Washoe Tribe
Human Health Risk Assessment
Exposure Scenario
for the
Leviathan Mine Superfund Site

Prepared for the

Washoe Tribe of Nevada and California

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March 17, 2005

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1. INTRODUCTION

This document presents the Washoe Exposure Scenario [‘Scenario’] for the Leviathan Mine and its affected area. An exposure scenario is a narrative and numerical representation of the interactions between human and/or ecological receptors and their immediate environment. Exposure scenarios include media-specific and pathway-specific exposure factors that are required to estimate a dose to the target receptor as they pursue a defined set of activities in particular locations.

Even though many Tribal lands have been lost and resources degraded, there are generally more traditional or subsistence practices followed by Tribal members than the general non-native population realizes. However, the objective of many Tribes is to regain land, restore resources, and encourage more members to practice healthier (i.e., more traditional) lifestyles. Therefore, the objective of subsistence exposure scenarios is to describe the original lifestyles and resource uses, not to present a current snapshot of restricted or suppressed uses, because the intent is to restore the ecology so that original pattern of resource uses 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. The intent of the Washoe scenario is to reconstruct what the original lifestyle and diet would have been in the affected area but for the contamination.

For the general United States population, an exposure scenario is typically designed to be an upper bound (generally around the 75th percentile) of the population being assessed. Some individual exposure factors are the 90th or 95th percentile; others are mean values. In the case of tribal exposure scenarios, there are no Tribal-specific databases of subsistence activities, resources, diets as there are for the general United States population. Cross-sectional surveys of current Tribal populations will not generate that data because much resource use has been suppressed due to loss of land and access, awareness of contamination, persecution by the dominant society, and many other reasons. This means that large and accurate statistical distributions for subsistence exposure factors are not available and cannot be developed. Therefore, ranges of exposures, or specified percentiles of exposure are not possible to calculate. Rather, the Washoe scenario is intended to be a reasonable representation of a traditional lifestyle, equivalent to a central tendency rather than to an upper bound.

For the general suburban population the exposure scenario is well defined in EPA guidance (Exposure Factors Handbooks). For Tribal communities, a two-step process is used. First, a general scenario based on the lifestyle and baseline conditions of regional natural resources is developed. This report presents the general lifestyle scenario along with initial information about the specific Leviathan-Bryant drainage system. A site-specific Reasonable Maximum Exposure (RME) scenario is then developed based on localized resource and habitat distributions within the affected area. The Scenario and RME, along with knowledge of contaminant transport and fate, are the bases of the Conceptual Site Models (CSM). Together, these tools are used to develop work plans for the remedial and restoration processes such as (1) identifying or verifying contaminants of concern, (2) determining the nature and extent of contamination by identifying culturally relevant and ecologically important natural resources, (3) developing sampling plans for media and biota, (4) developing remedial goals, and (5) evaluating baseline and residual risks.

This Scenario identifies general exposure pathways specific to Washoe lifestyles and key resources that the Washoe people use. It starts with a general description of baseline natural resources that might be (or might have been) present in the Leviathan-Bryant Creek drainage system where people will return after cleanup. It is unknown whether any resources contaminated by the Mine are being used currently by Washoe members and, if so, whether decisions to use such resources are being made with the knowledge that the resources may be contaminated. However, the exposure scenario is intended to describe what people would do if the resources were unaffected by the mine. A general understanding of what people do (or would do in the absence of contamination) in the drainage system and what resources are available for their use provides the basis for developing preliminary exposure factors. The Scenario describes the activities that traditional people undertake to survive and thrive in the local ecosystem, including hunting, gathering foods and medicines, fishing, making material items, farming or gardening, raising livestock, irrigating, and various cultural and domestic activities.

The exposure scenario reflects a traditional subsistence lifestyle. "Subsistence" refers to the hunting, fishing, and gathering activities that are fundamental to the way of life of many indigenous peoples. Subsistence utilizes traditional and modern technologies for harvesting and preserving foods as well as for distributing the produce through communal networks of sharing and bartering. The following is a useful explanation of “subsistence,” taken from the National Park Service:

> “While non-natives tend to define subsistence in terms of poverty or the minimum amount of food necessary to support life, native people equate subsistence with their culture. Among many tribes, maintaining a subsistence lifestyle has become the symbol of their survival in the face of mounting political and economic pressures. It defines who they are as a people. To Native Americans who continue to depend on natural resources, subsistence is more than eking out a living. While it is important to the economic well-being of their communities, the subsistence lifestyle is also the basis of cultural existence and survival. It is a communal activity. It unifies communities as cohesive functioning units through collective production and distribution of the harvest. Some groups have formalized patterns of sharing, while others do so in more informal ways. Entire families participate, including elders, who assist with less physically demanding tasks. Parents teach the young to hunt, fish, and farm. Food and goods are also distributed through native cultural institutions. Most require young hunters to distribute their first catch throughout the community. Subsistence embodies cultural values that recognize both the social obligation to share as well as the special spiritual relationship to

> the land and resources. This relationship is portrayed in native art and in many ceremonies held throughout the year."[1]

In economic terms, a subsistence economy is one in which currency is limited because many goods and services are produced and consumed by the same families or bands. Today, currency (symbols of specified quantities of useful resources) is limited, but important. For example, subsistence in an Arctic community includes the following:

> "The modern-day subsistence family depends on the tools of the trade, most of which are expensive. Snowmobiles, gasoline, guns, fishing nets, and sleeping bags are necessities. Subsistence households also enjoy many of the modern conveniences of life, and are saddled with the economic demands which come with their acquisition. Today's subsistence family generates much-needed cash as wage-labourers, part-time workers and trappers, professional business people, traditional craftmakers, and seasonal workers. A highly-integrated interdependence between formal (cash-based) and informal (barter and subsistence-based) economic sectors has evolved."[2]

Once the activities comprising a particular subsistence lifestyle are known, they are translated into a form that is used for risk assessment. This translation captures the degree of environmental contact that occurs through activities and diet, expressed as numerical "exposure factors." Exposure factors for direct exposure pathways include exposure to abiotic media (air, water, soil, and sediment), which can result in inhalation, soil ingestion, water ingestion, and dermal exposure. Indirect pathways refer to contaminants that are incorporated into biota and subsequently expose people who ingest or use them. There are many unique exposure pathways that are not accounted for in scenarios for the general public, but may be significant to people with certain traditional specialties such as basket making, flint knapping, or using natural medicines, smoke, smudges, paints and dyes. These activities may result in increased dust inhalation, soil ingestion, soil loading onto the skin for dermal exposure, or exposure via wounds, to give a few examples. While the portals of entry into the body are the same for everyone (primarily via the lungs, skin, mouth), the amount of contaminants may be increased and the relative importance of some activities (e.g., basketmaking, wetlands gathering), pathways (e.g., steam immersion or medicinal infusions) or portals of entry (e.g., dermal wounding) may be different than for the general population.

Foraging theory data from the anthropological literature is particularly useful for developing exposure scenarios because the major dietary and resource staples may be described as well as how much time and effort is needed to obtain them. Together, this information is then used for the foodchain portion of the scenario and to calculate the direct exposure factors.

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[1] National Park Service: http://www.cr.nps.gov/aad/cg/fa_1999/Subsist.htm
[2] http://arcticcircle.uconn.edu/NatResources/subsistglobal.html

This process is laid out in the following sections according to the general sequence:

1. Environmental setting – what resources are available;
2. Lifestyle description – activities and their frequency, duration and intensity, and resource use;
3. Diet;
4. Exposure pathways;
5. Exposure factors – iterative crosswalk between pathways and direct exposure factors; cumulative soil, water, air, and dietary exposures.

Because the method for developing exposure factors is derived from an understanding of the lifestyle rather than from large statistical databases (national drinking water rates, or USDA databases of national average food intakes) and is unfamiliar to many readers, it is described briefly here (more detail is presented below).

Because these large databases are not available and cannot be constructed, we take a top-down approach. For example, we do not attempt to develop a complete diet based on surveys of the uses of the typical 200+ natural resources available and used with an ecoregion. Rather, we develop a calorically complete food pyramid that identifies the major staples and their rough percentages in the original diet. Similarly, we do not attempt to develop an average day by tracking hundreds of individual activities from many people. The basic process is to:

(a) start with an understanding of the major categories of subsistence activities (such as hunting, fishing, gathering, basketmaking, and sweat lodge purification),
(b) describe enough of the sub-activities that the complexity and interconnection of resources and activities can be appreciated,
(c) identify the major activities that contribute to exposure, and then
(d) iteratively crosswalk between activities and conventional exposure factors to develop cumulative exposure factors.

For example, each of the major activity categories includes activities that result in exposure to soil, and therefore to soil ingestion. By estimating the relative amount of time spent in activities that result in high, medium, or low soil exposure for each activity category, an overall soil ingestion rate can be estimated. However, we do not attempt to be overly quantitative in enumerating the myriad activities and resources in each category – this implies more precision than is warranted and is likely to include proprietary information that cannot be released. Lastly, a review of existing literature (biomedical, anthropological and so on) enables us to double-check whether multiple lines of evidence leads us to a similar conclusion for each exposure factor.

2. ENVIRONMENTAL SETTING

This section is intended to provide a general introduction to habitats and plant communities that are present in Washoe territory. General resource use throughout the Washoe territory is described, with reference to the Leviathan-Bryant Creek drainage or similar drainages as available. It does not necessarily specifically address resources that might be (or might have been) in the area affected by the Leviathan Mine, because “a biogeography of Leviathan Canyon proper has not been undertaken” (Hammett et al., 2004). It is important to note that a CERCLA exposure scenario is intended to reflect exposures that would be received if a particular lifestyle is pursued within the assessment area irrespective of whether contamination is present or not. Therefore, baseline environmental conditions (rather than today’s degraded conditions) are approximated in this section.

The Washoe culture evolved around Lake Tahoe and exploits a wide range of resources and ecological niches. The Washoe territory includes the boreal Lakes and Sierra crest conifer zone (with Lake Tahoe, Honey Lake, and Topaz Lake), the transition zone with pinyon pines, and the Sonoran or sagebrush zone. Permanent settlements were located primarily on the flanks of the larger valleys on high ground near rivers and springs. The distribution of resources was largely the same in all major valleys, with some north-to-south gradations.

Many authors have described the general environmental setting of the Sierra Nevada, Pinyon-Juniper and Great Basin ecosystems (Barbour and Major, 1977; Brown, 1986; Foster and Hobbs, 1992; Holland and Kiel, 1995; Lanner, 1981; Moore, 2000; Muir, 1988a,b; Schaffer, 1998; Smith, 2000; Tilford, 1997; Tingley and Pizarro, 2000; Winnett, 1987). There are two distinct ecosystem types in the original Washoe territory - the heavily timbered and well watered Sierra Nevada mountains and the semi-desert Great Basin. The Leviathan Mine (at 7000 ft) lies within the central Washoe territory, along the ecological boundary between the high Sierra Nevadas on the west and the sage-greasewood zone that extends down into the Great Basin floor.

