A Description of the Raptor Nesting Community in the Hells Canyon Area

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ABSTRACT

From 1995 to 1999, Idaho Power Company (IPC) surveyed the nesting raptor community along Brownlee, Oxbow, and Hells Canyon Reservoirs located on the Snake River in the Hells Canyon Area. The objective of this study was to describe the nesting raptor community within the reservoir complex. Specifically, this included: 1) a determination of cliff-nesting birds of prey, based on occupancy surveys, and 2) an estimation of the relative abundance of nesting raptors based on point surveys and incidental observations. In spring of 1995 and 1996, we used 2-hour survey bouts from fixed points to survey sections of cliff along all three reservoir reaches for nesting raptors. From these point surveys, 31 occupied territories were documented, including 11 golden eagle (*Aquila chrysaetos*), five red-tailed hawk (*Buteo jamaicensis*), five prairie falcon (*Falco mexicanus*), five common raven (*Corvus corax*), four American kestrel (*Falco sparverius*) and one peregrine falcon (*Falco peregrinus*). In addition, another 40 occupied territories were documented through incidental observations from 1995 through 1999, increasing the diversity of nesting raptor species by seven. Additional species included five owl species, the bald eagle (*Haliaeetus leucocephalus*), and Cooper's hawk *(Accipiter cooperii)*. Owl species documented included the great horned owl (*Bubo virginiana*), common barn-owl (*Tyto alba*), western screech-owl (*Otus kennicottii*), long-eared owl (*Asio otus*), and burrowing owl (*Athene cunicularia*). Although the species richness and diversity between the three reservoir reaches was similar, species composition among the three reaches was quite different. The Oxbow reach can be considered a transition area, with a raptor community similar to both the Brownlee and Hells Canyon reaches. However, marked differences in species composition occurred between the Brownlee and Hells Canyon reaches. The average density of nesting raptors was 13.3 per river mile and was similar among the three reaches surveyed. Overall, the most common nesting species observed was the golden eagle with 14 occupied territories, followed by the red-tailed hawk (13), American kestrel (9), prairie falcon (9) and nine other species including the common raven. While the golden eagle appeared to be more evenly distributed, 11 of the 13 the red-tailed hawk territories were along Brownlee Reservoir. The species composition in our study was similar to findings of previous studies in the area, though there were some notable differences. Previously, the Swainson's hawk (*Buteo swainsoni*), turkey vulture (*Cathartes aura*), northern goshawk (*Accipiter gentilis*), northern harrier (*Circus cyaneus*), and short-eared owl (*Asio flammeus*) have been observed to nest in the study area. Although all of these species have been observed in the study area, we made no observations of these species nesting. Similarly, we documented several species that had not previously been recorded (several owl species) or species that have not been observed nesting in the study area recently, including the bald eagle and the peregrine falcon. Differences in survey effort and techniques may account for differences in the composition of nesting raptors between studies. Historical sites of two endangered species, the bald eagle and peregrine falcon, were surveyed annually from 1995 through 1999. During our surveys, none of the historic bald eagle territories were occupied. However, two new bald eagle nesting territories were established, one in 1998 and one in 1999. A peregrine falcon nesting territory, discovered in 1995, was occupied from 1995 through 1999.

1. INTRODUCTION

Raptors (species of the orders Falconiformes and Strigiformes) are among the most politically sensitive groups of birds with which federal agencies are concerned (Olendorff et al. 1989). Because raptors are at the top of the food chain, they are both biologically important and environmentally sensitive. Recognizing the special needs of this taxonomic group and, in many cases, their declining populations, the Bureau of Land Management's overall goal is to manage resources to ensure the existence of an adequate number of healthy and vigorous populations of each raptor species (Olendorff et al. 1989). Populations must be of sufficient size and resilience to withstand severe environmental impacts, and they must have appropriate sex and age ratios and recruitment rates to viably maintain their populations. Suitable habitat components include: 1) habitat for prey species; 2) sites for breeding and rearing offspring; 3) habitat for winter survival; and 4) abundant open space for normal dispersal, dispersion of young, migratory movements, and territorial behavior (Olendorff et al. 1989). Compared with other groups of birds, raptors often nest in low numbers in remote areas (Newton 1979), making them difficult to survey.

The steppe community characterizing much of southern Idaho is used primarily by open-country, soaring raptors. Twenty-two (49%) of 45 raptor species found in the western United States occupy this habitat. Principal species are the golden eagle *(Aquila chrysaetos*) and the prairie falcon (*Falco mexicanus*). The sagebrush steppe is also important habitat for the red-tailed hawk (*Buteo jamaicensis*), ferruginous hawk (*Buteo regalis*), Swainson's hawk (*Buteo swainsoni*), northern harrier (*Circus cyaneus*), barn owl (*Tyto alba*), great horned owl (*Bubo virginiana*), and long-eared owl (*Asio otus*). Throughout the shrub steppe, nest sites are often restricted to canyons, rock outcrops, and bluffs. Within the Hells Canyon Area, prairie falcons, peregrine falcons (*Falco peregrinus*), and golden eagles nest almost exclusively on cliffs while the red-tailed hawk, American kestrel (*Falco sparverius*), great horned owl, and common ravens *(Corvus corax)* nest on cliffs as well as in trees found primarily in riparian habitat. Several species nest exclusively in trees, including the long-eared owl, western screech-owl (*Otus kennicottii*), northern goshawk (*Accipiter gentiles*), Cooper's hawk (*Accipiter cooperii*), and sharp-shinned hawk (*Accipiter striatus*). Three species common to this area, including the northern harrier, short-eared owl (*Asio flammeus*), and burrowing owl (*Athene cunicularia*), nest on the ground.

In the Blue Mountains Province of Oregon, 17 species of diurnal raptors and 12 owl species have been reported (Marshall 1986). Fourteen species of diurnal raptors nest in the Blue Mountains region: turkey vulture (*Cathartes aura*), osprey (*Pandion haliaetus*), bald eagle (*Haliaeetus leucocephalus*), northern harrier, sharp-shinned hawk, Cooper's hawk, northern goshawk, Swainson's hawk, red-tailed hawk, ferruginous hawk, golden eagle, American kestrel, prairie falcon, and peregrine falcon (Marshall 1986). Eleven species of owls have been recorded to breed in the Blue Mountains region: the common barn owl, flammulated owl, western screech-owl, great horned owl, northern pygmy-owl (*Glaucidium gnoma*), burrowing owl, barred owl (*Strix varia*), great gray owl (*Strix nebulosa*), long-eared owl, short-eared owl, and northern saw-whet owl (*Aegolius acadicus*) (Marshall 1986).

Throughout southern Idaho, many areas along the Snake River support a dense and diverse raptor nesting community (Howard et al. 1976, Thurow et al. 1980, USDI 1996). In southwestern Idaho, cliffs along the Snake River Canyon in the Snake River Birds of Prey National Conservation Area (SRBOPNCA) support high densities of nesting raptors. Further north along the Snake River in southwestern Idaho, Brownlee and Oxbow reservoirs have been identified as key raptor areas (Olendorff et al. 1989, USDI 1992). Similarly, the area around Hells Canyon Dam, with a number of hack sites used for peregrine falcon reintroduction (Bechard and Levine 1988), is important for raptors.

In 1974 and 1975, Asherin and Claar (1976) documented nine nesting raptor species along the three-reservoir complex in Hells Canyon. Six diurnal raptors (northern harrier, red-tailed hawk, Swainson's hawk, golden eagle, prairie falcon, and American kestrel) and three species of owls (common barn owl, great horned owl, and short-eared owl) occupied nesting territories within the three-reservoir complex. Species diversity was highest along Brownlee Reservoir (9), followed by Oxbow (3), and Hells Canyon (2) reservoirs. The American kestrel was the most common nesting raptor recorded, followed by the red-tailed hawk and golden eagle.

Levine and Erickson (1990) conducted a raptor survey in the Hells Canyon National Recreation Area in 1990. Thirty-one points were used to survey sections of cliff from 1 to 4 hrs to determine territory occupancy for cliff-nesting raptors. Seven raptors species with occupied territories were recorded. In order of frequency, they included the golden eagle with 27 territories, American kestrel (10), red-tailed hawk (7), northern goshawk (3), great horned owl (2), prairie falcon (1), and turkey vulture (1). Levine and Erickson (1990) considered the number of observed golden eagle nesting pairs to be conservative. Isaacs and Opp (1991) reported on numbers, distribution, and productivity of golden eagles in Oregon over the period 1965–1982. Fifteen nesting attempts were recorded for Baker and seven for Wallowa County. These numbers seem to be very low compared with the number of golden eagle pairs recorded along the Snake River corridor by Levine and Erickson (1990). However, Isaacs and Opp (1991) noted that the surveys were by no means exhaustive.

The objectives of this raptor survey were to describe diurnal raptor resources in the study area. Specific objectives were to: 1) determine the species of cliff-nesting diurnal birds of prey, 2) estimate the relative abundance of cliff-nesting raptors, based on occupancy surveys, and 3) document all nesting raptor species observed incidentally. Baseline survey data collected on nesting birds of prey by Idaho Power Company (IPC) will be useful to state and federal resource agencies in their efforts to protect and conserve this sensitive group of birds.

2. STUDY AREA

2.1. Location

The Hells Canyon Reach of the Snake River is situated in west-central Idaho and northeastern Oregon (Figure 1). The Hells Canyon Study Area is located between the city of Weiser and the confluence of the Salmon and the Snake rivers (from approximately RM 351 to RM 188). The

Snake River, a major tributary to the Columbia River, is the focal point of Hells Canyon. Its generally northward flow forms part of the boundary between Idaho and Oregon. The Hells Canyon Hydroelectric Complex is located on the Snake River in the southern portion of Hells Canyon and includes three reservoirs—Brownlee, Oxbow, and Hells Canyon. The reach below Hells Canyon Dam is unimpounded, although the three-dam complex controls flows.

Federal agencies, including the Bureau of Land Management (BLM) and U.S. Forest Service (USFS), are responsible for managing the majority of public land in Hells Canyon. These areas fall within the jurisdictional boundaries of the Wallowa–Whitman National Forest, Oregon; Payette National Forest, Idaho; Nez Perce National Forest, Idaho; Cascade Resource Area (RA) of the Boise District, BLM–Idaho; Cottonwood RA of the Coeur d'Alene District, BLM–Idaho; Baker RA of the Vale District, BLM–Oregon; and Northern Malheur RA of the Vale District, BLM–Oregon. Other agencies with natural resource jurisdiction in the greater project area include the USDI National Marine Fisheries Service (NMFS), USDI Bureau of Indian Affairs (BIA), USDI Fish and Wildlife Service (USFWS), and state agencies from Idaho and Oregon.

The area upstream and downstream of Hells Canyon Dam can be broadly divided into five reaches, based on distinct geomorphic features, river characteristics, and legal project boundaries:

- Upstream of Brownlee Reservoir to the Weiser Bridge (approximately 12 miles; RM 351.2 to 339.2).
- Brownlee Reservoir (approximately 55 miles; RM 339.2 to 284.6).
- Oxbow Reservoir (approximately 12 miles; RM 284.6 to 272.2).
- Hells Canyon Reservoir Reach (approximately 25 miles; RM 272.2 to 247.0).
- Downstream of Hells Canyon Dam to the confluence of the Snake and Salmon rivers (approximately 59 miles, RM 247.0 to 188.2).

The study area below Hells Canyon Dam is extremely difficult to access. Access below Hells Canyon Dam is restricted to powerboats and whitewater rafts. During the spring months, when raptor surveys were to be conducted, flows in the Snake River were often too high for either type of boating. As a result, our surveys were restricted to the area from Weiser to just below Hells Canyon Dam (Figure 1).

