A nuclear-free land for Kennewick Man

John Asmus
University of California San Diego, Department of Physics (0319), 9500 Gilman Dr, La Jolla, CA 92093-0319 USA

ABSTRACT

In 1964 a human skeleton was discovered in the sediments of the Columbia River near Kennewick, Washington (the extreme northwest portion of the United States). Subsequently, these bones were analyzed in several scientific laboratories and dated at more than 6000 years BP. Now known as "Kennewick Man", the remains are associated with the "Clovis Period" and, indeed, a Clovis spear point was discovered imbedded in the bone of the pelvis. Equally significant were DNA results indicating the individual was of Caucasian racial origin. Consequently, this sensational archaeological discovery stimulated widespread debates concerning the populating of the Western Hemisphere: the migration routes, the eras of the waves of migration, and the peoples involved. In spite of the enormous historical and cultural significance of the Kennewick find, contemporary Native American Indian Tribes (Nez Perce, Umatilla, Yakima, Wannapum, Colville) prevailed in the courts and were awarded the bones for a "dignified" and "sacred" reburial on the Columbia River bank at the discovery location. Whereas this reburial may have been culturally sensitive, it was both dangerous and imprudent. The internment site is only a short distance downriver from one of the most contaminated nuclear repositories in the world. The Hanford Nuclear Reservation has twelve shutdown atomic reactors that were constructed almost seventy years ago and built for the production of plutonium. The facility also encompasses five chemical-processing complexes for the extraction and refining of plutonium. During the past few decades many of the reactors, as well as their single-wall waste storage tanks and ponds, have deteriorated and have been leaking radioactive and toxic-chemical waste into the local aquifer. This contaminated ground water has been seeping ever closer to the banks of the Columbia River and the resting place of Kennewick Man and other associated (yet to be found) artifacts. Without remediative steps the toxic flow will continue past Kennewick to threaten cities such as Portland with a Chernobyl-like tragedy. Consequently, a remediation program was initiated to drain the leaking tanks and ponds so that the toxic wastes could be buried elsewhere and/or transferred to more secure double-shell reservoirs. Unfortunately, hazardous substances adhere to pores and corrosion on the vessel walls after draining. This poses problems when disposing of refuse materials and hardware from the site. It has been experimentally determined that this hazardous surface contamination may be ejected by means of radiation ablation. It was concluded that this is most effectively accomplished with underwater flashlamp irradiation. In this manner the dislodged surface contamination is freed to float in the water and is then captured and concentrated by the filters of the fluid circulation systems. The final phase of the project was assistance in designing a Stonehenge-like monument to celebrate the cleanup of the Hanford Reservation and the removal of the radioactive threat to the final resting place of Kennewick Man ("The Ancient One").

Keywords: Decontamination, ablation, flashlamp, nuclear waste, Hanford, nuclear reactor

1. HISTORY OF THE HANFORD NUCLEAR WORKS

The USA's nuclear weapons program known as the "Manhattan District" was established shortly after Prof. Albert Einstein wrote to President Franklin Roosevelt regarding the technical feasibility of an atomic bomb. The Los Alamos Scientific Laboratory (LASL, then LANL) was established to design and fabricate nuclear weapons. The Oak Ridge facility was established in order to refine uranium in order to concentrate U235 for uranium gun-design devices such as Little Boy. The Hanford Works facility was established in Eastern Washington State in order to produce plutonium (Pu239) for the Fat Man Implosion weapon. Figure 1 shows representative views of Hanford and the Columbia River in 1960 (left) and a modern enclosed reactor in 1990 (right). A schematic diagram of an enclosed and shielded reactor appears in Figure 2 (left) and a photograph of an open reactor core pool is seen in Figure 2 (right).

O3A: Optics for Arts, Architecture, and Archaeology III, edited by Luca Pezzati, Renzo Salimbeni,
Proc. of SPIE Vol. 8084, 808402 · © 2011 SPIE · CCC code: 0277-786X/11/$18 · doi: 10.1117/12.883011

