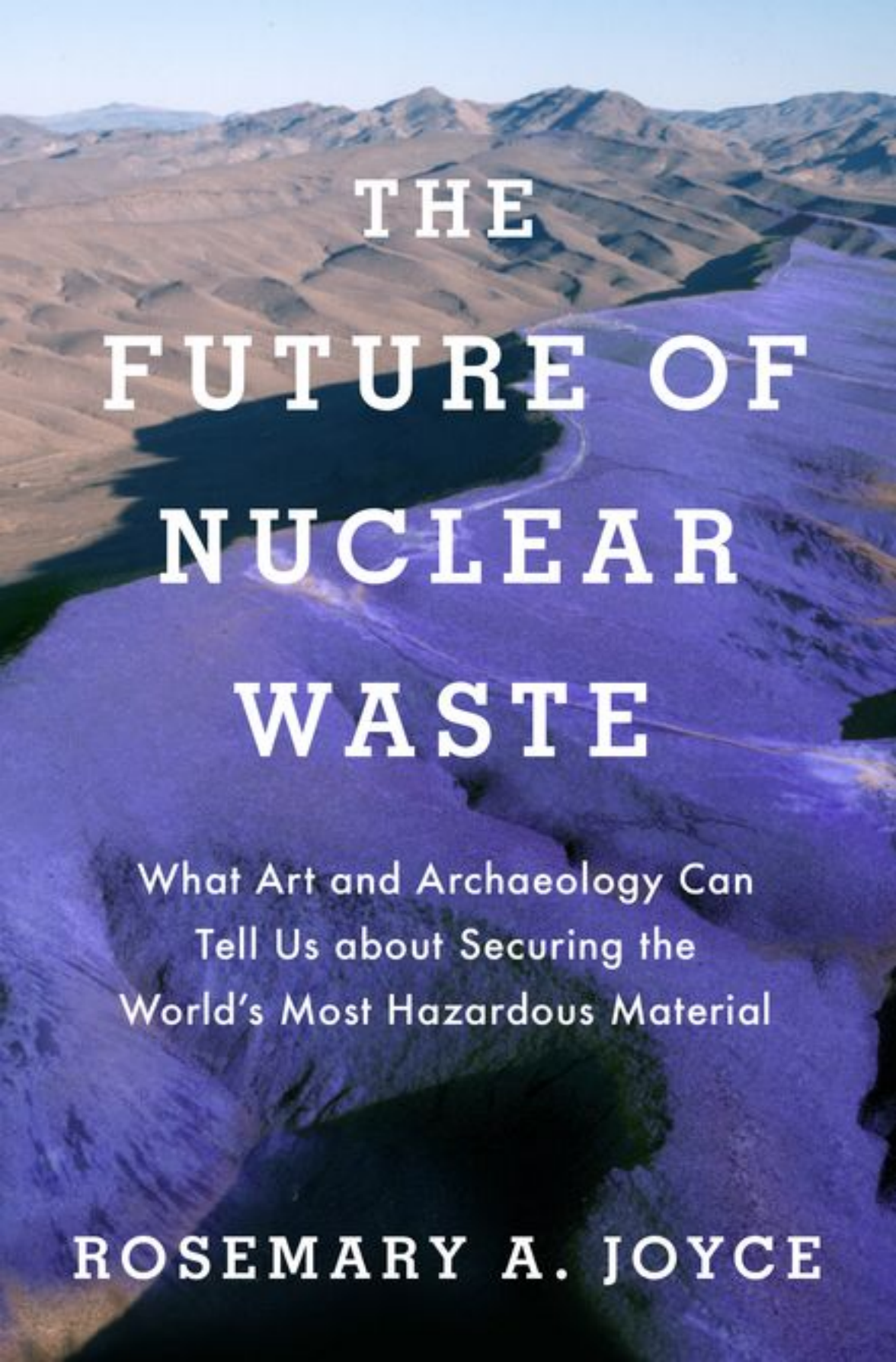
THE
FUTURE OF
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Tell Us about Securing the
World's Most Hazardous Material
ROSEMARY A. JOYCE

