

Becoming Jane: The making and unmaking of Hanford's nuclear body

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Abstract

This article examines the politics of permissible exposure in American nuclear remediation. At its heart is Washington State's Hanford Nuclear Reservation, the nation's largest and most expensive nuclear cleanup effort. According to Superfund regulation, nuclear landscapes are considered remediated once acceptable carcinogenic risk levels have been met. The challenge of remediation, then, is to measure and manage the conditions of carcinogenic encounter—titrating environmental contamination with human activity to achieve the appropriate balance of permissible dose. In this article, I follow the genesis and development of “Jane,” a future human designed for life in post-cleanup Hanford. Jane embodies a distinct set of regulated movements and activities, each specifically calculated to ensure legal compliance within the terms of acceptable risk. In tracing Jane's genealogy, I examine the history of radiogenic science and the official making of nuclear safety. Next, I discuss the efforts of two local Native American tribes to craft their own future human template, a standardized indigenous body designed for use in Hanford's remediation planning. Rejected by federal regulators, the indigenous body is framed as Jane's constitutive outside, remediation's unthinkable subject. As such, I consider how cleanup efforts seek to reconstitute life itself—formalizing a new baseline from which to evaluate the boundaries and biologies of post-nuclear existence.

Keywords

Hanford Nuclear Reservation, nuclear body, remediation, exposure, radiation protection standards

Introduction

Jane rises at 6:00 a.m., after an exact 8.00 hours of sleep. With the practiced ease of repetition, she stretches, yawns, and walks to the bathroom in the soft morning darkness. Stepping onto the bathroom scale, she watches its digital screen blink once, then twice, radiating dim green light around her ankles. After the third blink, it registers her weight—70.00 kilograms—just as it has every morning of her adult life. She nods with satisfaction.

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A disciple of numbers, Jane measures and calculates her every action with devoted precision. When working outside, she makes sure that no more than 5700 cm^2 of her skin is exposed to area soils and she maintains a breath rate of $0.63\text{ m}^3/\text{hour}$ as she moves. Her caloric intake is equally deliberate, calibrated in weekly intervals. She consumes exactly four pounds of meat, 14 eggs, one pound of fish, two gallons of milk, and three pounds of fruits and vegetables every seven days. Each night she takes a bath, making certain that $18,000\text{ cm}^2$ of her skin is submerged for precisely 34.8 minutes. Then she retires to bed at 10:00 p.m. and is immediately asleep.

Jane is a member of a community that lives within the pages of the U.S. Department of Energy's *Human Health Risk Assessment* for the Hanford Nuclear Reservation (DOE, 2010). She is part of a subpopulation of future humans that make their living as subsistence farmers on remediated nuclear industrial land. Though currently residing on paper, she plans to engage in on the ground activities immediately following the successful remediation of the Hanford Site. Once settled, she and other exact copies of herself will abide by federally approved practices for ensuring human health and safety—regulating their breath, sleep, eating, drinking, bathing, and ultimately, their exposure—for the next ten thousand years.¹

Extreme regulation of the future human is necessary at Hanford, where more than four decades of weapons-grade plutonium production has created the most contaminated nuclear landscape in the United States. Since production began in 1943, an estimated 450 billion gallons of liquid nuclear wastes have entered the reservation's soil and water table, bioaccumulating in plants and animals (including humans), and forming a network of toxic groundwater plumes that communicate with the Columbia River. Home to more than two-thirds of the U.S. high-level nuclear waste inventory, Hanford is currently undergoing the largest and most expensive environmental remediation project in human history—tasked with managing, mitigating, and containing the byproducts of Mutually Assured Destruction.²

Under the terms of the Comprehensive Environmental Response, Compensation, and Liability Act (more commonly known as the Superfund Act),³ the U.S. Department of Energy must design and implement protective measures at Hanford that will prevent excessive threat to human health and the environment for the next 10,000 years (EPA, 1985). Thus, Hanford managers and policy makers must consider administrative eternity, creating cleanup actions and land-use regulations that extend beyond the lifetime of the nation.

Jane is one of many productive fictions critical to the remediation process.⁴ Her capacity to exist within the carefully measured bounds of nuclear daily life is central to the Hanford cleanup's success. It is important to note here that according to Superfund legislation, "clean" does not necessarily mean uncontaminated. Rather, nuclear industrial landscapes are considered officially remediated once the probability that a human will develop cancer from exposure to residual contamination is 1 in 10,000 (EPA, 1985). The challenge of remediation, then, is to measure and manage the conditions of carcinogenic encounter—titrating environmental contamination with human activity to achieve the appropriate balance of "permissible dose" (EPA, 1989). Thus, a "successful" cleanup is one that both contains nuclear waste and fashions subjects that can inhabit remediated space, producing an intricate co-constitution of body and environment that complies with the legislative terms of a post-nuclear future.