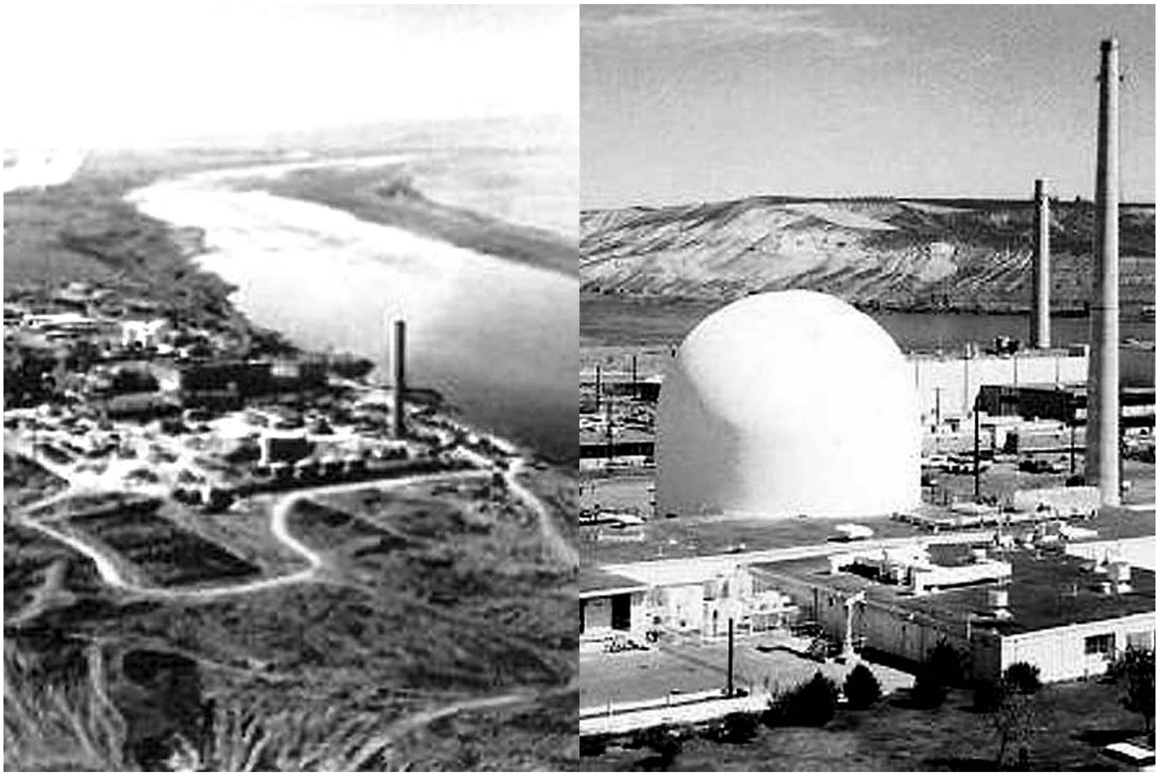

Figure 1. Aerial view of a Hanford nuclear reactor site in 1960 (left) and a modern enclosed reactor (right).

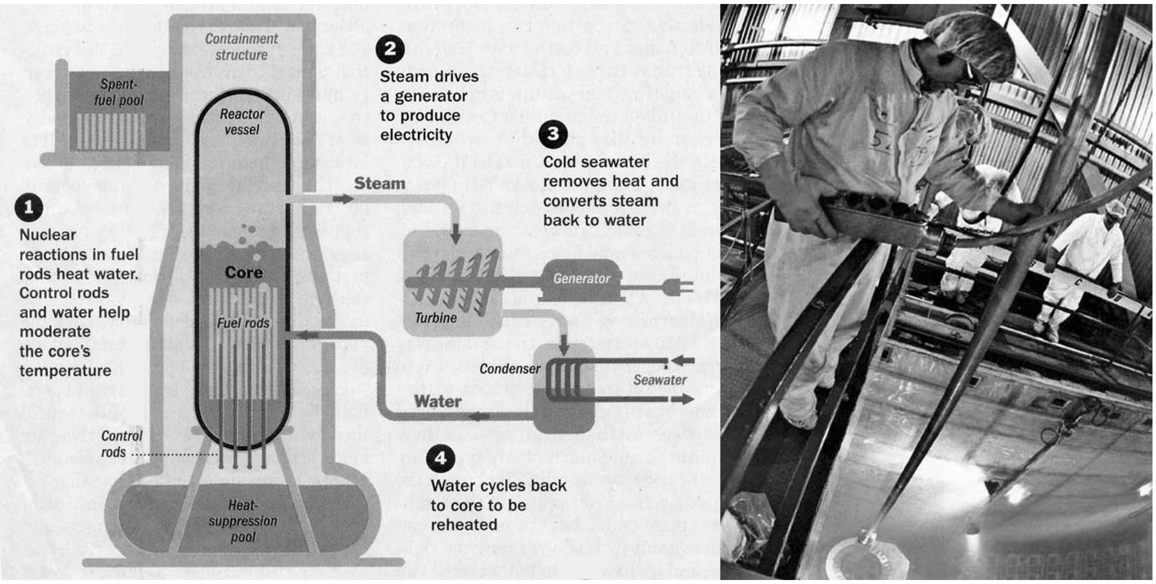

Figure 2. Schematic diagram of a water-cooled power reactor (left) and a view of an open reactor fuel-core water pool at Hanford (right).

2. HAZARDOUS RADIOACTIVE CONTAMINATION AT HANFORD

When the Hanford nuclear reactor facility established and expanded throughout the 1940s and 1950s the long-term storage and disposal of radioactive waste was not recognized as a significant problem. With the enactment of the SALT Treaties and by the end of "The Cold War" tensions it was recognized the Hanford Reservation was no longer needed. When plans for its closing were drawn and assessed, it was established that very serious nuclear waste decontamination and disposal issues had to be confronted[1].

