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BEFORE THE
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Southeast Oklahoma Power Corporation	)	
	)	P-14890-005
Pushmataha County Pumped Storage Hydroelectric Project	)	

THE CHICKASAW NATION AND CHOCTAW NATION OF OKLAHOMA'S COMMENTS ON PRE-APPLICATION DOCUMENT AND SCOPING DOCUMENT 1 AND STUDY REQUESTS

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Pursuant to the Federal Energy Regulatory Commission's ("FERC" or "Commission") Integrated Licensing Process ("ILP") Rules, *see* 18 C.F.R. § 5.8, and the "Notice of Intent to File License Application, Filing of Pre-Application Document (PAD), Commencement of ILP Pre-Filing Process, and Scoping; Request for Comments on the PAD and Scoping Document, and Identification of Issues and Associated Study Requests," eLibrary no. 20240708-3054 (Jul. 8, 2024) (Notice), the Chickasaw Nation and Choctaw Nation of Oklahoma (collectively, "Nations") hereby provide comments on the PAD (eLibrary no. 20240507-5119) and Scoping Document 1 ("SD1"), eLibrary no. 20240708-3026, and submit study requests for the Southeast Oklahoma Power Corporation's ("SEOPC" or "applicant") proposed Pushmataha County Pumped Storage Hydroelectric Project ("Project").

As described below, SEOPC's PAD does not comply with the Commission's ILP regulations or provide an adequate basis to initiate the scoping process under the National Environmental Policy Act ("NEPA"). The Commission has expressly recognized that an applicant's failure to exercise due diligence can undermine the entire process: "[we] stress once again, … the importance of potential applicant's exercising due diligence in obtaining information and preparing all components of the PAD. *It is central to the success of the enterprise.*"[1] SEOPC's failure to do the work required of it compels the Nations to request that the Commission suspend the administrative process, including NEPA scoping, until SEOPC files a revised PAD that addresses the deficiencies identified in Section VII, *infra.* However, during this period we request that the Commission proceed with government-to-government consultation with the Nations and any other Tribes that could be affected, *see id.*, as SEOPC's due diligence failures provide no reason for further delay in consultation.

Despite the deficiencies in the PAD, the Nations have made a diligent and good faith effort to provide comments and request studies. They reserve the right to supplement these comments and submit additional study requests in response to information that is later provided by SEOPC or later obtained through the Nations' or other stakeholders' continued due diligence.

The Commission has both a trust responsibility to the Nations, 18 C.F.R. § 2.1c(b), and an obligation to consider any adverse effects on their treaty rights, *id.* at § 2.1c(e). The Nations will fully participate in the Commission's ILP proceeding, as is necessary to protect their rights and enforce the Commission's obligations. They also will participate and exercise full rights in any proceedings before other agencies that may implicate the United States' trust responsibility to the Nations, the Nations' treaty rights, or the Nations' interests in Reservation waters.

These comments are organized as follows: Section I is an Executive Summary; Section II states the Nations' interests relevant to this proceeding; Section III discusses SEOPC's separate obligation to obtain a water right for the Project, which federal law requires be done in accordance with the settlement agreement the Nations entered into to resolve unsettled questions of law

[1] *Hydroelectric Licensing Under the Federal Power Act*, 68 Fed. Reg. 51070, 51106 (Aug. 25, 2003) (emphasis added).

relating to tribal water rights and jurisdictional authority over water permitting, *see* State of Oklahoma, Choctaw Nation, Chickasaw Nation, City of Oklahoma City Water Settlement Agreement of 2016 ("Settlement Agreement"); Choctaw Nation of Oklahoma and the Chickasaw Nation Water Settlement Act ("Settlement Act"), Pub. L. No. 114-322, §§ 3608(a)(2), (c)(1)(A); Section IV provides comments on SEOPC's PAD; Section V provides comments on the Commission's SD1; Section VI includes the Nations' study requests; Section VII asks the Commission to undertake further procedures to address the deficiencies in SEOPC's PAD and implementation of the ILP to date; Section VIII includes a request for the Nations' representatives to be added to the Commission's official service list for this proceeding; and Section IX concludes the comments.

I. EXECUTIVE SUMMARY

SEOPC's Project would occupy lands and use waters within the Choctaw Reservation, which is reserved as the permanent homeland of the Choctaw Nation of Oklahoma by treaty with the United States. The Project would pump waters of the Choctaw Reservation uphill to a reservoir to be located atop the Kiamichi Mountains, PAD § 4.1.1 at p. 4-2, drawing electricity from the energy grid that serves the Choctaw Reservation to do so, and then use the downhill flow of those waters to generate electricity for consumers in Texas, to be sold at a profit for SEOPC's investors.[2] Essentially, SEOPC would use lands and waters of the Choctaw Nation Reservation for the duration of the life of the Project so that it might derive private profit by converting those resources into electricity sold exclusively to Texas consumers. As stated in prior comments, both Nations

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[2] *See* ZGlobal, Southeast Oklahoma Pump Storage Project Final Draft (Aug. 23, 2023), *available at* https://s44740.pcdn.co/wp-content/uploads/Oklahoma_Storage-final-version-8.23.2023-003_NR-FINAL.docx.pdf (last accessed Nov. 4, 2024), p. 7. According to public records with the Nevada Secretary of State, SEOPC is a Nevada corporation apparently headquartered in Texas.

are federally recognized sovereign nations with rights and obligations to protect their homelands, including its lands, waters, and natural, cultural, and ecological resources, which sustain the Nations' existence. Both Nations, by treaty, retain and exercise rights that would be impacted by this Project. The Nations continue to oppose the Project as proposed by SEOPC because it would contravene those sovereign interests and risk direct harm to the Nations' rights.

As a threshold matter, the PAD fails to meet the minimum disclosure requirements established by the Commission in 18 C.F.R. § 5.6. That has left the Nations in the dark on matters crucial to the protection of their Reservations, their natural resources, and their Treaty rights. The deficiencies of the PAD include: (1) a failure to acknowledge the proposed Project would be located on the Choctaw Reservation, in violation of 18 C.F.R. § 5.6(d)(3)(xii); (2) a failure to identify and disclose in any level of detail as to when and how the proposed Project plans to obtain a water permit for the Project in accordance with the Settlement Agreement entered into by both Nations and other state and local stakeholders that was approved by Congress and now controls water use permitting within the Choctaw Nation Reservation as a matter of federal law, in violation of 18 C.F.R. § 5.6(d)(3)(i)(C), (iii), and (xiii); and (3) incorrect characterizations of the Project as a "closed-loop" project despite clear regulatory language to the contrary, in violation of 18 C.F.R. §§ 5.8(c)(2) and 7.1(c)(3). These deficiencies, and others, are explained in more detail below.

But the core defect, which only the Commission can require SEOPC to correct, is that by submitting the PAD with such deficiencies, SEOPC seeks to shift the burdens of production and proof onto the backs of both Nations—a procedural sleight of hand that, if unchecked, could impede application of the Settlement Act and Settlement Agreement and initiate a game of cat-and-mouse with respect to the suite of other economic, cultural, and natural resource impacts this Project risks for both Nations. In order to attempt to protect their sovereign interests, the Nations have already been forced to expend time and resources to try to understand what the proposed Project will entail and how it will impact trust and treaty resources and then notify the Commission of those impacts. Such work is akin to "looking through a glass darkly," as SEOPC alone knows its true intentions. And that allows SEOPC to disavow components of the Project that the Nations' work shows to be problematic by asserting that their undisclosed intentions have been misunderstood.

This approach is particularly problematic because it ignores not only the significance of that water settlement which is now federal law but also the work and resources the Nations have and continue to invest in its formation and implementation. For generations, the use and management of waters within those lands the United States promised and secured to the Nations by treaty has been a source of recurrent controversy. Precipitated by a proposed large trans-basin export of water from those lands, the Nations brought federal suit against Oklahoma and Oklahoma City and, after several years of negotiations, successfully built with those other parties a framework for the management and administration of waters, which has been approved by Congress and now binds the United States as a matter of federal law. Irrespective of this context, SEOPC fails to apprise the Commission of the existence of this federal law framework, other than by passing reference. It wholly disregards not only the substantive protections that will be brought to bear under that framework to its proposed project, but also the existence of a broad intergovernmental agreement formed pursuant to and in accord with federal law and policy respecting Tribal water rights.

In these circumstances, if the Commission were to allow SEOPC to advance on the basis of this PAD, it would deny both Nations the right, as sovereigns, to comment on the full range of issues that § 5.6 requires SEOPC to address. It would be fundamentally unfair for the Commission to allow SEOPC to proceed by ducking its regulatory obligations to perform fundamental due diligence or to otherwise strategically sidestep the Nations' settled rights. To do so would evoke past practices where tribal resources were routinely extracted to benefit others without fair process being provided to the tribes. The Environmental Justice standards set forth in Executive Order 12898 are meant to end those practices. And FERC cannot countenance a return to those days as it is now the Commission's obligation to ensure its decisions protect the Nations' trust resources and treaty rights, *see* 18 C.F.R. § 2.1c.

Notwithstanding SEOPC's failure to provide an adequate PAD, it is clear from what has been provided that the Project would have potentially significant direct, indirect, and permanent impacts to the land, water, wildlife, fisheries, and cultural resources of both Nations, while the power generated using the Nations' resources would be sold in Texas, for the exclusive benefit of others. The further studies the Nations identify would develop facts the Commission and other jurisdictional agencies need to fully evaluate Project feasibility and impacts prior to exercising their respective decision-making authorities.

We also note that, while the Nations are committed to fully participating in the Commission's licensing and related proceedings, we also have particular rights as sovereigns in a government-to-government relationship with the United States. The Nations therefore reiterate our requests for government-to-government consultation with the Commission to address the potential effects of the Proposed project on our rights and resources as soon as possible.

The Nations reserve all rights and remedies necessary to protect their interests, including through legal claims and/or proceedings against any party, at any stage in this process, in this or other forums, and expressly reserve their sovereign immunity from suit, which has not been waived and is not being waived in this proceeding.

II. THE NATIONS' INTERESTS IN RESERVATION WATERS, THEIR TREATY HISTORY, AND THE CONTROLLING EFFECT OF THE SETTLEMENT ACT AND AGREEMENT ON THE PERMITTING OF RESERVATION WATERS.

A. Interests of the Choctaw and Chickasaw Nations.

The Nations are federally recognized Indian tribes, *see* 89 Fed. Reg. 944, 946 (Jan. 8, 2024), occupying reservations originally set aside for them by the 1830 Treaty of Dancing Rabbit Creek, Sept. 27, 1830, 7 Stat. 333, ("1830 Treaty") and the 1837 Treaty of Doaksville, Jan. 17, 1837, 11 Stat. 573 ("1837 Treaty"), *see Okla. Tax Comm'n v. Chickasaw Nation*, 515 U.S. 450, 465 n.15 (recognizing that Article 1 of the 1837 Treaty applied the 1830 Treaty to the Chickasaw Nation), and modified by the Treaty of Washington with the Choctaw and Chickasaw, arts I-II, June 22, 1855, 11 Stat. 611 ("1855 Treaty") and the Treaty with the Choctaw and Chickasaw, art. 1, Apr. 28, 1866, 14 Stat. 769 ("1866 Treaty"). The Choctaw Nation governs a Reservation in southeast Oklahoma that includes all of Pushmataha County. The Chickasaw Reservation is west of and adjacent to the Choctaw Reservation. The Nations possess rights of self-government, inherent sovereign authority, and Treaty rights, which they exercise to govern persons and activities on their Reservations, protect cultural and natural resources, provide recreational and tourism opportunities, and create jobs that support their Reservations' communities and economies. All of this activity depends on the availability of water. The Nations' interest in this proceeding is in ensuring that water is available in southeastern Oklahoma to provide for the health and sustainability of their Reservations and to meet the future needs of their communities.

The importance of their waters to the Nations is deeply rooted in their history and culture. The Nations' originally occupied territories that are today within the southern and southeastern region of the United States. *Choctaw Nation v. Oklahoma*, 397 U.S. 620, 622 (1970) ("*Choctaw Nation*"). In their ancestral lands, Chickasaw warriors drew on "the spirits of the great Mississippi and Tennessee Rivers" as a source of spiritual power. Wendy St. Jean, Mapping Chickasaw History in the Eighteenth Century, 27 Am. Indian Quarterly 758, 767 (2003). And the Choctaw called the Mississippi River, "Misha sipokne.' *Misha* in Choctaw means 'beyond,' with the idea of far beyond; and '*sipopnmi'* means 'age,' conveying the idea of something ancient." Muriel Wright, The Meaning of the Name of the Mississippi River, Chronicles of Okla. Vol. VI, 529, 529 (1928).

The Nations also relied on waterways as routes for travel and trade. About 1723, a Chickasaw headman, "who probably had access to information accumulated by other tribe members," was able to map an area "ranging … from Texas and Kansas in the west to New York and Florida in the east." Gregory Waselkov, *Indian Maps of the Colonial Southeast in* Powhatan's Mantle: Indians in the Colonial Southeast 435, 444 (Gregory Waselkov, et al., eds., Univ. of Nebraska Press 2006). On that map "in every case 'river' is written 'Oakhinnau' (*okhina*', from *oka*' ['water'] + *hina*' ['road']), to emphasize navigability for canoe travel, instead of the more general Chickasaw term *abookoshi*'." *Id.* at 478 (alterations in original). And "when the first French explorer with trade in mind penetrated the Indian country of central Oklahoma by way of the Red River in 1719, he found the inhabitants of a Wichita village already trading with a Chickasaw, who soon returned to the Yazoo River." Helen Hornbeck Tanner, *The Land and Water Communication Systems of the Southeastern Indians in* Powhatan's Mantle: Indians in the Colonial Southeast, (Gregory A. Waselkov, et al., Univ. of Nebraska Press 2006) 27, 32 (footnote omitted).

The Nations' close relationship to water and waterways was severely tested by their removal from their ancestral lands to their Reservations in present-day Oklahoma, the details of which are further discussed *infra*, § II(B). Before they removed, the Choctaws explored their new homeland and its waters. Grant Foreman, Indian Removal 31-32 (Univ. of Okla. Press 1974 ed.). With respect to the Kiamichi River, they reported that:

> this stream will afford fine navigation for boats; it is something like 80 yards wide. There is excellent prairies to be found on the Kiamissa, and salt springs in abundance; the timber is very good, and excellent stock range and plenty of game. The Kiamissa will afford fine settlement. The game is plenty on this stream, such as bear, deer, and turkeys, and on the west side of the Kiamissa 15 or 20 miles there is buffaloe to be seen in great numbers.

Id.

After their removal, the Nations set to reestablishing their independence in their new homeland and developing their relationship with its waters and waterways. They relied on its waters to farm and to transport their crops. "Corn and pecans and large quantities of cotton were exported from the Choctaw country in exchange for manufactured goods. The shipping was carried on by means of steamboats which came up the Arkansas and Red rivers." Angie Debo, The Rise and Fall of the Choctaw Republic 59-60 (Univ. of Okla. Press 1961). That early success was stunted for a time by the late-19th century federal policy favoring the allotment of Indian lands, which eventually resulted in the allotment of the Nations' Reservations. But the Nations' Reservations survived allotment and their continued existence is judicially recognized, *Oklahoma v. Castro-Huerta*, 142 S. Ct. 2486, 2491-92 (2022) (citing *State ex rel. Matloff v. Wallace*, 2021 OK CR 21, 497 P.3d 686, *cert. denied sub nom. Parish v. Oklahoma*, 142 S. Ct. 757 (2022)); *Sizemore v. State*, 2021 OK CR 6, ¶¶ 8, 14-15, 485 P.3d 867, 870-71, *pet. for cert. denied* 142 S. Ct. 935 (2022); *Bosse v. State*, 2021 OK CR 30, ¶¶ 7-9, 12, 499 P.3d 771, 774.

Today the Nations rely on the lands, waters, and natural resources of their Reservations to sustain their cultures, communities, and economy.[3] The waters of the Nations' Reservations include, *inter alia*, the Kiamichi Basin, a river system that includes Sardis Reservoir and Hugo Reservoir; the Upper Little Basin, a river system that includes Pine Creek Reservoir; and the Clear Boggy Basin, a river system that includes Atoka Lake and McGee Creek Reservoir, the latter being located south and east of Atoka Lake.

Illustrative of the Nations' reliance on Reservation waters for cultural purposes is their reliance on "river cane," an indigenous bamboo-like plant that grows near riverbanks within the Choctaw Reservation, to make the traditional Choctaw river cane baskets. River cane is a critically threatened cultural plant, currently down to less than 5% of its original abundance. Stands of river cane persist on the terraces of the Kiamichi, and Choctaw Tribal members harvest it there. Additionally, the most common types of Choctaw traditional pottery are made by mixing native clays with freshwater mussel shells that have been burned and crushed. The Kiamichi River is one of the last viable places where Choctaw potters can collect the shells from dead mussels. Choctaw potters commonly collect dead mussel shells in the Kiamichi from *Lampsilis cardium*, *Quadrula pustulosa*, *Elliptio dilatate*, and other species.

The Choctaw and Chickasaw Nations have also had extraordinary success in building their communities and economies. Their enterprises, which include tourism-related hospitality and recreation venues, rely on Reservation waters, as do their government operations. These activities benefit Indians and non-Indians alike. The Nations' economic development in eastern Oklahoma

[3] *See, e.g.,* Drowned Land, directed by Colleen Thurston, *trailer available at* https://drownedland.com/ (last accessed Nov. 4, 2024) (documentary describing the cultural significance of the Kiamichi River to the Choctaw people; expected to be released in 2025).

is a critical component of development in the entire State. *See, e.g.*, Kyle D. Dean, *The Economic Impact of Tribal Nations in Oklahoma Fiscal Year 2019* at 21 (2022), https://www.oknativeimpact.com/wp-content/uploads/2022/03/All-Tribe-Impact-Report-2022-Final.pdf (last accessed Nov. 4, 2024) (noting that the total economic impact from tribes in Oklahoma in 2019 was $15.5 billion, when accounting for direct expenditures and the multiplier effect of those expenditures); *id.* at 22 (explaining that tribal-fueled economic growth "is especially important in rural areas where the national trend is decline").

To protect the waters of their homeland and resolve unsettled questions of law relating to Tribal water rights and jurisdictional authority over water permitting, the Choctaw and Chickasaw entered into a settlement agreement with the state of Oklahoma, Oklahoma City ("City"), the Oklahoma City Water Utilities Trust ("Trust"), the Oklahoma Water Resources Board ("OWRB"), and the United States. *See* State of Oklahoma, Choctaw Nation, Chickasaw Nation, City of Oklahoma City Water Settlement Agreement of 2016 ("Settlement Agreement"). Congress "approve[d], ratif[ied], and confirm[ed] the Settlement Agreement" in the Choctaw Nation of Oklahoma and the Chickasaw Nation Water Settlement Act ("Settlement Act"), Pub. L. No. 114-322, §§ 3608(a)(2), (c)(1)(A).

The Settlement Act provides that "[b]eginning on the enforceability date, settlement area waters shall be permitted, allocated, and administered by the OWRB in accordance with the Settlement Agreement and [Settlement Act]," *id.* § 3608(e)(2), and it became enforceable on February 28, 2024, *see* 89 Fed. Reg. 14, 699-700 (Feb. 28, 2024).[4] The Settlement Agreement

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[4] The Settlement Act's resolution of contentious water resource issues has widespread importance to state and local communities, as noted in Oklahoma State Senator George Burns' comments in opposition to SEOPC's proposed Project:

addresses the appropriation and use of water in the "Settlement Area," defined as bounded by the South Canadian River, the Oklahoma-Texas state line, the Oklahoma-Arkansas state line, and the 98th meridian—that is, the Chickasaw and Choctaw Nations' treaty-recognized territory, as set forth in the 1866 Treaty. *See* Settlement Agreement § 1.58 (defining Settlement Area); 1866 Treaty, art. I (defining boundaries); *see also* Settlement Agreement, § 2.1.1.5 (referencing treaties as source of Nations' claims). And as is especially relevant here, the Kiamichi River is part of the "Settlement Area Waters" which are subject to the Settlement Agreement, *id.* § 1.60, and Settlement Act, § 3608(b)(19).