In this article, I consider how Jane has become a figure through which this particular future manifests. I do this by first tracing a brief genealogy of what I call the *nuclear body*—a mathematical translation of flesh and function critical to nuclear industrial practice. Beginning with U.S. led studies of radiogenic injury in the aftermath of the Hiroshima

and Nagasaki bombings, I consider how exposed Japanese bodies became the primary data source for contemporary nuclear science and regulation. Next, I examine the invention and application of Reference Man, a “universal” human designed to standardize radiation dose calculations across multiple populations. Finally, I return my attention to Jane’s implementation in remediation practice at Hanford. Specifically, I discuss the efforts of two local Native American tribes to craft their own future human template, a standardized indigenous body designed for use in Hanford’s remediation planning. Rejected by federal regulators as “not physiologically possible,” the indigenous body is framed as Jane’s constitutive outside, remediation’s unthinkable and unrecognizable subject. As such, I consider how cleanup efforts seek to reconstitute life itself—formalizing a new baseline from which to evaluate the boundaries and biologies of post-nuclear existence.

Building the nuclear body

I use the term *nuclear body* to identify a statistically calculated human template that emerged in the early years of the Cold War. Designed to enable explicit statements of risk that could inform radiation protection standards, this composite figure materialized in step with a rapidly expanding nuclear industry and its associated field of radiation health science. The nuclear body represents a “historical ontology” (Hacking, 2004) of permissible exposure, a set of conditions in which nuclear contamination could be recognized as livable.

Radiogenic impact has been studied for multiple generations in a wide variety of populations. Notable examples include Marshall Islanders and American soldiers blanketed by fallout from above ground nuclear tests (Barker, 2004; Hansen and Schriener, 2005), as well as hundreds of thousands of nuclear workers exposed on the job (Cardis et al., 2005; Manusco et al., 1977). These individuals are joined by countless others, both human and non-human (Brown, 2013; Johnston, 2007; Welsome, 1999). From a policy perspective, however, the most significant analysis of radiogenic injury is the Atomic Bomb Survivor Study—a multi-decadal examination of Hiroshima and Nagasaki victims. Now in its 67th year and renamed the Life Span Study (LSS), atomic bomb survivors along with their children and grandchildren still provide the basic raw data for federal estimates of radiogenic risk in nuclear production, remediation, and worker compensation claims (Krupar, 2013; Richardson et al., 2013). Because of the centrality of this study in determining American radiation protection standards,⁵ I begin my critical genealogy of the nuclear body in the streets of wartime Japan.

The four square miles surrounding the epicenter of the Hiroshima bombing is known as the “zone of complete destruction” (Orient, 1988). Though this phrase is most often used to describe the spatial extent of structural wreckage, “complete destruction” also evokes the new categories of ruination that were born with the bomb’s blast. The massive explosion that ripped through city streets on that hot August morning represented a moment of total rupture, a material and psychological fracturing of what had formerly been understood as reality (Lifton, 1968; Takayama, 2000). Survivors struggled to describe their experience, often finding no words that could capture the unthinkable of the bomb’s impact. As Dr. Michihiko Hachiya wrote in *Hiroshima Diary*, “I had to revise my meaning of the word destruction or choose some other word to describe what I saw. Devastation may be a better word, but really, I know of no word or words to describe the view” (1955: 65).

The *hibakusha*⁶ that survived the bomb’s blast were deeply impacted both physically and emotionally by their experiences. However, their encounter with atomic catastrophe and their subsequent categorization as “the exposed ones” produced an additional layer of

collective transformation: it turned the *hibakusha* into the largest collection of experimental human subjects known to radiation science. The Atomic Bomb Casualty Commission (ABCC), an American organization investigating radiogenic impact in Hiroshima and Nagasaki, saw the *hibakusha* as “a scarce and precious intellectual resource” (Lindee, 1994: 4), a group of individuals that ABCC director Robert Holmes called, “the most important people living” (Lindee, 1994: 5).

Though the original engineers of the Atomic Bomb Survivor Study (ABSS) extolled the unique value of their study population, they acknowledged that drawing concrete conclusions from study data presented several fundamental challenges. First, and most troubling, was the near impossible task of identifying the exact amount of radiation that each survivor received from the bomb’s blast. This was especially problematic because a central function of the ABSS was to determine the precise level at which radiation exposure caused biological and genetic harm in humans. Without knowing the dose that each study subject received, the connection between exposure and injury could not be made with any certainty. Thus, ABSS researchers found themselves charged with quantifying the unknown, with making the ambiguous concrete.

In the thousands of interviews they conducted, the ABSS team asked survivors to relive the moment of the explosion, to recall the exact position of their bodies in relationship to walls or rooftops that could have provided potential shielding from the blast and its associated radiation. Survivors were expected to remember in detail their activities immediately following the explosion and to identify the radioactive materials that they could have ingested as they struggled to find family members, water, and shelter. In effect, researchers were asking the *hibakusha* to reconstruct the rubble of Hiroshima and Nagasaki in their minds, to translate moments of fractured reality for which no words existed into exact descriptions that could be used for statistical analysis.

