MONITORING OF AMPHIBIANS AND REPTILES IN THE POWDER RIVER BASIN OF WYOMING

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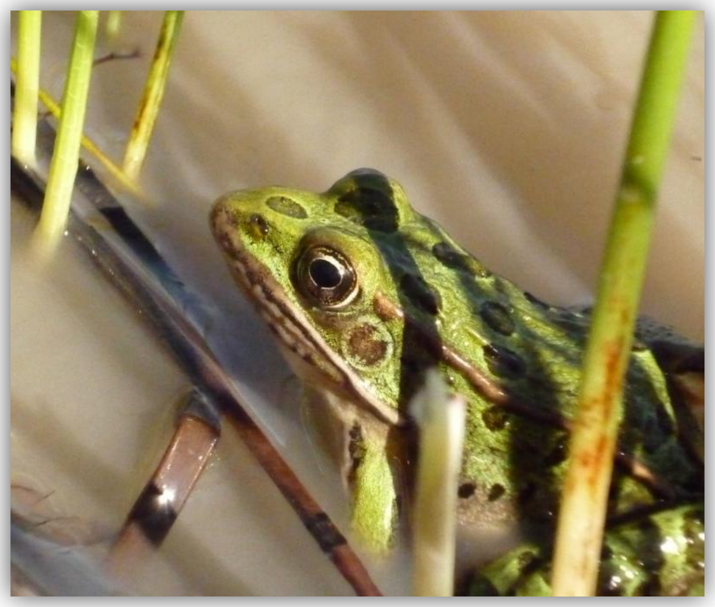

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ABSRACT

Due to concerns over the potential impact of CBNG development to amphibians and reptiles in the Powder River Basin, the Wyoming Natural Diversity Database (WYNDD) and the Buffalo Field Office of the BLM, in conjunction with the Aquatic Task Group (ATG), initiated a project to inventory and monitor herps in the area. Inventories and the monitoring efforts for most sites were completed in 2010, however, ecological monitoring reaches along the Powder and Tongue Rivers had not been established at that time. In June 2011, WYNDD conducted the first year of monitoring at 20 of 22 newly established ecological monitoring reaches. Woodhouse's Toads and Northern Leopard Frogs, as well as evidence of breeding of both species, were detected at many sites. We used occupancy modeling to estimate the probability of occupancy at sites after correcting for imperfect detection. We modeled occupancy for species presence, as well as presence of breeding. We summarize first-year results and provide locations of monitoring sites, datasheets and protocols, and recommendations for future monitoring efforts at these sites.

INTRODUCTION

Coal bed natural gas development is increasing dramatically in the Powder River Basin area of Wyoming. The Buffalo Field Office of the Bureau of Land Management (BLM) prepared an Environmental Impact Statement (EIS) for CBNG development in Wyoming and Montana that analyzed the impacts to resources as a result of oil and CBNG development (BFO BLM 2003). The EIS identified potential effects to amphibians and reptiles, which is supported by a wealth of literature that notes the environmental susceptibility of these taxa. In particular, there are major concerns regarding the effects of water produced by CBNG development to the hydrology and water quality on which amphibians depend for successful breeding. To release natural gas trapped in coal seams, deep aquifer water is pumped to the surface and discharged into ephemeral drainages or reservoirs. The aquifer water is usually colder than surface water and often has higher concentrations of sodium bicarbonate and other salts (Davis et al. 2006). For more background information about the potential impacts of water quality and road network changes on amphibians and reptiles, see Griscom et al. (2009; Appendix A). Further, there is concern regarding the direct effects of increased road construction and use on amphibians and reptiles, especially as they migrate between breeding, feeding, and hibernation sites.

Due to concerns over the potential impact of CBNG development to amphibians and reptiles, the Wyoming Natural Diversity Database (WYNDD) and the Buffalo Field Office of the BLM, in conjunction with the Aquatic Task Group (ATG), initiated a project in 2008 to inventory and monitor herps in the Powder River Basin. The project was intended to be a 3-year field study designed to a) inventory and map distributions of amphibians and reptiles in the Powder River Basin, Wyoming, prior to expanding coal bed natural gas (CBNG) development, and b) establish a long-term monitoring program for amphibian and reptile populations in the region to determine if CBNG development is impacting populations. The first 3 years of the study accomplished the first goal and part of the second goal and a final report detailing species occupancy rates and distribution maps for the Powder River Basin was completed in February, 2011 (Estes-Zumpf et al. 2011). Because the ATG had not yet identified fixed ecological monitoring reaches along the main stems of the Powder and Tongue Rivers, these areas were not included in monitoring efforts in 2010. Ecological monitoring reaches were established by the ATG by 2011, and the WYNDD was able to survey monitor reaches in June of 2011, completing the 2nd goal of the project by conducting the first year of surveys for a long-term monitoring plan along fixed riparian reaches of the Powder and Tongue Rivers.

WYNDD is a service and research unit of the University of Wyoming dedicated to the collection and dissemination of unbiased data on the biology and conservation of sensitive species in Wyoming. The mission of the Wyoming Natural Diversity Database (WYNDD) is to collect, manage, and disseminate unbiased information on animals, plants, and communities in Wyoming that can be used by natural resource managers to make informed decisions. The purpose of this study is to establish a baseline which natural resource managers can use to mitigate and monitor potential impacts of changes in water quality resulting from CBNG development in the Powder River Basin area.

Objectives

The overall goals of the project initiated in 2008 were to inventory, map, and begin monitoring amphibians and reptiles in the Powder River Basin area of Wyoming. The goal of the study in 2011 was to monitor responses of amphibian and reptile populations to CBNG development and its produced waters at newly established long-term monitoring reaches along the Powder River and Tongue River. Focusing on this area, the specific objectives of this portion of the project were:

1. To use newly established ecological monitoring reaches above and below confluences of streams and rivers with different levels of CBNG development to set up fixed long-term monitoring locations for amphibians and reptiles along the Powder and Tongue Rivers in Wyoming.
2. To conduct visual encounter surveys for eggs/larvae, juvenile, and adult amphibians as well as reptiles along established riparian monitoring reaches. Surveys were conducted in a manner which allows for analysis using multiple common methods for examining amphibian population trends.
3. To collect data on habitat, water quality, and survey conditions that can be used in analyses to understand species' population trends and to examine the overall ecological health of each monitoring reach.
4. To use occupancy modeling to determine current probability of occupancy of each species (and known breeding sites) across the study area in relation to factors of interest (e.g. water quality, above or below discharge points, etc.). The number of individuals detected and relative abundance of each species also are reported for each site.

METHODS

Study Area

The Powder River watershed in northeastern Wyoming (Figure 1) has an area of approximately 25,000 km^2. The river flows north into Montana where it joins the Yellowstone River. Within Wyoming, tributary streams that originate in the Bighorn Mountains to the west generally have perennial flow fed by snowmelt, whereas ephemeral tributaries originating in the plains to the south and east are characterized by short duration flows from rainstorms (Davis et al. 2006). Topography is complex and includes floodplains, escarpments, upland plains, and highly eroded breaks. The climate is semi-arid and land cover is dominated by two ecological systems; Inter-mountain Basins Big Sagebrush Steppe and Northwestern Great Plains Mixed-grass Prairie. Riparian vegetation along rivers and streams is usually composed of willows and tall grasses with cottonwood forests restricted to the larger rivers. Twenty-one species of reptiles and amphibians potentially occur in the Powder River Basin of Wyoming (Estes-Zumpf et al. 2011). Most of these species belong to the suite of Great Plains species whose far western range occurs in northeastern Wyoming.

Over 50% of land ownership in the PRB is private, limiting efforts to establish long-term monitoring sites on accessible public lands. Livestock grazing dominates land use with irrigated agriculture restricted to areas immediately adjacent to perennial rivers (Davis et al. 2006). CBNG production has increased greatly on both public and private lands in the last 10 years, especially in the eastern half of the PRB where natural gas is most easily recoverable. The majority of CBNG development in the PRB is below 1,370 m elevation.

In 2010 and 2011, the ATG worked closely with the USGS (Dave Peterson) and other entities to establish 22 monitoring reaches along the Powder and Tongue rivers in Wyoming. These monitoring reaches were established above and below major confluences in the summer of 2010 for long-term monitoring of CBNG influences on the aquatic ecosystem. Ideally, these reaches will be surveyed by a multi-agency team of researchers for water quality, invertebrates, fish, amphibians and reptiles, etc., at time intervals determined by the ATG. By collecting information on a suite of ecological components at fixed sites we hope to be able to use this detailed knowledge of the system to determine the cause of any changes noted in populations. WYNDD conducted amphibian and reptile surveys at established ecological monitoring reaches in June 2011 to establish initial occupancy estimates for herp species at these sites. To address the main goals and specific objectives of this project, at each survey site we collected data on the presence and relative abundance of amphibian and reptile species as well as general amphibian habitat data.