The Nations' core interests in protecting their Reservations' waters and natural resources are threatened by the Project, which seeks to draw water directly from the Kiamichi River by means of a "40-foot-long, 40-foot-wide funnel shaped intake structure at the [Kiamichi] river's bank. This intake structure would be positioned approximately 1.5 feet above the bottom of the Kiamichi River and would taper to a 10-foot-long, 10-foot-wide section." PAD § 4.2.4 at p. 4-25. "Two additional, 20-inch diameter, 525-foot long pipes with two 110-kilowatt pumps would be designed to move water from the Kiamichi River to the regulating reservoir." *Id.* § 3.2.1.3 at pp. 3-5 to -6. The water diverted from the Kiamichi River would be used to fill and recharge the

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> The potential damage of this proposed plant further extends to the historic Water Settlement Agreement (WSA) between the State of Oklahoma, Oklahoma City, the Choctaw Nation of Oklahoma, and the Chickasaw Nation. The proposed facility threatens to violate this historic agreement, in which the State and the Nations agreed to responsibly cooperate and share the water resources in southeast Oklahoma, including the Kiamichi River. This potential violation of the WSA is yet another unacceptable consequence of the proposed hydroelectric facility.

Comments of Oklahoma State Senator George Burns, eLibrary no. 20241007-5061 (Oct. 7, 2024), p. 1 (Senator Burns Comments).

proposed Project's upper,[5] lower,[6] and regulating reservoirs.[7] The upper reservoir "would intersect two subbasins," the Kiamichi and Upper Little subbasins. *Id.* at 4-1 – 4.2, "The dividing line between these two subbasins is the Kiamichi Mountains, on which the proposed upper reservoir would be located." *Id.* at 4.2. The upper reservoir would also impound Long Creek 4.8 miles from its headwaters in the Upper Little subbasin, redirecting any inflows from Long Creek to the Project powerhouse along with waters withdrawn from the Kiamichi River. *Id.* at 4-37.

The proposed Project's three reservoirs would be stacked above the Kiamichi and Little Rivers. The upper reservoir would have a "normal maximum surface elevation" of 1,670 feet above mean sea level ("msl"), PAD, Table 3-1 at p. 3-4, which is over 1,000 feet above the intake structure in the Kiamichi River, which would be located at 593 feet above msl. PAD § 3.2.1.3 at pp. 3-5 to -6. The Projects' three reservoirs would have a total surface area of 1,526.92 acres and a total storage capacity of 118,184 AF. *Id.* tbl. 3-1 to 3 at pp. 3-4 to 6. These reservoirs would be

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[5] *See* PAD § 3.2.1.1 (describing upper reservoir and appurtenant facilities as consisting of an "886-foot-long, 282-foot-high, concrete-faced, rockfill upper dam with a 196.85-foot-long, 17-foot-high emergency spillway with a channel to Long Creek…. Inundation from the upper dam would create an upper reservoir with a surface area of approximately 599.55 acres and a storage capacity of approximately 68,269 acre feet (AF)" and stating further that "[w]ater would be transported to and from the upper reservoir via a 98.4-foot-long, 39.4-foot-high, concrete upper intake/outlet structure that would convey flow through a 7,030-foot-long, 32.8-foot-diameter, steel and concrete headrace tunnel to and from an underground pumping station/powerhouse.").

[6] *See id.* § 3.2.1.2 (describing lower reservoir and appurtenant facilities as follows: "[w]ater would be transported to and from the underground pumping station/powerhouse via an 8,243-foot-long, 32.8-foot-diameter tailrace tunnel through a 98.4-foot-long, 39.4-foot-high, concrete lower intake/outlet structure to a lower reservoir with a surface area of 887.37 acres and a storage capacity of 48,699 AF. The lower reservoir would be inundated by a 13,615-foot-long, 68.9-foot-high, earthen lower dam with a 33-foot-long, 13-foot-high emergency spillway with a channel that becomes a tunnel to the Kiamichi River.").

[7] *See id.* § 3.2.1.3 (describing regulating reservoir and appurtenant facilities by stating "[t]he lower reservoir would be connected to a regulating reservoir with a surface area of 40 acres and a storage capacity of 1,216 AF via two 20-inch-diameter, 1,085-foot-long pipes with 110 kilowatt pumps. The regulating reservoir embankment would be composed of earth and concrete. Two additional, 20-inch-diameter, 525-foot-long pipes with two 110-kilowatt pumps would be designed to move water from the Kiamichi River to the regulating reservoir. Water would enter the two withdrawal pipes via a 40-foot-long, 40-foot-wide funnel shaped intake structure located 1.5 feet above the bottom of the Kiamichi River at approximately 593 feet above mean sea level (msl) and tapering down to 10-foot-long, 10-foot-wide section known as the water supply channel.").

filled by an initial withdrawal that SEOPC "estimate[s] as 68,269 AF," *id.* § 3.2.5.2, and asserts "could be conducted over a 24- to 30-month period, by diverting between 10% to 15% of the actual stream flow of the Kiamichi with a 260-cfs pump structure." *Id.* § 4.3.5. In addition, after construction, "[w]ater from the Kiamichi River, via the regulating reservoir, would also be used as a source to replace approximately 20,000 AF of leakage and evaporative losses." *Id.* § 3.2.5.2.

The entirety of the proposed Project's facilities and a significant portion of the proposed 99.96-mile-long transmission line would be sited within the "Settlement Area" established by the Settlement Agreement, § 1.58, and Settlement Act, § 3608(b)(18), and thus would be within the boundaries of the Choctaw Reservation. Despite the massive size of the Project and its near-continual need to withdraw water from the Kiamichi River, "SEOPC does not propose any environmental protection, mitigation, and enhancement (PM&E) at this time." *Id.* at 11. SEOPC's deliberate indifference to the impacts of the proposed Project, shown by *inter alia* its admission that "site-specific geologic and soil studies have *not* yet been conducted in the Project area" in the five years SEOPC has held a preliminary permit (PAD, p. 4-26 (emphasis added)), heightens the threat the proposed Project represents to the Nations' interests.[8] That magnifies the need for the Commission to direct SEOPC to develop more information necessary to evaluate the scope and nature of the Project impacts, as the Nations cannot protect themselves from what they do not know.[9]

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[8] The purpose of a preliminary permit is to preserve the priority of the permit holder against competitors while it undertakes "examinations and surveys, for preparing maps, plans, specifications, and estimates, and for making financial arrangements." 16 U.S.C. § 798.

[9] The PAD shows a lack of analysis regarding how "the project would impact the Kiamichi River within and beyond the (narrowly defined) proposed site, especially the interwoven lifeways of the potentially impacted Tribes, such as the Choctaw and Chickasaw, who have a long and mutually supportive human-environmental relationship with the Kiamichi. Impacts of the proposed pumped storage project to related natural resource Tribal sovereignty issues have

SEOPC's PAD fails in another, equally alarming, respect. Federal law requires that "settlement area waters shall be permitted, allocated, and administered by the OWRB in accordance with the Settlement Agreement and [Settlement Act]," Settlement Act § 3608(e)(2), and the Settlement Agreement requires OWRB to process water permits under state law and "consistent with the Settlement Agreement and the Settlement Act," Settlement Agreement, § 5.3.1. Yet SEOPC does not even acknowledge the Settlement Act in the PAD, and the cursory treatment it affords the Settlement Agreement misreads its terms. Taken together, these failures indicate that SEOPC is in no position to move forward with the proposed Project.

B. <u>The Choctaw and Chickasaw Nations' Treaty and Removal History.</u>

The Chickasaw and Choctaw Nations' aboriginal lands are in the southern and southeastern parts of the present-day United States. *Choctaw Nation*, 397 U.S. at 622. After the Louisiana Purchase in 1803, the United States adopted a policy to relocate Indians to new lands west of the Mississippi River. *Id.* at 623. The federal government then undertook to apply this policy to the Nations, which it did through a series of treaties.

In the Treaty of Doak's Stand, Act of Oct. 18, 1820, 7 Stat. 210, the Choctaw Nation agreed to exchange approximately half of its lands for a large tract of land in Arkansas Territory and an even larger tract farther west. *Choctaw Nation*, 397 U.S. at 624. Before their removal to those lands had even begun, the Choctaws' Arkansas Territory lands were occupied by white settlers. *Id.* In the Treaty of January 20, 1825, 7 Stat. 234, the Choctaws were persuaded to cede back to

not been adequately explored in the current study, the importance of which are well known in light of the more recent water rights settlement." Letter from Jacqueline Vadjunec, Ph.D. (Oct. 18, 2024) ("Vadjunec Letter"; Attachment 7), p. 1.

the United States the eastern portion of the lands granted to them in the Treaty of Doak's Stand. *Id.*

In the 1830 Treaty, the Choctaws agreed to remove to new lands west of the Arkansas Territory. *Id.* at 625. The "country west of the Mississippi River" that the 1830 Treaty secured to the Choctaws to "exist as a nation and live on it" is described in article 2 of the 1830 Treaty. *Id.* at 625-26.[10] Article 4 of the 1830 Treaty secured to the Choctaw Nation "jurisdiction and government" over "all the persons and property" within that territory and promised that "no Territory or state shall ever have the right to pass laws for the government of the Choctaw Nation" and that "no part of the land granted them shall ever be embraced in any Territory or State." *Id*.

The Chickasaw Nation signed its first removal treaty with the United States in 1832, and acknowledged in the preamble to that Treaty that:

> The Chickasaw Nation find themselves oppressed in their present situation; by being made subject to the laws of the States in which they reside.… Rather than submit to this great evil, they prefer to seek a home in the west, where they may live and be governed by their own laws. And believing that they can procure for themselves a home, in a country suited to their wants and condition, provided they had the means to contract and pay for same, they have determined to sell their country and hunt a new home.

Treaty of Pontitock Creek, Act of Oct. 20, 1832, 7 Stat. 381, pmbl.

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[10] Article 2 provides:

> The United States under a grant specially to be made by the President of the U.S. shall cause to be conveyed to the Choctaw Nation a tract of country west of the Mississippi River, in fee simple to them and their descendants, *to inure to them while they shall exist as a nation and live on it*, beginning near Fort Smith where the Arkansas boundary crosses the Arkansas River, running thence to the source of the Canadian fork; if in the limits of the United States, or to those limits; thence due south to Red River, and down Red River to the west boundary of the Territory of Arkansas; thence north along that line to the beginning.

(emphasis added).

The Chickasaw Nation resisted removal for another five (5) years, at which time it entered a new Treaty with the Choctaw Nation and the United States that secured to the Chickasaw Nation governance and proprietary rights within the lands the United States had previously secured to the Choctaw Nation. Treaty of Doaksville, Act of Jan. 17, 1837, 11 Stat. 537. Under the 1837 Treaty, the United States secured to the Chickasaw Nation a "Chickasaw District" within the Choctaw Nation's Reservation, guaranteed rights of homeland ownership and occupancy to the Chickasaw Nation "on the same terms that the Choctaws now hold it, except the right of disposing of it, (which is held in common with the Choctaws and Chickasaws) …" and secured to the Chickasaw Nation "all the rights and privileges" of the Choctaw Nation. *Id*. at art. 1; *see also Oklahoma Tax Comm'n v. Chickasaw Nation*, 515 U.S. 450, 465 n.15 (1995) (recognizing that art. 1 of the 1837 Treaty applied the 1830 Treaty to the Chickasaw Nation).

Removal involved significant suffering by the Choctaw and Chickasaw people who were forced to travel along the infamous Trail of Tears. Many tribal citizens perished before reaching the new homelands. Alexis de Tocqueville, who witnessed the Choctaw Nation's removal, offered this bleak testimony:

> At the end of the year 1831, whilst I was on the left bank of the Mississippi at a place named by the Europeans, Memphis, there arrived a numerous band of Choctaws …. These savages had left their country, and were endeavoring to gain the right bank of the Mississippi, where they hoped to find an asylum which had been promised them by the American government. It was then the middle of winter, and the cold was unusually severe; the snow had frozen hard upon the ground, and the river was drifting huge masses of ice. The Indians had their families with them; and they brought in their train the wounded and sick, with children newly born, and old men upon the verge of death. They possessed neither tents nor wagons, but only their arms and some provisions. I saw them embark to pass the mighty river, and never will that solemn spectacle fade from my remembrance. No cry, no sob was heard amongst the assembled crowd; all were silent. Their calamities were of ancient date, and they knew them to be irremediable.

De Tocqueville, Alexis, Democracy in America, vol. 1, 346 (Colonial Press 1900 ed.) (1835).

Once they arrived in what is now Oklahoma, the Nations governed their lands in accord with the treaty promises of self-government and engaged in further treaty-making with the United States. The Choctaw and Chickasaw Nations' rights under the 1830 and 1837 Treaties were reaffirmed in the 1855 Treaty, which provides that "[s]o far as may be compatible with the Constitution of the United States and the laws made in pursuance thereof, regulating trade and intercourse with the Indian tribes, the Choctaws and Chickasaws shall be secured in the unrestricted right of self-government, and full jurisdiction, over persons and property, within their respective limits, excepting all persons, not being citizens or members of either the Choctaw or Chickasaw tribe," who "shall be considered intruders, and be removed from, and kept out of the same, by the United States agent," subject to the further exception of "such persons as may be permitted by the Choctaws or Chickasaws, with the assent of the Indian agent, to reside within their limits, without becoming citizens or members of either of said tribes." *Id.* art. 7. The Choctaw Nations ceded "any and all lands, west of the one hundredth degree of west longitude;" *id.* art. 9, altering the western boundary of the Treaty Territory, *see id.* art. 1, and the Choctaw and Chickasaw Nations "lease[d] to the United States all that portion of their common territory west of the ninety-eighth degree of west longitude," *id.* art. 9. The 1855 Treaty also modified the boundaries of the Chickasaw Reservation, *id*. art. 2, and established the remainder of the Choctaw and Chickasaw country as the Choctaw Reservation, *id*. art. 3. Finally, the 1855 Treaty promised that "the United States do hereby forever secure and guarantee the lands embraced within the said limits, to the members of the Choctaw and Chickasaw tribes," and that "[n]o part thereof shall ever be sold without the consent of both tribes." *Id.*

Following the Civil War, the Chickasaw and Choctaw Nations signed the 1866 Treaty with the United States, which provides that "[p]ermanent peace and friendship are hereby established between the United States and said nations." *Id.* art. 1. The 1866 Treaty reaffirmed the obligations of the United States and the rights of the Nations under prior treaties, *id*. arts. 10,[11] 45,[12] and ceded from the Nations to the United States the "territory west of the 98 degrees west longitude," *id.* art. 3. Under these treaties, "[i]n many respects, … the Indians were promised virtually complete sovereignty over their new lands." *Choctaw Nation*, 397 U.S. at 635; *see also Bosse*, 2021 OK CR 3, ¶¶ 8(5), 9.

By the end of the 19th century, the federal government's allotment policy and pressure for the Nations' lands had taken their toll and resulted in the Choctaw and Chickasaw Reservations being allotted to their members. This was done under the Atoka Agreement—set forth in the Act of June 28, 1898, ch. 517, § 29, 30 Stat. 495, 505 ("Curtis Act")—and the Act of July 1, 1902, ch. 1362, 32 Stat. 641 ("1902 Act"). As a result, the Nations eventually lost much of their lands within their Reservations – though their Reservations were not disestablished, as the courts have recognized, *see supra* Section II.A at p. 9, and their Reservation boundaries remain intact. As the Supreme Court made clear in *Choctaw Nation*, those boundaries are subject to the same rules that apply to a "boundary between nations or states," 397 U.S. at 631 n.8 (quoting *Barney v. Keokuk*, 94 U.S. 324, 337 (1877)). In the Settlement Act, Congress found that "pursuant to the Atoka

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[11] Article 10 of the 1866 Treaty provides:

> The United States re-affirms all obligations arising out of treaty stipulations or acts of legislation with regard to the Choctaw and Chickasaw Nations, entered into prior to the late rebellion, and in force at that time, not inconsistent herewith; and further agrees to renew the payment of all annuities and others moneys accruing under such treaty stipulations and acts of legislation, from and after the close of the fiscal year ending on the thirtieth of June, in the year eighteen hundred and sixty-six.

[12] Article 45 of the 1866 Treaty provides:

> All the rights, privileges, and immunities heretofore possessed by said nations or individuals thereof, or to which they were entitled under the treaties and legislation heretofore made and had in connection with them, shall be, and are hereby declared to be, in full force, so far as they are consistent with the provisions of this treaty.

Agreement as ratified by section 29 of the Act of June 28, 1898 (30 Stat. 505, chapter 517) (as modified by the Act of July 1, 1902 (32 Stat. 641, chapter 1362)), the [Choctaw and Chickasaw] Nations … conveyed to individual Choctaws and Chickasaws, all right, title, and interest in and to land that was possessed by the Nations, other than certain mineral rights; and [that] when title passed from the Nations to their respective tribal members and citizens, the Nations did not convey and those individuals did not receive any right of regulatory or sovereign authority, including with respect to water." *Id*. § 3608(e)(1)(A)-(B).

C. The Settlement Agreement and the Settlement Act.

In the Settlement Act, Congress expressly provided that "[b]eginning on the enforceability Date," which has now passed, *see* 89 Fed. Reg. 14,699-700 (Feb. 28, 2024), "settlement area waters shall be permitted, allocated, and administered by the OWRB in accordance with the Settlement Agreement and [Settlement Act]." *Id.* § 3608 (e)(2). The Settlement Agreement specifically addresses the appropriation and use of water in the "Settlement Area," defined as bounded by the South Canadian River, the Oklahoma-Texas state line, the Oklahoma-Arkansas state line, and the 98th meridian—that is, the Chickasaw and Choctaw Nations' treaty-recognized territory, as set forth in the 1866 Treaty. *See* Water Settlement §§ 1.58 (defining Settlement Area), 2.1.1.5 (referencing treaties as source of Nations' claims); 1866 Treaty, art. I (defining boundaries). When Congress approved the Settlement Agreement it expressly recognized the boundaries of the Settlement Area, Settlement Act § (b)(18), 130 Stat. at 1798-99. That area includes all the proposed pumped storage facilities and much of the transmission line.

The Settlement Agreement and Act comprehensively protect the Nations' interests in the Settlement Area waters.

First, the Settlement Agreement protects specific water resources in the Settlement Area from diversions that could degrade the cultural, recreational, or ecological values of Settlement Area waters. These safeguards prevent excessive diversions of water from the Settlement Area outside of the State of Oklahoma, *see* Settlement Agreement § 5.3.3, and (when the applicable threshold is met) out of their source basin. They also guarantee that the Nations can participate in developing the model which governs approval of water diversions, in order to protect the cultural, recreational, and ecological values of the Settlement Area waters.

The Settlement Agreement contains specific provisions that protect the Kiamichi Basin's long-term ecological, recreational, and economic health. The Kiamichi River is a source of surface water for local users and supports cultural and environmental resources. The Kiamichi Basin also includes Sardis Lake, which is a major recreational resource, provides water for local users, and is a critical source of flow for the Kiamichi River. When a proposed out-of-basin diversion from anywhere in the Kiamichi Basin meets the conferral threshold set out in Section 5.3.1.1.2.2 of the Settlement Agreement, *see infra* § III.A at pp. 30-31, the OWRB is required to assess the proposed diversion using the Kiamichi Basin Hydrological Model as the "starting point for OWRB's determination [of whether an Adequate Hydrologic Model is available] under Section 5.3.1.2.5," *id*. § 5.3.1.2.5.6; *see also id.* §§ 1.35, 5.3.1.2.5.7, which protects reliance on the Kiamichi Basin's waters for "projected beneficial use within the basin," and "water quality, ecological, and recreational needs" within the basin, *id.* § 5.3.1.2.2.1. And the Upper Little River Basin is likewise protected; when a diversion out of the Upper Little River Basin exceeds the conferral threshold of Section 5.3.1.1.2.2, then OWRB is required to use an Adequate Hydrological Model to protect that Basin's waters for "projected beneficial use within the basin" and "water quality, ecological, and recreational needs" within it. *Id.* § 5.3.1.2.2.1.