In addition to fundamental uncertainties in dosimetry, the Atomic Bomb Casualty Commission faced other significant barriers to effective data collection. First, the initial years of the ABSS were conducted during the American occupation of Japan, intensifying an already problematic power dynamic between American researchers and Japanese study subjects. Second, identifying who should count as a survivor proved difficult, as the chaos of the bomb upended standard forms of record keeping in Japanese hospitals, police stations, and city government. Unless a victim remained in hospital for many months, survivor records were based almost entirely on voluntary self-identification by the victims themselves. As Susan Lindee writes in *Suffering Made Real: American Science and the Survivors of Hiroshima*,

Many survivors had substantive reasons for keeping their experiences to themselves. There was a stigma associated with having been exposed to the bomb’s radiation. Many believed that survivors would be unable to have healthy children due to radiation-induced heritable mutations, and in a social world where marriages were commonly arranged, some families concealed exposure in an effort to secure desirable matches for their children. In addition, until 1957, survivors qualified for no special assistance of medical care and therefore had little incentive to come forward and register (1994: 8).

Furthermore, while it was possible for epidemiology to make connections between exposure and illness in certain cases, the more subtle, long-term impacts of radiation such as genetic mutation were nearly impossible to detect (GAO, 2000). Authors of the ABCC’s genetic study warned that because the majority of radiation-induced mutations were likely recessive, they would not become evident for multiple generations—and even then, it would

be hard to distinguish radiation-induced mutation from “naturally occurring” mutation. In their initial report on the bomb’s genetic impact, study authors cautioned,

it is important to emphasize that the condition of these initial observations...permit the detection of only a small fraction of the total genetic effect of exposure to an atomic bomb. Given our estimates of the radiation dosages involved, it has...always been doubtful whether significant findings attributable to the genetic effects of irradiation would be apparent. (Neel et al., 1953: 541)

Despite its inherent uncertainties, the ABSS genetics study was cited repeatedly in policy documents and the popular press as proof that atomic materials presented little or no long-term hazard to future generations. Exposed Japanese bodies, reincarnated as bodies of data, were thus used to justify nuclear industrial expansion—to recommend investment in peaceful uses of the atom and to calm fears about above ground nuclear testing. As such, atomic boosters and policy makers were able to make something out of “nothing,” using an absence of information to produce truth claims about the relative hazard of atomic living. Uncertainty became a management tool in and of itself, a means for generating political and economic value. In effect, the visible invisibilities of the ABSS data were its greatest gift to nuclear industry.

As both peaceful and military applications of nuclear technology expanded in the early years of the Cold War, the U.S. government was under increasing pressure to calculate industry standards for permissible dose. Thus, while radiation’s physical impact was being analyzed in Hiroshima and Nagasaki, scientists also set about determining a standardized body that could be used to estimate harm in broader populations. In 1949, the International Commission on Radiation Protection (ICRP) created what it called “Standard Man” (later renamed Reference Man)—an individual that it believed could represent a basic “set of biological parameters” for risk calculation (1975: 1). Though Japanese bodies produced the majority of raw data about radiogenic injury, Reference Man became the official body through which such information could be applied and understood. With his consistency of form, Reference Man was meant to facilitate discussions among the wider scientific community and to allow for greater ease in quantifying and formalizing radiation’s effects.

Though some of Reference Man’s biological and physiological parameters have been modified in the decades since his birth, he has retained his general form and fitness for the last 66 years. He continues to be, in the words of the ICRP,

‘20-30 years of age, weighing 70 kg, is 170 cm in height, and lives in a climate with an average temperature of from 10° to 20°C. He is a Caucasian and is a Western European or North American in habit and custom. (ibid: 4)

Of course, the ICRP acknowledges that “young western white male” does not adequately describe large sections of the world’s population. For this reason, the Committee cautions that Reference Man should not be qualified as “an average or median individual.” Rather, he should serve as the internationally agreed upon starting point for estimating radiogenic risk. Radiation scientists and practitioners should use Reference Man as the basis from which further adjustments can be made to suit individual situations, as appropriate. As the Committee states,

The fact that Reference Man is not closely related to an existing population is not believed to be of any great importance. If one did have Reference Man defined precisely as having for each attribute the median value of a precisely defined age group in a precisely limited locality (e.g. males 18–20 years of age in Paris, France, on 1 June 1964), these median values may be expected

to change somewhat with time, and in a few years may no longer be the median values for the specified population. Moreover, the Reference Man so defined would not have this relation to any other population group unless by coincidence. To meet the needs for which Reference Man is defined, this precise statistical relationship to a particular population is not necessary. Only a very few individuals of any population will have characteristics which approximate those of Reference Man, however he is defined. The importance of the Reference Man concept is that his characteristics have been defined rather precisely, and thus if adjustments for individual differences are to be made, there is a known basis for the dose estimation procedure and for the estimation of the adjustment factor needed for a specific type of individual (ibid: 4).

In other words, the ICRP argues that Reference Man's particular race, age, culture, and gender need not preclude him from estimating exposure in a wide variety of human populations. Health physicists should simply start with the white male as their basic human model and adjust skin color, dietary preferences, and/or reproductive organs accordingly. Like Adam in an atomic Eden, the ICRP positions Reference Man as the basic building blocks for a nuclear humanity. Reference Woman, for example, need but emerge from his carefully calculated rib.