Monitoring of Amphibians and Reptiles

We conducted visual encounter surveys (VES; Heyer et al. 1994) to survey for amphibians and reptiles at each monitoring reach. Surveys were conducted during the breeding season when species are most detectable. We documented the presence/non-detection of amphibians and reptiles within each reach. Surveys were conducted using standard VES protocols (Appendix A) and involved trained technicians canvassing designated riparian reaches on foot during morning and late afternoon hours when animals are most likely to be basking and/or foraging.

Technicians surveyed all amphibian habitat within 5-20m of the shoreline, depending on the type of shoreline (e.g., steep cutbank vs. shallow mudflat). Because access to reaches was limited, an inflatable kayak was used access amphibian habitat on the opposite shoreline at sites. Technicians recorded the type and number of amphibians encountered, paying particular attention to evidence of breeding (i.e., eggs, tadpoles/larvae, and juveniles).

Surveys were conducted by 2 observers working independently at each site (dual observer method) and most sites were visited at least 2 times over the course of the field season. Thus, all sites had 2-4 independent surveys, allowing estimation of the probability of detecting a species. Surveys were conducted using a uniform level of effort at all sites under suitable weather conditions, resulting in data on presence/non detection and probability of detection of each life history stage of each species at each site. If field identification of the species was questionable, photographs of tadpole/larvae samples were taken and later identified to species by taxonomic experts. A subset of frogs and toads detected were caught by hand or dip net and swabbed for chytrid fungus (*Batrachochytrium dendrobatidis*; see below).

Characterization of Habitat

For each riparian site visited, we recorded general habitat characteristics and specific metrics designed to evaluate suitability of habitat for amphibians and reptiles. These metrics included water quality parameters (i.e., water temperature, pH, total dissolved solids (TDS), specific conductance, and salinity), hydrologic features (substrate, permanence), and basic estimates of vegetation (e.g., cover type, cover density). Habitat and water quality metrics were also used as site covariates when modeling occupancy at sites. Reference photographs were taken at each shoreline surveyed along each monitoring reach.

Data Analysis

We modeled site occupancy for species using program PRESENCE (Hines 2006). For each species, we obtained estimates of the proportion of all sites occupied and the probability that a particular site was occupied after correcting for bias due to imperfect detection. Estimates were obtained for both species presence and presence of breeding. We tested if amount of cloud cover, air temperature, or strong winds significantly influenced species detectability during surveys and if different aspects of water quality (temperature, pH, conductivity, salinity, TDS), the amount of emergent vegetation present, or the river (Tongue or Powder River) influenced occupancy by a species. Use of occupancy modeling allows monitoring of changes over time by tracking the proportion of sites occupied and other population parameters (e.g., colonization/extinction rates, proportion of sites where breeding is evident). These data can be used to determine current species status in relation to habitat characteristics and will allow comparison across years for monitoring efforts.

Monitoring Pathogens

Chytrid fungus (*Batrachochytrium dendrobatidis*) has been implicated in amphibian declines around the world, especially in concert with other environmental stressors, and infected animals have been documented in several amphibian species in the PRB (Turner 2007, Estes-Zumpf et al.

2011). Because chyrid fungus occurs in the PRB and the ATG is concerned about potential environmental stressor associated with CBNG (changes in water temperature, increased levels of sodium bicarbonate, etc.), any amphibian monitoring program in the region should include monitoring of chytrid prevalence in local amphibian populations.

To identify whether amphibians were infected with chytrid fungus, we collected epithelial tissue samples from a subset of all amphibians found at each site during surveys. Sample collection followed established procedures (Livo 2003). Amphibians were systematically swabbed with sterile cotton swabs to collect epidermal DNA. Swabs were immediately stored in sterile microcentrifuge tubes containing 95% ethanol and labeled with unique specimen numbers. We stored samples in a -20°F freezer until shipping. Samples were sent to Dr. John Wood at Pisces Molecular LLC in Boulder, Colorado, for analysis via PCR test to determine if the fungus was present.

RESULTS & DISCUSSION

Amphibian and Reptile Surveys

We conducted surveys for amphibians and reptiles at 20 of the 22 ecological monitoring reaches along the Tongue and Powder Rivers (Figure 2). Technicians were unable to survey 2 reaches along the Tongue River (TR1 and TR4) due to severe flooding resulting from above average snowpack in the Bighorn Mountains and heavy spring rains. Amphibian habitat on both shorelines of each reach was surveyed when present, and start and end coordinates for surveys on each shoreline were recorded to establish long-term monitoring sites (Table 1). We completed 4 surveys at 19 of 20 sites. We only conducted 2 surveys at PR8 due to problems with access. We detected over 345 individuals from 3 amphibian species and 14 individuals from at least 5 reptile species. Amphibians were detected at all but one reaches (PR1) and reach PR17 contained the greatest number of amphibians (63) with most occurring in a muddy pond along the eastern shoreline. A list of acronyms for the species referred to in this report is provided in Table 2.

Occupancy

<u>Northern Leopard Frog</u>

We detected Northern Leopard Frogs at 13 of 20 sites. Although there was a trend for detectability of this species to decrease with cloud cover, this model was not significantly better than the model with constant detectability. We then modeled occupancy of Northern Leopard Frogs at monitoring reaches after controlling for detectability. Model which controlled for the influence of water quality, emergent vegetation, or river were not a significant improvement over the simplest model with constant probability of occupancy across sites and conditions. Overall, probability that a site was occupied by Northern Leopard Frogs was 0.6599 ± 0.1086 (Table 3). The probability that Northern Leopard Frogs occupy each individual site given survey detection history in 2011 is given in Appendix C.

We detected evidence of breeding by Northern Leopard Frogs at 10 of 20 sites. Only juvenile Northern Leopard Frogs were documented along monitoring reaches. No egg masses or tadpoles were found along the shoreline of the Powder or Tongue River. Detectability of juvenile Northern Leopard Frogs was 0.6173 ± 0.0845 and did not vary between survey occasions or with environmental conditions. Therefore, we modeled the presence of breeding at sites after controlling for constant detectability. The simplest model with constant probability of occupancy across sites and conditions, again, was the top model. The overall probability that breeding occurred at a site was 0.5110 ± 0.1147 (Table 3). Site specific estimates of the presence of breeding are given in Appendix C.

Presence of Northern Leopard Frogs and of breeding by this species was estimated to be relatively high (66% and 51%, respectively). The species occurred at monitoring reaches along both the Tongue River and Powder River (Table 4). Surveyors detected the largest number of Northern Leopard Frogs (*n* = 27) at PR6 (Table 5). Occupancy estimates from 2011 surveys were higher than estimates across lotic and lentic sites (42%) in 2010 (Estes-Zumpf et al. 2011). Declines in western populations of the Northern Leopard Frog are well documented (Rorabaugh 2005), and the species was petitioned for listing under the Endangered Species Act in 2006. Although listing was denied because western populations of this species do not constitute a Distinct Populations Segment (DPS) relative to eastern populations, the USFWS recognized the magnitude of declines in western populations (USFWS 2011). Because the Powder River Basin area currently appears to support western populations of this species, efforts should be made to continue to monitor species presence and habitat quality to provide insight into population trends in this region.

Woodhouse's Toad

Woodhouse's Toads were detected at 18 of 20 sites. Surveyors were more likely to detect Woodhouse's Toads at warmer air temperatures. The probability of detecting toads increased from p = 0.5187 ± 0.1412 to p = 0.9082 ± 0.0711 as air temperatures varied from 12.8°C to 33.4°C. Thus, we modeled occupancy of Woodhouse's Toads at monitoring reaches after controlling for variation in detection probability due to air temperature. The top competing model suggested that the probability of occupancy of a site by Woodhouse's Toads varied between the Powder River and Tongue River. Overall probability of occupancy for sites along the Powder River was 0.9451 ± 0.0540. The probability of sites along the Tongue River being occupied by Woodhouse's Toads was 0.5031± 0.3359 (Table 3). The large standard error associated with the occupancy estimate at Tongue River sites likely is due to the low sample size of sites for that river (*n* = 2). The probability that Woodhouse's Toads occupy each individual site given survey detection results in 2011 is given in Appendix C.

Evidence of breeding by Woodhouse's Toads was detected at 18 of 20 monitoring reaches. As with the Northern Leopard Frog, evidence of breeding was determined primarily by the presence of juveniles. No eggs or tadpoles were found along the shorelines of either the Tongue or Powder Rivers, however, unidentified toad tadpoles were detected in a muddy side pond along the eastern shore of PR17. Detectability of juvenile Woodhouse's Toads increased with warmer air temperatures, ranging from p = 0.4452 ± 0.1335 to p = 0.8618 ± 0.0927. The top model suggested that the overall probability that breeding occurred at a site was greater for sites in the Powder River (0.9468 ± 0.0542) than in the Tongue River (0.5085 ± 0.3597; Table 3). However, because only 2 sites were surveyed along the Tongue River, estimates of the probability of breeding at Tongue River sites should be regarded with caution.