The Settlement Agreement establishes a Technical Committee to evaluate, refine, or further develop models used to evaluate water appropriation permits, including the Kiamichi Basin Hydrological Model. *Id.* §§ 5.3.1.2.1.2.2-.3, § 5.3.1.2.5.7 (making Kiamichi Basin Hydrological Model subject to updates and providing it "shall be used for the allocation of water and administration of water rights in the Kiamichi Basin"). Through their appointment of a member of the Technical Committee, the Nations participate in creating the standards by which applications for permits to divert water in the Settlement Area will be allowed, and they then confer with the OWRB on the application of those standards.[13] The Technical Committee has two representatives, one appointed by the Nations and one by the State, to which a third representative is appointed by the City when applications to divert water in the Kiamichi Basin are considered. *Id.* § 5.3.1.2.1. When a permit applicant seeks to divert water out of the Settlement Area or source basin in an amount that could threaten the availability of water to current and future users in the Settlement Area, the OWRB is required to confer with the Technical Committee over the application.[14] The

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[13] In addition, the Nations have special rights to comment and confer on proposed new OWRB rules or amendments that affect the permitting or administration of Settlement Area waters. *Id.* § 5.2. Another conferral right is afforded by the Annual Planning Meeting, where representatives of OWRB and the Nations present their technical studies and water planning efforts in the Settlement Area from the past year, as well as their future work plans and goals relating to Settlement Area waters. *Id.* § 9.2.1.

[14] The Technical Committee then submits to its members copies of the application and of the OWRB's preliminary assessment of the Adequate Hydrological Model available to evaluate the permit's impact on Settlement Area water resources. *Id.* § 5.3.1.2.4.1. Adequate Hydrological Models are models that use defined empirical data or "inputs" to evaluate whether a withdrawal will degrade the value of the water source from which it is diverted. The model must also show whether a proposed use would interfere with existing beneficial uses of water. *Id.* § 5.3.1.2.2.2. For the Kiamichi River Basin, the Settlement Agreement requires that the Kiamichi Basin Hydrologic Model, with any updates, be used for this purpose. *Id.* § 5.3.1.2.5.6-.7 (subsections of Section 5.3.1.2.5 requiring use of Kiamichi Basin Hydrologic Model); *compare id.* § 5.3.1.2.4.1 (requiring use of "any model for the relevant basin that the OWRB previously determined to be an Adequate Hydrologic Model under Section 5.3.1.2.5"). If the OWRB determines that an Adequate Hydrological Model – which is one that meets these standards – is available, it informs the Technical Committee and processes the application. *Id.* § 5.3.1.2.5.2. If an Adequate Hydrological Model does not exist, the OWRB must request the Technical Committee to develop such a model within 180 days, and then is required to use that model in making its determination. *Id.* § 5.3.1.2.5.4. The Technical Committee is obligated to seek consensus between the Nation and State representatives in this modeling work. *Id.* § 5.3.1.2.1.2.1.

Settlement Agreement also includes specific restrictions on the City's water permit to divert water from the Kiamichi River[15] to ensure that flows in the River and water levels in Sardis Lake are adequate to support recreation and fish and wildlife uses of those waters. *Id.* § 6.[16]

Second, the Settlement Agreement protects the Nations' rights to use Settlement Area waters. Section 7 protects the Nations' rights to continue all existing permitted, and non-permitted uses, §§ 7.2.1, 7.2.2, 7.4.1, 7.4.2. The Nations also have the right to further develop their water resources, which is done on Nation-owned fee land under the OWRB permitting process, §§ 7.6.1, 7.7.1, and on the Nations' trust land within limits and procedures that protect Settlement Area water resources from being overdrawn, *id.* §§ 7.6.2, 7.7.2 to 7.7.5. If necessary, these rights can be vindicated by filing suit, or by participating in stream adjudications. *Id.* § 2.5.2.[17] Each Nation is also guaranteed rights to future water storage or diversion projects in the Settlement Area. The

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[15] Section 6 sets out conditions on the permit OWRB issued to Oklahoma City to divert water from the Kiamichi, which include restrictions "to support recreation, fish and wildlife needs, and to resolve the Nations' objections to the OWRB's consideration" of the City's pending permit application. The permit allows the City to store water in Sardis Lake and release that water for delivery to a point of diversion on the Kiamichi, where it can then be diverted and beneficially used outside of the Kiamichi Basin. *Id.* § 6.1.1. That diversion right is qualified by requiring that the City guarantee a 50 cfs flow rate in the Kiamichi past the diversion point, *id.* §§ 6.1.5, 6.1.6.1, and that diverted water only be used for the City's municipal use, and wholesale and retail water sales to customers and other Oklahoma public water supplies entities, *id.* § 6.1.7. While stored in Sardis Lake, the water can be used for "incidental purposes in Sardis Lake for recreation, [and] fish and wildlife benefits …." *Id.* § 6.1.7.

[16] Stored water can only be released pursuant to Section 6.1.8, which requires the City to maintain Sardis Lake's recreational and ecological values by not allowing the Lake's surface level to fall below certain minimum levels, contingent on the season, *id.* § 6.1.8.1, and current drought levels, *id.* § 6.1.8.2. During any drought conditions, as defined by the Settlement Agreement, § 1.27 (incorporating by reference §§ 1.4, 1.32, 1.42), the City cannot release water from Sardis without showing it has implemented water conservation measures previously negotiated by the Nations with the City and State, *id.* § 6.1.8.2; Ex. 12. Additionally, during "Advanced" or "Extreme" Drought Conditions, as defined in the Settlement Agreement, *id.* §§ 1.4, 1.32, the City must offer to meet and confer with the Nations and OWRB before making water withdrawals from Sardis Lake, *id.* § 6.1.8.2.4, and must show that it has implemented water conservation measures, and a water conservation program as required by *id.* § 6.5.1. The City, OWRB, and Nations will then consider whether to engage in technical negotiations under Section 6.5.7, to determine whether to develop technical mechanisms to allow for changes in water storage in Sardis, taking into account potential benefits to the City and Nations.

[17] The Nations also retain the right to file suit to stop any unauthorized diversion of water, and to recover damages associated with "any hunting, fishing, gathering, or cultural right …." *Id.* § 2.5.4. And all other rights not specifically waived in the Settlement Agreement are protected by a general reservation of rights in § 2.5.5.

Choctaw Nation retains the right to build one water impoundment in one of several named basins in the Settlement Area. *Id.* § 7.7.6. The Chickasaw Nation is also guaranteed water transport capacity in the City's planned Parallel City Pipeline. *See id.* at § 6.3.

Third, the Settlement Agreement establishes several Committees, which include representatives of the Nations and the State, that protect water resources in the Settlement Area from being overdrawn. As previously discussed, the Technical Committee establishes the Adequate Hydrological Models used by the OWRB to determine whether to permit proposed diversions of Settlement Area water resources, *id.* § 5.3.1, and OWRB and the Technical Committee work to evaluate, refine, and develop those models, *id.* § 5.3.1.2.1.2.2-3. (We describe application of these models further below.) OWRB is also required to consult with the Technical Committee about the assessment of proposed diversions that could threaten the availability of water to current and future users in water basins in the Settlement Area. *Id.* § 5.3.1.2.4.1. The Settlement Agreement also recognizes that "as of the Execution Date, state law prohibits any Out-of-State Use of Settlement Area Waters," and that "[n]othing in the Settlement Agreement changes such state law or otherwise permits or authorizes such use." *Id.* § 5.3.3.1.

Another body established by the Settlement Agreement, the Settlement Commission, will review any future proposed out-of-state use of Settlement Area waters, *id.* § 5.3.3.2 to .3, and then report on proposals to the state Legislature, which will decide whether and how to approve them, *id.* § 5.3.3.3.3. The Settlement Commission will oversee the distribution of funds from any out-of-state sale of such waters, which the Settlement Agreement provides may be used only for public water infrastructure in the State, with a preference for projects in the Settlement Area. *Id.* §§ 5.3.3.4; 5.3.3.5.2.3 to .4.

Fourth, the Settlement Agreement creates the Atoka and Sardis Conservation Projects Board to protect and improve the environmental and recreational value of Sardis and Atoka Lakes. The Board manages a special fund solely devoted to "purposes of scoping, designing, implementing, operating, and maintaining projects to enhance recreational use or habitat for fish and wildlife at Atoka or Sardis Lake and/or to mitigate environmental impacts at Atoka or Sardis Lake." *Id.* §§ 6.5.2.1.1, 6.5.2.1.2.1. The Nations appoint two of the four members of this Board. *Id.* § 6.5.2.1.1. The Board will award projects out of a $10 million fund, half of which was contributed by the City and half by the Nations. *Id.* § 6.5.2.1.2.1 to .2.

In addition to these substantial benefits, which are now guaranteed as a matter of Federal law, the debt owed by the Trust to the United States for the storage of water in Sardis Lake is waived under the terms of the Settlement Act, *id.* § 3608(d)(54)(B). In addition, all parties, including the United States, agree to waive their sovereign immunity *against each other* in actions to enforce the Settlement Agreement in the United States District Court for the Western District of Oklahoma. *Id.* at § 3.2.

III. SEOPC'S DISREGARD FOR THE SETTLEMENT ACT'S AND AGREEMENT'S CONTROL OF WATER PERMITTING FOR THE PROPOSED PROJECT RENDERS THE PAD INCOMPLETE AND UNRELIABLE.

Settled law establishes that the Federal Power Act ("FPA") does not authorize the Commission to adjudicate water rights, *Escondido Mutual Water Co. v. La Jolla Band of Mission Indians*, 466 U.S. 765, 782 (1984) ("[t]he Commission is expressly forbidden to adjudicate water rights." (citing 16 U.S.C. § 821)), as the Commission itself has repeatedly held. *Idaho Water Resource Board*, 84 FERC ¶ 61146, 61793 (Aug. 4, 1998) ("The Commission does not adjudicate or determine water rights." (citing FPA section 27, 16 U.S.C. § 821[18] and *Escondido*, 466 U.S. at 782.)); *City of Tacoma*, 110 FERC ¶ 61140, 62073 n.13 (Feb. 14, 2005) ("Under Section 27 of the FPA, the Commission has no authority to adjudicate state water rights."); *Puget Sound Power & Light Co*., 26 FERC ¶ 61405, 61894 (Mar. 29, 1984) (declining to consider the impact of the project on claimed water rights of the tribe because "[t]he issue of determining water rights, of course, is outside our jurisdiction."); *Southern California Edison Co*., 23 FERC ¶ 61240, 61514 (May 18, 1983) ("jurisdiction to adjudicate and quantify Indian water rights resides in the Federal courts."). At the same time, "the license applicant must submit satisfactory evidence [to the Commission] that he has obtained sufficient water rights to operate the project authorized in the license." *Escondido*, 466 U.S. at 782 (citing 16 U.S.C. § 802(b) (now codified at 16 U.S.C. § 802(a)(2)).[19] In addition, a PAD must include "[e]xisting and proposed uses of project waters for irrigation, domestic water supply, industrial and other purposes, including any upstream or downstream requirements or constraints to accommodate those purposes," 18 C.F.R. § 5.6(d)(3)(iii)(D), and "information on existing water rights and water rights applications potentially affecting or affected by the project," *id.* § 5.6(d)(3)(iii)(E).

SEOPC ignores these settled rules and requirements in the PAD. As the PAD's discussion of water resources, *see id.* § 4.3, defies the applicable rules, SEOPC's claims as to the feasibility

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[18] Section 27 of the FPA, 16 U.S.C. § 821, expressly reserves state authority to adjudicate water rights by providing:

> That nothing herein contained shall be construed as affecting or intending to affect or in any way to interfere with the laws of the respective States relating to the control, appropriation, use, or distribution of water used in irrigation or for municipal or other uses, or any vested right acquired therein.

[19] The provision that the *Escondido* Court cites to as 16 U.S.C. § 802(a) is now codified at 16 U.S.C. § 802(a)(2). It requires: "Satisfactory evidence that the applicant has complied with the requirements of the laws of the State or States within which the proposed project is to be located with respect to bed and banks and to the appropriation, diversion, and use of water for power purposes." *Id.*

of its plans cannot be independently verified. And the water resources discussion SEOPC offers in the PAD is contradicted by positions SEOPC has taken before the Commission in a related matter. These flaws make the PAD incomplete and unreliable.

A. **The Settlement Act and Agreement Control Water Permitting for the Proposed Project.**

The management and use of water in southeastern and southcentral Oklahoma has been a recurrent matter of dispute and controversy for generations. As discussed, these are the treaty homelands and reservations of the Chickasaw and Choctaw Nations. These are also areas treasured for a relative abundance of water resources of high quality, which resources are fundamental to the region's culture, character, and future. During the early years of Oklahoma's existence as a state, many saw those resources as a source for wealth and growth *outside* the region, which prompted strong opposition from non-Tribal residents and the Nations. In 2009, when faced with a new threat to the sustainability of those resources, the Nations brought federal suit to enjoin any claim by Oklahoma to exercise unilateral state law control over the management and disposition of the Nations' waters. That lawsuit, followed by years of negotiations, resulted in the formation of a water settlement—now authorized, ratified, and approved by federal statute and fully effective as a matter of federal law—establishing a historic intergovernmental framework to control the permitting and use of waters throughout the Nations. *See generally* Water United Oklahoma, https://www.waterunityok.com/ (last accessed Nov. 4, 2024). SEOPC's PAD ignores this context and fails, altogether, to provide the Commission, OWRB, or the Nations with information sufficient to fully evaluate the likely impacts of its proposal within this framework.

Under this framework, SEOPC can only obtain a water right for its proposed Project in accordance with the Settlement Act and Agreement, *see supra* Section II.A at pp. 11-12. The

Settlement Act and Agreement apply to any water rights sought by SEOPC for the proposed Project because the proposed Project's pumped storage facilities would be located within the Settlement Area, which is coextensive with the Chickasaw and Choctaw Nations' affirmed reservations. The Settlement Act defines the "settlement area" as bounded by "the South Canadian River and Arkansas River to the north, the Oklahoma-Texas state line to the south, the Oklahoma-Arkansas state line to the east, and the 98th meridian to the west," *id.* § 3608(b)(18)(A),[20] and "the area depicted on Exhibit 1 to the Settlement Agreement and generally including" all or portions of twenty-two listed counties, *id.* § 3608(b)(18)(B), among them, Pushmataha County, *id.* § 3608(b)(18)(B)(xxi). The Settlement Agreement defines the Settlement Area in identical terms. *Id.* § 1.58. The proposed Project "would be located … in southeastern Oklahoma, within Pushmataha County, approximately 5 miles south of the town of Talihina along the Kiamichi River," PAD at § 1.1.1, and therefore would be within the Settlement Area. As already discussed, this is the same area defined by the 1866 Treaty and the Nations' respective constitutions as their jurisdictional areas and reservations. *See supra* Section II.A at pp. 7, 12.

The proposed Project contemplates using Settlement Area waters to fill and maintain its reservoirs. The Settlement Act defines "settlement area waters" to mean waters within the Settlement Area that are also within a basin depicted on Exhibit 10 of the Settlement Agreement, *id.* § 3608(b)(19)(A)-(B), and specifically includes Kiamichi (5 and 6), and Upper Little (3), *id.* § 3608(b)(19)(B)(iv), (xv), both of which are designated "Class B Basins" by the Settlement, denoting those stream systems as "contain[ing] surface streams of significant cultural, ecological

[20] These are also the boundaries of the Chickasaw and Choctaw Nations' Reservations (which are adjoining), as set forth in art. 2 of the Treaty of Dancing Rabbit Creek, Sept. 27, 1830, 7 Stat. 333 (1830 Treaty"), as modified by the Treaty with the Choctaw and Chickasaw, art. 1, Apr. 28, 1866, 14 Stat. 769 ("1866 Treaty"). The Choctaw Reservation includes within its boundaries all of Pushmataha County.

or recreational values within the Settlement Area." Settlement Agreement § 5.3.1.1.1.1.[21] SEOPC will use water in the Kiamichi and Upper Little basins: "[T]he lower reservoir, regulating reservoir, and powerhouse (underground) are in the USGS-delineated Kiamichi subbasin. The upper spillway, dam, upper reservoir, and upper intake are in the USGS-delineated Upper Little subbasin." PAD § 4.3.1.2 at p. 4-29 (citing Figure 4-9).

The PAD states that, "[t]he Kiamichi River is the principal water body proposed to be used for initial fill of the Project reservoirs." *Id.* § 4.3.2.1. In addition, after construction, "[w]ater from the Kiamichi River, via the regulating reservoir, would also be used as a source to replace approximately 20,000 AF of leakage and evaporative losses." *Id.* § 3.2.5.2.

The upper reservoir would impound waters of the Upper Little basin, because it "will dam up the headwaters of Long Creek for 4.8 miles eliminating water flow in Long Creek for this section of the creek.…" *Id.* § 4.3.3.1 at p. 4-36. These waters, would be intermingled with stored Kiamichi River water, and then be discharged through the powerhouse in the Kiamichi River basin and from there potentially back into the Kiamichi River: "Any water diversion from Long Creek will go through the powerhouse, tailrace, lower reservoir, and then into the Kiamichi River …." *Id.* These transfers would continue for as long as the Project were to operate. In addition, water from the upper reservoir, including Kiamichi River water, could be discharged into the Upper Little basin, because the upper reservoir spillway channel is designed to discharge water in the upper reservoir into Long Creek. *Id.* § 3.2.1 at p. 3-3. Therefore, SEOPC may only obtain a water permit to operate the proposed Project from the OWRB in compliance with the terms and

[21] *Accord* Settlement Agreement, § 1.60 ("Settlement Area Waters" means "[g]roundwater located within the Settlement Area," *id.* § 1.60.1, and "[s]urface waters located within both a Settlement Area Hydrologic Basin, and the Settlement Area," *id.* § 1.60.2); *id.* 1.59.4 and .10 (listing Kiamichi (5 and 6) and Upper Little basin (3)).

conditions of the Settlement Act and Agreement, yet it fails even to identify the robust requirements it will be required to satisfy in proceedings conducted under the specific auspices of the Settlement Agreement and characterizes those requirements, instead, in a perfunctory and conclusory manner.

For example, once a specified "conferral threshold" is met, which it appears would be the case here, *see* Settlement Agreement § 5.3.1.1.2.2., the Settlement requires, in consultation between Oklahoma and the Nations, the use of a hydrologic model that is adequate to ensure the Settlement's protective standards are brought to bear on the proposed water use. Those protective standards require particularized inquiries and findings before a water use may be lawfully permitted—namely, that the water use proposal would: (i) "not interfere with existing rights in the source basin"; (ii) "not interfere with projected future consumptive-use water needs within the source basin: and (iii) with respect to certain stream systems, among which both the Kiamichi and Upper Little are counted, *see* Settlement Agreement §§ 5.3.1.3.1.1 to .3, and 5.3.1.1.1.2., and with reference to Oklahoma's regulations established to safeguard quality and flow of scenic and wild rivers, be sufficient to protect "existing water quality, ecological, and recreational needs." *Id.* § 5.3.1.3. One of the "existing rights in the source basin" is Oklahoma City's now-permitted right to take water from the Kiamichi River pursuant to additionally protective terms and conditions set forth in the Settlement Agreement Section 6, e.g., diversion restrictions and bypass flow requirements, the exercise of which is now also protected as a matter of federal law pursuant to the Settlement, *id.* § 6.1.10; *see also id.* § 6.4.2.

On top of these considerations, an applicant to use water must show a need for the amount of water requested, that the water will be put to use "within a reasonable time but not longer than seven (7) years," and that "the works intended for the delivery of the water are feasible and capable of efficient delivery of the water requested for appropriation without committing waste." *Id.* § 5.3.1.3.2.2. Finally, if there is a dispute as to whether any of these protective mechanisms have been appropriately implemented with respect to a proposed water use, the disposition, review, and remedy of such dispute is reserved exclusively to the United States District Court for the Western District of Oklahoma. *See id.* § 3.1.1.1.

SEOPC so far ignores all this in the PAD, failing altogether to recognize the federal law and policy implications of engaging in a basin that is subject to an Indian Water settlement agreement. It avoids the specific provisions of the Settlement Act, which provides the exclusive processes that will be conducted under the Settlement as a whole and which will be subject to the exclusive federal court jurisdiction for any dispute, and offers insufficient explication of its proposal so that the Nations, as parties to that hard-won Settlement, could properly evaluate the hydrologic risks the proposal poses. Instead, it merely acknowledges the Settlement Agreement's existence, offering that the Agreement "limits the water that can be withdrawn from the Kiamichi River and Sardis Lake and ensures that Tribes have an active role on decisions regarding water management" and that "Oklahoma statutes outline that the OWRB is responsible for the appropriation, allocation, distribution, and management of water quantity in the state," PAD, § 4.3.4 (citing OWRB Water Permitting (2023)). The Commission's moving forward based on this form of notice pleading would be inconsistent with the explicit federal policy objective of engaging in Tribal water rights matters in a manner that is "conducive to long-term harmony and cooperation among all interested parties through respect for the sovereignty of the States and tribes."[22] These

[22] U.S. Department of the Interior Working Group in Indian Water Settlements, Policy Statement, Criteria and Procedures for the Participation of the Federal Government in Negotiations for the Settlement of Indian Water Rights Claims, 55 Fed. Reg. 9223 (Mar. 12, 1990).

federal objectives were achieved through the Settlement Agreement, which the Commission should recognize and respect.[23]

By ignoring or minimizing the federal law and policy framework that now controls water allocations under the Settlement Act and Agreement, SEOPC has provided the Commission an incomplete description of "[e]xisting and proposed uses of project waters … including any upstream or downstream requirements or constraints to accommodate those purposes," and incomplete "information on existing water rights and water rights applications potentially affecting or affected by the project," which are required by the Commission's regulations. 18 C.F.R. § 5.6(d)(3)(iii)(D), (E). The Settlement Act and Agreement impose requirements and constraints on the proposed Project's use of waters, and the process that controls the permitting of Settlement Area waters is important information relevant to both existing water rights and water rights applications. Further, the Commission must approach this matter consistent with the federal policies supporting the finality and durability of Indian water right settlements.