Major activities associated with the closing of Hanford first centered on disassembling the reactors, the chemical plants, and the waste storage facilities. Radioactive parts and assemblies were to be transported across state boundaries to the Yucca Mountain long-term underground storage caverns in the western wilderness of the state of Nevada. However, a number of developments conspired to obstruct this plan. First, was a political impasse. The citizens of the State of Nevada objected to the importation of dangerous toxic substances into their state. Second, was a related financial problem associated with the preparation and transportation of a prodigious mass of contaminated materials. Finally, it was discovered that significant quantities of radioactive wastes were leaking from storage containment vessels and ponds into the soils and aquifers beneath Hanford (Figure 3). It was discovered that the liquid wastes were seeping toward the Columbia River. Upon reaching the river, the contamination would next be swept on to the extremely important Kennewick archaeological dig, which may hold secrets of the human migration to North America. Major population centers such as Portland and Vancouver are further down stream, and, together with Kennewick, may have to be evacuated as in the cases of Chernobyl and Fukushima. Consequently, funds that were destined to close Hanford and move the nuclear wastes to Nevada had to be redirected toward the prevention of the radioactive polluting of a major river. This entails moving the wastes to more secure newer double-shell reservoirs, decontaminating the old containment facilities, and stopping the underground seepage toward the river.

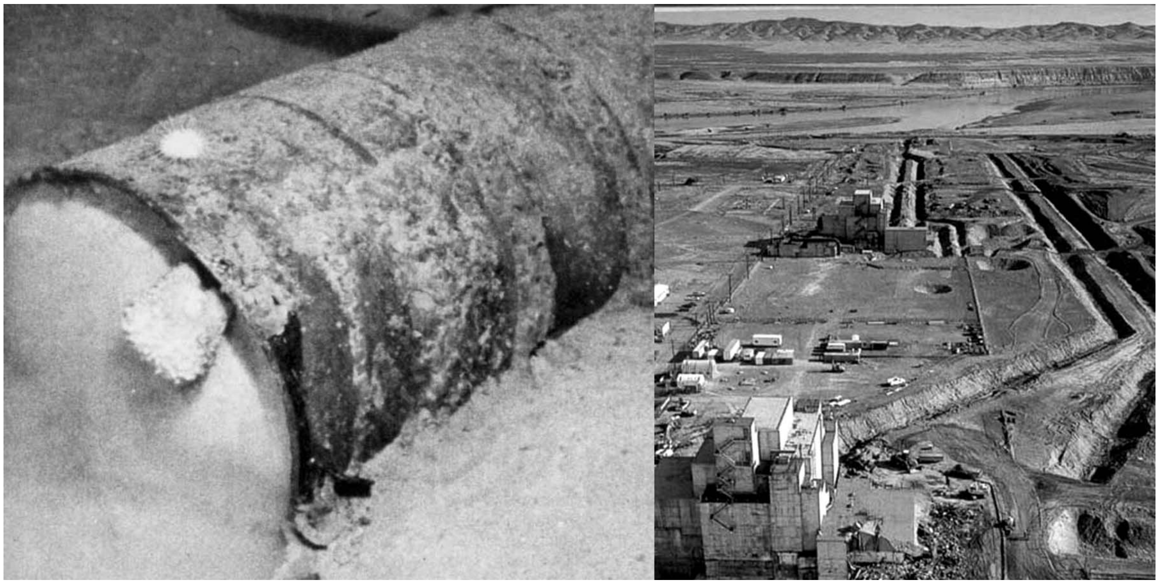

Figure 3. A corroded and leaking nuclear waste storage drum (left). Hanford nuclear reactor and its earthen waste drainage ditches with leaking liners (right).

3. NUCLEAR REACTOR ACCIDENTS

Human errors, natural events, and engineering deficiencies have also led to the spread of hazardous radioactive contamination (Figure 4). A portion of the Hanford problem has been traced to the accidental opening of a valve that drained radioactive and toxic chemicals directly into the aquifer. This tragedy was exacerbated by the tardy realization of the human mistake. Apparently, the Chernobyl disaster is traced to a similar human error. The Fukushima explosion and partial meltdown can be attributed to the natural catastrophe (earthquake and associated tsunami) and/or to an inadequate engineering safety margin and emergency safety plan. In any event, all require major decontamination efforts for the safety of the human populations as well as to return the local environments to habitability and productivity.