Woodhouse's Toads were the most common amphibian species detected along monitoring reaches (Table 4) and were estimated to occur and breed at or near 95% of Powder River sites and 50% of Tongue River sites. Occupancy estimates from 2011 surveys were higher than estimates across lotic and lentic sites (49%) in 2010 (Estes-Zumpf et al. 2011). Monitoring reaches PR17 and PR13 had the most number of detections (n = 63 and n = 43, respectively; Table 5). However, the vast majority of Woodhouse's Toads detected in PR17 where observed in a small muddy pond immediately adjacent to the shoreline, rather than in the Powder River proper.

Boreal Chorus Frog

We detected Boreal Chorus Frogs at only 3 of 20 sites. Boreal Chorus Frogs occurred at one site on the Powder River (PR8) and both sites on the Tongue River. Occupancy across sites was too low to obtain reliable model estimates for the probability of occupancy of a site based on the likelihood of detecting the species. Thus, only naïve estimates are provided (Table 3). No evidence of breeding by Boreal Chorus Frogs was detected at any site.

Boreal Chorus Frogs are one of the most common amphibian species in Wyoming and are found throughout much of the Powder River Basin (Estes-Zumpf et al. 2011). Although Boreal Chorus Frogs are heard more often than seen, the species was estimated to occupy 75% of sites surveyed with similar VES techniques in 2010 as part of a monitoring plan incorporating both lotic and lentic sites (Estes-Zumpf et al. 2011). It is unclear why occupancy was substantially lower at monitoring reaches in 2011, however, previous surveys from 2008-2010 in the Powder River Basin focused on ponds and tributaries of the Powder River, rather than the main river corridor. It is possible that the Powder River channel is less suitable for Boreal Chorus Frogs than smaller tributaries and ponds. Occupancy trends in Boreal Chorus Frogs should continue to be monitored along the Powder River.

Reptiles

We detected 4 species of snakes and at least 1 species of turtle at monitoring reaches, however, numbers of occurrences of each species were low and precluded modeling of occupancy. Naïve occupancy estimates (Table 4) and/or relative abundance (Table 5) could prove useful in comparisons with future monitoring efforts and, thus, are provided. Wandering Garter Snakes (*Thamnophis elegans vagrans*) were the most common snake detected and was observed at 5 sites (Table 4). Prairie Rattlesnakes (*Crotalus viridis*) were detected at 2 sites, and both the Common Garter Snake (*Thamnophis sirtalis parietalis*) and the Bullsnake (*Pituophis catenifer sayi*) were detected at one site each. The low number of detections of reptiles is likely due, at least in part, to the survey method used. VES surveys of riparian areas primarily target amphibians, while VES surveys of rock outcrops and south facing slopes are typically used to target reptiles. Roadkill/basking surveys can also be used to target reptiles; however, this method resulted in a low number of reptile detections in the Powder River Basin in previous studies (Estes-Zumpf et al. 2011) and may not be a useful method for monitoring reptiles in this landscape.

Characterization of Habitat

Monitoring reaches varied in the quality and amount of amphibian habitat present. Reaches such as the west shorelines of PR2 and PR7 with shallow banks, backwaters, and mudflats provided more amphibian habitat than sites with long expanses of steep cutbanks, such as the east bank of PR2 (Table 1). Typically, one shoreline in a reach would have shallower banks and better amphibian habitat than the other. By surveying both shorelines at each reach, we hoped to reduce the bias associated with individual shorelines. Should only one shoreline be able to be monitored in the future, however, data for each shoreline at each site is available for comparisons. Photos of survey sites at each reach were taken for comparison of site conditions with future monitoring surveys (Appendix D). We also collected water quality data during each visit to a reach. The Tongue River sites had lower water temperature, specific conductance, TDS, and salinity than Powder River sites. Tongue River sites also had the lowest pH of all sites in the Powder River except PR1 (Table 6).

Monitoring Pathogens

Seventy-eight amphibians from 18 monitoring reaches were sampled for chytrid fungus in 2011. Individuals from 6 reaches (33% of reaches sampled) tested positive for chytrid fungus (Figure 3; Table 4). The proportion of monitoring reaches with chytrid-positive individuals in 2011 (33%) was an increase from the proportion of lotic and lentic sites with chytrid in 2009 (27%) and 2010 (17%; Estes-Zumpf et al. 2011). Both Northern Leopard Frogs and Woodhouse's Toads were infected with the fungus. Although we did not detect chytrid fungus at the Tongue River site sampled in 2011, amphibians from another Tongue River site sampled in previous years did test positive of the fungus (Estes-Zumpf et al. 2011). Thus, chytrid is known to be present in both drainages.

RECOMMENDATIONS

1. The Powder and Tongue River basins encompass a large spatial extent and are home to as many as 21 species of reptiles and amphibians. Land managers are concerned about the potential impacts of extensive CBNG development on local amphibian and reptile populations. Under the direction of the ATG and the Buffalo Field Office of the BLM, WYNDD has developed a suite of monitoring sites and protocols (Estes-Zumpf et al. 2011 and this report) and collected the first year of monitoring data at all sites. The sites and protocols used attempt to cover as many of the herp species present, but some methods are better at detecting certain species than others. If the BLM and the ATG would like to continue monitoring but at a lower funding level, we recommend that a suite of target species of concern be identified so that monitoring protocols be chosen that will best monitor population trends in those species.

2. The frequency of monitoring of reptiles and amphibians in the Powder River and Tongue River basins should be assessed. Due to natural variation in amphibian populations, multiple (>5) sample increments are typically necessary to differentiate between annual variation and actual population trends. Using this guideline, the ATG and BLM should consider the time frame over which they would like to assess population trends, and adjust frequency of monitoring to meet their needs.
3. Replicate surveys are necessary to assess detectability, a necessary component of occupancy modeling. We visited almost all monitoring reaches twice with 2 surveyors, resulting in 4 replicate surveys at each site. Detectability estimates had less variability (smaller confidence intervals) than previous monitoring efforts, resulting in more precise occupancy estimates. Thus, we recommend that 2 visits with 2 surveyors be conducted at as many of the monitoring sites as possible during future monitoring efforts.
4. In general, amphibians need shallow, slow moving or still waters for breeding. Breeding habitat in the Powder and Tongue Rivers may be limited and vary significantly with annual runoff. Adjacent floodplains, oxbows, and backwaters, as well as smaller, slower moving tributaries likely are more commonly used by breeding amphibians. We successfully detected a large number of juvenile frogs and toads at monitoring reaches along river in 2011, indicating that breeding was occurring *in the area*. However, we cannot conclude that breeding was occurring in the rivers along monitoring reaches. For example, the only tadpoles observed during the course of surveys in 2011 were detected (largely incidentally) in isolated oxbows, side ponds, or tributaries (Pumpkin Creek). Juvenile toads and frogs likely leave these areas after metamorphosis and disperse to the adjacent river, oftentimes the only permanent water source in an area. This observation could influence conclusions about changes in breeding habitat along rivers in the future The ATG should decide if their goal is to assess trends in breeding *in the area* or at particular breeding sites. The current monitoring sites and protocols appear to successfully document presence of breeding *in the area* for Northern Leopard Frogs and Woodhouse's Toads.

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We would like to thank Dave Peterson (USGS) for providing locations, maps, and notes for monitoring reaches. We sincerely thank Bud Stewart (WGFD) for contacting landowners and obtaining permissions to access monitoring reaches on private lands. Robin Greene and Angie Stiles did an excellent job battling flood waters via inflatable kayak to reach and survey almost all sites despite challenging field conditions. Bill Ostheimer, Bryce Maxwell, Zack Walker, and the Wyoming Game and Fish Department provided much appreciated conceptual and logistical support. Amanda Bowe contributed significantly throughout all aspects of this project, from field preparations to data entry and synthesis. Annie Munn and Kristina Hooper also assisted with data entry. We sincerely thank the Buffalo Field Office of the BLM and the Aquatic Task Group for providing financial support for this study.

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Table 1. Location and habitat description of survey stretches at each ecology monitoring reach established by the USGS and the ATG along the Powder River and Tongue River. See Appendix B for landowner contact information provided by the USGS and WGFD.