B. SEOPC's Conflicting Statements about Kiamichi River Waters Require Explanation.

These errors are exacerbated by the PAD's statements regarding the availability of water from the Kiamichi River for the proposed Project, which rely on a 2018 study and contradict statements made by SEOPC to the Commission on that very issue in 2019. In the PAD, SEOPC relies on HDR Consultants, *Water Source and Fill Rate Study*, Prepared for Southeast Oklahoma Power Corporation. Tulsa, Oklahoma (2018) ("HDR 2018 Study"). *See* PAD, § 4.3.2.1, Monthly

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[23] *See also* Charles V. Stern, "Indian Water Rights Settlements," Congressional Research Service (Oct. 13, 2023) ("Indian water rights are vested property rights and resources for which the United States has a trust responsibility"), *available at* https://crsreports.congress.gov/product/pdf/R/R44148#:~:text=As%20of%20October%202023%2C%2039%20Indian%20water,U.S.%20Departments%20of%20Justice%20and%20the%20Interior (last accessed Nov. 4, 2024).

Minimum, Mean, and Maximum Flows; *id.* Table 4-6, Estimated Flows for the Kiamichi River at the Point of the Proposed Diversion; *id.* § 4.3.5, Environmental Issues, Data Gaps, and Proposed Studies; *id.* § 8, Literature Cited by Section. While the PAD does not include the study,[24] SEOPC subsequently filed it at the direction of Commission staff. That document raises more questions than it answers, particularly when read in light of SEOPC's prior assertions to the Commission.[25]

In Section 4.3.5 of the PAD (p. 4-49), SEOPC states:

> SEOPC has conducted a preliminary study of the water source and fill rates for the proposed Project, which indicated that the initial fill of the lower reservoir could be conducted over a 24- to 30-month period, by diverting between 10% to 15% of the actual stream flow of the Kiamichi with a 260-cfs pump structure. This slower rate of fill over a longer period would be beneficial to adjacent landowners and interested stakeholders, such as those with existing water rights.

SEOPC also states, "the proposed Project does not include extraction of groundwater resources." *Id.* at 4-32.

But in 2019, the year *after* the HDR 2018 Study was completed, SEOPC took a very different position on water availability from the Kiamichi. In opposing the application for a preliminary permit filed by Tomlin Energy, LLC for Project No. 14983, SEOPC told the Commission that:

> A preliminary hydrologic evaluation performed for SEO *based on information gathered to prepare its Pre-Application Documents* indicates SEO may not be able to rely solely on unallocated flows in the Kiamichi River in order to maximize development of its projects, and *SEO may need to acquire additional water in the vicinity of the projects, including existing allocated or permitted water, groundwater, or water from other sources*.

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[24] *See* Letter to Johann Tse, Southeast Oklahoma Power Corporation, re: Additional Information Required for Pre-Application Document (May 29, 2024), eLibrary no. 20240529-3068.

[25] *See* SEOPC, Preliminary Results of Determination of Water Source and Fill Rates re the Pushmataha County Pumped Storage Project under P-14890 (May 30, 2024), eLibrary no. 20240530-5020.

Motion to Intervene and Protest of the Southeast Oklahoma Power Corp., Project No. 14983, eLibrary no. 20190611-5080 (Jun. 11, 2019), p. 4 (emphasis added). SEOPC further explained,

> Based on this preliminary hydrologic information, the probability of SEO withdrawing sufficient water every six months to make-up for the expected range of evaporative losses at its projects ranges from approximately 13 to 82 percent, depending on a range of factors, including pump sizes, diversion rates, and diversion locations. As a result of these probability ranges, during the permit terms for Project Nos. 14887 and 14890, *SEO intends to investigate the possibility of acquiring rights to existing allocations on the Kiamichi River, and acquiring other sources of water in the area, including the possibility of groundwater*.

Id. at 5 (footnote omitted; emphasis added). SEOPC reiterated that position to the Commission on June 27, 2019, stating

> Tomlin's response [to SEOPC's June 11, 2019 filing] refers to the active permits for entitled water from the Kiamichi River, *the fact that there may be no more available rights to unallocated water on the Kiamichi River, and the fact that groundwater availability in the area may be insufficient to fill a pumped storage project reservoir*. It is for precisely these reasons that SEO is concerned about competing for the same water resources as Tomlin in the vicinity of SEO's proposed pumped storage projects. In reviewing the hydrological record to prepare its pre-application documents, a preliminary hydrological evaluation performed for SEO indicates that, after the initial fill of SEO's lower reservoirs, *the probability of withdrawing sufficient water from the Kiamichi River every six months to refill SEO's lower reservoirs to account for evaporative losses and maintenance-related flushing ranges from 13 to 82 percent, depending on the selected pump size, diversion rate, and diversion location. Based on this probability range, SEO presumes it will need to obtain rights to additional sources of water in order to develop its project, which may include acquiring allocations from existing water users on the Kiamichi River, accessing groundwater, or accessing other sources of water*.

Answer of Southeast Oklahoma Power Corp. to Comments of Tomlin Energy, LLC, eLibrary no. 20190627-5063 (Jun. 27, 2019) ("SEOPC's Answer"), pp. 3-4 (emphasis added).

SEOPC's omission of these facts and analyses from the PAD, its unexplained reliance on a 2018 study that tells a different story, and the PAD's cursory treatment of the Settlement Agreement and its failure to even acknowledge the Settlement Act, render the PAD incomplete and unreliable and raise serious questions about how SEOPC intends to obtain the necessary water rights for the proposed Project.

Even when viewed on its own terms, the HDR 2018 Study paints an incomplete picture of the actual withdrawals planned by SEOPC, so SEOPC's reliance on it in the PAD does not provide the Commission or the Nations with the information they need to fully evaluate the proposal. And the Commission's unquestioning reliance on the HDR 2018 Study to describe "the initial fill of the reservoirs" is concerning. *See* SD1, p. 9.

In particular, the HDR 2018 Study considers "the potential to fill the proposed lower reservoir and provide an estimate of the time required to fill the lower reservoir, including daily losses." HDR 2018 Study at 1. The "fill potentials for the lower reservoir were based on an assumed volume of 38,000 acre-feet and a constant surface area of 727 acres." *Id.* at 3. However, SEOPC now says that it will require an estimated 68,269 acre-feet for the initial fill of the Project (PAD at 3-8), which means that SEOPC will apparently need considerably more water for an initial fill than the HDR 2018 Study assumed would be needed.[26]

More water will be required to make up for evaporative losses and leakage. Here, too, the HDR 2018 Study falls short. The HDR 2018 Study only assessed evaporative losses "[a]ssuming a lower reservoir surface area of 727 acres." HDR 2018 Study at 2. But the lower reservoir would have a surface area of 887.37 acres, and the regulating reservoir would have 40 additional acres. In addition, the upper reservoir would have a surface acreage of up to 599.55 acres (PAD at 4-29, tbl. 4-3), and would also have evaporative losses. Because the HDR 2018 Study's evaporative loss

[26] SEOPC is also proposing a much larger, lower reservoir that would have a storage capacity of 48,699 acre-feet. PAD, p. 4-29.

estimates are based on incorrect assumptions regarding reservoir surface area they are of limited value.

Furthermore, the HDR 2018 Study says nothing at all about leakage losses, which could be substantial. SEOPC recently admitted that up to 87% of diverted water could be lost to evaporation and leakage, *see supra* Section II.A at p. 14. Again, this is likely an underestimate because SEOPC did not consider site-specific conditions. According to the Nations' expert analysis, "[t]he geologic and hydrogeologic attributes of the project's location significantly increase the likelihood of underestimated leakage rates from all the proposed reservoirs, which would require increased annual replacement water withdrawals from the Kiamichi River." Expert Report of Ethan Schuth ("Schuth Report"; Attachment 6) ¶ 5; *see also* Expert Report of Dr. Arden D. Davis ("Davis Report"; Attachment 2) ¶ 23 ("Evaporation and leakage from the proposed reservoirs would cause losses of available water in a basin where water resources currently are stressed.").

In short, the information SEOPC has provided indicates the initial fill would require more water than SEOPC claims, and dramatically underestimates evaporative losses and leakage that would continue throughout the life of the Project. The latter errors render unreliable SEOPC's projection that the Project would require diversions of 20,000 AF a year in the future to compensate for losses to evaporation and leakage. As a result, that conclusion must be studied and independently verified.

C. <u>SEOPC's Careless Treatment of the Availability of Kiamichi Rivers Waters for the Project and its Cursory Treatment of the Settlement Act and Agreement Demand Explanation.</u>

SEOPC's omission from the PAD of more recent information, less favorable to SEOPC, regarding water availability betrays SEOPC's failure to recognize that its ability to obtain a water right from OWRB for the Kiamichi River depends on compliance with the detailed and comprehensive terms of the Settlement Act and Agreement. SEOPC admits that the proposed Project is subject to a "complex water rights landscape," but shows no cognizance of the terms of the Settlement Act and gives the Settlement Agreement only a passing nod. PAD § 4.3.4.

The Settlement Act and Agreement cannot be dismissed in this fashion. While the Commission may not adjudicate or interfere with the State's authority to administer water rights in compliance with the Settlement Act and Agreement,[27] SEOPC must still provide "[s]atisfactory evidence that [it] has complied with the requirements of the laws of the State … within which the proposed project is to be located with respect to … the appropriation, diversion, and use of water for power purposes" before it can obtain a license under the FPA from the Commission. 16 U.S.C. § 802(a)(2); 18 C.F.R. § 4.51(a)(5)(i) (application for license must include in the initial statement "the statutory or regulatory requirements of the state(s) in which the project would be located that affect the project as proposed, with respect to bed and banks and to the appropriation, diversion, and use of water for power purposes …"). To date, SEOPC has offered nothing on this issue, other than two conflicting positions. SEOPC must provide the information required by the FPA, 16 U.S.C. § 802(a)(2); 18 C.F.R. § 4.51(a)(5)(i); and ILP rules, 18 C.F.R. §§ 5.6(d)(3)(D) (PAD shall include description of "[e]xisting and proposed uses of project waters …, including any upstream or downstream requirements or constraints to accommodate those purposes,"), (E) (PAD shall include "information on existing water rights and water rights applications potentially affecting or affected by the project"). It must also provide a full explanation of its decision to rely on the HDR

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[27] And "the United States District Court for the Western District of Oklahoma shall have exclusive jurisdiction *for all purposes* and for all causes of action *relating to the interpretation and enforcement of the Settlement Agreement* … or *interpretation or enforcement of* [the Water Settlement Act] …." § 3608(j)(1)(A)(i) (emphasis added).

2018 Study in the PAD notwithstanding its admission in 2019 that "there may be no more available rights to unallocated water on the Kiamichi River."

IV. COMMENTS ON THE PAD

SEOPC's primary interest in the Project is economic gain, essentially by siphoning power from the Choctaw Reservation for sale and use in Texas. Simply stated, SEOPC plans to buy power off-peak (and thus inexpensively) at least in part from the Oklahoma power grid, presumably, and sell Project power at peak times (and thus expensively) in Texas, while leaving all environmental impacts of the Project and its operations in Oklahoma, specifically on the Choctaw Reservation. If the Project is viable, that would benefit SEOPC while unloading the social, environmental, and economic costs of the Project on others. But SEOPC has failed to show the Project is viable, and its PAD falls far short of regulatory requirements. Again, SEOPC seeks a benefit—Commission's blessing that the ILP can move forward—while unloading onto others all the burdens—investigating and developing the facts. As the Nations now explain, the ILP should not progress until SEOPC submits an adequate PAD.

Under the Commission's regulations, a license applicant is required to prepare a PAD that provides "existing information relevant to the project proposal that is in the potential applicant's possession or that the potential applicant can obtain with the exercise of due diligence." 18 C.F.R. § 5.6(b)(1). The PAD is intended to help the Commission, Tribes, other resource agencies, and stakeholders "identify issues and related information needs, develop study requests and study plans, and prepare documents analyzing any license application that may be filed." *Id.* Thus, a license applicant must do its own work, providing information it has, and gathering additional information through due diligence. It cannot rely on others to do its work.

The Nations' review, set forth below, demonstrates that the PAD is incomplete and does not comply with the minimum content requirements under the Commission's regulations, *see* 18 C.F.R. § 5.6(d). It is missing important information that is both relevant to the Project and could have been obtained by SEOPC with the exercise of due diligence. First and foremost, the PAD fails to acknowledge that the Project would be located within the Choctaw Nation Reservation boundaries, which is within the Settlement Area within which the Settlement Agreement and Settlement Act control further allocations of water resources.[28] Further, the PAD does not adequately address "[e]xisting and proposed uses of project waters … including any upstream or downstream requirements or constraints to accommodate those purposes," 18 C.F.R.§ 5.6(d)(3)(iii)(D), nor does it provide "information on existing water rights and water rights applications potentially affecting or affected by the project." 18 C.F.R. § 5.6(d)(3)(iii)(E). Evaluating how existing water rights will affect or be affected by the Project necessarily requires consideration of what water rights SEOPC must obtain to operate the Project, as to which it has offered no clear statement.

Further still, SEOPC's characterization of the Project as "closed-loop" appears incorrect based on the proposed upper reservoir's impoundment of Long Creek.

The inaccuracies and other gaps in the PAD make it very difficult to evaluate the appropriate scope of environmental analysis, develop study and additional information requests, and otherwise participate effectively in the licensing and related permitting proceedings. The Nations cannot comment on information that is not provided to them, much less fully evaluate its impacts on their interests. Going forward, the Commission and its Office of Energy Projects

[28] *See* PAD, p. 4-45.

("OEP") and Office of Public Participation ("OPP") staffs should act proactively to ensure SEOPC timely provides "all necessary or relevant information to the Commission" for purposes of the Commission's environmental analysis under NEPA and ultimate decisionmaking under the FPA.[29] 18 C.F.R. § 380.3(b). As stated in Section VII, *infra*, we specifically request that Commission staff suspend the administrative process until SEOPC files a revised PAD that complies with Rule 5.6.

Section 1.1.1 Brief Description of the Pushmataha Pumped Storage Project

SEOPC has presented the Project as a "closed-loop" pumped storage project. *See, e.g.,* PAD, p. 1-1; *see also* SEOPC, Preliminary Permit Application, eLibrary no. 20180801-5213 (Jul. 1, 2018), Exhibit 1, p. 7. A "closed-loop" pumped storage project is one that does *not* have an ongoing hydrologic connection to a natural body of water. The Commission has explained that the "[t]ypes of reservoirs that lend themselves to a closed-loop project include reservoirs located in surface mine pits or underground mines."[30]

As noted in SD1 (pp. 10-11), the Commission has also adopted regulations further defining closed-loop pumped storage projects that may qualify for expedited procedures *if* they meet the following criteria:

(i) Cause little to no change to existing surface and groundwater flows and uses;

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[29] Requiring the applicant to timely provide complete and reliable information is important to help address the inherent imbalance between the applicant and local communities and individuals, as was noted in the Commission's Report on the Office of Public Participation (June 24, 2021): "commenters emphasized the need for the Commission and OPP to place affected communities on equal footing with well-resourced industry stakeholders, with a large number of commenters expressing concern that the Commission historically has favored industry preferences at the expense of communities and consumers," p. 14 (*available at* https://www.ferc.gov/media/ferc-report-office-public-participation (last accessed Nov. 4, 2024)).

[30] FERC, "Guidance for Applicants Seeking Licenses or Preliminary Permits for Closed-Loop Pumped Storage Projects at Abandoned Mine Sites (Docket No. AD19-8-000)," (Oct. 2019), *available at* https://cms.ferc.gov/sites/default/files/industries/hydropower/gen-info/guidelines/hydro-development-guide.pdf (last accessed Nov. 4, 2024).

(ii) Is unlikely to adversely affect species listed as a threatened species or endangered species, or designated critical habitat of such species, under the Endangered Species Act of 1973;

(iii) Utilize only reservoirs situated at locations other than natural waterways, lakes, wetlands, and other natural surface water features; and

(iv) Rely only on temporary withdrawals from surface waters or groundwater for the sole purposes of initial fill and periodic recharge needed for project operation.

18 C.F.R. § 7.1(c)(3).

The Project does *not* meet the basic definition of closed-loop pumped storage, and it most certainly does *not* meet the Commission's criteria for a "qualifying" closed-loop pumped storage project. As described in the PAD (p. 3-8), the upper reservoir would impound Long Creek, which is a surface water body and a natural waterway: "Long Creek will be dammed 4.8 miles from it's [*sic*] headwaters." Construction of the upper reservoir alone would, therefore, cause the Project to fail to satisfy three necessary criteria of a "closed-loop pumped storage project," as it would alter the surface hydrology of Long Creek, situate a reservoir on a natural waterway, and rely at least in small part on inflows from Long Creek to maintain water levels in the upper reservoir. *Cf.* 18 C.F.R. § 7.1(c)(3)(i)-(ii), (iv). Further, the PAD's description of the regulating reservoir facilities and operations is not specific enough to show that the Project would *not* also have an ongoing hydrologic connection to the Kiamichi River.[31] Lastly, Section 4.7 of the PAD describes potential Project impacts on federally listed wildlife, plant, and aquatic species and designated critical habitat. *Thus, contrary to the information presented to the public in the PAD and SD1, the Project*

[31] Department of Energy, "What is Pumped Storage Hydropower?," *available at* https://www.energy.gov/eere/water/pumped-storage-hydropower (last accessed Nov. 4, 2024).

would be a conventional pumped storage hydropower project, not *a potentially "qualifying" closed-loop one*.

Commission staff should take immediate action to correct the information provided in SD1 and expressly clarify that the Project is *not* closed-loop and does *not* qualify for any expedited procedures under 18 C.F.R. § 7.1. Staff should also direct SEOPC to correct the PAD and other public materials to remove any claims or references to the proposed Project being closed-loop pumped storage to avoid further misleading jurisdictional agencies, stakeholders, and other members of the public.

SEOPC's description of land ownership in the Project area as entirely private is also misleading, but by omission. The PAD (p. 1-1) states the Project would be located on private land:

> The proposed pumped storage site would be located entirely on private land in southeastern Oklahoma, within Pushmataha County, approximately 5 miles south of the town of Talihina along the Kiamichi River …. The associated transmission line would also be located on private land and extend 99.96 miles through Pushmataha and McCurtain Counties, Oklahoma, and Red River and Lamar Counties, Texas, to its proposed point of interconnection in Paris, Texas.

As stated in Section II, *supra,* the PAD fails to disclose that the proposed pumped storage site and many miles of the associated transmission line would be located within the boundaries of the Choctaw Nation Reservation, as established by the 1830 Treaty of Dancing Rabbit Creek. Even if the proposed Project area would not be directly located on trust lands, SEOPC's characterization of the lands only as "entirely private" ignores entirely the Choctaw Nation Reservation, the Choctaw Nation's sovereign authority over its Reservation under its Treaties, and the importance of its Reservation to the Choctaw people.[32] It also ignores the Nations' shared proprietary interest

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[32] The PAD's characterization of the lands as entirely private fails to "recognize that the crisp binary logic (of Tribal-non-Tribal, private-public, etc.) becomes easily fuzzy given the complex history of Tribal land sovereignty and dispossession …." Vadjunec Letter, p. 1.

in the retained treaty estate, which extends to the bed, banks, and submerged lands under navigable waters that may be impacted by the Project, including its proposed transmission line. *See Choctaw Nation*, 297 U.S. at 628-35. As we discuss further below, SEOPC instead treats the Nations, when the PAD considers them at all, as part of a historical narrative, not as modern-day sovereigns with rights and authority in and over their existing Reservations that are held by treaty, federal statute—including their rights in the Settlement Area protected by the Settlement Act—and under federal common law.

