford to Du Pont commercial work prior to September 1; but to try to have a smooth transition going from Du Pont to General Electric, there were twelve (12) of us that were asked to stay on there for an additional four (4) weeks and so I was one (1) of those twelve (12) and so I reported to the office in Richland, the administrative office those four (4) weeks and our responsibility or our assignment was to answer questions that might arise out in the area … in the hundred (100) areas; What do we do now?, Where is this?, Where is that and so the twelve (12) of us stayed for an additional four (4) weeks. I then transferred back East and I had received employment offers from four (4) different locations with Du Pont and it was difficult to make a decision which one (1) to select while I was out at Hanford. So I asked if I had the opportunity to come back and look over the jobs before I make a decision, they said, "Yes" so I transferred then from Hanford to Wilmington and went and looked over each of those assignments and finally selected the job with the Plastics Department in Arlington, New Jersey.

MS: What was it like … what did you have to do in the Plastics Department?

PD: I was in research and helped develop the process to make Teflon.

MS: Oh, okay. I guess that didn't have any application at Savannah River Site, did it?

PD: No, although we used some Teflon at Savannah River, but no.

MS: Let's see, I can't think of any additional questions to ask at this point but if you want to volunteer anything …

PD: No, I think I've rambled enough!

MS: But if you want … I don't know if the recorder still needs to be on or not, it probably should.
If you want I'll fill this part in the release form and if you want to sign it I think we will have the official part taken care of.

PD: Okay.

MS: That was 703 right?

PD: Uh-huh.

MS: Floral Drive?

PD: Uh-huh.

MS: And uh, if you would look over that and it that's agreeable with you if you would … and I could leave you a copy of that too, it won't be signed but just to … oh I gave it to you, it's over there.

PD: The …

MS: I'm turning the tape recorder off now.

Interview Transcription with Paul Dahlen, December 14, 2004

Mark Swanson: This is an interview with Paul Dahlen and it is the 14th of December [interviewer is Mark Swanson]. Paul, if you wouldn't mind could you just tell us briefly how you got affiliated with Savannah River Site.

PD: I worked on CMX for the Hanford Project and it proved to be extremely beneficial for the overall success of the reactors there at . So when Du Pont was asked to do the so-called Hydrogen Bomb Project at Savannah River they immediately decided that we'd better have another CMX; and as much as I had worked on CMX at Hanford, why I then was asked to head up CMX here at Savannah River.

MS: What exactly was going on at CMX?

PD: Initially they thought that there might be a corrosion problem because … well, first of all, Hanford was different than Savannah River as far as the reactors are concerned. At Hanford, we pumped the river water directly through the reactor and the only thing that separated the stainless steel nozzles on the face of the reactor from the aluminum tubes going through the reactors was the gasket and they thought there might be electrolytic corrosion between those two (2) metals, so that's why they decided to have a CMX at Hanford. We had a mock-up of some reactor tubes and we pumped river water through the tubes and the dummy slugs were heated with steam. Back during the World War II, there was a shortage of some equipment and that so instead of having a conventional boiler to supply the heat for heating the water going through the tubes; they used five (5) steam locomotives. This was back at the time when the railroads were converted from steam engines to diesels and so old locomotives were available. They hooked up five (5) locomotives, side-by-side, and we hired some retired railroad engineers to operate that steam source and it worked out beautifully for us.

MS: Uh-huh.

PD: What we … ran the water through the tubes and that we soon found out that very quickly there was an increase in the pressure drop of the water going through the tubes, so we shut down and tried to find out what's causing it and didn't see anything wrong so we started up again, did that several times, finally we decided; "Okay, let's get the water in the tubes when we shut down and examine it then." and we found that there was a build-up of a gelatinous material, film, on the dummy slugs there and that's what increased the pressure drop going through there. We took our thumbnails and scraped on that and could see this gelatinous film; analyzed it and found out it was a hydrated silicate film and so our attention, instead of being on corrosion, was [on] film formation and how to prevent that film from forming. It formed from material in the river water. The Columbia River water looked beautiful, nice and clear, cold … but it contained some silicate and due to what they call the streaming potential there was a difference in charge between the silicate particles and the walls of the tubes. So it was attracted to that and plain enough … so Du Pont being a large company with a large background of specialists and that we were able to get a fellow who was from the [inaudible] Chemical Department who was a specialist in silicate; came as a consultant to us down here at CMX. We got a fellow form the experimental station who knew how to set up the electro … experiments so we could get the electronic charge going back and forth and so after time we were able to determine what the charge was of these particles and eventually we found that the proper chemical balance we could essentially eliminate the formation of that film. But then we also found out that if we do get that film that we found way of removing it using Dichromate to add to the water to erode that film that formed. This was extremely important because if we had not found this out before we tried starting up the reactors, we would have started and eventually the pressure drop would have been such that we couldn't have continued operating. But then we wouldn't have been able to analyze it because it'd be radioactive from the nuclear reaction there in the reactor. We at CMX could handle it and do whatever we wanted with it and found out the solution to it. So at one time they thought it would probably be necessary to de-mineralize the water going through the reactors. That's a terrific amount of water going through and be a terrific demineralization plant. We did filter the water with conventional water filtration processing. At the time that they had to decide where the first reactor at Hanford, we hadn't determined exactly what we could do to cope with this film formation so they did order and construct a demineralization plant for the first reactor but by the time they froze the design for the subsequent reactors we found that we didn't need them so that demineralization plant was built, we tested its operation, but we never used it in the production process.

MS: Oh, okay, right. This was all at Hanford, right?

PD: That was all at Hanford; so then when we were going to do the work here at Savannah River they decided, "Boy, that was very valuable, let's have another CMX" so I was asked to head up the CMX project here at Savannah River. So we, the Engineering Department, designed and built the CMX facility on the banks of the Savannah River Plant. I came into the Savannah River Project the end of 1950 and made my first visit to Savannah River in February of fifty one ('51) and we worked on the design and build the facility. I came down here the end of July in 1951; we started up the CMX operation in September of 1951. Is this too much detail?

MS: Oh no, it's fine.

PD: So we had a conventional fuel oil type boiler here we had to have the locomotives … We tried water directly from the Savannah River; one of the tributaries to the Savannah was Upper Three Runs Creek. So we hauled water from Upper Three Runs Creek, ran experiments with that just to see what the results were. We found out that we did not have the film formation problems that we had at Hanford. While the water here isn't as good looking as what the Savannah River was, I mean as the Columbia River was; it's more turbid, it's got color in it, but that proved to be beneficial and so we filtered the water at CMX but we ultimately determined that we didn't have to filter it. But there again, they had to freeze a design for the first reactor before we had a final answer so for the first reactor we did have a filtration plant for all the water that was going through the heat exchangers.

MS: All reactors, right?

PD: Yeah … but we never operated it to take care of the cooling water. We had [inaudible] for sanitary water and so forth. But ultimately we just ran the Savannah River water through the heat exchanger. We chlorinated it to keep down algae formation, but the results from CMX saved a tremendous amount of money in that we didn't have to get the filter plant for the reactors … we didn't have to operate and get them which would have added up to millions of dollars.

MS: Right, yeah. They had like a settling basin that they put into R reactor?

PD: Yeah.

MS: Did they do that with P?

PD: Yeah.

MS: But they didn't use it for the other ones?

PD: We had the settling basins but we didn't filter.

MS: What about the … what were some of the other things that went on at CMX?

PD: Well, I wasn't associated with that but they had a power plant for some of the separations of the processes.

MS: Oh yeah for TNX? Yeah, anything that you know about TNX, feel free to …

PD: I don't know much about it … that was a separate institution.

MS: Uh-huh.

PD: We supplied some utilities to them but as far the … what they did and that … we worked on [inaudible].

MS: What was … I read that CMX doesn't mean anything.

PD: No. Uh, CMX was a code that was used by Engineering Departments to identify different projects in the Engineering Department. Back in Hanford, some of the people said CMX meant, Corrosion Mock-Up Experiment; but that was just talk.

MS: I guess that's also true for TNX?

PD: I don't know about TNX. TNX there was a special explosives that was made by Du Pont Company and they had a plant in Indiana towards the tail end of World War II that they referred to as TNX. But, there again, people said that means Third New Explosive.

MS: [laughs]

PD: But … the CMX project at Hanford and similarly here at Savannah River was the first operating facility to start at those two (2) locations and at Hanford, I had badge number one (1); at Savannah River I had badge number five (5).

MS: I don't guess you have those do you? You wouldn't be able to keep those for a souvenir?
What kind of a reactor do they have, don't they have like a partial reactor at CMX or …?

PD: No, it was a mock-up of the … at CMX at Savannah River Site it was a mock-up of the heat exchangers. At Savannah River Site, the water going through the reactor was heavy water and the heat that was picked up in the reactor; that heat was removed by heat exchangers. Those heat exchangers were large, they were like a big railroad tank car, each one, and we had at the reactors, twelve (12) of those heat exchangers. The heavy water flowed through the tubes and the river water, to remove the heat, was on the outside of the tubes in the shell of the big heat exchangers.

MS: Yeah, that way the river or the cooling water wouldn't get contaminated with the radioactivity.

PD: Yeah, it picked up some radioactivity, but light.

MS: Was this … I heard that there was some kind … maybe in later years … there was some kind of like a, not a reactor but it was like a partial reactor so they could test the fuel and target sublease, the water flow, it was like a 1/6th?

PD: Yeah there was some of that, I had left CMX by the time they did that.

MS: Oh, okay, okay. When did you leave CMX?

PD: I would guess it was late fifty-two ('52).

MS: Oh, okay.

PD: I went to the Reactor side, initially to be a Reactor Tech, then into the Reactor Department.

MS: Where did you go after that?

PD: Well, I worked in Reactor Tech as a Chief Supervisor and then in 1961, early, I transferred to the Reactor Department and ultimately became a superintendent in the Reactor Department and the Heavy Water Department.

MS: When did you leave Savannah River Site?

PD: I retired in 1977, February 1977.

MS: So you retired before Du Pont left?

PD: Oh yeah, yeah.

MS: What about … when you were working at CMX what was there at the time, I mean, how many buildings, what kind of facilities?

PD: We had one main building, which was our mock-up of the heat exchangers and it was complete with a chemical laboratory. We had our boiler to supply the heat for the facility. TNX was a separate building at the CMX site. Of course, it was enclosed with the security fence and a patrol house and gate that we went through and so forth.

MS: Right. Uh-huh.

PD: We had a river … we had pumps down at the river to supply the water to our facility.

MS: Were there … I heard that later years there were at least three (3) buildings there that were in that enclosure, is that true; the early fifties ('50s)?

PD: I just recall the two (2), the CMX and TNX.

MS: Right, uh, how many people worked in there?

PD: Oh, on each shift we had a shift leader and probably a couple of engineers, a couple of works engineering type people and maybe a couple of chemists in the laboratory and on the day shift we had a greater number of people, probably on the order of ten to fifteen thousand people (10,000 – 15,000).

MS: Did CMX run around the clock?

PD: Oh yeah. In fact in the early days before the plant … the utilities, the electric power and so forth, for the area was frequently interrupted by electrical storms in the area; and there wasn't much heavy industry. Apparently, people tolerated them. When we started up at CMX, we ran into some of that and that would ruin our experiment. If we lose power the water flow would stop, things would be all upset so we had our powering department people at the plant. We had a deal with the electrical utilities to get them to upgrade their switch gear and so forth so it wouldn't be sensitive to lightning. The initial attitude was, "Oh, so what, the power was out for a couple of minutes but it came back on." Finally we cut across and the power supply became so much better.

MS: So you did use local power? What about … what kind of security did you have at CMX?

PD: We had a patrol around the facility around the clock, all of the time,
checking in and out with your badge to the parking lot outside where we parked out vehicles.

MS: What about … at CMX did you all have any direct dealings with the reactor works and 777-10A or was that like apples and oranges?

PD: Yes, we did testing.

MS: What about … what was the connection between CMX and the laboratory?

PD: You mean Savannah River labs?

MS: Uh-huh, yeah.

PD: We didn't have any dealings with them.

MS: Oh really? Okay, I heard that later on it was more of a …

PD: Later on they did work for the lab, but I reported directly to Wilmington.

MS: Oh, okay, okay.

PD: Every morning I gave a verbal report by telephone directly to Wilmington as to what was going on.

MS: Did that change after the rest of the plant at Savannah River Site opened up? But in the early days, you were the only Operations Supervisor?

PD: Yeah, yeah.

MS: I imagine that the early construction period must have been pretty confusing.

PD: Well, it was busy. I wouldn't call it confusing; it was done remarkably well. Looking back on Hanford, never having built a facility like this before, it was phenomenally successful. They could design, build and operate the facility as well as it did. Similarly, Savannah River entirely different design for the reactors, but it went very smoothly and remarkably fast. These days you couldn't get half of the paperwork done in the time it took to build the plant.

MS: I'm sure that true. What about … what was a typical day like in the early day at CMX, or was there a typical day?

PD: Well, we ran around the clock and the people on the day shift supervision, top supervision there, would analyze the data and so forth and design the next experiments to be run. Some of these experiments would last weeks. Sometimes results would indicate that we should change our course of action and the run would be a couple of days or so we'd decide to do something different. It was a busy time, we were under pressure, of course, to get the results as soon as possible, but we had full support from top management in Wilmington so things we needed we received.

MS: So, when did you determine that … can you remember the date that you determined that we did not have to have anything extra done to the Savannah River water to run it through the reactors?

PD: I expect it was some time in fifty-two ('52), mid-year or something like that.

MS: That would have been roughly … that would have been just about six (6) months or eight (8) months after CMX started running?

PD: Yeah, we started running about September 1, 1951 and I'd say maybe nine (9) months after, but this is ball park.

MS: Right, uh-huh, right; and this was the most important thing that you had to do at CMX?

PD: Yeah, yeah.

MS: Were there any other smaller projects that were on-going?

PD: Not really, we were studying corrosion and so forth, and that wasn't a major problem.

MS: Uh-huh, right, uh-huh. So you didn't really have any dealings with the laboratory at that time because the lab probably hadn't even been built yet?

PD: No it hadn't. Milt Wahl, who was director of the lab, he was on-site, I guess the latter part of 1951 and some other people started coming in but this was … they were still constructing the lab facilities.

MS: Uh-huh, right, okay. So all of your commands, I guess, are people that you got your direction from?

PD: Yeah.

MS: I mean, there was nobody at Savannah River Site that you had to talk to about …?

PD: Yeah. Uh we had hourly wage roll (hourly) people assigned to us and the Personnel Department was starting up at Savannah River about the time that we were there, so we consulted with the Personnel Department with respect to personnel dissentions and so forth, to make sure that we were consistent with the plant regarding personnel matters.

MS: What about … is there any other topic or item of those early days at CMX that I haven't thought to ask? I'm sure you know a lot more about that sort of thing than I would even begin to be able to ask about.

PD: I think we covered the principal things.

MS: Yeah. Now I was kind of intrigued about the early CMX days at Hanford; if I knew that earlier, I'd forgotten about it.

PD: You probably didn't know.

MS: Unless we covered it in our previous interview, but …

PD: I don't think we talked about it.

MS: We might not have, not in any detail anyway, so that was kind of interesting so there actually was an earlier CMX at Hanford? To what degree did you know of, did the water quality at Savannah influence the decision to move the plant here in the first place?

PD: Well, that was a major factor. The Du Pont Company, as a site selection group within the Engineering Department, which was used to determine sites for Du Pont's commercial work and so that group was used to try to find out where we should locate and ultimately became Savannah River Group; and back when I first came into the Savannah River Group they had decided definitely where the site was to be located but the factors that influenced it, of course, was availability of good water and the Clark Hill dam was very beneficial in that it helped even out the flow of water throughout the year and so they could maintain a minimum volume of water going down the Savannah River past our site. The other big factor is availability of electric power and an area of land, large area, that was not too heavily populated but had adequate transportation facilities and near fairly large communities so that people could be located there to live.

Now a big difference between Hanford and Savannah River; one was that Hanford was secret. Savannah River, everybody new that this was a hydrogen bomb site, the other big difference is that at Hanford the housing was government housing; here it was all privately owned, the government didn't get into providing housing and so most of the personnel for Savannah River, the operating people and construction people located in the Aiken area or Augusta area and then some in other towns around the plant site but primarily Aiken and Augusta.

MS: Where did you live when you first came here?

PD: We moved here in August of 1951. At that time, we were able to rent a new house that had just been build on Brandy Road on the other side of Aiken and in a couple of months we bought our lot in [inaudible] field and started construction of our home. We moved into that in April of 1952. Now at Hanford, several of us lived in the basement of a private home in Pascal, Washington; the home of the principal of the high school.

MS: Wow!

PD: What they did was they got bunk beds and put them in the basement, they had a john down there; our washing facilities for shaving and washing your face and so forth were the laundry tubs down there, they had a shower head with a circular shower curtain around there for us to take our showers and a drain in the floor. We had that for a number of months. Then some of the housing was being completed in the village of Richland. I was single when I went to Hanford and being single I wasn't eligible for the housing, that went to married people with children, but then I got married in April of 1944, went back to Wilmington to get married, brought my wife and a few weeks after we came back to Richland as a married couple we got one of the government's houses and lived in that until I moved out.

Du Pont turned it over to G.E. September 1, 1946. Du Pont's contract with the government was that Du Pont could pull out after one (1) year after the crisis was over, the emergency was over, so after the Germans and the Japanese had surrendered, Du Pont then told the government that they wanted to pull out so they did September 1. The bulk of the people stayed there, employees, but Du Pont had the privilege of tAikeng the people they wanted to their private location.

MS: Uh-huh, right.

PD: And so some of tops of the management they chose to take went there. There were twelve (12) of us from Du Pont that were asked to stay four (4) weeks beyond the September 1 date to just take care of emergencies that might arise or be consultants to help; I was one of the twelve (12) and so I left the Hanford site on September 28, 1946 and went into the Plastics Department of Du Pont.

MS: Oh, okay, right. And so, you didn't have, did you have any more dealings with atomic matters until Savannah River Site decided to open up again?

PD: Yep.

MS: I guess they kept all of the plans from Hanford though, just in case?

PD: Yeah, the Records Department that they … they had all of that at Du Pont.

MS: Why did Du Pont not want to stay in the atomic business?

PD: Because they didn't feel that that was their area of expertise. Du Pont at that time, considered themselves a chemical company and that continued interest in atomic energy was more suitable for electric power companies; G.E., Westinghouse, like that, and Du Pont had made a big sacrifice in operating the Hanford facility in that many of their fine engineers and management did all this work for the government; paid a dollar for the whole contract instead of making money for Du Pont. All of that was not helping Du Pont.

MS: Right. Just out of curiosity, did the … has Du Pont collected on that dollar from Hanford yet?

PD: Oh yeah, they got that.

MS: Oh they did? I've heard that they had not collected again for Savannah River Site because of pensions … due to pensions and everything else they're still outgoing, that's what I heard.

PD: Well, I assume probably that a portion of my pension comes from the government because most of the time I worked at Du Pont it was government work and I assume that the pensions and the benefits was a portion so the time I spent working for the government, the government pays for it.

MS: Right. What about uh … I'm trying to think of some other angles that I didn't uh … about the early days of CMX and Savannah River Site, uh …

PD: We, of course, had no cafeteria or any food service and so everybody carried their own lunch. There were a few times when I'd be touring management from Wilmington, I'd come to CMX, want to be toured on the construction of operating facilities. Once in a great while at lunchtime, we would go to Castle's, a

	store in the old town of Ellenton. That was an interesting experience, a lot of construction people would go there also, and for lunch they had a big long counter; at the head of that counter you'd tear off a piece of butcher paper, you'd go down the counter, you'd put on a couple of slices of bread, you'd put on some meat or cheese or tomato or lettuce, whatever you wanted on the sandwich and maybe pick up some milk or coffee and you'd go to the end of the line and they'd look at that and they'd say okay, that's $2.25. You'd pay for that and you'd go eat your lunch in the car. That store was a real country store. They had everything there; clothing, harnesses for horses, all kinds of food supplies, fertilizer, a real country store.
MS:	When did they close down Ellenton for the last time?
PD:	That was closed I think in March of 1952.
MS:	That was when the whole town shifted to leave Ellenton?
PD:	They moved a number of homes out of the old town of Ellenton and some of the rural areas. Back in those early days you'd see one (1) or two (2) or three (3) homes being moved on Route 19 from the plant site towards New Ellenton or toward Aiken; some homes were moved as far as Aiken and set up there.
MS:	Whatever happened to Castle's?
PD:	The store? That was torn down.
MS:	Hmmm, so they didn't move that?
PD:	No, no. They had a high school in Ellenton and that was taken over by the project for training purposes. The Personnel Department took that over and used it for training, but the churches, the homes were not removed. The stores, the bank, the little commercial district that was all torn down.
MS:	I still go to the town site now, and you can still see it.
PD:	You can see the curbing where the buildings were, and so forth.
MS:	Right.
PD:	It was a nice little town. Of course the railroad goes right through that. Back in the early days, I made quite a few trips up to Wilmington to report what we were designing and things like that and it was very convenient. I'd jump on the train there in the old town of Ellenton around 5:30 or so in the afternoon and I'd get up to Wilmington, Delaware, about 7:00 in the morning, 7:30, get off of the train and go to work, put in a full day's work and so forth, coming back just the reverse. It was very convenient.
MS:	Those were the days. You couldn't make that trip now. I'm not sure you could make it at all, much less in that time period, not the train.

Side Two

MS:	It just seemed that every two (2) or three (3) months you had to go back and forth between Ellenton and Wilmington?
PD:	Yeah.
MS:	That's surprising; I just can't imagine train transportation being that efficient.
PD:	It was good, they had a club car, kind of like a dining car that had good meals, good service and it worked out fine.
MS:	How much did it cost?

PD: I don't know.

MS: When was it that the … I know in the early days they used trains a lot to move equipment around at Savannah River Site; when did that pretty much cease?

PD: Well, the construction … the bulk of construction was done by then, of course, they used the train tracks and so forth that they built on the site to haul coal and some supplies and so forth. They continued that as long as the reactors were operating.

Of course, that wasn't too much traffic. It was available, the big reactor parts were manufactured up at the New York ship company in Canton, New Jersey, and that was shipped by barge down the Delaware River to the Atlantic Ocean and down the coast to the mouth of the Savannah River, up the Savannah River and they built a special dock and big handling facilities so that could unload those reactor parts onto trucks. Now these parts were so big, that they couldn't have traveled by highway; couldn't go under the bridges and would have been too wide for the highway so it worked out well to be able to ship it by water.

MS: Yeah, uh-huh, alright. Where was that special dock?

PD: That was … are you familiar with the pump houses?

MS: Yeah, uh-huh.

PD: Okay, as I recall, it was a little bit north of the pump houses.

MS: Oh okay, pretty much at the head of navigation?

PD: No, navigation went to the lock and dam near the airport in Augusta …

MS: Oh okay.

PD: … so it wasn't that far.

MS: What about the … you know, I'm thinking about CMX itself, the building and the facilities right around it, what do you remember specifically was there? Like you know, we talked the talked about the mock-up of the heat exchanger.

PD: Yeah, and the [inaudible] and the pumps and the laboratory; we had the offices there.

MS: In the early days when you had the CMX building, I heard that later on they shared those offices with TNX people, was that true in the early days?

PD: No, TNX had their own offices.

MS: Hmmm.

PD: They didn't have as many personnel as CMX did.

MS: Oh okay, I think in later years that was reversed.

PD: It probably was.

MS: Yeah, because I think they were doing defense and fuel projects and things like that.

PD: Yeah.

MS: I'm sorry, going back to the CMX thing and what they might have had.

PD: Well, we had the pump house down on the river to pump the water for CMX. We had the security patrol, they would patrol going down to the pump house and occasionally see wildcats at night down there.

MS: Uh-huh.

PD: It was pretty isolated accept for our facility.

MS: Right, uh-huh, yeah. Was the building air conditioned back in those days?

PD: Yeah. Uh, when we were operating it was air conditioned, and that was pretty essential here.

MS: Uh-huh.

PD: When we first came down here, I was the first one here, and then a few of the engineers that I had reporting to me up in Wilmington were transferred down here and we started writing operating procedures for operation of CMX and I recall that before the building was built at CMX construction had little shanties that they'd move around to construction sites, therefore, they'd use that as their offices so we got one or two of those little shanties down near CMX, where they were constructing them, and our fellows were writing operating procedures in there and I'd go and visit them and see how they were doing and the perspiration was streaming off of them, their arms would be wet with perspiration, the paper that they were trying to write on would be soaked and the pencil or pen that they were using would go through the paper and I felt so badly for those guys sitting in these little shacks with no air conditioning …

MS: Did they have any fans or anything?

PD: No, we didn't have a fan. This was September or so, and fortunately the weather got a little cooler and as soon as we moved into the CMX facility we had air conditioning.

MS: Oh, okay, uh-huh.

PD: My initial office was in one (1) of the construction buildings at the central place where the star shaped building was.

MS: Right, right. When was that, do you remember?

PD: That was July and August of 1951.

MS: This shanty that you were talking about, how close to that, which would later be the CMX building was that?

PD: It was right near it.

MS: Was that something … I missed that part, was that something that was already there or did you add it in?

PD: Du Pont … these shanties were portable so they just moved them wherever they needed them.

MS: Uh-huh, right, I guess they got demolished later?

PD: Oh, yeah, yeah.

MS: I was trying to think of … if there anything else that you can add about the early days of CMX that would be great, I can't think to ask anything else right off the bat but it doesn't mean that there isn't some good stuff in there.

PD: Well, I've been yacking quite a bit.

MS: [laughs]

PD: Goes back a few years. But both Hanford and Savannah River were unique experiences, particularly Hanford, because there we were supplied transportation. We were getting by the government a station wagon and so we'd drive from Pascal to the site, which was near the old village of Hanford, right on the Columbia River. Once you would drive there and relieve the people that were working they'd take the car back to Pascal, leave it there in the place, the next shift would pick it up and go to the work site. They just kept it going back and forth like that.

MS: Wow, hmmm.

PD: And that was thirty (30) something miles.

MS: Out of curiosity, what did they tell the people that lived like in Pascal and the communities in Washington State that were near Hanford, what did they tell them was going on?

PD: That it was a government project related to the war.

MS: And that was it? They didn't know anything about the …?

PD: The bulk of the people working there didn't know what was going on.

MS: Uh-hum.

PD: Most of the people [at] CMX there didn't know what it was all about.

MS: Huh? Well, that would not have been the case at Savannah River Site?

PD: Oh, everybody, the public knew. As an example, my wife was at the hairdresser the day the first atomic bomb was dropped in Hiroshima. This was the days when they didn't have TV but they had the radio on at the hairdresser. They broke in with an announcement that an atomic bomb had been dropped in Japan, the material for the bomb had been manufactured at the Hanford Engineering Works. That was the first she knew about it. It was amazing how well that was kept secret. Amazing!

MS: Yes, it is amazing; although it's not so amazing that the Soviets didn't find out about it.

PD: Yep, yep.

MS: But that's a different story.

PD: Yep, yep.

MS: Are there any other stories about CMX either at Hanford or Savannah River Site that … because this CMX and Hanford stuff is very interesting.

PD: Well … yep, uh-huh. It was interesting there at Hanford in that in the old town of Hanford, they had the construction village and those were like army barracks. They had separate barracks for male and female. A married couple didn't live together in the barracks. Because of that there was a trailer village, mobile home village, at Hanford too; and that became quite popular because married people would like to have one of those places so that they could live together. At Hanford, they had up to sixty thousand (60,000) people in the construction force. It was, I think, the third or fourth largest city in the state of Washington at that time. They had mess halls for eating, we ate there a few times and that was an experience. The construction personnel were pulled in from all over the country and a big mix of people at the mess hall that served the food family style, big bowls of potatoes, meat, vegetables, what-not, passed around. When the bowl got empty you'd hold it up and somebody would come and take it and give you a fresh one. There were interesting stories because of the great mix of people. There was a story about … there were some people that came from the sticks and had never seen that amount of food before so some of them they'd take extra food, mashed potatoes, meat and put it in their coat pockets.

MS: [laughs] I've heard that, but that's like … I've heard of people taking drum sticks and putting them in their boots.

PD: Yeah, yeah, yeah. One interesting story … they had the construction people housed there at Hanford until the reactor, first reactor, was about ready to start up. They had reduced the force significantly but they still had a fair number of construction people. They had to be relocated because they couldn't be living that close to the operating reactor so some of them were moved to dormitories that had been constructed in the town of Richland. There was one fellow from Mexico who was in the labor group in construction at Hanford. He was a real good worker, did his work, kept to himself, no problems, and so they kept him on when they reduced the force and so he had to move from Hanford to Richland, and a few days after he moved this foreman noticed that he didn't seem to be his usual vigorous self. He asked him, "What's the problem?" he said, I'm hungry. He said, "Why are you hungry?" He says, "I don't have any money, I can't buy any food." When he was at Hanford, they deducted his room rent and his meals from his paycheck, when he got to Richland they didn't do that and so he had to pay for it… they asked him, "Well, you got your paycheck." He didn't realize what the paycheck was. Fortunately, he had saved the checks that he had gotten when he worked … when he was living at Hanford so they got that out … his supervisor went with him, took him to the bank, got it all deposited and suggested that he go home to Mexico rather than let somebody else find out about this and trick him out of his money. I thought that was a fantastic story. He didn't realize that those pieces of paper were his pay.

MS: Right. Well, you know, it's possible that somebody had worked in a situation where you just get room and board instead of cash, that probably … he was unaware of what banks were.

PD: Yep, that's what happened. Yep, yep.

MS: Going back to … talking about CMX at Savannah River Plant, what was it that finally tipped you all off that the Savannah River did not need to have any treatment on it to run the water through … it was just experiments, back and forth?

PD: Yep.

MS: You ran it filtered and you ran it non-filtered and you just found out that … was it the silt or sand that was in Savannah River that made …?

PD: A combination of the turbidity and also some of the color in the Savannah water is tanins from wooded areas, the head waters of Savannah River and those tanins are a natural inhibitor of the formation of the film.

MS: Okay. That film that you mentioned that there was a problem at CMX at Hanford, is that common in a lot of rivers or …?

PD: Probably.

MS: Nobody ever really thought to experiment with that, huh? So it just so happened that Savannah River did not need to have it done … which that wasn't the reason they moved the plant here.

PD: Oh no. In fact, initially we felt that we'd have a greater problem with Savannah River water because it was more turbid, its color and so forth. The Columbia River was such a beautiful … that's a beautiful cold water.

MS: Right, yeah. Well that's all of the questions I can think to ask you.

PD: Okay.

MS: Oh yeah, what about, this was long after you left CMX but you may have heard something about this, what about the clam problem they had … that was later I think, like in the seventies ('70s) or something?

PD: Pardon?

MS: Like in the seventies ('70s) I think?

PD: Yep. Well, I forget where the clams originally came from … I think it was from some ships that came up the Savannah River and probably emptied some tanks and so forth of water and the initial clams got in there.

MS: They just came in the intake and it went up the tubes?

PD: Yep, and that became somewhat of a problem at the power plants and the reactor areas.

MS: How did they deal with that?

PD: I don't really recall that.

MS: Uh-huh. I think that's pretty … one other question about the… when you were working with the people, your bosses at Wilmington …

PD: Yep?

MS: … and you had to tell them what you were doing at CMX, who did you report to?

PD: Dale Babcock.

MS: Dale Babcock, okay. Did he later have anything to do with Savannah River Site?

PD: He had a lot to do with it and continued I guess up until his retirement but he was never assigned down here.

MS: Okay.

PD: He continued working in Wilmington with the management for the atomic energy phase of the work, of course, which was located in Wilmington and they had a technical support group and Dale was heading up one of those technical support groups for the reactor.

MS: Uh-huh.

Out of curiosity, why was CMX and TNX, why were they put together?

PD: Just logistics, they uh … we had the water supply, electrical supply and used the same security force and so forth, parking lot. Yep, but like the work at the plant, those of us at the Reactor Department had nothing to do with the people in the separations department except to supply them with material but their operations and all of that was kept …

MS: It was just purely logistics that put them together, they didn't have anything connection except sharing electricians or something like that?

PD: Yep, yep. No. Dewey Waters was the head of CMX but he passed away a long time ago.

MS: Okay, and CMX was there first, right?

PD: Yep.

MS: And then TNX came in … did TNX come in while you were there or …?

PD: Yep, yep.

MS: What about … according to Bebbington, CMX was closed down in 1984 is that?

PD: I don't know, I retired in 1977 and prior to my retirement I had no connection with CMX for years.

MS: Right, right. Who did you work with at CMX that you can remember?

PD: Well, initially, my assistants were Dan Wingard, G-A-R-D, Ray Good, Earl Nelson … those were the three (3) principle assistants to me.

MS: When did …?

PD: Two (2) of those are deceased I don't know where the other is, but they all went into other Du Pont commercial areas before too long.

MS: So they didn't … did they not stay at Savannah River Site?

PD: Not too long.

MS: Okay, so they went back up to Hanford. Was that the case in the early days, a lot of the people that came to work at CMX did not stay there?

PD: The initial group it so happens that …

MS: Okay, well that's all I can think of to ask right now, if there's any other questions or any other comments that you want to make, I got probably plenty of tape at the time but I can't think of anything else that I need to ask right now. I will say, if you don't mind I might give you a call later if I find out something more or have another question.