Monitoring Reach	Site Name	Start UTM East	Start UTM North	End UTM East	End UTM North	Land Owner	County	Notes
PR1	PR1E	398830	4847655	398948	4847888	BLM (access through Mason Skiles)	Johnson	Grassy cutbank with some shrub covered muddy banks. Shallow oxbow on site.
	PR1W	398835	4847709	398946	4842819	BLM (access through Mason Skiles)	Johnson	Mix of cutbanks and muddy flats with almost no vegetation. Cottonwood, willow and junipers along the tops of the banks.
PR2	PR2E	405242	4862855	405303	4863106	State	Johnson	Cutbanks and muddy flats dropping off sharply at the waterline. No shrubs present. Some vegetation along the waterline and on top of the banks.
	PR2W	405191	4862628	405258	4863117	State	Johnson	Shallow, well-vegetated mud flats along the south end with 1-3ft grassy cutbanks on the north end. Some small muddy ponds present.
PR3	PR3E	406304	4875441	406511	4875427	Harriet L & L	Johnson	Most of site is steep banks. Lots of rushes on the edge of river with bushes higher up on the bank. Well and other natural gas gear on property with an outflow pipe upsteam of site.
	PR3W	406305	4875497	406515	4875468	Harriet L & L	Johnson	Wide muddy banks with lots of driftwood. Vegetation mostly rushes and sparse shrubs. Lots of natural gas development.
PR4	PR4E	405938	4876039	406077	4876031	Harriet L & L	Johnson	Sparsely vegetated wide muddy bank, rocky in areas. Lots of mining activity across the river.
PR5	PR5E	406961	4883278	406828	4883553	Harriet L & L	Johnson	Short muddy banks with emergent vegetation. Coal refinery in the area.
	PR5W	406933	4883280	406801	4883526	Harriet L & L	Johnson	Wide, shallow mud bank with lots of emergent and dead vegetation. Shrubs on bank.
PR6	PR6E	408505	4886102	408250	4886226	Harriet L & L	Johnson	Shallow, muddy bank with side channels at downstream end. Emergent grasses and some shrubs on shore. Outflow pipe upstream from site.
	PR6W	408511	4886053	408215	4886174	Harriet L & L	Johnson	Muddy grassy bank with emergent vegetation and some shrubs.

Table 1. Continued.

Monitoring Reach	Site Name	Start UTM East	Start UTM North	End UTM East	End UTM North	Land Owner	County	Notes
PR7	PR7E	408130	4889222	408290	4889572	Anadarko Petroleum	Johnson	Steep banks dropping into grassy mud flats. Lots of mining activity.
	PR7W	408106	4889243	408241	4889557	Anadarko Petroleum	Johnson	Wide, sparsely vegetated mud flats becoming more densely vegetated upstream. Some shallow ponds at the south end.
PR8	PR8W	408567	4900787	408330	4900965	Bobby & Dolly Arndt	Johnson	Mostly muddy banks with some grasses and young junipers.
PR9	PR9W	408500	4901313	408712	4901313	Bobby & Dolly Arndt	Johnson	Wide shallow banks are a mix of mud and sand. Vegetation mostly grasses and rushes with junipers upslope.
PR10	PR10W	410113	4903190	410522	4903127	Lula Wagner & Dell Jenkins	Johnson	Wide muddy/sandy banks with sparse shrubs and grasses. Mostly pool habitat with some emergent vegetation.
PR11	PR11E	408576	4909303	408358	4909325	Bob Kennedy	Johnson	Shallow muddy banks with juniper shrubs higher on bank. Very narrow shallows. Natural gas well downstream
	PR11W	408551	4909268	408342	4909296	Bob Kennedy	Johnson	Wide, shallow, muddy bank with emergent vegetation along the shore and bushes higher on bank. Southern end is narrow mud banks bordered by steep cut banks, also lots of dry, dead vegetation.
PR12	PR12E	408496	4919391	408496	4919693	Joaquin Michelena	Johnson	Shallow mud bank with some small ponds on shore. Heavily vegetated with rushes along the water and some juniper bushes on the banks. High cutbank (12m) on opposite shore.
PR13	PR13E	410932	4943905	410625	4943895	Randy Jahn	Sheridan	Wide sandy banks with rushes along the waterline. Cottonwoods & Russian olives along the shore. Recent beaver activity in area.
PR14	PR14E	410529	4945541	410544	4945690	Keith Troll	Sheridan	Shallow sandy bank with some cobbled areas. Lots of grasses and rushes with some juniper pines. Some small islands in the river.
	PR14W	410465	4945492	410513	4945731	Keith Troll	Sheridan	Sand and sandstone banks on the north end, which turn to grassy mud banks. Lots of grasses, sedges, and rushes growing high on the banks. Some rapids through the site.
PR15	PR15W	412986	4962342	414216	4962432	Jim Gibbs	Sheridan	Wide muddy banks with some areas with no vegetation and some areas with lots of young trees and grasses. Tall cutbanks on the east side.

Table 1. Continued.

Monitoring Reach	Site Name	Start UTM East	Start UTM North	End UTM East	End UTM North	Land Owner	County	Notes
PR16	PR16E	422096	4975112	422459	4975397	PeeGee Ranch	Campbell	Most of site is a vegetated muddy bank with a 1 foot drop-off. Upstream part of site has wide shallow bank with tall rushes. Found pipe out of river.
	PR16W	422105	4975249	422409	4975470	PeeGee Ranch	Campbell	Mix of steep cutbanks topped by dense grasses and shrubs and sparsely vegetated mudflats.
PR17	PR17E	424868	4976287	424990	4975994	PeeGee Ranch	Campbell	Small section of shallow, muddy bank. The rest of transect is a steeper and grass-covered. There was small muddy side pond, which dried out later in the season. Outflow tube downstream.
	PR17W	424930	4976310	424996	4976055	PeeGee Ranch	Campbell	Most of site is steep cutbanks, but there are 2-3 shallow banks about 3 m wide. Lots of dried grasses and some submerged shrubs.
PR18	PR18E	426756	4978227	426896	4978437	Vaughn Cresswell	Campbell	Most of site is a gelatinously muddy bank about 1 - 6 m wide. There is sparse vegetation, except for the last 100m which has dense grasses.
	PR18W	426745	4978321	426865	4978485	Vaughn Cresswell	Campbell	Small muddy bank with emergent vegetation and shrubs on bank. Steep cutbanks on southern end. Dense alfalfa growing on shore in the middle of site.
TR2	TR2E	354422	4983244	354838	4983369	R & R Mischke	Sheridan	Mostly grassy banks with about a 1 ft drop-off. Flooded, marshy area adjacent to site.
	TR2W	354437	4983300	354694	4983334	R & R Mischke	Sheridan	Flooded area consisting of shallow, grassy banks with lots of trees and shrubs
TR3	TR3E	356649	4983921	356290	4984081	R & R Mischke	Sheridan	Very grassy banks with some cutbanks. Lots of downed trees and fallen branches.
	TR3W	356563	4983862	356284	4983933	R & R Mischke	Sheridan	Marshy, grass covered flats mixed with some steep banks. Wetland area adjacent to site.

Table 2. List of acronyms for species names used in tables and figures.

BCF	Boreal Chorus Frog	**CGS**	Common Garter Snake
NLF	Northern Leopard Frog	**BS**	Bullsnake
WHT	Woodhouse's Toad	**PR**	Prairie Rattlesnake
WGS	Wandering Garter Snake	**SST**	Spiny Softshell Turtle

Table 3. Occupancy estimates (Ψ) for amphibians and reptiles detected during visual encounter surveys at monitoring reaches along the Powder and Tongue Rivers in 2011. Naïve occupancy rates (number of sites where detected / number of sites surveyed) are provided for each species. For species with sufficient detections, we estimated detection probabilities (p) and corrected occupancy estimates for bias due to imperfect detection. Standard errors (S.E.) are provided for estimates.

Species	Naïve Ψ	Ψ	S.E.	p	S.E.
NLF	0.65	0.6599	0.1086	0.6497	0.0713
NLF (breeding)	0.5	0.511	0.1147	0.6173	0.0845
WHT	0.9	0.9451 (Powder) 0.5031 (Tongue)	0.0540 (Powder) 0.3359 (Tongue)	varied w/air temp. (+)	variable
WHT (breeding)	0.9	0.9468 (Powder) 0.5085 (Tongue)	0.0542 (Powder) 0.3597 (Tongue)	varied w/air temp. (+)	variable
BCF	0.15	-	-	-	-
WGS	0.25	-	-	-	-
CGS	0.05	-	-	-	-
BS	0.05	-	-	-	-
PR	0.1	-	-	-	-
SST	0.05	-	-	-	-

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Table 4. Species of amphibians and reptiles detected at each ecological monitoring reach along the Powder and Tongue Rivers. Presence of chytrid is also recorded if any amphibians from a reach tested positive for *Batrachochytrium dendrobatidis.*

Monitoring Reach	Amphibian Species	Reptile Species	Chytrid?
PR1	None	*Pituophis catenifer sayi*	none tested
PR2	*Anaxyrus woodhousii*	None	N
PR3	*Anaxyrus woodhousii* *Lithobates pipiens*	None	N
PR4	*Anaxyrus woodhousii* *Lithobates pipiens*	None	N
PR5	*Anaxyrus woodhousii*	None	N
PR6	*Anaxyrus woodhousii* *Lithobates pipiens*	None	Y
PR7	*Anaxyrus woodhousii* *Lithobates pipiens*	*Thamnophis elegans vagrans*	Y
PR8	*Anaxyrus woodhousii* *Lithobates pipiens* *Pseudacris maculata*	None	Y
PR9	*Anaxyrus woodhousii* *Lithobates pipiens*	None	Y
PR10	*Anaxyrus woodhousii*	None	N
PR11	*Anaxyrus woodhousii*	*Crotalus viridis* *Thamnophis elegans vagrans*	N
PR12	*Anaxyrus woodhousii* *Lithobates pipiens*	*Thamnophis elegans vagrans*	N
PR13	*Anaxyrus woodhousii*	None	N
PR14	*Anaxyrus woodhousii* *Lithobates pipiens*	Crotalus viridis	Y
PR15	*Anaxyrus woodhousii* *Lithobates pipiens*	None	N
PR16	*Anaxyrus woodhousii* *Lithobates pipiens*	*Thamnophis elegans vagrans*	N
PR17	*Anaxyrus woodhousii* *Lithobates pipiens*	None	Y

Monitoring Reach	Amphibian Species	Reptile Species	Chytrid?
PR18	*Anaxyrus woodhousii* *Lithobates pipiens*	None	N
TR2	*Pseudacris maculata*	None	none tested
TR3	*Anaxyrus woodhousii* *Lithobates pipiens* *Pseudacris maculata*	*Thamnophis elegans vagrans* *Thamnophis sirtalis parietalis* *Apalone spinifera* *Unknown turtle*	N

Table 5. Number of individuals (adults and juveniles) of each species detected at each monitoring reach along the Powder River and Tongue River. Relative abundance of each species across sites also is provided.