The Future of Nuclear Waste

OXFORD STUDIES IN THE ARCHAEOLOGY OF ANCIENT STATES

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In memory of Thomas C. Joyce, the ideal reader for this work.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

THIS BOOK CAN BE READ as a contribution to four different literatures. It adds to the burgeoning body of work on nuclear or atomic culture. Studies in this vein consider how living with nuclear technologies has led to the development of new cultural forms, including museums and monuments.[1] Nuclear waste disposal sites and the markers proposed and sometimes installed on them belong in this lineage. A robust anthropological literature is part of this broader field.[2] A substantial theme in broader nuclear culture is the place of the US West in nuclear development, something that links both the development of nuclear waste disposal sites in the West and the imagination of how to mark them as a form of art practice.[3]

There is also a specific literature on nuclear or atomic archaeology to which I am contributing. There are two different strands to this body of work. Long-established archaeological approaches to nuclear waste are pragmatic. Accepting the necessity of the nuclear industry, they seek to bring archaeological knowledge to aid in public safety planning.[4] I return in the conclusion of the book to my own perspective on the place of archaeology in this pursuit. I admit at the outset that I am skeptical of the promise archaeology seems to be making, of any certainty about futures that seems to be offered by such efforts. In that sense, this book is neither about a past on which planners depended for their models or a future that might come into being if their plans were realized. It is about the present and how people today think about the material qualities of things and their capacity to act on behalf of people's intentions, their ability to convey meanings over long periods of time.

This orientation toward understanding the present aligns my contribution more with the broader field of archaeology of the contemporary.[5] This is a relatively recent self-conscious articulation of identity among archaeologists coming from material studies, historical archaeology, and cultural resource management fields.[6] We

find ourselves, by necessity or choice, dealing with the landscapes in which people are living today, landscapes in which things made in the past are taken up, used, given meaning, recycled, interpreted, and contested. This is the first approach archaeology has developed that embraces and celebrates the material of everyday life today as something more than a resource for analogies about the past.

Many of the landscapes in question contain things that emerged in distant pasts that are incorporated in people's lives today. The archaeology of the contemporary is thus not limited to the study of things made recently, but it has made visible otherwise neglected material residues of the contemporary era. Many of these things are products of militarization and conflict.[7] Archaeology of the contemporary is self-aware, critical, and takes seriously the capacity of things to act beyond the human. The archaeology of the contemporary encompasses the kind of nuclear archaeology with which I would align my own project. This involves critical examination of the material traces of the development of nuclear power and nuclear weapons, and of resistance to them, and their normalization.[8] A few authors use nuclear waste planning as I do, as a case for contemporary archaeology to analyze human capacities and material affect.[9]

The main project I explore in this book, a US government proposal to mark the site of buried nuclear waste in New Mexico, now serves as a model for marking other proposed nuclear waste repositories in the US and for similar projects elsewhere. It has been discussed in histories of the management of nuclear waste in the United States, although not in depth or from the perspective I bring to the project.[10] Peter van Wyck takes part of the planning process as a focal object for an examination of the ecological imagination of risk and threat.[11] Where van Wyck situated his analysis as a study of death, meaning, and time, I explore above all else the way this deeply consequential project reveals aspects of contemporary thought about the predictability of human engagement with materials, and the capacity to bridge temporal gaps between past and present, present and future, through the promise that enduring materials will stabilize human responses. Like van Wyck, I don't represent this book as a definitive history of this project but rather as a critical investigation of some of the logic underpinning it.

While I acknowledge the connections this book has to these well-established domains of scholarship, I align it most directly with the anthropology of common sense, building on formulations by ethnographer Michael Herzfeld.[12] Calls for an anthropology of common sense can be traced back at least to the work of Clifford Geertz and Mary Douglas.[13] Common sense played an important, if not always highlighted, role in the work of Pierre Bourdieu, which has had a profound effect on contemporary anthropology.[14]

What I find particularly useful in Herzfeld's work is his insistence that anthropology is at its heart a *comparative* study of common senses, which he insists

can only be recognized through comparison across different "cultural settings." Herzfeld suggests that historical research and ethnographic fieldwork are among the best ways to explore how common sense is actually deployed. This book is a historical examination of common senses on multiple scales. It examines documented statements from different cultural settings at distinct moments in time, and, as Herzfeld proposes, confronts them with my "own version of common sense . . . a key element in the comparative exercise."[15] My own common sense comes from the understandings of the behavior of things that I have developed as an archaeologist. This common sense might otherwise be thought of as expertise. Following Herzfeld's lead, I treat expertise itself as a form of contextually specific common sense.

