**APPENDIX 4-8. Additional Qualitative Species Analyses**

# Step 2a: Is the species exposure pathway considered incomplete?

For carbaryl, three types of species characteristics led to a conclusion that the exposure pathway is incomplete: species that only occur on uninhabited islands, species that predominantly occur in the open ocean and terrestrial species that only occur in caves. Additional explanation of why the exposure pathway is incomplete for these three types of species habitats is provided below.

Species whose ranges only occur on uninhabited islands are not expected to be exposed to carbaryl because carbaryl is not reasonably expected to be applied in areas not inhabited by humans. According to carbaryl’s usage data (**APPENDIX 1-4**) the majority of carbaryl’s usage is on residential and agricultural uses, which would not be expected to occur on uninhabited islands. Other registered uses of carbaryl, including forestry and rangeland (**APPENDIX 1-2**) would not be expected to be needed in areas where people do not live.

Exposures to species that predominantly occur in the open ocean (*e.g.,* whales) or rely on ocean species (*e.g.,* seabirds) are reasonably expected to be *de* *minimus*. This is because carbaryl is not applied directly to the ocean and does not bioaccumulate.

Carbaryl is not registered for applications within caves. Exposures to terrestrial organisms living within caves are expected to be *de minimus*. As discussed in Chapter 3, the major transport routes of carbaryl from treatment sites to non-target areas include spray drift and runoff. Since caves are enclosed, spray drift transport is not reasonably expected to result in exposures to cave dwelling organisms. Runoff transport may lead to carbaryl reaching ground water that is associated with caves. Therefore, for aquatic species that inhabit caves (e.g., barton springs salamander), exposures and associated risks are assessed in Steps 2e through 2i.

For listed terrestrial species that are obligate to caves (e.g., spiders), exposure from water is expected to be *de minimus*. The atmosphere of the inner cave (where these obligate cave species live) is saturated with water vapor. Species have adapted to this hydrating environment by increasing their permeability such that they “become freshwater animals living in an aerial environment” (Howarth 1987). This means that species get the majority of their water needs met by the atmosphere and from consumption of their prey. For terrestrial obligate cave species, water sources are limited to the condensation in the cave and on cave walls resulting from groundwater sources or from detritus/guano. Carbaryl is classified as non-volatile from dry non-adsorbing surfaces and water. As a result, carbaryl is not expected to be presented in water vapor or condensation water that may occur in caves.

Another possible route of exposure is from leaf litter, animal droppings, and carcasses that may fall or be washed into cave systems. While there is evidence in the literature indicating that animal feces (*e.g*., guano) and carcasses contaminated with pesticides have been found in cave systems (*e.g*., Land, *et al.* 2019; Eidels, *et al*. 2012; Eidels, *et al.* 2007; Land 2001; MacFarland 1998; and Sandel 1999), carbaryl residues were either not detected or detected but not quantifiable. Study authors suggest that carbaryl residues may not be found because it is rapidly metabolized and excreted from the body. Therefore, exposures to species that rely on food items that are derived from exterior sources are expected to be *de minimus*.

# Step 2d: Are exposure models considered unreliable for assessed species?

At this time, the current exposure models used in this assessment do not estimate exposures for all types of pesticide applications, all habitat types, or for all potential exposure routes relevant to listed species. Therefore, there may be uncertainty in the exposure values being used for a particular species based on what potential uses its range or critical habitat may overlap with, what type of habitat the species is found in, or what the main potential exposure route(s) might be. For species and critical habitats that have not been determined to be NE or NLAA based on the above analyses, consideration is given to how well the conceptual model of the relevant exposure model(s) matches up with the specific species being assessed. If the model estimates are not considered representative of the exposure of the species (due to an inconsistency in the exposure model and assessed species’ habitat), a qualitative analysis is conducted.

The qualitative analysis considered whether exposures to carbaryl are reasonably certain to occur given the habitat of the listed species (e.g., ocean, beach, and/or freshwater habitats) and, if exposures are expected to occur, are impacts to an individual likely. The analysis also considered the potential for effects to the PPHD of the species and whether those effects would rise to the level of impacting an individual of a listed species.