However, managing the "uncertainties" of diversity through real-time adjustments in the Reference Man model presents several obvious problems. First, it fails to acknowledge the obduracy of the regulatory structures in which Reference Man is applied. Radiation protection standards are not supple, self-reflexive beings—their very point of existence is to draw lines in the sand, to enforce a singular and universal notion of permissible dose. The physical infrastructure of nuclear industry is similarly intractable. Nuclear reactors, for example, must be designed according to specific metrics for permissible exposure. They cannot be continually demolished and rebuilt to account for biomedical discoveries or changes in worker population.

Therefore, calculating for diversity in nuclear regulatory standards has meant finding a singular body that can adequately account for collective variety. Many policy documents acknowledge, however, that it would be inappropriate to use only the male body to estimate radiogenic risk, when women are 37.5% more likely to develop fatal cancer from the same level of exposure (NAS, 2006). Rather than simply adopting a standardized female body as the basis for risk calculation, however, policy makers engage in what they consider a suitable compromise: they simply give Reference Man breasts, ovaries, and a uterus—creating a hermaphroditic human in order to "solve" the problem of radioactive gender inequality.

Indeed, this multi-sexed version of Reference Man informs much of U.S. nuclear remediation policy. For example, the Environmental Protection Agency's current Federal Guidance Reports on internal and external radiation exposure describe their use of a "hermaphrodite...derived from ICRP Reference Man data" (1993: 184). Though the EPA has also used gender-specific models to calculate dose coefficients, its Federal Guidance Reports specify that "most calculations of organ dose from the intake of radionuclides are based on the hermaphroditic [model]" (ibid: 184). So too, the U.S. Department of Energy's *External Dose-Rate Conversion Factors for Calculation of Dose to the Public* describes its "reference individual" as "an adult hermaphrodite" which consists of a male body that has been "modified [to] include ovaries, uterus, breast, and red bone marrow" (1988: 8).

The notion that Reference Man's hermaphroditic transformation equalizes gender inequality in risk calculation ignores the appropriative character of his statistical sex change. More importantly, it denies the material impact of his continued use for real women's bodies. Though the hermaphroditic Reference Man has female reproductive organs, the rest of his body is male. He retains his original height, weight, and

physiological parameters. The amount he urinates, the fat content of his body, the percentage of water in his cells—each calculated using data for a male body—remains the same. Indeed, Reference Man even retains his male signifier when in hermaphroditic form. Study authors use phrases like “the uterus in the Adult Male,” for example, to describe “his” female components (Cristy and Eckerman, 1987).

Rather than troubling fixed categories of sex and gender, Reference Man-as-hermaphrodite reinforces the notion that women are wholly defined by their reproductive organs. Ironically, this reductionist philosophy fixates on certain parts of female biology, while ignoring others that also influence risk. Women are, for example, generally lighter weight than men and, “the lighter the person, the greater the dose from a given amount of external radiation to internal organs. . .since there is less shielding of these organs by the rest of the body” (Makhijani, 2008: 14). In addition, women’s bodies are chemically different from men and they generally contain a greater percentage of fat—characteristics that produce a different relationship to contamination and its associated hazard. By adding breasts, ovaries, and a uterus to an otherwise male body, nuclear policy evokes a (limited) biological imagination of female identity to claim that it has calculated for a gendered difference in risk. It uses a language of equality to create what remains an unequal regulatory framework.

By comparison, Reference Man’s race receives far less attention than his sex in radiation protection standards. Indeed, the EPA’s Federal Guidance Reports do not mention race at all, stating simply that they use a “hypothetical average adult person” with Reference Man’s anatomical and physiological characteristics in order to calculate permissible dose (1999: GL-8). This is problematic for a number of reasons, most notably because the health risks associated with nuclear industry are not borne equally by all people, and an average masks this uneven distribution. Furthermore, the causes of racialized differences in health are multiple and complex, the result of social and economic disparity rather than biology (Bridges, 2011; Epstein, 2007; Montoya, 2011). Therefore, policies that rely heavily upon biological parameters in determining risk, ignore and thus reproduce the greater structural inequalities of exposure-related illness.

Of course, it is this simplicity—this abstraction from the lived experience of exposure—that makes the nuclear body politically useful. Nuclear standards must make radiogenic injury generalizable, translating data from diverse and often incomplete sources into explicit statements of cause and effect. Indeed, building the nuclear body has required untangling exposure-related illnesses from the social and spatial relations that give them meaning. It has meant standardizing notions of risk that can travel easily between the disparate spaces of the battlefield, power plant, and remediation site. Finally, it has meant identifying the official boundaries of permissible exposure and acceptable contamination—bureaucratic markers for survival in an increasingly radioactive world. Thus, building the nuclear body has ultimately meant first defining life, and then determining the conditions in which that life should be considered livable.

Hanford’s impossible bodies

In practice, the internal contradictions of a universal human template come quickly into focus. Because it was designed to be applicable in every radioactive environment, the nuclear body itself is profoundly a-spatial. Critical geographic scholarship has long rejected the notion of a placeless body, pointing instead to the co-constitutive relationship between humans and their daily, lived experiences in space (Cresswell, 2003; Massey, 1994; Nast and Pile, 1998). At Hanford, it is easy to see how daily life in a radioactive environment

would differ from its statistical assemblage. Indeed, Jane's story at the beginning of this article demonstrates the awkward results of such ground truthing.

