Journal of Environmental Radioactivity 129 (2014) 86–93

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad

Radionuclides in bats using a contaminated pond on the Nevada National Security Site, USA

Ronald W. Warren*, Derek B. Hall, Paul D. Greger

National Security Technologies, LLC, 2621 Losee Rd., North Las Vegas, NV 89030-4129, USA

ARTICLE INFO

Article history:
Received 21 May 2013
Received in revised form
12 November 2013
Accepted 12 November 2013
Available online 3 January 2014

Keywords:
Bats
Myotis
Pipistrellus
RESRAD-Biota
Dose
Radionuclides

ABSTRACT

Perched groundwater percolating through radionuclide contamination in the E Tunnel Complex on the Nevada National Security Site, formerly the Nevada Test Site, emerges and is stored in a series of ponds making it available to wildlife, including bats. Since many bat species using the ponds are considered sensitive or protected/regulated and little information is available on dose to bats from radioactive water sources, bats were sampled to determine if the dose they were receiving exceeded the United States Department of Energy dose limit of 1.0E-3 Gy/day. Radionuclide concentrations in water, sediment, and flying insects were also measured as input parameters to the dose rate model and to examine trophic level relationships. The RESRAD-Biota model was used to calculate dose rates to bats using different screening levels. Efficacy of RESRAD-Biota and suggested improvements are discussed. Dose to bats foraging and drinking at these ponds is well below the dose limit set to protect terrestrial biota populations.

1. Introduction

The United States (U.S.) Department of Energy (DOE), National Nuclear Security Administration Nevada Field Office (NNSA/NFO) operates the Nevada National Security Site (NNSS – formerly the Nevada Test Site) in south-central Nevada. Historical nuclear weapons testing and related activities have resulted in areas contaminated with man-made radionuclides. NNSA/NFO has obligations, and is committed, to managing lands in a manner that protects the environment (DOE, 2010). As such, there is a need to demonstrate that radiological dose limits established by the DOE (DOE, 2002a) are not exceeded. An NNSS site-wide biota dose assessment was conducted in 2003 using the graded approach described by the DOE Standard for conducting biota dose evaluations (DOE, 2004a) and the RESRAD-Biota model version 1.0 (DOE, 2004b). In general, the approach consists of comparing concentrations of radionuclides observed at the location of interest with Biota Concentration Guides to determine whether there is potential for the DOE dose limits to be exceeded. Multiple locations on the NNSS failed the level-1 screen using maximum radionuclide concentrations but subsequently passed on the level-2 screen using average radionuclide concentrations (DOE, 2004a). One such area was an isolated series of ponds known as the E Tunnel Ponds. Although the ponds passed the level-2 screen, bats were selected to test the validity of the graded approach and the RESRAD-Biota model because very little is known about radionuclide uptake by bats and several state of Nevada sensitive or protected/regulated bat species are known to use the ponds. In arid environments water sources are sparsely distributed and are critical resources necessary for the survival of bats that concentrate around them to drink and forage. Several studies have been conducted to determine the effects of many types of chemical contaminants on bats (Clark and Shore, 2001; Clark, 1981; O'Shea et al., 2000). Smith et al. (1955) and Meehan et al. (2004) have described the biological effects of varying external dose levels of ionizing radiation to bats, and there is documentation of bats using areas contaminated with radionuclides (Baron et al., 1999; Bechtel Nevada 2003; Bechtel Nevada 2005, DOE, 2001; Hall, 2000), but there is only limited information on radionuclide concentrations in bats using areas that are radiologically contaminated (Gashchak et al., 2010).

The objective of this research is to provide data on radionuclide concentrations in bats drinking and foraging over a radioactively contaminated pond and to use the RESRAD-Biota model to estimate internal and external radiological dose received by those bats. Radionuclide concentrations were also measured in pond water and sediment and in flying insects trapped near the ponds to document concentration ratios and to be used as input parameters to the RESRAD-Biota model. For comparison, radionuclide

* Corresponding author. Tel.: +1 702 295 5595.
E-mail address: warrenrw@nv.doe.gov (R.W. Warren).

0265-931X/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jenvrad.2013.11.005

concentrations were also documented in bats using a distant, non-contaminated pond on the NNSS.

1.1. Study sites

The E Tunnel Ponds are located at the base of Rainier Mesa in the north-central portion of the NNSS (Fig. 1) at an elevation of 1828 m. This region is at the southern end of the Great Basin Desert in a Blackbrush/Nevada jointfir shrubland association (Ostler et al., 2000). Several features such as cliffs, trees, buildings, mines and tunnels provide suitable habitat for several bat species. Five ponds were constructed to collect and hold water draining from the E Tunnel Complex. This water is predominantly contaminated with tritium but also contains mixed fission products and traces of plutonium and americium resulting from nuclear weapons testing in the tunnels, 1958–1977. At the time of this sampling only one pond, Pond 5, was receiving, and contained, water. Pond 5, referred to hereafter as E Tunnel Pond, is approximately 0.018 ha with a maximum depth of about 1.8 m. The only other perennial water source of comparable size relatively near the E Tunnel Pond is a construction water source pond, known as Camp 17 Pond which is 7 km southwest of the E Tunnel Pond. In addition, two natural springs, Captain Jack Spring and Whiterock Spring, are within 3 km of E Tunnel Pond. The E Tunnel Pond is the only perennial source of radiologically contaminated water on the NNSS.