The altitude of the Sierra Nevadas causes westerly-directed air currents that are saturated on its trip from the California coast to drop most of its moisture on the western slope. This results in a rain shadow on the eastern slopes of the Sierras. The western side of the Sierras (from the central California valleys up to the peaks of the Sierras) has more gradual transitions and more precipitation and therefore more ecological zones than the eastern side. The western Sierra slopes include chaparrals and ponderosa pine-oak woodlands which the eastern slopes lack, while the eastern slopes (from the peaks eastward to the Great Basin floor) have the pinyon-juniper plant communities which the western slopes lack, as well as most of the sagebrush steppe.

A general sequence of vegetation types from higher to lower elevation are described by Walker (2003), Hammett et al. (2004), and references cited therein, and is summarized in the following sections.

2.1 Boreal Zones

2.1.1 Upper Montane Zone

This boreal zone typically contains Jeffrey pine, white fir, and incense cedar (on gravelly dry slopes at higher elevations and moister north slopes at lower elevations), with understories of greenleaf and pinemat manzanita, tobacco brush and/or snow bush, depending on soil type, moisture, canopy cover, and aspect. Oaks are shrubs at this elevation (huckleberry oak and bush chinquapin). This zone can also include white and lodgepole pine if the water table is high, and red fir in flats with deep soils. This broad zone includes several subzones: the alpine and subalpine belts at higher elevations, and the lodgepole-fir belt.

2.1.2 Lower Montane Zone

This boreal zone typically contains pines, red fir, and western or Sierra Juniper with chaparral understories of manzanitas, deer brush, whiteleaf, snowberry, serviceberry (*Amelanchier*), tobacco brush (*Ceanothus velutinus*), mountain mahogany (*Cercocarpus lidifolius*), mountain misery, or sagebrush, depending on soil type, moisture, aspect, and canopy. There are also some black oaks, western white pine, and sugar pine. Where fires have been suppressed, white fir and incense cedar overtake the ponderosa and black oaks; regular fires promote ponderosa, oaks, and ceanothus (deer forage). In higher meadows or sand flats formed on pumice flats, a ring of water-tolerant lodgepole pines may surround the moist flat. In drier areas, the understory may be characteristic of Basin sagebrush, with mountain mahogany, rabbitbrush, grasses, mule ear (*Wyethia mollis*); squirrel tail (*Elymus elymoides*); Great Basin wild rye, and forbs such as yarrow (*Achillea millefolium*), sulfur flower (*Eriogonum umbellatum*), and lupine (*Lupinus argenteus*). These latter species are also being used for revegetation at the mine site.[3]

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[3] Lahontan Regional Water Quality Control Board, State of California (2003). 2002 Year-End Report for Leviathan Mine, Alpine County, California, p.24, http://www.swrcb.ca.gov/rwqcb6/Leviathan/PDFs/2002_year_end_report_FINAL.pdf.

2.2 Transition Zones

2.2.1 Pinyon-Juniper Habitat (*Pinus monophylla - Juniperus osteosperma*).

This habitat covers slopes of the eastern Sierra in areas with gravelly, well-drained soils, transitioning into the sagebrush belt below. This community is closely associated with sagebrush scrub, often with pinyons on upper slopes and sage just below them on flatter drier areas. The understory is most often sage, bitterbrush, rabbitbrush, green ephedra (Mormon tea), mountain mahogany, with a variety of perennial wildflowers and grasses.

2.2.2 Sagebrush Steppe

Intermountain Grassland and Basin Sagebrush plant associations occur at lower and drier elevations with sage (*Artemesia tridendata*), rabbitbrush (*Chrysothamnus nauseosus*) and a variety of grasses and flowers. In the Basin (by the East Fork of the Carson River around Dresslerville), the vegetation on the bench lands includes Wyoming big sagebrush, rabbitbrush, bitterbrush, greasewood, spiny hopsage, green ephedra (Mormon Tea), Anderson peachbush, balsamroot, Thurber needlegrass, bottlebrush squirreltail, a variety of grass seeds, mustard, pigweed, saltbrush, rabbitbrush, sand grass, and other grasses. It also includes the sego lily, which is a food source that sustained Washoe people and Anglo settlers during times of scarcity.

2.3 Great Basin Valley Floor

The valley floor is included because some of the contamination from the mine may have come to be located in the lower reaches of the East Fork of the Carson River. The lowest zone in the Great Basin is the shadscale zone, named after its most abundant shrub, and typically includes green rabbitbrush, sagebrush, four-winged saltbrush, Bailey's greasewood, and littleleaf horsebrush. The more saline areas may be dominated by big greasewood along with desert blite and green molly.

Desert Marshlands. The Great Basin has no river outlets, but exhibits high evaporation rates; therefore, some wet areas can contain alkaline waters and soils/sediments. Depending on the alkalinity, these waterlogged areas may contain salt-tolerant sedges and rushes. For example, the Stillwater Marsh (near to but not in the affected area) has four lakes that drain from one to another, causing the salinity to increase sequentially. The first lake receives the freshest water (still potable), and has cattails, bulrush, willow, and sago pondweed. The next lake is more saline and has muskgrass, sago pondweed, and wigeongrass. The third basin has alkali saltbrush or nutgrass. The final basin is most saline (similar and up to twice as saline as seawater) and has few plants but many brine shrimp and brine flies.

2.4 Mountain Meadows, Springs and Creeks

These habitats occur throughout the montane and transition zones. Riparian species change somewhat with elevation, and may include dogwood, alder, elderberry, currants and other berries, quaking aspen, willow, coffeeberry, birches, cottonwood, rushes, sedges, grasses, horsetail, ferns, and a variety of bulbs and tubers. Springs and associated marshes and riparian habitats are extremely important to the Pine Nut Mountains' wildlife and to the Washoe people. They are widely scattered over the Pine Nut Mountains. While some wet areas are saline and alkaline marshes, most are small pools with warm to cool water sources. Where the water table is highest (mesic soils), mountain meadows are present, with willows, alders, huckleberries, wild rose, aspen, and cottonwood at lower elevations (a sign of water). Meadows have the highest plant diversity, with up to a hundred species in a single meadow. Mule Ears (an aromatic large-leafed sunflower) can form colonies in dry meadows that are tens of acres in size. Berries, swamp onions, fern, various bulbs and tubers such as lilies, wild potatoes and Indian sweet potatoes, wild spinach, and wild lettuce may be present. Tule, cattail, sedges, and other rushes can be present if moist enough. On the river bottom lands wild rye, western wheatgrass, Nevada bluegrass, sedges, rushes, silver buffaloberry, rubber rabbitbrush, Basin big sagebrush, Fremont cottonwood, and willow can be found.

3. OVERVIEW OF GENERAL WASHOE ECOLOGICAL LIFESTYLE

> "Water has always had a special significance to the Washoe people. All life is derived from water in Washoe beliefs, and water is considered sacred. There are legends and mythologies related to water. The many uses of water range from spiritual, medicinal, and ceremonial uses, to everyday uses such as drinking, bathing, cooking, and cleaning with water. Water -- whether in springs, streams, rivers, or lakes -- has such a defining and profound role in the culture of the Washoe people that it could be described as the essence of the Washoe people."[4]

The Washoe did not have to travel very far to obtain all the resources they needed, along with trade across the Sierras into California (Cook, 1941). The Washoe economy focused on plant gathering, fishing, and hunting (Price, 1980; Kelly, 1995; Tucker et al., 1992). The predominant staples included fish and pinyon nuts, both of which were zealously defended (Downs, 1966). There is evidence that Washoe families had a form of ownership interest of pinyon plots, which is rare in hunting and gathering societies. Additional staples included rabbits, acorns (obtained from northern Washoe areas or by trade from across the Sierras into California), large game, small game, fowl, and many bulbs, roots, seeds and berries (Walker, 2003; Hammett et al., 2004). World-famous basketweaving and fine rabbit skin robes indicates that a considerable amount of time was available for the material aspects of the culture. The number of people who still know and practice traditional ways (or remember them) is high, based on the number of people available for interviews by Walker and Hammett.

3.1 Historical Seasonal Patterns of the Washoe

This section describes both the historical cycles and the modern adaptations that still follow seasonal resource availability. Although some of this description uses the past tense, it should be understood that a resource-oriented lifestyle must still conform to the natural environment. Thus, even if people do not physically move their place of residence seasonally, they still pursue original seasonal activities in original locations from a permanent home base, since modern conveyances and tools enable them to reach these areas quicker and process resources faster. Also, pine nut camps, hunting camps, fishing camps, or other resource-based camps are still used by many native peoples.

The Washoe year includes annual cycles for fishing, gathering, and hunting (Downs, 1966; Kelly, 2001). Fishing occurs all year long, but begins in earnest as soon as the snow begins to leave the lower foothills. Whitefish from Lake Tahoe and the rivers provided welcome fresh food, along with game and early spring plants. By June, people had moved back to the lake from the winter camps in the pinyon belt or

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[4] Darrel Cruz, Washoe Tribal member and Washoe Tribe Environmental Specialist, March 10, 2005.

lowlands, and caught the spring migrations of trout and suckers from the lakes to the tributaries. Fish were dried and lasted most but not all of the year, supplemented by smaller fish fresh from streams and rivers (the Carson River, Truckee River, Bryant Creek, and their tributaries). When the spring spawning runs were over, families moved to higher lakes, where the mountain meadows provided an increasing amount and diversity of food and more fish and animals became available. By late summer, seeds from many lowland grasses were ripening, so a round of seed gathering was made. In the fall the pinyon nut harvest was ready, with associated ceremonies, large gatherings, and other events. Tremendous amounts of nuts were gathered, parched, and stored for winter and year-round use.

Washoes were active during all seasons, although less activity occurred in the winter due to weather conditions (Downs, 1966; Kelly, 1995; Hammett et al., 2004; Walker, 2003; Price, 1980; Tucker et al., 1992). In the winter, gathering of fresh green plants was primarily limited to watercress. The main winter foods were pine nuts, dried and frozen meats, dried berries, fish, fowl, seeds, dried root and seed cakes, and teas and medicines. Some of the pine nuts were partially processed, but grinding, winnowing, skinning, and other activities, were still required. Gathering firewood was required year-round. There was also winter fishing for whitefish and winter hunting, as well as an emphasis on making tools, baskets, and other material items. Food and material preparation were constantly required regardless of the weather. The full range of plant and animal processing was constant, including hulling, grinding, pounding, scraping, roasting, excavating cooking pits, carrying loads of food and materials and firewood, and building smoking racks, hearths, caches, and shelters. Similarly, people were always scouting, tracking game, monitoring areas to determine what resources were ready for harvest, or looking for good stands. A longer list of activities is presented in Hammett et al. (2004).

In addition to these activities, the Washoe were especially noted for their superb basketry. "Washoe baskets are the finest in the world" (Sprout and Sprout, 1999; Mason, 1904; Cahodas, 1979). Today, the Washoes are still renowned for making twined or coiled baskets, primarily out of willow. Inner bark is used for the white twining and sewing elements, and is brown if left in the sun (Barrett, 1988). The other primary colored materials are the bracken root (*Pteridium aquilinum,* which is black if soaked in mud) and the brown or red redbud bark (*Cercis occidentalis*), the latter historically obtained by trade from the western Maidu (Garey-Sage, 2003). Softer basket materials include cattails and a variety of grasses and sedges. Tules are used for rafts and mats. Most cordage is made from dogbane (*Apocynum*) as well as milkweed (*Asclepias*), sagebrush, or iris (Lindstrom, 1992).