In this study, then, I examine as different forms of common sense ideas circulating broadly among publics, but also specialist knowledge and even formally elicited expert opinion. By acknowledging that all of these are forms of common sense for some participants in specific cultural settings, I can examine contradictions not as forms of error but as differences in understanding the world. In an overview of the topic, Herzfeld cites an archaeologist, Robert Dunnell, who argued that "common sense is culture—it determines the kinds of observations, rules for assembling those observations into sense, and even what constitutes sense. As a sense-making system, common sense is functionally equivalent to theory in the sciences."[16] This is a step in the direction I take, but only a step away from a deeply rooted history of treating common sense as something opposed to scientific thought, the pair identified as *episteme* and *doxa*, knowledge and "opinion."[17] Defining anthropology as the comparative study of common sense, we can alternatively think of common sense as the embedded understandings that, called *doxa, orthodoxy, and heterodoxy,* underwrite the practice theory of Pierre Bourdieu, or that, as the "practical reason" of Marshall Sahlins's Americanist approach, are the knowledgeability that underwrites action in social and cultural life.

My intent in writing this book was to take the consequential planning exercise I examine as a way to understand disjunctions between what different groups take for granted when they think about the endurance of landscape-scale human traces. As an archaeologist, I found myself often astonished by what the planners—all experts in their own right—thought archaeological research demonstrated. My understanding of archaeological knowledge is thus compared with the understanding of archaeology of the planning experts, as two common senses.

The archaeological sites whose meanings were taken for granted in the planning exercise are mainly ruins of monumental scale distinctive enough to qualify as World Heritage sites today. This leads me to also examine the institutionalized assumptions that guide the modern identification of some sites as cultural heritage, noting their intersections with, contributions to, and divergences from the other kinds of common sense employed. I argue that the government agencies and

the experts they employed shared some of this cultural heritage common sense, embodied in the process used by UNESCO in assessing nominations for World Heritage listing.

As described in the UNESCO convention, to achieve listing, cultural properties must either be monuments that exemplify "outstanding universal value from the point of view of history, art or science" or groups of buildings that "because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history, art or science," or sites that "are of outstanding universal value from the historical, aesthetic, ethnological or anthropological point of view."[18] The UNESCO convention conveys an implicit temporality, indexed by the repeated citation of "point of view," firmly rooted in the present when we look at these things as evidence of history, art, science, aesthetics, or anthropological or ethnological interests.

In this universal framework, the "outstanding universal value" of a cultural heritage site is to be identified through assessment of a series of criteria defined in the "Operational Guidelines for the Implementation of the World Heritage Convention."[19] Most archaeological features are registered as World Heritage under one or more of the first four criteria. Criterion (i) requires a site "to represent a masterpiece of human creative genius." Criterion (ii) recognizes features that "exhibit an important interchange of human values" influencing "developments in architecture or technology, monumental arts, town-planning or landscape design." Criterion (iii) says a site must "bear a unique or at least exceptional testimony to a cultural tradition or to a civilization." Under criterion (iv) features are determined to be "an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history."

As these general expressions of "outstanding universal value" make clear, scale and meaning are at issue in determining whether a set of features constitutes a monument worthy of cultural heritage designation, or is durable enough and effective enough at conveying meanings to serve as models for contemporary projects. This leads me to juxtapose common sense about archaeological sites by experts from within and outside archaeology, involved in the planning process I analyze, with other conceptions of the meaning of human action at this scale expressed in art works. I show that projects conceived of as artworks, and the proposed product of the planning process I describe, which seem at first to be very different, actually cross over and intertwine, drawing at many points on shared common sense, especially about the suitability of the US West as a surface for marking.