In the absence of this important context for the lands and waters that would be impacted, the PAD (p. 1-1) goes on to assert that the Project "would provide a stable source of cost-effective renewable energy … while also conserving the water resources of the Kiamichi River (SEOPC 2023)." As described below, the information contained in the PAD does not support these sweeping statements as to Project benefits and SEOPC has not yet disclosed any specific plans to gather information sufficient to overcome the deficiencies in the proposal.

Section 1.1.3 Purpose of the Pre-Application Document

Contrary to SEOPC's claims (*see* PAD, p. 1-3), the PAD does not fulfill the basic regulatory purpose, which is to provide the Commission and other interested entities with "existing, relevant, and reasonably available information … to enable them to identify issues and related information needs, develop study requests and study plans, and prepare documents analyzing any license application that may be filed." 18 C.F.R. § 5.6(b)(1).

Section 2.1 Process Plan and Schedule

SEOPC's proposed Process Plan and Schedule do not describe adequate outreach to Tribes and landowners. For example, the plan does not list any milestones for government-to-government consultation between the Commission and the Nations or other Tribes. This is inconsistent with the Commission's "Policy Statement on consultation with Indian Tribes in Commission Proceedings," which provides the following, in part:

> Through several Executive Orders and a Presidential Memorandum, departments and agencies of the Executive Branch have been urged to consult with federally-recognized Indian tribes in a manner that recognizes the government-to-government relationship between these agencies and tribes. In essence, *this means that consultation should involve direct contact between agencies and tribes and should recognize the status of the tribes as governmental sovereigns*.

18 C.F.R. § 2.1c(a) (emphasis added).

SEOPC's Process Plan similarly omits milestones related to the Commission's consultation obligations under National Historic Preservation Act ("NHPA") section 106, 54 U.S.C. § 306108. While the Commission may use an applicant "to prepare information, analyses, and recommendations" (36 C.F.R. § 800.2(a)(3)), it *cannot* delegate its "statutory obligation … to fulfill the requirements of section 106" to any applicant or consultant (*id.* at § 800.2(a)). Further, neither Nation has consented to a consultation process administered by SEOPC. Instead, both have requested government-to-government consultation. The Chickasaw Nation has further requested that information related to historical and cultural resources be provided by the Commission, not SEOPC: "***Accordingly, given our sovereign status and the nature of confidential information shared in government-to-government consultation (which information may need protections provided by federal law), we request all project correspondence with the Chickasaw Nation concerning historic and cultural resources come from the Commission, itself***."[33]

Given the scale of the proposed Project, its location within the Choctaw Reservation and within the "Settlement Waters" and "Settlement Area," as defined in the Settlement Agreement

[33] Letter from Chickasaw Nation Division of Historic Preservation (CNDHP) to Acting Sec'y Reese, eLibrary no. 20240905-5175 (Sept. 5, 2024) ("CNDHP Comments"; Attachment 8), p. 2 (emphasis in original).

and Act, and the incomplete information regarding the proposed Project location provided by SEOPC, Commission staff should meet with the Nations and other interested Tribes and landowners, not just rely on written comments, prior to defining the Area of Potential Effects ("APE") for purposes of the NHPA. FERC must ensure such meetings take place in order to comply with its consultation obligations to the Nations, 36 C.F.R. § 800.2(c)(2)(i), as well as its obligation to "identify and discuss relevant preservation issues" regarding historic properties of tribal significance to Indian tribes and "resolve concerns about the confidentiality of information on historic properties." 36 C.F.R. § 800.2(c)(2)(ii)(A).

Aside from its failure to describe and plan for adequate consultation, SEOPC's PAD also puts the cart before the horse in its study proposals. SEOPC proposes to initiate "Year 1 Studies" *prior* to the study plan meeting and the end of the comment period on the initial proposed study plan (*see* 18 C.F.R. § 5.11(e), 5.12), and months in advance of the OEP Director's issuance of the study plan determination (*see id.* at § 5.13(c)). That does not comply with Commission regulations, which require that a study plan will be approved by the study plan determination, *id.* § 5.13(d), and that the applicant "gather and conduct studies *as provided for in the **approved** study plan and schedule*." *Id.* § 5.15(a) (emphasis added). SEOPC should not start licensing studies before the Commission has approved the specific study plans. And the Commission can only approve of those study plans after the public, other federal agencies, and the Nations review and comment on SEOPC's proposals and SEOPC modifies is plans to meet their concerns (or explains why it has decided not to modify them), and the period for a formal study dispute has passed. *See id.* §§ 5.12, 5.13(a)-(b), 5.14(a). Studies performed outside of the requirements of the ILP do not satisfy SEOPC's obligations and may result in a deficient license application.

SEOPC's proposed schedule for completion of its studies is also inordinately short. Although it is divided into "Year 1" and "Year 2" studies, SEOPC proposes to complete studies within twelve months of initiation, and over nine months of work. SEOPC apparently intends to complete Year 1 Studies within three months (October 25, 2024, to January 17, 2025). *See* PAD, p. 2-1, Table 2-1. It also proposes to file the initial study report a scant two months after the OEP Director's study plan determination. *Id.* SEOPC then proposes, a little over a month later, to undertake Year 2 studies in just an additional six months, from July 20, 2025, to January 17, 2026, and only for "resource areas that require additional data gathering" in SEOPC's estimation. *Id.* at 2-1 to 2-2, Table 2-1 (stating Year 2 studies would go from "July 20 to January 17, 2025 [*sic*]"). Although these exact proposed deadlines may change due to the extension of the comment period to which SEOPC consented,[34] SEOPC has given no indication it intends to give more time for Year 1 and Year 2 studies.

This compressed time period, coupled with SEOPC's truncated schedule for Year 1 Studies, would not provide adequate opportunity for SEOPC to study and document baseline conditions or potential Project impacts. It clearly does not give enough time to complete Commission review of the initial study report under 18 C.F.R. § 5.15(c)(2)-(7), or enough time to obtain Commission approval for "new information gathering" which SEOPC apparently contemplates, *cf. id.* § 5.15(e). So, the "Year 2" studies *could not* comply with the ILP. Aside from SEOPC's failure to comply with the ILP regulations, the proposed study periods for both Year 1 and 2 studies are fatally flawed because they would partially omit typically high-flow periods of

[34] The PAD says that SEOPC will "revise and maintain" an updated version of "the process plan and schedule on the Project website," p. 2-1, but there is no timeline or schedule on the rudimentary website available at the URL provided in the PAD. Nor does it include most of the information which SEOPC claims it will maintain there to keep the public informed about the project, *see* p. 2-2.

the year, when SEOPC would withdraw flows from the Kiamichi River to fill and recharge Project reservoirs. These periods of time need the most study, not the least.

<u>Section 2.2 Stakeholder Participation</u>

The PAD states (p. 2-2(a)):

> SEOPC has exercised due diligence in determining what information exists that is relevant to describing the existing environment, this was done by SEOPC's consultant SWCA who reached out to the various Federal, state, and interstate resource agencies, Indian Tribes, local governments to gather information contained in this PAD.

The Nations vehemently dispute these statements. The numerous deficiencies in the PAD show that SEOPC has *not* exercised due diligence to date despite having been awarded its first preliminary permit in early 2019, more than 5 years ago.[35] In its initial preliminary permit application, SEOPC proposed to "[d]iscuss water rights and existing hydrologic data with the Choctaw Indian Nation [*sic*]" within the first twelve months after the permit was granted.[36] Years later, these discussions have yet to occur. SEOPC failed to achieve another stated goal for the first year of its permit, which was to "[c]onsult with and enter into agreements with appropriate governmental agencies." *Id.* Instead, SEOPC's first recorded contact with the "Chicasaw" [*sic*] and Choctaw Nations was via email in November 2023 (PAD, Appendix A, p. 2). But, because SEOPC's contact list for the Choctaw Nation is incomplete and the information for specific representatives is incorrect, that November email communication did not result in adequate information sharing or consultation with the Nation. These errors, which could have been avoided through due diligence, have contributed to the Nations' representatives not receiving complete or

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[35] *See* FERC, Order Issuing Preliminary Permit, Denying Competing Application, and Granting Priority to File License Application under P-14890 and P-14965 (Apr. 10, 2019), eLibrary no. 20190410-3039.

[36] SEOPC, Application for Preliminary Permit for Pumped Hydroelectric Storage Project (Jul. 31, 2018), eLibrary no. 20180801-5213, p. 13.

timely notices. *See* Chickasaw Nation and Choctaw Nation of Oklahoma's Joint Request for Extension of Time to File Comments on Pre- Application Document and Scoping Document 1 and Study Requests (Aug. 15, 2024), eLibrary no. 20240815-5171 ("Request for Time Extension"), p. 6.

Furthermore, SEOPC through its SWCA Consultants have, on multiple occasions, failed to provide requested information to the Choctaw Nation of Oklahoma Historic Preservation Department ("CNHPD"):

> The Choctaw Nation of Oklahoma Historic Preservation Department (CNHPD) received a copy of the transmittal letter from Indya Messier, Project Manager with SWCA Environmental Consultants, on February 1, 2024. CNHPD requested additional information on March 1, 2024, but no additional information was provided. CNHPD received a copy of the pre-application document for the Choctaw Nation Environmental Protection Service on April 2, 2024. CNHPD attempted to contact Randa Horton (SWCA), the tribal liaison listed in the pre-application document, on June 7, 2024, but the phone line was disconnected.

CNHPD letter to FERC Docket, eLibrary no. 20240906-5006 (Sept. 6, 2024) ("CNHPD Comments"; Attachment 9), p. 1.

As stated above, the Nations object to Commission Staff's acceptance of the Notice of Intent and PAD filed by SEOPC in May 2024. Based on our review, it does not appear Commission staff adequately verified fundamental elements of SEOPC's proposal, like whether it actually meets the definition of a "closed-loop" Project, before it accepted this latest PAD. Staff accepted the PAD, notwithstanding SEOPC's failure to correct the previously identified deficiencies in stakeholder engagement that were the basis for Staff's rejection of SEOPC's initial PAD. More specifically, the PAD dated May 7 does not address OEP's direction to "summarize how any responses [from Tribes and landowners] were incorporated into the PAD pursuant to section 5.6(b)(5) of the Commission's regulations" (eLibrary no. 20240419-3004, p. 2).

The PAD (p. 2-3) also provides incorrect information regarding Section 106 consulting parties' and landowners' rights to access certain Project-related information that may be filed as non-public.[37] Allowing an applicant to provide incorrect instructions for accessing information is inconsistent with OPP Staff's efforts to "empower, promote, and support public voices in Commission proceedings." Letter from OPP Staff to Community Leaders, "Seeking Public Comments on the Proposed Pushmataha County Pumped Storage Hydroelectric Project," (July 23, 2024), p. 3.

<u>Section 3.1 Project Location, Boundary, and Land Ownership</u>

The Commission's regulations require that a PAD include:

> Detailed maps showing lands and waters within the project boundary by township, range, and section, as well as by state, county, river, river mile, and closest town, and also showing the specific location of any Federal and tribal lands, and the location of proposed project facilities, including roads, transmission lines, and any other appurtenant facilities.

18 C.F.R. § 5.6(d)(2)(ii). The PAD (p. 3-1) references Figure 3-1 as satisfying these mapping requirements. However, Figure 3-1 and other maps provided in the PAD fall far short of the mark.

As stated above, the proposed Project would be sited primarily on the Choctaw Reservation and would rely on the same waters relied upon by both Nations. However, SEOPC has repeatedly denied the Choctaw Nation timely access to adequate information regarding Project location. *See* Request for Time Extension, pp. 4-7. The PAD continues this pattern. The poor quality of the mapping resolution in Figure 3-1 makes it very difficult to understand or evaluate the proposed

[37] The PAD provides the instruction that, "[a]nyone seeking confidential or Privileged information from FERC must file a Freedom of Information Act ["FOIA"] request." *Id.* This is incorrect. FERC's regulations include procedures for obtaining information, which is filed as privileged in proceedings that are subject to a right of intervention, that do not require filing a FOIA request. *See* 18 C.F.R. § 388.112(b).

location of principal Project features and verify SEOPC's representations regarding land ownership. Other stakeholders have objected to SEOPC's "fuzzy and unreasonable" maps, too.[38]

SEOPC finally provided the Choctaw Nation maps and GIS files in July 2024 (*see id.* at 7). But those maps and files are likewise inadequate. They do not depict land ownership, land use, or unique characteristics of the physical landscape. The information provided to the CNHPD includes only crude lines to indicate the boundaries of the Project and the transmission lines. As a result, the information regarding the proposed Project location has become known to the Nations only through our own due diligence, research, and site visits conducted by our staff—even though at this stage, providing this information is the *applicant*'s obligation, and should have been done in the PAD.

Based on our preliminary review of the information we have collected, it appears that the Project boundary in the area of the pumped storage facilities includes multiple tracts of established ranch lands, including a ranch that sells their products internationally, family homesteads, bed and breakfast accommodations, prime hunting lands, and other tourist attractions on the Kiamichi River. The Project boundary around the pumped storage facilities also includes several tracts of federal lands administered by the U.S. Forest Service ("USFS") and tracts of state lands. SEOPC should include this information in a revised PAD, and overall provide more transparency about the characteristics of the area and types of land use.

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[38] *See, e.g.,* Pushmataha County Rural Water District, "Public Comment In Opposition to Project Number 14890 for the Construction of a Closed-Loop H Plant on the Kiamichi River," eLibrary no. 20240730-0002 (July 30, 2024), p. 1 (RWD Comments) ("Also, we have asked multiple times for clear maps of the project area so that we can see exactly what area and meters will be affected. All the maps have been fuzzy and unreadable."); "Study Request Submission and Official Opposition Comments by the Town of Albion, Oklahoma," eLibrary no. 20240904-5086 (Sept. 4, 2024) (describing "undiscernible maps provided by the prospective applicant") (Albion Comments); August 9 Scoping Meeting Transcript, 20240823-4005 (Aug. 23, 2024), p. 19 (Seth Willyard: "The maps they presented were unreadable.")).

The PAD does not adequately show or describe waters within the proposed Project boundary. The upper reservoir facilities would dam Long Creek, located within the Upper Little River Basin, but the figures in the PAD do not even depict Long Creek. Further, there are multiple ephemeral outflows from the mountain – Clear Creek, Albion Creek, and Walnut Creek – that feed the Kiamichi River during precipitation events. As a result of the construction of the lower and re-regulating reservoirs, these creeks could be completely cut off from the overland flow that contributes to the mean annual flow for water availability modeling in the Settlement Agreement. *See* Settlement Agreement §1.39.

Further, the PAD states that the proposed Project boundary would include thousands of acres for transmission line right-of-way ("ROW"):

> The remaining 24,575.96 acres (69.75%) of Project lands are right-of-way (ROW) buffers surrounding the proposed transmission line.… The currently proposed route would be co-located with existing transmission for approximately 23.28 miles and constructed along a new path for the remaining 76.68 miles, a total of 99.96 miles. A 150-foot ROW would be secured for the portion of the transmission line co-located with existing transmission lines and a 0.25-mile ROW for the portion constructed along a new path …. The exact route, number of circuits, voltage, and configuration of the proposed Project's point of interconnection with the transmission grid will be determined in consultation with Electric Reliability Council of Texas (ERCOT) during the pre-application and scoping phases to minimize effects to resources and landowners.

Id. at 3-1.

The PAD, including Figures 1-1 and 3-1, does not satisfy SEOPC's obligation to show the specific location of the proposed ROW. These figures do not even depict the location of the existing transmission line with which SEOPC proposes to co-locate the Project transmission line, nor does SEOPC describe any factors relevant to the feasibility of co-location. Again, the mapping resolution in the figures is too poor for the Nations and landowners to determine which properties could be impacted by the ROW.[39]

Section 3.2. Project Facilities, Components, and Operations

As with the Project location information, the PAD's description of proposed Project facilities, components, and operations is incomplete. The Commission's regulations require an applicant to provide a detailed description of the proposed project facilities, components, and operations. *See* 18 C.F.R. § 5.6(d)(2)(iii). That an applicant's proposal may subsequently be modified based on further studies does not excuse its responsibility to provide a complete proposal for purposes of informing the public and scoping the Commission's environmental analysis under NEPA, 42 U.S.C. § 4332, and comprehensive planning under the FPA, 16 U.S.C. § 803(a). An incomplete description suggests either that the applicant has not developed a plan for the Project, or that the applicant intends to engineer the Project only as it moves forward, neither of which satisfy 18 C.F.R. § 5.6(d)(2)(iii).

An applicant must also show the specific location of proposed project roads. Instead of providing this information in Section 3.2, SEOPC vaguely describes its intent to consult further

[39] The Oklahoma Attorney General objected to SEOPC's failure to provide information regarding which landowners would be impacted by the proposed Project, and to SEOPC's intended "liberal reliance" on condemnation:

> … while SEOPC gives an indication it intends a liberal reliance on powers of condemnation to acquire private property from Oklahomans to build its project, it remains utterly opaque as to who might be affected. Most of the proud Oklahomans who call the Kiamichi region home have lived there for generations. And I intend, as Oklahoma's Attorney General, to ensure that their private property rights are safeguarded to the full extent of the law.

Letter from Oklahoma Attorney General to Secretary Reese, eLibrary no. 20240829-5052 (Aug. 28, 2024), p. 2 ("OAG Comments"). Furthermore, the Town of Albion (Albion Comments, p. 2) also expressed concern:

> The current project area encompasses 35,235.67 acres of land, impacting approximately 520 landowners in Oklahoma and Texas. The facility and transmission line construction will require vast condemnation of private land. Given advances in BESS (Battery Energy Storage Systems), we question the project's ability to demonstrate public benefit and request FERC thoroughly review alternatives before issuing a license.

regarding road access needed for the Project: "[h]owever, SEOPC will continue to consult with local authorities to determine which access roads may need to be constructed or improved for either construction or operation and maintenance of the Project during the term of the license." PAD, p. 3-3. The PAD later indicates the need for road and other access improvements may be significant given the rural and largely undeveloped character of the private lands within the proposed Project boundary: "[i]t is worth noting, however, the limited access to lands within the proposed Project boundary surrounding the pumped storage site, which is located fully within private property. [¶] Vehicle access is limited to a small number of narrow, unimproved county roads …." *Id.* at 4-106. SEOPC says nothing about the type, weight, and frequency of use of the vehicles that would use these roads, even though that information is essential to assessing its roadway needs.

The PAD describes the Project's potential reliance on a USFS road to access the upper reservoir facilities: "[t]he upper reservoir facilities site is accessible via Kiamichi Trail, a [USFS] road known as K-Road, which is a dirt road that runs east-west along the Kiamichi Mountain Ridge." However, the PAD does not describe any consultation with agency staff to discuss the feasibility of using USFS roads or other facilities for Project construction, operation, and maintenance, or what authorizations would be necessary. The PAD also fails to disclose that the Kiamichi Trail, or "K-Trail," is a historic resource.[40] This does not comply with SEOPC's obligation to "[n]otify the Commission staff of all other Federal actions required for completion of the proposed action so that the staff may coordinate with other interested Federal agencies." 18 C.F.R. § 380.3(b)(5).

[40] Letter from CNHPD to FERC Docket, eLibrary no. 20240906-5006 (Sept. 5, 2024) (CNHPD Comments), p. 2.

Moreover, SEOPC's representations are incorrect. Based on the Nations' field investigation, the proposed upper reservoir site is *not* accessible from the Kiamichi Trail. The reservoir must be accessed by privately constructed and maintained access roads or along ONEOK's gas line right-of-way, which runs down from the ridge line, through private property, to Long Creek. And the Kiamichi Trail is not simply a "dirt road." It is a one-lane, rock and dirt trail that can only be traversed using four-wheel drive or an all-terrain vehicle, which passes through numerous private, residential parcels. SEOPC says nothing about how it intends to improve this road and construct new access roads or improve existing ones to reach the upper reservoir site. That failure leaves unanswered the question of whether construction access is feasible.

SEOPC's failure to include a reasonably complete description of roads needed and proposed to be improved and/or constructed and permitted for the Project is another data gap in the PAD that should be corrected *before* the Commission moves forward with scoping.