In the upstream reach, the Snake River can be characterized as a low-gradient (0.2 to 0.4 m/km) river, with several island complexes. Agricultural impacts are apparent with high amounts of irrigation returns causing higher turbidities and increased nutrient loading. Farmland and rural development on flat to gentle topography surround this reach. Brownlee Reservoir is a steep-sided reservoir with a maximum depth approaching 300 feet near the dam. Large rock outcrops occur throughout the entire length. Oxbow Reservoir is a small re-regulating reservoir surrounded by moderate to steep topography (20 to 75% slopes). Shorelines are primarily basalt outcrops and talus, except for alluvial fans created by small tributaries. Hells Canyon Reservoir is a re-regulating reservoir with maximum depths approaching 200 feet. Shorelines in the reservoir are generally very steep, and substrates are primarily composed of basalt outcrops and talus slopes. The Snake River in the downstream reach is a high-gradient river (1.8 m/km) with a wide diversity of aquatic habitat, including numerous large rapids, shallow riffles, and deep pools. Substrates are highly diverse, ranging from large basalt outcrops and boulders to cobble/sand bars. This unimpounded reach of the Hells Canyon is considered to be the deepest gorge in North America. The Hells Canyon reach is surrounded at the upstream end by nearly vertical cliff faces.

2.2. Physiography

Hells Canyon is the deepest and one of the most rugged river gorges in the continental United States. It ranges between 2000 and 3000 feet in depth from Weiser to Oxbow Dam. Below Oxbow Dam, the river enters a narrow, steep-sided chasm measuring up to 5500 feet deep. From the confluence with the Grande Ronde River, the Snake River then flows into a lava-filled basin and through a much shallower canyon to Lewiston, Idaho (USDE 1985). The elevation of the Snake River near Weiser, Idaho, is about 2090 feet msl, descending to about 910 feet msl at the confluence of the Salmon River, about 59 miles below Hells Canyon Dam.

Throughout the canyon, topography is generally steep and broken with slopes often dominated by rock outcrops and talus slopes. At the deepest points of the canyon, the walls rise almost vertically. Canyon walls are deeply dissected by numerous side canyons with tributaries to the Snake River. The Seven Devils Mountains to the east and the Wallowa Mountains to the west form the upper reaches of the canyon walls. These mountains form a series of jagged peaks reaching almost 10,000 feet, with subalpine and alpine conditions (USDA 1990) to the west.

2.3. Land Features and Geology

Hells Canyon consists of a series of folded and faulted metamorphosed sediments and volcanics overlain unconformably by nearly horizontal flows of Columbia River basalt. This basalt group covered much of eastern Washington, northern Oregon, and adjacent parts of Idaho (Bush and Seward 1992). The older rocks in the series are Permian to Jurassic in age and represent at least two episodes of island arc volcanism and adjacent marine sedimentation similar to that found today in the Aleutian Islands west of Alaska. These rock units represent old island arc chains that were sequentially “welded” to the west coast of North America during the late Paleozoic and early to mid-Mesozoic eras by subduction of a tectonic plate beneath the North American Continental tectonic plate (Asherin and Claar 1976, USDA 1994).

In more recent geologic time, Hells Canyon was formed through erosion, by the Snake River, of the Blue Mountains in Oregon and Seven Devils Mountains in Idaho (USDE 1985). The Snake River has existed since the Pliocene and probably cut to its present level during the Pleistocene. During the Pleistocene, glacial meltwater provided abundant runoff for down-cutting, while regional uplifting created weak points in the 2000- to 3000-foot-thick basalt plateau that overlaid the Blue and Seven Devils mountains. Resulting erosion formed the currently observed drainage pattern that established the Snake River (USDE 1985). Northeast-trending, high-angle fault patterns characterize the extensive Snake River fault system running throughout the study area (Fitzgerald 1982).

Besides basalt, other rock types are also present within the study area. Extensive limestone outcrops are found in some tributary drainage areas, and local granitic outcrops also occur.

2.4. Soils

The soils throughout Hells Canyon are derived primarily from Columbia River basalt, covered in most areas with a thin mantle of residual soils from weathered native rock. Isolated areas contain deposits of windblown silt. Unconsolidated materials include ash-loess from the Mount Mazama eruption 6900 years ago, river sands and gravel deposited during the Bonneville floods 15,000 years ago, and colluvium and talus deposited more recently. The amount of soil cover declines northward through Hells Canyon. Near Hells Canyon Dam (RM 247), most rock faces are nearly vertical with little soil cover (USDA 1994).

Most soil complexes are well drained and vary from very shallow to moderately deep. Loams are the dominant textural class and vary from very stony to silty, often with a clay subsoil component (NRCS 1995).

2.5. Climate

From late fall to early spring, the climate of west-central Idaho and eastern Oregon is typically influenced by cool and moist Pacific maritime air. Periodically this westerly flow is interrupted by outbreaks of cold, dry continental air from the north, which is normally blocked by mountain ranges to the east. During the summer, a Pacific high-pressure system dominates weather patterns, resulting in minimal precipitation and more continental climatic conditions overall (Ross and Savage 1967). Hells Canyon, located in the High Desert region, is significantly influenced by the rain shadow of the Cascade Mountains to the west.

Climatological information is summarized for Weiser, Richland, Brownlee Dam, and Lewiston (Figure 2). Average annual precipitation is lowest at the southern end of the study area (Weiser, 286 mm), increases northward (Richland, 298 mm), peaks around Brownlee Dam (445 mm), and declines towards Lewiston (326 mm). The average annual precipitation ranges from about 380 to 500 mm (15 to 20 inches) depending on elevation. Nearly 45% of the average annual precipitation at Brownlee (445 mm [17.8 inches]) falls from November through January, which strongly contrasts with the 9% average recorded for July through September. Thus, most precipitation occurs in the spring and winter (Tisdale and others 1969), (Tisdale 1986, Johnson and Simon 1987) and little or no precipitation falls during the hottest months of summer. Average annual evapotranspiration is estimated to be about 1300 mm (52 inches).

Mean annual temperatures are similar among the four weather stations. Generally, the climate tends to become drier and warmer downstream of Brownlee Dam. Climatological information from Brownlee Dam (RM 284.6) is probably characteristic of the central section of the study area and is discussed in more detail here. The canyon bottom area is dry with seasonal temperatures ranging from lows of about –5 °C in January to highs of about 35 °C in July (Figure 2). Temperatures below freezing are normally experienced from mid-November through mid-April. As a rule, winters in the canyons are mild, while summers on the canyon floor may be hot. Mean temperatures above 2000 m (6562 feet msl) elevation range from –9 °C in January to 13 °C in July. By contrast, mean temperatures below 1000 m (3281 feet msl) elevation range from 0 °C in January to between 28 °C and 33 °C in July (Johnson and Simon 1987).

2.6. Vegetation

The types of vegetation growing along the canyon slopes of the Middle Snake River are the result of three primary ecological factors: topography, soils, and climate. Climate exerts the strongest influence on the development of plant life. The relatively mild winters below the canyon rim have allowed the development of disjunct species such as hackberry (*Celtis reticulata*), which is most often found in the southwestern states, though it commonly occurs in the middle and lower Snake River area (Tisdale 1979, DeBolt 1992).

Within the context of regional climate, topography is a major influence on the development and distribution of vegetation (Tisdale and others 1969, Tisdale 1979, 1986). The topographical complexity of Hells Canyon has produced a mosaic of vegetation types (Tisdale 1979, BPA 1984,USDI 1987). Grassland, shrubland, riparian, and coniferous forest communities exist in close proximity. Interfingering of grassland and forest, for example, occurs at a number of sites throughout the canyon due to variations in aspect (Tisdale 1979).

Fourteen cover types were identified along the Snake River in the Hells Canyon Study Area. The area that was classified covered up to approximately one mile on both sides of the Snake River or associated reservoirs. The dominant cover types were *Grassland* (35.5%), *Shrub Savanna* (21.0%), *Lotic* (16.1%), *Shrubland* (6.6%), and *Cliff/Talus* (5.6%) All remaining cover types covered less than 5% of the area classified.

Wetland and Riparian Communities—Information is limited on wetland and riparian communities in Hells Canyon (Huschle 1975, Asherin and Claar 1976, Miller 1976, DeBolt 1992). Emergent wetland communities are composed mostly of common cattail (*Typha latifolia*), narrowleaf cattail (*Typha angustifolia*), American bulrush (*Scirpus americanus*), and common spikerush (*Eleocharis palustris*). Willows are sparsely represented, and various forbs grow on the shoreline side of the stands (Asherin and Claar 1976). A narrow band of diverse riparian communities follows the course of the Snake River and its many tributaries. Although it is limited in geographic area, this riparian zone is vital because of the biological diversity it provides (USDI 1987). Predominant tree species in riparian areas include white alder (*Alnus rhombifolia*), water birch (*Betula occidentalis*), and black cottonwood (*Populus trichocarpa*). Predominant shrub species in riparian areas include syringa (*Philadelphus lewisii*), netleaf hackberry, chokecherry (*Prunus virginiana*), black hawthorn (*Crataegus douglasii*), and poison ivy (*Toxicodendron radicans*).

There is no riparian vegetation along many shoreline sections. Rather, upland vegetation on steep canyon slopes simply meets the rocky shoreline. Grassland communities are also common along the Snake River and its tributaries. Where these grassland communities occur, such as on the canyon slopes, the dominant species are bluebunch wheatgrass (*Pseudoroegneria spicata*), cheatgrass (*Bromus tectorum*), and Idaho fescue (*Festuca idahoensis*) (Asherin and Claar 1976).

Herbaceous-Dominated Vegetation Types—The dry climate and typically stony, shallow soils of the canyon have favored the development of grassland steppe communities at the lower and middle elevations (Tisdale 1979, Tisdale 1986). Commonly occurring grass species in the study area include bunchgrasses such as bluebunch wheatgrass, Sandberg bluegrass (*Poa secunda*), and Idaho fescue (Garrison and others 1977, BPA 1984, Tisdale 1986, Franklin and Dyrness 1988). Sand dropseed (*Sporobolus cryptandrus*) and red threeawn (*Aristida longiseta*) are also common and, at times, dominant (BPA 1984, Tisdale 1986).

Habitat types in which bluebunch wheatgrass is dominant occur throughout the study area and occupy over half of its grassland area (Tisdale 1986). Bluebunch wheatgrass flourishes on deep, loamy soils but adapts to coarser and shallower soils as well. Generally, it is associated with Idaho fescue on deeper soils and with Sandberg bluegrass on shallower soils.

Shrub-Dominated Vegetation Types—Shrub species comprise a large segment of the canyon's overall vegetation composition. Shrub-steppe vegetation types occur at mid-elevations in the Hells Canyon study area, especially in the southern region of the study area. For example, big sagebrush (*Artemisia tridentata*) is a dominant species in the southern sector of the study area, particularly in the area around Brownlee Reservoir (BPA 1984). Commonly occurring shrubs include big antelope sagebrush, bitterbrush (*Purshia tridentata*), hackberry, serviceberry (*Amelanchier alnifolia*), and bitter cherry (*Prunus emarginata*) (BPA 1984, Tisdale 1986). Other species of sagebrush are also present, including low sagebrush (*Artemisia arbuscula*), stiff sagebrush (*Artemisia rigida*), and silver sagebrush (*Artemisia cana*) (Tisdale and Hironaka 1981, Franklin and Dyrness 1988). For the most part, sagebrush stands are limited to the area around Brownlee Reservoir. In these stands, the herbaceous layer is dominated by Sandberg bluegrass, with a variety of forbs also occurring.