Throughout the book, I build on insights from recent, transdisciplinary theoretical work in what is called new materialisms.[20] New materialisms ask us to consider the liveliness or animacy of materials that have often been treated as inert objects of human action but need to be seen as acting along with humans and other animals.

A serious engagement with concepts of animacies embraces humans, nonhuman animals, and matter. It sees effects as caused by assemblages in which intentions of one part of the assemblage—notably, the human—are not always, or even often, the best explanation for what ultimately happens. Throughout the book I explore what we think we know about the intentions of makers of archaeological features singled out by the nuclear planning experts and how their actual histories of relative durability and change are explained as much as or more by the activity of the materials used.

It would be easy in following the path of a project at once technocratic and romantic, to treat it as an abstract object of academic interest. So it is critical to underline that the broader effort I examine is immensely consequential. If successful, it would help authorize the concentration of nuclear waste in spaces conceived of as relatively empty landscapes, removing waste from more populated areas. It would do so as part of a project designed to assert that these concentrations of nuclear waste can be kept safe from accidental release of radioactivity for long periods of time. In the last chapter of this book, I return to this ethical framing. There, I critically examine the selection of indigenous place as the empty space for waste disposal. I argue that indigenous inhabitation of these places demonstrates the effectiveness of alternative ways of maintaining knowledge of place and raises questions about harm beyond human interests.[21]

Along the way, readers will be taken on a global exploration of materials with long histories that have survived and been singled out as significant in the nuclear waste marker project. In order to guide this journey, I take one aspect of the archaeologically based marker conceptual design as a focus in each chapter, exploring the archaeological sites and materials used as support for the likely effectiveness of each. By examining what the planning experts took for granted about each element, I am drawn to follow traces of understandings ranging from the durability of certain stone, to the legibility of certain inscriptions, and the ways popular understandings of a variety of phenomena influenced how they were pressed into service. Because my interest is in the circulation of ideas as common-sensical, not only visual art but poetry and fiction, journalism and tourist guides form part of my materials.

If I am successful, readers will end, not with an understanding of an archaeological case study, or of archaeological research, but with a model of how to think like an archaeologist: viewing the past, present, and future as mutually constituted, but not deterministically shaped, always providing for emergent understandings that transform how we embrace the material worlds of which we are part. They will understand the limits of the common senses of experts, including archaeologists, and be more prepared to examine how we might better understand long-term traces of humans on landscapes.

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The first public presentation of this project was given as the Distinguished Lecturer of the Archeology Division of the American Anthropological Association in 2003, an invitation I gratefully acknowledge and an honor I feel was premature but hope to have finally merited with this book. Further development was hampered by changes to the online availability of documents following the September 11, 2001, attacks. I thus gratefully acknowledge the continued encouragement provided by invitations from Stanford University's Archaeology Center in 2006, and from Anne Porter at the University of Southern California in 2009, to be part of a program at the Interdisciplinary Center of Commemorative Studies "Stonehenge, Past and Future." The latter event gave me inspiration to renew my analysis of the contrast between Stonehenge as envisioned by the nuclear markers experts and as it was being revealed by new research, presented at that event by Michael Parker Pearson.

I was able to pursue the project during a sabbatical year in 2010–2011, supported by a John Simon Guggenheim Foundation Fellowship. During that sabbatical, a more developed version of my arguments was presented in December 2010 as a departmental colloquium at Manchester University, and as a public lecture at Oxford University, where I was an Astor Visiting Lecturer sponsored by the Pitt-Rivers

Museum. I thank Dan Hicks and Chris Gosden for this invitation and support. On my return to Berkeley, I had the serendipity of being invited to present the project as part of a conference sponsored by the Science, Technology, and Society Center of UC Berkeley in 2011. There I had all-too-brief conversations with other Berkeley affiliated scholars, which enriched my understanding of the contemporary field of studies of nuclear/atomic culture. An invitation to Memorial University in St. John's, Newfoundland, in 2014 provided encouragement as I further developed the analysis of thinking about archaeological materials in the nuclear planning process.