This dissonance between data and lived experience is problematic for Native American tribes surrounding the Hanford site. Hanford occupies 586 square miles of territory that was ceded to the Yakama Nation, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) through the Treaty of 1855.⁷ This treaty guarantees that tribes may use Hanford lands in perpetuity for hunting, fishing, pasturing horses and cattle, and gathering traditional foods and medicines (Gephart, 2003). Though in 1943 the U.S. government restricted tribal use "temporarily" for the war effort, tribes argue that current remediation efforts must restore full access and respect their legal right to use Hanford lands safely.

Fulfilling treaty rights means re-negotiating how nuclear safety is measured and managed in Hanford's cleanup. As Stuart Harris, director of the CTUIR's Department of Science and Engineering argues, "risk assessment as it stands now is woefully inadequate for addressing Native American concerns" (1998: 2). The first and most obvious problem, he explains, is that Hanford's remediation strategy is based on a suburban model. This not only underestimates tribal risk on a practical level by ignoring exposure from activities like wild food harvesting and spiritual ceremonies, but it also renders structural inequalities between the suburbs and the reservation invisible. As Harris points out,

tribal members typically have a larger burden of co-risk factors such as poor nutritional status, loss of natural diet, poorer access to health care, differences in metabolism, and so-on. This means that tribal members might hypothetically not only receive more exposure [than suburban populations] but might also be more sensitive to that exposure. (ibid: 6)

Tribes argue that addressing these structural differences in Hanford's risk framework requires more than changing diet and activity parameters. As Harper et al. write, "Traditional lifeways are not simply suburban during the week with camping out or attending powwows on the weekends" (2012: 813). It is not enough to "simply add more fish or some wild food to a suburban scenario" (Harper, 2012). So too, risk frameworks that position humans and the environment as distinct and separable units, miss the integration of culture, environment, and body critical to tribal identity and practice. "Our ties to the environment are much more complex and intense than is generally understood," Harris explains. "Because my tribal culture and religion are essentially synonymous with and inseparable from the land, the quality of the sociocultural and eco-cultural landscapes is as important as the quality of individual natural resources" (1998: 3).

In voicing these concerns, Harris and others are participating in a larger national debate about race, industrial contamination, and the politics of scale. Since its inception, the Superfund program has drawn criticism from environmental and health activists who argue that remediation policies fail to address the raced and classed geographies of exposure. In response to these critiques and a growing attention to environmental justice in the 1990s, the Clinton Administration initiated a series of Superfund reforms intended to "prevent minority and low-income populations from bearing the brunt of pollution" (EPA, 2015). At the same time, the EPA faced pressure from regulated industries that claimed that Superfund actions were overly protective and lacked consistent and replicable procedures (Nakamura and Church, 2003). Thus, in the same breath, the EPA promised that Superfund reforms would both standardize the remediation process at a national scale and customize it to fit local problems and politics (EPA, 1997). The result is a contemporary cleanup policy that requires public participation and local community input, but that ultimately must

translate the particularities of place and person into a set of nationally recognized standards and procedures.⁸

For Hanford area tribes, then, influencing remediation means existing in contradiction. While they argue that statistical models cannot truly capture the web of relations that inform tribal culture, tribes continue to perform quantitative risk assessments for use in Hanford's remediation planning (Harper and Harris, 2010). The Yakama Nation and the CTUIR,⁹ for example, have written official exposure scenarios—creating standardized data sets for tribal behavior that can be “systematically validated” within the terms of U.S. law (Harper et al., 2008: 231).

Based on a template indigenous person who engages in statistically calculated traditional activities, tribal exposure scenarios often evoke normative categories of Native American identity. The CTUIR's *Traditional Tribal Subsistence Exposure Scenario and Risk Assessment Guidance Manual*, for example, depicts the difference between indigenous and non-indigenous life using a series of stock cartoon images. One such image, entitled “Bridging Perspectives,” presents two cartoon islands connected by a red bridge. On the first island is a white businessman standing beside a miniature nuclear reactor and a large dollar sign. His face is serious as he points to a line graph and the words “cost-benefit” and “dose-responses.” The second island holds trees and a Native American elder and child dressed in traditional garb. Clutching a doll in one hand, the child looks over her shoulder, while her elder stares solemnly across the water. Behind them is a miniature Egyptian pyramid with the words “time” and “land” floating above it.

In another example, the same stock image of a Native American has been placed against a backdrop of evergreen trees and purple sky. Surrounded by a series of circular arrows that one might find on a recycling bin, the Native American floats among the treetops as if enchanted. Immediately below, a counter-image labeled “suburbia” depicts a white couple in business attire. Briefcase in hand, the woman cocks her hip to one side while the man looks at her and smiles. Set against a white backdrop, they are encircled by other stock images meant to represent the trappings of suburban life: a computer, a shopping cart, a Christian church, a hospital, a child sitting at a school desk, and a city skyline. Entitled, “Where People Go to Fulfill Elements of Their Lifestyle,” the associated caption reads,

Indigenous people live embedded within the environment and derive many services from it. They may leave it only to visit ‘suburbia’ to obtain money. Suburban dwellers consider the ‘environment’ as something to be visited during recreation, and derive most of their services from other suburban locations. (Harper et al., 2008: 18)

Each image communicates an overt message of difference: different bodies, different practices, different perspectives, and most importantly, different expressions of risk in a nuclear environment. Indeed, in the first image, Native Americans and non-Native Americans exist on separate islands indicating a fundamental break.