PD: Sure, yeah, don't hesitate.

MS: Okay. Well if you don't have anything else, I'll go ahead and turn the tape off.

PD: Okay.

MS: Okay.

We're just resuming the taping and this is just to get some biographical information.

PD: I'm Paul Dahlen, I was born in Minneapolis, Minnesota in 1913, March 22nd. I received my Bachelor of Technical Engineering degree from the University of Minnesota in 1936 and from 1936 to 1939 I worked with the Northwest Research Foundation and continued in the graduate school of the university and received my Masters of Science Degree in Chemical Engineering in 1939 and I was hired by Du Pont Company in 1939, started working at the experimental station outside of Wilmington, Delaware in the Ammonia Department. Initially, in the development of intermediates for nylon which had recently been invented and they were trying to develop procedures and material for the big scale production of nylon. I transferred from the Ammonia Department to the Explosives Department in 1941 and was assigned to military explosives training at the [inaudible] in New Jersey and then transferred to the Alabama Ordinance Group in Childersburg, Alabama. From Childersburg, Alabama, I was transferred back to Wilmington to start working on the atomic bomb project in the Wilmington office on design in April of 1942, April 1943, excuse me, and continued working in Wilmington until I was transferred to Hanford in August of 1943. On my trip to Hanford, I stopped off to visit the reactor pilot plant at Enrico Fermi and his associates had built and operated in connection with the University of Chicago and that was a very interesting visit and then reported out to Hanford. After I left Hanford, I worked with Du Pont Plastics Department initially in Arlington, New Jersey and then when the new research facilities had been constructed at the experimental station in Wilmington I was transferred to the experimental station back in 1950. While I was in the Plastics Department, I assisted in the development in Teflon Suspense [inaudible], that's the form of Teflon that could ultimately be used to coat wire, Teflon being the insulated material, also in a form that could be used for coating cookware for using anti-stick properties and ultimately used to treat fabric to prevent soiling and so forth.

MS: Okay great, well thank you very much.

END OF INTERVIEW

Oral History Interview – Claude Goodlett

A native of South Carolina, Claude G. Goodlett was born in 1932 and was awarded a B.S. degree in Chemical Engineering at Clemson College in 1954. He was hired by Du Pont to work at Savannah River Plant that same year. At SRP, Mr. Goodlett initially worked with the Technical Group in the Separations Area, where his primary responsibility was to work on the mixer-settler tanks, scheduled to be used in the Building 221 Canyons. He transferred over to the Savannah River Laboratory in 1959, where he continued research on the mixer-settlers, but also expanded his research into the growing issue of nuclear waste.

Goodlett was transferred to TNX in 1961 and would work there for the next 12 years. There, he did research on the centrifugal contactors used in the mixer-settlers, but was even more highly involved in nuclear waste management research. As a result, Goodlett became one of the foremost experts at SRP on the treatment of nuclear waste.

In 1973, he was transferred back to the Savannah River Laboratory, where he worked on the processing of neptunium and californium, man-made elements created in the Special Products work done at SRP in the late 1960s and early 1970s. Along these lines, Goodlett worked at the Multi-Purpose Processing Facility (MPPF) for a number of years. He retired from SRP in 1989, the year Du Pont left the facility, and lives today in Aiken, South Carolina.

Interviewee: Claude Goodlet

Interviewer: Mark Swanson, New South Associates

Date of Interview: December 15, 2004

Mark Swanson: This is an interview with Claude Goodlett and it's the 15th of December 2004 [interviewer is Mark Swanson]. If you would, just give us some information about your early life and then how you got involved with Savannah River Plant.

Claude Goodlett: I graduated in with a B.S. degree in Chemical Engineering from Clemson in 1954. I was hired at Savannah River Site, well Savannah River Plant in those days by Du Pont. I reported in and worked in the Technical Group assigned to the startup of [inaudible] separations plan. I worked there for a year or so during … well, before startup and during startup, and then I went to "H" area, which is the other separations plant. I worked there during … before startup and during startup and then after working in various groups in the separations areas I transferred to Savannah Laboratory; I believe it was 1959. I worked in the Savannah Laboratory on certification and nuclear waste. In fact, I was the first person in the United States with actual [inaudible] waste in solid form. In 1961, I believe I was transferred to TNX. I worked at TNX; people there my supervisor at times Bill Mottel; worked with some others, Al Kisbaugh, Vince Corachilow and I don't remember … maybe one other person, very low employment type thing. TNX being the area which did the developmental work for the 200 Areas. The Waste Management in those days was under the 200 Areas. I had extensive experience in the separations areas so I did that type of work initially; then in those days Waste Management was sort of the back burner, nobody ever worried about it.

I became involved in Waste Management from actually the lack of anybody else wanting to do it, because the high profile work was in the reactors, initially, and then the separations areas and then much later, Waste Management. Most of the Waste Management work wasn't started until much later when I got involved in it. The TNX was originally built to prototype the work for the 200 Areas; mainly the solvent extraction, the resolving of the fuel elements solvent extraction, the materials and the recovery of them.

The original tritium work at Savannah River Site was done at TNX on the [inaudible] tritium. Actually radiated slugs of fuel from the reactors were distracted in the TNX area. The separations processes as originally installed use steam jets or steam abductors to transfer solutions from one tank to another, or to feed the solvent extraction facilities. They were all originally developed at TNX. Some of the work was done at Capel and then we had people that did the work at TNX. Ed River, I guess, was sort of the known person for the jets at that time. His initials were EJ and he was know as "E. Jets River", that was the nickname he had. The solvents extraction mixer … is this the kind of stuff you're interested in?

MS: Uh, yeah, yeah.

CG: They were installed in "F" area; "F" area had a nominal capacity and I don't know whether that number is still classified or not, so many tons per day. They were modified, the original [inaudible] were developed at Capel.

MS: What was Capel?

CG: An old Subatomic Power Laboratory.

MS: Okay.

CG: Up in New York State.

Al Kisbaugh was involved in the Mixer-Settlers from day one. Al Jennings was also an expert in Mixer-Settlers. Al Jennings lives here in Aiken. I haven't seen him in about six (6) months, but he was in fairly good shape the last time I talked to him.

When they build the Mixer-Settlers or installed them in "F" area, which had this nominal capacity with "H" area as a backup facility in case it didn't work. In those days people had to have a product and the only way you got the plutonium [inaudible] was for "F" area to work. Modifications of Mixer-Settlers were developed and these modifications were developed at TNX, which allowed them by putting different pumping veins on the Mixer-Settler Units to increase capacity maybe a Factor 3, so the units they were putting in "H" area, which I was involved in during startup in "H" area. I was over on the receiving end of a lot of this information but being a technical group there, we worked with the people at TNX.

MS: Uh-huh.

CG: These modified Mixer-Settlers were installed in "H" area with a significant increase in throughput. Experiences with "F" area led us to modify the "H" area facility; adding extra tanks doing certain things, which allowed us to get this higher throughput. Then they decided they wanted even something higher throughput. So a program was started at TNX to build larger Mixer-Settlers, larger evaporators and larger dissolvers. These Mixer-Settlers were designed in the philosophy that we'll put the biggest thing in the canyon that will fit.

MS: Uh-huh.

CG: It didn't have a throughput goal per say; but let's put in the biggest Mixer-Settlers that will fit in the canyon. They were developed at TNX, they were built … "F" area was shut down, the old equipment was taken out and this larger equipment was installed; Mixer-Settlers and again evaporators.

MS: Uh-huh. Where were these installed at?

CG: In "F" area; in the canyon, 221.

MS: In the canyon itself?

CG: 221.

MS: Okay.

CG: When I'm speaking of installing, processing, chemical processing, was basically done in 221 Building.

MS: The big canyon?

CG: Right. The original installation in "F" area was small to do a certain throughput.

MS: Uh-huh.

CG: And then they modified these units and put the same sized units in each area when it was built, or it started out, and then went back and took all of the small stuff, most of the small stuff, out of "F" area and put the new stuff in that was designed at TNX.

MS: So in other words, effectively "F" area was de-emphasized later as "H" area was …

CG: But then "F" area came back and it had a higher throughput than "H" area.

MS: Oh, okay, okay.

CG: And then …

MS: So they sort of oscillated then, back and forth?

CG: Yeah, they started out …

MS: Uh-huh.

CG: And then started a higher throughput "H" about a year later.

MS: Uh-huh.

CG: And then went back and cleaned out and restarted "F" with higher throughput.

MS: Uh-huh.

CG: At that time "H" area was modified to handle enriched uranium …

MS: Uh-huh.

CG: … versus natural uranium, which was the original throughput plan.

MS: Okay.

CG: The enriched uranium equipment was developed also at TNX and have critically safe Mixer-Settlers and critically safe dissolvers. That was designed … all of that experimental work was done at TNX.

MS: Hmmm, okay.

CG: The difference between … and I'll blow the horn a little bit; I have good friends at Hanford, the difference between Hanford and Savannah River was Savannah River had an experimental facility, TNX, Hanford did not. So they were not able to do the experimental work. In fact, during my work at TNX, actually, we did some work for Hanford. Of course, that's common now, but originally SRL was to support Savannah River and had nothing to do with anybody else.

MS: Yeah.

CG: But, I can remember doing some waste work after I got into it where we were involved in … we had some equipment and I ran some experiments for friends at Hanford and the laboratory director at that time, he said, "Look we're not going to charge them, we're not going to write the reports if they'll send somebody there and tell us what we want to do and you want to work with them." If I wanted to work with them, we'll go ahead and do the work for them, we'll given them the data, they interpret it, we don't want to be involved in their business. So that's a little … and it was a significant difference between the Hanford people. They just didn't have the experimental facility that we had at TNX.

That's how we got in to the diversity. After I went to TNX, I did work on … I guess the centrifugal contactors, which actually replaced the Mixer-Settlers - centrifugal contactors, solvent extraction units that replaced the Mixer-Settlers. Al Jennings, Al Kisbaugh and John Webster were the people behind the development and the [inaudible] of the centrifugal contactors. The advantage of the centrifugal contactors was in the Mixer-Settlers, we had larger hold ups; the amount of material in a solvent extraction unit was very high. The solvent degraded and resulted contact with a high radioactivity. So it had … the solvent degraded over a period of time; you got a different kind of solvent that wouldn't extract, it would emulsify, so the centrifugal contact were actually low hold up units in a matter of a small number of gallons versus tens, hundreds of gallons. So, they were developed and tested TNX – the idea was really, I think, Donna Webster's.

Al Kisbaugh did the development work on them. They were installed in the separations areas later, because the solvent didn't degrade as much. So that was another TNX development.

MS: And when did this happen?

CG: Uh, must have happened along about 59ish, give or take.

MS: This is with centrifugal contactors, right?

CG: Right.

MS: Oh, okay.

CG: The bigger Mixer-Settlers had been put in before that …

MS: Okay.

CG: … and then the centrifugal contactors came in and they were installed. They gave high throughputs …

MS: Is the Mixer-Settler the first thing that went in?

CG: Yes.

MS: That was the first …?

CG: There are two (2) ways you can do solvent extraction; you can do it – in those days – Mixer-Settlers pulse columns. Hanford chose pulse columns, Savannah River chose Mixer-Settlers and that original development work, as I said, was done at Capel. Hanford never did switch; they always used pulse columns. We just … we upgraded our Mixer-Settlers, and the centrifugal Mixer-Settler is just a much higher quality or later development of a gravity Mixer-Settler.

MS: Uh-hum.

CG: Instead of using gravity settling the solvent [inaudible] … we used centrifugal filled to [inaudible]. That development came out of TNX. Then another development that came out of TNX was the co-dissolution of uranium aluminum. Originally the fuel elements were aluminum jacket on a metallic core … a metal uranium core, so you dissolved the aluminum jacket in a caustic solution, which did not dissolve uranium metal. Then you went in with an acid dissolution of the uranium metal. You threw the aluminum jackets with the caustic solution away as a coating waste. It's a lower-level type waste. Then the uranium metal went through a solvent extraction as a nitrate – the plutonium, which we covering in those days – we went with it and then you purified the plutonium through a couple of cycles and sent it to "B" line where it's converted to plutonium metal.

MS: Uh-huh.

CG: The uranium went out to what we called the "A" line in those days and converted to UO-3 and stored as UO-3 in fifty-five (55) gallon drums, I guess is when it was shipped off to plant now. The dissolution process again, originally, there was no criticality hazard.

MS: Uh-huh.

CG: Then we went to the enriched uranium processing, which used the drivers in the reactor. It was a matrix of uranium aluminum in an aluminum jacket. So what you did there was find out if you added mercury as a catalyst then you could dissolve the aluminum and uranium … the aluminum jackets and uranium aluminum alloy core at the same time using the mercury catalyst. So that's where the mercury came from … we used … I don't remember the concentrations, it's very low of mercury. These dissolvers, original dissolver was tested, I guess … one thing I should say is quite different from the way the plant operates now, it we used … relied on Du Pont Engineering Department very heavily.

MS: Ummmm.

CG: And those of us in research worked directly … the Du Pont Engineering Department had the responsibility for designing the facilities; Du Pont Engineering basically and Wilmington. We at TNX worked with them, we developed the data, we ran the experiments, and we tested the equipment that basically Du

Pont Engineering designed. That's through DWPF, DWPF is presently designed, regardless of what Westinghouse people will tell you … was designed by Du Pont Engineering Department and not Bechtel!

MS: All right.

CG: I wanted to give you that little insight into the way we worked. Like … when I did most of the waste work it was done at Savannah River. I worked with a fellow, Ed Hine and others in Du Pont Engineering Department. They would do engineering … it was an interactive type thing.

MS: Uh-huh.

CG: If they … Ed … wanted a pump tested or we ran the facilities to transfer radioactive waste underground, I really did the running of the stuff and passing information to him.

MS: Uh-huh.

CG: Because they had no facilities to do that kind of thing. They're sort of like the [inaudible] people were. So a lot of this stuff that was developed at TNX … a lot of it was actually designed by people in Wilmington. And tests … ideas maybe came from the people in SRL. The design basically came out of Wilmington and the testing of the design was done at TNX before it was put into the plant.

MS: Uh-huh.

CG: I got involved in the waste management and the leakage, sealing of cracks, the pumps to pump the waste underground and so forth and I can …

MS: When was that?

CG: Well, I went down there in sixty-one ('61) and I stayed for twelve (12) years.

MS: At TNX?

CG: Yeah.

MS: And that's when … you mostly worked at … on the waste problem?

CG: No, I worked … I did work on the centrifugal contactors too, I did work on tritium, I did work on [inaudible] and stuff. I guess I wrote quite a few papers or presentations, but I did switch over towards the waste a little bit.

MS: Uh-huh.

CG: Uh-huh, while other people were doing it and here's a list of documents I wrote. I don't remember the dates of most. A lot of it was done in the sixties (60's).

MS: Uh-huh.

CG: I guess when I think about it I was … mid-sixty (60), I was born in thirty-two (32) so I was about 35-years-old when I did most of my, what I'd say was productive.

MS: Uh-huh.

CG: I did work on the evaporation waves, I developed the scheme(?) which converts liquid waste to a solid form by evaporation and put it in waste tanks.

MS: Uh-huh.

CG: And the pump to do it with, pumping the waste miles underground using these pumps. I was doing work on a pump to transfer the waste within [inaudible] areas. I found out that the pump we were using is kind of an interesting design and I kept plugging it up and I can remember we had the pump manufacturer out talking to us. He said, "I can't guarantee it'll work!" I remember Ed Hines from Engineering said, "We didn't ask you to guarantee it, all we want you to do is build it!" And so we came up with our own design of how he should modify their pump ...

MS: Uh-huh.

CG: … they were a big nuclear pump manufacturer, to do our job. He produced the pump like we wanted. We tested it, it worked fine. It was more efficient than what we had so later on he switched his old pump design to that new type of design. We did the evaporation of the waste, we did the transfer of the waste, uh, actually we found out we could reduce the volume of waste about a factor of three to four (3-4) by this evaporation process, which was put in. But then if you evaporate it you've got to transfer it so that's where the transfer systems came from. To transfer this concentrated waste at high temperatures to a waste tank, because when it cooled it solidified. We found we could pump up to twenty (20) volume percent solids through pipes for several miles. We learned all of that at TNX, we were just all in the plant and it's still used out there.

MS: Hmmmm.

CG: Another thing we did down there was the removal of the waste from the pumps since they … I did work on dissolving waste; taking it from the salt cake back to a liquid that we could then transfer to another tank. You know that tank started leaking or we needed to process it.

MS: Right.

CG: Then we got down to the sludge removal from the tanks; radioactive sludge as a reactive waste has a sludge layer that settles in the bottom of the tank.

MS: Uh-huh.

CG: And it contains the strontium and the [inaudible] basically stays in the [inaudible]. The strontium, the plutonium and the other are in the sludge. That's what actually, they are putting into the waste canisters, is the sludge.

MS: Uh-huh.

CG: So Art Hill, who is still with Jay Hill, he lives here in Aiken; he met with this sluicing method by which we would sluice the waste out of the tanks. Then at TNX, that was my forté it was the time to do the waste down there and I got assigned the job; so Art came up with … he actually used fresh water and ____ wells, which is a … they actually are oil well people. We brought them in and we set up a simulated sludge, which I kind of developed how it should be. We built a half mock-up of a waste tank. We built the high pressure put pumps in and we sprayed it and found out we could indeed remove this simulated waste out of the … the sludge out of the tanks. The only trouble with that was it took fresh water. So the idea was, "Hey!" and then it went back to us again. "Is there some way we can keep from adding all this extra water to the tanks?" One (1) it's corrosive and two (2) you've got to get rid of it sooner or later. So we were having a meeting one day and we said, "Well we can get about sixty (60) pounds fresher from a centrifugal pump, that's about all you can get. These may be running two to three thousand, (2000-3000) pounds. So we came up with the idea that we'd get a centrifugal pump. Then the fellow I worked with, Mike Mobley, found a report, which was actually written by a Du Pont person, which gave the cleaning radius or the amount of distance a jet stream would go. Depending on … and it turned out to be a momentum number, not a pressure number. So we found that we could put these centrifugal pumps in by controlling the nozzle or the flow through the nozzle, we could actually clean the waste for the same distance we'd use in the weight of the liquids that were already in the tank. So that's where the "sludge removal pumps" they have out there now came from.

MS: Uh-huh.

CG: I was involved in that. I made a list of large pump manufacturers that we decided could do this kind of work for us and visit them. It turns out that most of these pump companies are on the West Coast. We went to B & Ryman, which was in Portland Oregon. I was out there about two (2) months ago, my son's out there. B & Ryman is no longer there but there is a German pump company in that same building. So they developed what the fellow, I think his name is Jack something, I don't remember his name. He sort of took this under his wing; I don't know what kind of pull he had because this is not a big money-making thing for a company like that. And so, with our help, engineering department help, people in the plant, we in the experimental group, we designed … we told them how we wanted this pump built and they winding up building these things. I don't know, they were like a million dollars ($1,000,000) to copy some five (5) or six (6) years ago. And so they were basically, that development and those sludge removal pumps came out of TNX. We built the facility and then we came up with an idea that, "hey you can get longer cleaning radius because you're limited for the number of holes in a tank that you can put a pump in."

MS: Uh-huh.

CG: There were like eight (8) or so in a tank and then we learned to get longer distances, cleaning distances. So, we came up with this equation that somebody had and it worked! And so we were able to use … not add water, use a lower pressure system and to clean the waste from the tank using these prototypes and then what we were putting into the plants. All that work was done at TNX, this was after I left down there.

MS: Now these are … we're talking about cleaning tanks, these are waste tanks?

CG: Waste tanks that carry the high-level waste. If you take a waste tank containing high-level waste and if you took it fresh out of the building …

MS: Uh-hum.

CG: … and then you put it in the tank and it settles out and you've got maybe a five (5), ten (10) percent volume of sludge and then you've got the remainder of liquid.

MS: Uh-huh.

CG: And so, when I was doing the concentration, I actually took the liquid, boiled it down to a series of evaporations; and you've got some reasons why you have to do this because of chemistry, the certain carbonating sulfates are not affected by temperature insolubility.

MS: Uh-hum.

CG: And so you concentrate waste and take it back to the tank and cool it and some of that crystallizes out as salt; sort of like the salt that you use on the table and it looks like that type of thing. Then we take the liquid back and concentrate it and put it back in the tank and that's how you can get this volume reduction to about a factor of three (3) to four (4). It saved many, many, many millions of dollars in building tanks. So we were able to take, I don't know what the latest numbers are – what seventy million (70,000,000) gallons of waste behind the buildings. We were able to store it like in thirty million (30,000,000) gallons and so I saved lots of dollars.

MS: Yeah, uh-hum, alright. Now, the waste tanks we're talking about, these are the big ones that …?

CG: The big ones, they're seven hundred fifty thousand gallons (750,000), million (1,000,000) gallons, 3.3 million gallon tanks.

MS: Right, yeah.

CG: And uh … but again, all of that work came through TNX.

MS: Uh-huh.

CG: A lot of the ideas came out of TNX, some came from the plant people, some came from the engineering department. Every once in a while a manager would come up with an idea. We'd call the bosses in those days. Then one, I guess one of the next things that came through is the DWPL. We actually built facilities to pilot the melters, the DWPL.

MS: Was that in the eighties (80's) when that became a big thing?

CG: Yeah, probably. And that was probably at TNX it was an original group of us, supervisors, flow sheets, we had the [inaudible] in those days. I had the feed systems and all the equipment. I was responsible for building the building to put it in … all the equipment that went into it. So that was done at TNX and then on a parallel basis, the N10 Melter, which was done at TNX also, that's a continuous melter, which was originally selected based on work at B&L, it was tested and [inaudible] is what we used to feed the waste in and into the can and heat the can. If it's in-can you don't know whether you've melted it or what have you, you know.

MS: Uh-huh.

CG: If it goes through the continuous melter and close-out then you know pretty well it's … it was a liquid and you didn't get a bunch of crap that came out as solids.

MS: Right.

CG: So this and … work on both of those types of melters was … we had a couple of people that lost their jobs between the in-can melter and the continuous melter.

MS: Hmmm, when was this?

CG: I'm not sure. That shouldn't be in the report but in reality it was …

MS: I mean as far as the uh, not about the people losing their job or anything but just the … when was this, you know, the In-can Melter vs the Continuous Melter …?

CG: That would have been probably the seventies (70's).

MS: Seventies (70's) okay.

CG: I have a hard time remembering because I retired in eighty-nine ('89) and I have to … I'm having to try to figure these things in about when I was there. Other things that were done there when the plant was … did the curing and recovery campaign, you read a little bit about the neptunium that was being used?

MS: Right. The Californium-Neptunium system; that was in the sixties (60's) I think or …?

CG: It was sixty-nine (69), seventy (70) or seventy-one (71) so I went from TNX along with a couple of other people that pulled some engineers that had fifteen (15) years of experience; had them running this pilot facility up in the Savannah River Laboratory's main building. Some of us went up there and worked; actually I ran one of the shifts and a couple of the other people ran the other; John ran one of the shifts. We recovered the California Neptunium system. Then the decision was made in a facility called MPPF, Multi-Purpose Processing Facility, which was installed in "F" area. I actually went in and cleaned one end of the canyon out and put these things called a frame concept.

MS: Uh-huh.

CG: It was installed, it never really was used and that's where you could run the same steps that we did on a small scale, kind of where the laboratory caves lived. I guess you know what a cave is? That's a shielded facility, it is remotely operated.

MS: Uh-huh.

CG: That equipment was developed and tested at TNX. Prior to that time there was something … the frame concept originally was … the original separations areas concept. You'll have to excuse me, it's getting tangled up because I'm trying to put things together here.

MS: Uh-huh, yeah.

CG: I don't remember a lot of things, it's so much. There were tanks. The original separations area used a tank here and a tank here and a tank here or a Mixer-Settler or a … they were all in units and then the concept came through that you don't need these great big tanks and these big facilities, can we put them in smaller units? So we built what we call a frame rack concept and it was a big stainless steel frame with these tanks on it with the various functions. They were small scale version of say the big main process. That was put in … it was the dissolver to recover the neptunium way back in the early sixties (60's) and they were put in on this concept. Again, equipment was designed by an engineer and then put by various people and tested at TNX and put in the 200 Area. So this concept, it went through all of the TNX … I think that's the basic concept, you had to plant people, you had the engineering department and you had the technical people at SRL that did this type of thing. So they went through the MPPS, which really was never used; there's some advantages to it. Uh, it's part of TNX and again, we might … they can probably tell you more about the tritium business than I did but there was a tritium extraction furnace down there. The basic work on those processes were all done at TNX and people said it wasn't real. Indeed it ran natural uranium which is not a problem. But there were some irrigated fuel and some stuff from Hanford that came in that was processed down there.

MS: Hmmmm, when did that stuff come in? Just roughly?

CG: Well I got there in sixty-one ('61) and it had come in before then.

MS: Okay.

CG: So maybe a year or two (2) before then. You got to remember, the real time-frame … nothing started until about fifty-two ('52), which … fifty-one ('51), fifty-two ('52) we announced the plant in fifty ('50) … all that work, if there is … separations plant in fifty-four ('54).

MS: Right.

CG: "H" area plant started up in fifty-five ('55) and maybe, I believe fifty-six ('56). So a lot of that, all of the separations and the original tritium stuff was all done very early and then the waste management, really it didn't get going until mid sixties (60's) to early seventies (70's).

MS: After you had a certain amount of stuff already produced and then it became more of …

CG: When we started the plan up … the fact is, I had the technical responsibilities for the "H" area tank farm. All of the tanks and everything down there myself as an engineer and I worked on it maybe half time. A friend of mine, Mel Shroder, had responsibility for the "F" area tank point. Now there were, technically speaking, there was about one and a half (1-1/2) of us … half a million … I guess he was maybe three quarters (3/4) and that was all the technical oversight there was! Now you've got the whole dadgum technical people out there working on it, you know, it's just …

MS: Uh-huh.

CG: One (1), it became more of a problem and then it became more of a political problem and so that's sort of the way that it happened and CMX the same way; I guess you've heard that, I mean they work regular with the people that did the reactor stuff, when somebody developed a new tube they ran test on it and …

MS: Right and add the facilities down there and uh, I talked to Paul Dahlen yesterday morning …

CG: Yeah.

MS: … he said that when he was first down there at the CMX that he reported to Wilmington, there was nobody here at Savannah River to report to …

CG: Right.

MS: … he just called and talked to him on the phone every morning and told him what was going on.

CG: Actually the head of the technical guy for the whole separations part was in Wilmington and I worked for the lab at Savannah River and the Lab Director reported to this guy. That guy would call me up every once in a while and we'd discuss something and he'd want something done and so the management decided, "Oh let's let Goodlett do what he wants to do." that keeps him out of our hair. You know? But I had direct interaction with Wilmington management on some of these waste things.

MS: Because there was nobody else at the Savannah River Site?

CG: No, there were people there but you know when you get good technical people, they're going to have to keep their fingers in the pot a little bit. So, he wanted to kind of … he had these ideas and I guess he found out if he could come to me … I usually do … of course, I made the bosses aware and he made the other bosses aware; but he had an idea that he wanted to see how bad the … we ran test on plugging leaks in waste tanks … the steel cracked. So, we set up experiments to plug the tank and the steel cracks, the dissolving and all of this type of thing and we're actually the … I guess you'd say we were almost the grunts for the plant. I mean, when something had to get done and they had a problem, we did it. We ran … you know when you shut your valves off and sometimes you get this clanging in the pipes? Well, they split a pipe over there one time with a water hammer, it was called water hammer. So I set up an experiment and measured the pressures you could get when you shut the tank … pipes off. We were transferring it from "S" area to "H" area and it's a high point in the line.

MS: Uh-huh.

CG: And you'd find out if the pump stopped and you restarted it you could get up to very high pressures in the pipes. So we found that you had to put safety [inaudible] on the pumps so that you couldn't restart them without somebody going through some … I mean if the pump stopped you couldn't restart, because you were pumping into a vacuum, we could get three thousand (3000) pounds of pressure in the pipe lines.

MS: Yeah.

CG: Uh-huh. You know, that kind of thing, something would happen and we'd go ahead and work it out.

MS: Uh-huh, right.

CG: I guess then TNX started growing because when we worked there were four (4) engineers and one (1) supervisor. Then we had this operating crew that ran all the … we did an awful lot of work because we had very few engineers and Motley used to show us on the board every time, how much it cost per minute for us because if you charged the engineers for the cost of running an area, we're the maintenance people, the electricians, the operating people and around the clock shift coverage. It's a pretty high number and then you only had a very few technical people. Most of the work we did … I mean we didn't sit back and do to much dreaming, it was getting out and doing the job.

MS: Right.

CG: Most of the people there were all … they were all very highly qualified people.

MS: Uh-hum, yeah, uh-hum.

CG: In fact Motley got to be Plant Manager and moved on to Wilmington and quite a few of the people I worked with, they moved on up because they were all good people. It's not like you had somebody sitting back at the computer playing around, dreaming up stuff. It was a "get it done" type job.

MS: Yeah, you had problems and you had to solve them I guess … well it worked out pretty good. What about … remember you were talking about the Mixer-Settlers?

CG: Yeah.

MS: How big were those?

CG: Well some of them … the big ones that they put in at the end were like two (2') feet deep … the canyons were fifteen feet (15') wide … twenty-one feet (21')? Something in that neighborhood and they … and the big ones just would go from one side to the other. They were pretty … I mean, the biggest thing you could physically put in…

Side Two

CG: The original was only twelve (12) inches deep or something like that and maybe six (6) feet wide or something like that. There were reports on them and I don't remember the exact size. I mean this is stuff; a lot of it has been before you were ever born.

MS: Right.

CG: Most of the people who did it, they are all gone.

MS: Uh-huh, right.

CG: And uh, and then they started moving – again we went from what I'd consider a lean operation to – we got more people there, they cut down the price of cost per engineer. People looked and said, "Why that engineer's cost is so high?" So then what you do is you put more engineers down and use the same number of people and then say you're accomplishing more it's just that the accountants get a lower number.

MS: You were talking about that MPPF?

CG: Yeah, Multi-Purpose Processing Facility.

MS: Yeah uh, what exactly was that?

CG: Okay, what it was, we installed in the high-level caves in 773 Laboratory. This facility to recover Californium-Neptunium and it was done in these shielded facilities. Then somebody had decided that we

were going to need a lot of Plutonium 238 and there are a couple of uses for it; part of space probes and some other good reasons for it, and so people decided that we were actually [inaudible]
Frank and I worked on the [inaudible] later on after I retired and so they installed this facility, which was actually equipment; larger sized equipment behind shielded facilities, windows with manipulators in one end of the canyon. I think it was about four (4) or five sections of the canyon; canyon was sectioned about four to three (4-3) feet long; this thing was about fifty (50) feet long, fifty-five (55) feet long and where we could take the sludge in and dissolve them, separate the Californium, Neptunium; well, the Californium thing kind of went bust and they had no use … they had a lot of good use but it wasn't a sellable thing. The Neptunium requirements kind of went down because the people that forecast these tremendous requirements; Plutonium 238, they kind of went down. So that facility was built and I don't believe it was ever really operated in any significant amount of time.

MS: There's really more [inaudible] anyone to special projects …

CG: Right. It was Californium … and it turns out you could do anything in there to where you needed … see Oakridge had facilities to do small stuff …(Phone rings) Excuse me. … Savannah River did not and that was sort of our facility that was going to do small type runs and material.

MS: Yeah, right.

CG: That … and again, things just kind of started petering down.

MS: Uh-huh.

CG: That's the first and the, I guess reduction in the business, you know.

MS: Uh-huh. Where … where was this facility?

CG: It was in "F" area.

MS: Uh-huh. Yeah I bet the uh …

CG: I guess I've talked an awful lot.

MS: Oh yeah, that's good – it's like uh …

CG: When I left the plant I …

MS: You've actually exceeded my knowledge of TNX and certainly the separations area.

CG: Well …

MS: I was working on the earlier report four (4) or five (5) years ago. I was sort of like the … I did the reactor stuff.

CG: Yeah.

MS: So separations was something that … it was there and it was important but I didn't really understand it.

CG: Well, see I went through startup and I worked over there from, I guess fifty-nine ('59) I left; so I worked over there five (5) years; through both startups and through restart and then I went to the lab and got involved. But it was always in a technical aspect but Applied Technology.

MS: Right.

CG: I'm an Applied Chemical Engineer and not necessarily a deep thinker.

MS: Uh-huh.

CG: I had an office with [inaudible] who was very sharp; he came from the University of Wisconsin – Chemistry Department, I think it was Chemistry and you know [inaudible] and all this kind of stuff so you understood thermodynamics and I could relate to him and George sat there one day and he said, "CG:

what do you think about this and this and this, you know?" It was sort of out of my … beyond my mental ability to think about these things, but I was able to ask, "Well George", I'd say, "What so and so!" I just knew enough I could ask questions and Peter he'd solve it himself.

MS: Uh-huh, right. Well sometimes that will work.

CG: But then I wound up in, I guess we had the [inaudible] reactors when we were supporting DOE and starting from the nuclear reactors and commercial power reactors. Then I went back to DWPF and went to the building of DWPF. Went through the technical aspects of DWPF and then back to the production end.

MS: Uh-huh, all right.