The most complete realization of the vision for the book that has appeared to date was the TAG *Antiquity* Keynote Lecture I was invited to present at the Theoretical Archaeology Group Conference at the University of Southampton in December 2016. My sincere gratitude to the organizing committee for this invitation, and to Marta Diaz-Guardamino, in particular, for a sustained dialogue about issues in materiality. I would also like to thank the Faculty of Archaeology at Leiden University, and Miguel John Versluys and the Material Agency Forum there; the Honors College at Portland State University and its director, Brenda Glascott; Guido Pezzarossi and the Department of Anthropology at Syracuse University; the Department of Anthropology at McMaster University, particularly Shanti Morell-Hart and Andy Roddick; Andrew Bauer and Steve Kosiba as organizers of a session at the 2016 North American Theoretical Archaeology Group conference at the University of Colorado; and the Stanford University Archaeology Center for other invitations in 2016 and 2017 where I rehearsed my arguments about the animacy of materials in the context of this project. Responses to the Stanford presentation were particularly helpful in encouraging me to clarify the ethical stakes of the project, and the specificity of the history of Egyptian antiquarianism in the 19th-century US that I trace here. Interlocutors at McMaster greatly encouraged both my engagement with animacies of matter and with indigenous scholarship. An exchange during the University of Colorado TAG conference gave me the chance to have someone associated with Los Alamos read how I was discussing the accidental release of radioactivity in New Mexico that has been blamed on work done at Los Alamos, to ensure I was giving fair consideration to the people involved.

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University. While plans for a publication from that conference have been delayed, the exchanges there with Karen and others, especially Alice Gorman, Paul Graves-Brown, Ömür Harmanşah, and Uzma Rizvi, convinced me that this project is, indeed, part of the archaeology of the contemporary—an identification first made by UC Berkeley doctoral candidate Mario Castillo. I should also acknowledge Cornelius Holtorf and Anders Högberg for including me in their proposed edited book *Cultural Heritage and the Future*, now under development.

The piece of this project that has taken me farthest from my comfort zone has been work on the relationship between nuclear markers proposals and various forms of art practice. Here again, I would single out doctoral students at UC Berkeley for their enthusiastic support for pursuing aesthetic domains, from fiction to poetry to the visual arts, as either alternative discourses or ones that intersect with the archaeological sensibility: in particular, Annie Danis, Seth Denizen, Laura Devendorf, Amanda Guzman, Katie Kinkopf, Jeanne Lopiparo, Colleen Morgan, and Daniela Rosner. I would also like to acknowledge Doug Bailey as an inspiration for willingness to take risks and pursue the project of archaeology and art, no matter where it leads. I owe a debt to museums that have given me the space to talk to curators, faculty, students, and the general public about materiality and the intersection with aesthetics. The Getty Conservation Institute, the Museum Volkenkunde in Leiden, and the Haffenreffer Museum and RISD have each provided important opportunities to develop these broader ideas. I would like to thank Neville Agnew and Janet Bridgland, Laura van Broekhoven and Alex Geurds, and Robert Preucel for specific invitations. I also want to record the encouragement of Vonda McIntyre, who responded to my questions about *Dreamsnake* by initiating an exchange of books, and who I wish could have read this one.

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INTRODUCTION

THIS IS A BOOK about the intersection of three unlikely things: large-scale artworks installed outdoors (Land Art or Earth Art); archaeological sites so monumental they are worthy of recognition as World Heritage sites; and waste, specifically, nuclear waste. What these phenomena have in common is the expectation that they did or will last a very long time. How that fact led to archaeological sites and artwork being proposed as markers for nuclear waste and what it tells us about how we think about long-enduring things are the questions explored in the pages that follow.

Intentionally produced monuments and some works of art endure far beyond the lives of their creators. However, the most enduring things humans have created are actually accumulations of trash. The modern discipline of archaeology rests on recognizing this fact: the quantity, variety, and concentration of discarded materials is what allows archaeologists to understand human life in its fullness.