Section 3.2.1 Dams, Reservoirs, and Water Conveyance Features

The PAD (p. 3-3) provides the following overview of the pumped storage facilities:

> The proposed closed-loop pumped storage Project would generally consist of three distinct aboveground areas: upper reservoir, lower reservoir, and regulating reservoir facilities. In general, a high flow diversion structure adjacent to the Kiamichi River would allow for both initial fill and periodic recharge of the system, as needed, when flows are high in the river.

The scale of the proposed facilities is immense and will require "multiple complex steps" to construct. Expert Report of Fred P. Ehat, P.E. ("Ehat Report"; Attachment 3) ¶ 6. In addition to concerns regarding the Project's withdrawals from the Kiamichi River, the Nations are concerned that the Project reservoirs could pose a significant threat to public safety and property in circumstances of dam failure or spillway operations. *Id.* ¶ 14. Project design is a key component of dam safety,[41] but the PAD does not describe how SEOPC has considered safety in the proposed design. For example, the PAD does not state whether SEOPC intends to install a liner to prevent leakage at the upper reservoir and, if so, what material would be used.[42] This is of concern because leakage from the proposed upper reservoir and associated facilities could contribute to instability, which could lead to landslides or other geologic hazards in the area and in turn, undermine the stability of the upper reservoir dam.[43] It could also interfere with utility infrastructure in the Project area, including but not limited to the ONEOK natural gas transmission line described below, which could present localized dangers as well as risks for local communities that depend on that utility infrastructure.

Further, the PAD does not provide specific information regarding suitability of soils and geologic resources in the Project area to support the Project reservoirs, pipelines, powerhouse, and other appurtenant Project structures. This is a glaring gap in the PAD, given the importance of geologic and hydrogeologic conditions to evaluating constructability of the Project, particularly this one which includes construction of high-hazard dams to create high-storage capacity reservoirs, and underground tunnels, powerhouse, and other infrastructure. *See* Ehat Report ¶¶ 9-15.

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[41] *See, e.g.,* Independent Forensic Team, Final Report Investigation of Failures of Edenville and Sanford Dams (May 2022), *available at* https://damsafety-prod.s3.amazonaws.com/s3fs-public/files/Edenville-Sanford_Final%20Report_Main%20Report%20and%20Appendices.pdf (last accessed Nov. 4, 2024), § 7.1.2.

[42] SEOPC's application for an extension of the preliminary permit depicted an impermeable liner at the lower reservoir in maps of reservoir sites that SEOPC described as "conceptual," *see* Application for Preliminary Permit Extension at 14; *id.* Ex. 3, Map B, pages 1-3, but the PAD does not describe any anticipated use of a liner at the lower reservoir.

[43] Extensive geotechnical investigation will be required to evaluate measures necessary for safe construction and operation of the project, and to determine whether it is even feasible for SEOPC implement those measures effectively. Ehat Report, ¶ 5 Such investigation should include, but not be limited to, "evaluating each dam's foundation for seepage potential, each reservoir's holding capability, dam foundation settlement potential, groundwater issues, rock foundation treatment, seismic loading, landslide potential, as well as identifying acceptable borrow areas for engineered fill zoning and waste areas." Ehat Report ¶ 9.

SEOPC states that it "anticipates" undertaking site-specific studies at the pumped storage facilities during the remaining term of its preliminary permit. We note that the Commission extended SEOPC's preliminary permit until March 31, 2027, *see Se. Oklahoma Power Corp.*, 183 FERC ¶ 62,012 (2023), which is *afte*r SEOPC plans to submit the Final License Application (proposed to be filed on March 5, 2027), *see* PAD, p. 2-2(a). Commission staff should ensure SEOPC's final study plan and schedule require that SEOPC complete site-specific studies and field investigations pre-application and as early in the proceeding as possible, consistent with the Commission's regulations, *see* 18 C.F.R. § 4.38, and "[b]ecause the[se] data gaps could impact the feasibility of the endeavor" (Ehat Report ¶ 5).

Section 3.2.1.1 Upper Reservoir Facilities

The PAD (p. 3-3) describes the proposed construction of a massive upper reservoir and appurtenant facilities, but states the feasibility of the proposed design has not yet been verified through field investigations:

> SEOPC proposes to construct an 886-foot-long, 282-foot-high, concrete-faced, rockfill upper dam with a 196.85-foot-long, 17-foot-high emergency spillway with a channel to Long Creek. It is anticipated that the 196.85-foot-wide spillway would funnel down to a spillway channel of an appropriate length. Inundation from the upper dam would create an upper reservoir with a surface area of approximately 599.55 acres and a storage capacity of approximately 68,269 acre feet (AF). Water would be transported to and from the upper reservoir via a 98.4-foot-long, 39.4-foot-high, concrete upper intake/outlet structure that would convey flow through a 7,030-foot-long, 32.8-foot-diameter, steel and concrete headrace tunnel to and from an underground pumping station/powerhouse. Detailed site-specific investigations have not been conducted for the proposed Project and are anticipated to be completed during the remaining term of the permit.

This is a very tall dam with a high storage capacity, which would impound an immense volume and weight of water when in use. And SEOPC does not presently know whether it can be constructed (or even assessed for construction, much less whether it can operate safely if constructed). For context, FERC imposes additional, independent dam safety inspection requirements for any dam "[t]hat is more than 32.8 feet (10 meters) in height above streambed" or has "an impoundment gross storage capacity of more than 2,000 acre feet," which is a fraction of the size proposed by SEOPC. 18 C.F.R. § 12.30.

Given the proposed upper reservoir dam's height and storage capacity, it would almost certainly qualify for a significant hazard or high hazard potential classification:

> Hazard potential for any dam or water conveyance is a classification based on the potential consequences in the event of failure or misoperation of the dam or water conveyance, and is subdivided into categories (e.g., Low, Significant, High).
>
> (i) High hazard potential generally indicates that failure or misoperation will probably cause loss of human life.
>
> (ii) Significant hazard potential generally indicates that failure or misoperation will probably not cause loss of human life but may have some amount of economic, environmental, or other consequences.

18 C.F.R. § 12.3(13)(i)-(ii). Yet, SEOPC says nothing to acknowledge the safety risks posed by this proposed dam or how they might be assessed—and ameliorated, if at all—through pre-construction assessments of safety or construction methods and design. Ehat Report ¶¶ 9-15 (describing investigations required to assess construction risks). It is of vital importance that this matter be studied and explained to the public as part of the ILP.

The volume, weight, and elevation of the water impounded by the dam, and its likely significant hazard or high hazard potential, also raise concerns about spillway safety and design.[44] In addition to the Commission's dam safety requirements, the U.S. Army Corps of Engineers'

[44] According to the Nations' expert analysis, the Project should include "an engineered fail-safe system incorporated for all project reservoirs, as appropriate, to prevent the potential for overtopping to avoid" potential dam failure (citing Taum Sauk). Ehat Report ¶ 14.

("USACE") policies direct that the applicant acquire lands downstream of spillways for hazardous dams:

> A policy of public safety awareness will be adhered to in all phases of design and operation of dam and lake projects to assure adequate security for the general public in areas downstream from spillways. A real estate interest will be required in those areas downstream of a spillway where spillway discharge could create or significantly increase a hazardous condition. The real estate interest will extend downstream to where the spillway discharge would not significantly increase hazards. A real estate interest is not required in areas where flood conditions would clearly be nonhazardous.

33 C.F.R. § 222.2.

Yet, the PAD does not describe whether SEOPC proposes to acquire lands downstream of the reservoir spillway to avoid or minimize risks to public safety and private property. It does not describe whether the capacity of the spillway channel has been sized to avoid or just mitigate flooding in the event of spillway operation or potential dam failure under emergency conditions. In fact, it does not describe any plans for slope stability analyses downgradient of the spillway. Again, based on our review, the PAD does not specifically address ***any*** dam safety considerations, including spillway design and operation. As with the risks of the dam design, the risks posed by dam spillways *must* be studied, evaluated, and explained to the public.

The PAD also fails to describe potential spillway operations. The Commission should require SEOPC to undertake modeling studies that evaluate potential spillway discharges to Long Creek, and the potential erosion and sedimentation impacts of those discharges. In addition to the physical impacts of spillway discharges on Long Creek's banks, channel, and bed, SEOPC should be required to study the potential water quality impacts, and attendant aquatic habitat impacts, of any potential project discharges, including those from the spillway. For example, SEOPC should be required to describe the likely water quality parameters, including turbidity, pH, and dissolved oxygen, to Long Creek and downstream waters, during any operation of the upper spillway for testing or in an emergency. This list is non-exclusive, as further review may indicate other water quality issues should be evaluated.

Although the construction of the upper reservoir would permanently dam Long Creek at its headwaters and convert up to 4.8-miles of a natural waterway into an impoundment, the PAD does not provide adequate information regarding the baseline "quantity and quality" conditions of Long Creek. It does not describe Black Fork and Pine Creeks, which are located downstream of Long Creek and part of the Little River tributary system (upstream of its confluence with the Red River).[45] As the U.S. Fish and Wildlife ("FWS") commented:

> Impoundment of Long Creek for the upper reservoir also would reduce flows in portions of the Little River watershed that support many federally-listed species. Project effects related to flow modifications have not been described in the PAD, *e.g.*, in sections 4.3.5, 4.4.6, 4.7.4., or 4.8.5. Prior to permit application, the SEOPC should describe potential effects of streamflow alteration and planned measures to avoid or reduce such effects.

Letter from Ken Collins (Field Supervisor) to Secretary Reese Dated July 30, 2024, eLibrary no. 20240731-5011 (July 30, 2024), p. 3 ("FWS Comments"). The Nations support the FWS's comments.

The PAD also does not provide adequate information regarding hydrogeologic resources at the upper reservoir site, *see infra* Section 4.3.1.4 at pp. 83-86.

Section 3.2.1.2 Lower Reservoir Facilities

The PAD (pp. 3-4 – 3-5) provides a high-level description of the lower reservoir facilities, but states details remain to be determined based on further investigations:

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[45] The PAD jumps straight from Long Creek to the Little River: "The Upper Little River Subbasin, includes Long Creek in the upper section of the Little River, a major tributary of the Red River …." PAD, p. 4-30. Table 4-4, "Surface Waters within the Proposed Project Boundary," does not list Pine Creek. *See id.*

> Water would be transported to and from the underground pumping station/powerhouse via an 8,243-foot-long, 32.8-foot-diameter tailrace tunnel through a 98.4-foot-long, 39.4-foot-high, concrete lower intake/outlet structure to a lower reservoir with a surface area of 887.37 acres and a storage capacity of 48,699 AF. The lower reservoir would be inundated by a 13,615-foot-long, 68.9-foot-high, earthen lower dam with a 33-foot-long, 13-foot-high emergency spillway with a channel that becomes a tunnel to the Kiamichi River. It is anticipated that the spillway channel for the lower reservoir would be 33 feet wide at the spillway and would transition into a tunnel linking the lower reservoir to the Kiamichi River; the tunnel would be regulated by a metal gate and used for emergency overflow only. Detailed site-specific investigations have not been conducted for the proposed Project and are anticipated to be completed during the remaining term of the permit.

Like the upper reservoir facilities, the scale of the lower reservoir facilities is immense. The lower dam—the location of which is not described in the PAD or shown on Figure 3-1(a), in violation of 18 C.F.R. § 5.6(d)(2)(iii)(A)—would also likely be designated as significant hazard or high hazard and subject to additional dam safety requirements. As with the upper reservoir, the PAD does not show the capacity of the spillway tunnel as designed will be adequate to avoid or mitigate downstream flooding in the event of spillway operations. It does not describe any plans for slope stability analyses downgradient of the spillway or describe why such studies are not needed.

According to the PAD, any operation of the lower reservoir spillway would result in discharges to the Kiamichi River. As with the upper reservoir, the PAD does not describe, even preliminarily, potential rates or volume of discharge under testing or emergency lower reservoir spillway operation. The Commission should require SEOPC to undertake modeling studies that show the range of potential spillway discharges to the Kiamichi River, and the potential erosion and sedimentation impacts of those discharges. In addition to the physical impacts of spillway discharges on the Kiamichi River banks, channel, and bed, SEOPC should also be required to study the potential water quality impacts, and attendant aquatic habitat impacts, of potential spillway operation. For example, SEOPC should be required to describe the likely water quality parameters, including turbidity, pH, and dissolved oxygen, of any potential discharges from the lower reservoir.

<u>*Section 3.2.1.3 Regulating Reservoir Facilities*</u>

The PAD's description of the regulating reservoir includes the facilities that would withdraw flow from the Kiamichi River, which SEOPC alternatively refers to as an "intake structure" and a "high flow diversion structure":

> Two additional, 20-inch-diameter, 525-foot-long pipes with two 110-kilowatt pumps would be designed to move water from the Kiamichi River to the regulating reservoir. Water would enter the two withdrawal pipes via a 40-foot-long, 40-foot-wide funnel shaped intake structure located 1.5 feet above the bottom of the Kiamichi River at approximately 593 feet above mean sea level (amsl) and tapering down to 10-foot-long, 10-foot-wide section known as the water supply channel.

PAD, p. 3-5.[46]

The PAD does not provide any explanation or justification for the proposed size and capacity of the withdrawal pipes, which appear over-sized in relation to the size of the Kiamichi River in this area. Commission staff should direct SEOPC to disclose the range of potential pumping rates and the flow capacity measured in cubic feet per second ("cfs") of the proposed withdrawal pipes.

SEOPC proposes to position the intake 1.5 feet above the bottom of the Kiamichi River bed and describes the intake as being designed to "allow for both initial fill and periodic recharge of the system when flows are high in the river" (*id.* at 3-3). The PAD does not quantify the "high"

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[46] The PAD initially describes "*a high flow diversion structure* adjacent to the Kiamichi River," (PAD, p. 3-5 (emphasis added)), but subsequently states "[t]he proposed Project *would not include a diversion structure*; instead, it would have a 40-foot-long, 40-foot-wide funnel-shaped intake structure at the river's bank" (*id.* at 4-25 (emphasis added)).

flows that are the basis for its intake structure design even though this information is material to the description of project facilities and also required to properly characterize water resources under the Commission's ILP regulations. 18 C.F.R. § 5.6(d)(3)(iii)(B)-(C) (requiring the PAD include "monthly minimum, mean, and maximum recorded flows in cubic feet per second of the stream or other body of water at the powerplant intake or point of diversion" and "[a] monthly flow duration rule curve during the period of record").

Further, the description in the PAD does not demonstrate that the intake as designed will be limited to operation during high flow events. For example, the PAD does not cite to channel cross-section data, preliminary hydrologic modeling or engineering studies to support SEOPC's claim that simply positioning the intake 1.5 feet above the river bottom would physically limit SEOPC's ability to withdraw water outside of high flow events. Our knowledge of the proposed intake area—which it appears SEOPC may have never actually visited—suggests that the River runs higher than 1.5 feet at this location, even during low-flow periods.

The PAD does not describe any potential operational rules, apart from intake positioning, that could prevent capture of flows outside of high flow events or help to avoid, minimize, or mitigate potential adverse environmental impacts of excessive withdrawals. Instead, based on the limited information in the PAD (pp. 3-5, 4-25), it appears SEOPC has prioritized only withdrawal capacity in designing the intake structure. Furthermore, an intake 1.5 feet above the river bottom is obviously highly vulnerable to damage from various sources, e.g., boating, floating debris, and to clogging from ingested debris and sediment.

SEOPC should also be required to clarify the extent to which proposed Project operations could result in discharges from the regulating or lower reservoirs back into the Kiamichi River.

Such return discharges could potentially impact water quality, aquatic resources, and existing water rights holders.

Section 3.2.2 Powerhouse

The PAD (p. 3-7) describes construction of a large underground powerhouse, but it does not show the specific location of the proposed powerhouse or describe the geologic and hydrogeologic characteristics at the site. The lack of detail is concerning given the logistics management required for this type of underground construction.[47] This is information that could have been obtained by SEOPC in the past 5 years with due diligence and should have been included in the PAD. At present, the only conclusion that can be drawn from that omission is that SEOPC does not know if the powerhouse can be built at the site.

The PAD (p. 3-7) provides a general description of proposed operations:

> Average annual energy output is estimated to be approximately 10 hours of generation, 7 days a week, 4,368,000 megawatt hours annually or 364,000 megawatt hours monthly. SEOPC proposes to use a variable speed, pumped hydro configuration with an overall cycle efficiency for pumping and generating of approximately 80%, and a power factor of 0.9. SEOPC will perform economic modeling, cost-benefit analysis, system need analysis, and market analysis to determine the optimal size and configuration. Additional details regarding the switchyard, cable tunnel, and access tunnels will be provided in subsequent licensing documentation.

SEOPC's statement that it proposes to develop a powerhouse configuration that operates at the upper end of potential overall cycle efficiency for any pumped storage project is precatory, at best, given that SEOPC has not yet performed economic modeling, cost-benefit analysis, system need analysis, or energy market analysis to determine feasible or optimal size and configuration

[47] "Significant tunneling – the logistics and time alone for driving five (5) or six (6) tunnels and the pump/generating house chamber will require significant coordination and planning." Ehat Report ¶ 6.

of the Project.[48] Without this information, SEOPC does not have a credible basis for its estimate of dependable capacity or average annual and monthly energy production and cannot be said to have met its obligations under 18 C.F.R. § 5.6(d)(2)(iii)(E).

In addition to evaluation of the feasibility of the proposed Project, SEOPC must provide more specific information regarding Project operations for the Commission, resource agencies, Tribes, and stakeholders to evaluate the Project's energy demands during pumping cycles, potential sources to meet Project energy demands, and the potential impacts of this increased energy demand on the local energy grid and market. This information is critical for evaluating impacts on the community, as pumped storage projects are a net energy consumer. The Nations are very concerned that the Project's demand for electricity in the surrounding community will increase the costs of energy for residents and the businesses and services they rely on.

Section 3.2.3 Transmission Lines

The PAD (p. 3-7) provides a very basic description of the approximately 100-mile proposed Project transmission line: "The proposed Project would include the construction of a 99.96-mile-long, 345-kilovolt primary transmission line, connecting the powerhouse to a point of interconnection with ERCOT's transmission grid in Paris, Texas." The PAD (p. 4-2(a)) later reveals that the transmission line would cross several waterways:

> Within the Upper-Little Basin the proposed Project's associated transmission line crosses several streams and rivers, including: the Little River of the Upper Little Subbasin; the Red River and Pecan Bayou of the Pecan-Waterhole Subbasin; Cuthand Creek in the Lower Sulphur Subbasin; and the Big Sandy Creek of the Sulphur Headwaters Subbasin. Notably, the Sulphur River is a key tributary of the

[48] "Margins on pump generating systems can be very tight with respect to cost recovery. The economics associated with the project should be clearly explained. An overall system hydraulic and hydrologic analysis needs to be performed taking into account operation requirements of the pump systems, pump/generating systems, river fluctuation, estimates of seepage, station service needs, cavitation potential, accounting for water rights, seasonal effects, evaporation, hydrology, etc. to verify the economic and engineering assumptions being made." Ehat Report, ¶ 5.

Red River on the Oklahoma and Texas border, which is also fed by the Kiamichi River.

The PAD does not describe SEOPC's proposed methods of waterbody crossings. For example, the Nations did not find description of whether SEOPC is considering overhead or underground crossings. Further, the PAD does not describe whether SEOPC has consulted with USACE Staff regarding federal authorizations that may be required for the transmission line to cross navigable waterways, or any discharges of dredged or fill material into wetlands or waters of the United States that may be required to construct and place transmission-related infrastructure.[49] This information is important for the Commission, other agencies, Tribes, and stakeholders to evaluate Project feasibility and potential environmental impacts.[50]

The PAD fails to provide explanation for the transmission line ROW buffers, including justification for their unusual width and how existing and future uses would potentially be restricted or prohibited within the buffers over the lifetime of the Project. The Nations share Texas Park and Wildlife Department's ("TPWD") concerns that the proposed width of the ROW appears excessive, particularly if SEOPC is considering co-location with existing lines. *See* TPWD Comments, p. 2. This does not meet SEOPC's responsibility to provide an adequate description of the proposed Project transmission line and ROW is required to be included in the PAD (*see* 18 C.F.R. § 5.6(d)(ii)-(iv)).