CG: I was transferred back to Savannah River laboratory to write the technical standards we called it in those days for DWPF; and these are the technical requirements that you run the building off of.

MS: Uh-huh, right.

CG: Then Du Pont left and Westinghouse took over and I … when I went back to SRL I told Jim Knight … "I'll come back to SRL but I'm not going back to TNX, I spent too long down there."

MS: Uh-huh.

CG: The only group he had was up in lab building 773-A and the name of it, the title of the group was Safety Analysis so he moved me into that group. Then Westinghouse came in, they said, "Okay, everybody in this group's going to write safety analyses" and I said, "I've written safety analyses and don't like safety analyses because you're looking for what's bad instead of what's good." So we had a hassle and I worked two (2) weeks for Westinghouse and left and went into consulting, worked for Stone Engineering Company, Tabasco Construction, Los Alamos National Lab, Pacific-Northwest Labs and Hanford, Brookhaven and I've been consulting for a while, for a while.

MS: Right, right.

CG: They use my expertise and I've kind of gotten the name of being one of the experts.

MS: Let me ask you this; talking about radioactive waste at the "H" area and "F" area, you're talking about the pipes and all of that. This is my own ignorance, but I wasn't aware that that stuff could move around. Can if go from like "H" area to "F" area?

CG: Yep, right. When "F" area was originally built it had eight (8) seven hundred fifty (750) gallon tanks. One of them was coating waste so we put the coating waste in one tank and then we put the high-level waste … they're both high level, but … the radioactive stuff in another tank. So we kind of segregated these. There was a factor of maybe uh, I can't remember the difference in radioactive level between these two (2) types of waste; but they still … all of them are high radioactively.

MS: Right.

CG: And so then we went to "H" area and we had four (4) tanks that were built. Again, "H" area was just a back up in case it didn't work.

MS: Yeah, uh-huh, right, uh-hum.

CG: And then they built bigger tanks and age and then they went back and built more and then they put evaporators in based on evaporation work we had done to concentrate the waste. Originally they were going to concentrate this coating waste and low-level waste. I worked out this scheme DP-1135 I guess was the report and DP-1136 and it's written up on that thing I've got here where we can actually concentrate the high level waste and do the same thing with it. Then we ran short, of course you're always short of tanks. You know, we worked up a system where we could transfer waste within the tanks in each area and then actually run "F" area to "H" area and reverse.

MS: Hmmmm.

CG: I did the basic research and work on that system … the transfer system. If you keep the velocity above, I think it's twenty (20) gallons a minute in a two (2) inch pipe, the solids won't settle out.

MS: Right, I knew that.

CG: And so we'd pump from one place to another.

MS: Uh-huh.

CG: Then we developed the pumps to pump from one place to another and that's when we talked with this guy and he said that's not the way you build pumps and he said, "Build them anyhow, they work."

MS: Right.

CG: And they've been working since the seventies ('70s) … the sixties ('60s).

MS: Huh, well. How do you install, I mean like all this waste material is like radioactive, right?

CG: Yeah.

MS: You know, highly, so how do you install these things?

CG: Well, what you do is you build a pump pit; in the old days we just built a pit and you had nozzles; pipe nozzles, pipe openings is what it really boils down to.

MS: Uh-huh.

CG: And then you put a tank in and you put what we call a jumper, which is a piece of pipe that bends over from this nozzle on the tank to a nozzle on the wall. It can handle solution or electrical or instruments or whatever you choose to do. It's a mini-canyon concept out in the open. Now we have some releases working on things like that outside so now all of them have a containment over them.

MS: Uh-huh.

CG: Back in the early days we didn't because nobody was really worried that much about them and we weren't going to change them that much. The tank farm went from a storage facility to a processing area. Actually the tank form is now a processing area.

MS: Right, yeah it sounds like it, yeah. Okay.

CG: But the canyons, uh, if they never had you out, you need to go to 717-F. They've torn it down by now, I don't know. That was something else we had that nobody else had. Hanford later built them one.

MS: Uh-huh.

CG: We had a complete mockup of the canyon, in a big air-conditioned building. You could put the tanks in and you could put the jumpers on and you knew that it was going to match in the canyon because everything was built with the same tolerance, it's …

MS: Right. We have to check them and see it it's still there.

CG: Yeah it's … you know … people are in the business of tearing things down.

MS: Yeah that's …

CG: And the reason is it's cheaper … easier to tear things down, just knock it down … I mean they haven't tackled the tough stuff yet.

MS: Yeah right, yeah that's true, that's true, that's why they … I'd better not say that.

CG: You're on tape; don't say that, I can say that, you can't.

MS: That's true. Going back to TNX, when you were working there, how many people worked there at TNX.

CG: Well, when I went there it was basically four (4) engineers working for Mark Mottel who was also an engineer. So there were like five (5) technical people. We had Gus Parks who is since deceased, who was originally sort of the head of it. But then he kind of relegated down to … he ran it. So there was Gus Parks there and then he had three (3) shift foreman; we worked three (3) shifts, five days a week and Tom Drummer, Mark Carpenter and I can't remember the other one. And so that … and then they had probably five (5) operators on each shift, so you're talking twenty (20) people and then there were a few day people and then there was the maintenance people; we had a maintenance foreman and an electrical instrument foreman. They probably had … people can disagree with me because I don't really remember exactly; probably no more than most of the others do. Probably had six (6) instrument, let's say five (5) instrument people and maybe eight (8) mechanics to build and do the stuff for us. I don't know how many that turns out to be, we're getting up to what fifty (50) or sixty (60) people I guess about now.

MS: Yeah, that's quite a lot, yeah. When you were working there at TNX, had you all already sort of invaded the office space that was in the original CMX Building?

CG: When I, when I was …

MS: TNX had a lot of offices in the original CMX Building.

CG: Okay, it was a "CMX" Building; 679-G. The CMX people were on the front end of that building and the TNX people wee on the back end of that building. There was door between to keep it separated. So there was 679-G, which had the CMX people on one part and they had a lot of the experimental facilities there in that building. The TNX part was just the office space.

MS: Right then that's what uh …

CG: And the cafeteria … I mean the lunch room was over there. And then the other building that was 67 … not that was 679, 678 was the middle building, which was the experimental equipment building. When I was there I was responsible for doubling the size of that building.

MS: That was for TNX, right?

CG: Right and then there was 677, which started out to be, that's where the reactor mock-up was.

MS: That was the, kind of the third (3rd) building furthest away from the gate, right?

CG: Okay, the tritium work that was done was there. The CMX people if you're not careful they …

MS: So the tritium work was done in the … ?

CG: 677 Building.

MS: Okay, that's the third (3rd) one?

CG: Well, yeah most of it was maybe a little bit down the middle; but basically the front building, the front half of it, three (3) quarters of the building was a power house and that was the experimental work for CMX and their office space was over there. And then if you went through the door, then the TNX engineers were in there basically and then the next building, and there was no experimental equipment over there, and then the next building was the TNX "678 Building" 67… yeah 678 Building, 679 was the first, 678 and then 677.

MS: Uh-huh, go ahead.

CG: And uh, the second building, that's where the work was done on the equipment, it was in the [inaudible] and then the last building was maintenance and E and I shops; there were some shops over in the first building, but they were just small support shops. Then the more maintenance electrical shops were in the last building. We have a lab over there … the tritium work was done over there, the six (6) scale reactor or whatever it was called was over there in that area.

MS: Yeah, I remember that last building …

CG: That building, Gus Parks, got it – it was a surplus building, I believe, by Central Shops and …

MS: Oh really?

CG: And it was moved in there, it was not … it was moved in later.

MS: Okay.

MS: When was that moved in? Was that before you got there?

CG: Oh yeah, I believe it was. They had a scaled reactor in there so it … I think it was probably move in in … If I had to guess, it was moved in the fifty-four ('54) time frame; fifty-three ('53), fifty-four ('54), fifty-five ('55) down in through there.

MS: Uh-huh. What about the … were there any other buildings around about that were associated with TNX?

CG: It was only three (3) buildings; there's the … powerhouse was in the first building and then we came in and I guess the first thing was, I wound up being responsible for the construction. Then we doubled the 678 Building and then we built probably … I guess the next thing built was probably the DWPF Building.

MS: Uh-huh. Now which one was that?

CG: I don't even remember. It's not one of those original three (3).

MS: Yeah.

CG: Then we built the uh …

MS: What was DWPF, [inaudible] building?

CG: Uh-huh. Well, it sort of did the DWPF processes.

MS: All right.

CG: Let me take a break and call that lady and see …

MS: Oh yes, in fact, I'll just turn this off.

CG: Really TNX was set up to act as a center; that's a Du Pont philosophy. When you build a facility you try to run it on a small scale before you build a big one, or you run it with, in this case, non-radioactive material. Essentially, everything that went into a processing plant and I guess this troop seen that the fuel and everything was tested before we every put them into real use. Again, the TNX area was pretty much technically run with hands on people, a fairly large staff – not a minor expense; and we had pressure on us just to do the things that were essential.

MS: Right.

CG: You couldn't go off on your own and do day-dreaming because it just cost too dog-gone much.

MS: What about uh … when did they shut down TNX, do you know?

CG: I was invited to the shutdown party about three years ago. I'm not sure exactly when, I've probably got it somewhere. Uh, but at that time the security thing said they would not let us back on … I was invited, but then I was uninvited, because I wasn't a plant employee.

MS: Yeah, right. Well … (laughs).

CG: And again, TNX sort of … as I say, it was a real thing in the early days. Then they built a … but then they, back at the plant site they continued to build. If it didn't have a production … part of a production output, you know, it just really wasn't there.

MS: Yeah. What about … did TNX actually stand for anything, or is it just a given name?

CG: There's been a lot of discussion about CMX/TNX and you hear Trinitro [inaudible]… and everything. I think it (TNX) was a code name that Du Pont had used for assembly work. This is the only thing that I ever heard that was … you know, I've heard … the fact is that it came out in the paper Trinitro [inaudible]… it just happens to fit.

MS: Uh-huh, right.

CG: There was a TNX out in Hanford, I understand, at one time.

MS: Hmmm.

CG: They were just code names I think, more than anything else.

MS: Yeah, I think … Bebbington just says it didn't mean anything, although people would make up things that they could fit. Like CMX was Corrosion Metal Experiment or something.

CG: Who knows where it came from; somebody dreamed up … it wasn't like Aiken was named for a person. Have you talked to [William] Bebbington, Mark?

MS: No I have not, uh no. Is he local or?

CG: He's over in Augusta at a retirement home out there on Washington Road.

MS: Hmm, would he be a good person to talk to about CMX or TNX?

CG: He'd be a good one but … Bill, he was in charge of the technical group in the plant. I worked for him and I could remember going into his … I was over there talking to Sam Smiley, who was Production Superintendent at that time and Bill stopped by and he said, "Come by to see me when you finish." So I go in his office and Bill said, "How would you like to go too." I know it was never a pause there, but my own mind … all of a sudden I said, "Hey, I just build a house, I've done this." He said, "How would you like to go to SRL was the story."

MS: Right.

CG: I would suggest the two (2) more knowledgeable people to talk to is Lee Myer in Augusta; L.H. Myer.

MS: That's Lee …?

CG: L-E-O-N, Leon.

MS: Oh, Leon, okay.

CG: L.H. Myer; Lee's, let's see I'm 72, Lee must be about 78 about now. Uh, Al Kisbaugh, but I don't … you might … the fiftieth (50th) anniversary people at the plant will have his address. A.A. Kishbaugh, and he's in the upper part of the state; one of those little towns up there. Uh, I would suggest … they are the people that I would suggest you talk to a little bit more. The other people, I can't think of anybody that's still alive in the real early days.

MS: Uh-huh.

CG: I guess, they blew up the evaporator TNX back in fifty-two ('52). We were running solvent extraction cycles down there to test them out …

MS: Uh-huh, uh-huh.

CG: … and boiling down the waste and a evaporator exploded throughout the end of the building and uh …

MS: Is that the worst accident that they ever had out there?

CG: And that was known as the explosion that was heard around the world … nuclear world.

MS: Hmmmm.

CG: Because nobody knew that the waste from the solvent extraction things could have some organics that blew up and it did!

MS: Hmmmm.

CG: They built a new evaporator and put a concrete wall around it, so if it blew, it would blow out in the field … see, Du Pont's philosophy was if you have an explosion, blow it out where it won't hurt anybody.

MS: Yeah. Well, that makes sense because their gunpowder plants were that way.

CG: Yeah and we built evaporators and had a concrete shield so nobody … and you couldn't go out there when you'd run the evaporators. They marked it off where people couldn't go out there.

MS: Hmmm.

CG: So that blew out the end of the building. That was, I guess, one of the first real noticeable things. As people said, you know, the Russians and everybody knew all about that.

MS: Uh-huh. Oh. What about … were there any other accidents later on?

CG: I can't think of any, I really can't. What we considered an accident is what the political people now is maybe a little different.

MS: Yeah and now it's got more overtones and stuff that it … I mean now it would just be like a nuclear accident with radioactivity everywhere.

CG: I mean somebody that's fallen off of a ladder now-a-days is going to be written up in the paper and there's going to be a big investigation and Westinghouse is going to get fined or something.

MS: Yeah, yeah, yeah.

CG: I'm sure we had minor … I can't remember anybody ever getting hurt or anything.

MS: So nobody got hurt on this accident, that uh …?

CG: No. Tom Drummond had been over reading the thing about thirty (30) minutes before it blew.

MS: Uh-huh. This was what year again? 1950?

CG: It must have been 1952, give or take.

MS: Okay. Well that sounds like it was probably the worst accident that occurred out there.

CG: And it was totally unforeseen, so they put all the experts in and we put limits … the plant could not run above twenty-five (25) pound steam pressure.

MS: Hmmm.

CG: Because we found out the reaction could not initiate at the steam pressure … at temperatures below so and so.

MS: Right.

CG: And G. Stern Nickels did all this experimental work and Tom McMillan on what initiates these reactions.

MS: Uh-huh, right.

CG: And they found out if they limited the steam pressure twenty-five (25) pounds, which we did, and [inaudible] less than a half percent it couldn't happen; or the probability of it happening was very slight.

MS: Right.

CG: But those operating requirements and …

MS: Well, thanks again for all of your information and if you don't mind, I might give you a call back later if I have any other questions.

CG: Well, after you think about it a little bit because I've given you a whole hodge-podge and I guess I've given you an awful lot of details and you're going to have to form your story out of that.

MS: Well, it's good to get your details and get other people's details and then we'll see where they join or where the influence is and that's how you, you know, get an idea of what was really important. Well, I'll continue that but I'll turn the tape off.

END OF INTERVIEW

Oral History Interview – Dave Honkonen

A native of Massachusetts, David Honkonen was awarded a B.S. in Physics from Tufts University in 1952. He was employed by Du Pont that same year. His first position was at Argonne National Laboratory, before going to Savannah River Plant in April of 1953. Mr. Honkonen would work at Savannah River for the next 41 years.

Honkonen's first position at SRP was with Reactor Technology (1953-55). There he worked to help start up the reactors, primarily the R and P reactors. In 1955, he transferred to the experimental physics group, based in Building 777-M (now 777-10A). Three years later, he began working with Technical Support at the Building 305 test pile. There he concentrated on the problems posed by nuclear criticality safety, both at the test pile and later with the Nuclear Test Gauge (NTG). The issue of nuclear safety became the main focus of his work, even after he was moved to the laboratory section of Building 320. His major contribution to nuclear safety was work on borated concrete. This form of concrete, impregnated with boron, was designed to absorb neutrons during rod storage and prevent unwanted critical situations. Borated concrete became the standard shielding used in both the 100 and the 300 areas of Savannah River. Mr. Honkonen retired from Savannah River in 1994 and currently resides in Aiken, South Carolina.

Interviewee: Dave Honkonen

Interviewer: Mark Swanson, New South Associates

Date of Interview: January 12, 2005

Mark Swanson: This is the 12th of January, 2005 [interviewer is Mark Swanson] and this is an interview with Dave…

Dave Honkonen: Honkonen.

MS: Honkonen. Okay. Is it is doctor or?

DH: No.

MS: Okay. So Dave Honkonen. And if you would just for the record, give us a little bit of biographical information.

DH: Okay.

MS: And then how you started with the Savannah River Site.

DH: How far do you want me to go back?

MS: As far back as you want to go.

DH: Beg your pardon?

MS: Far back as you want to go.

DH: I was born in Massachusetts and went to college at Tufts University where I got my BS in physics. And directly from there we went and we joined Du Pont and this was in '52. There were no facilities for the new hires at the Savannah River at that time, so we went to Argonne National Laboratory for about a year doing some training and working with the Argonne people, helping them out. Then in April of '53 we came to Savannah River and I started out working with the reactor technology group in our reactor. And that was, we started working before, let's see, it was April, and then the reactor went critical, the first critical was in December. So I was on the technical support group for our start up group and after they got that going I went to P area for their start up. Then from there to C area for their start up. I stayed there for a couple of years afterwards. Then I transferred to [Building] 777, the experimental physics group and I forget now how many years I was there, maybe five, something like that. Then I went into the ((inaudible)) area and took over the nuclear criticality safety program at the ((inaudible)). And also, well, first of all I went and took over the technical support for the 305 reactor for the test pile run. And then gradually worked into the criticality safety end of it and then about five or ten years I devoted all my time to the criticality safety area.

MS: Going back to the critical test pile in [Building] 305, was it M back then?

DH: 305.

MS: Yeah. When did you first start working there?

DH: It was in; I think it was the late '50s.

MS: Okay. So you were not there at the beginning?

DH: No, I was not there for startup.

MS: Oh, okay.

DH: I don't know if there is anybody left that were, well, Frank Gruci(?), no, I don't think he was involved with it. He may have been involved with it. But it was primarily, he's dead. He was responsible. They wrote a couple of reports on startup and the initial calibration.

MS: What about, how long did the critical test pile on 305, how long did that last before, wasn't it replaced by the…

DH: Nuclear test gauge. No, they used those continuously until they shut them down.

MS: Oh really?

DH: The NTG was developed later on, probably in the early '60s. But they both ran concurrently. The test pile was used primarily to test the uranium floats and control rods and then we, I think we continued to use that. Yeah, all the uranium metal continued to be tested in there. And we used the nuclear test gauge primarily for the enriched uranium aluminum fill tubes and the control rods and the uranium slugs then you'd be tested in the test pile.

MS: Okay. So you mentioned the NTG, the first one got established in like the early '60s.

DH: Yeah.

MS: And didn't they have another, like a newer NTG that…

DH: Well yeah. The original NTG sprung leaks. There was a galvanic corrosion set in and between the stainless steel and the aluminum. But the tank was an aluminum tank and so it started leaking and they replaced it and the modified the design a little bit and Norm Bauman was the engineer that worked on it and designed the new nuclear test gauge. But it was essentially the same, you know, just a little different test hole (inaudible) and maybe a little different pitch on the fuel slough valve.

MS: When did that happen?

DH: Dates are hard for me. I would say in the early '70s. There are a lot of reports on those, I don't know if they're still available.

MS: Yeah, I think that's probably where I saw those; the first mention of them was probably in the archives where they talk about it. And when we were doing that history a lot of that stuff we would run into and we wouldn't know exactly what it was. But then that's, we're going to figure out, or talk to people to find out what it did and things like that.

DH: Yeah.

MS: But what about I have heard, I may have gotten this from Mary Beth that you had some contribution with borated concrete.

DH: Yeah. Yeah.

MS: Was that used in the test pile?

DH: No. No. It was purely a nuclear safety item. The enriched uranium aluminum fuel tubes, if you submerged five of them in water, you could have a nuclear accident just by simply submerging them in water. Or if you had them stored in open racks and you turn a sprinkler on them they could go critical, it would be enough moderation on the sprinkler system. So that was a big concern because that's the first thing you would do is spray water on a fire.

MS: Right.

DH: And you can tell the fire department don't do it, but…

MS: Yeah. Right. Exactly.

DH: It goes against their basic training. So, what we did to assure that that couldn't happen and to provide a significant storage area, we made concrete slabs with a large amount of boron in them and in effect what we did is we said all right, the concrete is going to provide the moderation of neutrons. But we put enough boron in there so that there's no way it could go critical because the boron would absorb the neutrons. So we made these slabs, and they were 16 feet long and six feet wide and about eight inches tall and they had tubes running through them for the storage of the fuel elements. And we stacked those up to, I don't know, 12 to 16 high, something like that. So we had a very large storage area and they extended all the way across the south end of the 321M building. And around the corner too.

MS: This was primarily for the 321 building, right?

DH: Yeah. It was the 321 building.

MS: Okay. Was that later, was that borated concrete, was that used in other areas as well?

DH: After we built them in the 300 area, the 100 area used them in all the assembly areas. So, that was about the only place that they used neutron absorbers.

MS: Oh okay. When was this done, this borated concrete?

DH: You know, I've got a, let me go upstairs. I think I may have…

MS: Let me turn this off real quick.

DH: Yeah, yeah.

MS: Oh, okay.

DH: My resume'. I left reactor technology in 1955 and went to the experimental physics group. And I stayed there three years to 1958. In 1958 I went into technical support of the 305 test pile. And then they changed organizations.

MS: Yeah. As they often do.

DH: Yeah. So I was, we were originally a part of engineering and systems, and then they realized that test pile and nuclear test gauge were actually reactors, so we really belonged in reactor technology. So that…okay. All right. Let's look at what else I've got in here. Nothing in there. I kept a…

MS: Those look like reports.

DH: Beg your pardon?

MS: Look like reports.

DH: Yeah. Yeah. This one…there's the original test pile. I thought it might have some dates in here. Oh. I guess that's in an individual section. Okay. Yeah, I think that's the report on the test pile in 1956, I mean on the nuclear test gauge 1956, (inaudible). Now here's a quote on a borated concrete slab at the beginning of 1979 (inaudible).

MS: Oh, okay. Right.

DH: That's what they individually would look like.

MS: Uh-huh. Right. So you could actually just stack them.

DH: Yeah. Yeah. That's what they were. They were stacked three high.

MS: So then if the sprinkler system went off it wouldn't affect…

DH: No. No. No.

MS: The tubes or anything.

DH: No. Even if the concrete absorbed more water it wouldn't make any difference.

MS: Right. Uh-huh. Yeah.

DH: I thought there might be some more dates in here but I don't know.

MS: If you want to get it I can turn this back off and you can…

DH: Okay. Yeah.

MS: Well, as far as the other dates go I can always get it from somewhere else.

DH: Yeah. Yeah. I'm sure there are other…

MS: The major thing. But when did you leave work at Savannah?

DH: I left in '94.

MS: Okay, so that's after…

DH: After Westinghouse came.

MS: Right.

DH: I worked with Westinghouse for about four years.

MS: Okay. What were you doing for Westinghouse?

DH: Same thing. I was a nuclear safety (inaudible).

MS: Where were you in the 300 area?

DH: Well, we moved around. We started out in the 305 building. And then, let's see, we moved from there to 320 and I don't think I was in 321 at all. I spent most of my time in the 320M building. In the lab section. They had a lot of office space in there.

MS: Okay.

DH: And towards the end the new building seven, it was completely different, complete administrative building (inaudible).

MS: Oh, okay.

DH: Right next to it. I was close. It was close to 313.

MS: Okay. So in other words it's closer to the administration area, right?

DH: Yeah.

MS: Okay. All right. What were you doing when you were working with (inaudible)? What were you doing?

DH: What time?

MS: Let's say when you were working for Health Physics in general.

DH: No, I wasn't work for Health Physics.

MS: Oh, I'm sorry. But for nuclear safety.

DH: Nuclear safety. We were establishing the criticality limits for handling all the fuel and the enriched uranium and all the byproducts.

MS: So it was all working with the nuclear test pile and then the NTG.

DH: Okay. That was strictly nuclear safety.

MS: Okay.

DH: On the nuclear safety end we, any time we had a new piece of equipment come in we'd have to evaluate it for nuclear safety and run calculations to determine what the safety limits are for the equipment and any part of an operation. One of the most hazardous problems was the filings(?). We machined the uranium aluminum elements before we extruded them into two, and that created a lot of fine material. And it only took about maybe a kilogram of those filings(?) in water to cause a nuclear accident, so you had to be very careful with those. And the filters, if you dump one of the filters into a bucket of water, it would go critical, those big Hepa filters. So that was the primary thing on the nuclear safety end of it. When I was working on the 305 test pile, we had established new, we had to calibrate the test pile and the NTG whenever we had a new fuel element that was developed and produced. So we had to calibrate the pile and set up the calibration curves to determine the reading versus the uranium content on the lithium, the lithium six content. And we did do a complete recalibration of the test pile. It was a pretty extensive operation.

MS: What exactly did that entail when you had to recalibrate it?

DH: Well, we actually did some neutron profiles through the pile to determine where the best location to test each element. And we did things to measure the excess reactivity of the pile to see if it had changed over the years and to check the calibration of the control systems, the control rods, the vine(?) rod, and of course the control rod. Then we installed, no I guess that was the original one. So that was the program to recalibrate it.

MS: Uh-huh. And again, I know you don't want to hear this, but when was that roughly?

DH: That was probably in the early '60s. And of course then we had to recalibrate the nuclear test gauge when the new nuclear test gauge came in. And went through the same process for the NTG. You've got to be careful about what you tested in there, but if you put too much uranium in a vile and you test (inaudible) it can run away on you, so.

MS: Right. What was the, I know these were the critical test pile, I know this in a certain way, but in a way I don't. When I say critical test pile what exactly does that mean?

DH: That means the pile is not critical at the point where it's just at an equilibrium and if you increase the reactor and you pull the little control rod out the pile level starts to rise. If you put a little more in, more control rod in, it starts to drop.

MS: So it's right at the threshold.

DH: That's why you call it critical; it's at a critical position.

MS: It's like a threshold of taking off I guess.

DH: Yeah. Yeah. Yeah. That's how we make all the measurements. We put some target material in there like a control rod and you check the position of the reactor controls against what they were without any control, any test piece in there. And that's calibrated to determine how much the reactivity of that piece is.

MS: How big was that test pile?

DH: It was about 15 -foot cubed. And it had a monstrous shield. You know, in those days they really didn't have a lot of feel for how things are, and they over did a lot of things. And when they tore it down, they only tore down one wall because it was so massive and so concrete, reinforced concrete. They had a terrible time getting that one wall down. And the three other walls still stand today.

MS: Oh, okay. They decided to leave those then, right?

DH: Yeah.

MS: Oh, okay. Were there any differences at all between the test pile in 305 and what they had at like Hanford?

DH: They had a 305 test pile at Hanford.

MS: They did? Oh, okay.

DH: Yeah. And the one here is almost identical to it.

MS: Do they go by the same number? Was it 305 or?

DH: Yes it did. Yeah. And the only difference between the one at Hanford, the only significant difference and the one at Savannah River is the one at Savannah River had a helium atmosphere. It had an enclosed shell around it to keep it under a helium atmosphere because if you left it open to the air, then the amount of nitrogen in the air and in the pile would vary and nitrogen developed neutrons and it affects the critical state.

MS: Oh okay. Uh-huh. Right.

DH: So putting a helium atmosphere on it, then you didn't have to make a correction for the atmospheric pressure.

MS: So they didn't have that at Hanford?

DH: No.

MS: Okay, so that was just on ((inaudible)).

DH: Yeah. But it was expensive because we used a good fraction of the country's helium supply on that.

MS: Wow. Yeah, I'd heard that in the heyday of like AEC Construction in the mid '50s for example that a sizeable percentage of the concrete and steel and everything went to nuclear facilities.

DH: Yeah. Yeah.

MS: And it was like 10 or 15% or something.

DH: A lot of the rare elements were here too.

MS: Yeah. Right. Did you do any work with the special programs they had in the '60s with Glen Seaborg in particular, who is sponsoring?

DH: We did work on when they were producing the plutonium elements to (inaudible) higher isotopes.

MS: Right. Americium and (inaudible) and all that.

DH: Yeah. We, what we did is the 200 area fabricated the plutonium aluminum billets and then they were shipped to, I don't know if they, yeah, I think they encased them in aluminum, sealed in aluminum and then 300 area screwed it on to the fuel tubes. So I established the criticality goals for the 200 area process where they made the plutonium aluminum and the billet and also they handle them in the 300 area products.

MS: Oh, okay. Right. (Inaudible).

DH: We got in on that. It seems like there was another program that…we did irradiate thorium at one time. And of course we made the thorium out of elements in the 300 area, not thorium but metallic thorium slugs. We irradiate those.

MS: See, I've read that they did a lot of work, or they thought about doing a lot of work with thorium in the very early days.

DH: Yeah. Oh yeah.

MS: But they didn't do it later on.

DH: No. No. That pretty well died.

MS: What were they hoping to make with the thorium?

DH: There's a fissile isotope with thorium, maybe it's 233. I'm not sure. But I think that was the goal.

MS: Oh, okay so to make another fissile material they actually put it to reactors.

DH: Yeah.

MS: Yeah. What about, I guess if you were working in the 300 area you were there sort of at the beginning where they were doing the fuel and target tubes.

DH: Yeah.

MS: Versus the slugs.

DH: Yeah.

MS: How big a problem was that to have to switch over?

DH: Well, they had to build a new building. That was a whole new process.

MS: That was 321, right?

DH: Yeah. They built a new building and a new process, so. That came on fairly early.

MS: Uh-huh. Yeah, that was done like in the '50s wasn't it?

DH: Yeah, I think so.

MS: Now, the technology they used at Hanford, was that purely slugs and then they…

DH: Yeah. They didn't have any enriched uranium reactors. They may have made tritium by some other process, but they were, all the production reactors were natural uranium and graphite and then they made, produced the plutonium (inaudible). The early Hanford reactors were all plutonium. They made, they built several more band(?) reactors, but they were mostly for experimental purposes.

MS: In Hanford's day, I mean the early days during World War II for example, they didn't care about tritium.

DH: No. That came on several…

MS: That was only after the hydrogen bomb.

DH: Yeah. Yeah.

MS: I still find it hard to believe that you can just have, you can just add tritium gas to the whole equation of an atomic bomb and you can make it a hydrogen bomb and make it infinitely more powerful.

DH: That has a lot of energy. And they had to concentrate it. Well, they still do concentrate it very, very highly under unbelievable pressures so they get…

MS: Is that a part of the little reservoirs that they did in the tritium?

DH: Yes. Yeah, the pits. That's the containers that they put the tritium in.

MS: Now what's the name of it?

DH: Beg your pardon?

MS: What was the name of it?

DH: They call them pits.

MS: Oh okay. Yeah, I've heard that, one word that I've heard anyway is like those little reservoirs that they used later on. And actually, those were actually components that went directly to the weapon and that…

DH: Yeah.

MS: And like Bebbington said, that was the closest that Savannah River Site actually came to being what all the locals called it, the bomb plant.

DH: Right. Yeah. Yeah. Yeah. And that was really the highest security agent facility on the site, still is.

MS: Yeah. That's true actually. You still have to go through, you have to remember your PIN number all that kind of stuff and be Q-cleared to go into tritium.

DH: As a matter of fact, I was asked to do a nuclear safety evaluation of that building, and I did and I wrote up my report and I turned it in. A month later I said where's my report? So I called them up and they said you don't have clearance to get that report. Can you believe that?

MS: That just goes to show…

DH: Soon it was out at (inaudible).

MS: Yeah right. You had clearance to write it, but…Yeah, that's the way it goes.

DH: Bureaucracy.

MS: Yeah right. How did, in the work that you did what were the major changes that you saw at Savannah River Plant over the years? And you can take that any way you want to, whether it's just in the kind of work that was done or just in the nature of the work environment.

DH: Well, the work environment of course changed drastically when we first went, I mean I had a BS in physics, had taken two nuclear courses at Tufts. There weren't many given in the early '50s. And most of my training came from on the job training. I had a great mentor, Hugh Clark, Dr. Hugh Clark. And that's where I picked up the majority of my nuclear criticality safety knowledge from him.

MS: Was he here at the Savannah River Site?

DH: Yeah. Yeah. Yeah.

MS: Okay.

DH: He was a great guy. He developed computer codes early on, you know, when they had to punch cards and all that stuff.

MS: Oh okay. You had to put them in right.

DH: And I remember I did one problem and it took 3,000 punch cards to do the problem. So that was a, that was a big change going, getting more advanced and better computer codes. Oh yeah, after, you know, the triple seven [Building 777], the PDP test pile was built to determine nuclear characteristics of the reactor fuel lattice that was going into there and it was all done experimentally. I mean we'd go in and stack thin gold foils through the, drill a hole in a few of them and stack those in there and then irradiate it and then take them out and count them and plot the flux profiles through the fuel assemblies and then it wasn't many years after that, that became no longer necessary. They could calculate the critical configurations very accurately. Like I said, computer codes were so accurate and it took a very powerful computer to do that. And follow 30,000 neutrons through a lattice and follow each interaction each neutron has as it works its way through the lattice and finally absorbed. That's a lot of calculations. And in so doing I now can predict very accurately with the, what the characteristics of any new lattice is going to be. That's one of the big changes I saw. I started out when I was at Argonne Laboratories working with a guy; he was writing a report comparing the Hanford reactors and the Savannah River reactors. And all day long I sat punching (inaudible). So I remember those days. And also, I don't know if it was because of the fact, but everybody felt they were on the breaking edge of technology and all in those days. And I really enjoyed going to work. I really enjoyed going to work. I mean it was challenging and there wasn't, and the DOE wasn't there on top of you micromanaging everything. It was a great place to work. And then when all the anti-nuclear sentiment broke out in the country and then DOE felt they needed more supervision and more oversight, things got terrible and then they finally shut down the reactors. And the last three or four years I was there it was not very good because all we were doing is writing reports and there was no, I couldn't get my hands dirty anymore and I enjoyed that. In earlier years we could do almost any kind of experiment that you wanted to do as long as it was safe. That changed very drastically. And it was more of a family thing, even the Du Pont Company in general. I'd only been working about four years and I developed very severe stomach ulcers and I had to have my stomach pumped out and Du Pont carried me on the rolls, full pay for four months. I don't know if that would happen today, but.