As specialists in understanding human life from trash, archaeologists have given substantial thought to what makes such things last. In an innovative and long-term series of studies, archaeologist William Rathje's Garbage Project explored the intentions and actual outcomes of trash disposal in the modern US, the unintended consequences of trash management, and the meanings that garbage can convey.[1] The Garbage Project began in Tucson, Arizona, in 1972. Operating within the then-dominant positivist and empiricist frameworks of archaeology, the project assumed that garbage would reflect people's lives in a less filtered and manipulated way than people's narratives of their own lives. Garbage would be a more unbiased record of activity.

Initially, Garbage Project researchers collected trash at house sites. Research expanded from Tucson to encompass samples from Milwaukee, Wisconsin; Marin County in California; and Mexico City.[2] The researchers compared what people

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discarded to what surveys in these cities said people consumed. They discovered that trash disposal sometimes systematically contradicted what people said they did and at other times was subject to what they called "irrational" behavior contradicting self-descriptions.

Garbage Project researchers branched out into exploration of landfills, ultimately excavating 15 landfill sites across the US dating from 1952 to 1989.[3] In these excavations, they found that biodegradation was not proceeding as their designers had assumed. The vast volumes of landfills—2.4 billion cubic feet, covering 3,000 acres, in one example from Fresh Kills, New York—obstructed the processes of decay that were expected based on observations of smaller waste sites. This led to garbage surviving longer than expected. Landfills, the Garbage Project showed, are more permanent and longer-lasting than intended or foreseen.

In conveying this discovery, Rathje compared the volume of landfills to the volume of a particular monument: the Egyptian Great Pyramid of Giza.[4] The Fresh Kills landfill was characterized as 25 times the volume of the Great Pyramid. This may seem simply like enlisting a convenient and archaeologically familiar project for comparison. Yet the selection of this measure, rather than something from contemporary experience, hints at ways we understand ancient monuments that are central to understanding the project I examine in this study, proposals to mark nuclear waste disposal sites for very long periods of time.

Rathje's use of an archaeological monument (the Great Pyramid) to communicate to a general public about something else that would last for a very long time (landfills) appeals to a common-sense understanding of monuments as things *intended* to last. It isn't just the volume of the Great Pyramid; it is its durable and enduring nature that Rathje invoked with this comparison, as a measure of lasting human intentions. The comparison reveals something unexpected: monuments and accumulations of trash share some characteristics by virtue of their sheer material scale. I go one step further: I suggest that just as landfills acted in ways unexpected by their makers, so perhaps did monuments. This aligns my understanding of the detritus of human residence—whether in forms we call trash or those now celebrated as cultural heritage monuments—with ideas about waste as spatial and material, and decay as temporal and processual, used by others to understand the nuclear waste disposal project I examine here.

This book will explore how ancient monuments that have lasted for long periods of time, like the Great Pyramid, came to shape thinking about their doubles: long-lasting deposits of waste. It explores assumptions made in attempts to plan for disposal of the longest-lasting human trash ever produced: radioactive waste.

Nuclear waste is a byproduct of military and civilian use of technologies that exploit the atomic structure of matter to release energy, creating materials that are radioactive—continually emitting energy as less stable forms of elements "decay"

into more stable ones. It is "produced at every step of the nuclear fuel cycle, starting from mining and mineral processing, through uranium enrichment, fuel rod fabrication and reprocessing, to nuclear power generation, and the decommissioning of nuclear power plants" as well as in military weapons production.[5] In the early 20th century, radium, a radioactive material occurring in the environment, was used in medical practice, and in industry to create glowing watch dials. The illness of workers in contact with radium provided the first opportunity to understand the negative effects of exposure to radiation.[6] A much larger challenge was ushered in by the development of atomic weapons in the Second World War. After the end of the war, government and industry efforts to find civilian uses for the techniques developed to unlock atomic energy for war led to the development of nuclear power plants and the continuing production of nuclear waste, potentially a danger to populations brought into close contact with disposal sites.