3.2 General Resource Use

Hammett et al. (2004) and Walker (2003) analyzed information on plant and animal use from historical and contemporary ethnographic sources including interviews with Tribal members. The interviews focused on the resources of the Leviathan-Bryant

Creek watershed that are or were used by Washoe Tribal members. The Walker report identifies many resources used. The Hammett report employed questions designed to identify and quantify some of the resources of the overall diet, and to describe the activity level associated with traditional activities needed to develop exposure factors. Other references are cited below for natural resource use across the Washoe territory as well.

3.2.1 Hunting and Fishing

Ethnozoological resources collected by the Washoe in the Leviathan Mine area, the Bryant Creek drainage, and the East Fork of the Carson River include but are not limited to deer, antelope, marmot, ground squirrels[5], rabbits, crayfish, clams, waterfowl, quail, sage hens, grouse, grasshoppers, and many other species.

Fishing was a highly important vocation. In the higher mountain section of the Washoe country, notably at Lake Tahoe, fishing was of similar importance as pine nut gathering. The Bryant Creek drainage has been not only a primary fishing area for the Washoe, but also contained some of the best hunting grounds (Walker, 2003). Fish of various kinds were abundant in the Bryant Creek drainage. Several native species of fish (Lahontan cutthroat trout, whitefish, suckers, and minnows) and introduced species (brown trout, brook trout, rainbow trout, golden trout, and carp) are now present (Walker, 2003), although diminished.

> "We depended on that creek [Leviathan and Bryant] before [mining]; we used to fish in it. There were big fish in it, and we fished it all the time." (Walker, 2003).

The annual deer migration from high to lower elevations through the Leviathan Creek corridor was a predictable event and the people relied upon it as a source of deer meat. However, as interviewees noted, the deer do not come over Monitor Pass or through the Leviathan Creek area any more, indicating disrupted migration patterns (Walker, 2003).

3.2.2 Gathering

The semi-arid portion of the general Washoe territory provides a variety of grasses with seeds for food as well as the pinyon pine whose nuts ("pine nuts") constitute such an important article of food throughout much of the Great Basin area.

Leviathan Creek was one of the best sources for gathering plant foods as well as willow branches for basket making (Walker, 2003). Many Leviathan-Bryant Creek plant resources are cited in the Walker and Hammett interviews. In the spring and

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[5] Different authors and interviewees use the terms gopher, woodchuck, marmot, prairie dogs, ground squirrel, and small or large ground squirrel without indicating species. We assume that woodchucks and large ground squirrels are actually marmots (Marmota flaviventri), and gophers and prairie dogs are actually ground squirrels (Spermophilus beldingi).

early summer numerous bulbs and roots were historically available such as wild onions ("There is a lot of 'busdi' up there" at the mine site; Walker, 2003), watercress, sego lily, camas, bitterroot, several other types of wild lilies, several types of wild potatoes, cattail, tule, and many medicines. Among the most common kinds of berries were western chokecherry, elderberry, buckberry, Saskatoon serviceberry, desert and golden currants, Sierra plum, and Sierra gooseberry. Varieties of wild strawberries were also traditionally gathered in the area and highly prized.

> "There were a lot of strawberries, spinach, and we had a lot of greens, like watercress. Mama knew a lot of the plants, like wild spinach. There were currants and strawberries, lots of them. There were very sweet. Chokecherries, as well." (Walker, 2003).

The leafy and/or tender parts of many plants gathered from the Bryant Creek drainage and the East Fork of the Carson River were often eaten raw, although many were cooked or dried. Several species of watercress grow along many streams; some varieties are available throughout the winter months and were eaten fresh as picked. Several types of mushrooms were gathered under trees after spring rains and ephedra tea was used as a stimulating tea and for medicinal purposes (Walker, 2003).

Some of the major plant resources are shown in Table 1 as well as some of the animal species that could be a priority to sample and include in both the human and ecological risk assessments. Higher trophic levels than those in the table would also be included in both the human and ecological risk assessments, but are not recommended for sampling (they should be modeled instead).

One major data gap is the distinction between the as-gathered and as-eaten forms. Some species are merely brushed off before eating, some are ground, some are pit-cooked. Residual soil on the outside of plants is known to be an exposure pathway but there is very little data on this point. Laboratory analysis should ideally test both what is internal to plants and what is left on the surface after being treated by Tribal members in their usual way; otherwise the contaminant load will be underestimated.

Table 1. Priority species for sampling and contaminant analysis. This table is not an exhaustive list of edible species, but includes representative edible and materially important species. Some categories contain multiple plant families, genera and species. Some indication as to what season a resource is gathered in (and therefore when the sampling should be done) is provided. Note that many of these categories include multiple species. In every case, co-located water, soil and/or sediment should also be sampled.

Species or Class	***Habitat type***	***Rationale***
Pine nuts	Pinyon-Juniper	Major food item; ripe in the fall.
Berries (different classes) elderberry, chokecherry, currant, gooseberry, strawberry, other.	Riparian or hillside	Berries from different plant families are used; some are eaten as picked without washing (dust pathway) or with washing (in contaminated water); some may contain contaminants in the fruit. Species should be varied and kept separate.
Seeds – mustard or sunflower/Balsamroot	Sagebrush steppe	Some Brassica and Helianthus hyperaccumulate metals.
Bracken fern	Riparian	Roots and fiddlenecks – bracken hyperaccumulates arsenic; edible fiddlenecks and basket material.
Willow shoots.	Aquatic-Riparian	Multiple uses, particularly baskets, high water uptake; stems chewed and held in mouth for splitting. Sample in spring growth cycle.
Tule (Scirpus), Cattail (Typha), Sedge (Carex)	Aquatic-Riparian	Multiple uses; edible. Collect shoots in spring (eaten), leaves (baskets), pollen (eaten), tubers (eaten, fall is the high starch storage season). The 3 species should each be sampled.
Watercress	Aquatic-Riparian	In-stream; edible, eaten especially in winter
Edible bulbs and tubers – wild potato, wild onions, wild sweet potato, yampah, Sego lily, others	Riparian or hillside-meadow	Below-ground edible foods can uptake and retain internal contaminants and/or external residual soil when eaten. Sample riparian areas as a priority. Keep plant families separate.
Greens – miner's lettuce, nettle, others	Hillside-meadow	Above-ground plants may have deposited dust and translocated contaminants; keep plant families separate.
Mushrooms	Various	Some species hyperaccumulate metals
Honey	Widespread	Bees forage, and honey can be a sentinel for localized contamination.
Burrowing rodent – marmot or ground squirrel	Riparian or hillside-meadow	Grooming of fur can be a major exposure pathway; some are pit-cooked.
Shellfish – crawfish, snail, mussel	Aquatic	Mollusks are filter feeders; crayfish are eaten. Also sample co-located sediment.
Aquatic insects	Aquatic	Ensure that testing for contaminants occurs as far downstream as the scenario is applied. Should be tested along with sediment as an aquatic foodchain base.
Resident fish – minnow or larger fish if present.	Aquatic	Bottom feeders and predators should be sampled.

4. HUMAN ACTIVITIES AND EXPOSURE SCENARIO

4.1 Methods for Describing the Diet

The approach used in describing an overall diet is to use the information about major resources present in the study area, foraging theory information, and information from the existing literature and interviews. An overall total caloric food pyramid with rough proportions of different food groups has been developed to show a typical traditional diet (Figure 1). This food pyramid is reconstructed from information about what the traditional diet actually was, rather than what it might be today if USDA recommendations about daily intakes were followed substituting wild for domesticated foods. In particular, the traditional Washoe diet was based on fish and game rather than grains.

The steps for reconstructing the Washoe diet are:

- Review foraging theory information specific to the Tribe, the local ecosystem, and, if available, for the specific location under consideration;
- Review ecological information for a rough estimate of resource abundance of natural resources under baseline conditions;
- Review interviews and other ethnographic sources for supporting information of species and abundance, habitat types, human activity levels, and methods of obtaining, preparing and using resources;
- Develop overall percentages of major food categories and major staples within the total diet;
- Estimate calories provided by the diet, and compare estimates of percentages of quantities and percentages of calories;
- Refine estimates of major staples and food categories after considering information about medicines, sweeteners, and other often-overlooked food/medicine types; macronutrients, and other factors.

The dietary input for the risk assessment is typically somewhat less complex than the food pyramid (due to intrinsic limitations of the risk methods). Nevertheless, the risk assessment must consider the totality of species and calories. A wide variety of species is used by the Washoes:

- “About 100 species of plants were used in some way as food, medicine, fiber, or construction.” (Price, 1980)
- Hammett lists about 100 plant species used. (Hammett et al., 2004).
- Around 150 edible and medicinal species including berries are in the general area. 75% (or at least 100) species are expected to be present in the Washoe territory. (Tilford, 1997).
- “The average woman was comparable to a botanist in her medical knowledge of plants.” Price (1980).

- The variety and amounts of plant foods was "almost infinite" but widely dispersed. Downs (1966). "Plant foods were gathered intensively from early spring until late fall."
- "There was a large variety of predictable resources close at hand." (D'Azevedo, 1986).
- Fowler (1986) lists over 200 species used throughout the Great Basin, many of which are in the Washoe areas.

4.2 Foraging Theory and the Washoe Diet

Kelly (1995) describes the concepts of eco-cultural lifestyles, also known as foraging theory. In the 1960s to 1980s the "Man the Hunter" concept (with males providing most of the provender) prevailed due to a previous archaeological emphasis on hunting and warfare artifacts (Lee and Devore, 1968). This gave way in the 1990s to a more balanced foraging model that emphasized plants as much as meat (and equality of genders in contributing to survival), and a relatively peaceful and secure "original affluent society" (Sahlins, 1972). The latter concept is supported by data (Kelly, 1995; Winterhalder, 1981) on the amount of time required to obtain survival necessities and to raise children, and the typically abundant amount of time available for socializing, education, ceremonies, material items, leisure, recreation, oratories, and so on. However, hunter-gatherers are not over-nourished, and face seasonal shortages even though outright starvation is rare. The lifestyle is also "physically demanding" (Kelly, 1995), giving rise to discussions about the number of calories available or required as well as about the activity levels used to develop exposure factors.

Efficiency or return rate for specific resources in specific habitats is estimated using foraging theory by evaluating the amount of calories expended in getting food (search costs) by means of hunting, gathering, or fishing relative to time spent or calories obtained. Foraging information is typically presented as return rates, or net calories obtained per hour of effort. Additional factors such as biodiversity, abundance, and patchiness or continuity of resources result in time allocation decisions that are intentionally or unintentionally made by foraging societies, such as optimal diet breadth, optimal foraging area, and optimal foraging group size for a particular ecosystem (Winterhalder, 1981). Depending on the evaluation methods used in a study, this return rate data may include (1) time and calories spent in preparing to hunt, fish, or gather (e.g., making nets), (2) time and/or calories spent in the actual activity, and (3) time spent in the processing of the resource after obtaining it. The drawback of oversimplifying foraging solely to caloric efficiency is that micronutrients (vitamins, minerals, specific amino acids, and fatty acids), medicinal or pharmacologically active compounds, other nutritional requirements, and non-nutritional attributes such as aroma or dye or material uses are often not considered (Lindstrom, 1992). Similarly, many plants and animals have multiple uses or are co-located with other resources; therefore, caloric calculations must not ignore the way that people actually make decisions about where to go or what to gather, or the reasons they seek to obtain particular resources.