MS: Yeah, that sounds pretty rare.

DH: So it was a very good atmosphere to work in. Everybody enjoyed it. And from the standpoint of nuclear safety, the same is true. In the early days they had to run experiments to determine what the reactivity of any assembly would be and how (inaudible) that reactor would be.

MS: Uh-huh. They can almost do the calculations and just forego the experiments.

DH: Yes. Absolutely. You always throw a little good margin of safety on that just because you don't know if those conditions are going to change at all.

MS: Yeah. I wonder nowadays if they were doing a project like this they probably wouldn't even need to have things like the CMX and TNX.

DH: Or the test pile or the NTG.

MS: Oh yeah, and right, all that stuff was like…

DH: Well, I guess you still need something to test the elements. You'd still need a, you'd still need to run nuclear tests on the material you produce to try to determine what the initial critical reactor is going to be. You can calculate pretty accurate.

MS: Did you ever have to go to CMX, TNX in that area?

DH: No, I never had much occasion to go down there.

MS: What about the laboratory?

DH: Oh yeah. Well, I worked, as I say, I worked very closely with Hugh Clark. And he was in the lab. And whenever I got stumped I'd always go over and talk to Hugh. Great guy.

MS: Is there anything else about the critical test pile at 305 that I have failed to ask that might be good to put on record?

DH: Well, the original nuclear test gauge had a radium beryllium neutron source. It had five grams of radium in it, which at that time was a good portion of the whole supply.

MS: Was that the test pile or the…

DH: No, the nuclear test gauge.

MS: Okay. Nuclear test gauge. Okay. All right. Yeah.

DH: And they replaced it with, what did they replace it with?

MS: Yeah, I think I remember hearing about that, but it's been a while since I did any reading on it.

DH: And you handle it on the end of a 20-foot long rod.

MS: And that was to replace the radium, right?

DH: Yeah.

MS: How many ports or openings did the original test pile have or do you remember?

DH: Oh, it said it had, let's see, there was two shot tubes where they had borated steel ball bearings that acted as a last safety surface. So they came out and took two of those and it had one vertical safety rod that we could drop in. And it had a horizontal safety rod that was spring loaded. And then it had a line control rod and a cross control rod. That was the control system. And then it had I think two major test ports horizontal on the, towards the center of the pile. And then it had, I'm not sure, maybe four to six quarts (inaudible) on the outer fringes of the pile because the test pile had such a low excess reactivity. If you took a reactor control rod and put it in the center and you couldn't bring it to power it would shut it down. So they had to test those on other fringes of the test pile. And they had these small holes on the outside of the fringes. I'm not sure exactly how many of them were there. But we generally only used one (inaudible) which one was best suited for the particular control rods we were running and all the control rods were essentially the same. We didn't ever test the cadmium rods because they were such strong neutron absorbers. So when you tested the lithium aluminum.

MS: Okay. Uh-huh. Right. Yeah. Well that's all I can think of to ask right now.

DH: Okay.

MS: And that's probably more of a function of my not knowing enough questions to ask. But if I think of something else to ask though if you don't mind I might give you a call back.

DH: Oh that's quite all right.

MS: And I can't think of any other questions that might be able to get some other aspect of in particular the test pile in 305. You don't know when that was built because that was done long before you got here.

DH: No. It went critical of course before the pile reactor did, so that was probably '51.

MS: Yeah, I think Bebbington made some mention of that in his book.

DH: That was the first critical facility.

MS: The first thing, the first critical facility at Savannah River Site, and he gave a date for it. And I think, I could be wrong on this, but I think it was December of '51.

DH: That's, that's pretty close to it I think.

MS: Okay. Yeah. So that meant that 305 had to be built really early on.

DH: Yeah.

MS: For it to hold that. What was the rough order of construction of buildings at Savannah River Site? I mean I know that, I mean clearly they got CMX was one of the first things they built down there, the river pump houses. 305 had to be one of the first sites that they built there.

DH: Yeah. And obviously they had to have 313 built to get the fuel for the reactor.

MS: Right. Yeah.

DH: So I'm sure there was a lot of that stuff going on.

MS: Generally the reactors went in first and then the separations area.

DH: Yeah. Well, first the fuel fabrication and the testing facilities and all that.

MS: Then the reactors, then the separations and within the separations I think F area basically was going first and then there was lots of overlap, but still you've got F area first then H area.

DH: Yeah. (Inaudible) heavy water facility…

MS: That happened fairly early, right. It looked like a lot of facilities on the river were done first.

DH: Yeah. And there was a lot of those that were going on concurrently.

MS: Right. Exactly. There was a lot of overlap there and only one (inaudible). And of course the administration building.

DH: Yeah. You've got to have that first.

MS: Yeah, that's true. Got to have that always, yeah.

DH: Well, as I say, when we came down here April of '52, there was no, still no office space for us. And we were, they set up our office in our reactor building in the contaminated tool room because they were…

SIDE TWO

MS: How about, there was another question I was going to ask. It'll come to me in a minute, I can't think of it right off the bat. But it had to do with the early days in particular. You didn't have any dealings with Ruth Patrick did you? She was the one that was doing that biological study.

DH: No. No.

MS: I know she was working along the river primarily back in the early days.

DH: Yeah. They didn't worry much about anything but the river in the early days. It was standard practice to dump all your waste into a filling basin, you know.

MS: Right. Uh-huh. Yeah.

DH: That was standard industrial practice in those days.

MS: Yeah. Uh-huh. Right. When did they stop doing that at Savannah River Site?

DH: Well, you know they continued that into the '80s. That was just standard industrial practice. And of course from a nuclear safety standpoint we've got to worry about that too because a lot of the waste went out there in the settling basin. So we would monitor what was going out and the accumulations that we were having.

MS: Right. What about, there was mention of Clarks Hill Dam, was like one of the first dams at the Savannah River upstream from Savannah River Plant.

DH: Do you know when that went in?

MS: It was almost…

DH: It was close to when we came down.

MS: Yeah, it was very close. And that was one of the things they had to worry about when they did CMX was what effect the dam was going to have on the river temperature and river water quality, that kind of thing.

DH: Yeah. When I was doing an overall safety evaluation of the 300 area, I had to consider if the dam failed and Clark Hill would have flooded the 300 area and caused a nuclear accident. But we were too high for that.

MS: Oh, okay. Right. I'm sure that F and H would be too high for that.

DH: Yeah.

MS: They are on the bluff. Well, that's all the questions I can think to ask.

DH: Well all right.

MS: One more thing. This may be not terribly significant, but what was a nickel gauge?

DH: A what?

MS: A nickel gauge?

DH: A nickel gauge.

MS: Supposedly it was, it measured nickel plate thickness.

DH: Yeah. Yeah. Yeah. It measured the thickness of nickel. What they did is they coated, is that nickel? No, it wasn't, it was an (inaudible) aluminum silicon when they coated the uranium (inaudible).

MS: Was that like a lock or something?

DH: It was a molten vat of aluminum nickel. And I think they talked about one of those, well all right. You're right. It was. Why did they call it nickel? Nickel plate, yeah. Here it is here.

MS: Oh, okay.

DH: It's nickel plate aluminum cores.

MS: Oh, okay.

DH: Okay. I guess they nickel plated them and then when they canned them they submerged everything in an aluminum silicon vat and inserted the uranium slug into the can after the slug had been nickel plated.

MS: Oh, okay. Okay.

DH: So that's what it was, yeah.

MS: Okay.

DH: Nickel gauge, yeah, there it is right there, nickel gauge.

MS: Oh, okay. That's right.

DH: Yeah.

MS: Yeah, I think it may have been that same report there that somebody was talking about a hall device, hall like somebody's name, h-a-l-l.

DH: Yeah. Yeah. Probably. This was a paper that had certain non-destructive testing, described several non-destructive testing equipment and this is how the nuclear test gauge got in there.

MS: Okay. I'm sorry. I had to write that stuff down. If I don't write it down I'll forget it later.

DH: All right.

MS: I can't think of anything else to ask at this point.

DH: Okay.

MS: If you don't mind I might give you a call back if there's some other material.

DH: Okay. Glad to help. So, when do you expect you're going to have something published?

MS: Let's see, I don't know. I can go ahead and turn this off.

END OF INTERVIEW

Oral History Interview – Dave Muhlbaier

David Muhlbaier was hired by Du Pont right out of college in 1961. He immediately went to work at Savannah River Plant, and was initially assigned to the 400 Area. Transferred to CMX in 1963, Muhlbaier worked at the pilot plant facility until 1972. During that time, he conducted hydraulic testing of reactor components, one of the main missions of the CMX facility after the reactor startups. Muhlbaier also did a considerable amount of safety work associated with the reactors. One of the most important achievements in this area was the carbon bed filtration system established at each of the reactors.

After 1972, Muhlbaier transferred to the heat transfer laboratory in Building 773, but he remained in contact with the operations at continued at CMX until the pilot plant facility was shut down in 1984. Muhlbaier retired in 1998, and currently lives in Aiken, South Carolina.

Interviewee: Dave Muhlbaier

Interviewer: Mark Swanson, New South Associates

Date of Interview: December 14, 2004

Mark Swanson: I apologize; I might pronounce your last name incorrectly [interviewer is Mark Swanson]. But this is an interview with Dave…

Dave Muhlbaier: Muhlbaier (pronounced "mull-bayer.")

MS: Muhlbaier. This is the 13th of December, 2004. If you would, just in your own words or however you want to describe it, you know, talk about your, when your first came to work at Savannah River Site, or how you first got associated with the plant.

DM: Well, I first became associated out of college when I interviewed Du Pont and had a business trip or an interview trip down here in 1961. And I liked Du Pont and I liked what I saw, so I decided to come here straight out of college.

MS: When was that?

DM: I arrived on site July 10th I believe it was 1961.

MS: Uh-huh. 1961?

DM: Yes.

MS: Okay. Uh-huh. What was happening at the CMX? Did you work at CMX initially?

DM: No, it was about two years later when I went to CMX. I worked at the 400 area first. They needed someone to take over a project there and I did that.

MS: And so you were in, in charge?

DM: No, I was not in charge.

MS: Oh, okay.

DM: Actually there was one supervisor there. The supervisor was in 773-A. The engineers worked there and we talked regularly. But we had a lot of authority and made our own decisions. I guess that was a really excellent place to work.

MS: Okay. What, when you started working there, what were they doing at CMX?

DM: It was hydraulic testing, and mainly hydraulic testing of reactor components. I went there since they had started a program to design and develop an air filtration system for their reactor buildings. And I went there to take over part of that program, which was to develop an in-place test for the carbon beds that were to be, that were stored in the reactor.

MS: Why were they, why were they using carbon beds in the reactor?

DM: Well, the filtration system consisted of, well; first of all, in an accident they would first of all have steam come out. They would have particulate matter, which would be radioactive, and they would have iodine, which would be a vapor and not particulate and would not be stopped by particulate filters. So in the filter compartments they had the misters that would take out the steam, particulate filters to take out the particles, and carbon beds to take out the vapors so it would take the iodine out of the air in the event of an accident. And they needed real high efficiency for those units and so we had to have an in place test to verify the…

MS: Well, unfortunately we had some mechanical problems. I think our tape was, the batteries were running low. So we're resuming the interview at this point. I'm just going to double check and make sure this is working. Okay. So we've got the, the tape recorder is now once again working, so hopefully we can resume the interview.

DM: Okay.

MS: The previous question that we were talking about that we only just barely got into unfortunately was talking about what you were making, I guess, when you were first working at the CMX or the project.

DM: The project, I was first on at CMX, where it's the in place test for the carbon beds. I guess you'd like me to go back over that.

MS: If you wouldn't mind, yeah. I apologize for the…

DM: Prior to about '61 there was no air filtration system on the reactor. There was one through-flow where it drew air into one end of the building and discharged down the stack, but there was no filtration. So in the event of an accident any radioactivity released from the reactor would go straight out the stack and be distributed to the environment. Well, they didn't want that and so there was a series of tests that went on that resulted in the development of filter compartments for the reactors, which consisted of the misters that would eliminate moisture or steam from the air or, you know, a moisture which could bow the particulates and then particulate filters to take out particles released from the reactor, and carbon beds, they would take out vapor and the vapor of concern was iodine, which would sublime at those temperatures and be in a form of a vapor rather than a particle. So it had to have carbon beds to capture that iodine. And there existed tests for the misters and the particulate filters. There were industry standards associated with those. But there was no test in existence for the carbon beds. And so we were looking for an in place test to evaluate the performance of the bed. They needed to be very high efficiency, greater than 99.9% efficient. And the theory was that we could use something like freon for a substitute for iodine and determine the efficiency of those beds because it was known that the carbon beds would capture the freon. It was a matter of running through all of, not all of them, but a lot of the freons that were available at that time. And there were a bunch of different freons available. And we got into some of them that were liquid at room temperature. And they were heavy enough or large enough molecule that they would attach to the carbon and stay there long enough to get a satisfactory reading from upstream and downstream of the carbon beds so that you could determine the efficiency of it. And when the test was over, the carbon would release that freon. So it would not take up any capacity of the freon, but would give you a good evaluation of whether there was any holes in that bed. And that was a concern that there may be holes, you know, settling of the carbon, there may create holes in that carbon bed and then if you've got holes in there of course it's not going to capture Freon or iodine. So that was the purpose of the in place test. And we developed that test and as I mentioned earlier, it became ASCME, ASTM standard for nuclear power plants with modifications as time went on.

MS: Now this was done in the 1960s?

DM: Yes.

MS: Uh-huh. So in 1960. And I know that we covered a lot of ground before we had the problem with the tape recorder, and I'll try to cover some of that again so we can get some of the answers down. I know that we're talking about most of the work that y'all did was with this flow testing, right?

DM: Yes.

MS: With testing new fuel and target assemblies?

DM: Yes.

MS: And if you wouldn't mind going back through the, the thing that you were diagramming over here.

DM: That was a, the result of trying to make some californium in the reactor.

MS: This was done in the late '60s?

DM: Late '60s. There was a program, and in order to do that you needed a very high flux in the reactor, which meant very high power assemblies, which meant they needed very high flow of coolant to keep them cool. In order to that, you had to have a small core in the reactor, but not the full complement of the assemblies, but just a core near the center. And when we did that, it resulted in the velocities of the coolant in the plenum being accelerated tremendously because instead of the water going in the outer tubes, it all channeled through the tube bank. And it was, it was set up so there were tubes like…these would all four be the same size here. Water comes in and flows around them, you know, like so. And when you're not taking the flow out, out of the outer edge of the core, it means as you move towards the center the velocity increases. And when that velocity increased it sets up some sort of fluidic type of device in the plenum. And the velocity may change, and I don't remember exactly what the numbers were, but maybe from five feet per second through here to 30, just, just like that. And when that happened, the velocity going past these slots, it shifted so, so much it changed the amount of flow that was going in there. So it changed the flow to the assembly, and this was recognized by reactor operations because they saw the flow signal change on the monitor panel. And it limited the amount of power they could operate at because of those flow oscillations. So we built replica of the plenum at CMX and duplicated the flow in the small core and that's where we, and put pitot tubes in the plenum arrangement, like in here, so that you could determine the velocity of each one of those things going past it. And then you could see the shift in flow, flow patterns in the reactor. And that was, there were pitot tubes put in here too and in the slots and you could see the change of flow into the slots. So it defined what the problem was. And the solution was a little bit more difficult to come up with. That's where we reduced, we changed the size of the slots, we did find eventually that there was recirculation around the [inaudible], the universal sleeve housing. And we eliminated those slots and that helped. And so we went from six to three slots in there and that helped, but it did not solve the problem. So then we tried different things, and I don't remember all that we tried, but we finally came up with a pattern of quarter-inch diameter holes as I recall throughout that, all the way around that universal sleeve housing so that the water came into the slots on the permanent sleeve of the reactor and went into each one of those holes rather than any recirculation occurring. And it resulted in a much more uniform flow to the assembly, even with this flow oscillation in the plenum, which we cold not do anything about. You know, that's a fixed situation in the plenum because what we did was minimized the effect by reducing the impact of this velocity on one slot by distributing the flow all the way around. Of course that was all determined experimentally.

MS: Uh-huh. Right.

DM: You know, you could have some ideas, but you had to go to the lab and prove it, experimental.

MS: Yeah. Right. How much, you know, you were given a lot of leeway apparently in what you did at CMX.

DM: Yes.

MS: If you had a problem like that, how much of it would be engineering work, paperwork, with, you know, and how much would just be experimentation with nuts and bolts? I'm not sure if I'm explaining the difference of it…

DM: Well…

MS: It's like how much of it can you solve through formulas and how much can only be solved by actually creating something, you know, physically?

DM: Well, you can get an idea about situations like that from formulas. You can calculate the velocities and the static pressure and calculate how much flow may go in that slot. But you can't know specifically how is going in that slot because there's so many variables that you can't possibly get a handle on, especially back then. Of course we didn't have any computer programs. We had a basic formula and we evaluated the data against that so that we would have some understanding. But other than the guidelines and guidance from the theory you had to go to the shop and build something and test it. Even today, you know, I ended up as manager of the thermal fluids lab in SRTC, a national lab now. Even then we had sophisticated programs. And the guys doing the computations, you know, that's especially now, and there is certain people who do those computations. But even then they wanted the data to see how something was working before they tweaked their programs to get the results that we measured in the lab. So back then, it was a lot of intuitive feelings about what was going on and then building something and testing it in the lab.

MS: Right. I'm going to try to, before I go on to any new questions we'll try to cover some of the questions I think we asked that maybe we missed when the tape messed up. But we were talking about CMX not standing for anything, not being an acronym, but apparently there was a…

DM: Well, I don't know. I had heard that with Corrosion Material Experimental, but I've also heard that it did not stand for anything. I don't know. You know, back then everything was secret and they didn't want to give away any information from acronyms or anything like that, so.

MS: Right. So even if it had been named for something nobody would have told you about it anyway.

DM: Yeah.

MS: And what about TNX?

DM: I don't know.

MS: And CMX wasn't known, it didn't have like a nickname or anything did it?

DM: No, I didn't, well, come to think about it they did get called the skunk works, but that's sort of a term that's given to a lot of different facilities.

MS: The skunk works?

DM: Skunk works, uh-huh. And it was called the Semi Works. That was common, Semi Works and CMX.

MS: Was it called the Semi Works at the, I know that was the name in the early years, was that also common in later years too or Semi Works?

DM: I had only heard it applied to CMX, TNX area because it was semi scale stuff.

MS: Right.

DM: Some small scale, some full scale, but just components of it.

MS: Uh-huh. Right. Okay. And I think we've talked about this at some point, but we may have missed it on the tape was why CMX and TNX were put together. Why were they located where they were?

DM: Well, CMX was there first to test the river water for fouling of heat exchange. And then it evolved into other facilities for testing reactor components. And I suspect that since it was a facility there for testing for the reactor the 200 area people needed something similar so they combined facilities there and share maintenance and E and I and the boiler there for power. It just made it simpler to establish another semi-works for the 200 area, you know, the same area that we had for the 100 area.

MS: But from this point, you know, CMX people and TNX people didn't really…

DM: No, no. The CMX were focused totally on the reactors and TNX were focused on the 200 area of the operations. They were more chemistry and chemical engineers. That was their focus.

MS: Uh-huh. Yeah. What about, how did CMX get river water?

DM: We had pumps down at the river. There was a little pumping station down there that had a couple, I don't know, two or three pumps in it that operated continually. Sometimes it would be covered with water and flood because they were so low. They're right down there next to the river.

MS: Right.

DM: And they just pumped water up the hill. They didn't have to pump too far, but there was quite a hill that they had to pump up to.

MS: What about, and we talked about the reactor that they had or the small version reactor they had at CMX.

DM: Yes.

MS: If you would just talk about that.

DM: It was called the cross flow tank. It was a 1/6th sector of the reactor tank. And the, it was scale of it for the tank. It was not scale for the plenum. And the pumps we had, I believe we had three pumps out there to provide the volume of water needed that one pump in the reactor was providing. And it was at low pressure. When we did that testing for California's program, we had to modify the reactor, I mean the plenum, we had to modify that plenum so that we had the same design characteristics as the real reactor before we could begin that program of evaluating what was going on in the reactor.

MS: Uh-huh.

DM: The plenum in the reactor I think was something like 8-¾ inches deep. And it was twice that or so in the CMX model. It was originally set up to look at moderator circulation patterns so that you had no hot spots in the moderator. And there was in fact designed a jet tube, which would sit within the lattice of the reactor, take up one position of the reactor tubes. And would take very high flow from the plenum and discharge the water along the length of that jet tube and in fact, it would discharge it upward, and it would help accelerate the water in the moderator and it would cause that up flow and it would help prevent any dead spaces. In fact, I believe that was developed, that was before my time. But it was developed in order to insure adequate circulation patterns in the reactor and prevent those dead spots where you could get overheating in moderator work.

MS: Uh-huh.

DM: So that was developed and CMX sort of tested there again.

MS: Uh-huh. Okay. Let's see…I'm trying to cover any of the questions that we might have already hit that maybe we didn't, let's see. We've already talked, we talked earlier about the actual buildings at CMX and TNX, and I've got a little diagram that you drew while you were talking. Rather than go into all the diagram stuff, if you would just talk about, just briefly the three buildings that were there.

DM: Okay. The first building consisted of offices and test facilities and a laboratory for CMX. I think there was a boiler in there too that our people operated. And that was about 2/3 of the building. The rest of it, that building was offices for TNX.

MS: Was the mock reactor in this building?

DM: No.

MS: Oh, okay.

DM: It was in the last building.

MS: Okay. So out of the…

DM: It sat over in here.

MS: Oh, okay. So that was in the building that was furthest, I'm going to say direction wise that would be southward maybe?

DM: Yeah, I guess that's right.

MS: Uh-huh. Okay. Uh-huh.

DM: And the pumps sat out here.

MS: Uh-huh.

DM: There were great big pumps that provided the flow to these areas [inaudible]. So the first building was CMX facilities and TNX offices. The second building was just TNX. We had no facilities in there. The third building, the furthest one south, was facilities mainly of TNX, but CMX did have facilities in the back of it. That's where the close flow tank resided and there was an item test facility back there too.

MS: Uh-huh.

DM: The facility where we actually did testing on the carbon to see how efficient it was for radioactive items. This was separate from the in place testing. We had to make sure we had carbon that was satisfactory for capturing iodine. So the only way to do that was with real radioactive iodine that we got from the lab and brought there and heated it up and vaporized it and ran it through a test carbon bed to see how well it captured.

MS: Okay. Yeah. What about, what about heavy water?

DM: We did not have any heavy water there. With all of our, you know, the reactor operated with heavy water, of course. And it made, because of the difference in density it made the pressure drops different. But we made that conversion theoretically, mathematically.

MS: Oh, okay, so that's why.

DM: So we didn't need any…

MS: You didn't need to add it there to…

DM: No, that was the simple conversion.

MS: Oh, okay. So you didn't mess with heavy water at all?

DM: No.

MS: Okay. When you have a new project to do, where did you get the, who would have told you what to do? Where would that have come from?

DM: That would come from my management. I worked for Al Peters when I first went over there. And he would call up and told me what he wanted if he could communicate it over the phone. A lot of times in the, you know, we knew that we were responsible for testing certain components. So the components people, the engineers there would say, well, we've got a new component and we need such and such tested and they would just send it on down.

MS: Uh-huh.

DM: And, you know, we didn't, we had to have mock-ups of the facilities because we had to draw into the tubes into the pressure taps in them and stuff like that.

MS: Uh-huh.

DM: And so the components people, the engineers would have built components that were all aluminum and not with any fuel in them. Now let's see, there was some exceptions. We used real assemblies for flow testing. A lot of the testing was just the mock-up aluminum assembly, so we can drill into it and put instrumentation in and things like that.

MS: Uh-huh.

DM: So those things would come directly from the engineers and the managers knew what was going on, but they didn't get in the way at all. I mean it was, really it was a smooth operation. I really enjoyed working there. It was an excellent place to work.

MS: And I know we covered this earlier, but you started working in 1961 there, right?

DM: '63 at CMX. I started at the plant in '61.

MS: Okay. Right. And then you worked at this area until when?

DM: About '72.

MS: Okay. Okay. And I think we covered this question earlier, but it may have been a part that was missed. How many people worked at CMX? And if you want to expand that and cover TNX as well, that's fine. Just the entire…

DM: The CMX, most of the time was there, we had two engineers. Occasionally another one would come in for various jobs. We had one foreman, four technicians, and that was the extent of the people that were connected directly with CMX. We had maintenance people, and I think we had like three. We had a maintenance shop. One machinist, one general maintenance [man], and one welder. And those guys also worked back and forth with CMX. And then there would be a power operator that came through there once in a while to check on everything. TNX, they had a much bigger contingent of people that we did.

MS: Uh-huh.

DM: They, I don't know, they had to have a dozen engineers, more technicians.

MS: Uh-huh.

DM: And more maintenance people.

MS: Why was that? Was that…

DM: I think they had, well it, I was going to say a wider array of problems than we did. But I'm not sure of that. We were generally dealing with fluid mechanics.

MS: When did, was there ever a period where you thought that y'all pretty much had all the problems that you were confronting, all of them solved or? I know we had talked earlier about, you know, CMX shut down about 1984, and then the operation, what was left of it, moved to the 700 area.

DM: Yes.

MS: Was that, anything you want to say about that would be very good.

DM: Well, the operational reactor, it was a routine operational reactors was everything was pretty routinely cut and dry by the early '70s. When those reactors were built, you know, they were designed from theory and a little bit of experience. And they were designed very conservatively and started off with, I forget what it was, maybe 300 megawatts power and they went almost to 3,000. So there was tremendous change in the performance of those reactors and so that all that theory and experimental work had to be carried along with that power increase. In fact, that's what allowed the power increase. But we got to the limit I guess in the early '70s or so. So there wasn't a whole lot more other than if they change the design of the assembly. And they were pretty well fixed. They did change the design based on what you wanted to make and at [inaudible] points they knew they wanted to make Californium and Curium and some of these other isotopes. So they had changed some of the things they did. But again, it was pretty well stable I would say by the mid '70s. But starting at that time, the early '70s, there was consideration of accident conditions, more consideration of accident conditions. And once you threw that into the mix, then that opened up a floodgate of stuff that you could look at. And that was being looked at primarily at the 700 area in the thermal fluids lab. That's what that, they called it heat transfer lab then. And that's what it was built for, to look at some of the accident conditions. That's where I went from CMX.

MS: To the thermal fluid lab, right?

DM: Yeah. No, TNX, it was called heat transfer lab at the time.

MS: Okay.

DM: Thermal fluids lab now.

MS: Okay. And that sort of work was carried out there at the heat transfer lab. And so by then you didn't really need CMX as it had originally been set up.

DM: Well, you needed it in case you changed any of the components. But there was a facility built at the heat transfer lab that would allow you to do that testing. So, but I don't think it was ever used it in fact. It was built…

MS: Built to be used as at the…

DM: To be used…

MS: At the heat transfer lab, right?

DM: At the heat transfer lab. But I don't think it was ever used.

MS: Hmm…oh, okay. Now if CMX was shut down in 1984, according to Bebbington, what about TNX? Or do you know?

DM: TNX wasn't shut down until a few years ago. I don't know the, I think it was since I was retired. The writing was on the wall when I retired in '98. But they moved from 200 area problems directly into a semi works for the glass plant. And so they had a tremendous amount of work there.

MS: At TNX.

DM: At TNX in support of the glass plant.

MS: Oh, okay.

DM: So they, you know, they had a big block of work come in.

MS: Is that ongoing or?

DM: I don't know the current status of it. I just know in the mentality there now I would guess there's not much experimental work, work going on in the relationship to any of that.

MS: Uh-huh, uh-huh. Yeah.

DM: They've got some problem associated with the high level waste, which last I heard they had not really dealt with. But and the glass plant, I think the biggest problem they have is with the melter and that they have to think of what to do to solve that problem. You know, they put a new one in there and put a new nozzle in there.

MS: Uh-huh.

DM: It was their big problem.

MS: Uh-huh. Yeah. What about, you know, we talked about this a little bit. I'll bring it up again. What was, just in a general way, what was in the CMX building? I know we talked about the three different buildings, but the, as far as the…

DM: CMX had a long-term flow test facility where you would put reactor assemblies in there, run them for a couple of months, pull them out, look for wear on the sleeves. You know, they had ribs on each of the fuel tubes, which would bear against the other pure element. And sometimes you could get vibration and wear through the cladding, then get into the fuel. Of course we didn't want that, so they had to be designed in such a way that you didn't have that problem. So any new assembly had to be tested that way and, you know, they'd pull it out, look at it, put it back together, and then flow test it some more. So some of the flow tests would go on probably about six, nine months, something like that. As much times as these elements would be in the reactor.

MS: Yeah.

DM: We had a facility for measuring the pressure drop in the various channels and components of the reactor assembly as was looking at the pressure drop across the orifices, across each fuel channel, across the end fitting, minimum pressure in the end fitting, all that type of stuff. That was, that was one facility that all it had was one element in it, but it had a bunch of access holes so you could get to the assembly and you could make changes to the assembly, hook up instrumentation and that type thing. And we had a facility for the monitor, monitoring of the performance of the bottom-fitting insert. As I mentioned earlier, I guess we lost that. It was a, the fuel tubes were monitored for quadrant temperatures because you could get a flux tilt in the reactor and one quadrant of the facility could be operating at a higher power than in another quadrant. So we needed quadrant monitoring of the fuel tubes to recognize when that occurred. So the bottom-fitting insert had to be designed so such that it did give you accurate readings of what the temperatures were in each quadrant. So we had a facility there that was a mock-up of the fuel element with a bunch of thermocouples in it. And I mean a bunch of them. It like had, I think it was like three and in each sub-channel, 12 in each channel, and sometimes four channels, maybe more than that. And so that you could control the flow into each channel and each sub-channel and control the temperature and measure the temperature in each channel and sub-channel and see how well the end fitting would mix that, but keep it separate from the other quadrants and deliver a temperature to the thermocouple monitor and the thermocouple that was indicative to what was going on in the channel and the sub-channels. And that was extensive testing. The same type of thing went on for the target assemblies, which were slugs, big assemblies. And there you worried about swelling of the slugs if you had a problem, and then reducing the flow through a channel or sub-channel. So there we had to have angular monitoring. Each channel was monitored so that the temperature from coming out of each channel was mixed and then sent to a given thermocouple so that you could determine how the channels were performing. It would identify problems with swelling of any of the fuel tubes and reduce the flow

MS: Right. Right. What about, I know we talked about this earlier, but I think this part got erased or this was, of course this occurred before you started work in '63. But we're talking about the very early days of CMX and how they discovered that Savannah River water was okay for the reactors directly without having to go through a treatment.

DM: There was, there was some other facilities there.

MS: Oh, I'm sorry.

DM: There was a laboratory there with a hood in it where we did small-scale testing. That's where…

MS: Where was that?

DM: It was…

MS: In the main building?

DM: Right in here.

MS: Okay. Uh-huh.

DM: There's where we initially ran the freon testing and with small-scale filters, three-inch type filters. There was the cross flow tank in the bank, which we talked about. It was only 1/6th scale model. And there was another facility…

MS: What did you call that?

DM: Cross flow tank.

MS: Cross flow talk. Okay.

DM: And there was another facility over in here, which is, which was a hooded area where we used the radioactive iodine for testing the carbon. And we had pumps in this area, which we sometimes; in fact we set up a little test out there one time. We had a problem with a vibrator stabilizer. It beat a hole in the housing of the ush(?), and nobody could understand how that happened. And what would show up as the flow would be reduced on the fuel assemblies or target assemblies. And so we ran a test on that and saw that that stabilizer, which is a heavy weight to sit on top of a slug, when it wasn't placed properly it was close enough to the pressure plate and the orifice above it that it reduced the pressure and when we lift that thing up it would sit there and dance, vibrate, and beat a hole in the housing. But that was done in there too.

MS: And that just, for the record, these are areas that are behind the main CMX building,

DM: Yeah, they were outside.

MS: They were outside, outside the building.

DM: Okay, now your other question about…

MS: Yes, I just want to get that for the record because you made some mention of the silica content of the river.

DM: Yeah.