For the CTUIR, these differences are not only cultural but temporal as well. Because the Treaty of 1855 describes access to a pre-Hanford landscape, they argue that cleanup should guarantee “*original* lifestyles and resource uses” rather than “*contemporary restricted or suppressed*” ones (2008: 27, original italics).¹⁰ As the *Traditional Tribal Subsistence Exposure Scenario* explains, “the intent is to restore the ecology so that the original pattern of resource use is both possible (after resources are restored) and safe (after contamination is removed). This is a different situation than for the general American population, where the intent of remediation is to allow people to continue their *current* (and portable) lifestyle in a newly cleaned location” (ibid: 67, original italics). Therefore, the standardized indigenous body in the CTUIR's exposure scenario represents a past that

tribes hope to reclaim: a time before Hanford, before the bomb, before tribal lands and lifeways were “degraded” or “impaired” (ibid: 20). In this sense, the CTUIR are effectively asking that the Hanford cleanup turn back time—retrieving not only chemicals and radionuclides, but a way of life.

In advocating for cleanup levels that recover a pre-Hanford past, the CTUIR simultaneously evoke an oft-criticized narrative that imagines Native Americans as historical subjects, rather than “active parts of the modern world” (TallBear, 2013). This and other “strategic essentialisms” (Spivak, 1988) in tribal exposure scenarios serve an important political function. As members of a minority population that Superfund reforms promise to protect, tribes argue that Hanford’s cleanup should not be considered complete until the level of carcinogenic risk required by law¹¹ reflects Native American lifeways. Thus, the standardized indigenous body with its culturally specific breath rates, soil inhalation factors, fish consumption levels, and so on, invokes the past in order to negotiate Hanford’s future. The more risk that tribes can demonstrate in their exposure scenarios, the more contamination that must be removed from Hanford’s soil and water table.

However, to communicate the cultural and temporal distinctions that form the heart of their critique, tribes must speak in a standardized language that Superfund legislation can understand. This means that, ironically, tribes must establish statistical and analytical parity in order to make the case for tribal difference. Thus, tribal exposure scenarios position the template indigenous person as a legitimate member of Hanford’s statistical family—an individual that exists at one end of a spectrum of officially imagined future humans. As Harper et al. argue,

the CTUIR scenario is at the foraging end of the subsistence spectrum, while the residential farmer [Jane’s scenario] is at the domesticated end of the subsistence spectrum. Both are active, outdoor lifestyles, and are consistent with the reasonable maximum exposure (RME)¹² approach to baseline risk assessment. (2008: 182)

Official exposure scenarios (both federal and tribal) are thus filled with hundreds of pages of data. In each of these documents, the intimate moments of daily life are given new meaning through statistical translation. In order to evaluate risk from sweat lodge ceremonies, for example, spiritual practice is rendered calculable—mouths and lungs become “exposure routes,” bodies become “receptors,” and sweat becomes integral to bureaucratic boundary making (DOE, 2010: 3–59).

So too, bodily functions become forms of evidence in disputes surrounding remediation planning. The act of breathing, in particular, has generated significant debate between Hanford area tribes and federal agencies. While the CTUIR argues that the indigenous body inhales 30 cubic meters of air per day (Harris, 2011) and the Yakama Nation contends that is 26 cubic meters (Ridolfi, 2007), the Department of Energy and Environmental Protection Agency maintain that 20 cubic meters is a more reasonable metric (DOE, 2010).

In a series of letters, tribes and agencies negotiate this cultural politics of breath. Defending agency calculations in a 2001 memorandum, the EPA’s Marc Stifelman writes, “the default inhalation rate of 20 m³/day . . . provides a protective margin and is significantly higher than the long term values recommended in the Handbook.”¹³ In a 2003 letter, the CTUIR’s Stuart Harris responds,

It is standard practice in risk assessments to include inhalation rates for industrial workers or construction workers (4.8 m³/hr), using the inhalation rate for heavy activity applied to an 8

hour work day...The memorandum from EPA choosing to apply the suburban rate of $20\text{ m}^3/\text{day}$ rather than an active outdoor or industrial/construction rate even though tribal activities more closely approximate the latter, ignores this completely...The value of $30\text{ m}^3/\text{day}$ is more scientifically defensible and more accurate for our outdoor lifestyles.

Referencing Superfund reform requirements that tribal populations be consulted throughout the remediation process, Harris continues, "Consultation does not mean informing the tribe what EPA decides or trying to argue the tribe out of its research exposure factors." In a subsequent 2003 letter, he writes in frustration, "[The fact that] I have to spend enormous amounts of time justifying that I live and belong to a unique natural resource based outdoor population seems quite excessive."