4.3 Washoe Foraging Studies

Three major foraging theory studies have been identified for the Washoe: (1) Lindstrom (1992) focused on fishing in the Truckee River, (2) Tucker et al. (1992) evaluated a more generalized area and diet, and (3) Kelly (2001) focused on Great Basin wetlands resources. While these studies did not specifically focus on the Leviathan-Bryant Creek drainage, they provide relevant information due to similarity of resources and uses. Each author's results are presented separately even if they included the same resources since there were some differences in methods and assumptions.

Lindstrom (1992) evaluated Truckee River fishing and Great Basin aquatic and terrestrial resources for caloric return rate efficiency associated with traditional methods, i.e., including the time needed to make fish nets and other implements and processing costs for storage compared to fresh consumption. She evaluated the hours spent obtaining and preparing resources (during their peak availability times). She also gathered information from interviews with Washoe members skilled at making and using traditional implements, and information from the archaeological record. She concluded that the Truckee River-based economy would have emphasized fish, grasshoppers (during peak years and seasons), big game, rabbits, small game, pinyon nuts (from the foothills), cattail pollen, and various individual seeds and roots, in that approximate order. "A high level of energy efficiency suggests fish were used as a principal resource whenever they were available" (Lindstrom, 1992). This assumes a certain efficiency of capture or abundance, especially during schooling or spawning, and ratios of specific capture methods. As Lindstrom notes, her ranking of resources from most to least preferred is not entirely consistent with notes from anthropologists, settlers, and visitors, or with Tribal traditional environmental knowledge. For instance, rabbits and pine nuts (from the pinyon pine) are ranked lower than their actual importance, primarily because her analysis focused on a single resource area rather than on the overall Washoe territory. This also suggests that a number of factors are not included in typical equations used to rank resources, such as possibly seasonally very high abundance, group hunts, storability, and other uses of resources (e.g., rabbits hunted for both food and skins, willows gathered for baskets as well as medicine, and many other material items made from mountain and foothill resources).

Tucker et al. (1992) describe an "idealized pre-contact Washoe diet" based on a diet breadth model using ethnographic and archaeological data such as frequency and location of bones and implements commonly found in excavations. The diet is also based on known resource abundance and caloric return rates per hour, but it underestimates soft matter such as plants and fish bones that decompose and leave less of a physical trace. Tucker et al. do not include energy expended in chasing or the efficiency of gathering co-located resources (other than indirectly through overall abundance of the resource), the energy expended in processing the resources, or other uses that might alter the preferential sequence. The approximate order in which individual resources would be preferred using only the caloric, seasonal abundance and archaeological information is:

1. Deer (return rate = 24,000 kcal/hr; assumes one kill per 8 hours of effort)
2. Antelope (return rate = 23,000 kcal/hr)
3. Jackrabbit (return rate = 14,000 kcal/hr)
4. Fish (return rate = 12,000 kcal/hr)
5. Ground squirrels (return rate = 10,000 kcal/hr)
6. Large ground squirrels[6] (return rate = 5,000 kcal/hr)
7. Honey (return rate = 3,000 kcal/hr)
8. Small ground squirrel (return rate = 3,000 kcal/hr)
9. Duck (return rate = 2,000 kcal/hr)
10. Pine nuts (return rate = 1,000 kcal/hr, including roasting, grinding, and cooking)
11. Sunflower seeds (return rate = 500 kcal/hr)
12. Great Basin wild rye seeds (return rate = 400 kcal/hr)
13. Indian rice grass seeds (return rate = 300 kcal/hr)

This list only partially accounts for co-locational or localized abundance. Therefore, as noted by Tucker et al. (1992), small seeds and greens as combined categories of resources (rather than individual species) are efficient resources to gather if they are sufficiently abundant and if gathered concurrently with higher ranked resources. This list also completely overlooks the many important greens, roots, bulbs, tubers, and rhizomes that were gathered in abundance, as well as basket materials and non-food items. Some of the listed resources would also rank higher if they store well or if they provide specific nutrients. The Washoes knew to expend extra energy in gathering storable resources as a hedge against famine, and are also well aware of nutritional or medicinal benefits of specific plants. For example, spinach and watercress were considered essential foods ("people craved this food [watercress], must have been something in it people need because parents insisted that children eat it;" Hammett et al., 2004). Thus, broad categories of plants (greens, fruits, roots, bulbs, tubers) are not represented at all in the above ranking. Even seeds, some of which are recovered archaeologically, are probably underestimated, especially native grasses "from which tons of seed were gathered" (Cook, 1941).

Kelly (1995) evaluated Great Basin foraging in his discussion of many foraging societies around the world. Animals including waterfowl are all more efficient to gather than plants as long as they are relatively easy to catch. Return rates for a few resources (based on kcal/hr of effort, but not indicating how strenuous the effort is; on known abundance locally, and showing rates for worst to best years based on available data) were estimated as:

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[6] Probably the marmot.

- Deer = 17,000-31,000 kcal/hr (poor year to best year)
- Jackrabbit = 14,000
- Gopher = 10,000
- Cattail = 300
- Pine nuts = 800-1,400

Kelly (1995) estimated that the overall Washoe diet was obtained 30% from hunting, 40% from gathering, and 30% from fishing. This was based on estimates of abundance, density of resources, seasonality, and harvesting or cooking technology. Unlike the list in Tucker et al., 1992, plant resources are very prominent. For example, cattail roots harvested in the summer have a poor return rate because they have expended their energy into the leaves, but when harvested in the late fall or winter when energy is being stored, have a much higher return rate and would be a preferred food choice. Lower caloric return rates are provided by cattail pollen, squirrels, ducks, gambel oak acorns, tansy mustard seeds, pine nuts (low overall calorie return due to the time required to roast the cones, gather seeds, and grind them into meal), bitterroot roots, wild rye seeds, minnows (caught with nets), saltbush seeds, bulrush seeds, other grasses, sunflowers, and roots. Among plant resources, cattail pollen was estimated to have the densest caloric content, with acorns, pine nuts, and tansy mustard seeds next, followed by all other roots and seeds. However, although cattail pollen is calorically dense, it takes time and effort to obtain; therefore, its return rate is lower than cattail roots, which is a poorer food but easier to obtain in quantity. However, cattail pollen can be eaten right off the stalk, and thus may have no processing costs (although it was typically ground into flour before use).

Kelly (2001) focused on the level of resources obtained from Great Basin wetlands (Stillwater Marsh near Carson Lake, southeast of Pyramid Lake), based on foraging theory and a caloric balance that includes walking to a resource, carrying a load back, and harvesting and processing costs. Based on all costs, Kelly estimated that a typical family's foraging area is 6 km in radius until resources are reduced beyond a certain abundance (hunting areas might be larger). A large amount of storable resources, such as dried fish or game or pine nuts, allows a family to maintain a central residence such as a winter home (which was always by springs or streams). Thus, "fish, large game, seeds, and pinyon appear to have been particularly important." Kelly concluded that the rates of return were greatest for grasshoppers (collected en masse after they periodically washed up on lake shores and form windrows, then roasted), followed by local large game, small game, waterfowl, a variety of seeds and nuts, and winter-gathered cattail and tule roots.

Kelly (2001) also estimated return rates for foraging away from home and included an estimate of kcal expended during the foraging activity. Foraging in a marsh from a residential base near the marsh (camps were generally ¼ to ½ mile from a marsh due to mosquitoes) was based on an assumption of moderate walking at 300 kcal/hr on the way out, plus 30% more carrying a 32 liter load back, all within an 8 hour day, and an average return rate of 1830 kcal/hr (not including processing). After taking the return rate and subtracting the energy cost of walking there and collecting and returning with a load, the species which have the most effective return rates are (more examples appear in Kelly, 2001; Table 3-8):

- Cattail pollen = 4500 kcal/hr (the highest return rate kcal/hr)
- Chub = up to 4000
- Rodents, waterfowl, bulrush seeds = around 1000
- Many other seeds ranging from 100 to 800

The effective return rate for large game is more difficult to estimate, since the time spent in finding them is so variable. Foraging from a pine nut camp with walking distance of 30 km at 450 kcal/hr on a grade is estimated at:

- Pine nuts = 800 to 9600 (depending on distance and other conditions)
- Large game = up to 4,500 at 8 hours per kill
- Small game = up to 2500
- Bitterroot = 1250
- Ricegrass and wild rye seeds = 350

Kelly (2001) also compared the most efficient caloric return rates for plants in several habitats. These are presented as examples of methodology and species identification. Within each habitat, examples of species preferences are as follows (from most preferred to less preferred; the original reference has longer lists):

Wetlands

- Tule bulrush (*Scirpus acutus, americanus*, or spp) shoots in spring, pollen in summer, seeds in fall, tubers in fall
- Nutgrass (*Scirpus or Carex* and spp) seeds, tubers in the fall
- Cattail (*Typha latifolia* and spp) shoots in spring, seeds in fall, and tubers in fall.
- Sago pondweed (*Potamogeton* spp) tubers in summer, corms in winter or spring,
- Chufa fatsedge (*Cyperus esculentus*) tubers in spring
- Water plantain (*Alisma geyeri*) seeds in fall
- Spikerush (*Elercharis palustris*) seeds in fall
- Seepweed (*Suaeda depressa*) seeds
- Pickleweed (*Allenrolfea occidentalis*) seeds
- Mollusks (*Anadonta* spp) all year, referred to as both clams and mussels.
- Brine fly (*Ephydra*)

Lowlands and Riparian

- Onion (*Allium anceps, nevadense*) corms and leaves in spring,
- Wild potatoes, several species
- Sego lily (*Calochortus nuttali* and other lily spp) bulbs
- Many seeds, berries, stems, leaves, and bark

Uplands

- Nevada desert parsley (*Lomatium nevadense*) roots in spring, summer
- Yampah (*Perideridia bolanderi*) roots in summer
- Bitterroot (*Lewisia rediviva*) roots in spring
- Spring beauty (*Claytonia umbellata*) roots in spring
- Other bulbs and tubers
- Balsamroot (*Balsamorhiza* spp) roots, shoots, seeds
- Many berries

4.4 Interview Data (Hammett et al. 2004)

Qualitative information from the interviews in Hammett et al. (2004) on resources gathered from the Leviathan-Bryant Creek drainage is presented for approximate relative importance of some of the resources. This is not a total amount consumed per person per year, but it does identify many of the most important representative species gathered from the affected area and gives a rough idea of abundance or availability. The numbers indicate how much could be gathered by one or more people in a season for personal use, family use, and/or sharing or trading.

Nuts

Pine nuts – up to 1500 lbs of nuts

Note: Price (1980) indicates consumption of 300 pounds of pine nuts per person per year, eaten at a rate of 1 pound of pine nuts per person per day, or one-half of the total food consumption. At roughly 600 kcal per 100g after shelling and winnowing (USDA database), and 454 g/pound, this means that 2700 kcal per pound of pine nuts could have been available per person per day. If pine nuts comprised half the diet, this would mean that 5,000 kcal/day was consumed, which is double the typical forager dietary intake (Kelly, 1995). On the other hand, pine nuts are a well-known staple. “At certain seasons they have fish... for the remainder of the year they live upon the pine nuts, which form their greater winter subsistence.” (Lindstrom 1992, citing Nevins, 1956).