	NLF		WHT		BCF		WGS		CGS		BS		PR		SST	
Monitoring Reach	***n***	**Rel. abund.**	***n***	**Rel. abund.**	***n***	**Rel. abund.**	***n***	**Rel. abund.**	***n***	**Rel. abund.**	***n***	**Rel. abund.**	***n***	**Rel. abund.**	***n***	**Rel. abund.**
PR1		0.00		0.00		0.00		0.00		0.00	1	1.00		0.00		0.00
PR2		0.00	6	0.03		0.00		0.00		0.00		0.00		0.00		0.00
PR3	21	0.17	15	0.07		0.00		0.00		0.00		0.00		0.00		0.00
PR4	2	0.02	5	0.02		0.00		0.00		0.00		0.00		0.00		0.00
PR5		0.00	17	0.08		0.00		0.00		0.00		0.00		0.00		0.00
PR6	27	0.22	9	0.04		0.00		0.00		0.00		0.00		0.00		0.00
PR7	13	0.11	2	0.01		0.00	1	0.20		0.00		0.00		0.00		0.00
PR8	12	0.10	3	0.01	1	0.17		0.00		0.00		0.00		0.00		0.00
PR9	7	0.06	5	0.02		0.00		0.00		0.00		0.00		0.00		0.00
PR10		0.00	2	0.01		0.00		0.00		0.00		0.00		0.00		0.00
PR11		0.00	5	0.02		0.00	1	0.20		0.00		0.00	1	0.50		0.00
PR12	2	0.02	5	0.02		0.00	1	0.20		0.00		0.00		0.00		0.00
PR13		0.00	43	0.20		0.00		0.00		0.00		0.00		0.00		0.00
PR14	16	0.13	9	0.04		0.00		0.00		0.00		0.00	1	0.50		0.00
PR15	1	0.01	8	0.04		0.00		0.00		0.00		0.00		0.00		0.00
PR16	8	0.07	17	0.08		0.00	1	0.20		0.00		0.00		0.00		0.00
PR17	1	0.01	62	0.29		0.00		0.00		0.00		0.00		0.00		0.00
PR18	1	0.01	2	0.01		0.00		0.00		0.00		0.00		0.00		0.00
TR2		0.00		0.00	2	0.33		0.00		0.00		0.00		0.00		0.00
TR3	10	0.08	2	0.01	3	0.50	1	0.20	1	1.00		0.00		0.00	1	1.00
Grand Total	121	1.00	217	1.00	6	1.00	5	1.00	1	1.00	0	0.00	2	1.00	1	1.00

Table 6. Average water quality and site conditions at ecological monitoring reaches along the Powder River and Tongue River in 2011.

	Water Quality[a]					
Monitoring Reach	Water Temp. (°C)	Conductivity (mS/cm)	pH	TDS[b] (g/L)	Salinity (ppt)	Emergent Veg. >50%[c]
PR1	17.40	0.58	7.15	0.45	0.37	No
PR2	20.83	0.72	8.39	0.50	0.40	Yes
PR3	21.65	0.79	9.03	0.58	0.40	Yes
PR4	21.30	0.92	9.23	0.64	0.50	No
PR5	16.90	0.43	8.58	0.30	0.28	Yes
PR6	18.48	0.58	8.07	0.47	0.35	Yes
PR7	18.15	0.56	8.24	0.42	0.30	Yes
PR8	17.30	0.59	7.54	0.45	0.30	No
PR9	18.95	0.71	8.23	0.51	0.40	Yes
PR10	14.35	0.47	8.36	0.39	0.30	Yes
PR11	21.60	0.81	8.76	0.55	0.43	Yes
PR12	15.45	0.60	8.64	0.47	0.35	Yes
PR13	19.35	0.61	8.29	0.45	0.35	Yes
PR14	16.95	0.52	8.86	0.45	0.33	Yes
PR15	20.90	0.67	8.11	0.47	0.40	Yes
PR16	16.78	0.39	8.80	0.30	0.25	Yes
PR17	17.75	0.41	8.55	0.31	0.25	No
PR18	17.38	0.43	8.61	0.33	0.25	No
TR2	12.57	0.16	7.97	0.14	0.10	Yes
TR3	12.28	0.22	7.70	0.19	0.13	Yes

[a] Water quality measures were averaged across shorelines (east & west) and across visits for each monitoring reach
[b] Total Dissolved Solids
[c] Whether or not emergent vegetation was found along more than 50% of the shoreline of a reach

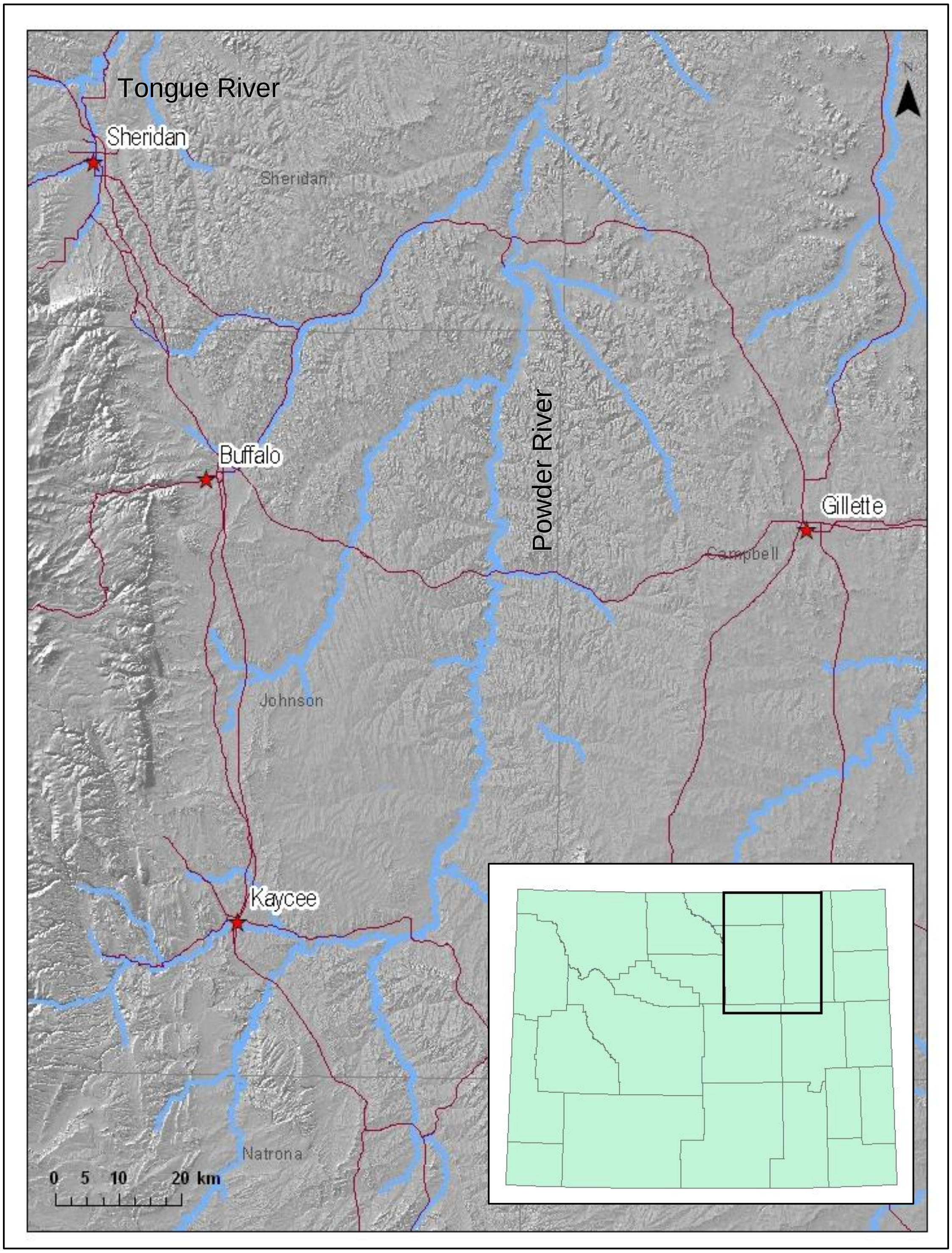

Figure 1. Map of the Powder River Basin and Tongue River area where amphibian and reptile surveys were conducted by WYNDD in 2011.