Stands of hackberry may be found throughout the study area, either on lower slopes with rocky residual/colluvial soil or on alluvial terraces with sandy soil (Tisdale 1986). In these stands, hackberry is often mixed with a number of other shrub and tree species, including antelope bitterbrush, blue elderberry (*Sambucus cerulea*), and ponderosa pine (BPA 1984). The herbaceous layer is most often dominated by bluebunch wheatgrass, with cheatgrass and sand dropseed dominant in those areas that have been heavily disturbed by the grazing and trampling of cattle.

Tree-Dominated Vegetation Types—Although coniferous forest communities are generally restricted to the higher elevations of steep canyon slopes, they do reach down to the Snake River in certain locations of the study area. The predominant forest community is a ponderosa pine (*Pinus ponderosa*)/bluebunch wheatgrass plant association, which extends to the river on north-facing slopes at sites along Oxbow and Hells Canyon reservoirs (Asherin and Claar 1976, Bonneville Power Administration 1984). This association typically occurs as a savanna of ponderosa pine trees distributed over a grassland steppe dominated by bluebunch wheatgrass. Shrubs are almost completely absent, except for sparsely distributed, drought-resistant species such as antelope bitterbrush and serviceberry (Garrison et al. 1977, Johnson and Simon 1987). A ponderosa pine/hackberry type may also extend down to the river in this area. Hackberry dominates the shrub layer in moderate density, and poison ivy is also abundant (Asherin and Claar 1976).

2.7. Land Use

The study area and vicinity is still dominated by the land-use patterns established at the turn of the century: irrigated and nonirrigated agriculture, livestock grazing, mining, large areas of open space, scattered rural development, and rapidly growing recreational activities. The bottomlands adjacent to the reservoirs are generally used for grazing, some farming, and recreation.

3. Plant Operations

Hells Canyon, on the Oregon–Idaho border, is the deepest canyon in North America and home to IPC's largest hydroelectric generating complex, the HCC. The HCC includes the Brownlee, Oxbow, and Hells Canyon dams, reservoirs, and power plants. Operations of the three projects of the complex are closely coordinated to generate electricity and to serve many other public purposes.

IPC operates the complex to comply with the FERC license, as well as to accommodate other concerns, such as recreational use, environmental conditions and voluntary arrangements. Among these arrangements are the 1980 Hells Canyon Settlement Agreement, the *Fall Chinook Recovery Plan* adopted in 1991, and, between 1995 and 2001, the cooperative arrangement that IPC had with federal interests in implementing portions of the Federal Columbia River Power System (FCRPS) biological opinion flow augmentation, which is intended to avoid jeopardy of the FCRPS operations below the HCC.

Brownlee Reservoir is the only one of the three HCC facilities—and IPC's only project—with significant storage. It has 101 vertical feet of active storage capacity, which equals approximately 1 million acre-feet of water. On the other hand, Oxbow and Hells Canyon reservoirs have significantly smaller active storage capacities—approximately 0.5 and 1.0% of Brownlee Reservoir's volume, respectively.

Brownlee Dam's hydraulic capacity is also the largest of the three projects. Its powerhouse capacity is approximately 35,000 cubic feet per second (cfs), while the Oxbow and Hells Canyon powerhouses have hydraulic capacities of 28,000 and 30,500 cfs, respectively.

Target elevations for Brownlee Reservoir define the flow through the HCC. However, when flows exceed powerhouse capacity for any of the projects, water is released over the spillways at those projects. When flows through the HCC are below hydraulic capacity, all three projects operate closely together to re-regulate flows through the Oxbow and Hells Canyon projects so that they remain within the 1-foot per hour ramp rate requirement (measured at Johnson Bar below Hells Canyon Dam) and meet daily peak load demands.

In addition to maintaining the ramp rate, IPC maintains minimum flow rates in the Snake River downstream of Hells Canyon Dam. These minimum flow rates are for navigation purposes and IPC's compliance with article 43 of the existing license. Neither the Brownlee Project nor the Oxbow Project has a minimum flow requirement below its powerhouse. However, because of the

Oxbow Project's unique configuration, a flow of 100 cfs is maintained through the bypassed reach of the Snake River below the dam (a segment called the Oxbow Bypass).

4. METHODS

4.1. Background

Surveys are defined as: 1) the process of finding individuals in relation to geographic areas or habitat features and 2) an index of the abundance of individuals in an area from which inferences about the population can be made (Ralph and Scott 1981, Fuller and Mosher 1987). Raptor survey techniques have been reviewed by Call (1978), Fuller and Mosher (1981, 1987), and Kochert (1986). Raptors are difficult to enumerate because they often occur at low densities and they tend to nest in inaccessible areas. Consequently, raptor surveys are labor intensive and costly (Fuller and Mosher 1981, 1987; Kochert 1986).

Several methods are used to survey for nesting raptors: 1) aerial, 2) calling, and 3) ground surveys (Kochert 1986). Aerial surveys can be effective when used to study species that have large, conspicuous nests or other easily enumerated characteristics. Calling surveys are mainly used with Strigiformes, though they can be used for some Falconiformes as well (Fuller and Mosher 1981). Ground surveys include searches by foot (including point, walking, and quadrant surveys), boat, and land vehicle. They also allow time for close inspection of specific sites and are often used in combination with other methods (Kochert 1986) to determine nest occupancy. Ground surveys are considered to provide the best coverage, particularly of small areas, and are most effective for secretive raptors (Fuller and Mosher 1981, 1987; Kochert 1986). Therefore, we considered ground-survey methods most suitable for raptor surveys in the study area. Many authors have commented on the stability of nesting raptors through time (Newton 1979). Therefore, one well-timed survey is adequate to document occupied raptor nesting territories, defined as a confined location with a nest or an area that is defended, often in successive years, where no more than one pair has ever bred at one time (Steenhof 1987).

4.1.1. Historic Information

Little historic information is available on raptor populations in the Hells Canyon Study Area. Portions of the study area have been surveyed over time for threatened or endangered species such as the bald eagle and peregrine falcon (Levine and Erickson 1990). However, the only comprehensive survey for nesting raptors in the study area was conducted by Asherin and Claar (1976). Their survey for nesting raptors was conducted from the three reservoirs during the springs of 1974 and 1975.

4.1.2. Time of Year

Surveys for cliff-nesting raptors were conducted from late March through early April to determine territory occupancy. Most diurnal raptors in southwestern Idaho lay eggs between early March and mid-April (USDI 1979). Surveys in the Hells Canyon Study Area were conducted at the same time as they were for southwestern Idaho because the altitude of the study area is approximately the same. The optimum survey time for prairie falcons is between the second and last weeks of March (Holthuijzen 1989, 1990), which is also a reasonable time during which to monitor other diurnal raptors (USDI 1979, Marzluff et al. 1995). Therefore, surveys were conducted during the last two weeks of March.

4.2. Sampling Design

Two coordinated but separate studies were conducted to document cliff-nesting raptors: 1) point surveys conducted by Marzluff et al. (1995), contracted through Boise State University, and 2) point surveys conducted by IPC in 1995 and 1996. In addition, historic bald eagle and peregrine falcon nest sites were monitored annually from 1995 through 1999. Finally, all nesting raptors detected incidentally were recorded.

4.2.1. Point Surveys, BSU

Marzluff et al. (1995) conducted an occupancy survey while investigating the length of time necessary to determine territory occupancy in the Hells Canyon area. This survey was restricted to portions of Hells Canyon Reservoir from Big Bar (RM 256.0) to just below Hells Canyon Dam (RM 247.0). Multiple observations were made from twelve points adjacent to Hells Canyon Reservoir, spaced at approximately 1-km intervals over a four-week period. All raptor observations were recorded on 1:24,000 topographical maps and their behaviors recorded in a field journal. Behavioral observations were then used to help determine occupancy. Potential bias related to surveying the same raptor territories repeatedly was not determined.

In June, a productivity survey was conducted for the nest sites identified by Marzluff et al. (1995) in the spring of 1995. Nest sites identified earlier in the spring were visited by foot or by helicopter. These sites were evaluated based on the presence of young or other evidence of breeding. Based on these observations, the nest fate was determined.

4.2.2. Point Surveys, IPC

Areas to be surveyed were identified by delineating polygons on 1:24,000 USGS topographic maps where the topography was steep enough to be considered cliff. Using the delineated polygons as a guide, observers were stationed at points where they could observe the maximum amount of delineated cliff. Cliff within 1 km of the Snake River corridor was mapped; however, all sections of cliff visible from each survey point (up to 2 km from the Snake River) were observed. Along the Snake River Canyon, observers surveyed only one side of the canyon at a time, while in the much narrower tributaries, both sides were observed simultaneously.

As many as five observers were used to survey for nesting raptors. Often, all five observers surveyed for nesting raptors from a series of observation points along large sections of cliff or up a tributary. Although each observer was responsible for a particular section of cliff, their proximity to one another allowed them to communicate raptor movements into and out of adjacent survey polygons via two-way radios. Thus, large sections were surveyed simultaneously, which reduced the risk of missing or double-counting occupied territories. Observation bouts began at sunrise and lasted 2 hours. Up to three observation bouts were made per day. Observers followed protocol guidelines established by Glinski et al. (1990). Although the focus was on cliff-nesting raptors, all nesting raptors (diurnal and nocturnal) and common ravens were recorded and plotted on 1:24,000 USGS topographical maps during the survey.

Occasionally, raptor activity during a point survey would suggest territory occupancy, but data were inconclusive. Once the point survey was complete, an observer would use a walking survey to try to determine occupancy. In such cases, the observer walked in the direction of raptor activity while continuing to record behavioral observations.

4.3. Survey Protocol

4.3.1. Record Taking

Observations began once the observer reached a point where the predetermined section of cliff could be effectively observed. The location of the survey point and a polygon of the area observed were plotted on the 1:24,000 USGS topographical map. At the start of each survey, general weather conditions—including temperature (°F), wind speed (mph), and cloud cover (%)—were recorded. With 15–40× spotting scopes and 10 × 40 binoculars, observers scanned the cliffs and surrounding trees for raptors or nest sites (stick nests and whitewash). The following information was recorded for all raptor observations: 1) time of day (24-hr clock), 2) species observed, 3) behavior of the bird (perching, flight, patrol, courtship behavior, reproductive behavior, aggression), and 4) location of bird. Raptor observations were recorded in a field notebook, and nest sites (stick nests and scrapes) were assigned unique names and plotted on quad maps. If a territory was considered to be occupied but the nest was not observed, the center of activity for the survey period was recorded to indicate the general territory location. All survey polygons, nest sites, and occupied territories were later transferred to a Geographical Information System (GIS).

4.3.2. Breeding Status

At the end of each survey, field notes were evaluated for evidence of occupied raptor nesting territories within the area observed. The following criteria were used and are restricted to the courtship and early incubation phases of the breeding season (Steenhof 1987). An *Occupied, Unknown Breeding* designation was assigned to sites where field signs (such as whitewash or decorated nests) or behavior (such as courtship, copulations, or nest defense) indicate that the site was occupied, but a breeding attempt was neither confirmed nor refuted. Two subcategories are distinguished: 1) *Occupied, Unknown Breeding, No Data*, the site lacks evidence of breeding or successfully fledging young or 2) *Occupied, Unknown Breeding, Unsuccessful*, certain that no young fledged but it is uncertain whether a breeding attempt was made. Generally, occupied territories fall into the *Occupied, Unknown Breeding, No Data* category.