Cook (1941) interviewed Washoe families regarding pine nut availability at that time. Families could gather up to twenty 100-pound sacks in good years, although they typically sold up to half. Some families got far less, presumably depending on their access to pine nut allotments, whether it was a good year, or other reasons. A 100 pound sack yields 60 pounds of meat after shelling and winnowing (which Price, above, may not have considered). Cook also discussed fresh pine nuts versus the dried nuts (after parching for storage), which could reduce the weight by 15%. This would mean that 100 pounds of fresh nuts yields about 50 pounds of ground meal at approximately 2100 kcal per pound of nut flour, which is one of the forms eaten.

Berries

Blueberry – not quantitative
Buckberry – not quantitative
Chokecherry – up to 20 gallons
Currants – not quantitative
Serviceberry – not quantitative
Strawberry – 2 gallons
Elderberry – up to 100 gallons
Gooseberry – up to 20 gallons

Bulbs and Roots

Green onions – 5 lbs
Lily – 400-1200 bushels
Sego Lily – 300 lbs
Arrowroot – not quantitative
Sweet potato – 25 lbs
Wild garlic – 12 bushels
Indian potatoes – up to 75 lbs
Wild onions – up to 460 gallons; 7.5 gunny sacks (225 gallons)
Swamp onion – 12 grocery sacks

Greens

Tops of wild onion – not quantitative
Wild rhubarb – up to 100 lbs
Watercress – 3-10 gallons; 15 gunny sacks (450 gallons)
Tule shoots – 60 plants
Wild mustard – 20 lbs

Other

Mustard seeds – 6-9 lbs
Mushrooms – 24 gallons
Lomatium tea – not quantitative
Wyethia stems – up to 48 stems
Ephedra – 1 grocery sack

Fowl

Chukkar – 20-60 birds
Dove – 20-60 birds
Goose – 32 birds

Quail (both mountain and valley) – 20-60 individual birds each
Sagehen – 20-60 birds

<u>Game</u>
Deer – up to 2250 lbs of meat
Jackrabbit – up to 420 lbs of meat
Marmot – 12 lbs of meat
Porcupine – 1 animal at 30 lbs
Prairie dogs – up to 33 animals or 25 lbs of meat
Rabbit – up to 240 animals or 616 lbs of meat

<u>Fish and Shellfish</u> –
Trout (various species) – up to 168 fish per year per person

4.5 The Washoe Diet

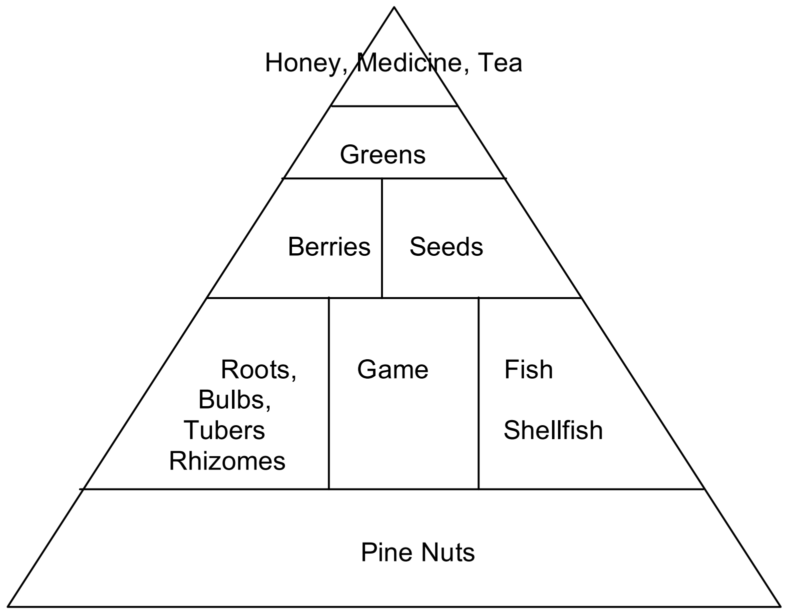
This section uses the information from the previous sections to derive estimates of major categories of food types as percentages. It considers the number of species, the foraging studies with their dietary estimates, and recent interview data. This information is combined to reconstruct a diet that was obtained from stream-river drainages such as the Leviathan-Bryant Creek system. It is intended to describe what the diet actually was before contamination altered the natural resources. This diet is presented as percentages and as a food pyramid (Figure 1).

Kelly (1995) estimated the traditional Washoe diet to be obtained 30% by fishing, 30% by hunting, and 40% by gathering. Kelly's estimate included the large spawning runs in Lake Tahoe, whereas the present scenario is centered on smaller drainages such as Leviathan-Bryant Creek that have lower carrying capacities. Therefore, fish are ranked lower in the diet shown below. It does not include acorns from the northern part of the Washoe territory.

Based on interviews and existing literature, foraging theory, dietary calories, and related information, the traditional Washoe diet for foothill drainage systems such as the Leviathan-Bryant Creek system is estimated as:

1. Pine nuts (20% of total calories)
2. Fish and shellfish (15%)
3. Game (large and small, and fowl) (15%)
4. Roots, bulbs, tubers, rhizomes (15%)
5. Greens (10%)
6. Berries (10%)
7. Seeds (10%)
8. Honey, rose hips, medicines, teas (5% combined).

Figure 1. Washoe Traditional Food Pyramid. This figure reflects the estimated caloric percentages of major food types as they were originally obtained from riverine drainages.



4.6 Nutritional Analysis

A brief nutritional analysis is presented here in order to cross-check the amounts eaten with an estimate of macronutrients that would be provided. This is done to ensure that a full amount of calories is accounted for, and the diet is roughly balanced within the ranges of other foraging diets. It is impossible to be more quantitative than this given the lack of data on native foods—nutritional data on the specific resources available to the Washoe are almost totally lacking. Therefore, all of the information in Table 2 is from the USDA database (except where noted) for an average member of the same or nearest plant or animal family (the "representative species" column in Table 2). Where specific information is available from the USDA database, such as for game species, it is used. Where possible, the data for fresh or cooked foods matches the form of native plants eaten. We recognize that domesticated species of plants have been bred for certain characteristics such as low fiber content, more sweetness, and other characteristics. Tribal members often refer to wild varieties as "stronger" than domesticated varieties. This is a well-known data gap.

Table 2 indicates the macronutrient content for representative species, Table 3 estimates calories for the major food categories, and Table 4 estimates macronutrients for the major food categories. We are assuming, as other authors have, that 2500 kcal is adequate for foraging activity levels in a 70 kg person; however, higher calorie levels may also be appropriate. For this analysis, we are conservatively assuming the lower calorie rate.

Protein and carbohydrate provide roughly 4 kcal/g. Fats and oils provide roughly 8-9 kcal/g. Therefore, from Table 3:

> 170 g protein x 4 kcal = 680 kcal from protein;
> 102 g lipid x 9 kcal/g = 918 kcal from lipid;
> 244 g CHO x 4 kcal = 976 kcal from CHO,

for a total of 2574 kcal. (26% of calories come from protein; 36% from lipid; 38% from carbohydrate). Due to the lipid content of the nuts and seeds, this diet is higher in lipid than many foraging diets.

> For comparison, Hunn (1990) described a typical daily Columbia Plateau diet that included 1300 grams per day (gpd) roots (providing 1330 kcal), 100 gpd berries (62 kcal), 500 gpd salmon (850 kcal), and 240 gpd venison (302 kcal). The total intake is 2140 gpd (2543 kcal), or roughly 4 to 5 pounds of food per day. The Columbia Plateau diet provides 168 gpd protein, 334 gpd carbohydrate, and 55.4 gpd lipid (30% protein, 60 % carbohydrate, and 10% lipid). However, Walker (1998) believes that Hunn overestimates roots and underestimates fish in that particular Plateau diet.

Table 2. Macronutrient content based on dietary proportion.

Representative 2500 kcal Diet					
Food Category	% of 2500 Kcal	Nutrients per 100 grams			
		Kcal per 100g, (Representative species)	Protein per 100g	Lipid per 100g	CHO per 100g
Pine nuts	20% or 500 kcal	630 kcal	12 grams	61 grams	21 grams
Fish	15% or 375 kcal	Mixed trout, cooked - 190	27	8.5	0
Roots, tubers, rhizomes, bulbs	15% or 375 kcal	Raw Chicory root - 73 Potato (baked tuber) - 93 Bitterroot, fresh – 90 Camas bulb, fresh – 113 Leek, onions and bulbs (bulb & leaf) – 31	1 2 0.7 0.7 1	0.2 0.1 0.1 0.2 0.2	17 15 22 27 8
Game & fowl	15% or 375 kcal	Deer, roasted - 158 Rabbit, wild, roasted - 173 Quail, cooked - 234	30 33 25	3 3.6 14	0 0 0
Berries	10% or 250 kcal	Raw elderberries - 73	0.7	0.5	19
Greens	10% or 250 kcal	Raw dandelion greens – 45 Raw watercress - 11	3 2.3	1 0.1	9 1.3
Seeds	10% or 250 kcal	Raw dried sunflower seeds – 570 Sesame seed flour - 526	23 31	50 31	19 27
Honey, Tea, sweeteners, misc.	5% or 125 kcal	Honey - 304	0.3	0	82

All USDA data except bitterroot and camas (Hunn, 1990).
Pine nuts (*Pinus edulis* and *Pinus pinea*) are in the USDA database; *Pinus monoplylla* is not, but there is no indication of major differences between pine species, even though *monophylla* nuts are more meaty and less greasy than other pine nuts, so there is less rancidity upon prolonged storage.
Greens include watercress, and the leaves, stems, shoots of other species.
CHO = carbohydrate

Table 3. Estimated caloric content.

Food category	Assumption	Estimate of Daily Quantity
Pine nuts	500 kcal	500 kcal x 100g/630 kcal = 80 gpd*
Fish	375 kcal	375 kcal x 100g/190 kcal = 200 gpd
Roots, tubers, rhizomes	275 kcal	275 kcal x 100g/90 kcal = 300 gpd
Bulbs	100 kcal Allium family	100 kcal x 100g/30 kcal = 300 gpd (Allium bulbs)
Game	300 kcal game and	300 kcal x 100g/165 kcal = 180 gpd
Fowl	75 kcal fowl	75 kcal x 100g/200 kcal = 40
Berries	250 kcal	250 kcal x 100g/75 kcal = 333 gpd
Greens	250 kcal	250 kcal x 100g/30 kcal = 833 gpd **
Seeds	250 kcal	250 kcal x 100g/550 kcal = 50 gpd
Honey, teas, etc.	125 kcal	125 kcal x 100g/300 kcal = 40 gpd

* The original diet had 450 gpd of pine nuts available per person per day (Price, 1980); a lower estimate considers the lack of clarity in the forms (fresh or parched; whole or ground) analyzed by prior authors.
** Greens include watercress, leaves, stems, and shoots. This estimate includes a consideration that a home garden would include above-ground garden vegetables and may be part of the exposure scenario.

Table 4. Estimated macronutrients of major food categories.