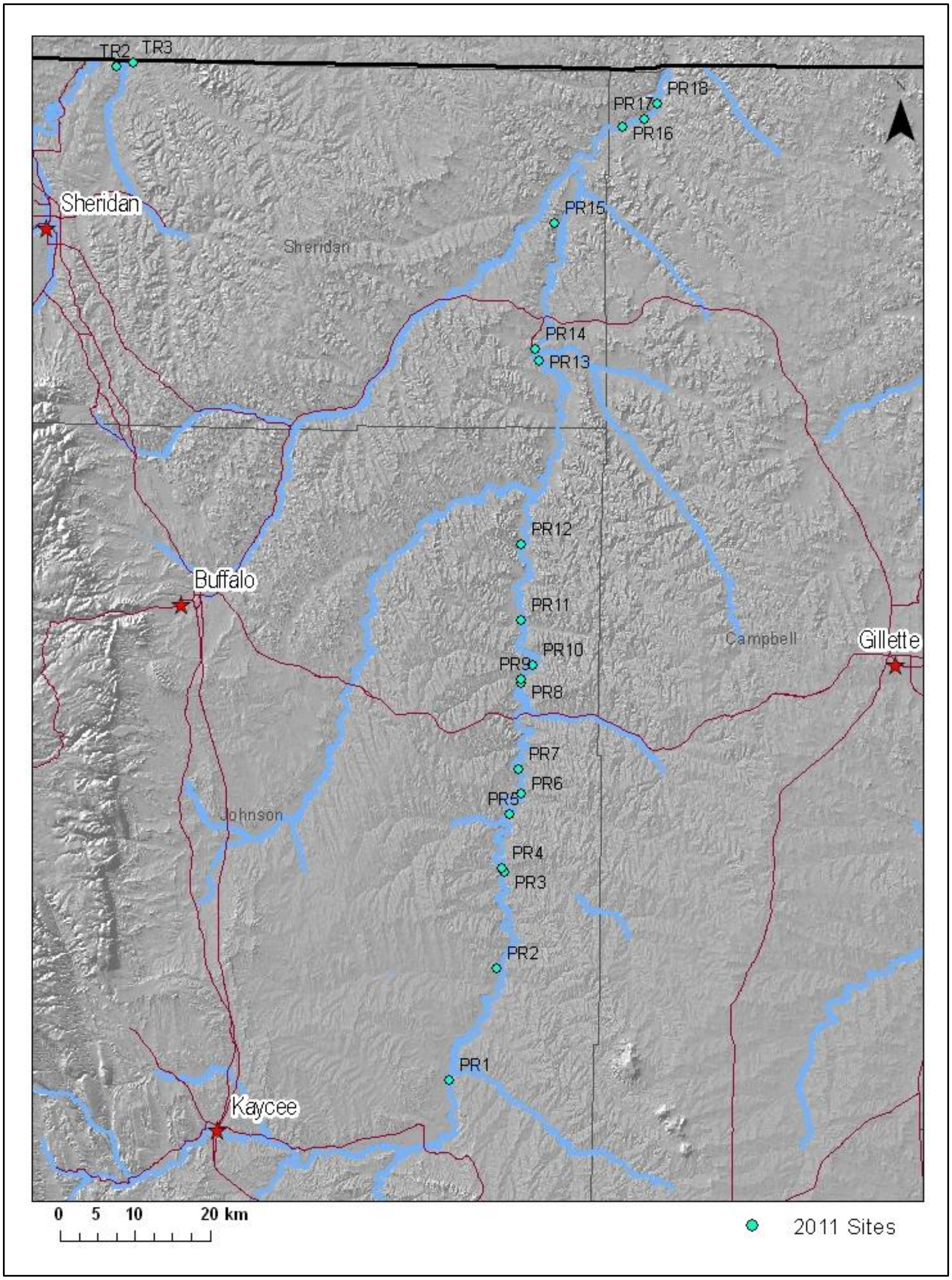

Figure 2. Locations of ecological monitoring reaches along the Powder River and Tongue River established by the USGS and ATG and surveyed for amphibians and reptiles by WYNDD in 2011. The two flooded sites along the Tongue River, TR1 and TR4 are not displayed.

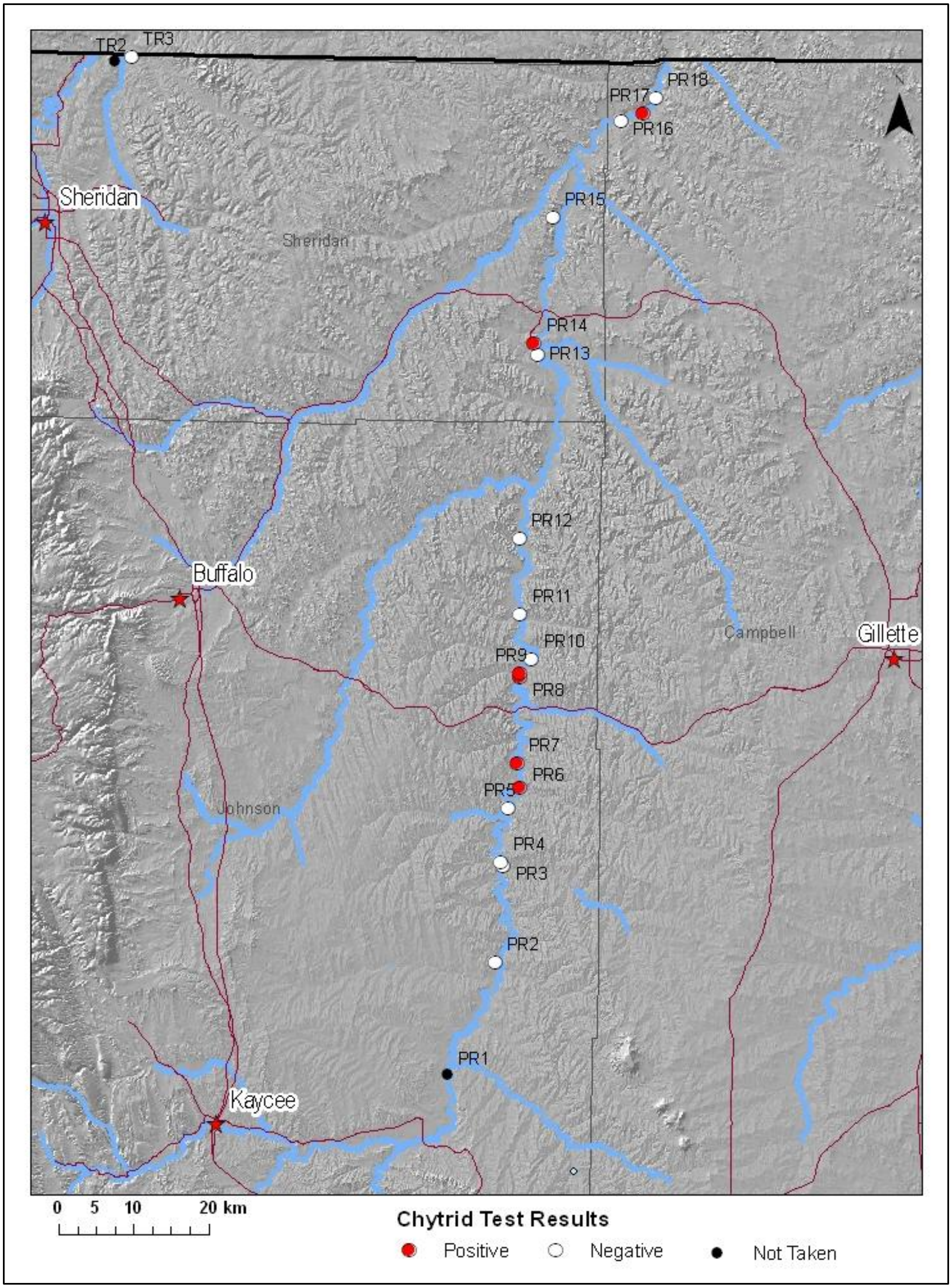

Figure 3. Monitoring reaches along the Powder and Tongue Rivers where amphibians tested positive for chytrid fungus in 2011.