MS: I had heard that before, so if you could…

DM: The original purpose of CMX, to my understanding, was to evaluate fouling of, possible fouling of the heat exchangers by Savannah River water. And the original design called for water treatment plants in each of the 100 areas to treat the 186,000 gallons a minute of water coming from the river, well, I guess at that time it wasn't that much flow. But it was a large amount of water that would have to be treated

	is you were going to treat it passing through the heat exchangers in the 100 areas. So they wanted to know how much treatment they needed, if any. And so they set up a test and CMX found out that there was enough silica in the water that it would clean up the tubes from bio-fouling such that they didn't need any river water treatment whatsoever. And that resulted in the largest cost savings that they'd ever had, that Du Pont ever had. I don't know about Westinghouse. But it was a tremendous cost savings because it eliminated the need for the river water treatment at each of the 100 areas.
MS:	How did they determine that? Did they just let it run through the tubes long enough to see if it would work or?
DM:	I was not there at the time, but that's the way I would set it up is…
MS:	Just do it [inaudible].
DM:	Just do it.
MS:	Yeah.
DM:	You know, I would put different flows, flow velocities and things like that and look at it different times a year because of the biological fouling that may occur with different river water temperatures and the times of the year and stuff like that.
MS:	What about, this is something I heard about and I'm not, I'm not sure of the details. But wasn't there a problem with clam infestation or something?
DM:	Yeah. We did most of that testing in the 700 area at the heat transfer lab.
MS:	When was that clam problem?
DM:	Early '70s I believe it was. Yeah, there was an infestation of clams that grew in the heat exchanger, that grew in the basin, and I guess they reduced the flow. And there was concern about them wearing holes in the tubes. I actually did a test on that in the 700 area looking at the wear of a claim against the stainless steel tube. There may have been…

SIDE TWO

DM:	…he'd [Al Peters] come down and maybe once a week I'd have him sit and talk. And we'd talk about the projects. And he would just bring things off the top of his head. And he had millions of ideas. And he could give me ten times more work than I could possibly do. So, when he told me to do something I didn't do it unless I thought it was important. So I made my own decisions that way, as long as it was consistent with what he was doing.
MS:	Yeah.
DM:	But if he told me three times to do it, then I would go ahead and do it just because I knew it was on his mind.
MS:	Uh-huh. Right.
DM:	And it was important to him.
MS:	Uh-huh.
DM:	But he would throw off a bunch of stuff off the top of his head, and then you'd never hear it again.
MS:	Uh-huh. Right. Uh-huh.

DM: So, you know, you had to call what he said to do because you just couldn't do everything that he…but I enjoyed working for Al. Al was a real sharp guy.

MS: Uh-huh. Yeah.

DM: He had lots of good ideas and it was fun working for him.

MS: Yeah. Well, that's on, we may have talked about this earlier before we had that problem with the tape and all that, but where did you get your orders from directly? We already, we did…

DM: Well, we talked a little bit about that. I don't know whether it was on the tape or not.

MS: Yeah, I can't remember either. It won't hurt to re-do it just in case.

DM: Well, a lot of it came from, directly from my managers. Like the first program I worked on over there, that was like a five-year program.

MS: Uh-huh.

DM: That was a long, maybe it wasn't quite five years, but four, to develop that test and to demonstrate it and get it standardized and published.

MS: Was that the test that you were…

DM: That was an in-place test for carbon beds.

MS: Okay. Right.

DM: Freon tests for carbon beds.

MS: Okay.

DM: That was the initial project, and Al was my manager for that. And so, you know, that evolved. It wasn't a new assignment per se. It just kept evolving.

MS: Right. Right.

DM: So, you know, like I say, he might be down once a week and we'd talk about it at length and see where we were going the subsequent week and see what progress we'd made in the past week and that type of thing.

MS: Uh-huh.

DM: So while I was on that project, that just sort of evolved and it depended on what you found out and on what direction you went in. You couldn't really predict exactly where you were going to go because you had to have the results from some of tests to determine where you were going to go next.

MS: Uh-huh. Right.

DM: And, you know, a lot of that could be handled by phone. So there wasn't an awful lot of direction associated with that per se, any big assignments. Subsequently when I got in, more into the hydraulic testing, you know, they would say well, here comes the Mark 32, check out this end fitting. And there you knew what they wanted. They wanted the highest efficiency you could possibly get for that end fitting. And, you know, the first ones we measured, they were very poor. And I think they were in the reactor by that time, but at low power because, you know, you knew the efficiency was low. And we redesigned those end fittings. That's something we actually did at CMX. And tried different things and finally got something that worked well. And then send that design back to the designers, they put it on drawings and get it manufactured and it goes in the reactor.

MS: Um, uh-huh.

DM: Again, well, a lot of that stuff just evolved. You know, the engineer couldn't make these decisions. He could make them as well as anybody, better than most people because of the evolution of the problem. The managers, you know, just wanted to make sure that you're working on it, actively working on the project, that you're making progress, and then write reports regularly. So, it was an excellent place to work. I really enjoyed it.

MS: Where did the reports that you wrote on that, did they all just go to the laboratory?

DM: A lot of them were monthly reports and they just went to the laboratory. But on this freon test, they were published externally because that was interest throughout the whole DOE complex. And in fact I went to New York and did a workshop on that for other DOE people and other contract people throughout the country.

MS: Yeah. What about, did CMX have any direct dealings with, you know, the reactor works and the 777-10A buildings? Or was that just two different things?

DM: Not directly. I don't know of any direct involved. But that, they did the, they were nuclear testing.

MS: Yeah, they were more interested in that sort of thing rather than [hydraulic] flow.

DM: Right. And I don't know whether they got the assembly the same time we did or not, because it was a sub-critical reactor and they could have gone ahead and looked at the nuclear performance of an assembly independent of the hydraulic because, you know, there was no power to speak of there.

MS: Uh-huh. Right.

DM: And they didn't really care too much about that. In fact I'm not even sure they had flow in that facility.

MS: I don't think they did. I mean from what I've seen of the building, it's been a number of years since I've been in there, but I don't think they…

DM: Yeah, I don't think they did.

MS: I don't think they had, I don't remember seeing any piping for that and it was just sort of like there.

DM: Yeah. They may have had moderators.

MS: Uh-huh.

DM: But it was a sub-critical and they were just looking at the multiplication ratios I think with different lattices.

MS: Uh-huh.

DM: Whether they could take it from there with the calculations up to the reactor to look at the performance. And then of course when we put them in the reactor we gradually increased power and we could tell from the thermocouples the temperature [inaudible] what was happening as far as power was concerned. We knew the flow and the temperature difference. We could calculate the power. And as long as everything is consistent with what you predict, you know, you're all right. You can go to full power where you expect to be.

MS: Yeah. Uh-huh. Right.

DM: If you reach inconsistencies, that's why there was a number of technical people in the 100 area to watch that stuff. And any time you put in a new charge there were people out there looking to see what was going on.

MS: Uh-huh. Right. Yeah. Okay. What was a typical day like at CMX? Or was there such a thing?

DM: Well…

MS: Say for example, how many shifts did they have? I mean, and who worked them and that sort of thing?

DM: TNX had people who worked around the clock.

MS: Uh-huh.

DM: That's one of the reasons it [TNX] had more people. We [CMX] did not work around the clock. We had long-term flow tests that ran around the clock. But they were monitored by power people because they were in the area anyhow.

MS: Uh-huh.

DM: Our people…

MS: When you say our people…

DM: The technicians and the foremen, the engineers, when I say our people I mean those are the people directly associated with the work at CMX.

MS: Okay. Uh-huh. right.

DM: They did not work around the clock. You know, and there were times when something happened that you had to work extra, but.

MS: Uh-huh.

DM: But generally we just worked day-work.

MS: Uh-huh.

DM: So the tests ran around the clock, but they were monitored by power.

MS: Uh-huh. Right. Now you said they were monitored by power…

DM: Power people came in to check the boiler and they would check to make sure the pump was running for the long-term flow test.

MS: So they're sort of like a cross-trained electrician or the maintenance man or something.

DM: Well, they were operators. And they looked at equipment that operated routinely and may take a reading on it to make sure and record the reading that everything is where you expect it to be. If it's not, then you call somebody.

MS: Yeah. Uh-huh.

DM: So, they were not in the area at all times. Of course in the long-term flow test had limit switches and stuff associated with it so if something went wrong it would shut down. And the operator may come in and find out everything is shut down.

MS: Uh-huh.

DM: Or they may find the temperature is too high or something like that, in which case they call a foreman and then we would do something about it. Sometimes, you know, it's just a matter of wait until we come in the next day.

MS: Yeah.

DM: If it wasn't that important.

MS: Uh-huh. Right. What, what actually went into CMX, as far as like, I realize it was a test facility, there's no heavy water involved but we just have, like the materials coming in would have just been like items to be tested and you've got the water flow?

DM: Yeah. And you, what are you asking about? What kind of unique supplies we may have had?

MS: Yeah, something like, along those lines.

DM: Well, virtually routinely, it's like you said, you know, we had the water there from the river and…

MS: And you mentioned the pumps at the river. And I hope that wasn't the part that we, that we lost, but it might have been. You said there were like, were there…

DM: There were two or three pumps down there, I don't remember which, that pumped the water up to the area. So we had continuous supply of water. It went through a little treatment plant there, I believe. And then it was pumped wherever it needed to be in the area. A lot of the tests were recirculation, so we didn't have a lot of demand for water flow. And it was heat exchangers in there to take out heat.

MS: Right.

DM: Of course the components, the reactor components were shipped in from 700 area. We did use a lot of mercury. We had mercury manometers. And a lot of that got spilled in the early days.

MS: Uh-huh.

DM: You know, I don't know whether you're familiar with manometers, but they are a device for measuring pressures, and they are highly accurate, highly reliable method of measuring pressures and pressure differences. So we used a lot of them. And…

MS: I should know this, but I don't, but how do you spell manometers?

DM: M-a-n-o-m-e-t-e-r I believe it is.

MS: Okay.

DM: So we used a lot of mercury because you'd get a system upset or you open a valve too fast and the pressure would skyrocket and it would blow the mercury out of the manometer and, you know, into a ditch there and we'd try to recover what we could, but didn't worry a whole lot about it that time, you know. We had carbon for the testing of the, different quantities of carbon. We had some of the, some specialty chemicals and we had a variety of freons, some of them liquid, some of them gas. We had hexane, some of the solvents that we'd dissolve freon in to get calibration of…we had gas chromatographs for that freon test because they would measure into the parts per billion level, real sensitive, meaning that you could use a small amount of freon to test those carbon beds and you would saturate the beds. So we had the hexane I believe it was to dilute the Freon and calibrate the gas chromatographs. I don't…well, we had dryers. We had an electro-sieve I believe it was for drying air as part of looking at the performance of those carbon beds with various degrees of moisture and how that affected the speed with which the freon would come off the carbon, so it affected the test. I don't recall any other special materials, but I'm sure there were some. But…

MS: What about, did you have a problem with vandalism from the river? I remember I've been by some of the pump houses where they actually had constructed like some kind of like a concrete barrier right beside the transformer so that people that would be on the river couldn't shoot them out.

DM: I think I did hear about that on the powerhouses. But we never had any problem that I'm aware of. One of the biggest ones I guess, one of the few problems I remember associated with those pumps was a snake got sucked up into the impeller and chipped off the pump.

MS: Uh-huh.

DM: A guy went down there to, the maintenance people went down there to find out what the problem was and one guy was down there just fiddling around with it trying to get it, something, there was something caught in it and he was reaching in there and trying to get it out. And he was just playing around, he just wasn't very aggressive. So this other guy, and he was an aggressive son of a gun, he jumped down there, let me in there, you know. I want to see what's going on. He reached up in there and grabbed that snake and pulled it out. Ah…he was scared to death of snakes. But it was dead, you know. It was a big moccasin.

MS: Right. Uh-huh. How big are these pumps you're talking about?

DM: Oh, they're not real big. They were submersible.

MS: Uh-huh.

DM: I don't know, 400 or 500 gallons a minute, something like that would be probably as big as they were. You know a couple of them there might, you might pump 800 gallons a minute, 1,000 gallons a minute. I doubt we pumped more than that. They were relatively small.

MS: Yeah. What about, did y'all have air conditioning?

DM: Yes. When I got there. We still had the fans in the office.

MS: Oh, okay.

DM: Because…

MS: So the offices were not air-conditioned?

DM: No, they were not air conditioned initially. They had big windows and fans that hung up on the wall in the office in the corner that blow down on you.

MS: Uh-huh. Yeah.

DM: But when I got there, they had air conditioning.

MS: All, all over the place or just in the, in the main, not in the…?

DM: Well, in the offices they had air conditioning. I think all the offices had air conditioning.

MS: So in other words, by the time you got there the whole thing was air-conditioned.

DM: Not the labs.

MS: Not the labs, okay.

DM: None of that area. Now none of this test area was air-conditioned.

MS: Okay. But the offices were.

DM: Just, just the offices in that, in that area.

MS: Right. Okay. So, that's pretty much all the questions that I have to ask, but I'm sure there's lots of other stuff that I don't know enough to even know to ask. So if there's anything that you want to add…

DM: Oh no, I sat down and jotted some stuff down.

MS: Uh-huh.

DM: Let me see if there's anything here that…that we didn't cover. We looked at the septifoil design. We didn't mention that. That was…

MS: Okay.

DM: That was an assembly that contained the control rods. And the control rods moved up and down and were in various positions at any given time. So you have to have a little bit of coolant flow going through there to cool those control rods. And that was a very special design. There was one in every hex.

MS: Yeah, [inaudible].

DM: Around the center. Somewhere in the middle. Yeah. And it was an unusual design. It sat on an up-flow pen. It was fed from the bottom. Everything else was fed from the top. But the top of the septifoil was open up to allow the control motor that's way up in the high hat to move those control rods up and down [inaudible]. We had different monitoring pens, which affected the design in that bottom fitting insert that we had talked about. And some of the mantra pens KC type had a flow, high flow to them, so it was easier to get monitoring to some of those. That P type didn't have much flow through it, so it was more difficult to get monitoring there. The, they built thermocouple assemblies to put in the reactor when they were building a new element for the reactor. And these were assemblies that had fuel in them. And but they also had an array of thermocouples in them, so you could find out what was happening in each channel and sub-channel in the reactor, especially designed assemblies. We would flow test those. We didn't really measure any temperatures or anything like that in there. We would flow test and make sure they were, we knew the characteristics of them. We ended up changing the design of that bottom fitting insert, putting in double pressure plates and it resulted in a, like a three or four percent increase in reactor power. That was done in the early '80s and this was the time when there was a push on production. I think this was about the time that Reagan put the push on Russia. And so this was just one of the game plans, I think, to increase our production and have our [inaudible].

MS: What was it that, what were you putting in there?

DM: The end fittings had an orifice plate in them. And at, at the jet created by the orifice plate, and there was multiple holes in those orifice plates. But at the, in the contracting of the jet was the minimum pressure. And that's where you would limit the reactor power based on that minimum pressure. Well, we put in double pressure plates, and consequently dropped the pressure in stages, which resulted in a higher minimum pressure, which meant that you could get higher power out of those assemblies, which meant you could get more production. Production was just about directly related to power.

MS: Yeah.

DM: We did some dynamics testing. Most of it was, when I say dynamic I mean transient. Most of the stuff we did was [inaudible], but we did some small scale testing of the vacuum breakers and this was in looking at accident conditions in a, and it postulated the accident. There could be a sudden increase in the pressure in the tank; the reactor tank and it would blow the vacuum pressure. And so it was, that was the time period when we were trying to get the safety rods in to shut it down, so it was critical in knowing how, what the performance of the vacuum pressure was that's maintaining the pressure while the safety rods were going in. So we did that transient testing of the vacuum breaker.

MS: I know we talked about that earlier, and I'm not sure if we got that on the tape or not where you were talking about most of the reactor problems were worked out by the early 1970s.

DM: Yes.

MS: And as a result of that, and when that was done then there was a greater interest in working out, you know, possible safety problems.

DM: Yes. Right.

MS: And…

DM: There was always concern about safety problems, but…

MS: It was almost like, you know, by, by, as the main thing got taken care of that if they had more time to divert to it.

DM: Well, the filtration system, the air filtration system on the reactors was, the need for that was conceived early on. I don't know when the work was started on that, the late '50s. It was, and they were installed about '60 or '61, the filtration system. But they needed in-place tests, and that was developed while I was there. Let's see, where was I going? What were we talking about?

MS: Oh, about the safety possibilities?

DM: Oh, the safety aspect, yes.

MS: And a lot of the stuff may have been done as they went to the heat transfer lab.

DM: Yes. The heat transfer lab, there wasn't a heat transfer lab in 773 from early on. But it had, it was small and just a little bit of capability.

MS: Uh-huh.

DM: And around 1970 they built the heat transfer lab. I guess it was finished in '71 or so. And it had three megawatts of DC power in it, which we could use for direct heating of fuel elements to look at what would happen in the event of an accident. And for example, one in which the control rods drove out and the power just increased exponentially. What would happen if you had a pump shaft break and the flow suddenly reduced in one sector of the reactor? Or what would happen if you had a line break? You know, those types of things were looked at, I mean they were thought about a long time ago, but as the power increased they became more and more important. And so that was around 1970 when they had started looking at that in much more detail.

MS: Uh-huh. Right.

DM: It was, like I say, it was always thought about, but it wasn't critical when the reactor had lower power.

MS: Uh-huh. Right.

DM: It was a gradual transition there from, you know, understanding the hardware and how it performed and understanding what would happen in the event of an accident.

MS: Uh-huh. Right. Yeah. What after, after CMX was shut down in 1984, what happened to the facilities?

DM: I think they just sat there, they just took the people out and they just sat there. I don't know that…

MS: TNX didn't take it over or anything or?

DM: It surely wouldn't have wanted the facilities. They may have taken the offices over. I'm not aware of that. They probably did take the offices over.

MS: Uh-huh.

DM: But the test facility, that would not have been of any value to what they were doing unless they removed the equipment. And I'm not aware of what happened after.

MS: Okay.

DM: One test that I did forget to mention was we were getting into this consideration of accidents and this was in the late '60s. We did what was called a starved pump test.

MS: [Inaudible]

DM: Starved pump test. And that was what would happen if you had a line break and you pumped all but moderator out on to the floor of the reactor and the light water injection system would come on at that point and inject water inside to keep the reactor cool. What they wanted to know was how would these pumps perform under those conditions. So we did a number of tests at CMX to look at these, some small-scale pumps and how they performed when they were starved, suction condition.

MS: Uh-huh.

DM: And when I say starved what it means is the suction line is open to the atmosphere. You've got water flowing into it, but you can suck air in too.

MS: Uh-huh. Right.

DM: And so we characterized pump performance under those conditions at CMX, and then went to the reactors and actually did testing, which we lowered the moderator so far that it was flowing by gravity into the pumps so air was going into the pumps as well as the, the water.

MS: Uh-huh.

DM: And that was a major reactor test. It was a big deal. When we ran that it sounded like rocks going through the piping system and it was pumping the air and water and it was flowing through there, the pipes moving around. It was incredible. But, you know, it all hung together well and it showed that you would get significant cooling, not just from the light water going in, but from the recirculation of those pumps continuing to operate.

MS: Oh, okay. Uh-huh. Right.

DM: So it reduced the impact of a, an accident significantly.

MS: Uh-huh. Very good.

DM: I guess that's about all that I had thought of and made notes on.

MS: Okay. Great. Well, that, I can't think of anything else right off the bat. But if you don't mind I might give you a holler if I run into some other information from some of the other interviewees.

DM: Sure.

MS: You know, we can always add to this tape. I won't pull the tab off until the end. I'll be in Aiken anyway, so it's like easier to find. So I'll go ahead and shut this off now if you want.

DM: Sure.

END OF INTERVIEW

Oral History Interview – Art Osborne

Born in Cleveland, Ohio, in 1939, Art Osborne moved to Sparta, North Carolina, when he was in high school. After four years in the Navy (1958-1962), he attended N.C. State for one year, and then transferred to Appalachian State, where he graduated with a degree in Chemistry in 1965.

That same year, he was employed by Du Pont, and worked at Du Pont's Martinsville, Virginia plant, in addition to other places. Osborne did not begin work at Savannah River Plant until 1977, where he made a career of working with nuclear waste management.

Osborne's first job at Savannah River was a two-year stint in the Waste Tank area. By 1980, he was transferred over to TNX, where he worked with the waste management problems associated with melters used in the waste glassification process. This work was some of the earliest done for what would later become the Defense Waste Processing Facility (DWPF). By 1984, Osborne was working at the Savannah River Laboratory, and was still concentrated on the issues associated with waste management. Retired in 2002, he currently lives in Aiken, South Carolina.

Interviewee: Art Osborne
Interviewer: Mark Swanson
Date of Interview: December 20, 2004

Art Osborne:	…to tell you when it starts working?
Mark Swanson :	No, that's not going to tell you. But we'll assume it's starting now. This is the 20th of December, 2004. And we're talking with Art Osborne [interviewer is Mark Swanson].
AO:	Correct.
MS:	If you would just give us a little bio information.
AO:	Bio in terms of education or this that and the other thing.
MS:	Whatever you want to, sure.
AO:	Okay. Well, born in Cleveland, Ohio in 1939, transplanted to North Carolina with the family when I was a junior in high school. It was a small mountain town named Sparta, North Carolina, close to the Blue Ridge Parkway and the Virginia border. After high school enlisted in the navy and spent four years in the navy. Got out of the navy in August of '62. Attended NC State for a year. Initially majoring in nuclear engineering. Then transferred to Appalachian State and ended up graduating in 1965 with a degree in chemistry. Employed by Du Pont in August of 1965, worked at the Martinsville, Virginia plant in the laboratory and various manufacturing and personnel assignments and then transferred to the Savannah River Site October 1st, 1977. And initially at Savannah River I formed and established a construction checking organization and began operations to kind of oversee the quality of the construction of the new type 3 waste tanks at the site. Worked in that organization until about oh late '79 or early 1980 when they asked me to transfer to TNX to kind of awaken TNX. TNX had in the early years of the plant been very active in receiving equipment to the site and testing equipment for the reactors and then later through the separations process. At the time I went to TNX there had been very little activity over the last 10 or 15 years. In fact, people used to like to comment that TNX was kind of asleep at the time. So I went down and kind of woke TNX up, organized it, and built the organization to support the research on the what was called the 1941 melter where they were developing the processes that would be used in the glassification of high level waste. And of course that facility is operating today at the site. Then after TNX, stayed down there two, two and a half years, went to the Savannah River Laboratory and worked in various management positions there. Then formed a works engineering organization for waste management back within the site and from the works engineering organization went into the quality business shortly after Westinghouse took the contract. And just worked in quality and then later in planning and sort of a financial management position when I retired. And retired April 1st of 2002.
MS:	Okay. All right. Well that's…
Art:	So that's me.
MS:	That's a better memory than I've got…
AO:	Yeah, that's me.
MS:	For dates than I've got. You were talking about TNX was kind of asleep I guess when you went down there.

AO: That's the way I would characterize it.

MS: Right.

AO: There couldn't have been more than oh, maybe 20 to 25 employees, a very small operating group, a small works engineering contingent. And I believe that the process control laboratory had one person assigned in TNX. But there was a lot of activity that was really getting underway on the site where they needed the facilities at TNX. A couple of them that come back to mind is the waste management organization was in the middle of using these big Bingham (inaudible) slurry pumps to slurry out the waste in the tanks so that it could then be handled and transferred.

MS: Right. Uh-huh.

AO: So they had a test facility at TNX and these pumps are rather huge. We're not talking about your typical little house water pump. But these things must have been, oh I don't know, 40 or 50 feet tall and two or three feet in diameter, really very huge pieces of equipment. So they had a test facility there for those. And at the time, the processes that would later be used in the defense waste processing facility, the DWPF, where the high level waste was glassified, were not yet set. And there was still the debate as to whether the best way to feed the waste to this melter would be through calcining it and drying it into a powder and then mixing it in with the borosilicate glass in the melter, or whether you needed some kind of a slurry feed to the melter. And in fact, it wasn't even sure what's the best way or the best process to use. So in addition to the feed technology competing one with another, there was the question of is the best way to melt this waste because now remember the whole idea is they take borosilicate glass, which is basically like a glass bead and they put some additives with it and then they pump the slurry waste into the melter so that what you get is you just get a solid piece of glass when you're finished or when it cools and settles. So, the question was are you better off to melt the solution before you pour it into the canister, which is its final container. And I'm sure you probably know that the canister I'm speaking of here is solid stainless steel, two feet in diameter and about 10 feet tall. And it is in and of itself quite an object. So the question was do you melt this and then pour it into these stainless steel receptacles? Or do you put the stainless steel receptacle in the device that can heat the whole unit to a temperature that would melt and form the glass? So, and the vernacular for that process was called the in can melter versus the what came to be the process that was used, the 1941 melter. So at that time in '80 and '81, they were just finishing up a project to test the first DWPF melter.

MS: I'm sorry, what was the date for that?

AO: Pardon me?

MS: What was the date for that when this was going on?

AO: Oh, this would have been, and I'm speaking from memory now. But I'm sure there are records you can check. Probably in 1980, maybe the summer of '80 or perhaps '81 when the things got started up. And they had built a facility to accommodate this. And this was like a three or four story facility with the melter on the first floor; excuse me, and then all of the accompanying cooling water and systems that needed to be there to support the melter itself. And then on the upper levels they had what they called the calciners because remember I said there were competing processes, either a dry powder feed or a slurry kind of feed to it. So they had built this facility. And basically we had to have the staff up and then quality check the facility to be sure it was safe and built to spec and able to be started. And then get the people into the organization to man that facility and to operate it on a 24/7 basis. So that was a big part of the time that I spent there. Then in addition to that, because the DWPF was such a major project, we had a lot of visitors that would come. And these included all the political leaders and civic leaders in the area and people like that, as well as Du Pont management and executives who were down almost on a constant basis. In fact, we had a, I had a speech that I made up to welcome tour groups. And I forget how many times I went through that talk. But it was like a five-minute welcome to TNX. We're delighted, you know, and then on and on and on about how the place started and how TNX was, in case you want to know what that stands for, don't ask because nobody really knows what it stands for. But according to the story at the time they started this some people thought that well if we called it TNX, if the Russians hear about it they'll think we're working on trinitroxylene, some new kind of explosive like TNT, except we're going to call it TNX. So it was a lot of fun.

MS: Yeah, I can imagine so. You're talking about explosives.

AO: But…not only did you have to build the equipment to test the processes, but as you got more people in and as you had more of what I used to call the high paid help that wanted to come and see what was going on, there was a great deal of ancillary support work that had to be done, all the way from building a new storage building at the rear of the area, to putting in new office trailers, to planting and landscaping to make the place look professional and acceptable. So, it was a very, very busy time. And had some of the greatest people in the organization that you could ever know. I mean I remember, you probably have heard this name, if you haven't you will. A great fellow named Augustus Parkes, P-a-r-k-e-s, Gus Parkes. And Gus was really kind of a character. But he had been at TNX since day one, since they cut the road down to the river and built the landing dock where the barges could come up and offload the equipment. Gus had been there, seen everything. And you've heard that old expression, "been there, done that," well, Gus had literally been there and done that from day one. And so he was quite a character. And then another fine person that did a lot of fine work down there, the guy named Tom Drummond, D-r-u-m-m-m-o-n-d. And Tom, like Gus, had spent most of his years at TNX. So when I went down to TNX, Gus and Tom basically ran TNX. Excuse me. I don't know why all this coughing. Talking too much I guess.

MS: Yeah, that'll do it to you. Are either of them still alive?

AO: Uh-uh.

MS: They're not. Okay.

AO: No, they both since have passed on.

MS: Uh-huh. Okay. Out of curiosity…

AO: Well, I say that. Now I am not, I'm 100% sure on Gus Parkes. Tom Drummond, he or his, perhaps his widow might still, because I'm 65, Tom is probably, oh I don't know, 10 years older than I am. But I know that I have not heard nor seen him in, oh golly, five years or more.

MS: All right.

AO: But if, he used to live in a little place called Fox Chase right here in Aiken. I do not see his name in the phone book.

MS: Okay.

AO: My belief would be that Tom has passed on.

MS: Okay. I can check that from other sources. Going back to DWPF.

AO: Yeah.

MS: And the whole idea of the melted glass thing.

AO: Uh-huh.

MS: Where did they come up with that whole idea anyway as a means of stabilizing?

AO: That came, I don't know. You would have to talk to someone who was on the technical end of it.

MS: They determined that that was…

AO: I can give you the names of the people, some names who were instrumental in developing that process. There's a Du Pont employee named Sam Mirshak, M-i-r-s-h-a-k. And then there was a, and he was one of the top members of the management team. And another top management team member, Dr. Jim Kelly. And I imagine if you had to say when Du Pont thinks about the DWPF process, the name that comes to mind would be Jim Kelly because he without a doubt was the big impetus behind it because not only did have a brilliant technical mind, but he also had the, oh, just had the personality of a top flight salesman and motivator and here's why we need to do it this way and you just can't reach any, he was sort of like a used car salesman. He was very, very good. And very good at communicating. Jim Kelly probably would be the, and he's left and I have no idea where he is because he left the employ of Du Pont. And nor do I know where Sam Mirshak is. But depending on how important it is to track down more of the technical faces, I know that Sam Mirshak has a son who's a lawyer in Augusta, so I'm sure that you could find out if Sam is still around or available for that.

MS: Oh okay. Great. I was just wondering if that, but by the time you got involved with that that process had already been established. I mean the idea…

AO: Pretty much. There still were some questions…

MS: As to how to best to do it, but it was going…

AO: In some of the chemical processes that the material had to undergo before it was suitable to be fed to the melter, they were answering questions like well, if I perform this process in this tank, how many times do I have to flush the tank to be sure I get it all out? You know, they were answering questions like that, more the technology.

MS: Right.

AO: Of how the process has to operate, rather than the fundamental basic chemical processes.

MS: Uh-huh. Right. But like I say, there was the debate about whether you feed the material, is it a slurry or is it calcite powder. And it didn't take us long to find out that you did not want to do it as a powder because people told me that this calcite, basically it was the same process or a similar process to the way they made freeze dried coffee. And that was fine, except the way we were operating the process is you spend all your time beating on the side of the wall of the calciter to get the powder to come off of it and go down into the mix. So I mean it was just such a, so much potential for people having to get near this. And of course you know that when you're talking these processes the whole idea is to kind of…

MS: To keep people away, yeah.

AO: To make a hands-off process. So the calcining idea died a pretty quick death once we got that unit started up. And they decided then they would have the slurry feed it.

MS: Right.

AO: Then they were also working on processes down there of, which I'm sure you've heard the description that the high level waste at the site kind of comes in three forms. It comes; it's a high-level sludge, kind of the consistency of warm peanut butter. Or it can come in a salt, kind of a pure looking white salt cake, or just as a liquid. And the process that we've been talking about is intended for the highest stuff, that black looking sludge where most of the curries are. The salt had some, and then of course the liquid is pretty well managed through a well-established evaporation process. So just to maintain and minimize the volume that you're dealing with. So it's parallel with the work that was going on to handle the really hot sludge were various processes for what you do with the other, the salt cakes and the liquid. And is it better after you've done all the evaporation, should you use an ion exchange process? And if so, which of an infinite number of resins should you use in the ion exchange column to achieve what you want to do? And then what do you with the resin when it's absorbed all it can, because then it becomes radioactive and how do you deal with that? And there was a lot going on. And I guess at the peak we probably had close to 200 people, maybe even almost 300 if you counted all the technical people assigned at TNX.

MS: Okay. So during this period that would have been the main thing that was going on at TNX.

AO: Absolutely. Well, the work in waste management for the slurry pumps, but by far the lion's share of the work was prototyping and refining the processes for the DWPF. And then there, like I say, there were a few ancillary little things that they were messing with where maybe one or two technicians or technical people would occupy a little corner of this building or a little cover of that building and set up their pilot experiments. I'm trying to recall some of the smaller things that were going on. A lot of the smaller things that were going on concern the early stages of an ever-increasing consciousness of what do we need to do to clean this place up? And how are we going to do that? And what is the best way to approach it? And I remember right before I left TNX, getting a lot of satisfaction out of over, oh I guess a year period, working with the State Department of Health and Environmental Control and succeeding in filling and closing one of the early seepage basins that we used at TNX. So but that was just in the beginning stages of what has now become kind of the main business at SRS.

MS: Which is pretty much…

AO: A major part of it.

MS: Right.

AO: We were in the early stages of that.

MS: When you first went to TNX, what was there building wise?

AO: Well…

MS: And if you want to you can just draw a little sketch map if you want to.

AO: Yeah. I'd be happy to. Basically what was there was…

MS: And you can, it doesn't have to be just the TNX building, it can be the whole complex if you want to.

AO: I know. Yeah.

MS: It's all, they didn't do work together, they were logistically together.

AO: All right. Here's the river, the Savannah River. And this would be the last crossroads before you get to TNX because down here is the landing dock. And let me remember now. Okay. 677. 678. These are all building numbers. 679.

MS: These were 677-G wasn't it?

AO: Yeah. Right. And over here were trailers. And back here was the train. When I first went down there, and probably I'm going to say the gate would be about here. And then this is the road that went down the hill to the river. When I first got there you came through this last crossroads and then you went into TNX. Let's say the gate was about here. And of course at that time I don't think there was even a gate. There were three main buildings, 677, 678, and 679. Okay. 677 was originally built for reactor testing, okay. That was, that is what they called CMX, okay, which we're turning to that guy you interviewed who was a hand for that. They brought it here. And then the boat dock was here. And actually this dock, it looks like it's a long way, but it's not a long way from TNX. And what they would do is they would barge the components up the Savannah River, they would offload them at the dock, and then from there they could transport them across the site, or if need be, they would drop components right like at 677 to test them before. They could see it. And I'm talking before I was, you know, this is back in the '50s.