If subsequent visits made to nests identified during the surveys or nests observed later in the breeding season when young were present, a breeding assessment was made. A *Breeding* designation meant there was evidence that an egg had been laid, apparent by one of the following: 1) eggs or chicks in the nest, 2) eggshell fragments, 3) an adult on the nest in incubation posture, or 4) fledged young in the immediate area of the nest. This category is further subdivided into two subcategories: 1) *Breeding Unknown Success*, a breeding attempt where it is uncertain whether young fledged and 2) *Breeding Successful*, confirmed by observation of fledged (or fledging-age) chicks at or near the nest site. A *Breeding Unsuccessful* designation applied to breeding attempts where it was absolutely certain that no young fledged. Information on nesting success was done from a distance; no nests or aeries were entered by field personnel.

4.3.3. Threatened and Endangered Species

Historically, both the bald eagle and peregrine falcon have nested in the Hells Canyon area. Two historic bald eagle territories were monitored based on information filed with the Idaho Conservation Data Center. Peregrine falcons had not been observed nesting in the area since the late 1960s. However, a number of birds were released from hack sites in the area during the 1980s (Bechard and Levine 1988) as part of the recovery effort. Historical nest sites of these two species were monitored annually from 1995 through 1999 using point surveys. In 1996, IPC entered a cooperative agreement with the Wallowa-Whitman National Forest to survey portions of Hells Canyon within the National Forest for nesting peregrine falcons (Akenson 1996). Timing of surveys, field methods, and data collected were the same as for point surveys conducted by IPC in 1995 and 1996, as described above.

4.3.4. Incidental Observations

While collecting data on a variety of wildlife and botanical projects from 1995 through 1999, field personnel documented all incidental observations of nesting raptors. Just as the observers in the occupancy surveys had done, field personnel documented time of day, species observed, its location, breeding status, and behavior of the bird.

4.4. Data Analysis

4.4.1. Occupied Territories

A number of potential biases in raptor surveys may render data collected difficult, if not impossible, to analyze. Raptor survey biases have been reviewed by Fuller and Mosher (1981, 1987), Kochert (1986), and Steenhof (1987). Sampling error occurs when pairs sampled do not represent the population. Occupied nesting territories were identified based on their breeding status, which was determined by behavioral data collected during each survey. Nest sites and occupied territories were plotted as points on 1:24,000 USGS topographical maps. In areas where nests were not located but occupancy was confirmed, the point reflected the center of the activity recorded for the nesting pair. The number of occupied territories for each species in each reach was calculated and standardized by river mile.

4.4.2. GIS Analysis

Recent advances in GIS capabilities allowed us to evaluate the accuracy of our original cliff assessment from the topographic maps (done prior to current GIS capabilities). Using a Digital Elevation Model (DEM), we calculated the elevational change (slope) between 30 m pixels in a GIS system (Grid, Arc/Info®). Known cliff-nest sites were used as control points, and the model was run until known cliff-nest sites began to drop out. Using this threshold, we generated a model-predicting cliff within the study area. The survey polygons (digitized from 1:24,000 USGS topographic maps) were then overlaid to quantify the accuracy of our original delineation of cliff from topographic maps.

5. RESULTS

5.1. Point Surveys

5.1.1. BSU Survey

In 1995, Marzluff et al. (1995) surveyed sections of cliff along the lower portion of Hells Canyon Reservoir from 12 points (Figure 3). These points were surveyed repeatedly from March 27 to April 21 for a total of 284 hrs. Marzluff et al. (1995) reported four raptor species with occupied nesting territories in the reach surveyed. The golden eagle had the highest number of nesting territories (5), followed by the American kestrel (3), prairie falcon (1), and peregrine falcon (1). Of these, only three pairs were considered *Breeding Successful* during the June 1995 productivity survey. Two of the golden eagle pairs and the prairie falcon pair successfully raised young to fledging age. The fate of the three remaining golden eagle nests was determined as *Occupied, Unknown Breeding*, *Unsuccessful*, since breeding was not confirmed, but it was certain that no young fledged. The American kestrel and peregrine falcon territories were determined to be *Occupied, Unknown Breeding*, *No Data*, since the nests were never located.

5.1.2. IPC Survey

In 1995, IPC personnel surveyed sections of cliff from another 72 points for an additional 142 hrs along a portion of Hells Canyon reservoir (Figure 3). Only four additional occupied territories were documented in this reach, including three raptors (one each for the golden eagle, prairie falcon, and red-tailed hawk) and one common raven. Therefore, including the Marzluff et al. (1995) survey data for Hells Canyon Reservoir, a total of 14 occupied territories were documented from 84 survey points along Hells Canyon Reservoir in 1995. Species composition (followed by number of occupied territories) was composed of five raptor species: golden eagle (6), American kestrel (3), prairie falcon (2), peregrine falcon (1), red-tailed hawk (1), and common raven (1).

In 1996, IPC surveyed remaining sections of cliff in the study area, those not surveyed in 1995, from 66 points for a total of 136 hrs. Twenty-seven survey points were along

Brownlee Reservoir, 24 along Oxbow Reservoir, and 6 along Hells Canyon Reservoir (Figure 4). Results from this survey yielded 17 occupied territories. On Brownlee Reservoir, we observed 14 occupied territories, representing 4 raptor species and the common raven, in 54 hours of observation. The red-tailed hawk and common raven were most common with 4 occupied territories each, followed by the prairie falcon (3), golden eagle (2), and American kestrel (1). In 48 hrs of observation from 24 survey points along Oxbow Reservoir, only three occupied territories were observed. All three territories were occupied by golden eagles. The remaining points surveyed along Hells Canyon Reservoir included sites duplicated from the 1995 survey as part of our peregrine falcon and bald eagle monitoring described below.

When combined, point surveys conducted on sections of cliff in 1995 and 1996 in the study area resulted in a total of 31 occupied nesting territories represented by five raptor species and the common raven (Table 1). With 11 occupied territories, the golden eagle was the most abundant nesting species observed, followed by the red-tailed hawk (5), prairie falcon (5), common raven (5), American kestrel (4), and peregrine falcon (1). Hells Canyon Reservoir showed the highest concentration (0.54 territories/mile) and species richness (6) of cliff-nesting raptors among the three reaches surveyed (Table 2).

5.2. Threatened and Endangered Species

We surveyed two historic bald eagle nest sites from 1995 through 1999 but observed no evidence of occupancy. At both sites, the nests were blown from the nest trees in the late 1980s (Idaho Conservation Data Center), which was prior to our survey effort. In 1998, a bald eagle nest was discovered along Hells Canyon Reservoir. The nesting pair successfully fledged one young in both 1998 and 1999. In 1999, another bald eagle nest site was discovered on the Oregon side of Oxbow Reservoir. This pair successfully fledged one young as well. A third bald eagle territory was discovered in 1999. At this site, an immature bald eagle was observed bringing nesting material to a large nest in a tree. This site was considered to be a one-bird site since no evidence of breeding was found on subsequent visits. All three nests were built in Ponderosa pines and are considered to be new nesting territories. Current and historic bald eagle sites are shown in Figure 5.

Prior to 1995, peregrine falcons had not been observed nesting in the Hells Canyon area since the 1960s (Schomer 1997), despite a number of releases in the 1970s and 1980s as part of the reintroduction effort (Bechard and Levine, 1988). In 1995, Marzluff et al. (1995) documented a peregrine falcon territory near Hells Canyon Dam. Occupancy was based on several copulations by the pair; however, no aerie was ever located. In 1996, a survey of the suitable habitat within the Wallowa Mountains along Hells Canyon resulted in the location of a peregrine falcon aerie in Hells Canyon Creek near Hells Canyon Dam (Figure 5). One female young fledged successfully from this aerie in 1996 (Akenson 1996). This territory was classified as *Occupied, Unknown Breeding, No Data* for the period 1997–1999. In all three years, pairs were observed at the aerie exhibiting behaviors indicative of occupancy (prey delivery, copulation, and patrolling the territory). However, the aerie, located on a remote cliff face, is too far away to accurately determine breeding success from vantage points far below.

5.3. Incidental Observations

From 1995 through 1999, 40 occupied territories representing 11 raptor species and the common raven were recorded throughout the Hells Canyon Complex (Table 3). With 8 territories, red-tailed hawks were the most common species observed, followed closely by the great horned owl. Seven of these species were not recorded during cliff surveys conducted in 1995 and 1996, including five species of owls (great horned owl, common barn owl, long-eared owl, western screech-owl, and burrowing owl), the bald eagle, and Cooper's hawk.

5.4. All Surveys

For the period 1995–1999, we observed 71 occupied territories that included 12 raptor species and the common raven. During the spring point surveys conducted in 1995 and 1996, 31 territories were recorded along sections of cliff surveyed in the study area. An additional 40 occupied raptor nesting territories were discovered incidentally for the period 1995–1999. The most common nesting species for all years and surveys combined was the golden eagle with 14 territories, followed by the red-tailed hawk (13), American kestrel (9), and prairie falcon (9). The remaining species were found in smaller numbers (Table 4). All observations of nesting owls were obtained by incidental observations. Four nocturnal owl species, including the great horned owl, common barn owl, western screech-owl, were documented. The remaining species were considered to be diurnal.

When standardized by number of territories per 100 km^2, densities of nesting raptors were similar between reaches, as was the species richness and diversity (Table 5). The major difference between the reaches was how the species were distributed. Combined, the Oxbow and Hells Canyon Reaches had higher golden eagle densities than the Brownlee Reach (4.62 and 1.48 territories per 100 km^2 respectively), while the Brownlee Reach had higher red-tailed hawk densities, compared with the combined densities of the Oxbow and Brownlee Reaches (3.25 and 1.02 territories per 100 km^2 respectively). Although densities were not calculated for owl species because of differences in survey effort, the Brownlee Reach was characterized as having a much higher diversity of nesting owl species (Table 4). In fact, many owl species were unique to the Brownlee area in this survey. However, because owl species in particular were never specifically surveyed for and are represented only through incidental observations, nesting pairs may have been underrepresented or missed altogether.

Of the 71 occupied territories recorded in the study area, 31 were located in Idaho and 40 in Oregon. Forty-three territories were located on Brownlee Reservoir, 20 on Hells Canyon Reservoir, and 10 on Oxbow Reservoir. Nests or aeries were observed for 45 territories; the remaining territories were classified as occupied territories based on behavioral observations. Locations of all territories are illustrated in Figure 6. Three of the 12 raptor species (golden eagle, prairie falcon, and peregrine falcon) and the common raven nested exclusively on cliff substrate. Red-tailed hawks, American kestrels, and great horned owls nested both on cliffs and in trees. The bald eagle, Cooper's hawk, long-eared owl, and western screech-owl were found nesting exclusively in trees, while the burrowing owl and common barn owl nested in burrows located on the ground or in cut banks. A list of all territories recorded, the year occupied, reach, state, nest substrate, method of discovery, nearest river mile, breeding status, and accuracy of the nest location are listed in Appendix 1.

Although productivity surveys were not a primary objective, incidental observations of nesting territories late in the breeding season allowed us to classify 28 sites as *Breeding*. Twelve of these sites were classified as *Breeding, Successful* in one or more years. Species with confirmed breeding success included the bald eagle, golden eagle, red-tailed hawk, prairie falcon, peregrine falcon, great horned owl, and western screech-owl. The remainder of the *Breeding* territories were classified as *Breeding, Unknown Success*.