**LAA determinations**

***Aquatic Species***

The killer whale (*Orcinus orca*, Southern resident DPS), is found in the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound, and has an obligate relationship with Pacific salmon (which are anadromous), including several species (Chinook, chum, and coho) that are themselves considered threatened or endangered. Carbaryl exposures are reasonably expected to be *de minimus* due to dilution and the fate characteristics of carbaryl (i.e., not persistent, and not expected to bioaccumulate); therefore, exposures to killer whales are not expected. Because LAA determinations with strong evidence of risk were made for listed species of Pacific salmon (upon which the killer whales depend) (see **APPENDIX 4-3** for details on how many individuals of the salmon population may be impacted), there is a potential for effects to the PPHD of the listed killer whale DPS. The same conclusions and rationale apply to the designated critical habitat associated with this species. Therefore, a “Likely to Adversely Affect” (LAA) determination is made for the killer whale (Southern resident DPS) and its designated critical habitat from the use of carbaryl based on effects to the PPHD. An LAA determination is made for the killer whale with moderate evidence of risk because. While effects to the orca are not anticipated, there is strong evidence of effects to the PPHD (i.e., salmon) based on potential effects to an individual of the listed salmon species. There is uncertainty that effects to an individual of a listed salmon will result in effects to the orca. In addition, there are other species of non-listed salmon that may be available and were not assessed.

The Western manatee forages in freshwater, as well as marine environments and requires freshwater on a regular basis. There is a great deal of uncertainty in estimating potential carbaryl exposures in marine environments that support the Western manatee, but it is possible to use Estimated Environmental Concentrations (EECs) for the large flowing bins (3 and 4) to estimate exposures in freshwater environments (max daily EECs for HUC 3 = 625 µg/L). In addition, while there are uncertainties in the potential for effects due to uncertainties in the toxicity database, which utilizes small mammals as a surrogate, the effects thresholds for carbaryl are relatively low (LC50 = 104.3 mg/kg-bw; LOAEC = 30 mg-kg/bw/day based on decreases in fetal body weight and maternal body weight). Therefore, there is a potential for the manatee to be exposed to concentrations of carbaryl that may result in impacts to an individual. Manatees primarily forage on aquatic vegetation and algae, which may also be impacted by exposure to carbaryl in freshwater environments resulting in effects to the PPHD of the manatee (IC50 = 340 µg/L for non-vascular aquatic plants and IC50 = 23,900 µg/L for vascular aquatic plants). Therefore, a LAA determination is made for the Western manatee with weak evidence of risk because the potential for exposure and effects are uncertain.

**NLAA determinations**

***Aquatic Species***

Effects to marine mammals (e.g., pinnipeds, mustelids, polar bear, manatee), sea birds, and sea turtles are considered for both aquatic and terrestrial exposures. Effects to fish and corals are considered for aquatic exposures only. Since carbaryl is not considered bioaccumulative and is not expected to accumulate in the tissue of prey, exposure from eating contaminated fish would be very low. In the marine environment, exposure of these species to conventional pesticides is not reasonably expected to reach the estuarine/marine environments at concentrations high enough to impact an individual of a species because of dilution. Additionally, tidal reversal in freshwater streams and vertical stratification of the freshwater inflow due to differences in salinity and temperature can enhance the mixing process at the freshwater/marine interface and disperse potential pesticide concentrations that may occur in freshwater streams and rivers that discharge into marine environments, limiting the potential for a pesticide to reach individuals of the listed species. See **APPENDIX 4-1** for the complete list of species considered for exposure in the marine environment.

Marine mammals, sea birds, and sea turtles may also spend a portion of their life-cycle (*i.e.,* breeding and basking) on shore, so the potential for exposure in the terrestrial environment is also considered. See **APPENDIX 4-1** for the complete list of aquatic species with the potential for terrestrial exposure. Potential exposure routes include inhalation and dermal interception of spray droplets on the day of application. Since these species do not forage while on land, dietary exposure while in terrestrial habitats is not expected. Based on the points below, exposure at concentrations high enough to impact an individual are not reasonably expected to occur for these species.