MS: Right.

AO: That I'm talking now. And then once they had the reactors underway, then the next process of course was the chemical separation. Because you know after you have irradiated the rods, well how do you dissolve them and get out of there the materials that you want to get out of there? And that was what was called the separation process. And each of these buildings here were oh, I'm bad on sizes. But they were fairly big places, but not huge. Most of them had three or four levels like I know, I think the old CMX building, it actually went up six or seven levels in a narrow little portion of it to handle the testing for different kinds of rod assemblies and that. And the old separation building was oh, two, maybe three or four stories in places. But the thing they all had in common is they were just, oh, basically metal, metal sided buildings built with a lot of bridge work on the inside. And a lot of services and piping and electricity so that you basically could go down there and a chemical engineer could build any miniature chemical process almost that he could imagine. And they were equipped with several tanks that could be used for various things and different piping arrangements and that kind of thing. And then 679 was basically a laboratory building and also a building where a lot of the tritium research was done because I remember when they got into cleaning up 679, you know, there were a lot of issues with not only plutonium but the tritium. But they always tried to keep TNX, I don't know what the right way to say this is, fairly non-radioactive. In other words, they did not want TNX to become a controlled radiation zone. Although there were areas in TNX because of the history of what had gone on there, that some of them were mildly radioactive and you had to take protective measures for that. But the whole idea was to not, we used to say, crap the place up, if you will.

MS: Right.

AO: Now, when I got there, the first thing they did is they built; this is where the building was built for the 1941 melter, okay.

MS: Why was it called 1941 melter? Why 1941?

AO: That just happened to be the project number. It had nothing to do with time or…that was just the Du Pont project number.

MS: Oh, okay.

AO: Let's see. Okay, so they built that building. And then I had them build a storage shed at the rear of the area. And then they built another building right here, and that building was built for canister testing. Because the way they sealed these canisters, if you can imagine a two-foot diameter, 10-foot tall cylinder, and I don't know how thick the stainless steel is, but it's pretty thick. It comes up and does a number like this, that would be a side view. And then if you took that and looked at the top of it you'd have something that looked about like that, only these two are not at the same level. This is depressed a little bit and would be the outer edge. And that's, right down in that hole is where all the bad stuff went. So the question is once you fill that puppy up, how do you seal it? It's not like a screw-on top.

MS: Right.

AO: So what they did is they devised a plug, and I'm sure this is not an accurate representation. But from a side view looked something like that. And you'd just take that plug and set it down on that shoulder right there. And then you would put tremendous pressure on that plug and then you would pass some incredible amount of current through that. And I'm not even going to hazard a guess as to how much current that was because you'd have to talk to someone at the site that's familiar with it to get the right numbers. But they're extremely impressive because what that did is it essentially made this plug part of the stainless steel. And because what they would do, they would do this test and then they would basically cut that off and then cross section that. And you couldn't tell. You could not identify where the top ever was. It all looked like one solid piece of stainless steel.

MS: And that was done through current then right?

AO: Current. Yeah. And like I say, it's some incredible amount of electric. I mean what they had was built…

MS: Was that done there at?

AO: That was done in this building right here.

MS: In canister testing.

AO: Or in canister testing. And God, you should have seen the breakers and the electrical stuff that was in that building. I mean it blew my mind. And so that building was built. And then they got around, this is after I left, they completed a new administrative building right here. And there might have been a couple of more buildings back in here. They were built so long after I left that I don't know what they were for. But so basically, well, we added this building, added this building, this building, started work on this building, and added a bunch of trailers over here for the technical people. And then they had what they call here a mock-up tank facility. You remember I said they were testing those Bingham (inaudible) slurry pumps.

MS: Right. Uh-huh. Yeah.

AO: Okay. And this is where they did that in waste management right there. So it was in 1982, 3, and 4, I left, I'm not even sure when I left. It was either '81 or '82. But when I left, that was a hopping, very, very busy place and probably had 300 or 400 people.

MS: Wow.

AO: But as soon as they built the DWPF in the '90s, then basically the use for that facility just started disappearing. And there were, oh I guess the last 15 years of its existence, there were a lot of clean up experiments going on, a few things like that. But really nothing major. Nothing that would support the overhead of maintaining this facility, which is why DOE eventually came to the conclusion they just needed to shut it down.

MS: Right. Yeah.

AO: So but it was a lot of fun. It was one of the neatest jobs I ever had with Du Pont.

MS: Wow.

AO: And met some of the finest people during that process. You know, I mentioned Gus Parkes, Tom Drummond, a guy named Bill Carpenter, who headed up the engineering arm of my organization. He was just really good, you know, the engineering people because basically, I'm not going to say we had a blank check. But within certain budget constraints, which we all had to adhere to, it was pretty flexible as to what could be done in order to hurry up and get all of these things done. And if you were talking about administrating spaces, storage spaces, maintenance spaces, well, we had the old expression it was kind of an arm waving operation, you know, within the bounds of safety and integrity of the unit or the item you were constructing. You pretty much could just say well, if I wanted a sidewalk from here to there, you know, I didn't have to get six blueprints, I just got my construction counterpart and said hey Mark, we've got some people coming down here, we've got to have a sidewalk here. How about making it go from here to there and then swing it out here and go over there. And two days later there would be a sidewalk. But that was all necessary to support the growth and support the way it had changed. And from that respect, it was fun. It was (inaudible).

MS: So that was a, most of these buildings that you were talking about, the 1941 melter building, the storage shelter, the canister testing, that all, those began, that was added while you were there.

AO: That was added while I was there. Correct. Yeah, in fact we had a big opening ceremony for the 1941 building, you know, had guests come down and had the construction guy officially give me the key, kind of the key to the building to start the test. So it was a pretty exciting time.

MS: And DWPF wasn't built until the '90s?

AO: I'm bad on time. I don't know when, when did DWPF start up?

MS: I might be wrong, I'm just…

AO: No, now wait a minute. It was built, construction, I'm guessing, my guess would be the construction started in like '85, '84 or '85.

MS: Yeah, for some reason I'm thinking it started in the '80s.

AO: Yeah, in the mid '80s. And I think it was about 1990 when it cranked up. Because gosh, it was like a six-year period for the construction and the testing.

MS: Right. Uh-huh.

AO: But it seems to me like DWPF went hot around 1990 or '91. But again, if you're going to write that down somewhere, I'd certainly verify that date because I know there are all kinds of records that will show you that.

MS: Oh yeah. Uh-huh. I sort of remember thinking that the DWPF groundbreaking ceremony was some time in the '80s or something.

AO: That sounds about right, because I know it was before Du Pont left.

MS: Yeah, I know it was before Du Pont left.

AO: Okay, and Du Pont left in '89.

MS: Yeah, I…

AO: '88, '89.

MS: I think that's right.

AO: It was shortly after that terrible shuttle disaster that they made the announcement. You know, one of the early shuttle crashes.

MS: Oh, was that the one that happened in January of '86?

AO: Yeah, it blew up. And it was shortly after that…

MS: The Challenger.

AO: My guess maybe that summer that they announced that they would be turning it over to contract.

MS: That seems right, and they lasted for a few more…

AO: And they hung on for a year, a year and a half. And then at that time Westinghouse took over.

MS: Right.

AO: But yeah, I think that's very close. Construction started mid '80s and it went hot early '90s.

MS: Uh-huh. Right. What about, let me just go back to the notebook. Yeah, you've pretty much answered all the questions that I had to think of to ask. How much contact did you have with the Savannah River laboratory and the…

AO: Quite a bit.

MS: …doing of all that.

AO: As the manager of TNX, I reported through the Savannah River Laboratory. That was my management. The name Sam Mirshak and Jim Kelly, which I gave you.

MS: Right.

AO: I think I worked directly for Jim Kelly. And then, well, the place eventually before I left, they brought down another manager and had me report to him because the place had gotten so big that, you know, as the saying goes, it got above my pay grade. And they brought a very nice, effective manager in named Bill Taylor. And his daughter still works at the site. And we were all very saddened because he died in a tragic automobile accident on the way to see a Clemson football game. He got broad sided and he died and I think one of his children also died. But now his daughter still works out at the site.

MS: Wow.

AO: So Bill Taylor is and was an important name. What other names come to mind? Dan McIntosh. He was a Du Pont scientist and into this quite a bit. He since has passed on. Well of course, you mentioned Al Peters to me; Dixie Hendricks was a very key player in it. And Dixie lives right here in Woodside. And he's, well, he was a Du Pont assistant plant manager. And a very, very effective executive. And now retired, he still does work for Du Pont on a contract basis for their safety program, so.

MS: Right. Wow. That's great. What about accidents? I've heard somewhere along the line that TNX had kind of a bad accident. This may have been before you got there.

AO: I don't know. Let me use the restroom. If you need to there's one down at the end of the hall.

MS: I'll just turn this off and I'll…turn the tape recorder back on. Oh yeah, this is nice.

AO: Yeah. Okay. Let's put a little lighting on the subject here. Get rid of some of that glare. Are you seeing as much glare as I am?

MS: It must be more of a problem for you.

AO: Oh, okay. All right. That was an administrative trailer.

MS: What's the date for this picture?

AO: That would have been, oh, I'm going to guess 1980.

MS: Okay.

AO: Because when I left, that, we took a lot of that down. But what this is, that's an old settling basin because when they first built TNX they pumped water up from the river, directly from the river and settled it and then basically we had our own water purifying plant.

MS: Oh, okay. Okay.

AO: And that's how they got water. Well, when I got down, shortly after I got down there we got a couple of wells out of the picture over here and shut all that down. But this would be building 679, or 677 rather. So my office was…

MS: So that would have been the…

AO: CMX…

MS: CMX building.

AO: Stuff I was talking about right in here.

MS: Uh-huh.

AO: That would have been building 678, separations.

MS: The TNX building.

AO: Right. And back there would be 679. And I think you can just see the roof of the storage building.

MS: Oh, okay.

AO: The back of the area. Right in here is the melter building, hidden a little bit by 677 here. That's ((inaudible)). I think that's the top, that actually is a different building. That's the top of the 1941 building ((inaudible)) and this is where they did the canister testing in here. This is kind of the road that went around the area, kind of went all the way around, came back on the other side of this building. That's the new administrative office building that they built, finished after I left. And talk about a lot of names, okay, you've heard a lot of the names. They gave this to me when I left the area in '81. This was kind of a going away present.

MS: Right.

SIDE TWO

AO: A lot of folks down here.

MS: Yeah, uh-huh, right.

AO: Houston Brown, he was a technical manager.

MS: Yeah, there's Tom Drummond.

AO: Yeah, Tom Drummond. Dan McIntosh, just all sorts of folks. Tom Willis, Dave Vader, Jim Wilson, the works engineering guy. A bunch of people. But that's…

MS: Now I've heard of this guy too.

AO: Warren ((inaudible)), oh, very nice person. Very nice. Well spoken person. Came up through the ranks, earned his way into positions of responsibility and management. He was in my organization. Very effective person. Same with Larry Hill.

MS: Oh, okay.

AO: Biggest Georgia football fan in the country is Larry Hill. I mean talk about a Georgia bulldog, I mean he is one.

MS: This is great.

AO: Lots of people there. Now who has this neat handwriting? Chris Landau? I'm trying to make out that name there.

MS: Yeah, it looks like Landau, but I can't tell.

AO: I can't either. Whoever did this has got a distinctive handwriting. So there were lots of people. But you were talking about accidents.

MS: Yeah, the…

AO: I don't remember any, you know, that I…I know on my watch down there we never had a serious, we had maybe a minor injury or two. And I'm talking about a cut finger or something. But nothing serious.

MS: Now this was, I don't think they had an accident where anybody got harmed, but I think they had an accident where they, I think this was pretty early. And something they did…

AO: They claimed they had a few explosions down there.

MS: They have a few explosions, and there was one where they blew out the side of the building.

AO: In the early on days.

MS: But it was because, yeah, they were doing some of the early work on separations and there was something that occurred that they didn't really anticipate chemically.

AO: Right. Chemically.

MS: And it just sort of went of and kind of popped.

AO: Right. And I'm telling you about Gus Parkes. He was amusing to hear him talk about those things because we had this thing that Gus never would tell you anything until you kind of had the goods on him. And then he'd have a sudden burst of memory. And then bless his heart; we had more fun with him. I'd ask Gus; I'd say Gus, what happened out here? And this would be like when we'd be looking to clear the land to put a building on it. I'd say now Gus, because they're aiming to start digging out there tomorrow, now is there anything that ever went on out there that you remember? No. No. Nothing. So here they'd go out there and they'd start scratching around and damn, they'd turn something up. And they'd check it and yeah it had a little residual activity. I'd go back and say Gus; they found that out there. Now what, are you sure? And he'd say oh yeah, well I remember. But I don't have any first hand information at all on that.

MS: Yeah. Well, that's great. To be honest, I think we've hit all the points I can think of to ask.

AO: Well, good.

MS: At this point.

AO: Well, you've got my number.

MS: Yeah, if you don't mind I'll give you a call back if I come up with any other questions. I think we're just trying to interview as many people from different time periods at TNX and CMX.

AO: Right.

MS: I think we've done most of the CMX stuff already. Those are just the list that we got from…

AO: Well, if you run out of names, I've got that many on that picture.

MS: That's true. That's true. There are lots of names on that picture.

AO: Yeah, so I've got a lot of names.

MS: Yeah, so that would work out pretty good.

AO: Have you interviewed Dixie (inaudible)?

MS: No.

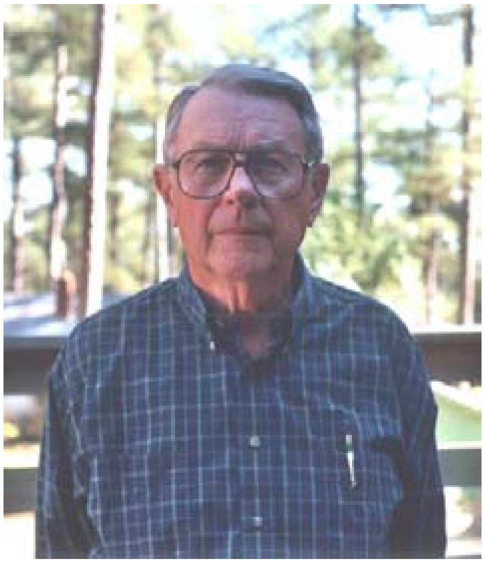
AO: (Inaudible).

MS: No, I'll put that down.

AO: Yeah, you need other kind of, yeah I think you wrote down you need to talk to Dixie because he, if you're talking about TNX, see; he was a member of what I referred to as the high paid help. And he would have a lot of interesting stories, more from the political standpoint with senators, with representatives and the top management of the place. Yeah. Here it is right here.

MS: Okay. Let me. I'll go ahead and turn this tape off…

END OF INTERVIEW



Oral History Interview – Al Peters

Al H. Peters, Jr., was born on May 9, 1929 in Summerville, South Carolina. After earning a B.S. in Chemical Engineering at Clemson College in 1950, he served in the Air Force during the Korean War. In 1953, Mr. Peters began a 36-year stint with Du Pont. The majority of his career was spent working at the Savannah River Plant.

Peters began his work at Savannah River at the CMX pilot plant, working within the Savannah River Laboratory. He was transferred to the plants' Reactor Technology Department in 1969 as a plant supervisor and continued to play a strong role in plant management. By 1977, he was appointed assistant plant manager. After a two-year stint at another Du Pont plant, he returned to Savannah River Plant to serve as manager of the Savannah River Laboratory, a post he held until 1981. During the 1980s, he served as manager of Plant Facilities and Services. He stayed on at Savannah River for one year after Du Pont left, to help with the transition to Westinghouse, and retired in 1990. He currently lives in Aiken, South Carolina.

Interviewee: Al Peters

Interviewer: Mark Swanson, New South Associates

Date of Interview: December 13, 2004

Mark Swanson: This is an interview with Mr. Al Peters and the date is December 13, 2004 [interviewer is Mark Swanson]. We're going to be talking about … well anything you want to talk about basically, but we kind of want to put the focus on the CMX/TNX area.

Al Peters: Right, right.

MS: So if you would, just state your name and when you were born and any bio information you want to give.

AP: My full name is Albert H. Peters, Jr. I'm 75-years-old, born May 9, 1929 in Summerville, South Carolina. BS Chemical Engineer in Clemson in 1950 and worked approximately thirty-six (36) years with the Du Pont Company after getting out of the Air Force and the Korean War and all but one (1) year of that service was at the Savannah River Laboratory in the Savannah River Plant and one (1) year after Du Pont left I managed the transition activities of Westinghouse and that's about it.

MS: Okay, great. Our particular project is to work on CMX and what was done there from the early days and how that might have changed over time until it closed down.

AP: Okay.

MS: Uh, when was the first time that you worked at CMX?

AP: I started my career with Du Pont at CMX, I think, January 23, 1953. So I was in the very early stages of CMX but it had been operating since 1951 and was the first operating site at the plant at that time.

MS: Uh-huh, okay. Which came first, CMX or TNX?

AP: CMX. CMX was the very first either research or plant facility that was operating on that plant. That doesn't count the construction forces and the construction buildings, which started in 1950 I guess.

MS: Uh-huh. Okay, why did they put TNX and CMX together?

AP: Well, they were experimental facilities to support the … CMX to support the nuclear reactor complexes; TNX was built to support experimentally the chemical separations facilities and the primary reason for putting CMX there was it was on a bluff, overlooking a swamp area next to the Savannah River, and the primary purpose of that facility initially was to test the fouling characteristics of the Savannah River water, which was used for cooling the heat generated and nuclear reactors. So, we set up an experimental, fairly large, it really was what Du Pont called the semi-works. It wasn't a small scale, it was a very large scale semi-works and the initial tests were on prototype heat exchanges, which we measured the fouling characteristics of the Savannah River water. The concern was that the water had a lot of silt in it at that time because initially, this was before the construction of the Strom Thurmond Dam and Lake, which was earlier called Clark's Hill. At any rate, that water was very silty and the concern was is that would foul the heat exchanges and limit the thermal capacity of the reactors. As it turned up, the silt actually kept the heat exchanger tubes clean so this facility had … CMX had a very large water clarification plant to remove all of that silt and turbidity and so we ran side by side comparisons with clarified water and … which we called treated water and with just raw water, right out of the river, and it turned out that as a result of that work, which ended about 1954 is as near as my memory serves me. At that time, our reactor was already built and these water clarification facilities were installed in our reactor. Subsequently the next year, P reactor was completed; they couldn't wait on this work to determine that.

MS: Uh-huh.

AP: The work saved about twenty-five million dollars ($25,000,000) in equipment costs in each of the three (3) remaining reactor areas. So it paid for itself in spades. That was just one (1) small part of the whole CMX complex work at that time. The CMX facilities had the equipment and all for pumping water from the Savannah River to this experimental complex. So it was only natural, I think, to answer your other question; that TNX was also built at that place. It made sense to do that because it was an experimental complex under the Savannah River Laboratory and so we could share common like steam, water, electric, all of the utilities …

MS: Okay.

AP: … plus the resources of the technical manpower.

MS: So both facilities were managed by the lab right?

AP: That's right, we reported to the laboratory. The Director at that time was Milt Wahl.

MS: Hmmm.

AP: Now let me ask you one question.

MS: Certainly.

AP: I don't who all you are interviewing but in terms of that work on the heat exchanger program, I came late in January 1953 because it was well underway. At first, if my memory serves me right, the very first head of the CMX, was Paul Dahlen.

MS: Hmmm

AP: Okay, I'm going to say you definitely ought to interview Paul Dahlen.

MS: Yeah, uh-hum, yeah.

AP: And then Paul Dahlen; just a little bit of history, was transferred from CMX to the plant in Reactor Technology, and succeeding him was a gentleman named Ray Hood; he's deceased – well, that's not going to help you any. Ray wasn't there too long before he was transferred, and he was succeeded by Earl Nelson; he is deceased.

MS: Okay.

AP: Uh Earl …

MS: I'm going to write their names anyway.

AP: Okay. Uh, Earl was transferred, again, to Reactor Technology because these two (2) facilities, CMX and TNX provided hands-on with much smaller scale and comparable equipment, both in CMX and TNX to support the plant. So while the plant was being built, they didn't need a lot of technologists following construction, so that's another purpose of the CMX facilities, was to utilize these technical people or to get them familiar with the nuclear technology and then transfer them into the plant. They all went into either Reactor Technology or Separations Technology. Subsequently, like myself, we ended up in production in the plant …

MS: Okay, all right.

AP: … in management but after Earl Nelson was transferred from the plant; actually he was transferred back and became head of the Pyle Engineering Division in the laboratory. CMX was a division of

Pyle Engineering Division, and Pyle comes from the first nuclear pile of reactors that they called piles at Hanford but it really was in Chicago.

MS: Oh, okay.

AP: And then Pyle came from the standpoint to use blocks of graphite to moderate the new drawings, but …

MS: Right.

AP: Earl subsequently was transferred to commercial but after Earl left, Fred Welty replaced him at CMX, as head of CMX, and then I replaced Fred Welty as Head of CMX. That's … I'm trying to think, when I left and transferred into Reactor Technology, the … I believe that Bascoe Watley replaced me as head of CMX. I was moved up to the main lab and I had CMX as a sub-group.

MS: Uh-huh, right.

AP: And that's where Dave Muhlbaier was working at the time for me.

MS: Oh okay, right.

AP: Uh, Bascoe Whatley, do you have his name?

MS: Uh-uh, no.

AP: Bascoe and Dave are both a little bit younger than I am, but Bascoe would be older than Dave and he lives in Allendale. B-A-S-C-O-E Watley W-H-A-T-L-E-Y; and Bascoe, I haven't seen in years.

MS: Uh-huh.

AP: I assume he's still alive.

MS: Okay, uh-huh.

AP: Subsequently a few years later; this would have been I think in the seventies (70s) but uh, Bill Durante do you have his name?

MS: Uh-huh. Bill Durante, right?

AP: Durante, he lives in North Augusta and I haven't seen him in a long time and I assume he's still alive. He was also at CMX uh though he started his career up in Pyle Engineering Division up in the main laboratory and was transferred down at CMX. So those are the people that you might want to put on your list. Right around in the seventies (70s) sometime most of that operation, I'd say late seventies (70s) had ceased at CMX and we had a minimum amount of work and they built public facilities and consolidated them all up in 773 up in the main laboratory.

MS: Oh, okay. Is that when they had the heat transfer lab or something?

AP: Yeah there was a heat transfer lab in 773 that did most of the heat transfer work, originally under Sam Mershak in the laboratory. Sam got promoted and that all came under me when I was transferred up there. But some heat transfer work was done at CMX by the same individual, Sam Mershak. It never was assigned to CMX but there in the early stages we had the utilities and the facilities to do this work and this was work … heat transfer work done to determine the … from the safety standpoint what we call the limitation of flow down the fuel element due to excessive heat generated by the fuel, in this case there was an electrical tube, and our concept was to have what they call, boiling disease protection.

MS: Hmmm.

AP: And that was really the only heat transfer work that Sam did at CMX.

MS: This was the 1970s right?

AP: No, this was the 1950s, the 1950s, now I'm going to go back to the fifties (50s) in a minute so you … I want to be sure that the total broad aspects you will gather.

CMX's primary purpose; if it became a fluid transfer operation, most of the work done at these initial works were done fluid dynamics for both liquid, water, in our case; and air and I'll explain those in a moment. Plus, we did work on the erosion and corrosion of two (2) element surfaces. Example, my very first assignment coming out of R&D in the Air Force was to determine the corrosion characteristics of the aluminum clad slugs, which when they discharge from the reactors are put in buckets in these huge underwater cooling bases. They stayed there three (3) months or so before they were shipped, dissolved in the separation facilities. Well it turns out there was a coupling electronic … electrical coupling between the stainless steel and the aluminum cladding. It caused the aluminum cladding, called galvanic corrosion, to corrode and if it corroded too much during storage it could penetrate the cladding into the uranium cores [inaudible – someone clearing throat] for that basin. So my work was to characterize that corrosion and prevent it and the way we prevented it was to put an aluminum liner in the buckets.

MS: Oh okay.

AP: And there is a DP report by me on that. Then the next phase of work and equally important, much more important than that corrosion work was the fluid dynamics around the fuel and target elements so we had facilities built initially to flow test a fuel and target elements and what we call a converter. A converter was just a misnomer, it was really a hydraulic facility for subjecting these fuel and target elements full length, full length-full mock ups to the fluid conditions they would experience in the reactors. We used heavy water for all these experiments.

MS: So there's no heavy water …

AP: No heavy water at CMX.

MS: Okay. When was this?

AP: Sixties (60s).

MS: Excuse me? In the sixties (60s) this was or late fifties (50s) early (60s) what?

AP: No, no, that started in the fifties (50s) also. I had that, I was doing work on fuel elements from the hydraulic casting in fifty-four ('54).

MS: Okay.

AP: These were the slugs, the very first Mark 1 slugs.

MS: Right, right.

AP: What we did is we subjected these targets and fuel elements to the same hydraulic conditions they would experience in the reactor. So we wanted to be sure that we didn't have excessive vibration that would cause again the damage to the cladding and expose the fuel and the vision products to the moderator and the reactor.

MS: Uh-huh.

AP: That became very significant. Particularly, what we did at the upper … the very top of the elements because early on we had heavy water pumps and the reactors that didn't pump as much heavy water coolant over the fuel elements, so we had to put restrictors. These pumps generated a fair amount of pressure and so our total flow capacity was limited by the pumping capacity.

MS: Uh-huh.

AP: Which ultimately we changed and we put in much bigger pumps that almost doubled that capacity. At any rate, for this boiling disease protection, we had restricting orifices at the top of these fuel elements. So if the flow decreased a little bit and decreased pressure dropped across the orifices and let more flow come back in. Now why would the flow decrease? Because of a blister on the cladding or boiling; so that was to prevent boiling disease.

MS: Uh-huh.

AP: And at the bottom of these fuel elements, we had a monitoring configuration we put over the monitor pins in the reactors and they had a pressure tab for monitoring and a pressure differential as fuel elements and full thermocouples; so even before our reactor achieved their initial design power, which was a few hundred megawatts, a drop in the bucket compared to what we ultimately achieved …

MS: Uh-huh.

AP: Our reactor was sitting there idling at just beyond critical station, very low power, because we had a problem in the monitoring efficiency. In other words, we wanted to be able to detect that if we had a pluggage in the sub-channel that the monitor pin would show you that and you could shut the reactor down and take that element out. It turns out the very first initial experimental work on our monitoring was done on our Engineering Research Laboratories in Wilmington, Delaware.

MS: Uh-huh.

AP: And then the Wheatstone Bridge complex for the thermocouples to properly measure, they made a mistake in the hookup.

MS: Hmmm.

AP: And they subsequently found that, but in the meantime, we're working with, you know, full scale elements and full scale hardware. So all of that work we took over at CMX and there again, that's in the early fifties (50s) late fifty-four ('54) and fifty-five ('55) we started this extensive program on that and Fred Welty was the initial guy in CMX doing that work.

So in fairly short order, we configured changes in the bottom fitting that would improve the mixing so that we could pick this up; made those changes in the reactors, also gave them calibration [inaudible] so they know what they were looking for and allowed them to proceed to full power at that time. So that was all done, it was lots and lots of work done in the fifties (50s) and the sixties (60s).

MS: Uh-huh.

AP: Okay, the other thing we did that led the very pioneering work layer; there's another gentlemen that worked for me down there that did work in the early fifties (50s) on the mechanical seals of the pumps and his name is Fred Apple, A-P-P-L-E. Fred left us after completing all that work on the mechanical seals and other work that I will tell you in a minute that he did for me and went to work for Georgia Tech in their test reactor. As far as I know that where he is, if he's still alive that's where Fred is. You might want to talk to him.

MS: Oh, okay.

AP: That … except a few … if you dig up detail laboratory reports, not too much is mentioned about that pretty pioneer work that Fred did on the mechanical seals. What we were concerned with there is we wanted mechanical seals with a long life and with very low leakage of heavy water. So right to begin with, the whole complex for the nuclear reactors was very sensitive about the safety in a very broad sense of the word. In other words, we didn't want a lot of heavy water leaking out.

MS: Uh-huh, right.

AP: That would have been costly; uh, you had to contain it and of course, if there were any fission products in the moderator why that was another source of leakage of fission products. Okay …

MS: Now how did you do that work if you didn't have any heavy water at the …

AP: The characteristics are the same as far as mechanical … heavy water is … has a higher density and the reason you use it in nuclear reactors is because it's much more efficient in moderating the neutrons to the desired level and captured by the uranium and breeding plutonium.

MS: Uh-huh, uh-huh.

AP: And if you …

MS: But for other characteristics, it was close enough to regular water so …

AP: That's right, as far as … a little difference in the density and a little difference in the boiling point but that's about it. A little … insignificant difference in viscosity, which is an important characteristic for determining pressure drop across surfaces.

MS: Right, right.

AP: But factor all of that in and like the monitoring. We didn't rely just strictly on the work I've done at CMX. Example, I did work on the mixing in the sub-tanks; are you familiar with the geometric shape of some of these fuel elements?

MS: Yeah.

AP: Do you know what we call a sub-channel is where between two (2) ribs, usually on the tubal elements you have four (4) ribs to support the thing laterally. We wanted to know what was the degree of mixing in a sub-channel. Was there any mixing from one sub-channel to the other? I did work on a small scale for that to determine that to help us know what that monitor pin was telling us down there, but to characterize what we did with monitor pin and that sub-channel work, what Sam Mershak did was heat transfer lab with what we characterized is another limit called BOSF, are you familiar with that?

MS: Uh, no.

AP: Burn-Off Safety Factor. We wanted to have a Burn-Off Safety Factor on the heat transfer of the fuel elements, which Sam characterized in small scales by heating electrical strips or electrical tubes with the same fluid dynamics they would have in a reactor. They keep putting the power in that until it actually, physically burned up and that's where the burn-off safety factor comes in. When you back away from that in the reactors; well now to be sure we knew what was happening in there, we had a mechanical counterpart in the old Pyle Engineering Division, which later the Dave [???] headed up.
Developed full-scale, took a full scale fuel element, instrumented with thermocouples in these sub-channels and bring all of those leads up to the top of the reactor and in an actually experimental condition measure in the reactor what the temperatures were in those sub-channels. That told us from a fuel element design standpoint we had, with all these sub-channels, we had to balance as best we could. So, our initial fuel design, we would test these in the reactor and we would make subsequent changes in the geometrical shape of the fuel so we could get a better balance as far as the distribution of coolant in those channel. Anyway, that's a pretty long story but it was very important from a safety standpoint that whole business. So we tested all of the fuel elements at CMX for vibration damage or erosion damage

and that subject of erosion became important to us for two (2) aspects. As we for the nuclear reactors … as we evolved with the technology and changed … put in more heat exchanges, put in more … bigger pumps to utilize all of that. Are you familiar with that book there?

MS: Yeah.

AP: Okay, so we've got a term in that book. I managed that by the way, we show the power increase that occurred. The production which is directly proportional … in those reactors and a lot of that came about because of this work that was done at CMX. Erosion, the question was, we originally designed these fuel elements based on heat transfer and experience that handled it. Also, at Columbia University if we had experiments at Columbia University going on parallel this whole project. So a lot of heat transfer work was done up there also. The question was, if we increase the flow so that the coolant velocity increased twenty-five (25) feet per second to fifty (50) feet per second, would that cause serious erosion of that aluminum cladding? So Brad Apple, again, we did pioneering research or you could say development on the erosion characteristics of aluminum, magnesium, stainless steel and titanium. If velocity that we were currently experiencing was twenty-five (25) feet per second; double that to fifty (50) feet per second, ultimately went to one hundred (100) per second. Now what's important about that one hundred (100) feet per second is that paved the way to show that the aluminum would stand those velocities in the production reactors.

That plus the heat transfer work done at those, plus the mechanical design and all was very important to the success of the high flux operation. Now that is referenced in this book. I don't know whether you were interested in that or not but we said so much of that was done a CMX that we could set world from a heat transfer standpoint and an engineering standpoint; we could have success if cooling velocities of ninety (90) to one hundred (100) feet per second.

MS: Right. When was this … when was this done?

AP: That was done in the late fifties (50s), early sixties (60s).

MS: Uh-huh.

AP: Now also in that time, just to tie it together a little bit. We were also interested in supporting the commercial nuclear technology business.

MS: Right.

AP: And we had that big tester/reactor built on site and we had a …

MS: What are you talking about … "Hector" [Heavy Water Component Test Reactor, or HWCTR]?

AP: Hector, right.

We had … we built a facility again to test the fluid dynamics, corrosion/erosion and things like that at the conditions that they expected at Hector; that was done at CMX in what was called a power test facility, which Brad and I designed, built and operated.

MS: Now this wasn't at … this power test facility was it CMX? Where was this?

AP: All right, if you, you know, you walk … I don't know is the building still standing? Are you familiar with the building at all?

MS: No. I've got uh … I was talking to Dave this morning and I had him just draw out an outline of the building plus the other two (2) buildings that were there that were part of the CMX/TNX complex.

AP: Alright, if you look out at the back of the building, there was a wing of offices from out there … see, here is the main complex where we had all the heat exchangers, the full test facilities, the corrosion/erosion and all the monitoring work on the bottom end fittings and all was in this complex. You walk into the building like this; there was an office complex here where major CMX engineers were sited and then there was a wing, and down this wing they had supporting ordinary water laboratory and offices for some CMX people and the TNX staff.