Ultimately, these breath rates have provided the rationale for denying broader tribal claims. As one EPA staff member told me,

The Yakama and Umatilla¹⁴ have developed their own scenarios, so we run those. Unfortunately, *they aren't physiologically possible*, so we don't choose them. What they did, particularly the Umatilla, is the breathing rate that they chose was from a soldier digging a fox hole, so they were breathing heavy continuously. Which you can't do, and so it makes your numbers go down. So for us, we can't choose it because it's not credible¹⁵

It is easy to see the irony in this statement. In qualifying the heavily breathing Native American body as not physiologically possible, the EPA ignores the calculative anomalies and uncertainties in its own human template. So too, this statement undermines the notion that Superfund reforms can address the structural inequalities of exposure. For even when tribal scenarios transform complex identities and practices into a singular normative body, that body can only be taken seriously when it does not challenge the official terms of acceptable risk. Once a Native American experiences excessive exposure, in other words, he or she becomes impossible. Thus, arguments about indigenous breath are but a proxy for much larger stakes. Hanford area tribes and federal agencies are not only debating lung capacity, they are negotiating the terms of post-nuclear existence—and whose future Hanford's cleanup will make possible.

Conclusion: becoming Jane

By its very definition, remediation implies full recovery. Descendent of the Latin *remediare*—to heal or cure—it is remedy's grammatical sibling. A noun of action, it is the process of reversing damage and setting right, of mending what has been broken. However, the magnitude of Hanford's contamination and the longevity of its radionuclides make it impossible for remediation to fulfill the promise of its name. Plutonium production at Hanford has created a multi-millennial waste stream that will long outlast the United States and its regulatory policies. Moreover, at a global scale, building and testing atomic weapons have spread contamination worldwide infusing the entire biosphere with trace elements of the bomb.

How, then, are we to understand Hanford's cleanup? If there is no "after" to nuclear contamination,¹⁶ and no place on Earth beyond its reach, what does it mean to remediate this space? In this article, I have made the case that a "successful" cleanup at Hanford is one that re-imagines the boundaries and biologies of post-nuclear existence. Remediation is complete, once it has made contamination livable by fashioning subjects that can survive in the post-nuclear future. In identifying who can inhabit remediated space, cleanup re-negotiates the relationship between safety, security, and the contamination it leaves

behind. In this way, the remediation process articulates a new social contract for nuclear threat in the post-Cold War era—one that defines the conditions of acceptable exposure, highlighting particular hazards while rendering others invisible.

In *Against Health*, Joseph Masco argues that the social politics of Cold War weapons production have transformed the meaning of health from what was once the “absence of disease” to what is now “a graded spectrum of dangerous effects. . . embedded in everyday life” (2010: 137). If making the bomb has redefined health and injury, then “unmaking” it through remediation has redefined the associated cure. In each formulation, the slow violence of nuclear contamination is rendered calculable, creating notions of exposure that can move easily between scientific studies and policy documents.

Jane’s daily practice in the pages of Hanford’s *Human Health Risk Assessment* represents this historically contingent sphere of intelligibility. With each breath, her lungs fill with the conditions of possibility for what (and whose) version of life is deemed livable. Thus, in her becoming, Jane embodies a social ontology of nuclear survival. As her calculated body and regulated days inform remediation planning, she remakes the very meaning of trauma and recovery in the atomic age.¹⁷

The government documents that describe Jane envision her life in breathtaking detail. Despite their extreme specificity, however, these official accounts are not intended to be read literally. The Department of Energy does not actually expect future humans to maintain the same exact body weight each day of their adult lives, nor does it imagine a society of obsessive compulsive individuals that only eat their fruit in fractions. Rather, the numbers that delimit Jane are informed by the laws of statistical error—the notion that mathematical order extends to the very edges of human behavior (Porter, 1986). Thus, Jane’s exposure scenario protects her from the hazards of a post-nuclear environment because it also sets the terms for what those hazards can be. By living her life in remediated space, then, Jane articulates the conditions of life itself. She creates the social and environmental order necessary to justify risk-based nuclear remediation.

In this article, I have examined several epistemological frames through which we have come to understand nuclear life. I have explored how scientific studies, standards, and social norms have fashioned a nuclear body out of radioactive remains. From the *hibakusha*’s indistinguishable genetic mutation and Reference Man’s universalized uterus, to Jane’s regulated movements and the Native American’s “impossible” breath, these framings have conditioned the ways in which radiogenic injury is made visible (and invisible), producing a recognizable subject that defines the very terms of living-being in the atomic age.

Of course, this recognizability is unevenly distributed—some lives are understood as more livable than others (Butler, 2010). Indeed, as I have demonstrated in this article, the nuclear body has been produced through a marked erasure of certain injuries, exposures, and lifeways. Thus, in drawing the bounds of radioactive safety, nuclear science and policy have created a human proxy that cannot truly identify the people it purports to protect. As such, seeking change does not simply mean expanding the nuclear body to include more individuals in its particular embrace, but to consider how the very act of its framing has depended upon distributing recognition and protection unevenly.