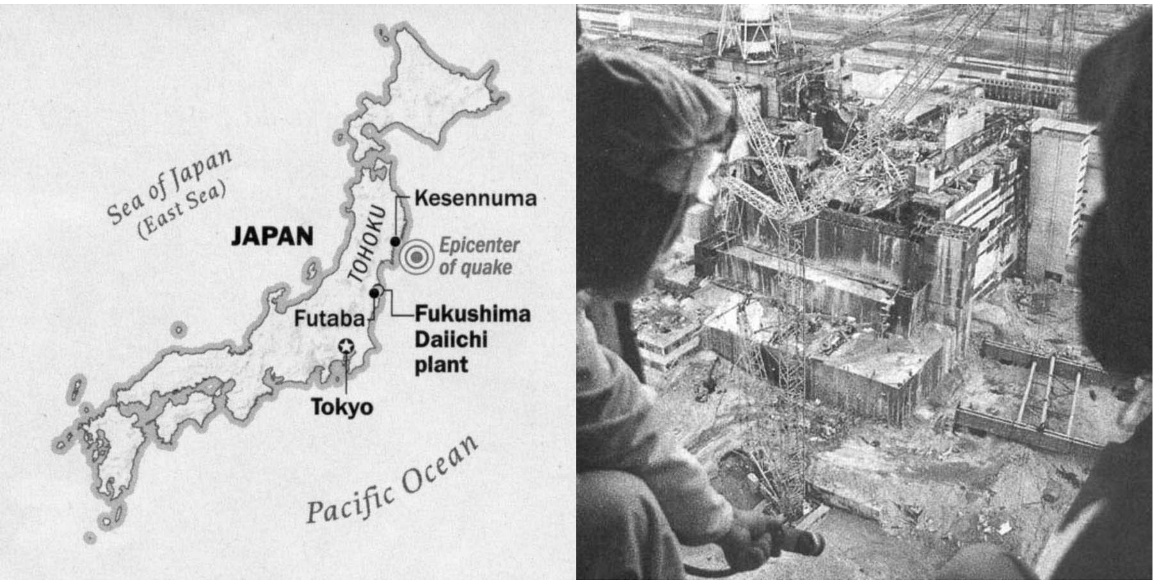

Figure 4. Map showing the location of the Fukushima nuclear power plant accident (left). Aerial view of the destroyed nuclear reactor at Chernobyl (right).

4. KENNEWICK MAN DOWN STREAM FROM THE HANFORD SPILL

Traditional salmon fishing as well as Kennewick-Man site archaeology take place along the banks of the Columbia River (Figure 5) immediately to the south of the Hanford Nuclear Reservation and are endangered by encroaching toxic waste.

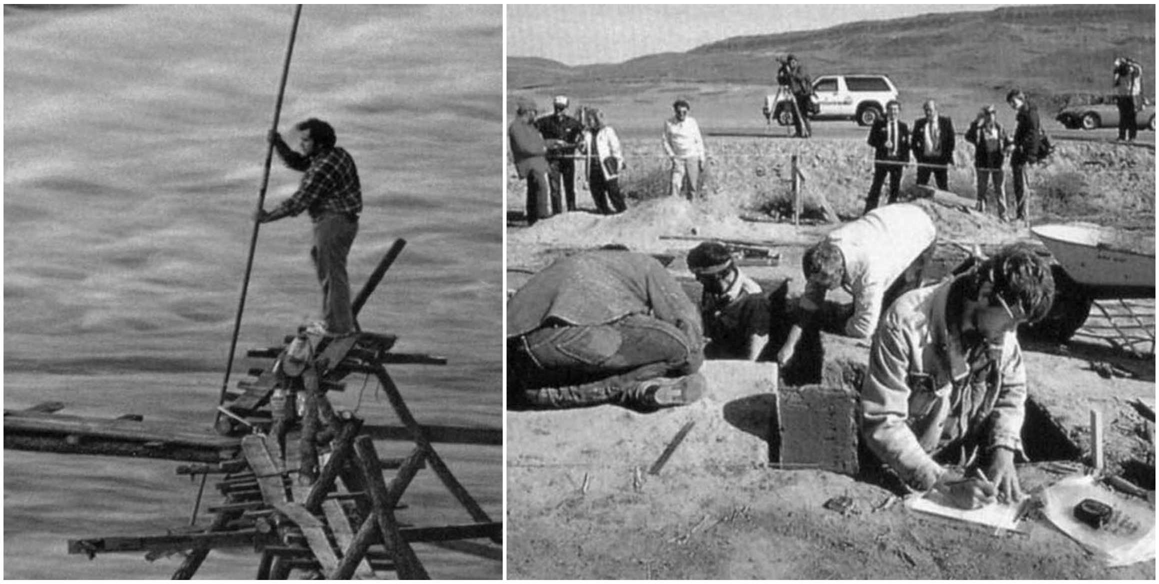

Figure 5. Traditional Native-American fishing (left) and Kennewick archaeological site (right) below Hanford.

In 1966 the skeletal remains of a 9,300-year-old Caucasian male were discovered on the shore of the Columbia River near the town of Kennewick, Washington. The skull (and bones at a later time) was discovered by two college students while watching hydroplane races. The office of the Benton County Coroner determined that the skeleton was not the result of a contemporary homicide, but was the consequence of the natural death of an "Ancient One" at least 9,200 years earlier. The remains of this five foot ten inch male (1.8 meters) were determined to be 90% complete and are among the oldest ever found in North America. Further, a two-inch (5 cm) "Clovis" spear point was found imbedded in his pelvis. The bone exhibited signs of healing indicating that he had survived a hostile attack. Photographs of the "Kennewick Man" skull and "Clovis" spear points are reproduced in Figure 6.

Figure 6. The skull of 9,300 year-old Kennewick Man (left). Very high quality "Clovis" spear points from the era of the Kennewick Man (right).

Predictably, the discovery of Caucasian remains that predated the earliest Asian remains found in North America turned asunder the generally accepted theory of the human migration across the Siberian-Alaskan land bridge at the end of the last Ice Age. The discovery of the Caucasian Kennewick Man seemingly lent support to theories postulating that seafarers who originated in or near Europe initially populated North America. Nevertheless, Native American Indian tribes (of Asian origin) claimed Kennewick Man as an ancestor and requested custody of the remains in order to perform a traditional religious burial. This issue became the subject of a court battle between anthropologists who desired to learn all they can about the relic and the U.S. Army Corps of Engineers (owner of the Columbia River shoreline at Kennewick) wanting to have it reburied in accordance with tribal wishes in order to put an end to the controversy. The local tribes (Umatilla, Nez Perce, Yakima, Wannapum, Warm Springs Nation, and the Colville Nation) maintained that the skeleton should be reburied without further study. They had no explanation as to how their "ancestor" could be Caucasian.