5.5. GIS Determination of Cliff

Using a DEM with a 30-m pixel resolution, we input slopes ranging from 89° to 45°. We used known cliff sites (stick nests on cliffs) to determine the slope that predicted all known cliff sites as cliff. At a slope of 45°, or an average change in elevation of 98 ft, all of the cliff nest sites were predicted as cliff. Running the model with a slope of 45°, cliff was predicted on each of the three reservoirs as follows: 5.6 km^2 on Brownlee Reservoir, 1.5 km^2 on Oxbow Reservoir, and 26.3 km^2 on Hells Canyon Reservoir. When intersected with our survey polygons, the percentage of predicted cliff surveyed was 20.7% along Brownlee Reservoir, 36.9% along Oxbow Reservoir, and 60.0% along Hells Canyon Reservoir. However, as shown in Figure 3, the proportion of predicted cliff to the total area for each of the three reaches was very low: Brownlee Reservoir (1.6%), Oxbow Reservoir (2.6%), and Hells Canyon Reservoir (19.4%).

6. DISCUSSION

Although the species richness and diversity among the three reaches was similar (Table 5), the species composition among the reaches differed considerably (Table 4). Only 6 of the 13 nesting species identified were common to both Brownlee and Hells Canyon reservoirs. Also, the numbers of species common to both the Brownlee and Hells Canyon reaches differed dramatically. For instance, the combined golden eagle densities along Oxbow and Hells Canyon reservoirs were higher, 4.62 territories per 100 km^2, compared with the Brownlee Reach, 1.48 territories per 100 km^2, which covered a much larger area. Conversely, the red-tailed hawk occurred at much higher densities along the Brownlee Reach, 3.25 territories per 100 km^2, compared to the combined density of the Oxbow and Hells Canyon reaches, 1.02 territories per 100 km^2 . In addition, a number of owl species were much more common, and in fact unique, to the Brownlee Reach (Table 4). Oxbow Reservoir can be considered a transition area, with a raptor community similar to both the Brownlee and Hells Canyon reaches. Several species, including the bald eagle, peregrine falcon, and Cooper's hawk, were unique to the Oxbow and Hells Canyon reaches.

Golden eagle densities were higher than expected based on available prey species within the study area. In southwestern Idaho, the primary prey of golden eagles is lagomorphs, particularly the black-tailed jackrabbit (Collopy 1986, Steenhof and Kochert 1988). Steenhof and Kochert (1988) found that golden eagle densities correlated with black-tailed jack rabbit densities in the

Snake River Birds of Prey National Conservation Area (SRBPNCA). However, black-tailed jack rabbits were not documented within the HCC (Sunderman Turley and Holthuijzen 2000), and the mountain cottontail was uncommon in the study area with densities of less than 1 per ha. (Sunderman-Turley and Holthuijzen 2000). Apparently, the golden eagles are using resources other than lagomorphs to sustain the number of pairs present. Within the study area, golden eagles have been observed capturing chukar, taking fish (or fish parts) from the surface of the reservoir (pers. obs.), and consuming the contents of Canada goose eggs (Valutis and Marzluff 1997).

The number and diversity of nesting raptors found in the HCC were considerably different from those for surveys conducted by Asherin and Claar (1976) and Levine and Erickson (1990). Asherin and Claar (1976) only documented 6 nesting raptor species throughout the study area, while we recorded 13 (Table 6). Levine and Erickson (1990) reported 4 nesting raptor species for the portion of Hells Canyon Reservoir they surveyed, while we documented 7. Differences in the number and diversity of raptors reported in each study may be attributed to differences in survey effort and methodologies. In this study we combined 250 hrs of point surveys with four years of incidental nesting observations documenting 71 nesting territories in the study area, including several species that had not been documented previously in the study area (Table 6). Nevertheless, Levine and Erickson (1990) and Asherin and Claar (1976) observed a number of nesting raptor species that were not observed in this study. Levine and Erickson (1990) observed northern goshawk and turkey vultures along Hells Canyon Reservoir, while Asherin and Claar (1976) observed the Swainson's hawk, northern harrier, and short-eared owls nesting along Brownlee Reservoir. While all of these species have been observed in the study area, no nesting attempts were ever observed. Because all of these species have nested in low numbers, it is likely that our survey effort did not detect them, especially the riparian nesters such as the Swainson's hawk and northern harrier. These species would likely nest in the riparian habitat at the upper end of Brownlee Reservoir. Because the upper end of Brownlee Reservoir has little cliff and is near the periphery of the study area, these species were likely overlooked.

In the HCC, we estimated 13.6 nesting territories per 100 km^2 for all species. While this estimate is higher than density estimates for other areas of southern Idaho (Howard et al. 1976), it is much lower than densities reported by Howard et al. (1976) for the SRBPNCA. Howard et al. (1976) reported nesting densities in the SRBPNCA and in the nearby Grand View section at 217.8 and 139.3 nests per 100 km^2, respectively. In 1980, much of the Grand View section was included in the current SRBPNCA. The SRBPNCA contains the highest density of noncolonial nesting raptors in the world (Olendorff et al. 1989). The Hells Canyon Complex, although important for nesting raptors, shows much lower densities than those documented in the SRBPNCA.

With the addition of 40 incidental observations of nesting raptor species within the study area, the species diversity increased by 6, from 7 to 13. Incidental observations were particularly important in documenting the owls and other species that do not use cliff as a nest substrate. Although great horned owls will nest on cliffs, most nesting pairs were observed in trees. All five common barn owl nests along the Brownlee Reach were in cavities found in cut banks along Brownlee Reservoir or nearby road cuts. Both the long-eared owl and western screech-owl were observed nesting in trees on the Oxbow Reach, while the only burrowing owl nest site (burrow) was observed on upper Brownlee Reservoir. Similarly, the Cooper's hawk nest sites observed on

Brownlee and Oxbow reservoirs were located in trees and would not have been observed during point surveys for cliff-nesting raptors.

Two bald eagle nest sites were recorded within the study Area, one on Hells Canyon Reservoir in 1998 and one along Oxbow Reservoir in 1999. Prior to these observations, no nesting bald eagles had been observed in the study since the mid-1980s (CDC), although historic sites had been monitored since 1995. During the winter, bald eagles are common in the study area (Isaacs and Opp 1991, Holthuijzen 1999).

An intensive survey effort in 1995 revealed the first occupied peregrine falcon nesting territory in over 20 years (Schomer 1997). Although the aerie was not located until 1996, the occupied territory detected in 1995 led to the cooperative effort between IPC and the Wallowa-Whitman National Forest (Akenson 1996). In 1996, the aerie was located and breeding status was confirmed to be *Successful* with a fledging-age chick in the nest (Akenson 1996). Because of the steep topography and distance from which this aerie could be viewed, it was difficult to assess breeding status at this site. However, this aerie has been considered *Occupied, Unknown Breeding* in each year surveyed since 1996.

The steep nature of the study area complicated our attempt to predict cliff based on the DEM. The distinction between steep grassy slopes and cliffs was further complicated by changes in topography between the Brownlee Reach and the Hells Canyon Reach. The Brownlee Reach is characterized by steep, grassy slopes with limited cliff. In fact, only 1.6% of the Brownlee Reach was predicted to be cliff, of which we surveyed approximately 20%, based on cliff polygons delineated from the USGS topographic maps. On the other hand, the Hells Canyon Reach is characterized by steep slopes interspersed with cliffs and rocky outcrops. Our slope model predicted that 19.4% of the Hells Canyon Reach was cliff, of which we surveyed 60%. Because the model was based solely on elevation differences and did not account for differences in habitat, direct comparisons between reaches may not be valid. At the 30-m resolution, the data are probably too coarse to predict suitable habitat for cliff-nesting raptors.

7. SUMMARY AND CONCLUSIONS

Although the HCC does not support the density of nesting raptors observed elsewhere along the Snake River, it does contain a very diverse nesting raptor community. Twelve species of raptors and the common raven were observed nesting in the study area. Several other species that were undetected during our survey—including the Swainson’s hawk, northern harrier, and short-eared owl—may nest in the area. Golden eagles and red-tailed hawks were the most common nesting species observed. Several special status species, including the peregrine falcon and bald eagle, nested in the HCC.

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Table 1. Number of occupied territories, by species and reservoir reach, documented during point surveys, Hells Canyon Complex, 1995–1996.

	Reach			
Species	Brownlee	Oxbow	Hells Canyon	Σ
Golden eagle	2	3	6	11
Red-tailed hawk	4	-	1	5
Prairie falcon	3	-	2	5
American kestrel	1	-	3	4
Peregrine falcon	-	-	1	1
Common raven	4	-	1	5
Σ	14	3	14	31

Table 2. Number, density (territories/river mile), and species richness of occupied territories by reservoir reach from point surveys, Hells Canyon Complex, 1995–1996.

Reach	Territories	Density	Species Richness
Hells Canyon (1995)	14	0.54	6
Oxbow (1996)	3	0.25	1
Brownlee (1996)	16	0.23	5
Total	31	0.31	6

Table 3. Number of occupied territories for each species documented incidentally by reservoir reach, Hells Canyon Complex, 1995–1999.

	Reach			
Species	**Brownlee**	**Oxbow**	**Hells Canyon**	Σ
Red-tailed hawk	7	1	-	8
Great horned owl	5	-	1	6
Prairie falcon	3	-	1	4
American kestrel	3	1	1	5
Common barn owl	4	-	-	4
Golden eagle	3	-	-	3
Common raven	2	-	-	2
Bald eagle	-	2	1	3
Cooper’s hawk	1	1	-	2
Long-eared owl	-	1	-	1
Western screech-owl	-	1	-	1
Burrowing owl	1	-	-	1
Σ	29	7	4	40

Table 4. Number of occupied territories by reach for all surveys, Hells Canyon Complex, 1995–1999.

	Reach			
Species	**Brownlee**	**Oxbow**	**Hells Canyon**	Σ
Golden eagle	5	3	6	14
Red-tailed hawk	11	1	1	13
American kestrel	4	1	4	9
Prairie falcon	6	0	3	9
Common raven	6	0	1	7
Great horned owl	5	0	1	6
Common barn owl	4	0	0	4
Bald eagle	0	2	1	3
Cooper’s hawk	1	1	0	2
Peregrine falcon	0	0	1	1
Burrowing owl	1	0	0	1
Long-eared owl	0	1	0	1
Western screech-owl	0	1	0	1
Σ	43	10	18	71

Table 5. Density (number of occupied territories per 100 km$^{2)}$, species richness, and Shannon Diversity Index by reach for all surveys, Hells Canyon Complex, 1995–1999.

Reach	Density	Species Richness	H′
Brownlee	12.7	9	0.88
Oxbow	13.4	7	0.79
Hells Canyon	13.3	8	0.86
Total	13.3	13	

Table 6. Number of occupied territories for each species observed by Asherin and Claar (1976), Levine and Erickson (1990) and Idaho Power Company (IPC), Hells Canyon Complex, 1995–1999.