Food Category	Assumption of grams per day	Protein (grams per 100g)	Lipid (grams per 100g)	CHO (grams per 100g)
Pine nuts	80	80 x 12/100 = 9.6	80 x 61/100 = 48.8	80 x 21/100 = 16.8
Fish	200	200 x 27/100 = 54	200 x 8.5/100 = 17	0
Roots, tubers	300	300 x 1/100 = 3	300 x 0.2/100 = 0.6	300 x 20/100 = 60
Bulbs	300	300 x 1/100 = 3	300 x 0.2/100 = 6	300 x 6/100 = 18
Game *	180	180 x 30/100 = 54	180 x 3/100 = 5.4	0
Fowl **	40	40 x 25/100 = 10	40 x 14/100 = 5.6	0
Berries	333	333 x 0.7/100 = 2.3	333 x 0.5/100 = 1.7	333 x 19/100 = 63
Greens***	833	833 x 2.5/100 = 21	833 x 0.5/100 = 4.2	833 x 5/100 = 42
Seeds	50	50 x 25/100 = 12.5	50 x 40/100 = 12.5	50 x 23/100 = 11.5
Honey, teas...	40	40 x 0.3/100 = 0.1	0	40 x 82/100 = 32.8
Total	**2356 g**	**170 g protein**	**102 g lipid**	**244 g CHO**

* Livestock that are substituted for game are assumed to be grass fed, not grain finished.
** Ducks and geese would have a higher lipid content
*** Greens are estimated somewhat high due to potential substitution with conventional vegetables

5. EXPOSURE FACTORS AND PATHWAYS

5.1 Approach

Exposure factors reflect the activity levels and resource use of the lifestyle scenario under evaluation[7]. Exposure factors for both direct and indirect pathways are developed. Indirect pathways include exposure via the oral ingestion of food and medicine (see previous section). This section focuses on direct pathways: direct inhalation, dermal exposure, and ingestion of water, air, dust, sediment, and soil (including soil on the outside of food or added through cooking).

Default exposure factors have been developed for conventional suburban, urban, occupational, and recreational scenarios based on national statistics. Only two complete Tribal traditional subsistence lifeways scenarios have been developed: the Confederated Tribes of the Umatilla Indian Reservation (Harris and Harper, 1997, as revised in 2004) and the Spokane Tribe (Harper et al., 2002).

Our approach to developing a tribal scenario is not to inventory every activity and every resource, but to provide an overall estimate of the general activity levels, anchored with specific information as available. The basic assumption is that the traditional lifeways are active outdoor lifestyles that are moderately physically demanding, even with some modern conveniences. Subsistence foragers (both genders) perform a combination of aerobic (high pulse and ventilation rates), strength, endurance, and stretching-flexibility daily activities, as well as more sedentary work and resting.

The exposure factors here are general to traditional subsistence lifestyles, regardless of their location. However, they may not be identical to the site-specific RME (reasonably maximally exposed) individual, which will be tailored to the habitats and resources found in the affected area once baseline and current ecological and environmental conditions are defined.

The conceptual steps in this process are:

1. Understand the lifestyle and the activities that comprise the lifestyle, and are required to obtain necessities and engage in the community culture.
2. Describe the day, the year, and the lifetime of men and women to identify any significant differences in activity levels between genders or ages.
3. Cross-walk activities with exposure pathways on the basis of frequency and duration of major activities, activity levels, and degree of environmental contact.
4. Estimate cumulative exposure factors.

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[7] http://cfpub2.epa.gov/ncea/cfm/recordisplay.cfm?deid=85843

5.2 Major Activities

Figure 2 and Tables 5 and 6 show the thought process for considering the wide range and numerous activities associated with the major activity categories (hunting, fishing, gathering, and sweatlodge purification). Figure 2 and Table 5 list a number of individual activities within each major category; this is included because most non-Indians have not learned much about traditional lifestyles and the complexity of daily life. Figure 2 shows the connection between activity categories. In actuality, many activities are sequential – for example, a resource might be gathered in one location, used in a second location to make an implement or basket, and taken to a third location for use in hunting or fishing[8]. The activities shown in Figure 2 are so interconnected that it is virtually impossible to separate a lifestyle into distinct categories, but they are presented as separate for illustration purposes.

Figure 2. Traditional Lifeways – Typical activities in the activity categories. Examples of activities involved in major categories are given to illustrate their complexity, as well as the interconnections between categories. The category of gathering includes both vegetal food procurement and basketmaking.

Hunting ⟺	***Purification/ Sweatlodge*** ⟺	***Gathering*** ⟺	***Fishing***
Learn skills	*Learn skills, songs*	*Learn skills*	*Learn skills*
Making tools	*Build lodge from natural materials*	*Previous gathering*	*Make nets, poles, tools*
Ritual bathing	*Gather rocks*	*Make baskets, bags*	*Travel to location*
Vigorous activity in hunting	*Chop firewood*	*Hike to areas*	*Catch fish, haul out*
Pack meat out	*Prepare for use, get water*	*Cut, dig, harvest*	*Clean, can, hard dry, soft dry, smoke, eat whole fish or fillet or liver or soup*
Process meat	*Use Lodge, sing, drink water, inhale steam and smudges*	*Carry out items*	*Return carcasses to ecosystem, use as fertilizer*
Scrape hides	*Close area & fire*	*Wash, peel, process, split, spin, dye*	
Tan, use other parts		*Cook and eat or make product or make medicine*	
Cook, smoke, dry, eat meat and organs			

[8] This is similar to the Cultural Ecosystem Stories concept developed Terry Williams (Tulalip Tribes) with the associated software, ICONS (see, for example, http://www.epa.gov/owow/watershed/wacademy/wam/comresource.html).

Table 5. Major Activity Categories.

Activity Type	*General Description*
Hunting	Hunting includes a variety of preparation activities of low to moderate intensity. Ritual bathing occurs before the hunt. Hunting occurs in terrain ranging from flat and open to very steep and rugged. It may also include setting traplines, waiting in blinds, digging-out small game, climbing, etc. After the capture or kill, field dressing, packing or hauling, and other very strenuous activities occur, depending on the species. Subsequent activities include cutting, storing (e.g., smoking or drying), returning the remains to the ecosystem, and so on.
Fishing	Fishing includes building weirs, scooping minnows, hauling in lines (we assume that large nets are not used in small drainages), gaffing or gigging, wading (for shellfish), followed by cleaning the fish and carrying them to the place of use. Activities associated with smoking and constructing drying racks may be involved. Remains are returned to aquatic ecosystems.
Gathering	Women gathered plants "perhaps within a day's walk from camp" using a digging stick, knife, and basket for carrying resources back to camp (Downs, 1966; Hammett et al., 2004). A variety of activities is involved, such as hiking, bending, stooping, wading (marsh and water plants), digging, bundling, carrying, and climbing over a wide variety of terrains.
Ritual Purification (Sweatlodge)	Sweatlodge building and repairing is intermittent, but collecting firewood is a constant activity. D'Azevedo (1986) lists 6 citations for Washoe ritual purification. Cold and hot springs were used for therapeutic healing. Today, every Washoe community has a purification lodge (Washoe Tribe, personal communication).
Materials Use and Food Preparation	Many activities of low to high intensity are involved in preparing materials for use or food storage. Some are quite vigorous such as pounding or grinding seeds and nuts into flour, preparing meat, and tanning hides, This category includes basketmaking, which is an example of a very important activity with its own set of prescribed activities, meanings, and cultural ethics.

Table 6 shows the cross-walk between activity categories and exposure pathways, with examples of how exposure factors are derived from knowledge about activities, interlinked resources and ecosystem stories, and the technical literature. Again, this is an iterative process that relies on multiple lines of evidence.

Table 6. Examples of factors to consider within major activity categories. This is not a complete listing of activities. It shows an example of the thought process used to iteratively cross-walk exposure pathways and categories of subsistence activities. In each case a gap identification step may be necessary, and greater uncertainty may require placeholder values until data is obtained. The last column ("totals") is where exposure pathways (such as soil ingestion) are evaluated by estimating across activity categories. This is not a statistical summation but rather a judgment based on multiple lines of evidence. Each estimate is then checked against technical literature for confirmation.

	Hunting and associated activities	***Fishing and associated activities***	***Gathering and associated activities***	***Ritual purification and associated activities***	***Material and food use and processing***	***Totals for major exposure factor categories***
Food, Medicine, Tea, other biota ingestion (diet)	*n* deer /yr diet; Total large-small game, fowl. Organs eaten	*n fish* /yr diet; Total pounds or meals/day-wk-yr; Organs eaten.	Includes foods, medicines, teas, etc.	No food, but herbal particulates are inhaled.	Both as-gathered and as-eaten forms; cleaning and cooking methods.	Must account for all calories. Extra factor for 100-200 plant species; parts eaten
Soil, sediment, dust, and mud ingestion	Terrain types such as marsh with more mud contact.	Sediment contact, dust and smoke if drying; weir construction in mud.	External soil on plants; cooking method such as pit cooking; ingestion when gathering.	Includes building the sweat lodge and getting materials.	Includes incidental soil remaining on foods; pit cooking.	Must also include living area, unpaved roads, regional dust, local dust-generating activities.
Inhalation rates	Days per terrain; Exertion level; hide scraping; load & grade.	Exertion level – nets and gaffing methods; cleaning effort.	Exertion level for load and grade; or gardening. Include making items.	Includes building the lodge, chopping firewood, singing.	Exertion level for pounding, grinding, etc.	Must account for exertion levels; smokes and smudges.
Groundwater and Surface water pathways	Ritual bathing, Drinking water; wash water; water-to-game pathways.	Drinking water; incidental ingestion, washing and cooking.	Drinking water, cooking water, soaking in mud or water.	Steam in lodge; drinking water during sweat.	Soaking, washing, leaching tannins, other uses.	Must account for climate, sweat lodge, ritual bathing.
Dermal exposure	Soil, air and water pathways, plus pigments etc.	Immersion considerations.	Same as hunting.	Immersion with open skin pores.	Includes basketmaking, wounds.	Must consider skin loading and habitat types.

5.3 The Family, the Day, and the Lifetime

This section describes a family-based exposure scenario based on a traditional Washoe lifestyle and diet. It is based on habits of Tribal members who live in a house in a sparsely populated riparian corridor with a home garden, and who have a high rate of subsistence activities, a regular schedule of other cultural activities and are seasonally occupied as field workers monitoring natural and cultural resources, taking environmental samples, and doing reclamation or restoration work. The lifestyles are moderately active outdoor lifestyles.

5.3.1 Lifestyle of a Representative Washoe Tribal Family

The families are intended to be reasonable maximum composites, and were constructed with the guidance of the Washoe Tribal Cultural Resources Coordinator. Each family includes (1) an infant/child (age 0-2 years) who breastfeeds for two years and crawls and plays, (2) a child (age 2-6) who plays in the house and outdoors, (3) a youth (age 7-16) who attends school, plays outdoors near his/her residence, and is learning traditional practices, (4) two adult workers (one male, one female, age 17-55; the female breastfeeds the infant) who work outdoors on reclamation and environmental and cultural activities and who also engage in subsistence activities; and (5) an elder (age 56-75) who is partly at home and partly outdoors teaching and demonstrating traditional cultural practices. All members (except the infant from 0 - 2 years) partake in cultural activities throughout the year.