At the heart of this controversy is the rewriting of American pre-Columbian history. Consequently, a group of Anthropologists joined in the lawsuit in 1996. This caused five of the Indian tribes to fight the anthropologists in court contending that the repatriation law covered Kennewick Man, and that scientific examinations disrespected Native American beliefs about the sanctity of their dead (Figure 7). In 2002 Judge Jelderks ruled in favor of the anthropologists. The U.S. Ninth Circuit of Appeals upheld that ruling in 2004. Subsequently, the relics have been placed in temporary storage in the basement of the Burke Museum. Twenty-two anthropologists have studied the skeleton and have performed thousands of measurements by means of radiocarbon, MRI, and DNA. It was determined that he died in his 30s, but not from the spear wound. In light of the ongoing litigation and the possibility that remains of the Kennewick skeleton will eventually be reburied (especially because the bones have already been studied so extensively) it is imperative to decontaminate Hanford before radioactivity reaches the burial site and other relics yet to be found.

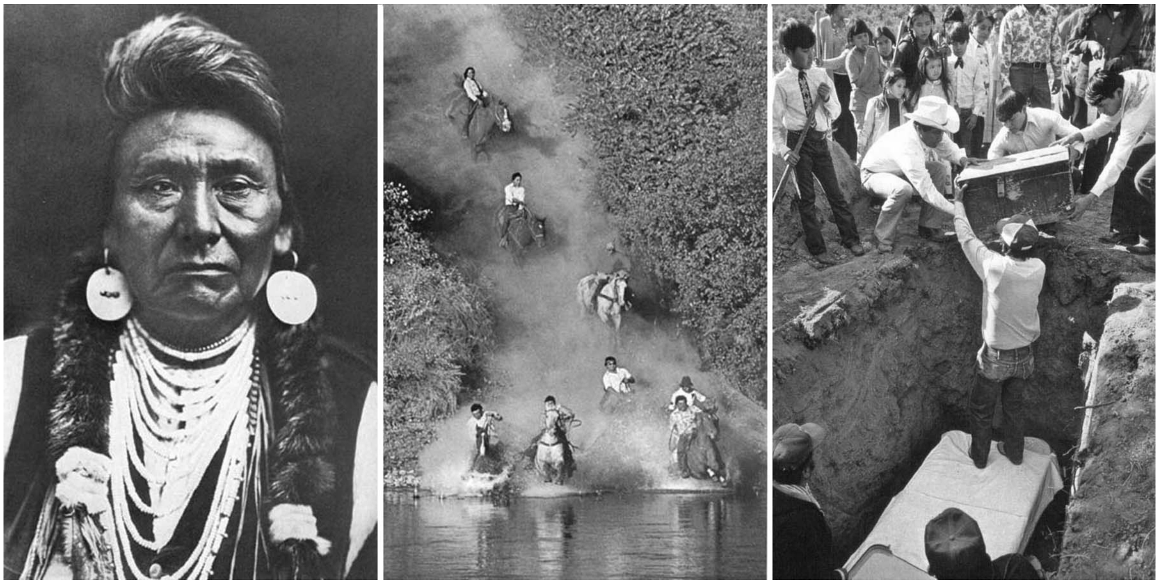

Figure 7. Chief Joseph of the Nez Perce Indian Tribe (left). Present-day Indian Warriors demonstrating for the return of Kennewick Man to Indian custody (center). Reburial of an ancient Native American body near the Kennewick site on the Columbia River (right).

5. FLASHLAMP ABLATION OF NUCLEAR CONTAMINATION

The disassembly, cleanup, decontamination, and decommissioning of the Hanford facility is an enormous task in its entirety. Soils and groundwater are polluted with radioactive isotopes and toxic chemicals, as are chemical processing plants, chemical handling equipment, and storage areas. Contaminated nuclear reactors together with spent fuel, fuel cores, and water-cooling and moderating systems present a wide range of technical and logistical cleanup issues. If large, heavy, and bulky equipment can be economically cleaned, only the concentrated hazardous waste substances will require expensive transportation to, and long-term storage in, secure facilities such as Yucca Mountain.

There are several advantages of light ablation surface treatments over conventional stripping and cleaning techniques. Some of these are inherent with the technology and benefit any suited application. Other advantages are specific to the area of radioactive contamination removal and relate to special problems faced at the Hanford site [as well as other U.S. Department of Energy (DOE) and commercial nuclear facilities]. Optical radiation ablation is favored in numerous surface-divestment applications due to inherent self-limiting and selectivity features. However, in nuclear decontamination the most profound advantage may be in cost reduction through secondary waste reduction. No abrasives or significant volumes of liquids are used. Further, at high optical irradiation fluxes most toxic organic waste chemicals are destroyed and converted into innocuous gases, and no additional secondary waste is formed. Figure 8 (left) shows, as an example, the flashlamp removal of contaminated rust from a steel beam. Figure 8 (right) is photograph revealing flashlamp divestment of a contaminated crust from concrete through radiation spallation (under water). Figure 9 presents measurements of the rates at which high-power flashlamp radiation ablates the contaminated surfaces of materials encountered vessel water-moderated reactor vessel walls. Flashlamp, rather than laser, radiation was employed in these investigations due to the enormous areas to be processed and the over riding importance of cost effectiveness.