APPENDIX A: Riparian Visual Encounter Data Sheet

Locality Information

Site Name (Drainage):		Date:	Observers:
Site Selection: Predetermined Opportunistic		Owner:	HUC Name/#
UTM Zone/GPS Datum:		County:	Photo #'s
Start Time:	Start UTM East:	Start UTM North:	Start Waypoint:
End Time:	End UTM East:	End UTM North:	End Waypoint:
			Total Search Time (min.):

Water Quality Information

Water Temp °C	Water pH	TDS	Conductivity	Salinity	Grab Sample Taken? Y N	Grab Sample #:
General site description and notes:						

Habitat Information

Air Temp (^{o}C):	Weather: Clear Partly Cloudy Overcast Rain Snow	Wind: Calm/Light Moderate Strong
Site Dry? Y N	Habitat Type: Reservoir/Stockpond Ephemeral/Channel Ditch/Puddle Spring/Seep Stream Channel Wetland/Marsh Backwater/Oxbow	Water Permanence: Permanent Temporary
Water Color: Clear Stained	Water Connectedness: Permanent Temporary Isolated	Relative Abundance (%) of Emergent Veg Types: ____ Sedges ____ Grass ____ Cattail ____ Water Lily ____ Rushes ____ Shrubs ____ Other
Water Turbidity: Clear Cloudy	% Site > 2 m Depth: 0 1-25 26-50 51-75 76-100	
Max Depth: < 1 m 1-2 m > 2 m	% Site ≤ 50 cm Depth: 0 1-25 26-50 51-75 76-100	
Emergent Veg Area (m2):	% Site Searched: 0 1-25 26-50 51-75 76-100	
Site Length (m):	% Site w/ Emergent Veg: 0 1-25 26-50 51-75 76-100	
Site Width (m):	% Site with Larval Activity: 0 1-25 26-50 51-75 76-100	Relative Abundance (%) of Substrate Types: ____ Silt/Mud ____ Cobble ____ Sand ____ Boulder/Bedrock ____ Gravel
Fish Detected?: Y N	Fish Species if Identified:	
Shoreline Characteristics: Shallows Present?: Y N Emergent Veg Present?: Y N		
Grazing Impact: None Light Heavy Structure Heavy Structure & Water Heavy Water		
Water Dammed/Diverted: Y N	Other Human Impacts or Modifications (Circle): CBNG Other (describe)___________	

Species Information

Amphibian Species		No. Egg Masses		Number Larvae	≤10 ≤100 ≤1000 ≤10K >10K		
Time at first detection	E L M J A	Number Juveniles		Number Adults		Chytrid samples Taken?	
		Vouchers collected?		Picture Number		If breeding with fish is cover present?	Y N
Amphibian Species		No. Egg Masses		Number Larvae	≤10 ≤100 ≤1000 ≤10K >10K		
Time at first detection	E L M J A	Number Juveniles		Number Adults		Chytrid samples Taken?	
		Vouchers collected?		Picture Number		If breeding with fish is cover present?	Y N
Amphibian Species		No. Egg Masses		Number Larvae	≤10 ≤100 ≤1000 ≤10K >10K		
Time at first detection	E L M J A	Number Juveniles		Number Adults		Chytrid samples Taken?	
		Vouchers collected?		Picture Number		If breeding with fish is cover present?	Y N

Amphibian Species		No. Egg Masses		Number Larvae	≤10	≤100	≤1000	≤10K	>10K
Time at first detection	E L M J A	Number Juveniles		Number Adults		Chytrid samples Taken?			
		Vouchers collected?		Picture Number		If breeding with fish is cover present?	Y N		
Amphibian Species		No. Egg Masses		Number Larvae	≤10	≤100	≤1000	≤10K	>10K
Time at first detection	E L M J A	Number Juveniles		Number Adults		Chytrid samples Taken?			
		Vouchers collected?		Picture Number		If breeding with fish is cover present?	Y N		
Amphibian Species		No. Egg Masses		Number Larvae	≤10	≤100	≤1000	≤10K	>10K
Time at first detection	E L M J A	Number Juveniles		Number Adults		Chytrid samples Taken?			
		Vouchers collected?		Picture Number		If breeding with fish is cover present?	Y N		
Amphibian Species		No. Egg Masses		Number Larvae	≤10	≤100	≤1000	≤10K	>10K
Time at first detection	E L M J A	Number Juveniles		Number Adults		Chytrid samples Taken?			
		Vouchers collected?		Picture Number		If breeding with fish is cover present?	Y N		

Reptile Species		Time at first detection	E J A	Number Individuals		SVL in CM		Tissue Number		Voucher Number	
Reptile Species		Time at first detection	E J A	Number Individuals		SVL in CM		Tissue Number		Voucher Number	
Reptile Species		Time at first detection	E J A	Number Individuals		SVL in CM		Tissue Number		Voucher Number	
Reptile Species		Time at first detection	E J A	Number Individuals		SVL in CM		Tissue Number		Voucher Number	
Reptile Species		Time at first detection	E J A	Number Individuals		SVL in CM		Tissue Number		Voucher Number	
Reptile Species		Time at first detection	E J A	Number Individuals		SVL in CM		Tissue Number		Voucher Number	
Reptile Species		Time at first detection	E J A	Number Individuals		SVL in CM		Tissue Number		Voucher Number	
Reptile Species		Time at first detection	E J A	Number Individuals		SVL in CM		Tissue Number		Voucher Number	
Reptile Species		Time at first detection	E J A	Number Individuals		SVL in CM		Tissue Number		Voucher Number	
Reptile Species		Time at first detection	E J A	Number Individuals		SVL in CM		Tissue Number		Voucher Number	
Reptile Species		Time at first detection	E J A	Number Individuals		SVL in CM		Tissue Number		Voucher Number	

APPENDIX A (*continued*):

Powder River/Tongue River Basin Survey Protocols

These amphibian surveys were designed to accommodate occupancy modeling of amphibians which will be used to assess long-term trends in amphibian populations in the Powder River Basin. Estimating the probability of detecting a species during a survey is critical to occupancy modeling. Thus, protocols are designed maximize the ability to estimate detection probability. Because egg and larval stages of amphibians are most sensitive to environmental conditions, recording evidence of breeding is critical to any amphibian monitoring program. Survey protocols and datasheets allow surveyors to detect and record evidence of breeding.

1. 2 people conducting separate surveys at a site is recommended to efficiently maximize the number of surveys used to estimate detection probability. **Each surveyor MUST fill out a separate datasheet.**

2. Each site should be surveyed **independently** by each surveyor with **no discussion of findings** or peer correction of datasheets after survey is complete.

3. Surveyors should start at opposite ends of the reach and survey towards each other until they meet in the middle. When surveyors meet at the far end, they should stop for ≥10 minutes and quietly fill out the site and survey conditions on the datasheet before continuing on with searches. This procedure allows amphibians disturbed by the first surveyor to resume normal behavior before the second surveyor searches that section.

4. Surveyors should walk slowly in a zig-zag pattern, surveying evenly across suitable habitat to cover as much potential habitat as possible.

5. Surveyors should search all accessible moist habitat.

6. Surveyors should dipnet every 5-10m or in patches of good habitat for amphibian larvae (quiet inlets/backwater areas or patches of emergent vegetation). Each dipnet event should consist of at least five sweeps with the net.

7. Surveyors should record all species detected during surveys, and the number adults, metamorphs, tadpoles, and egg masses found. **It is important to record any evidence of breeding (metamorphs, tadpoles, egg mass, or adults in amplexus (mating behavior)).**

8. Photographs should be taken of animals or egg masses that cannot be identified. Photos can be sent to WGFD or WYNDD for possible ID. If possible photos should include a side, belly, and dorsal photo.

9. Tadpoles should be identified to genus using a tadpole key. Specimens of unidentified tadpoles can be stored in vials with ethanol and sent to WGFD or WYNDD for possible ID. Only a few tadpoles from each aggregation should be collected for this purpose.

10. Up to 5 individuals of each species detected (excluding Tiger Salamanders) should be sampled for chytrid fungus (*see chytrid sampling procedure*) within each reach.

11. **Surveyors should make sure that datasheets are completely filled out and that all site and survey conditions have been recorded before leaving the site.**

12. Surveyors **MUST** follow chytrid fungus decontamination procedures after leaving the sites and before surveying another site **in a different watershed**. Decontamination should also occur between sites whenever possible.

13. Sites should be visited at least twice during the spring/early summer if possible.

Equipment List:

- Tall boots/waders
- Dip nets
- Watch
- Compass
- Camera
- Datasheets & survey protocols
- Thermometer for air and water temperature
- pH meter
- Sterile swabs and vials for chytrid sample collection
- Disposable rubber/latex gloves
- Decontamination equipment/supplies (kept in vehicle unless surveying in different watersheds). Includes bleach, water, scrub brush, sprayer/bucket.

APPENDIX B.