* In a quantitative assessment, the overlap analysis assumes that all individuals of the species are in the terrestrial portion of their range, which represents a relatively small fraction of the entire range of the species. This artificially inflates the overlap numbers resulting in low confidence in the potential for exposure.
* While in the terrestrial environment, exposure of these species would be limited to spray drift from use sites adjacent to nesting or basking sites. The potential for exposure in the terrestrial environment is limited because on the day of application, carbaryl would have to be transported by wind blowing from the application site toward the beach with little opportunity for interception of spray droplets.
* The duration of potential exposures would be limited as these species spend a relatively short amount of time on the shore for basking and/or breeding purposes. For example, sea turtles utilize beaches to lay their eggs, while some species use beaches to bask, however, sea turtles spend the vast majority of their lives in aquatic habitats.
* In addition, several of the species only occur in aquatic and terrestrial areas that are in Alaska. These species include the bearded seal, the Pacific walrus, the ringed seal, and the polar bear. Although, there are some potential pesticide use sites found in Southcentral Alaska, they are likely limited and/or largely removed from coastal areas. A limited amount of land is used for grains and fruits and vegetables, based on USDA’s Census of Agriculture data for Alaska (2012). Most of these crops are grown in the interior of the state (e.g*.*, near Fairbanks). Although, there are some potential agricultural use sites found in Southcentral Alaska (e.g., forage crops), they are limited and largely removed from coastal areas. Therefore, pesticide exposure to these species is not reasonably expected to occur.

Effects to the PPHD of marine mammals, fish, sea birds, sea turtles, and corals are also considered. The listed species considered rely on more than one dietary item, most of which are entirely marine. In estuarine/marine environments, exposures to conventional pesticides are not reasonably expected to decrease prey populations. Therefore, an NLAA determination is made for these species (**APPENDIX 4-1**).

Of the 47 species with NLAA determinations due to incomplete exposure pathways (step 2A), 15 have designated critical habitats. Additionally, of the 47 species with NLAA determinations due to unreliable exposure models (step 2D), 14 have designated critical habitats. NLAA determinations are made for the designated critical habitats of these species (**APPENDIX 4-1**). In addition, the beluga whale occurs in waters of the US and terrestrial areas that are in Alaska. Although, there are some potential pesticide use sites found in Southcentral Alaska, they are likely limited and/or largely removed from coastal areas. A limited amount of land is used for grains and fruits and vegetables, based on USDA’s Census of Agriculture data for Alaska (2012). Most of these crops are grown in the interior of the state (e.g., near Fairbanks). Although, there are some potential agricultural use sites found in Southcentral Alaska (e.g., forage crops), they are limited and largely removed from coastal areas. Therefore, pesticide exposure to the critical habitat of these species is not reasonably expected to occur.

***Terrestrial Species***

There is one species of terrestrial animal, the wood bison, that has extensive portions of its range located outside of the United States (i.e., in Canada). In a quantitative assessment, the overlap analysis assumes that all individuals of the species are in the portion of their range located in the United States, which represents a relatively small fraction of the entire range of the species. Since this artificially inflates the overlap numbers, which would result in low confidence in the potential for exposure, the overlap analysis was not run for these species and they are assessed qualitatively. For the wood bison, the population in the United States consists of a nonessential experimental population (NEP) established in 2015 in Western Alaska. This population is highly managed and tracked extensively. In addition, while there are some potential pesticide use sites found in Southcentral Alaska, they are likely limited and/or largely removed from areas utilized by the wood bison. A limited amount of land is used for grains and fruits and vegetables (USDA’s Census of Agriculture data for Alaska (2012)). Most of these crops are grown in the interior of the state (e.g., near Fairbanks). Although, there are some potential agricultural use sites found in Southcentral Alaska (e.g., forage crops), they are limited. Therefore, pesticide exposure to the wood bison is not reasonably expected to occur and a NLAA determination is made.

# References

Eidels, R.R., and J.O. Whitaker Jr. 2007. Insecticide Residues in Bats and Guano from Indiana. Proceedings of the Indiana Academy of Science 116(1):50-57.

Eidels, R.R., and J.O. Whitaker Jr. 2013. Screening of Insecticides in Bats from Indiana. Proceedings of the Indiana Academy of Science 121(2):133-142.

Howarth, F.G. 1987. The evolution of non-relictual tropical troglobites. International Journal of Speleology 16: 1-16.

Land, T.A., D.R. Clark Jr., C.E. Pekins, and T.E. Lacher Jr. 2019. Seasonal Emergence and Historical Contaminant Exposure of Cave Myotis (*Myotis velifer*) in Central Texas and Current Status of the Population. Environments; 6: 21.

McFarland, C.A. 1998. Potential Agricultural Insecticide Exposure of Indiana Bats (*Myotis sodalis*) in Missouri. Unpublished Master’s thesis.