MS: Uh-huh.

AP: This way, over there, is the river and the swamp. And by the way, we referred to ourselves as "swamp rats" at TNX.

MS: Oh, okay, uh-huh, uh-huh.

AP: Right over here was this power test facility then operated at two hundred sixty degrees (260^0) centigrade and about one thousand (1000) pounds of pressure. There again, because of the … of Hector, there was interest from a neutron economy standpoint in looking at magnesium.

MS: Uh-huh.

AP: So we did flow tests on fuel elements in that facility with magnesium and it eroded substantially. It was not a suitable cladding at those conditions for power reactor fuel. It's about that time when Fred was offered this job and we had finished most of the work that he had an offer to go to work for Georgia Tech and their test facility. We ultimately shut that down and the timing on that would be about the time that John Walker and I did a piece on the filters. I can calibrate you on that time. Interesting thought about that facility … you know for an engineer. I was a Chemical Engineer and John Walker, let's see, John Walker came after Fred Welty. So it was John Walker between Fred Welty and myself as Head of CMX.

MS: Okay.

AP: Okay and John … John was a brilliant mechanical engineer. That would have been 1963-ish. In the design of that facility you had to be extremely concerned about the thermo-stresses on the piping as well as the facility and all. I had never done any 3-dimensional stress, being a chemical engineer, and John Walker was an expert and he said I don't have time to do this. This is before he became head of CMX and he said, "Here is a book." So I did that and Fred Apple, who was a mechanical engineer, and Dave Palmer, I think Dave was mechanical, I'm not sure whether Dave was mechanical or chemical. I would guess mechanical.

MS: Okay.

AP: There was another one that worked for me in that period, by the way, Dave Ward.

MS: Uh-huh.

AP: Okay, so you got him on your list; he worked … he started his career at CMX also.

MS: Uh, yep, I got him on the list.

AP: Okay, Dave did work … Dave did work on a piece I haven't covered yet. But at any rate that was very interesting a design of that piping system for that power test facility; because with those conditions you had big changes and length of piping and things like that you know, could fail if they weren't properly designed and properly supported for the stresses, but anyway. So that was a big learning experience for sure for me.

Over in the TNX facility they ended up with quite a few buildings because, you know, most of the semi-works are done for the defense waste processing facility, which was done at TNX.

MS: Hmmm, right.

AP: Okay, in a building where a fair amount of tritium work was done … here again is CMX, there's CMX, right next to that was the original TNX building. Then it was another building over here and this doesn't count any of the defense waste processing facilities which added more buildings to that complex.

MS: Oh, okay.

AP: But this building over here was built to do some basic work on tritium and we needed a facility space to build a one sixth-scale model of the reactors from a hydraulic standpoint. This was when we were increasing the pumps and the nuclear reactors, and the question was in the moderator space part of this increased flow, would there be severe damage due to vibration of the fuel elements because we were talking about doubling the flow. So we wanted this facility and we called that the cross-flow tank and Dave Ward and I did all of the original basic work in that. Prior to that Dave did work on a smaller scale, where we subjected the fuel elements to a cross-flow. The work cross-flow comes out because the water generally goes up in the middle of the reactor, then down but there's also some going straight out this way into those open nozzles and the question was when that flow, going across those cause severe vibration and damage to the fuel elements? And as it turns out, it didn't, but we weren't sure with that smaller scale model it would uh, Dave built right in the main building. We built a one sixth-scale model and that was successful.

MS: When was that done?

AP: That would have been in the late sixties (60s), mid-sixties (60s) to late sixties (60s); before the pumps were put in whenever that was.

MS: Oh the new … the reactor pumps, the Binghamton pumps?

AP: Yeah, the Binghamton.

AP: Okay, after they … the other thing that was monitored carefully in the reactors was the bulk moderator temperatures outside the fuel elements but within the tank, okay? As we increased power and … like increasing the heat transfer capability in the system. More heat exchanges and more pumps, okay? Uh, and careful design of the fuel and elements; the moderator temperature, which was at the atmospheric pressure at that time; later, we put in vacuum breakers and increased the pressure slightly six (6) or seven (7) pounds, something like that. But the moderator began limiting power because it was getting close to the boiling point of B20(?). So the question is and this was near the center of the reactor … so we did work, Dave Ward did work for me in that tank, that big cross [inaudible] tank, to characterize the flow and also the … mainly the flow because we could not … the only way we could assimilate local heat generation is, we just heated the water up to one hundred (100) degrees and ran our test, was to put in a fuel element and hit it with steam so we could get local(?). We didn't have the capacity to get more than one fuel elements worth of heat. That took a huge steam accumulator outside that tank. I think that building may be gone now too, I really don't know. I haven't been out there since …

MS: I haven't been out there but I've been told that pretty much all of that stuff's gone.

AP: … yeah, well at any rate, we found out that by putting jet tools in the reactor the jet would flow up … a fairly high velocity, uh, then we could eliminate those hot spots that occurred in the middle of the rack improving the flow up and over and down and that work was done at CMX by Dave. And ultimately, since we had this capability now of ejecting steam in the reactor, we did safety analysis in that tank.

MS: Uh-huh.

AP: By injecting steam and things like that to determine the pressure characteristics of the system and Dave did that work also.

MS: Hmmm, okay.

AP: I know that all that work was completed before I was transferred to reactor technology, which was in sixty-nine ('69) and Dave had long since been transferred to reactor technology also. So that's like mid … I'm guessing, mid … early 60s, mid 60s something like that.

MS: Uh-huh.

AP: All right. Then the other major work that we did was the development of the filtration system or the containment system of the reactors.

That was done under me at CMX and the principles were Dave Muhlbaier, a fellow named George Priggy, who did most of the original work on the effectiveness of activated carbon for removing [inaudible] and … let's see Dave Muhlbaier. Dave did work on full-scale and he might have done some of the bench-scale, we did bench-scale works on filter samples, three (3") or four (4") inches in diameter. It was very important, because it was wet conditions, in an accident in which you lost coolant capability to reactors. You generated a lot of steam, and the question was would Hepa filters withstand that; and ninety-five percent (95%) of them wouldn't. We did experiments on all kinds, quoted them all and found one (1) particular filter that would withstand most of the conditions, but not all of them.

MS: Uh-huh.

AP: These were high strength water repellant Hepa filters. So we developed de-misters to put in front of these filters. This was all done on full-scale models, where we had that accumulator out there that could generate lots of steam?

MS: Uh-huh.

AP: And we actually could simulate steam flows ten (10) times the normal flow of [inaudible]. The activated carbon beds were the last thing in this chain to remove the [inaudible] fission box(?).

MS: Uh-huh.

AP: So we had a full-scale facility where we could test de-misters, filters and the activated carbon filters; all … those activated carbon filters, by the way, were designed by us at CMX.

MS: Hmmm.

AP: So we not only did the technical work on the effectiveness of them but then subsequently we found out by work that I had done in the main laboratory in Pyle Engineering, where we had a little test pile?

MS: Uh-huh.

AP: We subjected the carbon to high radiation fields and that work was done my Bob Miller; he's dead now.

MS: Uh-huh.

AP: But Bob was a co-author by this big confinement report that Bill Milant and Muhlbaier and myself wrote.

MS: Okay, uh-huh.

AP: Subsequent to me …

MS: Phyllis can find the report?

AP: Yes.

They found that the activated carbon acted like a catalyst and created methaliodine on the band itself and the carbon wouldn't retain that. So that work was done subsequent to CMX, it was done in the main laboratory and I can't remember the gentleman that replaced Miller up there, who did that work and he's still alive too; Muhlbaier would remember him I'm pretty sure.

MS: Hmmm, okay.

AP: Now Bascoe Watley did a lot of the work … hydraulic work on the fuel elements and also the monitoring work. That was mainly his area of expertise while he was at CMX. And when they moved those facilities to Pyle Engineering Division, up in the main laboratory, they subsequently brought Matt to do more safety studies related to loss of coolant accidents and Bascoe worked on that.

MS: I'm sorry, when did he start working with CMX?

AP: Let's see, he was a Chemical Engineering graduate up at Clemson uh … I'm … and he came three (3) or four (4) years after me at Clemson so, I'm guessing fifty-five (55), fifty-six (56) somewhere in there. And there was another guy from Clemson, a Mechanical Engineer that left and went back in the R&D Unit of Ray Patterson Air Force Base; Abercrombie. He's still alive I'm pretty sure; and he did work for me on the … [Tape side one ended here].

Side Two

AP: In my old career, which started the experiments at CMX and then up in the main lab where I had that and heat transfer work done. Then to reactor tank and the reactor tank, I had replaced John Maloney as Head of the Engineering Support Group. They had an Engineering Support Group, they had a Engineering Technology Group, and they had a Physics group in reactor tanks. And the interesting part about that is how that background from the initial experimental work all the way to see final setting world records on neutron and heat flux, I-flux reactors. That was a real rewarding experience. You know, I was a research supervisor at that time and sheet supervisor in reactor tech. But the way Du Pont operated; their supervisors were also working supervisors. All the way from technology into operations, so if you ended up as a desk supervisor, just strictly supervising people, you were not going to be very successful in Du Pont Company.

MS: Right.

AP: So, at any rate, it was … that was as equally challenging as the first criticality in our reactor, which I wasn't there for that, and … so those are very satisfying things in an engineer's life. There are others of course, but that one was particularly important. I can't … unless you've got some detailed questions, I can't think of anymore about CMX that might be of use to you.

MS: Uh, the questions that I've got are not probably going to be as comprehensive as what you've got, but there were some things that I remembered from doing some research years ago with that fiftieth (50^{th}) anniversary history that we worked on.

AP: Yeah, yeah. By the way, I don't have that book.

MS: Oh, okay.

AP: But they showed a picture in there of me and identifying the guy with me is incorrect. That is Fred Welty. I told Walt Joseph, I think, about that.

MS: Oh, okay. I've got a copy of that book but I don't have it with me.

AP: But at any rate that was me in my twenties (20s) and Fred Welty was … let's see, he had a PhD in Chemical Engineering so he might have been late twenties (20s).

MS: What about … I read I think it was in Bebbington's that you mentioned that the CMX operation was shut down in 1984?

AP: That's possible. Dave Omar applied a lot of that work that was continued safety fashion sort of went back to the …

MS: [inaudible – cross talking]

AP: That's what I was telling you about, where Bascoe Watley and Dave Muhlbaier went and so it was continued but the mission, the objective of the work was a little different.

MS: Uh-huh, uh-huh.

AP: But they were mainly doing hydraulic test under continuing safety analyses and in eighty-four ('84); well they brought me back in the plant to be Manager of Operations in eighty-two ('82) and so, you know, I didn't keep up with all that was happening with CMX at that time because I had then transferred to the [inaudible] and back as Manager of the Laboratory. But I know that CMX was still in operation when I was managing the laboratory. That would have been seventy-nine ('79) through early eighty-two ('82).

MS: Okay.

AP: In eighty-four ('84) I became Manager of Plant Facilities & Services and also Manager of Transitions and that's where I retired.

MS: Right. What was …

AP: But eighty-four ('84) as far as I know … I've got to tell you a little history about this book.

MS: Oh yeah, sure, go ahead.

AP: It was really my idea and Jim Conaway's to do this because we had no idea based on the history of the United States government and the atomic program of doing histories.

MS: Right.

AP: History had started about at Hanford and that was so far down the pipe that uh, you know, just like today a lot of the people are dead. Jim Fletcher's dead and he was a mentor of mine; but at any rate, to keep this book's cost down, I did that in my basement of my house to keep this book down. I didn't pay myself a cent and didn't pay Conaway a cent but we did all of our interviewing and I hired people on contract, retirees, to help us with this whole darned book. That's the only reason we could do this book and get the department to pay for it and we … somebody wanted one of these books not too long ago and I checked the Chamber of Commerce to see whether they still had any … I talked to Bonner to give him two thousand (2000) over two thousand (2000) books, giving them, to the Chamber of Commerce. So they wrote all of that off but the total cost of the project was five thousand (5000) books. We managed the cost because people were interested in doing this for nothing essentially, to a fraction of what was charged for the big fiftieth (50^{th}) anniversary. I wouldn't have done it otherwise, because I, you know, we were asking them to take it out of their commercial [inaudible] and pay for this darned book.

MS: Right, uh-huh.

AP: And the interesting thing is that we could only sell about a little over two thousand (2000) books.

MS: Right.

AP: Of the five thousand (5000) that were printed.

Millie: How are you?

AP: That's my wife Millie.

MS: Hey, how are you doing? I'm going to shut this off.

AP: You want to cut that off?

MS: Cutting this back on after our interruption here. Let's see, there are not that many other questions to ask but I did want to … did we mention, did we talk about how many people worked at CMX?

AP: No we didn't … counting the total number?

MS: Yeah.

AP: The peak was probably in the fifties (50s) and I'm guessing it was like uh, in the neighborhood of fifty (50) people counting the operators and counting the support people. The operators reported directly to us. The mechanics, the maintenance mechanics, electricians, HP people, those reported to their hierarchy and the laboratory. So they were not under out direct supervision, though they did exactly what we wanted them to do, so we directed their work. But they got their fitness reports from somewhere else.

MS: Oh, okay. What about the TNX?

AP: TNX I would say was about comparable size, around fifty (50) people or so at a max.

MS: Okay.

AP: Now when they … the Defense Waste Processing Facility, uh, that was in the eighties (80s) I would say may there was one hundred (100) people down there.

MS: Oh, okay, all right. What did … this is a little bit off of the track but since we're also interested in TNX eventually anyway, what exactly did TNX do for that … that program?

AP: For the uh …

MS: Yeah, Defense Waste.

AP: Defense Waste?

MS: Uh-huh.

AP: Uh, the Defense Waste Program; most all of their technical people came out of the separations technology group and in the hierarchy of things, the defense waste processing facility and the laboratory was in the same organizations of separations technology and it grew and expanded, it became particularly … you know like I was transferred into the plant in eighty-two ('82) to help them set up a project, Oriented Management Structure.

MS: Uh-huh.

AP: And that management structure put under a manager or general superintendent all of the resources directly reported to him to carry out his mission.

MS: Uh-huh.

AP: So like Joe Womack had reactors when he reported to me as Separations Manager and he had health protection, the maintenance department all reported directly to him.

MS: Uh-hum.

AP: The only thing that didn't report to him were that power people that supplied the utilities you see, water, steam and electricity. So the lab became also project oriented … I would say when a mission became fairly large in scope they would historically make a head of that. So Dan McIntosh, okay, became Research Director … or maybe he was a … what did they call it … he was a Section Director, I think, Section Director not a Research Director, Section Director of Defense Waste Processing Technology. So he had experimentation going on in the main laboratory and he had this big complex down at TNX and so he didn't report to the Section Director of Separations but it came out of Separations Technology. We did the same thing in the reactor business. When the whole problem came about that the reactors were beyond their useful life if we wanted to continue that, finally the Du Pont Management came around advocating building a new production reactor. So we formed, both in the plant and in the laboratory a separate team project management team to do that and Lowell Hibbitt headed if up at the plant and he had people in the laboratory supporting that and I think at that time, because it never got off of the ground, they stayed in the 405 Engineering Division.

MS: Oh, okay.

MS: What did they do about security at CMX?

AP: Well, we had security. We had, you know, it was a fenced off area with guards and as that work became declassified with time, they eliminated the security. But in my day down there you had to have an acute clearance. We couldn't do our work without knowledge … detailed knowledge of the engineering and physics characteristics and the operating conditions and the reduction, which was all top secret at that time. But as that became more and more declassified with time, my recollection is they had the guardhouse and they had a gate but they eliminated the guard. I'm guessing that was maybe late seventies (70s) or early eighties (80s) before they shut it down.

MS: Oh, okay, uh-huh, all right.

AP: Something like that.

MS: What about the … did CMX have any direct dealings with the reactor works they maintained at Triple Seven (777) or was it just apples and oranges?

AP: They … Triple Seven (777) was in the physics organization and we shared technology between all groups in the laboratory because we periodically had technical reviews at the main laboratory; so for instance, I think the first speech I ever gave was in the composite meeting of people from all of the divisions and it was on that work on the mixing … sub-channels. So other people got to see you and keep abreast of the technology. They had to have clearance for that however, but some of it was highly compartmentalized and wasn't shared.

MS: Right.

AP: Something like the mixing was, you know, more of a fundamental hydraulic thing so that wasn't a problem. The other thing of course was the research reports that came out monthly from the laboratory. Those were all classified secret so you had to have with your acute clearance … for instance, I didn't have access to the tritium work until I became a General Superintendent of production in the plant and they were under me. That's the first time that I had a special clearance for the tritium work.

MS: Oh okay, okay.

AP: So there was a compartmentalization of the work; in the early days everything was compartmentalized.

MS: Right and that was probably a security measure as well.

AP: Oh yes, that was a big security measure.

MS: What about the actual term CMX? Bebbington says that that doesn't mean anything at all.

AP: He's correct.

MS: But I've heard that people cooked something up.

AP: Yeah we cooked up corrosion, mechanical and experimental.

MS: That's what I heard, yeah.

AP: That's just … see Bebbington never worked at either CMX or TNX, he came up through the heavy water technology branch and was in Separations. I don't know that anyone … you need to ask, when you stop talking to TNX people, you need to ask them did they come with a phrase for TNX. We did for CMX just what I told you. I don't know whether there were others, there may have been others but not to my knowledge.

MS: Was the CMX area ever called anything else?

AP: No, not to my knowledge.

MS: Swamp?

AP: Yeah, we called ourselves in sports activities, we would have softball teams all over the plant and our name was, both CMX and TNX, in those events were the Swamp Rats.

MS: Oh, okay, okay. Let's see uh, what kind of shifts did they have at uh …?

AP: Regular shifts; three shifts, twenty-four (24) hours because see all of those tests went around the clock. We'd run erosion mechanical, like vibration tests on fuel elements for ninety (90) days, sometimes one hundred twenty (120) days.

MS: Yeah, uh-huh, all right.

AP: And so all of that went around the clock. We had operators responsible for taking the bulk shift data. In other words, we would provide them with data sheets that we wanted … we had special instrumentation …

MS: Yeah.

AP: … and they would record that for us.

MS: If it was an on-going experiment that the experiment … the engineer had to be there?

MS: Uh-huh.

AP: You stayed there.

MS: Uh-huh.

AP: So I … in my early days I've spent eighteen to twenty (18-20) hours on an experiment.

MS: Hmmm.

AP: Because it was … you needed that data … like one thing we found out in the reactors, we had two (2) types of monitor pins, are you aware of that? In the nuclear [inaudible]. One's a solid pin with full thermocouple holes in it and a pressure pin. The other one that was installed in K, L, &C has cores through it where part of the flow … initially all of the flow went over the thermocouple and out of the sides. Well they found when they started up with the higher flows with these new type monitor pins that they had unstable hydraulic signals from the monitor pins and the one thing you don't want in a nuclear reactor is an unstable signal; whether it's a hydraulic or temperature or a flex … you don't want those unstable signals. So all of the experimental work to solve that problem was a … I was the first principal investigator on that.

MS: Yeah.

AP: And what happened was, due to the accumulation of tolerances on the monitor pin and the sleeve that fit in the reactor, it's about four (4) or five (5) feet long. That … if the tolerances were on the negative side for the monitor pin and on the positive side for the sleeves and that bottom shield of that reactor where the flow would come out horizontally … you drilled a hole, four (4) holes through this monitor pin nose and you slotted it around so the flow would come out.

MS: Uh-huh.

AP: Well, if that bottom part of the pin was below the top of the sleeve, there was a critical point there in terms of a few thousandths of an inch where the flow would oscillate like this.

MS: Hmmm, uh-huh.

AP: It wouldn't be steady, it'd be up sometimes and it would oscillate frequently so the solution to that problem, and that's one where I probably worked around the clock to characterize that thing.

MS: Yeah.

MS: Uh-huh.

AP: What we did was take up and pin down some of the gaskets. You had double O rings sealing this monitor pin in the bottom of the thermal shield and you also had a gasket, flat gasket, we had to take that flat gasket up and rely on the O rings only.

MS: Yeah, uh-huh, right.

AP: And that would raise the monitor pin and that solved the problem most of the time, like ninety (90) to ninety-five (95) percent of the time. Not always, but most of the time. So that's where a type of an experiment that would go over a normal shift. The experimenter would stay there and he would have operators. At CMX and TNX we used operators not technicians.

MS: Ummm, hmmm.

AP: They were on a different wave scale.

MS: Oh, okay.

AP: And the technicians in the main laboratory were technicians, they were on a weekly pay rate. The hourly people were on an hourly pay rate and there was lots of friction sometimes between … as far as the Scope of Work on whether this technician should get paid more.

MS: Yeah, uh-huh, right.

AP: Uh, that sort of thing went on at both CMX and TNX but the operators were there to carry on a … the carryover work, which was fairly routine, they couldn't adjust to anything other than maintaining the flows that we wanted and the temperature that they wanted and to operate the clarification facilities for the heat exchanger work, operate the boiler. We had two (2) boiler explosions due to this operation, minor explosions, fortunately nobody was injured. The first one of those occurred when we had engineers around the clock on shift. Originally, CMX and TNX had engineers working three (3) shifts, seven days a week.

MS: Ummm, uh-huh.

AP: And as that became more standardized and the rush wasn't on to support the startup of a nuclear reactor or startup of a separation facility that … we got away from having the technical people on shifts.

MS: Yeah, right. That's when you just had the operators?

AP: Operators, right.

MS: Operators couldn't change dials or … okay, uh, hmmm that's pretty good.
Did they ever have any …?

AP: Oh, by the way.

MS: Yeah, go ahead.

AP: Did Dave Muhlbaier tell you about the work and characterizing the flow into the reactors moderator space? I think he did mention that, is that the one where they had the … well, he worked for me on that and that was very interesting.

MS: That was up in the plenum, was that it?

AP: Well we did the work in this tank okay, we developed a sub-mister and I'm pretty sure Dave was my principal investigator on that at the time but he and I worked on this darn thing.

MS: He talked about a number of programs; I'd have to go back and listen to the tape, but one was where you …

AP: He developed a little sensor that was based on a sub-mister that we could change the direction of this sub-mister inside an instrument tube in the reactor and the monitor, it would tell us which way the flow was going, officially. If it was going up some angle this way or it wasn't moving at all. So we developed that and when a reactor was down from routine charge … discharge, we took this device, Dave and I took this device over there and mapped that tank … mapped a reactor on the full hydraulic pool conditions.

MS: Uh-huh.

MS: Hmmm.

AP: And one place we stuck the damned probe in the reactor and it just stuck right here. We twisted it a little bit and we got it out but that ended the experiment right there we didn't go any further.

MS: Uh-huh.

AP: And the reason for that was again, was the accumulation of tolerances between the plenum and the shield, their sleeves, and one of those instruments position we put this thing in; there was a radial … there was a plus or minus tolerance railing going up on these big huge things so they had a little shift and you could stick that probe in and that's what happened, it got caught in the top thermo shield, it was okay in the plenum.

MS: Yeah, uh-huh.

AP: It got caught there and you had stainless steel on the stainless steel and that is, you know, bad if you've got any close tolerances. So out it came. But at any rate, that work is all published too.

MS: You wouldn't have the name of that would you?

AP: No, I can't remember the name of it or how we characterized that thing but I'm pretty sure that work was published; it wouldn't have been in here. That might … I can't remember whether we mentioned that or not in that book. But Dave Muhlbaier would remember.

MS: Okay.

MS: He may have mentioned that …

AP: Wait a minute! Wait a minute, it's not Dave … Dave was not the man.

MS: Oh, okay.

AP: Another one you should contact.

MS: Okay.

AP: It's hard for me to remember all of these folks from back that far; Elwin Wingo.

MS: Oh, I've got the …

AP: Elwin Wingo did the basic work on that.

MS: Okay, okay, I'm going to talk to him. I've got to call him after Christmas because this wasn't a good time and he wanted to do it after Christmas.

AP: I know Elwin's still alive; at least I saw him a year or so ago.

MS: Yeah, I talked to him last week, that same day that I called you I told him about it.

AP: Bill Durant, both of them live in North Augusta.

MS: Uhhhh, okay, okay. Bill Durant and Bascoe Watley, I haven't contacted them so I'll try to reach them …

AP: There's an interesting fellow, when you get around … you going to do TNX?

MS: Yeah, uh-huh, right. I've got CG: Goodlett for TNX and Art Osbourne.

AP: I didn't know that Art was at TNX, he might have been, I can't remember. Who else do you have?

MS: That's it for TNX. So is there anybody else that you can …?

AP: You should talk to Bill Mottel.

MS: Bill?

AP: Mottel, M-O-T-T-E-L. Gives you a nice trip down to Hilton Head.
Bill Mottel and I were colleagues at the same time at TNX and CMX. Now he was transferred from TNX into Separations Technology before I moved …

MS: Oh okay.

AP: … from CMX. Ultimately, Bill Mottel became Plant Manager and I was his Assistant Plant Manager so here you had … back in those early days they tried to match separations and reactor people into management level.

MS: Oh, okay, all right.

AP: Bill was Plant Manager when I was Assistant Plant Manager and I was transferred to Texas.

MS: Oh, okay.

AP: So that would have been seventy-eight ('78) 1978. I actually transferred at the end of seventy-seven ('77) and came back in January of seventy-nine ('79). But Bill Mottel was in that early TNX work. I'm pretty sure Bill was there when they had an explosion at TNX and I can't remember the particulars about that.

MS: Hmmm, oh, okay.

AP: Most of his technical experience, or engineering experience in the technology part of Separations in the plant was in tritium complex.

MS: Oh, okay.

AP: And to give you another example. My next assignment out of reactor technology was Superintendent of PU reactor and that was one of the most satisfying assignments I ever had from a people standpoint.

MS: Uh-huh, okay.

AP: Then from there I was a Chief Supervisor reporting directly to Bill Mottel who was a General Superintendent of Separations. I was in a Separations project team heading on a mission I can't even tell you about today.

MS: Hmmm.

MS: Hmmm. Well that's interesting.

AP: That one never flew.

MS: Yeah, uh-hum.

AP: Never flew and Bob Mahr replaced me in that assignment and ultimately Bob Mahr worked for me and he replaced me as Manager of Operations in the plant, now Bob's dead now but he was a great guy.

MS: Uh-huh, all right, okay.

MS: Great, great.

AP: That shows you how one way you can be reporting to a guy and then subsequently he can be reporting to you. It just depends upon the timing of retirements and things like that.

MS: Right yeah.

MS: I guess it's kind of the way Du Pont ran the place they kind of put people in management …

AP: Well, the people that they wanted in management, they moved and that was … I tell people I never had a slack day or slow day in my entire life with Du Pont at that plant.

MS: Uh-huh.

AP: And part of that's true because I had so many different assignments throughout the whole plant, and commercial experience was extremely rewarding because I got to see the project management system at Victoria, the Victoria Texas Plant.

MS: Yeah, uh-huh, alright.

AP: That was a very broadening experience; it showed how effective that could be.

MS: Uh-huh, right, right. Yeah that pretty much gets I think, all of the main topics I can think to ask.

AP: Okay.

MS: If you don't mind, I might give you a call back if I have more questions.

AP: That's fine, that's fine.

MS: Because as I talk to these other people they may mention something that I didn't know enough to ask you about.

AP: Well, if I had have had time, I would have looked over the reactor stuff to refreshen my memory but … like the one on the instability of the monitoring pressure … something triggered that when you asked a question and the moderator thing when I had the wrong guy was Elwin Wingo not Dave Muhlbaier.

MS: Right, yeah.

AP: Dave's principal work under me was in the reactor containment system, the filter work.

MS: Yeah he mentioned that, I remember that.

AP: And all the safety analyses that went along with that.

MS: Right, yeah he mentioned that. He said that was a really big thing. But great, okay, thank you very much, I appreciate it!

AP: You're quite welcome.

END OF INTERVIEW

Oral History Interview – David Ward

David A. Ward was born in 1930 in Joliet, Illinois. After receiving a degree in Mechanical Engineering from the University of Illinois, he immediately joined Du Pont in 1953 and was sent to Savannah River. While at Savannah River, Ward did most of his work through the Savannah River Laboratory. His first assignment was work in CMX.

Ward worked at CMX for the next nine years, and was familiar with the programs that tested the hydraulic characteristics of the new reactor components. Ward also did a considerable amount of work on the "Hector" program [Heavy Water Components Test Reactor], set up to test reactor components for an experimental heavy water power reactor. In the years that followed, Ward worked for the Reactor Technology Department. He resides today in North Augusta, South Carolina.

Interviewee: Dave Ward

Interviewer: Mark Swanson, New South Associates

Date of Interview: December 14, 2004

Mark Swanson: This is December 2004 and I'm talking with Dave Ward [interviewer is Mark Swanson]. We're talking primarily about CMX. Just for the record, if you would state your name and when you became involved first with the Savannah River Plant.

David Ward: Okay, I'm David Ward; David A. Ward and I hired in with the Du Pont Company in the summer of 1953, just after I graduated with a degree in Mechanical Engineering from the University of Illinois. I report down here to the Savannah River … what was called the Savannah River Laboratory at that time, which was the technical division of the establishment.

I was assigned … my first assignment was what was called CMX and CMX was a place where some of the components that were going to go, particularly heat transfer and flow components, they were going to become part of the reactor we were testing.

MS: When was that?

DW: That was July of … when I arrived, July 0f 1953 and CMX had already been in operation for a few months, I believe, at that time.

MS: Okay. What was the primary purpose of CMX?

DW: Well, the uh … a key part of the reactor cooling system were large tubing shelled heat exchangers and there was a concern that they would become sensitive to fouling, there wasn't a lot of experience with Savannah River water and large industrial plants such as this. The heat exchangers were very large stainless tubing shells, stainless steel each of the exchanges was you know, sort of like the size of a giant [inaudible] somewhat larger than that. But anyway, the heat … the power level of the reactors since it's related to production level and it was … it's related to it would ultimately be limited by how much heat you could safely transfer to the river, the river was the cooling sink. The rate of heat transfer was governed by the overall heat transfer coefficient of these heat exchangers, which would be the principle part of each reactor and so … so there were some prototypes made of those heat exchangers, much smaller with the same basic design stainless steel [inaudible – drowned out by clearing of throat]. And there was a system set up where … of a little boiler that burned fuel provided hot water at one side and the other side was cooled by Savannah River water and then over a period of weeks and months and I guess extended on to years a degree of fouling of the river water was measured and the idea that this would predict the fouling that would occur in the large reactors. There are two (2) kinds of fouling; one (1) was chemicals in the river over a long period of time that the heat would actually … well it played out on the surface of the stainless tubes and could also the resistance the heat transfer and the other is that solids in the river water would begin to foul the heat and produce the flow so both those things were monitored, that's what the interest is.

MS: Uh-huh.

DW: The second thing that was being tested were the … some of the components on the reactor itself were to be cooled by … the first reactor didn't start up until December of 1953; but everything was designed and this was sort of some final testing of the fluid flow and heat transfer characteristics. But anyway, there is some concern that the fuel elements in the reactor, which had fairly higher rates of flow of heavy water being pumped through could vibrate or otherwise become damaged to long exposure of the flow. Therefore, part of the setup at CMX was to have mockups really full sized fuel elements in a tank, which the simulator [inaudible-coughing] by the reactor and we just observed whether there was damage to those things from flow induced vibration.

MS: When did you all start having concern about the fuel target elements? That wasn't one of the initial things was it?

DW: Oh I think … I'm not sure, but I'm sure the designers who were in the engineering department with Du Pont probably had a concern all along and I think there had been some other test done at the facility up in New Jersey but there's just a big investment in this and if people guess wrong about whether there'd be fouling and heat exchanges or vibration and fuel elements it would be very expensive and expensive at times so this was … so the facilities at CMX were used for sort of last minute checking out of the system.

MS: Oh, okay, okay. How long were you at CMX?

DW: Actually I think I was there about nine (9) years.

MS: Hmmm, okay …

DW: But I …

MS: … that's one of the longest ones … I mean Paul Dahlen for example was not there that long.

DW: Oh no, I don't even remember Paul being … he must have been gone by the time I …

MS: He was gone … I think he was there from the very, very beginning but he was gone by fifty-three ('53) for sure.

DW: Yeah. I think a lot of people who were … Paul was more experienced of an engineer than some people who were hired in to go to the Reactor Department. Once the first reactor was getting ready to be staffed and started up …

MS: Uh-huh.

DW: … Dave started out at the beginning at CMX and they got familiar with some of the equipment and that sort of thing when they moved over to the Reactor Department.

MS: Right. When you were there was TNX there as well?

DW: Yeah, TNX was there and it was … they were just sort of next door neighbors and they were doing, I mean it wasn't similar work but kind of a parallel, if you look at the two different versions of processes, the reactors and the separations processes. They were there as a semi-works pilot plant to test out certain features of that process.

MS: Were they put together just for logistical reasons?

DW: What do you mean?

MS: Just to see uh …

DW: Oh! The two (2) things …?

MS: Yeah, right.

DW: Probably, I mean to build …

MS: It sounds like from all the people that I've talked to that there wasn't that much interaction going into it.