Powder River and Tongue River Landowners for ATG Sampling Sites in 2011[a]

Site ID	Site name	Land ownership	Notes for 2011
PR1	POWDER RIVER ABOVE DRY FORK	site on BLM land, need access through Soldier C Ranch, %Mason Skiles, 502 South 4th St, Laramie 82070 745-5184 Fred Carr 738-2604	
PR2	POWDER RIVER BELOW WILLOW CREEK	state land	
PR3	POWDER RIVER ABOVE PUMPKIN CREEK	Harriet Land & Livestock LLC, 613 W Hogerson St., Buffalo 82834 684-2977 Tom Harriet 684-8632	
PR4	POWDER RIVER BELOW PUMPKIN CREEK	Harriet Land & Livestock	
PR5	POWDER RIVER BELOW FOURMILE CREEK	Harriet Land & Livestock	
PR6	POWDER RIVER BELOW BEAVER CREEK	Harriet Land & Livestock	
PR7	POWDER RIVER BL BURGER DRAW	Anadarko Petroleum - Jeff Ramsey 307-685-4132 or 307-680-6438 (cell) or Bucky Stanley (Jeff's supervisor) 307-685-5740 or 307-684-4831 (cell) Tim Kalus (office) 307-682-2675 (cell) 307-620-5204	
PR8	POWDER RIVER ABOVE DRY CREEK	Bobby and Dolly Arndt, 2491 Upper Powder River Road, Arvada, 82831 736-2450	
PR9	POWDER RIVER BELOW DRY CREEK	Bobby and Dolly Arndt, 2491 Upper Powder River Road, Arvada, 82831 736-2450	
PR10	POWDER RIVER BELOW FLYING E CREEK	Lula Wagner and Dell Jenkins, Powder River Ranch Co., 2563 Upper Powder River Road, Arvada 82831 736-2459	
PR11	POWDER RIVER BELOW BARBER CREEK	Bob Kennedy, Faddis-Kennedy Cattle Co., 2 N Main St., Ste 301, Sheridan 82801 672-6494	
PR12	POWDER RIVER BELOW MITCHELL DRAW	Joaquin Michelena, 1863 Upper Powder River Road, Arvada 82831 736-2456	

Site ID	Site name	Land ownership	Notes for 2011
PR13	POWDER RIVER ABOVE WILDHORSE CREEK	Randy Jahn, PO Box 7, Arvada 82831 307-736-2664	Because he has cattle in the river pasture call him prior to sampling, leave message and your phone number so he can call back if there are concerns.
PR14	POWDER RIVER BELOW WILDHORSE CREEK	Keith Troll, PO Box 6, Arvada 82831 736-2386	
PR15	POWDER RIVER ABOVE IVY CREEK	Jim Gibbs, Gibbs Brothers Inc., 1459 Lower Powder River Road, Arvada 82831 736-2428	
PR16	POWDER RIVER ABOVE LX BAR CREEK	Giles W. Pritchard-Gordon, Pee Gee Ranch, 1251 Lower Powder River Road, Arvada 82831 main 736-2327, HQ 736-2461 Fleur Ahern	
PR17	POWDER RIVER BELOW LX BAR CREEK	Giles W. Pritchard-Gordon, Pee Gee Ranch, 1251 Lower Powder River Road, Arvada 82831 main 736-2327, HQ 736-2461 Fleur Ahern	
PR18	POWDER RIVER BELOW SA CREEK	Vaughn Cresswell, Bow & Arrow Ranch Inc, 491 Lowder Powder River Road, Arvada 82831 736-2437 ranch 674-4215 house in Sheridan	
TR1	TONGUE RIVER BELOW YOUNGS CREEK	Youngs Creek Mining Co. 673-1057. Lessee Charlie Larsen 307-751-2440	The mine has not replied about access to site TR1, so I called Charlie Larsen, the lessee. He says it is OK for your crew and the USGS crew to access the site. He asked that your crew **contact him on his cell phone at 307-751-2440 when you are within a day or two of sampling.**
TR2	TONGUE RIVER ABOVE PRAIRIE DOG CREEK	Ronald and Renetta Mischke, 2656 Coffeen Ave, Sheridan 82801 ofc 674-5045, cell 751-5809, home 672-0176	
TR3	TONGUE RIVER BELOW PRAIRIE DOG CREEK	Ronald and Renetta Mischke, 2656 Coffeen Ave, Sheridan 82801 ofc 674-5045, cell 751-5809, home 672-0176	
TR4	TONGUE RIVER ABOVE BADGER CREEK	Decker Coal Co. (Greg Passini) 406-757-2562, ext 229	
TR5	TONGUE RIVER ABOVE HANGING WOMAN CREEK	Tim & Lisa LoHoff, 23 U Ranch Lane, Birney MT 59012	
TR6	TONGUE BELOW HANGING WOMAN CREEK	Art Jr. (Bunny) and Marilynn Hayes, Brown Cattle Co., PO Box 578, Birney 59012 406-984-6260	

[a] Landowner contact list was compiled by Bud Stewart (WGFD) and Dave Peterson (USGS).

APPENDIX C. Occupancy of sites based on detection history (Ψ conditional) for presence and evidence of breeding for Northern Leopard Frogs (NLF) and Woodhouse's Toads (WHT).

	NLF Presence[a]		NLF Breeding[a]		WHT Presence[b]		WHT Breeding[b]	
Site	Ψ (conditional)	S.E.	Ψ (conditional)	S.E.	Ψ (conditional)	S.E.	Ψ (conditional)	S.E.
PR1	0.0284	0.0270	0.0219	0.0221	0.0112	0.0226	0.0430	0.0766
PR10	0.0284	0.0270	0.0219	0.0221	1.0000	-	1.0000	-
PR11	0.0284	0.0270	0.0219	0.0221	1.0000	-	1.0000	-
PR12	1.0000	-	1.0000	-	1.0000	-	1.0000	-
PR13	0.0284	0.0270	0.0219	0.0221	1.0000	-	1.0000	-
PR14	1.0000	-	1.0000	-	1.0000	-	1.0000	-
PR15	1.0000	-	0.0219	0.0221	1.0000	-	1.0000	-
PR16	1.0000	-	1.0000	-	1.0000	-	1.0000	-
PR17	1.0000	-	0.0219	0.0221	1.0000	-	1.0000	-
PR18	1.0000	-	0.0219	0.0221	1.0000	-	1.0000	-
PR2	0.0284	0.0270	0.0219	0.0221	1.0000	-	1.0000	-
PR3	1.0000	-	1.0000	-	1.0000	-	1.0000	-
PR4	1.0000	-	1.0000	-	1.0000	-	1.0000	-
PR5	0.0284	0.0270	0.0219	0.0221	1.0000	-	1.0000	-
PR6	1.0000	-	1.0000	-	1.0000	-	1.0000	-
PR7	1.0000	-	1.0000	-	1.0000	-	1.0000	-
PR8	1.0000	-	1.0000	-	1.0000	-	1.0000	-
PR9	1.0000	-	1.0000	-	1.0000	-	1.0000	-
TR2	0.0284	0.0270	0.0219	0.0221	0.0063	0.0102	0.0169	0.0265
TR3	1.0000	-	1.0000	-	1.0000	-	1.0000	-

[a] Model = Ψ (constant), p(constant)

[b] Model = Ψ (river), p(Air temp)

APPENDIX D

Site photos for monitoring reaches along the Powder and Tongue Rivers

Powder River Site 1 – East Bank. Picture taken facing north.

Powder River Site 1 – West Bank. Picture taken facing south.

Powder River Site 2 – East Bank. Picture taken facing south from 405242E 4862855N

Powder River Site 2 – West Bank. Picture taken facing north.

Powder River Site 3 – East Bank. Picture taken facing north.

Powder River Site 3 – West Bank. Picture taken facing south.

Powder River Site 4 – East Bank. Picture taken facing south.

Powder River Site 5 – East Bank. Picture taken facing south.

Powder River Site 5 – West Bank. Picture taken facing south.

Powder River Site 6 – East Bank. Picture taken facing south.

Powder River Site 6 – West Bank. Picture taken facing south.

Powder River Site 7 – East Bank. Picture taken facing south.

Powder River Site 7 – West Bank. Picture taken facing south.

Powder River Site 8 – West Bank. Picture taken facing north.

Powder River Site 9 – West Bank. Picture taken facing north.

Powder River Site 10 – West Bank. Picture taken facing south.

Powder River Site 11 – East Bank. Picture taken facing north.

Powder River Site 11 – West Bank. Picture taken facing north.

Powder River Site 12 – East Bank. Picture taken facing north.

Powder River Site 13 – East Bank. Picture taken facing south.

Powder River Site 14 – East Bank. Picture taken facing south.

Powder River Site 14 – West Bank. Picture taken facing south.

Powder River Site 15 – West Bank. Picture taken facing north.

Powder River Site 16 – East Bank. Picture taken facing north.

Powder River Site 16 – West Bank. Picture taken facing south from 422105E 4975249N.

Powder River Site 17 – East Bank.

Powder River Site 17 – West Bank. Picture taken facing south.

Powder River Site 18 – East Bank. Picture taken facing north.

Powder River Site 18 – West Bank. Picture taken facing north.

Tongue River Site 2 – East Bank. Picture taken facing north.

Tongue River Site 2 – West Bank.

Tongue River Site 3 - East Bank. Picture taken facing south.

Tongue River Site 3 - West Bank. Picture taken facing north.