Location and Type of Residence. The residence is located at the furthest upstream available allotment in the Leviathan Bryant Creek drainage. The family lives in a house with no landscaping other than the natural vegetation, no air conditioning, and wood burning in the winter for heat. The house has its own well for domestic use and a garden irrigated with groundwater or surface water (whichever is more contaminated). The road and driveway are not paved.

5.3.2 Activity Patterns of Each Family Member

Infant. The infant breast-feeds for 2 years, and crawls on the floor (with house dust exposure) from age 6 months to 2 years. Infants ingest more fluid per body weight than children do, and toddlers (6 months to 2 years) are likely to have the highest of the children's exposures due to crawling and mouthing behaviors, and their food and water per capita ingestion rates.

Child (ages 2-6 years). Beginning at age 2, the child eats the same food as everyone else, and spends some time accompanying the mother as she gardens and gathers.

Youth (ages 7-16). The adolescent is learning to hunt, gather, and fish (and spends equal time in each activity in their respective locations), plays outdoors, and attends school.

Adult Worker (ages 17-55). Workers are assumed to work for the Tribe collecting environmental samples, engaging in restoration/remediation or construction work, and caring for natural and cultural resources and tribal property. This type of activity is dusty in the summer and muddy in the winter. Both males and females are currently employed in this type of activity. Workers could be exposed to surface soil and dust, vegetation, surface water, sediments, and seeps. These workers have an average 8-hour workday. While in the field, the worker eats lunch brought from home, possibly supplemented with native foods gathered near the workplace, and does not have a place to wash food (dust ingestion).

Adult Hunter/Fisher/Gatherer. Each adult also hunts (male), fishes (male), or gardens and gathers plants (female). These activities are roughly analogous to each other with respect to the degree of environmental contact, and therefore are assumed to result in the same amount of soil or sediment ingestion for males and females. The additional time and contact during game processing, plant washing and preparation are also roughly equal. The location of hunting small game or fowl is in the same area as the residence, and the location of big game hunting covers a larger area. The garden is at the place of residence and uses the same water as the household, while the gathering occurs in a larger area. All of the hunters, gatherers and fishers spend some time near water, if it is present in the area, on activities such as washing plants or game, gathering aquatic plants and mollusks/crustaceans, and so on, with concomitant exposure to mud or sediment.

Elder (ages 56-75). The elder gathers plants and medicines, prepares them, uses them (e.g., making medicines or baskets, etc.) and teaches a variety of indoor and outdoor traditional activities. The elder also provides childcare in the home.

Ritual Purification (Sweat Lodge) (ages 10-75). A sizeable fraction of Washoe youth and adults participate in purification ceremonies in private or community ceremonial (sweat) lodges. The basic mechanics of lodge construction and use have been described in the open literature. The size of Washoe sweat lodges is roughly 5 feet high and 12 feet wide. The duration is generally about 2 hours per ceremony. The frequency is calculated based on 8 months during which the person participates in one 2-hour ceremony plus 4 months during which the person participates in a 4-sweat series, for a total of 24 2-hour sweats per year. This frequency is an average for Washoes who participate in purification ceremonies, but may somewhat underestimate the frequency for ceremonial leaders. During the ceremony, approximately 4 gallons of water is poured on heated rocks, forming steam (one gallon per half hour). Either groundwater or surface water may be used. Inhalation and heart rates and inhalation rates may be higher depending on activities that occur during the sweat lodge ceremony (e.g. singing).

Cultural Activities. All age-groups participate in day-long outdoor community cultural activities once a month, including seasonal ceremonial and private cultural activities (averaging about 0.5 hours/day). These activities are often gatherings with activities that result in a greater rate of dust resuspension and particulate inhalation as well as greater personal inhalation and water ingestion rates. If this scenario is applied in other locations, additional activities such as pow-wows could be considered.

Seasonality. The changes in activity patterns over the annual seasonal cycle has been modified in modern times, but the ecological cycle has not, so people must still gather plants according to when they are ripe, hunt according to game and fowl patterns, and fish when the spawning runs occur. Many items are gathered during one season for year-round use. While specific activities change from season to season, they are replaced by other activities with a similar environmental contact rate. For instance, a particular plant may be gathered during one month, while another month may be spent hunting, and a winter month may include cleaning and using the items obtained previously. Therefore, since we are assuming that all activities are roughly equal, there is no decrease in environmental contact rates during winter months.

Special Activities. It is recognized that there are special circumstances when some people may be highly exposed (and their exposure would be underestimated). For instance, some men hunt or fish for the general community, and many people provide roots and fish and game to elders in addition to their own families. Flintknappers may receive additional exposure through obtaining and working with their materials. Elders with special traditional environmental knowledge may spend more time in the field teaching.

Basketmaking. Exposure pathways specific to basketmakers are well-recognized[9], but data useful for exposure assessment are almost totally lacking. Gathering of some plants (e.g., willows, cattails, reeds and rushes) can be very muddy, and therefore river shore or lakeshore activities with sediment exposure may be underestimated. Washing, peeling, weaving rushes, and other activities result in additional exposure to dust deposited on leaves or soil adhered to roots. Some of the materials are held in the mouth for splitting, and cuts on the fingers are common. As more information becomes available, it will be evaluated to ensure that the exposure factors for each route of exposure account for these particular activities.

Similarly, other pathways unique to traditional practices also lack data and are therefore sources of uncertainty. For example, pharmacologically active medicinal plants may have differential uptake of contaminants into the plant as well as affecting the metabolism of the person and/or interacting with contaminants. Alkaloids in ephedra tea and other plants affect metabolism in various ways. Materials released from firewood, smokes, and smudges may contain contaminants or affect physiological parameters of the person. We have tried to consider these and other pathways in the cumulative roll-up of exposure factors, but these items remain as potential exposure pathways or potentially affect the way that a person reacts to single or multiple contaminants.

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[9] http://www.cdpr.ca.gov/docs/envjust/documents/basketweaver.pdf

5.3.3 Time Allocation throughout the Day

This section describes the time allocation that is reflected in daily exposure factors. The locations at which these activities occur will be defined in the RME report.

Identical Activities: From the age of 2 to 75 years, 15 hours of every day are similar: 8 hours sleep, 3.5 hours in other indoor activities, some time in the sweat lodge (averaged), 2 hours in nearby outside activity such as small game hunting, 0.5 hour in community cultural activities, and 1 hour traveling on unpaved roads. These activities are referred to as "common time."

Infant: Standard infant exposure parameters are used. House dust is assumed to have similar concentrations of contaminants as outside soil. The infant is breastfed for 2 years. The risk assessment may be performed assuming two different scenarios: (1) the mother has received 25 years of prior exposure from a contaminated area; and (2) the mother has not received such exposure. In situations where exposure has been occuring, a new mother may have been exposed as she was growing up and carry a body burden or heritable mutation that she might pass on to a fetus during gestation as well as during lactation. If contamination remains on site into the future, then future mothers could be exposed as children and then through pregnancy. In other situations, a female might not return to the site until after the baby is born, so the infant's exposure would not start until birth, and would not have been exposed in utero.

Child: The child, up through age 6, spends the same amount of common time in the same activities, and 4 hours indoors and 5 hours outdoors with the mother as she gardens and gathers.

Youth: "Common time" plus 6 hours at school 5 days/week (averaging 4.5 hours/day), 2.5 hours indoors, and 3 hours outdoors playing or accompanying an adult or elder learning traditional activities. It is assumed that the school is uncontaminated unless there is data about chemical usage or contamination, and it is also assumed that his or her near-residence outdoor time results in a higher amount of soil contact than at other ages; therefore, the youth's average contact rates are the same as the child's and adult's.

Adult: "Common time" plus 8 hours working 5 days/week (about 5.5 hours/day), 0.5 hour at home, and 3 hours in one of the subsistence activities.

Elder: "Common time" plus 3 hours at home providing child care, 3 hours outdoors teaching, 1 hour gardening or gathering, and 2 hours at home processing materials and making items.

5.3.4 The Lifetime

Traditionally, daily tasks were somewhat different for males and females: males tend to hunt and fish, while females gather and cook. However, even where activity patterns are show gender dimorphism, the rates of environmental contact were and are probably similar. In addition, both women and men are employed as environmental and construction workers, as well. Therefore, for the purposes of the exposure scenario, the genders have identical exposure factors.

Male Lifetime. The male lifetime consists of the standard infancy, childhood, and youth. At age 17 he specializes in either hunting or fishing and begins working as a reclamation /restoration/environmental worker. These activities are specified solely to determine their locations, which may have different contaminant concentrations. As an elder he changes his activity patterns to teaching and demonstrating as described above.

Female Lifetime. The female lifetime consists of the standard infancy, childhood, and youth. At age 17 she engages in gathering and gardening and also works the same job as the male. During motherhood, the woman may remain at home, which is located in the same sparsely populated area, and she continues to garden and gather, so her exposure does not diminish. Her earlier exposure may result in a dose to the fetus and breast-feeding infant.

5.4 Media, Pathways, and Direct Exposure Factors

As described previously, exposure factors are developed by crosswalking the activities described above with specific media-based exposure pathways. The identification of media pathways begins to sum exposures; for instance, all the soil exposures from hunting, gathering, household activities, processing and using materials, food processing and other activities are summed qualitatively. At a later step in the RME the time spent in various locations will be defined so location-specific exposure point concentrations can be determined.

Ground Water and/or Surface Water Pathways. The importance of bathing in Washoe ritual life makes access to clean and uncontaminated water particularly important. As mentioned previously, water is central to Washoe identify and life. Ritual bathing and/or steam purification occurs before hunting and other cultural activities. Water is also important for general cleanliness (which has always been very important to tribal members), soaking plant materials, and processing foods and materials. For purposes of evaluating risk, both ground water and/or surface water are directly ingested as drinking water. Both are also used to create steam in the sweatlodge. Other uses of these resources include typical household use (e.g. cooking, bathing, showering), irrigation of crops and/or garden, and livestock.

Air and Dust Pathways. As a general rule, the air pathway can result in exposure to volatiles, aerosols, and resuspended dust which might be present. Dust resuspension from unpaved roads and other unvegetated surfaces should be included as part of the inhalation exposure pathway. If there is a potential for exposure, inhalation of fire smoke or smudge should be included because some of these pathways can be frequent and significant.

Soil and Sediment Pathways. This pathway includes soil ingestion from hand to mouth activities associated with daily activities, gathering (e.g., digging roots) and gardening, food and material processing (e.g. grinding, scraping, pit cooking). Several foods are prepared by pit cooking: fish, ground squirrels, wild garlic, wild onions, acorns, pine nuts, and marmots (Hammett et al., 2004; Walker, 2003).

This pathway also includes direct ingestion resulting from residual soil on roots and bulbs. The as-gathered and as-eaten conditions of plants are important. Many vegetable foods were eaten raw and on the spot ("brush dirt off lily bulbs, eat raw;" Hammett et al., 2004). Grinding seeds and nuts also adds rock dust to the flour.

Gathering of willows, bracken fern, and other basket and cordage materials results in soil ingestion, and further exposure is received when splitting shoots into weaving strips by holding one end in the mouth while pulling strips off with each hand.