The following specific problem areas at Hanford have been identified for possible application of flashlamp ablative decontamination[2].

1. Cell wall decontamination. Waste Encapsulation Storage Facility (WESF) cell decontamination prior to transuranic (TRU) monitor test installation. The purpose would be to reduce gamma background to prevent interference with neutron detection instrument testing and operation.

2. Cell decontamination. The Reduction Oxidation (REDOX) Plant is scheduled to be the first canyon building onsite to undergo complete decontamination and decommissioning. The B Plant may also require limited cell decontamination in the next few years to accommodate WESF support operations. The areas to be

decontaminated include the tank exterior surfaces and cell walls. This will involve both paint stripping and concrete spalling.

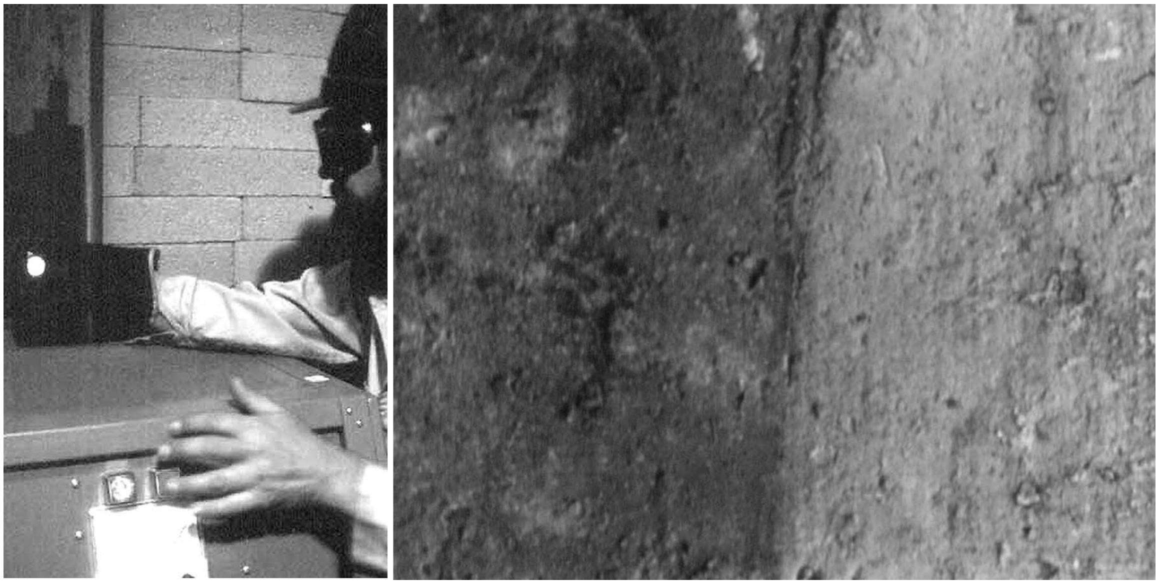

Figure 8. Xenon flashlamp of surface ablation in air of contamination on a steel beam (left). Concrete surface contamination on left and flashlamp divested region on the right side (right).

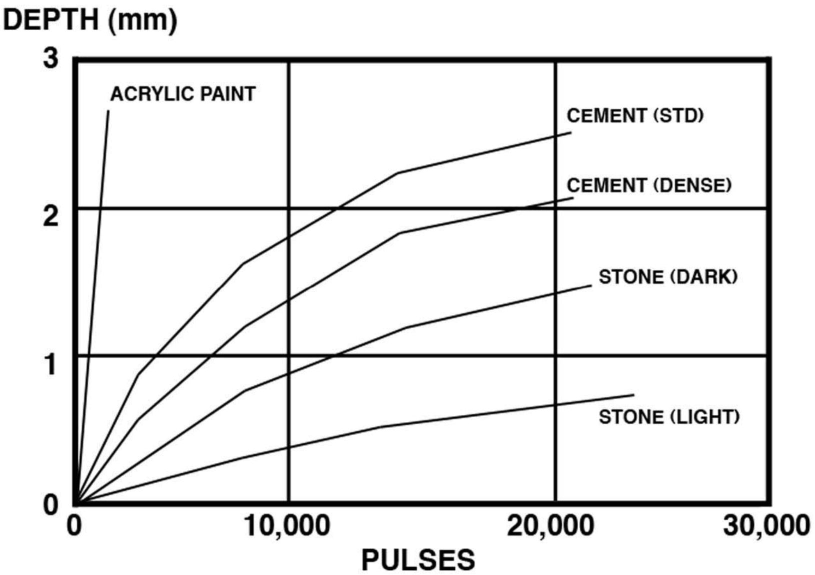

Figure 9. Experimental flashlamp ablation rates for the materials of nuclear reactor fuel water pools at an incident underwater optical flux of $8J/cm^2$.

3. Double-shell tank waste retrieval pumps and equipment. After water or chemical flushing the interiors of the pipe and pumps, the exterior may be irradiated to further reduce exterior contamination and corrosion.