	Reach						
	Brownlee		Oxbow		Hells Canyon		
Species	Asherin and Claar (1976)	IPC	Asherin and Claar (1976)	IPC	Asherin and Claar (1976)	Levine and Erickson (1990)	IPC
Golden eagle	4	5	2	3	-	6	6
Bald Eagle	-	-	-	2	-	-	1
Red-tailed hawk	3	11	3	1	2	1	1
Swainson’s hawk	2	-	-	-	-	-	-
American kestrel	4	4	2	1	5	-	4
Peregrine falcon	-	-	-	-	-	-	1
Prairie falcon	1	6	-	-	-	-	3
Northern harrier	3	-	-	-	-	-	-
Northern goshawk	-	-	-	-	-	1	-
Cooper’s hawk	-	1	-	1	-	-	-
Great horned owl	-	5	-	-	-	-	1
Common barn owl	-	4	-	-	-	-	-
Long-eared owl	-	-	-	1	-	-	-
Western screech-owl	-	-	-	1	-	-	-
Burrowing owl	-	1	-	-	-	-	-
Turkey vulture	-	-	-	-	-	1	-
Common raven	-	6	-	-	-	-	-

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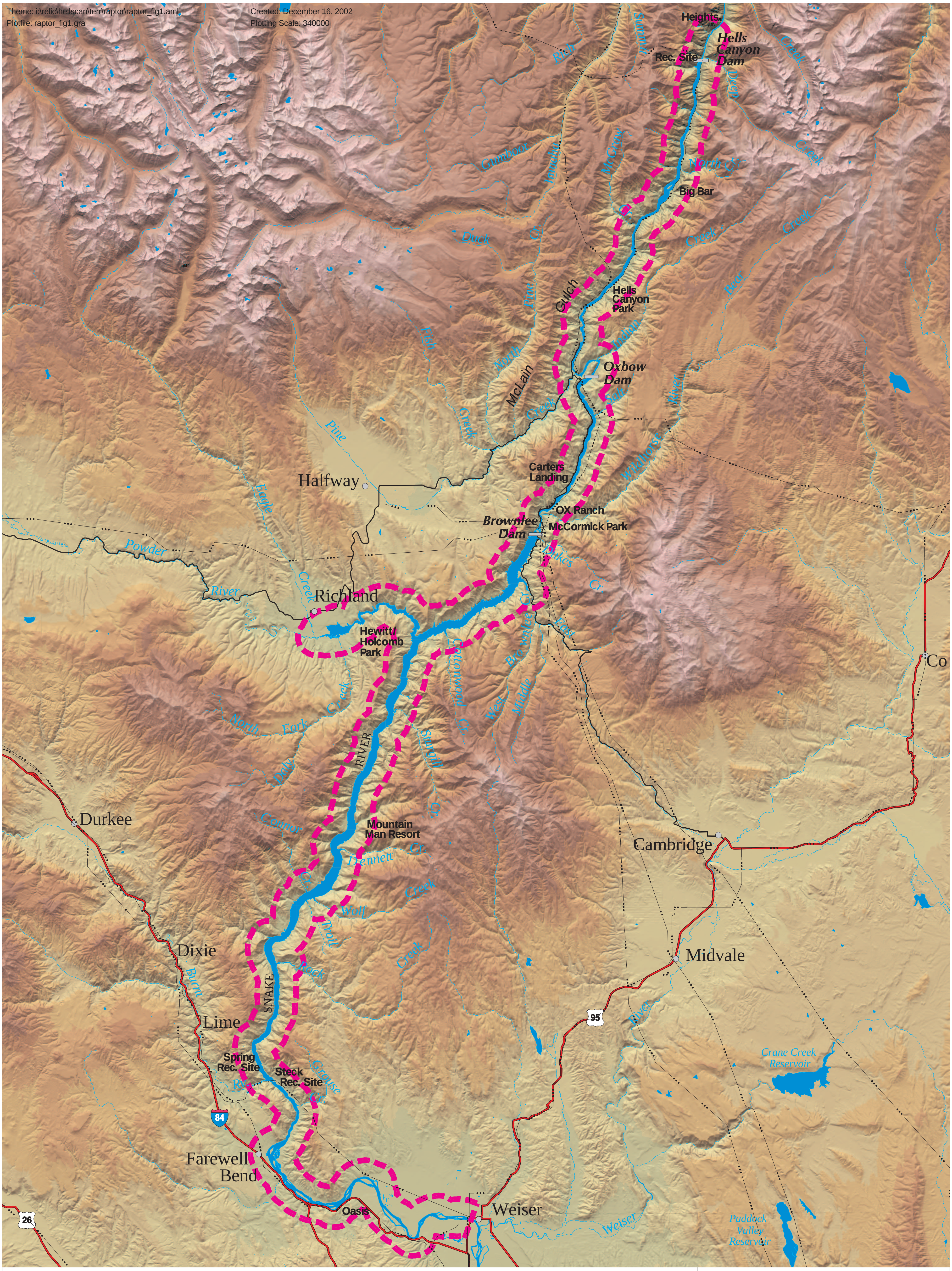

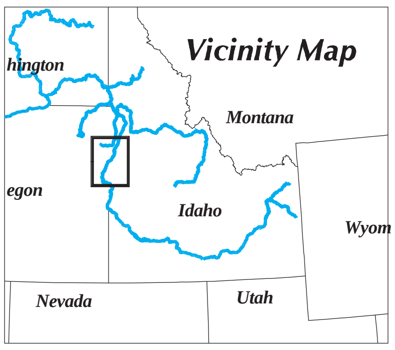

Features Legend

- Primary Route
- Secondary Route
- Streams
- Water Body
- Transmission Lines
- Idaho Power Facility
- City or Town
- Raptor Study Area

N

IDAHO POWER
An IDACORP Company

Hells Canyon Project - FERC No. 1971
Tech. Report E.3.2-15 Figure 1

Raptor Study Area, Weiser to Hells Canyon Dam, 1995 - 1999

IDAHO POWER COMPANY
BOISE, IDAHO

5 2.5 0 5 MILES

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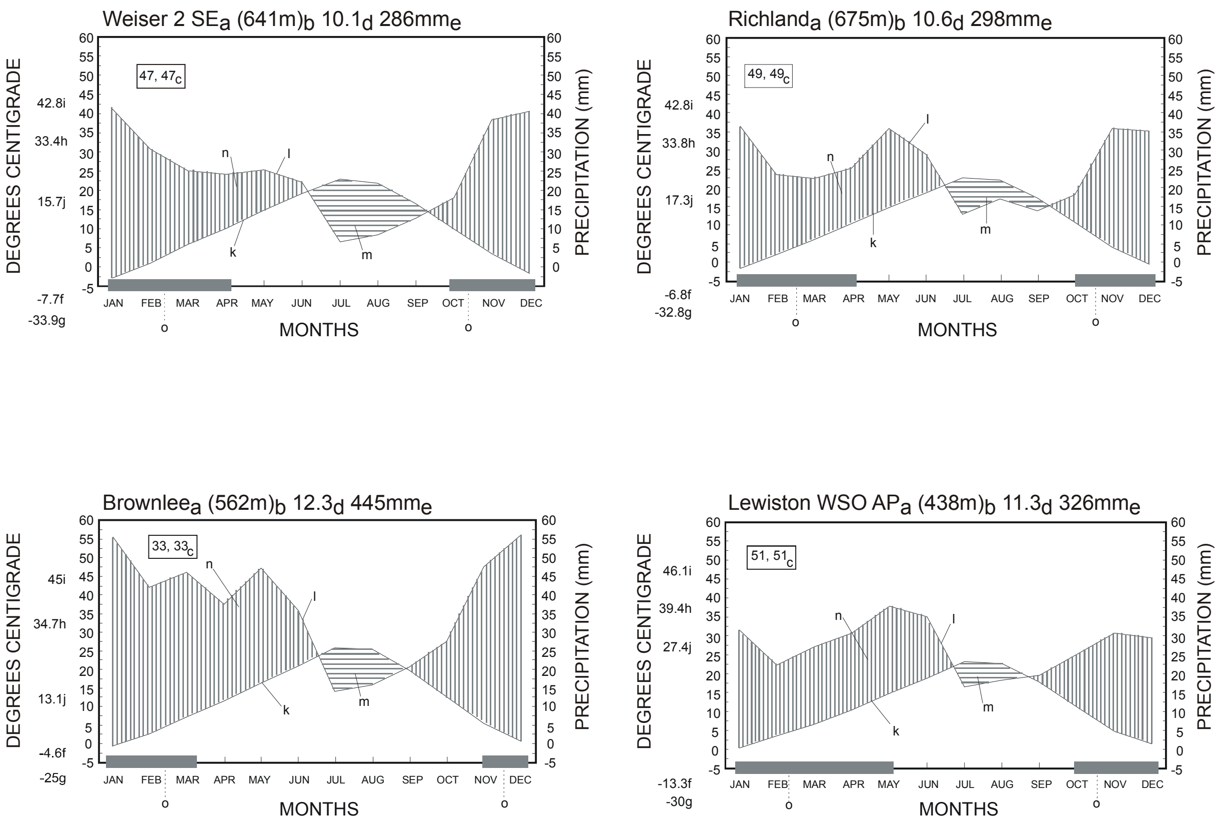

a: Station
b: Elevation
c: Number of years of observation (temperature, precipitation)
d: Mean annual temperature in °C
e: Mean annual precipitation in millimeters
f: Mean daily minimum of the coldest month
g: Lowest recorded temperature
h: Mean daily maximum of the hottest month
i: Highest recorded temperature
j: Mean daily temperature range
k: Monthly means of temperature in °C
l: Monthly means of precipitation in millimeters
m: Arid period (horizontal hatched)
n: Humid period (vertical hatched)
o: Months with an absolute minimum below 0 °C

Figure 2. Köppen climate diagrams for the Weiser, Richland, and Cottonwood weather stations, Hells Canyon Study Area, Idaho–Oregon border.

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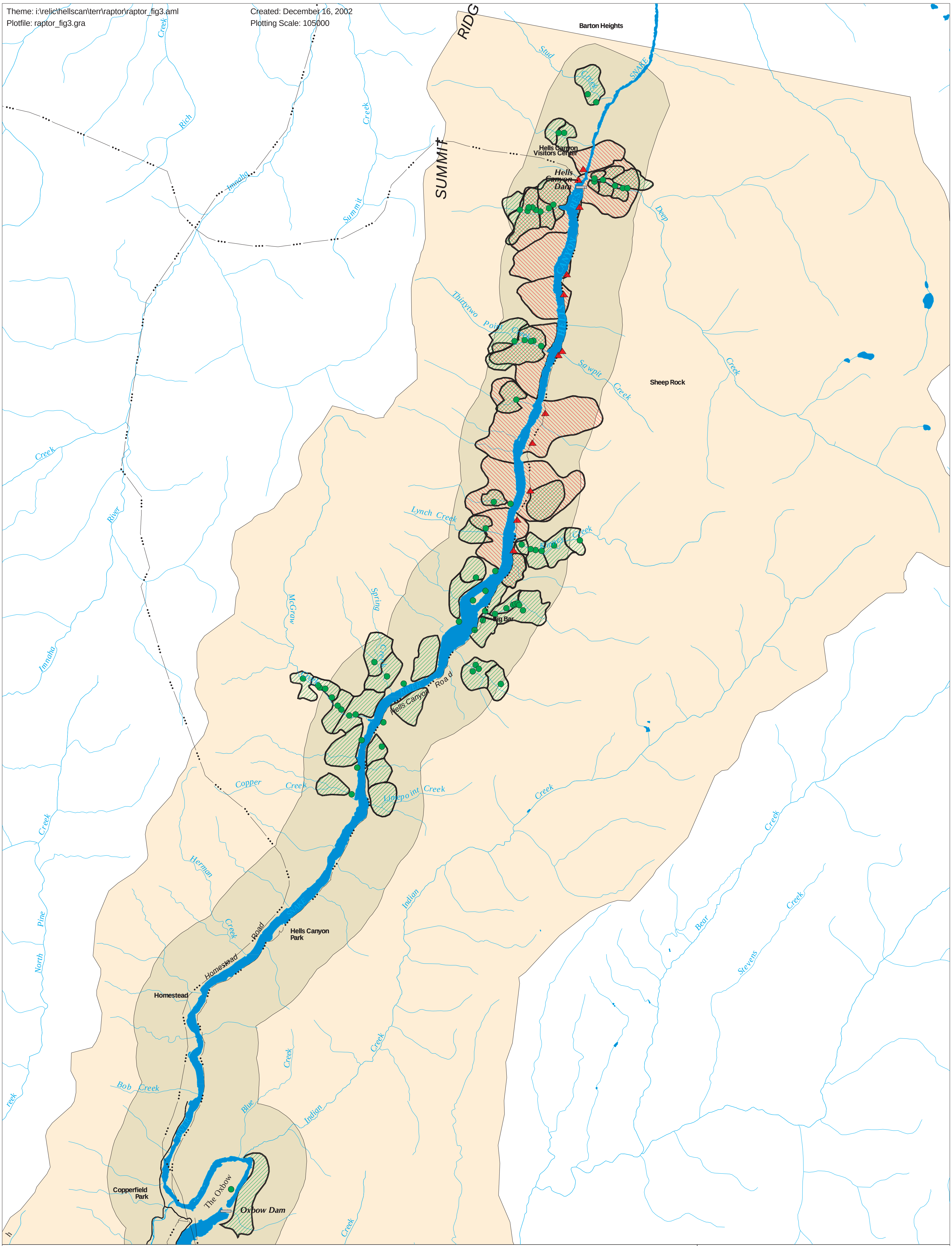