DW: No, very little at all, I mean guys were on the [inaudible] together put you know to put up a little small industrial site that only needed one (1) set of roads, one (1) fence and one (1) set of power lines and the one (1) boiler from Aikens-Steen for heating processes/test processes … I think that was the only connection.

MS: Oh, okay. Uh, the heat exchanger element that you had at CMX, that was in the main building right?

DW: Uh …

MS: The main CMX building?

DW: Yeah, right.

MS: And I heard that later they had when they were really testing the fuel and target elements, that they had another building that was on the far end; a third building.

DW: Yeah, yeah we build something … in fact, I had quite a bit to do with that around … we built something and we called it a "cross-flow tank." That was the term.

Well what it was, the reactors are, were, still are running but they're large tanks, about sixteen (16') feet in diameter, about sixteen (16') feet high. They are filled with these several hundred, well it's about six hundred (600) fuel elements and heavy water ran down the inside and up around the outside where they acted as a moderator. As we kept doing things to increase the power of the reactors, we had to increase the flow through to the reactors. At one point we put in more exchangers in the reactors, bigger pumps and everything. So again there was concern about the vibration of this water on the outside crossing over the fuel elements because of something called common water seeps; when flow goes over a tube alternating vortex's break off and send the thing in vibration and … bridges have fallen down because of that instantaneous … there's Civil Engineers or Construction Engineers have ingrained in their education memory system that bridges have fallen down because of vibration of the suspension gauge. Well anyway we were concerned about that and so we built this tank, which was a full sized sixteen (16') feet tall but just a one-sixth (1/6) pie segment of the reactor tank. We just pumped flow through that and observed vibration and what we could do about the design of the fuel tubes to make them less resistant to vibrations.

MS: Uh-huh.

DW: Then we ended up … I mean as the time went on at CMX there are a lot of facilities; they're pumps and pipes and valves, all sorts of stuff. There's a lot property … as issues came up if initially running the reactors concern about the steam formation and that sort of thing. We could use the basic facilities we had at CMX to do a lot of little experiments with different things and I did a lot of experimental work in this cross-flow thing. The original purpose was for this cross-flow was to see vibration in these long and slender tubes. It turned out that it wasn't all that much of a problem but we were concerned about possible steaming of the tank and what affect that might have and I had included a number of experiments along that line.

MS: Hmmm, okay. Are those experiments still written up or are they accessible for the lab or within the archives?

DW: Yeah, I imagine, we wrote a lot of reports.

MS: I guess they must be.

DW: They're in a lot of uh … DPS Team Reports is what we called them.

MS: Yeah.

Interviewer2: Yeah. Who did you work with?

DW: Well for … you know, it's funny, I just happened to get a friend, well you might find you have this. This is an organization chart of the Savannah River Laboratory in December 1953; now I came in July so … okay it's called Pile … in the beginning we didn't call them reactors, we called them piles.

MS: Because of the original University of Chicago thing they did?

DW: Yeah, yeah, yeah.

Okay and there was the CMX … Fred Welty, he died, Fred Apple, Bob Kirkland, Al Peters, I think you mentioned him?

MS: Yeah, I talked to him yesterday.

DW: And my immediate boss at the beginning, Kurt Rohr, this was our … Jerry Beck and that's me so that's who I worked with.

MS: Oh, okay. Great!

Paul Dahlen, when I talked to him this morning, he said in the beginning, he didn't report to the laboratory he only reported to … at the beginning there was anything there but him, except for …

DW: That's it, that's probably right. That might have been one of the first things that was actually built.

MS: He said he had to report into Wilmington everyday on the phone.

DW: Oh yeah.

MS: And every couple of weeks he had to go up there and that was about it, he said that his initial office was in that big star-shaped building that they constructed there.

DW: Oh, the construction building up there at the … yeah.

MS: That's kind of original, huh?

DW: Yeah.

MS: What about the … I remember your mentioning the people that you've worked with.

DW: Yeah.

Interviwer2: That gives you a pretty good idea of the list here.

MS: How many people would have worked at CMX, all total?

DW: Well, there were … I guess, you know, at any one time there were probably, I guess on that list there from December, there are probably a dozen engineers. But then there was a staff of operators also and the operators were really from the reactor department, the sign there temporarily is … I guess it was an assignment to run all the pumps and all of the equipment, so there are probably another dozen or fifteen (15) operators. And then there was a maintenance crew that was really kind of a maintenance and construction crew that built a lot of stuff, you know welders and pipe fitters and that sort of thing.

MS: And uh, then the instrument techs and the electrical mechanics.

DW: So I don't know how many people were there in total, probably maybe fifty (50) or so I suppose altogether.

MS: What about the TNX group you had?

DW: I think it's about the same size, in fact, the operators were entirely separate … the CMX and TNX operators were from the so-called Separations Department, but the maintenance, the mechanical maintenance, you know, the pipe fitters, welders, the electricians and the instrument mechanics were sort of shared by both TNX and CMX.

MS: Yeah. What about … was CMX named for anything?

DW: No, my understanding was that the initials didn't stand for anything but it was from … both TNX and CMX were terms that had been used at the Hanford plant that they built in Washington state. I'm not sure if they were code or initials for any particular …

MS: Yeah, Paul Dahlen said that it didn't stand for anything, it was just a sign … although people named it stuff just because they had the letters there.

DW: Yeah, because, because … yeah.

MS: Corrosive Metal Experiment or something …

DW: Yeah, that wasn't it …

MS: I've forgotten what he said TNX stood for but it was pretty funny. Was there any short end term that was used to identify that area? One of the operators said that people there were known as the Swamp Rats.

DW: Well, I guess so because it was right down on the river and tech … we used to have a … at that time there was a lot of young guys hiring in and in the summer … well, there was a recreations … the ORA it was called, what that stood for was Operations Recreations Association; anyway they sponsored a lot of things like softball leagues in the summer and I remember and I think for three (3) or four (4) years we had one at CMX and we called ourselves the River Rats as a matter of fact.

MS: Oh, okay, all right.

What about … you know as far as … going back to the heat exchanger or the part of the heat exchanger that you built there, just to test it out in the beginning, how big was that?

DW: Well, let's see, the heat exchanges were actually, you know, built at the, I think they were made by the Foster-Wheeler Company, which is a big power plant. They were just hauled in and put in place there. Okay, those …the heat exchangers that we had were probably three (3) or four (4) feet in diameter and I don't know maybe twenty (20) feet long.

MS: And this … this would have been in the building or were they outside?

DW: Oh no, they were inside.

MS: They were inside?

DW: Yeah, yeah.

MS: So that was like the main part of CMX building would have been those things?

DW: Yeah, yeah and then there was a … it was sort of a … almost like a little miniaturized fluid flow mock-up or a reactor system. There was a tank in which … through which the heavy water was pumped and that was about, I don't know, five (5) feet in diameter I guess and twenty (20) or thirty (30) feet tall altogether and that was similar just hydraulically to the reactor tank except it was much smaller, they were only, probably sixteen (16) fuel positions … when I say fuel, there wasn't really any fuel in there it was jus the metal components that simulate the flow characteristics.

MS: Right.

DW: And then the heat exchangers were arranged opposite that so I don't well at any rate, it would almost look like a model, a pilots or pilot plants that would need the major heat transfer hydraulic components of the reactor system.

MS: Uh-huh, okay and uh, now if I understood this correctly, the reactor, the part that you mocked up for the reactor to go ahead and test the fuel, was that in that same building as well or …?

DW: Yes, oh yeah that was it … they were all together.

MS: I heard from somebody else, but this was a later period too, this may have been in the seventies ('70s) that they had a third building there in the CMX/TNX complex and that they built a one-sixth (1/6th) size …

DW: Well that's what I was talking about, that's the cross [inaudible, but probably "cross-flow tank"] thing that I was talking about.

MS: Oh, is that it, okay.

DW: And that wouldn't have been in the seventies ('70s) it would have been earlier, yeah in … probably right in 1960 I guess is when they built that.

MS: Oh, okay, okay.

DW: And that was the one-sixth (1/6) pie shape full scale for the reactors.

MS: David, if you wouldn't mind, just for my benefit, it you wouldn't mind just drawing a little sketch map of what CNX and TNX contained, as best you remember.

DW: Oh, okay. Now after I left, I was long gone when a lot more of this stuff was sent to TNX.

MS: I think that Dahlen said that when he was there that there were only two (2) buildings.

DW: Yeah, yeah, yeah; but eventually the reactor work there sort of petered out and I think that TNX had a whole lot of stuff put in just because the nature of the need for the for …

Interviewer2: I think by the seventies ('70s) …

MS: One of the people I interviewed they said that even the original CMX building, they had TNX offices in it.

DW: Probably so, I'm sure they did because there was no longer any need for …

MS: Right, the TNX sort of just took over a lot of the facilities.

DW: Well, I don't know if I can draw the … okay, let's see the guard house came in here, the fence went out here, came in here … here was a … let's see, this was sort of an old office building around here. In a high day area for CMX, went something like this. This would have been the office area. Then over here in this corner there was a boiler, it sort of stuck out the back here and then there was a big water treatment plant, there were big … what we call precipitators and big filters over here in which the … then the river and then way down here were pumps in the river; they pumped the water up here in this building, sort of to simulate the thing in the uh …

MS: You called that a high bay, right?

DW: Yeah, this was a high bay in here … a high bay. The ceiling was probably uh, must have been thirty (30), I don't know, thirty (30) or forty (40) feet, I guess.

MS: Uh-huh, okay.

DW: And this was just … these were just small offices here and what I call the converter, I don't know why it was called the converter but it was the little reactor model, was full height, was there and then the heat exchangers were sort of like belong here … I've forgotten, can't remember how many there were, seems like there were four (4), and so then there were a couple of big pumps here with pumped water into the heat exchangers and they'd come out and went into the top of the reactor and came out the bottom back into the pumps. There were a lot of little … because the facility was there for example, these pumps, we just pumped what we call natural water, the ionized water through the reactor … through our simulated reactor where in the reactor itself, of course, that would have been heavy water but the heavy water is very expensive, extremely expensive to make.

MS: So there's no heavy …?

DW: No, no, we didn't have any heavy water at all, but we simulated with the ionized water just because … so the heat transfer and fouling characteristics would be similar. These pumps had fairly well advanced mechanical seals on them which were similar to the mechanical seals on the much larger pumps which were going to be run in the reactors areas and that was part of what was being tested too, the pumps. We would then have valves in the system and again, in the detailed side it was very important that the valves would be leak-proof you know that the … they had that, I don't know if you are familiar with valves, put valves have, typical valves has packing around the stem so when it comes up and down the water doesn't leak out. Well that wasn't good enough for heavy water, it had to have more elaborated systems in the bellows and we would end up testing a lot of stuff up there. Then another technical area that CMX got into … CMX, where the reactors started up, the reactor fuel elements typically had many types through the years but in order … one of the good things about the design of the reactors was that under each one of these six hundred (600) fuel element positions there was what we call the monitor pins sticking up the bottom of the reactor and that could measure the pressure but also had four (4) thermocouples in it and the reactor fuel elements were uh, well either uranium or aluminum uranium tubes and we had to be sensitive to any … they were clad with aluminum but uranium was very corrosive even in pure water so the aluminum had to be very good quality and it there was any leak through a crack or anything the uranium would start to corrode badly, swell up and that could have been very damaging in the reactor so a long story here, but in order to detect any swelling or anything abnormal in the fuel elements, these monitor pins with the four thermocouples had a lot of design work that went into the components above those so that they were very sensitive to the sampling efficiency of the temperature coming out of the fuel. So there is a lot of work, there was some facilities that were built over here that we called them monitoring tanks, I don't know if you run across that, but there was a lot of experiment work with that.

MS: Hmmm okay.

DW: Okay, and then there was some more offices here and some other just kind of pedestrian equipment out here and then this building went down here and then the TNX building was over here then and I … I don't know, I'm a little vague on … things were always being rebuilt so that's what it was. I don't know if that helps you or not.

MS: Well it does, it gives me kind of an idea. When you say like a high bay are you referring to the interior height of the ceiling?

DW: Yeah. It is so you can put tall things in there and put cranes up above the tall things to put stuff down in it and so forth. Probably they have to be, they're probably over fifty (50') feet tall I guess because you had to have this so-called reactor tank was a good twenty (20') feet tall and you had to be able to clear it with something lifting over the crane that was fifteen (15') feet yeah so probably the building had to be at least fifty (50') feet tall.

MS: What was the big thing that you called the little reactor tank?

DW: We called that a converter.

MS: Converter, okay. I was trying to think if I'd ever heard of anything, but I can't think of it. I don't suppose that connection or any work with the reactor people in 777–10A?

DW: Yeah, well a little bit. We did …

MS: Oh, okay.

DW: … but most of that was development of what, I guess what I'd call the physics of the reactor, where the new trends were going and CMX was worried about the BPO's and the GPM's were going so but in a way there was sort of the two (2) parallel, you know, experimental pilot plant test, servicer reactors. You look at the reactor it is a machine that generates heat by nuclear energy but … fissions; and then that heat has to be removed by the flow of water and heat transfer equipment. So CMX was all about that side of the reactor, triple seven (777) was all about trying to predict what the new trends were going to do and …

MS: Right, right, yeah. This is kind of off the wall but I was just kind of curious, was there ever any work done at CMX about possibly converting the production reactors to power reactors?

DW: No, I don't think so. No really, because the heavy water … the production reactors were very low pressured, relatively low temperature, they operated in just essentially you had this pressure … you pumped the water up to 150 pounds just to push it through the reactor but it came out at a very low…

MS: Right.

DW: Where an efficient power reactor has to be up in the range of 2000, well different kinds, a couple thousand …

Now later on we built what was called a heavy water components test reactor tube, the Hector.

MS: Yeah. The shell is still out there.

DW: Yeah I guess they just covered it up and sealed it up.

MS: Yeah I think the inside has been gutted but the shell is still there rusting away.

DW: Yeah, yeah, well. Well that was to … of course the purpose of that was to see if there was some future use of a heavy water style of a power reactor.

MS: Yeah, uh, what about the … let's see I talked about the reactor tank and the fuel and heat exchanger elements or tanks that they had at CMX, how were each of those … just like in feet?

DW: You mean the heat exchangers or?

MS: Yeah the heat exchangers and then the little reactor bar, how big a thing are we talking about?

DW: Oh okay, what we called the converter was a long vertical tank that was probably about twenty (20') feet tall and that's what I was trying to remember … it went like this, maybe five (5') feet in diameter.

MS: Okay, okay.

DW: Stainless steel.

MS: Uh-hum.

DW: All of that stuff we … the plant you saw is stainless steel and I think nobody else in the country could get stainless steel, I've heard …

MS: I think you're right, I think I heard that some place.

Interviewer2: And the original heat exchangers?

DW: Okay they were … I'm trying to fix … they were horizontal, they laid horizontal … I think they were about, what's that, I'd say three (3') feet in diameter and probably at least twenty (20') feet; they might have been longer, they might have been full length, that is the same length as those in the reactors. They were tube in shelled, these exchangers that inside each was a close packed bundle of stainless steel tubes through which, what we called the process water, which would have been the heavy water in the reactor that went through the tubes and then the river water went through the shell side in a path of so-called cross-flow and every couple of feet there'd be a hole; it'd make the water flow like this or over this tube on the … it's very common.

MS: Right, right. What about the … when they were at or did they do any testing of slugs over at CMX?

DW: Yeah, well one of the things that was in this so-called converter would be actual fuel slugs because they are very heavy and there was concern about whether they'd ran over the flow and so we put them in there an run them for weeks or months and take them out and see if there's any damage to them if they had ran because again, we didn't want the aluminum to be worn through and …

MS: Right, the water turbulence and then dings to start …

DW: Right, right.

MS: So if that were the case if you were studying slugs like that then you were doing that kind of work there all year long?

DW: Oh yeah.

MS: Yeah, as soon as the reactors got going.

DW: Yeah, well part of the reactors going that was part of the idea.

MS: Right, yeah.

DW: I really, you know I was just out of school, I'm not sure I had the big picture but the idea was to have enough lead-time so if indeed we found some major problem with the design slugs or the fuel elements or something or the heat exchangers there would have been time to correct that without too much loss of you know power and start up dates.

MS: Right, okay; from what you remember, just in case this may have been done before you got there, what did … how did you all find out that Savannah River water didn't need to have any special treatment water in the [inaudible] exchangers?

DW: Well I think … yeah that might … the problem might have been fairly well identified but I think just from … see this system with the little … they eyes water pumping through one side of the river water was just rotten continuously and there was uh … let's see, how did we get the uh, I'm trying to think, we had a steam. Oh, there was a steam heater on the water that was separate which would be sort of a … it wouldn't have been a real mock up before it was a reactor … but there is a steam heater to heat the water that went into the converter and so that water was cooled by the river water so that the $D^{2}0$ or the ionized water, the one in the heat exchangers would have been heated and it was cooled by the heat exchanger, that is what was be simulated by the river water and we could have, you know, monitoring of thermocouples were sensitive, thermocouples to monitor the temperature opposed to … and every day we could calculate the heat transfer and determine whether there was any loss in the … and then periodically take them out and pull the tubes and what they'd look at to see if there were any. But it did turn out it was sort of, hey, lucky, lucky, lucky that Savannah River water does not do a bad job of fouling. That was a big …

MS: Yeah, but I was kind of surprised that when I talked to Dahlen this morning that he told me about the earlier CMX work they'd done at Hanford, I didn't remember it. He said that there they did have problem water and they had some kind of substance that got on the metal parts that came from the Columbia River but and they said they didn't expect that because the Columbia looked so clean and when they got to the Savannah River they thought that they'd really have a problem …

DW: Yeah because it looked so muddy.

MS: Yeah.

DW: Yeah, yeah, right.

MS: As if turned out it was the other way around.

DW: Yeah, in fact that experience was part of the big reason we went to all the trouble … Du Pont went to all the trouble of piloting this and built this facility, I guess, because they had been burned by the experience at hand. I was in high school then.

MS: Right, right.

DW: So I don't know.

MS: Yeah.

DW: No that's right.

MS: But then …

DW: There was some also, some … some smaller heat exchangers, which we had but we thought were the same or the Andale Heat Exchangers, I think was just the brand A-N-D-A-L-E, which we had sort of off to the side and we did sort of small scale testing of fouling … you know we tried to see, "Well, what if we increased the flow, and they had fast and higher velocities through the heat exchangers, would that make it better or worse? What if we decreased the flow? What if, for example, it shut down periods if the flow was low we could get fouling from that?" So we tried different things like that; in fact, if you remember, one summer it became …

MS: Andale?

DW: Andale, yeah. And those were just much smaller heat exchangers, you know, less than a foot in diameter.

I remember there was a bank right over here somewhere that I used to mess with those quite a bit but they were much smaller and they were easier to put in and out and we'd just maybe run those for a few weeks at a time. In fact, I remember at one point there was concern that one of the river pumps, big pumping stations at the river was going to be taking preferentially water from a tributary, which was just upstream called the Upper Three Runs Creek, and so there was some concern; well maybe that Upper Three Runs, you know we're sampling the mixed Savannah River water and did this Upper Three Runs Creek for some reason it would be worse so for a while we had – I knew it was a little bit of a goofy program but we had the operators driving pickup trucks over and pumping water in big tanks to Upper Three Runs Creek, it was too far away to run pipe and we'd just run them through these small heat exchangers to see if we can get some advanced indication of whether perhaps water in this creek has …

MS: [inaudible – cross talking]

DW: It didn't but we tried to do that.

MS: Right. What was the characteristic [inaudible] of Savannah River water that made it good, was it the silt or …?

DW: It doesn't really have a … I don't know, it has a lot of visible silt, you know, it's opacity is high, it looks the same, but apparently the minerals in it and so forth just weren't the sort of thing that would plate out on the stainless steel tubes and I don't really know enough about it to tell you what. I'm sure there is somebody, but I just don't know enough about it.

MS: What about … when you were working there, how many shifts did they have?

DW: Oh well when I first got there in the summer of fifty-three ('53) they still had some, in fact I think I started working for a few weeks coming in … round, round the clock shifts and just to run the stuff and take the data and analyze the data; but it really wasn't all that necessary and after a while we ran it. The operators would come in around the clock but we didn't have any engineers there on shift after I know the first couple of months after I was there. It wasn't really necessary.

MS: Right, uh-huh. Yeah because it seems like in the early days they were talking about have three (3) shifts there around the clock.

DW: Yeah.

MS: But by the seventies ('70s) I think they just had regular four-fifths (4/5) (floor shifts?) and they said if was different at TNX …

DW: Well by the seventies ('70s) I don't think there was anyone at CMX in the seventies ('70s). I don't remember how … I left CMX, I left Hector in about, well, sixty-two ('62) I think and I don't know that … I don't know how much longer that there was a staff. Let's see but there hadn't been shift work or engineers since 1953 I don't think. I mean sometimes, some special program would come in but there wasn't any regular staff.

MS: Right, I think that whatever they had … well, you may be right because by the early seventies ('70s) they pretty much had the, the reactor work figured out …

DW: Right.

MS: … so they didn't have to do too much in testing and the last thing they probably did was work on fuel and something easy; but by the seventies ('70s) they pretty much had that standardized and uh …

DW: Yeah, there still was a lot going on but there wasn't anything that the … an experimental program was the sort that you could do at CMX was uniquely capable of … in fact, we did build a reactor experimental facility, a heat transfer laboratory for example, up in the main 773-A Building, that would have been in the sixties.

MS: Sometimes I understand that this pretty much took over all of the, or a lot of the work that they used to do at CMX.

DW: It did, that's correct.

MS: Uh, what about the … now the question I was going to ask, I forgot. [long pause] It will come to me later.

DW: I'm sorry.

MS: What about uh … what was the typical day like at CMX?

DW: What was the day like?

MS: Or was there a typical day?

DW: Yeah. Well I remember early on it was hot as hell in the … we didn't have air conditioning in the early days and so the day shift, it was hot, the windows would be open a lot; a lot of earth moving in the area so a lot of flies and fleas, it was kind of miserable I mean you can … in fact, I remember bitching about it in the … and eventually they did put in a more modern air conditioning system. I remember … I have no idea of what year it was unless it must have, probably had been two (2) years after I got there or something that they put the stuff in. Bill Wahl who was the lab manager came down just before Christmas and thanked the tour showing the flag to everybody and he had already said something to me about, "Well, how is the conditioning?" or something like that looking around. I don't know as a young kid I must have gotten some notoriety here. But it was sort of uncivilized.

MS: It was probably pretty hot.

DW: But it was, you know, the CMX group was … as I said we had a baseball/softball team and we were called the River Rats and there was … it was … I really enjoyed working there. There was a lot of camaraderie and we were kind of isolated from much of the rest of the plant and laboratory, which was good and bad but we had an opportunity to do a lot of kind of practical things; working with mechanics. For example, if you wanted to build something there wasn't a lot of red tape to go through to get approvals of this and that and the other thing, but you could just go over and talk to a mechanic and say, "Let's put this over here and so forth." and a lot of kind informal, more informal arrangements for doing things that I think made it part … the good folks, I still have very fond memories of the people I worked with, not just the engineers but the … some of the mechanics and operators. This was a nice place to start my engineering career.

MS: Yeah that was probably true, just for the record, would you mind stating again when you started working there and when you left?

DW: Okay, I … started in the summer of 1953 just out of college and I left I think in 1962 sometime when I went to …

MS: That's when you went to work for Akron …

DW: Yeah.

MS: I was going to get that in case I didn't have it here. What about the …

Side Two

MS: We were talking about the possible involvement of CMX and the special programs that they did at Glenn Seaborg.

DW: Yeah.

MS: I think they got introduced into Savannah River Site back in the sixties ('60s)?

DW: Yeah.

MS: Well, this main thing was probably all after you left.

DW: Yeah but that … yeah, actually by that time I was out in Reactor Technology Department in the plant so I was involved with those programs from that standpoint. I don't recall that there was an awful lot of … I can't remember much testing work that would further require CMX to support those programs so there might have been … there might have been …

MS: Yeah, there was a little bit, I think Dave Muhlbaier?

DW: Dave yeah, okay.

MS: He told me about some … I mean he's got it on tape but there was something about the … whatever it was but they were making Californium and they were bombarding the substances to make Californium and it required a tremendous increase of the flow and the pressure and flow and everything through and around the fuel and the targets and they had to do special tests at CMX to see if they can …

DW: Okay, well that's probably right.

MS: … probably withstand all of that stuff.

DW: Yeah, yeah and I think that's right and probably uh, I guess there was probably work in this so-called cross-flow tank, because the … what we called the high flux charge didn't fill the whole reactor …

MS: Uh-huh.

DW: … there was just about one hundred (100) tubes in there and so the flow patterns in the … outside the tubes in there would have been different and that was probably the test that modeled at the cross-flow tank, which was built earlier so I think that's probably right.

MS: Now the cross-flow tank was where again?

DW: That's this pie shaped thing, yeah I never did, I should have …

MS: I was under the impression …

DW: I think that was in that third building that was all the way in back.

MS: Yeah, yeah, yeah, yeah it was, this would be … this would be TNX and the cross-flow tank was over here somewhere.

DW: Right, right.

DW: That's right … cross-flow. I'm trying to think … I'm trying to remember … I think we had to walk out here to get … I don't remember but there was again, this was a … I may not be drawing the shape right but there were some offices here or something too but this was a high bay area right here. Yeah, I did a lot of work originally there and Dave, Dave … I know Dave Muhlbaier, he must have been … he was probably there uh … after a while there was no longer and organization at CMX but people that worked in the 773 Lab had ran tests down there a so forth and Dave was doing that. He was involved with …

MS: Did they add this building when you were there?

DW: Yeah. In fact, I was involved in building this and designing the experiment.

MS: Oh okay.

DW: That was probably in the, I don't know if I had to guess I'd say fifty-nine ('59) was when this was built or something like that.

MS: So that would have been 1959; what was the name of this building again?

DW: It probably had some name; we used to just call it the cross-flow tank building … the cross-flow tank facility, I think.

MS: Let me spell this right here, cross-flow tank building right?

DW: Yeah, there might have been another name for it.

MS: So this would have come back to the basic CMX building you had and later, there were TNX offices in it?

DW: Yeah, yeah.

MS: But that's a CMX building, TNX and then the cross-flow tank building?

DW: Yeah, right, right.

MS: Then the three (3) buildings?

DW: Well then much later, or all I know those were torn down and …

MS: There right there now.

DW: Oh yeah, but even in the late seventies ('70s) and eighties ('80s) I have no idea what was there, really. I have no idea what was there really.

MS: I'm not … what I was doing about that thing, the Savannah River thing, I was concentrating on the reactors, I didn't concentrate on CMX and TNX but I think they were there up until apparently not too long ago.

DW: Oh really?

MS: I could be wrong.

DW: You know another feature I probably should have shown … I mean …

MS: I know in later years they had a number of other buildings that were added to the complex that were not there the first couple of decades.

DW: Oh, okay, because there was a lot of testing work related to the glass log of …

MS: Right, that's where TNX got involved in that … right, right, right.

DW: You know, I didn't think of this … but the river is down here and there is a pump house down there, which pumped water up here.

MS: Okay. How big were the pumps that they used?

DW: First about the size … I'm trying to think what the flows we had, uh … I don't remember. I mean the flow … the original flow of river water through each reactor was one hundred fifty thousand (150,000) etm (gpm?); that was being pumped up from the river in each reactor. I think it was like maybe twenty thousand (20,000) or something like that at CMX.

MS: How big would that have been?

DW: Those pumps?

MS: I mean size-wise?

DW: I don't know, those pumps were, well, those pumps would have been six (6') feet by four (4') feet; something like that.

MS: Oh okay, so it's not monstrous.

DW: No, no, not like the ones for the reactor, it pumped much higher flows.

MS: Did the uh … were they transferred, or I guess the got the new pumps and the reactors … those new Bingham pumps?

DW: Yeah.

MS: Did that … were any of those installed at CMX or they didn't need to mess with that?

DW: I don't think so, let's see, not the pumps themselves … that would have been in the sixties ('60s) I guess something like … uh, I mean that caused the flow though the reactors to be … that was the whole point to increase the flow through the reactors. Uh, I don't know if they added some pumps at CMX to simulate that and you know just do some of the same sort of test in higher … I don't know I lost track of it.

MS: Okay. Was there ever a problem with vandalism? Like coming off of the river? I know with some of the power plants for example they got the pump houses now, they have these big like shields to protect the transformers from people shooting at them from the river.

DW: Really? I don't recall anything going on like that. Absolutely I do not recall.

MS: All right, all right. Well, that's all the questions I can think of to ask.

DW: Okay.

MS: But if there's anything else that you want to add, please do so because that … my lack of questions is probably just related to my lack of knowledge.

DW: Yeah, well … no you've done a good job in drawing things out, I can't … I'm trying to think if there was any.

MS: I can't think if there was any program that was going on at CMX that I'd have … heard about but …

DW: I can't think of anything.

MS: It seems pretty clear by the time you got to CMX you were obviously taking orders from the lab.

DW: Oh, it was part of the laboratory organization.

MS: Dahlen was by this morning because I asked him about the lab and he said, "In the early days I only reported to Wilmington, there was no lab to report to."

DW: Yeah, I think that's right. I'm not sure exactly when that transition was, but I guess it was just in early fifty-three ('53) I imagine. I think when I checked in … you know I'd just got off the boat … you know Bill Wahl or someone I think I did talk with and everything was … you know the paint wasn't very dry or anything in that building as I recall.

MS: I can't think of anything else that I need to bring up but if there's anything else you can think of or, I know another thing. Were there any accidents or explosions? I know TNX had a couple of incidents.

DW: Yeah, yeah it did. I think just before I got … we had this little boiler and … the thing that made some steam for the fuel oil, it made steam to heat the water we could run through the heat exchangers, we had steam like going over to TNX also to furnish them with steam and I think before I got there that boiler had blown up once; I heard stories about that and then I remember the lighting of the boiler was a little exciting for us. Mostly it ran all of the time but I remember I had to learn how to light it. Let's see, you let it by a torch that you ran over a port hole, you opened the port hole and you'd light this torch which was some wadding on the end of the long poles and stick it in there and you had to stick it in and turn on the oil at just the right time. If it got in there too late there'd be too much oil in there and that's what happened when it blew up. I don't think there was anybody hurt; the boiler was sticking out of the building in the back.

MS: You're talking about CMX, right.?

DW: At CMX, it was at CMX.

MS: Okay, right.

DW: What I remember was you had to get the torch out of there and to put the flame out you'd dunk it in a barrel of oil, which there was a pail of oil setting there and you'd dunk it out it down into there which always seemed a little counter-intuitive to me but that's the way you did it. That's the only uh, I think that there was an evaporator explosion at TNX at one time; I don't think anybody was hurt in that. Usually things like that would … you know you'd provide for the possibility as far as getting, you know, somebody injured as opposed to just equipment damage.

MS: When you had something like that, you know, a boiler blow up at CMX, what were the repercussions; did you have like people come from the lab to …

DW: Oh yeah, no, safety was a big deal. In fact, I remember at the … over at the cross-flow tank, I was sort of embarrassed once in that, I had built a little tank next to it for some reason, I can't remember what that was all about; to simulate some steam development in the reactor and I had a Plexiglas window in the bottom of it and I had some big heavy power [inaudible] around it because I was afraid something might blow out. Well anyway, it overheated and the Plexiglas window, I shouldn't have been using this

Plexiglas, blew out – booom! – big … and I was extremely embarrassed and subjected to a detailed safety inspection that's a all a safety … not inspection but a investigation and a, I don't know, we'd have people come from other parts of the plant, you know, took it very seriously. I worked for many years after I left the plant in the … as a consultant in the initial powering district and that sort of basic training or learning I guess on my part about the process safety I got at Du Pont served very well on that. Du Pont has been a model for industry as a whole for processing. In fact, that's how Du Pont got involved in the first place.

MS: Uh-huh, yeah.

Yeah come on in, yeah.

Female: Excuse me we had to get …

MS: Turn this off.

MS: Okay, what were we talking about?

DW: Safety and safety … how we used to do safety inspections and any kind of an accident or near miss would be a safety investigation a major part of the culture which was good.

MS: Yeah, I think so, I think that does sound as though Du Pont really took safety serious and that, uh. What about, talking about safety though, what kind … did you have regular safety meetings at CMX?

DW: Oh yes, sure and again as a young buck that was … we would have monthly safety meetings this little crew at CMX would get together and we'd have … typically the plant laboratory would have some safety engineers and they'd give us a little lecture on something or a demonstration on this or that or another thing. They say it was an education for a young crew of engineers to just get indoctrinated pretty deeply in safety culture.

MS: Yeah, uh-huh.

DW: So that was … I don't think it's a waste of time at all, pretty good.

MS: Also, just for the record too, if you wouldn't mind; where were you born and when?

DW: I was born in Joliet, Illinois in 1930.

MS: Okay.

And where did you go to school at?

DW: I went to the University of Illinois and I got a bachelor's degree in mechanical engineering in 1953 and my wife was a … graduated the second year, we were married and came down here and been here every since, fifty-two (52) years.

MS: Wow! That's great. Well that's all I can think of to ask at this point. If there's anything else you want to add but uh …

DW: Okay, no I think that's.

MS: If I have any other questions, if you don't mind I might give you a call.

DW: I'd be pleased to help you in anyway.

MS: Okay, great. Well I'm going to go ahead and shut this off.

END OF INTERVIEW