4. Hot-cell and glove box laboratory instruments.
5. Lead brick shielding used in laboratories, hoods, canyons, and cells that have developed corrosion films that have collected radioactive surface contaminants, characterizing these as mixed wastes.
6. Fast Flux Test Facility (FFTF) equipment maintenance.
7. Heavy equipment / Field operations
8. Cesium source capsules.
9. Single-shell tank clean-out equipment.
10. Core sampling equipment.
11. Maintenance tools.
12. Organic destruction. Destruction of complex concentrated organics from the thin-film reactor process.
13. Repair of hot-cell electrical equipment that is intolerant to water/acid/salt decontamination.
14. Fuel / Capsule storage pools.

As most of the decontamination operations listed above are favorably performed under water (in order to contain the ejected contaminants), submerged flashlamp irradiation experiments were performed. Figure 10 (employing laser, rather than flashlamp ablation for photographic clarity) reveals how optical irradiation under water constrains the blow off plasma. Figure 11 demonstrates that performing the optical ablation underwater enhances the strength of the impulse over that generated in air. Further, underwater ablation facilitates capturing the contamination in the water so that filtration systems readily collect and concentrate the radioactive waste.

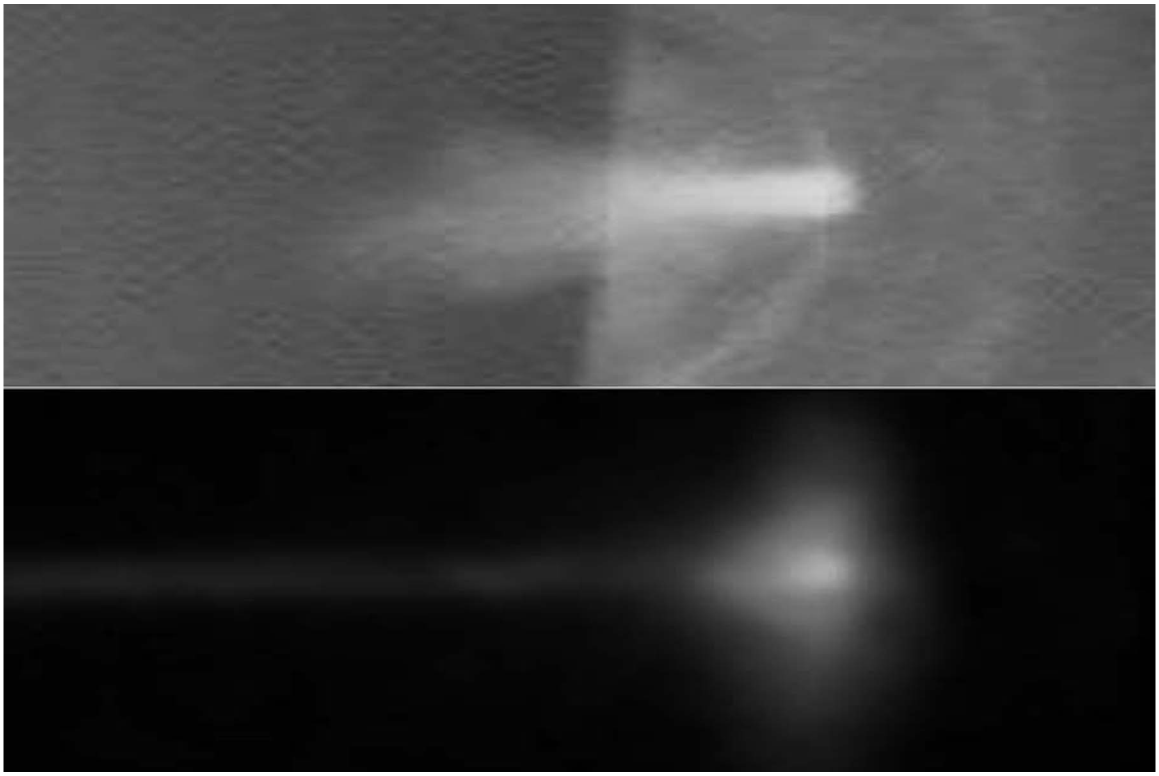

Figure 10. Blowoff plasma luminosity from laser irradiation (1.06µm, 250µs, 8J/cm^2) of concrete in air (top) and underwater (bottom).