Features Legend

- Primary Route
- Secondary Route
- Streams
- Water Body
- Transmission Lines
- Idaho Power Facility
- City or Town
- Raptor Study Area
- Hells Canyon Complex
- Survey Points (BSU)
- Survey Points (IPC)
- BSU Survey
- IPC Survey

N

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Hells Canyon Project - FERC No. 1971
Tech. Report E.3.2-15 Figure 3

Areas Surveyed for Cliff Nesting Raptors, Marzluff et al. (1995) and IPC, 1995

IDAHO POWER COMPANY
BOISE, IDAHO

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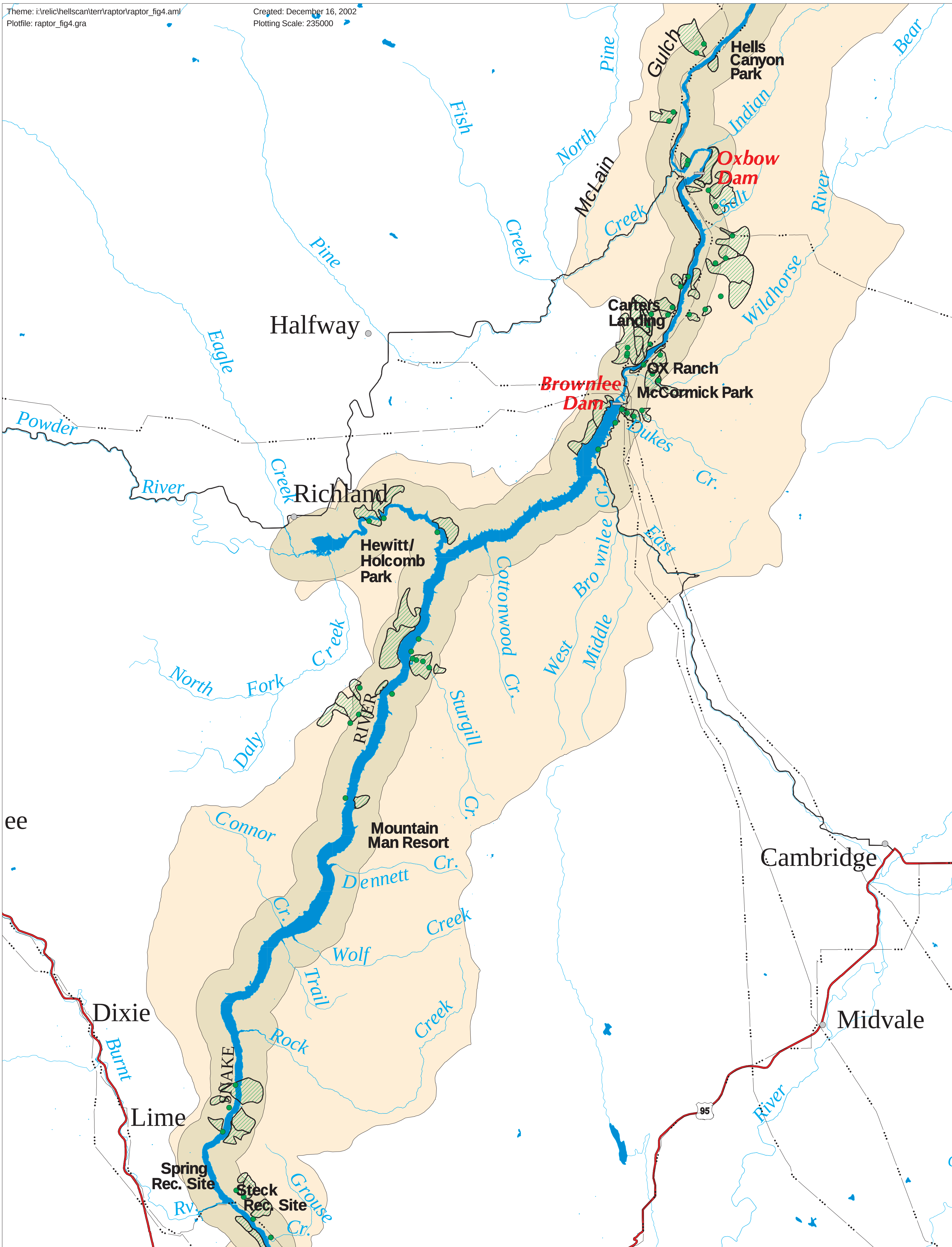

Features Legend

- Primary Route
- Secondary Route
- Streams
- Water Body
- Transmission Lines
- Idaho Power Facility
- City or Town
- Raptor Study Area
- Hells Canyon Complex
- Survey Points (IPC)
- IPC Survey

N

IDAHO POWER
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Hells Canyon Project - FERC No. 1971
Tech. Report E.3.2-15 Figure 4

Areas Surveyed for Cliff Nesting Raptors, IPC, 1996

IDAHO POWER COMPANY
BOISE, IDAHO

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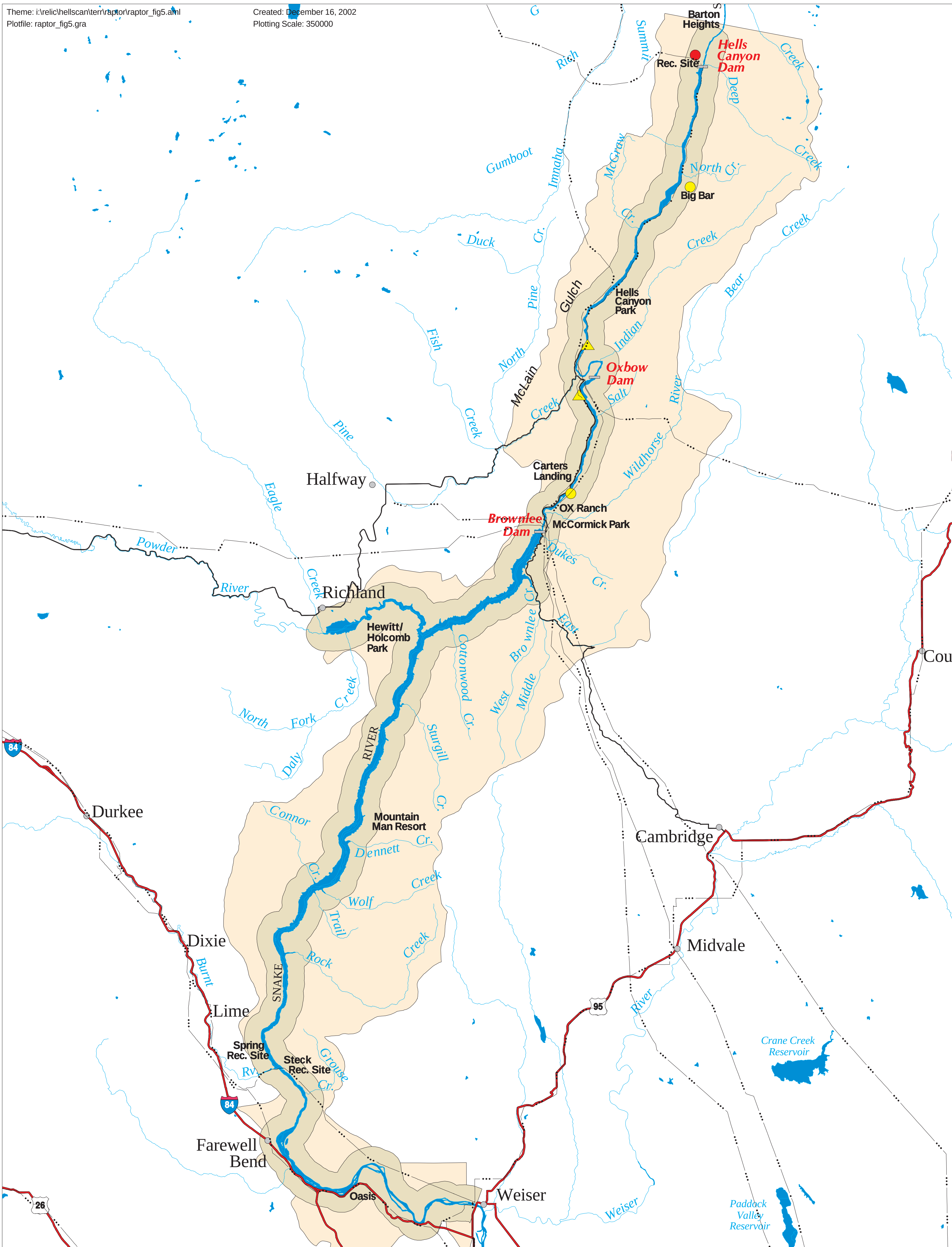

IDAHO POWER
An IDACORP Company

Features Legend

- Primary Route
- Secondary Route
- Streams
- Water Body
- Transmission Lines
- Idaho Power Facility
- City or Town
- Raptor Study Area
- Hells Canyon Complex
- Historic Bald Eagle Sites
- Bald Eagle Nests
- Peregrine Falcon Nest

N

Hells Canyon Project - FERC No. 1971
Tech. Report E.3.2-15 Figure 5

Locations of Historic and Current Bald Eagle and Peregrine Falcons Nest Sites, Hells Canyon Area, 1995-1999