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[49] As discussed above, SEOPC, as the applicant, is responsible to "[n]otify the Commission staff of all other Federal actions required for completion of the proposed action" to facilitate inter-agency coordination. 18 C.F.R. § 380.3(b)(5). The Nations agree with the Oklahoma Attorney General's comments that it does not appear SEOPC "has adequately begun to consider implications under other federal law—such as the Endangered Species Act, the Natural Historic Preservation Act, the Clean Water Act, and others, as well as State laws," and are concerned this could impede interagency coordination and adequate environmental analysis. OAG Comments, p. 2.

[50] For example, the Texas Parks and Wildlife Department has recommended "SEOPC route transmission lines to avoid crossing streams, riparian areas, wetlands, and open water habitat, to the extent feasible." Letter from Karen B. Hardin to Acting FERC Sec'y Reese, eLibrary no. 20240903-5082 (Sept. 3, 2024), p. 3 ("TPWD Comments").

The PAD's description of the proposed Project transmission line reiterates previous statements that the proposed Project would join with ERCOT's transmission grid in Paris, Texas, but states that specific plans have not yet been developed: "[t]he exact design, route, number of circuits, voltage, and configuration of the proposed Project's point of interconnection with the transmission grid will be determined in consultation with ERCOT during the pre-application and scoping phases to minimize effects to resources and landowners." PAD, p. 3-7.

The Project's proposed plans for interconnection to the ERCOT grid are foundational to considering the purpose, need, and feasibility of the Project and, as such, SEOPC should have described them in the PAD. The Commission should direct SEOPC to supplement the record with this information now, not later. This supplemental information should include SEOPC's analysis for how the proposed interconnection will comply with the federal energy standards and potentially affect the current regulatory regime for the Texas energy grid.

Section 3.2.4 Project Access

See comments regarding road access in Section 3.2, *supra.*

Section 3.2.5.1 Pre-Construction Activities

The PAD (p. 3-8) describes SEOPC's plans to defer certain studies until the 3 years *following license issuance*: "Pre-construction activities would begin following license issuance and are anticipated to take three years. During this phase, SEOPC would conduct geotechnical investigations, transmission interconnection studies, final design engineering, and develop and execute off-taker agreements." SEOPC's proposal to defer critical geotechnical investigations, transmission interconnection studies, design engineering studies, and provide evidence of binding commitments to purchase Project energy until post-license issuance is reckless and untenable. The

Commission's regulations require that studies relevant to the financial or technical feasibility of a project and potential environmental cultural impacts be completed pre-application:

> (1) Unless determined to be unnecessary [by the OEP Director in their final study determination[51]], a potential applicant must diligently conduct all reasonable studies and obtain all reasonable information requested by resource agencies and Indian tribes under paragraph (b) of this section that are necessary for the Commission to make an informed decision regarding the merits of the application. These studies must be completed and the information obtained:
>
> (i) Prior to filing the application, if the results:
>
> (A) Would influence the financial (e.g., instream flow study) or technical feasibility of the project (e.g., study of potential mass soil movement); or
>
> (B) Are needed to determine the design or location of project features, reasonable alternatives to the project, the impact of the project on important natural or cultural resources (e.g., resource surveys), or suitable mitigation or enhancement measures, or to minimize impact on significant resources (e.g., wild and scenic river, anadromous fish, endangered species, caribou migration routes) ….

18 C.F.R. § 4.38(a).[52]

[51] The PAD makes no claim, and there is no basis for the OEP Director to find, that the studies SEOPC proposes to delay to post-licensing are unnecessary. It should be obvious that all of these studies, which go to the technical feasibility and financial viability of the Project and the siting of Project features to protect public safety, are necessary.

[52] The Commission may allow for completion of studies post-application but pre-license in limited circumstances and will only allow studies post-license if necessary to *refine* operations or *modify* facilities approved in the license, not to *determine* project operations and facilities.

> (ii) After filing the application but before issuance of a license or exemption, if the applicant otherwise complied with the provisions of paragraph (b)(2) of this section and the study or information gathering would take longer to conduct and evaluate than the time between the conclusion of the first stage of consultation and the expiration of the applicant's preliminary permit or the application filing deadline set by the Commission;
>
> (iii) After a new license or exemption is issued, if the studies can be conducted or the information obtained only after construction or operation of proposed facilities, would determine the success of protection, mitigation, or enhancement measures (e.g., post-construction monitoring studies), or would be used to refine project operation or modify project facilities.

None of these circumstances are present here.

Commission regulations further require that an "*applicant must also*" do the following:

(1) Provide all necessary or relevant information to the Commission;

(2) Conduct any studies that the Commission staff considers necessary or relevant to determine the impact of the proposal on the human environment and natural resources;

(3) Consult with appropriate Federal, regional, State, and local agencies during the planning stages of the proposed action to ensure that all potential environmental impacts are identified;

(4) Submit applications for all Federal and State approvals as early as possible in the planning process;

(5) Notify the Commission staff of all other Federal actions required for completion of the proposed action so that the staff may coordinate with other interested Federal agencies.

18 C.F.R. § 380.3(b).

SEOPC may have proposed to defer site-specific geotechnical studies and other critical field investigations until after it obtains a license because it is concerned that existing landowners will not grant SEOPC access to their lands at the Project site.[53] But that is no reason to defer studies that are needed to determine whether the Project is even feasible. SEOPC cannot ask the Commission to find that the Project is viable and issue it a license on that basis, and then—with its license in hand—seek to determine whether the Project is viable, just so that it will be able to seize those property owners' land under FPA section 21, 16 U.S.C. § 814, and undertake those studies without need for their permission. This would be an abuse of the licensing process, but is

[53] *See, e.g.,* James Cunningham et al., "Petition[s] to FERC Concerning Hydropower Facilities in Southeastern Oklahoma," (Aug. 18, 2024), eLibrary nos. 20240828-0001, 20240828-0002, 20240828-0003, 20240828-0004, 20240828-0005, 20240828-0006, 20240828-0007, 20240828-0008, 20240828-0010 ("I assert all of my Constitutional and Property Rights to deny access to any person(s), corporation(s) or other organizations seeking to explore or conduct seismographic, geophysical, geochemical, hydrological, aquatic, botanical, wildlife, habitat, archaeological, or any other form of study or survey on my property.").

consistent with prior statements by SEOPC's consultants signaling SEOPC's intent to seek to use the federal government's power of eminent domain to acquire property rights for the Project rather than acquiring rights through voluntary transactions with landowners.[54] If that is the case, SEOPC should reconsider the Project, because it cannot obtain a license without showing the Project is feasible and in the public interest, and it cannot make such showing based only on desktop studies and speculation. Nor should SEOPC be able to use the licensing process to manipulate land values in the Project area.

Whatever SEOPC's plans, it must still provide environmental information to the Commission as part of the licensing process so that FERC and other jurisdictional agencies can comply with their statutory and regulatory duties. Commission staff should flatly reject SEOPC's proposal to complete transmission interconnection and design engineering studies and provide additional evidence of binding commitments to purchase Project energy until post-license issuance.

Section 3.2.5.2 Construction Activities

The PAD (p. 3-8) states that "Project construction is anticipated to take between 3 to 4 years." SEOPC provides no basis for that time estimate, which may be an under estimate given the significant gaps in SEOPC's current Project proposal. Assuming, for the sake of argument, that estimate is realistic, that would be 3 to 4 years in addition to the 3 years after license issuance during which SEOPC proposes to undertake pre-construction activities. Then there

[54] *See, e.g.,* ZGlobal, "Southeast Oklahoma Pumped Storage Project ('*The Project*')," (Aug. 23, 2023), *available at* https://s44740.pcdn.co/wp-content/uploads/Oklahoma_Storage-final-version-8.23.2023-003_NR-FINAL.docx.pdf (last accessed Nov. 4, 2024) ("Specifically, the FPA grants FERC licensees the ability, if necessary, to condemn 'lands or property of others necessary to the construction, maintenance, or operation of any dam, reservoir, diversion structure, or the works appurtenant or accessory thereto.'").

would be an additional 2 to 3 years to fill the Project reservoirs, although the length of the fill period would depend on hydrological conditions.[55] That means, if everything goes according to SEOPC's proposed schedule, there would likely be construction-related disruption to the surrounding landscape and communities and the flow of the Kiamichi River for approximately a decade or more. Given the rural, undeveloped character of the lands within the proposed Project area, and the unique resources of the Kiamichi River, this would be an unreasonable hardship.

The PAD provides a very high-level description of excavation activities for the pumped storage facilities: "[r]eservoir design would be optimized to balance cut and fill volumes, and any excavated material from the reservoir construction would be tested to ensure the material is suitable for use in the embankments. *Id.* If the excavated material is unsuitable for embankment fill, other sources of material would be utilized." We do not understand how, five years after it obtained its preliminary permit, SEOPC does not yet have a firm understanding of the suitability of excavated material from the reservoir construction for use in the embankments or of proposed alternative sources for use in fill. We are also concerned by SEOPC's seeming incomprehension that the import of fill from other locations could adversely impact ecological and cultural resources.

The PAD (*id.)* goes on to deny knowledge of any adverse impacts: "[n]o known potential environmental adverse impacts or issues are known prior to construction …." This statement is absurd in light of the significant uncertainties about construction length or sourcing for embankment materials.

[55] In addition to high flow availability, the infill period could be further extended due to safety considerations: "first fill loading against the dam embankments is a critical dam safety operation and could easily be required to take more than a year." Ehat Report ¶ 15.

Section 4.1 General Description of River Basin

Section 4.1.1 Basin Overview

See Section III, *supra,* for discussion of the Settlement Agreement and Settlement Act which control the allocation of water rights from the Kiamichi and Upper Little Basins.

Section 4.1.2 Climate

The PAD (p. 4-4) describes climate in the Project area as "subtropical and characterized by hot and humid summers with mild winters," with average annual precipitation of 45-50 inches. It further states that, "lake evaporation *exceeds* annual rainfall in both states, ranging between 45 and 55 inches, contributing to humidity and weather patterns, including severe seasonal thunderstorms and tornados …."[56] *Id.*

As described above, the upper and lower Project reservoirs would each have a high storage capacity. The PAD states that 20,000 AF is included in the initial fill estimate of 68,269 AF to compensate for leakage and evaporative losses from Project reservoirs, but does not explain the basis for this estimate. Commission staff should require SEOPC to disclose this analysis so it may be independently verified. The PAD also does not describe the volume or frequency of additional withdrawals that will be necessary to recharge Project reservoirs over the lifetime of the Project. Given the high rates of evaporative losses under current climate conditions, the Nations are concerned Project demand for Kiamichi River water to refill Project reservoirs could be significantly higher during the lifetime of the Project under a warming climate.[57]

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[56] These storms can have devastating consequences for life and property. *See, e.g.,* NCEI, "Oklahoma Climate Summary" (2022).

[57] For example, according to the NOAA National Centers for Environmental Information (NCEI), "[e]ven if summer precipitation remains the same, higher temperatures will increase evaporation rates and decrease soil moisture, leading to increased intensity of future droughts and increased risk of severe wildfires." NCEI, "Oklahoma Climate Summary"

As the U.S. Environmental Protection Agency ("EPA") has explained, changing climate will increase water demand *and* decrease water availability for myriad of uses:

> Changing the climate is likely to increase the demand for water but make it less available. As rising temperatures increase evaporation and water use by plants, soils are likely to become even drier. Average rainfall is likely to decrease during spring and summer. Seventy years from now, the longest period without rain each year is likely to be at least three days longer than it is today. Increased evaporation and decreased rainfall are likely to reduce the average flow of rivers and streams. Drier soils will increase the need for farmers to irrigate their crops, but sufficient water might not be available. Approximately 16 percent of Oklahoma's farmland is irrigated.… Decreased river flows can create problems for navigation, recreation, public water supplies, and electric power generation.… Decreased river flows can also lower the water level in lakes and reservoirs, which may limit municipal water supplies; impair swimming, fishing, and other recreational activities; and reduce hydroelectric power generation.[58]

Thus, in addition to environmental impacts, reduced water availability due to climate change is likely to adversely affect the feasibility of the proposed Project which will have significant, continuous—and likely enlarging (due to increased evaporation and significant leakage)—water demands when water supplies are becoming more scarce and less reliable.

In later discussion, the PAD (p. 4-27) acknowledges the waters of the Red-Little Basin "are being stressed by a combination of climate change, water demands, and human-related land use and management practices." *See* discussion of Section 4.3.1.1, *infra*. We agree. Climate change

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(2022), *available at* https://statesummaries.ncics.org/chapter/ok/#:~:text=Oklahoma%20is%20in%20a%20region,runoff%20into%20streams%20and%20lakes (last accessed Nov. 4, 2024).

[58] EPA, "What Climate Change Means for Oklahoma," EPA 430-F-16-038 (Aug. 2016) (emphasis added), *available at* https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ok.pdf (last accessed Nov. 4, 2024). *See also* D. Russell Sanford II and Susy Boyd, Draft Watershed Assessment for the Kiamichi Watershed of Oklahoma Hydrological Unit Code (HUC): 11140105 (2012), *available at* https://www.researchgate.net/publication/254558602_Watershed_Assessment_of_the_Kiamichi_River_Watershed_Oklahoma (last accessed Nov. 4, 2024): "Precipitation and temperature patterns can vary widely from year to year in Southeast Oklahoma, as this region of the United States is prone to drought" (p. 5); "In spite of high run-off figures, the Kiamichi Watershed is prone to dry spells, which have been increasing in recent years" (p. 7).

has already led to prolonged periods of drought and will continue to do so with increasing frequency and intensity.[59]

Droughts severely impact the Kiamichi River flows and water quality, causing the same types of impacts identified by EPA, which create hardships for members of the community who rely on the River for their livelihoods.[60] For that reason, it is critical that the Commission and other jurisdictional agencies evaluate the Project's potential impacts on water and other natural resources, and even the Project's reliability, over the lifetime of the Project when the effects of climate change are predicted to worsen, and require SEOPC to provide the information necessary to facilitate that evaluation.

Section 4.1.3 Major Land Uses

Remarkably, the PAD says absolutely nothing about the fact that a natural gas transmission line is located in the Project footprint, and that this pipeline would underly the upper reservoir. ONEOK Gas Transportation, LLC operates and maintains an intrastate natural gas transmission line that runs perpendicular to the upper reservoir and would underlie the reservoir only a few hundred feet upstream from the reservoir's proposed dam. *See* ONEOK System Map, *available at*

[59] *See* U.S. Geological Survey, "Drought and America's Southwest," *available at* https://www.usgs.gov/science/science-explorer/climate/droughts-and-climate-change (last accessed Nov. 4, 2024). According to the U.S. Drought Monitor, at the time of these comments, this area is abnormally dry. U.S. Drought Monitor, *available at* https://droughtmonitor.unl.edu/Maps/CompareTwoWeeks.aspx (last accessed Nov. 4, 2024). Droughts are a frequent and severe hazard in Oklahoma. NCEI, Oklahoma Climate Summary (2022), *available at* https://statesummaries.ncics.org/chapter/ok/#:~:text=Oklahoma%20is%20in%20a%20region,runoff%20into%20streams%20and%20lakes (last accessed Nov. 4, 2024).

[60] *See, e.g.,* National Integrated Drought Information System (NIDIS), "Drought by Sector: Public Health," *available at* https://www.drought.gov/sectors/public-health (last accessed Nov. 4, 2024); National Drought Mitigation Center, University of Nebraska, "How Does Drought Affect Our Lives?," *available at* https://drought.unl.edu/Education/DroughtforKids/DroughtEffects.aspx (last accessed Nov. 4, 2024); NIDIS, "Drought by Sector: Recreation and Tourism," *available at* https://www.drought.gov/sectors/recreation-and-tourism (last accessed Nov. 4, 2024); U.S. Centers for Disease Control and Prevention, "Health Impacts of Drought," *available at* https://www.cdc.gov/drought-health/health-implications/index.html (last accessed Nov. 4, 2024).

https://www.oneok.com/ogt/system-map (last accessed Nov. 4, 2024). The Nations also understand that there is an electrical transmission line co-located in the natural gas pipeline right-of-way. The proposal to locate a reservoir on top of an existing natural gas line presents public safety and engineering issues that require additional study and permits.[61]

In contrast to the pipeline omission, the PAD (p. 4-4) highlights the proposed Project's proximity to the Ouachita National Forest Ranger District, which is located just "4 miles northeast of the Project and provides year-round camping, hiking, and fishing opportunities." We assume this means within four miles of the proposed Project boundary. Project impacts, particularly road-building and other Project construction activities, would result in impacts on the environment and local species that extend beyond the Project boundary. These could reach the Ouachita National Forest, which was established to protect these resources and recreational uses occurring there that depend on those resources. The same is true for the federal lands administered by the Bureau of Land Management ("BLM"), which the PAD also mentions as being located "immediately adjacent to the proposed Project." *Id.*

We agree with the PAD's characterization of the lands within the proposed Project area as being rural and undeveloped: "[e]xisting land use in the Project vicinity includes recreation and tourism, cattle grazing, and forestry." PAD, p. 4-4. Development on the scale of the proposed

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[61] For example, the Oklahoma Underground Facilities Damage Prevention Act provides that, "[n]o excavator shall demolish a structure, discharge an explosive or commence to excavate in a highway, street, alley or other public ground or way, a private easement, or on or near the location of the facilities of an operator without first complying with the requirements of the Underground Facilities Damage Prevention Act and the Oklahoma Explosives and Blasting Regulation Act." Okla. Stat. Ann. tit. 63, § 142.5. According to the PAD, construction activities for the upper reservoir would include excavation. Although the PAD does not specify an excavated depth, it is likely to exceed the buried depth of the pipeline. *See, e.g.,* 49 C.F.R. § 192.327 (describing minimum cover requirements for buried transmission lines ranging from 18 to 36 inches). Despite this, SEOPC's stakeholder outreach records do not include ONEOK.

Project at and near the proposed reservoirs would dramatically and irreversibly change the character of these lands and existing land uses.

The PAD (*id.*) mentions recreation as an existing land use, but finds the Project is unlikely to destroy recreational facilities: "the proposed Project is not expected to contribute to the destruction of any existing, developed recreation amenities, and pending final plan design, may include Project-specific recreation areas. As described in Section 4.9, the Project would be located on private land, which would pose limited impacts on public outdoor recreation in the area" (*id.* at 6-6). This analysis is fundamentally flawed in several respects. Foremost, the Project's potential impacts are not limited to *those* that would cause outright destruction of a given resource, property, or facility. For example, SEOPC is required to study and disclose the Project's impacts on the historic K-Trail and several other trails in the Project area that serve recreational purposes, even if the Project would not destroy those trails completely.[62]

SEOPC's analysis also ignores the fact that most recreational uses within the Project area are informal and dispersed, often depending on the use of private lands and not tied to a specific, designated recreational facility. And SEOPC is not limited to avoiding Project impacts to public recreation areas. Rather, SEOPC must provide information necessary for the Commission's evaluation of Project impacts on recreational use occurring on private lands, which is plainly an important aspect of a landowner's use and enjoyment of their property, whether it is done by the landowner or others the landowner allows there. Similarly, the Commission must also consider the Project's potential impacts on future recreational opportunities, not just existing ones.

[62] CNHPD Comments (Attachment 9), p. 2.

The PAD's treatment of tourism is similarly deficient, in part because it does not recognize that the Kiamichi River is a major tourist attraction that supports the local recreational economy. The extended construction period, siting of a large, permanent intake structure at the river, significant withdrawals from the river, visual obstruction caused by the transmission line, and Project facilities' permanent changes to a currently rural landscape are likely to significantly diminish the qualities that make this area a popular place to visit.[63] Tourism is critical to the local economy, and so potential impacts to recreation should also be evaluated as potential socioeconomic impacts.

Section 4.1.4 Major Water Uses

See comments regarding PAD, Section 4.3, "Water Resources," *infra*.

Section 4.2 Geology and Soils

Section 4.2.2.2 Project Geology

The PAD (p. 4-22) describes geology at the upper reservoir location as follows:

> The elevation and topography profile of the Kiamichi Mountains are influenced by the Jackfork formation. The hard and dense nature of the Jackfork is likely able to support tunneling without steel liners, although this would be confirmed during testing and drilling. The upper reservoir is designed to impound Long Creek near the crest of the Kiamichi Mountains, and due to the bedrock composition, reinforced concrete is expected to be sufficient for the tunnel lining.