Well J-11 Pond is located in Jackass Flats in the Mojave Desert Ecoregion in the Creosotebush/White bursage shrubland association (Ostler et al., 2000) at an elevation of 1048 m approximately 46 km south-southwest of E Tunnel Pond (Fig. 1). This pond was selected as a control site because it is a perennial water source with about the same dimensions and depth as the E Tunnel pond and is not radiologically contaminated.

2. Methods

2.1. Water and sediment sampling

On September 8, 2004, water and sediment were sampled from E Tunnel pond. A water sample with duplicate was taken from the pond water. Each water sample was comprised of a 500 mL aliquot in a glass bottle for tritium analysis (no preservative) and a 1 L aliquot in a plastic bottle for analysis of gamma-emitting radionuclides by gamma spectroscopy, ^{238}Pu, $^{239+240}$Pu, and ^{241}Am by radiochemical separation and alpha spectroscopy, and ^{90}Sr by radiochemical separation and beta counting. The 1 L aliquot was preserved to a pH $\leq$ 2 with HNO_3. Water samples consisted of composites from three locations around the pond, each taken within 2 m of the edge at a depth of approximately 30 cm. Sediment samples, one sample with one duplicate, were comprised of approximately 500 g dry-weight of sediment sifted with a 2-mm sieve. Sediment samples were composites with equal parts taken from the 0–5 cm depth approximately 15 cm below the waterline at three locations around the pond. Sediment samples were analyzed for gamma-emitting radionuclides by gamma spectroscopy; ^{238}Pu, $^{239+240}$Pu, and ^{241}Am by radiochemical separation and alpha spectroscopy; and ^{90}Sr by radiochemical separation and beta

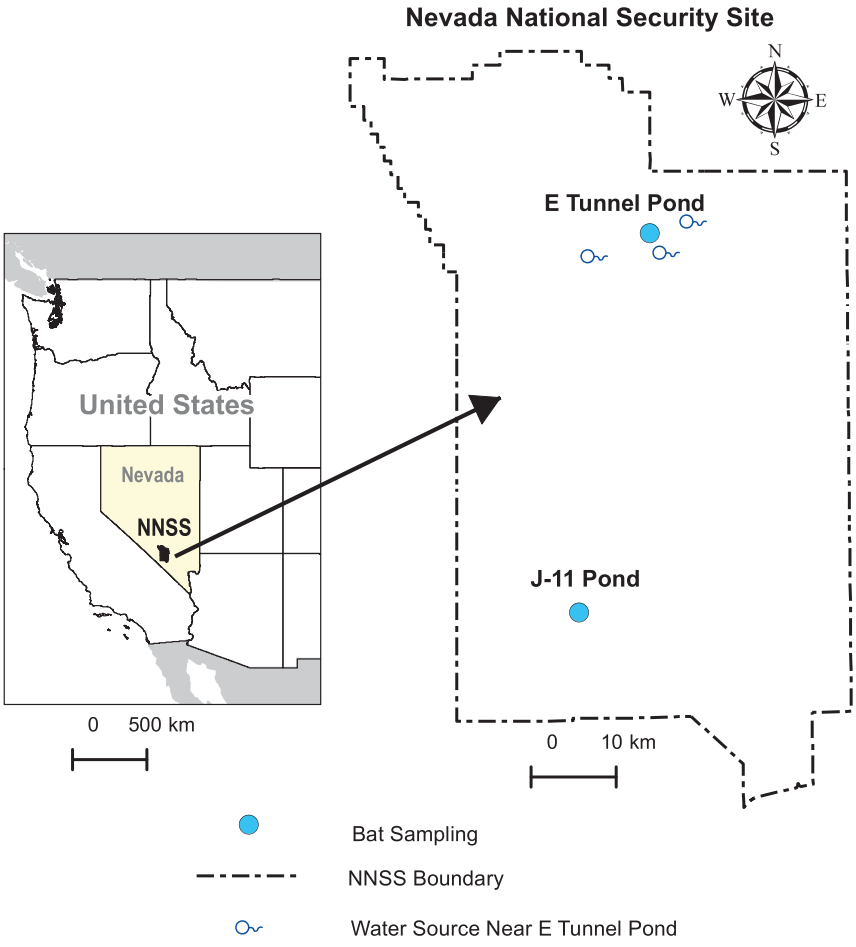

Fig. 1. Nevada National Security Site, bat sampling locations, and water sources near E Tunnel Pond.