The United States government developed policies to control the disposal of radioactive byproducts of these modern activities. The US Nuclear Regulatory Commission (NRC) defines two categories of nuclear waste.[7] Low-level nuclear waste includes everything from medical equipment to clothing contaminated by exposure to radioactivity. High-level nuclear waste is produced as byproducts of the use of nuclear reactors or through the reprocessing of exhausted reactor fuel to recover still-usable material for use as additional fuel. Radioactivity continues to be emitted by nuclear waste until the elements involved "decay" into more stable forms. For high-level waste, this process can require hundreds of thousands of years.

As a result, nuclear waste has to be managed: stored safely for long periods of time in ways that insulate humans from potential exposure. Low-level waste is stored where produced until "it has decayed away and can be disposed of as ordinary trash, or until amounts are large enough for shipment to a low-level waste disposal site."[8] There are presently four sites for disposal of low-level nuclear waste in the US, licensed by the NRC—in South Carolina, Texas, Utah, and Washington state.[9] The NRC has a single location under consideration for high-level waste disposal, Yucca Mountain, Nevada, modeled in part on something called the Waste Isolation Pilot Plant (WIPP) developed by the Department of Energy (DOE) near Carlsbad, New Mexico. Planning proposals and licensing applications for these two locations of high-level nuclear waste disposal sites created the documents examined in this book.

Rather than see the disposal of nuclear waste as an unprecedented challenge that exceeds human understanding, I explore how human understandings that are shaped by experiences with materials that we intend to contain are extended from known to unknown situations. Peter van Wyck argues that nuclear waste is different from other waste because it cannot be completely contained or disposed of over a

time scale consistent with the human life span or even multi-generational memory. "There is always leakage," he writes.[10] The same is true, Rathje showed, of waste in landfills. Human expectations for the way materials would decay and the length of time involved as well as human hopes that waste could be contained are both disappointed.[11] From an archaeological perspective, the 10,000 year horizon used for planning of nuclear waste disposal projects in the US represents only the very recent past of a species whose archaeologically documented history stretches back millions of years. From this perspective, leakage, the capacity of nuclear matter to "drift," is not unique but rather typical of residues of human habitation that slowly shift from recognizably human-engaged assemblages to others we label natural.

The chapters that follow draw connections between the logic employed by different participants in the planning process for nuclear waste disposal marking in the United States. They examine what each took as common sense about human behavior. One focus is the comparison with the challenges of interpretation that have faced archaeologists dealing with the same questions, in regard to the things taken as models by the nuclear waste planning exercise. A second thread considers how materials continually escape from any expectations people have formed about their behavior in the past, in part because of an anthropocentric tendency to underestimate the activity that materials can manifest on their own.

In pursuit of the anthropological project of a comparison of common senses, this book juxtaposes proposals for marking nuclear waste disposal sites based on popular understandings about the monuments archaeologists documented with other proposals for nuclear waste markers based on very different antecedents. These alternative proposals were based on or originated from the contemporary art world, some through the same planning process that employed archaeological monuments as evidence, others through art practice in opposition or response to the challenge of marking waste disposal sites for deep futures.

Archaeological monuments were treated as examples of universals of human behavior and understanding in the development of the US government's selected proposal to mark nuclear waste disposal sites. The selection of a proposal using archaeological monuments as models, rather than an alternative based on the emotional power of archetypal designs developed in the same expert consultation, stems from seeing art projects as more ambiguous, accepting that they were likely to unfold and be understood in different ways. One conclusion I reach is that as specialists in understanding products of past human action that have endured over long periods of time, we archaeologists actually understand sites seen as monuments today in ways more consistent with the visions of contemporary art projects than of those planners who used archaeological sites as justification for their claims that nuclear waste markers could be designed that would communicate sufficiently clear messages long into the future to ward off a disaster.

In the end, I hope to demonstrate that while we operate within our own commonsense understandings that always make sense to us, these cannot be taken as guidance for the common sense of other times and places, whether in the past or the future. I specifically question the degree to which we can continue to assert the primacy of human intentions in the face of the repeated demonstrations offered by histories of inhabitation that show that materials often act in ways unintended by people who assembled them.