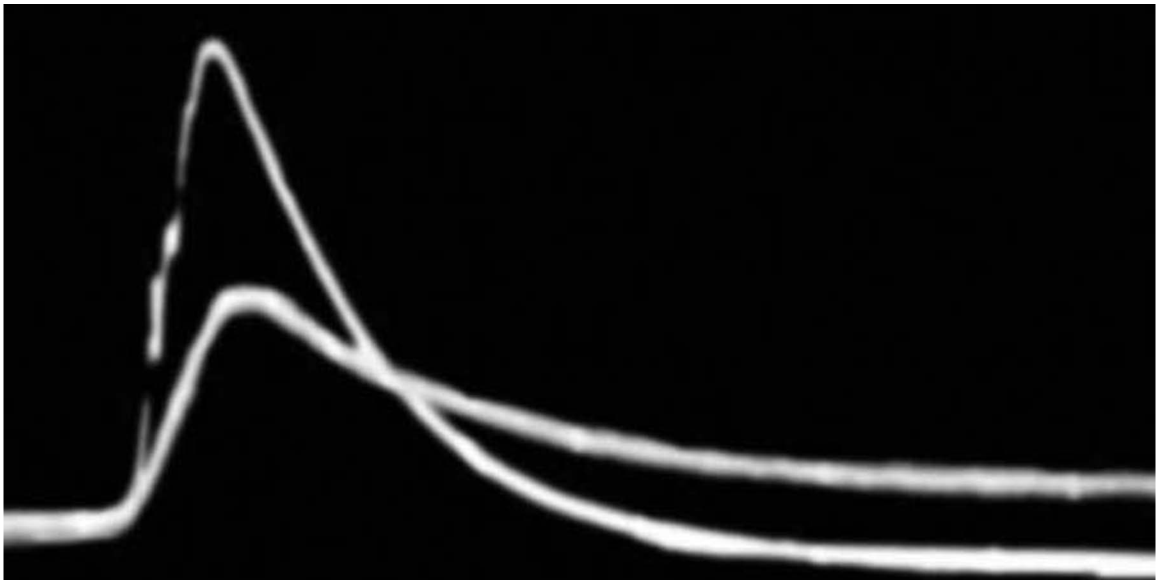

Figure 11. Impulse from laser irradiation of acrylic surface in air (lower trace) and underwater (upper trace).

Figure 12 shows a prototype underwater flashlamp ablation system in operation at a reactor fuel cell pool.

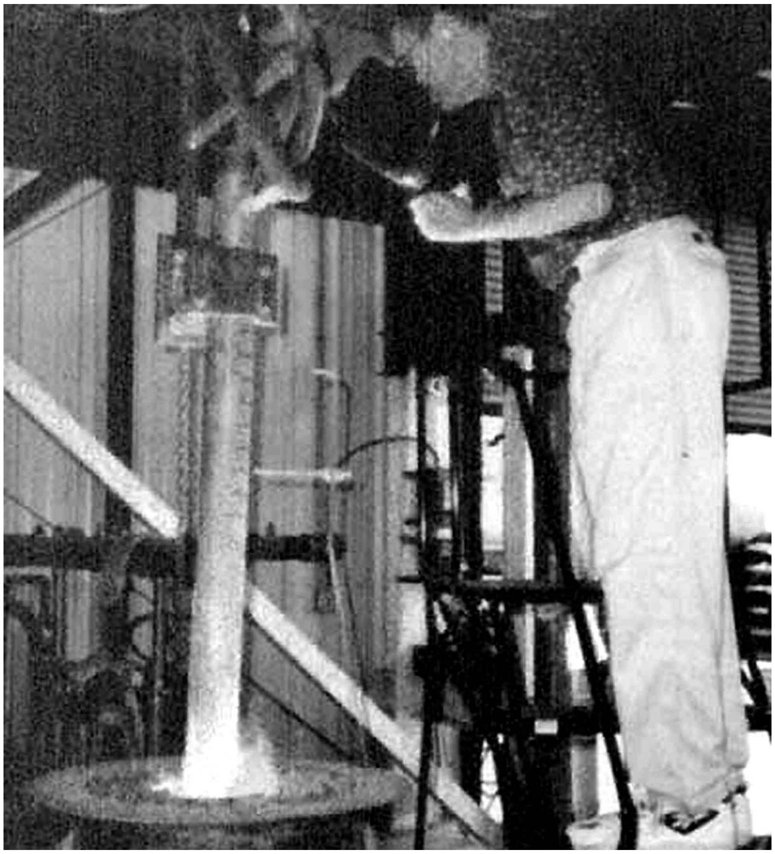

Figure 12. Observing the flashlamp ablation process taking place within a nuclear reactor fuel core water pool.

The technologies (including flash ablation) to cleanup the various contamination zones at Hanford have been developed and tested. Unfortunately, radioactive seepage and migration continues as the political roadblock to the use of Yucca Mountain for long-term storage remains unresolved. However, as the radioactive contamination threat to high population areas grows, a political accommodation must be reached.

6. THE FUTURE OF ANTHROPOLOGY AT THE KENNEWICK SITE

Radioactive seepage from Hanford will reach the Kennewick region in a few decades if the present advance rate continues. At that point millions of inhabitants in Portland, Vancouver, and smaller cities will face evacuation as in the case of Fukushima disaster. Of course this prospect will break the political impasse and a site will be selected to receive the Hanford waste and the radiation ablation decontamination of the facility will proceed in haste. The excavation of the area around the Kennewick Man discovery will proceed and the anthropological mystery of the populating of the Americas may be resolved through acceleration of the ongoing investigations (Figure 13).

Figure 13. Ongoing study of anthropological specimens extracted from the Kennewick site.

REFERENCES

[1] U.S. Department of Energy, "Disposal of Hanford defense high-level transuranic and tank wastes," Public Document, DOE/EIS-0113, VOL. 5 (December 1987).

[2] Westinghouse Hanford Company, "Light Aided (Laser) Decontamination," Westinghouse Document, WHC-SD-WM-TI-518 (1992).