5.5 Exposure Factors for Direct Exposure Pathways

A description of activities for the purposes of developing exposure factors focuses on:

- Frequency of activity
  - Daily, weekly, monthly
- Duration of activity
  - Hours at a time
  - Number of years
- Intensity of environmental contact and intensity of activity
  - For soil ingestion and dermal exposure, is the activity more than, less than, or equal to gardening, camping, construction/excavation, or sports?
  - For inhalation rates and calorie needs, is the activity level more than, less than, or equal to standard EPA activity levels for specific activities with known respiration rates and caloric expenditure?

The following table (Table 7) includes three adult scenarios: the suburban resident, the rural residential farmer-gardener, and the subsistence forager. The first two scenarios are typically used in risk assessments, and the third reflects the set of activities that comprise the Washoe lifestyle. Each scenario is intended to be physiologically “coherent,” which means that the dietary intake, activity levels, and inhalation rates are physiologically linked. For instance, the more sedentary suburban scenario is based on national data on typical lifestyles (light occupational activities sitting or standing, with some moderate activity at home), while the residential farmer has a higher activity level, higher inhalation rate, and higher soil ingestion rate due to his rural farming activity pattern. The subsistence forager is still more active, with a proportionally higher inhalation rate, as well as a higher soil ingestion rate due to a higher degree of soil contact.

The following table shows adult values, as does the dietary discussion above. Children’s exposure factors are scaled from the subsistence forager rates as is conventionally done in risk assessment (from the Children’s Exposure Factors Handbook), with the exception of the soil ingestion rate, which is left at 400 mg/d throughout the lifetime. Body weight is a consistent 70 kg because that is the standard EPA assumption used in risk assessments.

Table 7. Exposure factors for direct pathways.

Direct Pathway	Exposure Factors (Adults)		
	Default Suburban Lifestyle	*Rural Residential Farmer Lifestyle*	*Subsistence Forager Lifestyle*
Inhalation	20 m^3	25 m^3 While EPA does not have official exposure factors for this lifestyle, it is reasonable to assume that a person who farms, gardens, irrigates, and cares for livestock has an intermediate inhalation rate.	30 m^3/day. This rate is based on a lifestyle that is an outdoor active lifestyle, based on EPA activity databases, foraging theory and ethnographic description of the activities undertaken to obtain subsistence resources as well as allotment-based food (livestock and garden). It is higher than the conventional 20 m^3/day because the activities with associated respiration rates are higher than suburban activities.
Drinking water ingestion	2L/d	3L/day. This rate is based on water requirements in an outdoor moderately arid environment.	3L/d plus 1 L for each use of the sweat lodge during ritual purification; at 24 uses per year, this is 3.065 L/d, which we are rounding down to 3L.
Soil ingestion	100 mg/d (conventional suburban); 50 mg/d (manicured suburban; less outdoor time).	300 mg/d.	400 mg/d. This rate is based on indoor and outdoor activities, a greater rate of gathering, processing, and other uses of natural resources, as well as on residual soil on grown and gathered plants. Episodic events (1 gram each) are considered, such as wetland gathering, cultural activities with higher soil contact, and so on. It does not specifically include geophagia or pica.
Dermal Pathways	Must be included in the risk assessment. Greater environmental contacts must be factored in; however, suburban defaults may be used until data for traditional lifeways are developed, although a greater fraction of the skin surface and a higher dermal loading rate should be considered.		
Other parameters			
Exposure frequency	Up to 365 days per year, but varies. Hours per day varies; typically 24 hrs/d.	Up to 365 days per year, but varies. Hours per day varies; typically 24 hrs/d.	365 days per year. Hours per day varies; typically 24 hrs/d.
Exposure duration	30 years	30 or 70-75 years	70-75 years

Drinking Water

Harper et al. (2002) estimated an average water ingestion rate of 3 L/day for adults, based on total fluid intake in an arid climate. In addition, each use of the sweatlodge requires an additional 1L for rehydration (24 L per year). It should be noted that water intake in an arid environment may be more than 3L per day. For example, the Army assumes that the maximum individual daily amount of drinking water required by military personnel to remain combat-effective ranges from 5 to 15 liters (L)/day, depending on the climate, season, and intensity of work[10]. The Army Quartermaster assumes that military personnel in hot climates require 3 gallons per day as drinking water.[11]

Soil and Sediment Ingestion

Soil ingestion includes consideration of direct ingestion of dirt, mud, or dust, swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact. The Washoe soil ingestion rate of 400 mg/day is based on a review of EPA guidance, soil ingestion studies in suburban and indigenous settings, and dermal adherence studies (a small portion of which is summarized here). It is also based on knowledge about subsistence lifestyles with their higher environmental contact rates and local climatic and geologic conditions. It reflects a variety of soil pathways such as pit cooking, gathering and gardening, residual soil or dust on foods and medicine, localized soil-generating activities, holding natural materials in the mouth while processing or using, driving on unpaved roads, and similar considerations. It also considers many "1-gram days and events" such as root gathering days, tule and reed gathering days, horse training and riding days, sweat lodge building or repair days, grave digging, and similar activities. There are also likely to be many high or intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work). A baseline number of these events is incorporated, but this would need to be reconsidered in the RME if a large number of such events becomes evident.

The soil ingestion rate of 400 mg/d for all ages is the published upper bound for suburban children (EPA, 1997), and is within the range of outdoor activity rates for adults but lower than the typical 480 mg/d applied to outdoor work to allow for some low-contact days. Subsistence lifestyles were not considered by the EPA guidance, but are generally considered to be similar in soil contact rates to construction, utility worker or military soil contact levels. The US military assumes 480 mg per exposure

[10] http://www.nap.edu/execsumm/NI000954.html Guidelines for Chemical Warfare Agents in Military Field Drinking Water (1995).
[11] http://www.pasols.org/energy/water2.pdf

event[12] or per field day. The UN Balkans Task Force assumes that 1 gram of soil can be ingested per military field day[13]. Anecdotally, US forces deployed in Iraq report frequent grittiness in the mouth and food. Haywood and Smith (1990) also considered sensory reports of grittiness in their estimate of 1-10 g/d in aboriginal Australians.

Simon (1998) reviewed soil ingestion studies from a perspective of risk and dose assessment. Because of their high dependence on the land, indigenous peoples are at highest risk for inadvertent ingestion, along with professions that may bring workers into close and continual contact with the soil. Simon recommends using a soil ingestion rate for indigenous people in hunters/food gathering/nomadic societies of 1g/d in wet climates and 2 g/d in dry climates. He recommends using 3 g/d for all indigenous children.

For the Washoe climate and lifestyle, the soil ingestion rate for young children (0-6 years) is assumed to be 400 mg/day for 365 days/year. This is higher than the prior EPA default value of 200 mg/day (USEPA, 1989). This rate reflects both indoor dust and continuous outdoor activities analogous to gardening or camping (Van Wijnen, 1990), but it is less than a single-incident sports or construction ingestion rate (Boyd, 1999).

Inhalation Rate

The inhalation rate in the Washoe scenario reflects the active, outdoor lifestyle of traditional tribal members. Traditional tribal communities have no sedentary members except the frail elderly, whereas one-quarter of modern American adults of all ages report no leisure time physical activity at all.[14] We have documented the activity levels associated with the traditional lifestyle and diet with published anthropological studies, ethnographic literature on foraging theory, hunting-gathering lifestyles, and interviews with Tribal members. Using EPA guidance on hourly inhalation rates for different activity levels, a reasonable inhalation rate for an average tribal member's active lifestyle is a <u>median</u> rate of 26.2 m^3/d, based on 8 hours sleeping at 0.4 m^3/hr, 2 hours sedentary at 0.5 m^3/hr, 6 hours light activity at 1 m^3/hr, 6 hours moderate activity at 1.6 m^3/hr, and 2 hours heavy activity at 3.2 m^3/hr. Unlike most other exposure factors, which are upper bounds, the inhalation rate is a median rate. This is inconsistent with the usual RME approach used in Superfund risk assessments, and could result in under-protection of children, the elderly, athletes, asthmatics, and the half of the population with above-average inhalation rates. Due to a tribal desire to protect more than just the average traditional person, the inhalation rate is rounded up from 26.2 m^3/d to 30 m^3/day.

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[12] http://www.gulflink.osd.mil/pesto/pest_s22.htm, citing US Environmental Protection Agency, Office of Research and Development, <u>Exposure Factors Handbook, Volume I</u>, EPA/600/P-95/002a, August 1997 as the basis for the 480 mg/d.

[13] UNEP/UNCHS Balkans Task Force (BTF) (1999). The potential effects on human health and the environment arising from possible use of depleted uranium during the 1999 Kosovo conflict. http://www.grid.unep.ch/btf/missions/september/dufinal.pdf

[14] http://www.cdc.gov/brfss/pdf/ 2001prvrpt.pdf and http://www.cdc.gov/brfss/pubrfdat.htm.

Dermal Exposures

The dermal pathway has not been fully researched for this scenario, but EPA methods[15] for dermal exposure can be used. However, a greater surface area and a greater skin loading of soil (soil adhered to skin) should be used. Two relevant papers are summarized here. Kissel, et al. (1996) included reed gatherers in tide flats in a study of dermal adherence. "Kids in mud" at a lakeshore had by far the highest skin loadings, with an average of 35 mg/cm^2 for 6 children and an average of 58 mg/cm^2 for another 6 children. Reed gatherers were next highest at 0.66 mg/cm^2 and an upper bound for reed gatherers of >1 mg/cm^2. This was followed by farmers and rugby players (approximately 0.4mg/cm^2) and irrigation installers (0.2mg/cm^2). Holmes et al. (1999) studied 99 individuals in a variety of occupations. Farmers, reed gatherers and kids in mud had the highest overall skin loadings. The next highest skin loadings on the hands were for equipment operators, gardeners, construction, and utility workers (0.3 mg/cm^2), followed by archaeologists, and several other occupations (0.15 – 0.1 mg/cm^2).

Children's Exposure Factors

Children's exposure factors are based on "Child-Specific Exposure Factors Handbook"[16] but scaled from the adult subsistence values for the inhalation rate. The diet is scaled for children from the food categories indicated above for adults. The soil ingestion rate for children is a constant 400 mg/day, without age stratification. If age stratification is done for other exposure factors, the Washoe Tribe can be contacted for recommendations.

[15] http://www.epa.gov/superfund/programs/risk/ragse/

[16] U.S. Environmental Protection Agency (EPA). (2002) Child-specific exposure factors handbook. National Center for Environmental Assessment, Washington, DC; EPA/600/P-00/002B. Available from: National Information Service, Springfield, VA; PB2003-101678 and http://www.epa.gov/ncea.

6. CONCLUSION

This report has presented the Washoe scenario and supporting information for use in human health risk assessments. This report is intended to describe enough about the traditional subsistence lifestyle that a risk assessor who is familiar with developing exposure scenarios can understand the derivation of the exposure factors even if she does not have an in-depth familiarity with the Washoe lifestyle. Where information is not presented, it is assumed that conventional parameters are suitable (e.g., skin surface area).

A companion report will present the RME, or site-specific reasonable maximum exposure scenario. It will be tailored more closely to the natural resources located in the Leviathan-Bryant Creek drainage system.

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