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Notes

1. The figure who I have called "Jane" in this article is simply called "Subsistence Farmer" in the DOE's *Human Health Risk Assessment*. Subsistence Farmer (Jane) is one of eight statistically-calculated human types competing for future use rights at Hanford. She is joined by Avid Angler, Avid Hunter, Casual User, Non-residential Tribal member, Industrial Commercial Worker, Resident Monument Worker, and Native American Resident (DOE, 2010).
2. At present, Hanford's waste inventory includes,
 - more than 50 million gallons of high-level waste in 177 underground storage tanks, 2,300 tons of spent nuclear fuel, 12 tons of plutonium in various forms, about 25 million cubic feet of buried or stored solid waste, about 270 billion gallons of groundwater contaminated above drinking water standards, spread out over about 80 square miles, more than 1,700 waste sites, and about 500 contaminated facilities. (Hanford Natural Resources Trustee Council, 2013)
3. Superfund is a federal program administered by the Environmental Protection Agency designed to assess and remediate abandoned hazardous waste sites in the United States. Established in 1980 by the Comprehensive Environmental Response and Liability Act, the program enables the EPA to facilitate cleanup at these sites—either by engaging in remediation activities directly or by compelling responsible parties to perform the necessary cleanup actions. At Hanford, the EPA works with the U.S. Department of Energy (the responsible party) and the Washington Department of Ecology to design and fulfill cleanup requirements through the Tri-Party Agreement.
4. By providing an official vision of controlled risk in post-nuclear life, Jane represents a version of what Lee Clarke calls "fantasy documents," rhetorical instruments that manage catastrophic potentialities through bureaucratic ritual rather than material action (1999).
5. The U.S. Environmental Protection Agency, for example, considers the Life Span Study to be the "most important source of epidemiological data on radiogenic cancer" (1993: 146) and uses LSS data to develop detailed mathematical models for estimating risk (EPA, 2011a). In addition, the National Academies' seminal reports on the Biologic Effects of Ionizing Radiation (BEIR) use Japanese atomic bomb survivors as "the primary source of data for estimating risks of most solid cancers and leukemia" (NAS, 2006: 2). This data set also informs the U.S. Federal Guidance Reports for exposure to radionuclides that direct nuclear remediation efforts (EPA, 1993; EPA, 1994).
6. *Hibakusha* is a Japanese word that identifies atomic victims—roughly translated as "survivor" or "exposed one."

7. The Wanapum Band also lived on Hanford lands and maintains strong cultural and material ties to the land. However, because they did not sign the Treaty of 1855, they do not have legal standing in this case.
8. Geographer Ryan Holifield writes that while the Superfund reforms were explicit in their intent to address environmental justice issues, “most were oriented toward preserving the program in a form more palatable to regulated industries” (2012: 594). For example, as part of the reform process, the EPA abandoned its prior default assumption that remediated lands could eventually become residential spaces. Instead, Superfund language now bases its risk assessment and remedy selection on the more ambiguous terms of ‘reasonably anticipated future use,’ a flexible bureaucratic definition that often implies less stringent cleanup requirements.
9. The Nez Perce Tribe, which also holds treaty rights to Hanford lands, has not yet created an exposure scenario.
10. In contrast, the Yakama Nation’s exposure scenario emphasizes contemporary resource uses and risks to tribal members.
11. As a reminder, cleanup is considered complete under the terms of Superfund legislation, when no more than 1 in 10,000 people will develop fatal cancer as a result of exposure to residual contamination.
12. As defined by the Superfund program, a Reasonable Maximum Exposure is, “the highest exposure that is reasonably expected to occur at a site, but that is still within the range of possible exposures” (EPA, 2004: 22).
13. Here, Stifelman is referring to the *Exposure Factors Handbook* (EPA, 2011b), an EPA publication that details human behavior as it relates to contaminated space. The Exposure Factors Handbook provides activity parameters for the nuclear body in Hanford’s remediation planning.
14. The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) are often simply called the “Umatilla” in Hanford discussions.
15. This interview was conducted during 2012. The name of this interviewee has been withheld by mutual agreement and reflects the terms of the author’s Human Subjects Compliance protocol.
16. Hanford’s waste challenges human-based concepts of time. Plutonium, for example, has a half life of about 24,000 years, meaning it will remain radioactive for approximately 240,000 years. Thus, when I say there is no “after” to nuclear waste, I am referencing human time-scales, rather than geologic ones (Van Wyck, 2005).
17. Because Jane negotiates the terms of nuclear risk in her everyday life, and because her daily practice legitimizes state visions of radiogenic recovery on a broad scale, one could argue that she is engaging in what Adriana Petryna has termed “biological citizenship” in the aftermath of the Chernobyl disaster (2002). However, Jane’s framing is slightly different. While the exposed Ukrainians in Petryna’s account emphasize damaged biologies in order to stake citizenship claims, Jane is not requesting compensation. In fact, according to the statistical and legal logic that made her, Jane has not been injured because her daily exposures have been reconstituted as acceptable. Thus, while she is certainly “producing new kinds of ecologies, bodies, and social orders” (Masco, 2006: 301), Jane lends legitimacy to the nuclear state through different means.

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