IDAHO POWER COMPANY
BOISE, IDAHO

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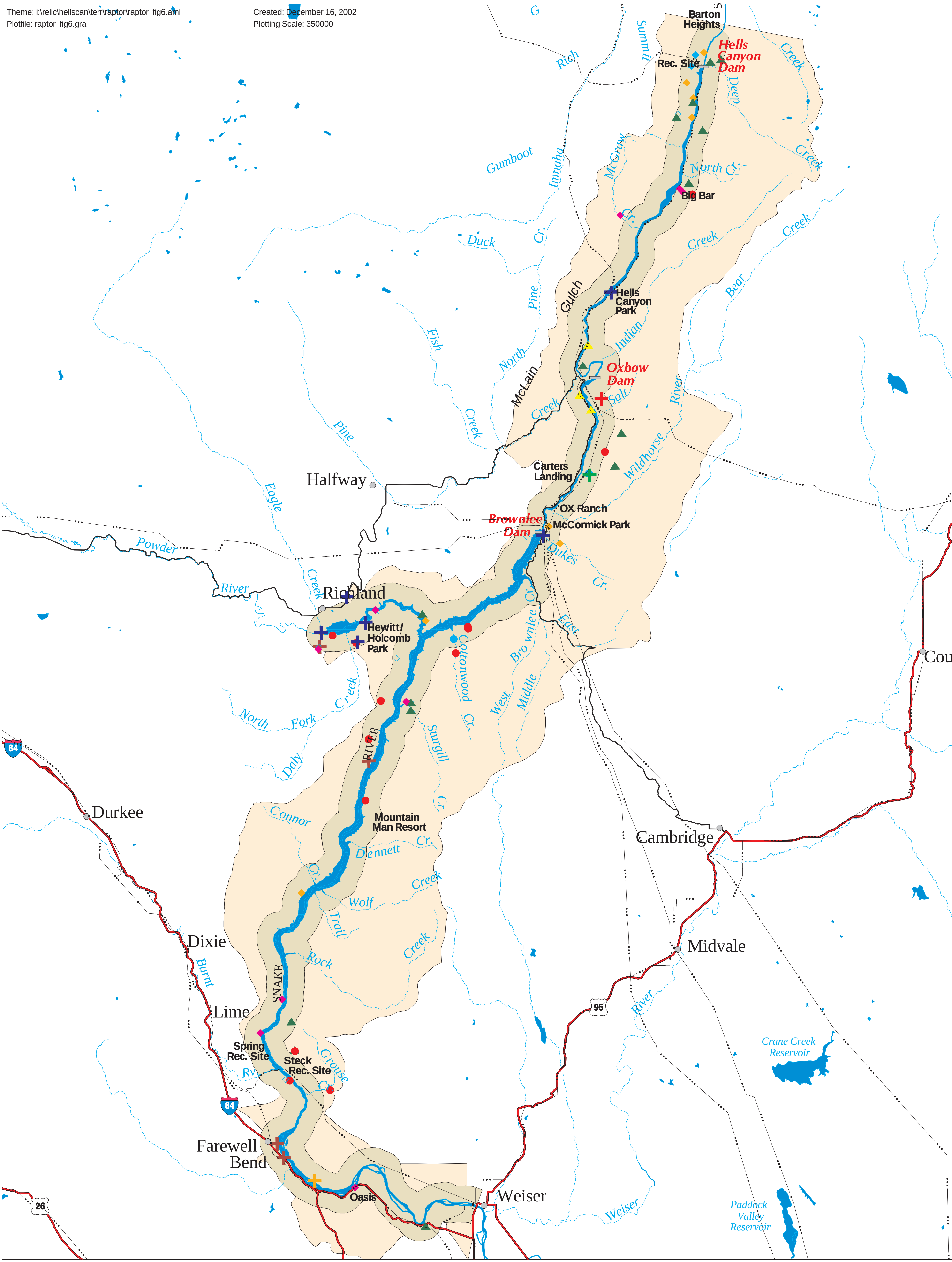
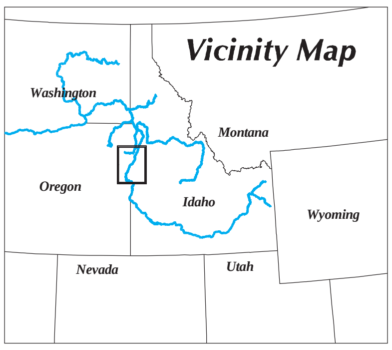


Features Legend



Primary Route	
Secondary Route	
Streams	
Water Body	
Transmission Lines	
Idaho Power Facility	
City or Town	
Raptor Study Area	
Hells Canyon Complex	

Occupied Territories

Bald Eagle	Great Horned Owl
Golden Eagle	Common Barn Owl
Peregrine Falcon	Long- eared Owl
Prarie Falcon	Burrowing Owl
American Kestrel	Western Screech- owl
Cooper's Hawk	Common Raven
Red- tailed Hawk	

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IDAHO POWER
An IDACORP Company

Hells Canyon Project - FERC No. 1971
Tech. Report E.3.2-15 Figure 6

Locations of Occupied Raptor and Common Raven Territories by Species, Hells Canyon Area, 1995- 1999

IDAHO POWER COMPANY
BOISE, IDAHO

5 2.5 0 5 MILES

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Appendix 1. Characteristics of occupied territories documented along the Hells Canyon Complex, 1995–1999.

SPECIES[1]	SITE	YEARS OCCUPIED	REACH	STATE	NEST SUBSTRATE	SURVEY TYPE[2]	RM	BREEDING STATUS[3]	ACCURACY[4]
AMKE	POWDER RIVER ARM	96	BR	OR	-	P	1.1	1	S
AMKE	EAGLE CREEK	96	BR	OR	TREE	I	9.4	1	N
AMKE	FOX CREEK	96	BR	OR	-	I	315.1	1	S
AMKE	SWITCHYARD	96	OX	ID	-	I	283.9	1	S
AMKE	DUKE'S CREEK	96	BR	ID	-	I	284.6	1	S
AMKE	HELL'S CANYON CREEK	98	HC	OR	CLIFF	I	246.9	1	N
AMKE	EAGLE BAR	95	HC	OR	-	P	249.7	1	S
AMKE	THIRTY-TWO POINT	95	HC	OR	CLIFF	P	250.9	2	S
AMKE	FLAT IRON	95	HC	ID	-	W	256.0	1	S
BAEA	AIRPORT	98,99	HC	ID	TREE	I,I	267.7	3,3	N
BAEA	COTTONWOOD	99	OX	OR	TREE	I	275.6	3	N
BAEA	BOAT RAMP	98,99	OX	OR	-	I,P	275.4	1,4	S,N
BUOW	HUFFMAN	98	BR	ID	GROUND	I	337.2	1	N
CBOW	MYER'S GULCH	96,97	BR	OR	BANK	I,I	9.7	1,1	N
CBOW	INTERCHANGE	97	BR	OR	BANK	I	334.8	2	N
CBOW	FAREWELL BEND	97	BR	OR	BANK	I	333.9	2	N
CBOW	BELOW CANYON CREEK	98	BR	OR	BANK	I	305.0	2	N
COHA	JACOBS LADDER	97	OX	ID	TREE	I	279.5	1	S
COHA	COTTONWOOD	98	BR	ID	TREE	I	295.0	1	S
CORA	SLAUGHTERHOUSE RIDGE	96	BR	OR	CLIFF	P	329.0	1	N
CORA	STURGILL CREEK	96	BR	ID	CLIFF	P	301.1	1	N
CORA	POWDER RIVER	96	BR	OR	CLIFF	P	4.5	1	N
CORA	COYOTE FLAT	96	BR	OR	CLIFF	P	299.8	1	N
CORA	THIRTY-TWO POINT	95	HC	OR	CLIFF	P	251.0	1	N
CORA	MYER'S GULCH	96,97	BR	OR	CLIFF	I,I	9.7	1,1	N
CORA	BROWNLEE SPILLWAY	96	BR	OR	CLIFF	I	286.2	1	S
GHOW	DUKES POND	95,97	BR	ID	CLIFF	I,I	284.6	2,2	N
GHOW	DALY CR	96,98	BR	OR	TREE	I,I	8.1	2,2	N
GHOW	EAGLE CREEK	96	BR	OR	-	I	9.4	1	S
GHOW	RICHLAND	97	BR	OR	TREE	I	7.9	1	N
GHOW	POWDER RIVER	97	BR	OR	CLIFF	I	3.0	3	S
GHOW	HELLS CANYON PARK	98	HC	ID	TREE	I	263.5	3	N

SPECIES[1]	SITE	YEARS OCCUPIED	REACH	STATE	NEST SUBSTRATE	SURVEY TYPE[2]	RM	BREEDING STATUS[3]	ACCURACY[4]
GOEA	BELOW 10-MILE	96	BR	ID	-	P	324.3	1	S
GOEA	STECK PARK	96	BR	ID	-	P	327.8	1	S
GOEA	STURGILL CREEK	96	BR	ID	CLIFF	P	301.1	1	N
GOEA	INDIAN CREEK	96	OX	ID	-	P	270.5	1	S
GOEA	LITTLE SHEEP CREEK	96	OX	ID	-	P	276.4	1	S
GOEA	COUGAR CREEK	96	OX	ID	-	P	278.9	1	S
GOEA	GOAT CREEK	95	HC	ID	CLIFF	W	247.5	1	S
GOEA	WHITE CLIFF	97	BR	OR	CLIFF	I	346.7	2	N
GOEA	DEEP CREEK	95	HC	ID	CLIFF	P	247.7	1	N
GOEA	EAGLE BAR	95	HC	OR	CLIFF	P	249.8	1	N
GOEA	THIRTY-TWO P0INT	95	HC	OR	CLIFF	P	250.9	3	N
GOEA	BLACK POINT	95	HC	ID	CLIFF	P	251.6	1	N
GOEA	FLAT IRON	95	HC	ID	CLIFF	P	255.0	3	N
GOEA	POWDER RIVER	97	BR	OR	CLIFF	I	1.0	2	N
LEOW	JACKOB'S LADDER	97	OX	ID	-	I	279.5	1	S
PEFA	STEAMBOAT	95	HC	OR	-	P	247.9	1	S
PEFA	HELLS CANYON CREEK	96,97.98	HC	OR	CLIFF	P	246.9	3,1,1	N
PRFA	McGRAW RIDGE	95	HC	OR	CLIFF	P	259.2	1	N
PRFA	10-MILE CREEK	96	BR	ID	CLIFF	P	323.3	1	N
PRFA	RUTH GULCH	96	BR	OR	CLIFF	P	5.1	1	N
PRFA	MOUTH STURGILL CREEK	95,96	BR	ID	CLIFF	I,P	301.1	1,1	N
PRFA	BURNT RIVER	96	BR	OR	-	I	325.4	1	S
PRFA	MYER'S GULCH	97	BR	OR	CLIFF	I	9.7	1	N
PRFA	ALLISON CREEK	98	HC	ID	CLIFF	I	255.5	1	N
PRFA	OASIS	98	BR	OR	CLIFF	I	339.8	2	N
PRFA	FLAT IRON	95	HC	ID	CLIFF	P	255.2	3	N
RTHA	UPPER ALLISON	95,96	HC	ID	-	P,P	256.2	1,1	S
RTHA	STECK PARK	96	BR	ID	-	P	328.4	1	S
RTHA	HOLLOW RIDGE	96	BR	OR	-	P	300.6	1	S
RTHA	X-SODA CREEK	96	BR	ID	-	P	307.4	1	S
RTHA	CAVE UP	95,97,98	BR	ID	TREE	I,I,I	293.1	1,3,3	N
RTHA	COTTONWOOD CREEK	95	BR	ID	TREE	I	295.0	1	N
RTHA	GRADE CREEK	95,96,98	BR	OR	TREE	I,P,I	303.7	1,2,1	N
RTHA	GROUSE CREEK	96	BR	ID	TREE	I	330.0	2	N
RTHA	DALY CREEK	96	BR	OR	TREE	I	8.1	2	N
RTHA	EAGLE CREEK	96	BR	OR	TREE	I	8.8	2	N

SPECIES[1]	SITE	YEARS OCCUPIED	REACH	STATE	NEST SUBSTRATE	SURVEY TYPE[2]	RM	BREEDING STATUS[3]	ACCURACY[4]
RTHA	SLAUGHTERHOUSE RIDGE	98	BR	OR	CLIFF	I	328.6	1	N
RTHA	WILLIAMSON CREEK	98	OX	ID	-	I	278.1	1	S
WSOW	WARM SPRINGS	98	OX	ID	TREE	I	275.3	3	N

1 AMKE-American kestrel, BAEA-bald eagle, BUOW-burrowing owl, CBOW-common barn owl, COHA-Copper's hawk, CORA-common raven, GHOW-great horned owl, GOEA-golden eagle, LEOW-long-eared owl, PEFA-peregrine falcon, PRFA-prairie falcon, RTHA-red-tailed hawk, WSOW-western screech-owl.

2 P=point survey, I=incidental survey, W=walking survey

3 1=Occupied, Unknown breeding, 2=Breeding, Unknown success, no data, 3=Breeding, Successful, 4=One bird site

4 S=Site of territory, N=Nest observed

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