The nuclear waste disposal project I examine sought security in universals and ideas about changelessness that I show are also ideals of modern cultural heritage management, the process that transforms ruins into monuments. I argue that in the end we might do better to embrace insights from critiques of cultural heritage common sense, and recognize that it is usually living connections, passed on from person to person, that maintain intelligibility of place, with all the potential that such chains of transmission have for misunderstanding and creative reinterpretation.

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Monuments and Nuclear Waste

The project of creating nuclear waste repositories concerns the ultimate in long-lived trash: radioactive materials expected to remain dangerous for at least 10,000 years. The 10,000 years used as a horizon in these projects is a period of time with no particular natural grounding, based on abstract models for when the remaining radioactive waste will "no longer [be] harmful to life."[12] The US Environmental Protection Agency (EPA), which adopted the 10,000-year time frame in its original regulations, argued for this length of time based on its calculations of cumulative risks of exposure to sufficient radiation to produce deadly effects exceeding an arbitrary acceptable level.[13] The EPA later described projecting human conditions so far into the future as speculative, saying it exceeded the bounds of predictability.[14] The arbitrary nature of the time span was highlighted when in response to a court decision, the EPA proposed to change its standard to 1 million years, a time frame for which no defensible arguments based on human history might be made for the effectiveness of even the construction of containers for waste, let alone monuments marking such sites.[15]

The proposals I examine come from government consultation for two disposal sites: WIPP, near Carlsbad, New Mexico, and a successor facility proposed for Yucca Mountain, Nevada. The first completed stage of US permanent disposal of nuclear waste was the design and implementation of WIPP as a "research and development facility to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the U.S. exempted from regulation by the Nuclear Regulatory Commission."[16]

At WIPP, nuclear waste would be buried deep underground in geological formations asserted to be stable and impervious to water filtration that might otherwise spread radioactivity. According to the official chronology maintained by the WIPP project, drilling, proposed in the 1970s, began in 1981.[17] In 1985, the EPA issued guidelines for disposal of waste from radioactive elements intended to guide safe use of the WIPP facility, updated in final form in 1993 primarily to extend the time horizon for limiting impacts of radioactivity on people and water to 10,000 years, an increase from the original legal standard required, which was just 1,000 years.[18]

By 1989, the Department of Energy completed its construction of the WIPP storage facility. Shortly thereafter, in 1991, the DOE proposed to begin using the WIPP facility, characterizing this as a "test," in advance of EPA approval. This proposal led to lawsuits and court injunctions, and by 1993 the "test" phase proposal was dropped. Eventually, the EPA certified WIPP for use in 1998. In 1999, shipments of radioactive waste began to arrive, truckloads packed with containers. By 2006, half of the planned segments of underground storage ("panels") had been completed and more than 5,000 shipments of radioactive waste were in place at the site in Carlsbad, New Mexico. As of February 21, 2018, the number of shipments received was over 12,000, six of the seven panels constructed to date were closed, and over 92,000 cubic meters of waste had been put in place.[19]

During the ongoing operational phase, the DOE is still developing plans for marking the site after closure to ensure that it will not be disturbed and create an environmental hazard.[20] WIPP documents posted online for the broader public describe the "conceptual design" for marking the site to prevent disturbance developed through a process of expert consultation. This proposal, and the process of expert consultation that led to its development, is the primary focus of this book.[21]

In 2008, the DOE began the process of applying for a license from the NRC to create a second nuclear waste repository, this one at Yucca Mountain, Nevada.[22] Yucca Mountain would be used for spent fuel from nuclear reactors and waste produced from reprocessing reactor fuel. In 1982, the US Congress passed the Nuclear Waste Policy Act, amended in 1987 to designate Yucca Mountain as the sole candidate for an underground disposal facility for such waste.[23] The act designated the EPA as responsible for defining standards for environmental safety of the site, the DOE as responsible for designing and operating the facility, and the NRC for implementing the EPA standards and licensing the DOE operations.

Standards set for licensing require that applications for operation of nuclear waste repositories provide a plan for controlling access to the site, "including a conceptual design of monuments that would be used to identify the controlled area after permanent closure." An amendment to any license received would be needed when the repository was ready for closure, describing the monuments "designed,