The PAD does not cite any expert analysis or scientific literature to support SEOPC's "expectations" regarding the Jackfork formation's suitability and structural integrity to support Project facilities. Indeed, SEOPC itself admits the indeterminacy of its expectations by noting that

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[63] The Town of Albion (*see* Albion Comments, pp. 1-2) expressed the same concern:

> We find no benefit to the town of Albion as this area relies heavily on tourism to support the local economy. The project will forever be a blight and nuisance to residents who enjoy the outdoors and appreciate the scenic wonders of this region, including the unpolluted night sky allowing for stargazing.

the nature of the Jackfork formation would be "confirmed during testing and drilling," although apparently SEOPC has not engaged in any testing to date. And the PAD does not discuss at all expectations about the suitability and structural integrity of Stanley shale, even though significant lengths of pumpstocks will have to travel through Stanley shale between the lower and upper reservoirs. *See id.* at 4-12, fig. 4-5.

Instead, the PAD (p. 4-26) notes that "site-specific geologic and soil studies have not yet been conducted in the Project area," and then vaguely offers that, "SEOPC plans to undertake a geomorphic analysis and sampling study to gather additional information. This involves drilling to understand characteristics of Project area soil and rock physical and chemical properties, including wind and water erosion rates and salinity, among other items." These studies must be spelled out, as they are necessary to inform SEOPC's application. We are concerned that SEOPC did not provide additional detail regarding its plans, including schedule and what the reference to "other items" encompasses. Without these details, there is no way for the Commission or other stakeholders to find SEOPC's plans adequate. As described above, we are also concerned that SEOPC does not intend to conduct soil and geologic studies until post-license issuance, which is too late in fact and law.

The Nations' expert analysis directly counters SEOPC's bald assertions that geologic conditions are suitable for project construction. Our analysis finds that the geologic conditions in this area would make project construction environmentally destructive and unsafe.

> The planned upper reservoir for the project is proposed to be located on the Jackfork Group, which consists mainly of sandstone with some interbedded shale. These sandstone deposits are permeable and would allow water to seep into underlying bedrock at the site. The proposed lower reservoir would be located partly on shale of the Stanley Group and partly on alluvial terrace deposits in the valley of the Kiamichi River. A proposed regulating reservoir also would be located on terrace deposits. The alluvial terrace deposits are permeable and would allow seepage of

> water from the lower reservoir and the regulating reservoir. Sandstone of the Jackfork Group is exposed on a steep slope and ridge in the southern part of the proposed site. Infrastructure proposed for construction in these sandstones and shales, including tunnels, inlets, and outlets, would be susceptible to landslides and related rock failures. Leakage from the proposed reservoirs and associated infrastructure could contribute to the likelihood of landslides. Loss of water by leakage and evaporation from reservoirs for the proposed project is a related concern because water resources in the basin currently are stressed. A rise in the water table also could cause environmental and ecological damage. Activation of landslides poses additional risks for the area besides safety, including potential damage to cultural and archeological resources.

Davis Report ¶ 1.

The risks related to landslides are high and of "crucial importance" due to the site-specific geologic conditions. *Id.* ¶ 11. Project infrastructure could increase the probability of landslides by disturbing already unstable geologic formations[64] *and* would be vulnerable to failure due to landslides, which are occurring with increasing frequency

> The Ouachita Mountains of southeastern Oklahoma are a region of high landslide potential, according to the U.S. Geological Survey (2024a).… The steep slopes above the Kiamichi River south of the proposed lower reservoir site appear to be extremely susceptible to slope failures.
>
> … Future landslides and reactivation of old landslides pose a serious risk for the area. Slope failures such as landslides are a common risk in the Ouachita Mountains…[65]

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[64] Jackfork and Stanley Groups are characterized by flysch deposits, which are particularly vulnerable to disturbance:

> The structural competence of the Stanley Group is dramatically lower than that of the overlying Jackfork Group due to its high shale content, non-resistant, and easily erodible nature (Pitt et al., 1982). Any construction project developing underground facilities or tunneling in known flysch deposits (Stanley and Jackfork Groups) should undergo specialized geoengineering characterization due to the general nature of these deposits being "low strength and tectonically disturbed" (Marinos, 2014). Flysch deposits can also "produce heavily sheared and chaotic masses," making additional geotechnical and geoengineering evaluations necessary to avoid or identify potential points of failure, geohazards, and supplementary construction mitigation measures (Marinos, 2014).

Schuth Report ¶ 16.

[65] Landslides in this area may be triggered by seismic events, such as earthquakes, which have generally increased in Oklahoma over the past decade. *Id.* ¶ 12. A

Id. ¶ 10.

The Project area is also characterized by expansive soils, which contribute to geologic instability:

> SEOPC's PAD states that expansive soils occur in 75% of Oklahoma, including the northern part of Pushmataha County, citing the Oklahoma Geological Survey (2008). It also states that smectite and montmorillonite could be present in clay-rich shales or weathered shales.… Expansive soils can develop great pressure in the presence of moisture (Rahn, 1996). Alternatively, expansive clays can shrink drastically when they dry out, causing additional instability.… *Landslides and swelling soils regularly produce the greatest annual economic loss of all geologic hazards* (Rahn, 1996).…

Id. ¶ 15 (emphasis added); *see also id.* ¶ 14.

These geologic conditions indicate this is *not* an acceptable site for a major undertaking such as the Project. Davis Report ¶ 24. Beyond the significant disturbance caused by Project construction, leakage from Project reservoirs could increase the risk and severity of geologic hazards, and it is not clear that leakage could be effectively minimized or mitigated in reservoirs of this size.

> Leakage from the proposed upper reservoir and associated facilities could cause instability and lead to landslides in the area. SEOPC's PAD indicates that the proposed upper reservoir would have a volume of 68,269 acre-feet of water and a surface area of about 600 acres. The average depth of the reservoir thus would be about 114 feet. At that depth, the hydrostatic pressure would be about 7100 lb/ft^2 (about 49 lb/in^2). SEOPC's PAD also states that the height of the dam for the proposed upper reservoir would be 282 ft. If the water depth near the dam is assumed to be about 250 feet, the hydrostatic pressure at that depth would be about 15,600 lb/ft^2 (108 lb/in^2). *The PAD does not mention a membrane liner, and it is doubtful that natural soils or artificial fill could withstand such pressures without substantial leakage. Leaking water thus could saturate material under the reservoir and adjacent to it, causing instability of the adjacent soils and rocks*.
>
> Similar calculations for the proposed lower reservoir show that its average depth could be about 55 feet. At this depth, the hydrostatic pressure would be about 3425 lb/ft^2 (about 23.8 lb/in^2). Because the proposed lower reservoir would be located partly on permeable alluvial terrace material and partly on shale of the Stanley

> Group, this could lead to serious leakage of water and could cause instability problems, including landslides.
>
> Large-scale landslides could occur, especially in the southern part of the proposed project site. Other facilities for the proposed project, such as tunnels, spillways, and outlet works, could cause difficulties because of leakage or erosion. For example, if the emergency spillway for the upper reservoir discharged water during a large rainfall event, it could cause erosion of shales in the Jackfork Group and potentially could contribute to a large slope failure. Construction during the project, especially on steep slopes, could pose special problems for slope stability.

Id. ¶¶ 17-19 (emphasis added).

The PAD's description of geologic conditions does not comply with the Commission's Rule 5.6(d)(3), which requires in part, descriptions of geological features, and of "the soils, including the types, occurrence, physical and chemical characteristics, *erodability and potential for mass soil movement*." (emphasis added). Additional investigations are needed and "should explain the potential impacts of leaks from the proposed upper and lower reservoir, as well as associated facilities, and should outline mitigation procedures in the event of leaks, landslides, and related problems. Issuance of a license before determining potential effects associated with these concerns is an unacceptable risk." Davis Report ¶ 24; *see also* Ehat Report ¶ 9.

Section 4.3 Water Resources

According to the PAD, the Project would primarily rely on the Kiamichi River to fill and replenish Project reservoirs. As described in Section III, *supra*, the PAD does not provide an accurate or reasonably complete description of the water rights and environmental and cultural resources that would be impacted by additional consumptive demands on Kiamichi River flows.

Other federal, state, and local stakeholders have also expressed concerns regarding the Project's impacts on water resources.[66]

Section 4.3.1.1 Drainage Area

Although not discussed under the "climate" section, the PAD (p. 4-27) describes water resources in the Red-Little Basin as *currently* impacted by multiple stressors: "[w]ater resources in the Red-Little basin are being stressed by a combination of climate change, water demands, and human-related land use and management practices." We agree with that assessment, which is why we are concerned by the PAD's incongruous and unsupported claims that this Project "would provide a stable source of cost-effective renewable energy … while also conserving the water resources of the Kiamichi River." *Id.* at 1.1.

Section 4.3.1.4 Groundwaters

The PAD (p. 4-32) describes groundwater use as limited within the Project area, but it does not actually describe the characteristics of the Kiamichi Minor Groundwater Basin ("KMGB") that underlies the proposed Project area. Without this information it is impossible to fully understand the extent to which Project facilities may adversely impact groundwater resources.

The pumped storage facilities would overlie the KMGB, which is located within the Settlement Area and within the Kiamichi River Basin. This basin "covers approximately 3,020,000 acres of southeastern Oklahoma," and underlies the entirety of the Project boundary." Schuth Report, ¶11. The geologic and hydrogeologic conditions of the KMGB at the pumped storage facilities are characterized by high permeability, which increases the likelihood there will be substantial leakage from the reservoirs that would be lost to groundwater storage.

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[66] *See* FWS Comments, p. 3; RWD Comments, p. 1; OAG Comments, pp. 1-2, Albion Comments, p. 2; Senator Burns Comments, p. 1.

> The proposed Project's regulating pond and the lower reservoir would be located within the unconsolidated-undifferentiated alluvium and terrace deposits within the Kiamichi River Valley floor. Those deposits can have much higher porosity and permeability than the underlying KMGB strata of the Jackfork and Stanley Groups, potentially causing large volumes of water to leak into or out of the regulating pond and lower reservoir from a change in hydraulic gradients (Johnson, 1983).
>
> The development of the regulating pond and lower reservoir would initially create an area of void space within the deposit causing subsurface flow paths to be redirected into them. Afterwards, with increases in the water level of both features from surface water pumping, those subsurface flow paths would be reversed pushing water into the deposits along with any contaminants.… The regulating pond and lower reservoir would also be partially sited within the Stanley Group, which is primarily recharged via faults, fractures, and jointing planes that occur sporadically throughout the group.
>
> The upper reservoir would be located in the Jackfork Group, which has multiple alternating sandstone and shale layers potentially acting as recharge zones in addition to any fault or fracture planes (Wilkins, 2001). Both the alternating layers of sandstone and shale, along with the faults, fractures, and jointing planes could significantly contribute to unaccounted water loss or gain into the proposed Project with unknown impacts on localized groundwater levels from changes in hydraulic gradient differentials, regional surface water flow rates, and water quality.[67]

The "[u]naccounted water losses from reservoir leakage could impact localized groundwater levels by artificially increasing them and potentially transferring any contaminates from the project's features into the groundwater systems."[68] *Id.* ¶ 15. "A higher water table could cause wetlands to appear, changing animal and plant habitat and causing difficulties because of saturated, muddy soils." Davis Report ¶ 21. As described above, reservoir leakage could also cause or contribute to risk of landslides. *Id.* "Future landslides and reactivation of old landslides [aggravated by reservoir leakage] pose a serious risk for the area, not only because of safety

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[67] *Id.* ¶¶ 13-15.

[68] *See also* letter from Tracie Williamson, Dep't of Interior's Bureau of Indian Affairs ("BIA"), to Sec'y Reese, eLibrary no. 20241104-5183 (Nov. 4, 2024) ("BIA Comments"), pp. 1-2 (describing need to study "the effects on groundwater (quantity and quality) due to Project construction and operations" and "the connectivity between groundwater and surface water, including the effect of on surface water from the Project's impact on groundwater, as well as the effect on groundwater from the surface water use the Applicant proposes").

concerns for human life and property, but also for archeological and cultural resources." *Id.* ¶ 23; *see also id.* ¶ 21.

Further, these unaccounted water losses from leakage would increase demand for replacement water from the Kiamichi River. Schuth Report ¶ 15; *see also* Davis Report ¶ 20. Thus, the Project would deprive the Kiamichi River of flows in at least two ways: construction of the regulating and lower reservoirs within the KMGB would redirect subsurface flow paths that contribute base flows to the Kiamichi River, particularly during drought events, and the intake structure would directly withdraw instream flows to fill and recharge the reservoirs. Schuth Report ¶ 19; Davis Report ¶ 20.

Yet the PAD does not include any maps or other depiction of the KMGB boundaries or meaningful discussion of its geologic or hydrogeologic characteristics. These resources must be studied and adequately identified and described prior to license issuance, "to prevent the [Project] from adversely impacting groundwater levels and water quality, or impeding preferential groundwater flow paths that provide supplementary base flows to the Kiamichi River." Schuth Report ¶ 18; *see also* Davis Report ¶ 24. Such studies are also necessary to prevent adverse impacts to community members that rely on wells in the project area for their domestic use. The Nations estimate that there are no less than thirty (30) domestic wells located in or near the regulating pond and lower reservoir sites.

The PAD's description of groundwaters does not comply with the Commission's Rule 5.6(d)(3), which requires in part: "[a] description of the water resources of the proposed project and surrounding area. This must address the quantity and quality (chemical/physical parameters) of all waters affected by the project, including but not limited to the project reservoir(s) and tributaries thereto …." The PAD's incomplete reporting of hydrogeologic conditions in the KMGB and groundwater resources that could be impacted by the proposed Project could lead to errors in NEPA scoping and agency decisionmaking. "Issuance of a license before determining potential [geologic and hydrogeologic] effects associated with [reservoir leakage, landslides, and related problems] is an unacceptable risk." Davis Report ¶ 24.

The Nations also note that although the PAD (*id.*) states, "[t]he proposed Project does not include extraction of groundwater resources," this is not consistent with the public description of SEOPC's prior proposal, developed by SEOPC's contractor ZGlobal, which stated: "[c]ompensation for leakage and evaporation provided by groundwater wells and the Kiamichi River." ZGlobal, "Southeast Oklahoma Pumped Storage Project ('The Project')," (Aug. 23, 2023), *available at* https://s44740.pcdn.co/wp-content/uploads/Oklahoma_Storage-final-version-8.23.2023-003_NR-FINAL.docx.pdf (last accessed Nov. 4, 2024). It is also inconsistent with SEOPC's earlier representations to the Commission that, given the amount of water available in the Kiamichi and likely evaporative and leakage losses from the reservoirs, "additional sources of water, including … groundwater … are likely necessary to develop the SEO projects." Motion to Intervene & Protest of SEOPC, No. 14983, eLibrary no. 20190611-5080 (June 11, 2019). This discrepancy is worrying. We are concerned that the disavowal of groundwater use in the PAD was adopted for expediency, rather than accuracy.[69]

Section 4.3.3 Water Quality

The PAD (p. 4-2(a)) generally describes the Kiamichi River and Little River as having "exceptionally low dissolved solid content, a slightly acid pH, and normally excellent water quality. These characteristics along with exceptional habitat allow for unique aquatic species to

[69] *See also* BIA Comments, p. 2 ("groundwater feasibility should be studied to verify Applicant's claim that it will not require groundwater").

thrive throughout the watershed." We agree with this assessment of the baseline water quality in the Kiamichi River and the Little River (including tributaries like Long Creek). While SEOPC plainly does not have any understanding of the extent of potential Project impacts on water quality for surface or groundwaters, the PAD is adequate to show the likelihood for significant degradation.

The PAD summarizes some recent water quality for the Kiamichi River and other waterways in the Project, but the summary contains numerous errors and warrant additional scrutiny by FERC Staff. It is incomplete. For example, it does not include any data for Long Creek. It also includes several inaccuracies.[70]

[70] Additional errors in the data as reported in the PAD, are listed below.

- Table 4-7 (PAD, p. 4-63), 2022 303(d) listed Water Bodies within the Proposed Project Boundary, states that Cypress Creek is only listed as impaired for Dissolved Oxygen (DO). This is incorrect. Appendix C - 2022 Oklahoma 303(d) List of Impaired Waters states that Cypress Creek is impaired for DO *and* pH: "OK410210010070_00 Cypress Creek 20.73 MILES 5a 5a CWAC Oxygen, Dissolved 2 46, 59, 87, 92, 108, 111, 133, 136, 140 5a CWAC pH 2 8, 92, 102, 140, 155," (PAD, p. 4-36).
- Table 4-7 states that Kiamichi River is only listed as impaired for Lead. However, Appendix C - 2022 Oklahoma 303(d) List of Impaired Waters states that the Kiamichi River is impaired for Lead *and* Silver: "OK410310010010_00 Kiamichi River 26.35 MILES 5a 5a WWAC Lead 2 49, 82, 140 5a WWAC Silver 2 49, 56, 140," (PAD, p. 4-39).
- Table 4-7 states that Little River, Black Fork is only listed as impaired for DO. However, Appendix C - 2022 Oklahoma 303(d) List of Impaired Waters states that this waterway is impaired for DO and pH (*see* PAD, p. 4-37): "OK410210030020_00 Little River, Black Fork 31.00 MILES 5a 5a CWAC Oxygen, Dissolved 2 140 5a CWAC pH 2 155."
- Table 4-7 states that Terrapin Creek is only listed as impaired for pH. However, Appendix C - 2022 Oklahoma 303(d) List of Impaired Waters states that this waterway is impaired for pH *and* Turbidity: "OK410210020150_00 Terrapin Creek 13.47 MILES 5a 5a CWAC pH 1 140 5a CWAC Turbidity 1 140," (PAD, p. 4-36).

Section 4.3.3.1 Designated Beneficial Uses and Water Quality Standards Oklahoma Water Quality Standards

The PAD (pp. 4-37 – 4-44) summarizes water quality standards applicable to waterbodies within the proposed Project Area in a series of tables. As with the summary of water quality data, this summary contains several inaccuracies.[71]

Section 4.4 Fish and Other Aquatic Resources

The PAD's (p. 4-50) overview of aquatic habitat highlights key characteristics of aquatic habitat in the Project area and the adverse impacts of increased human activity on suitable habitat:

> The most prominent aquatic habitat found in the Project vicinity includes the upper reaches of the Kiamichi and Little Rivers in Oklahoma, both of which consist of relatively shallow, clear, and fast-moving waters with a substrate of cobble or bedrock, and provide habitat for numerous fish, amphibians, and semi-aquatic reptile species [citations omitted]. Increased human activity, including impoundment, diversions for agriculture, recreational use, and habitat

[71] We describe some of these inaccuracies in the information provided in these tables, below.

- Table 4-10 (PAD, p. 4-39), "Water Quality Data for Kiamichi River South of the Community of Tuskahoma for Most Recent Year of Record," states that there are no data for phosphorus from, or since 2012, or recent data from other parameters. In reaching this conclusion, it appears that SEOPC relied solely on OWRB's dataset. However, the Choctaw Nation has collected more data for Nitrogen, Phosphorous, Temperature, pH, Dissolved Oxygen, Turbidity, Conductance, and Chlorophyll, which it has reported to EPA in WQX for the past twelve years at three sites along the Kiamichi River.

- Table 4-11 (PAD, p. 4-40), "Total Metals in the Kiamichi River South of the Community of Tuskahoma for Period of Record," has many errors concerning the standard for public and private Drinking Water column per EPA Primary drinking water standards. Highlighted analytes show EPA values that are different from the ORWB report, which are available at https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations (last accessed Nov. 4, 2024), and summarized below:
    - Arsenic 10 micrograms or 0.01 mg/l.
    - Barium 2000 micrograms or 2 mg/l.
    - Cadmium 5 micrograms or 0.005 mg/l.
    - Chromium 100 micrograms or 0.1 mg/l.
    - Copper 1300 micrograms or 1.3 mg/l.
    - Lead 15 micrograms or 0.015 mg/l.
    - Mercury 2 micrograms or 0.002 mg/l.
    - Silver 100 micrograms or 0.10 mg/l. (per EPA Secondary Drinking Water Standards).
    - Selenium 50 micrograms or 0.05 mg/l.
    - Thallium 2 micrograms or 0.002 mg/l.
    - Zinc 5000 micrograms or 5 mg/l.

> fragmentation have led to national decreases in the health of freshwater aquatic communities; these trends are exemplified in the Kiamichi and Little River subbasins [citations omitted].

Development and operation of the Project will include the types of activities that typically degrade aquatic communities, including but not limited to significant withdrawals from the Kiamichi River, permanent damming of Long Creek at its headwaters to create a 4.8-mile impounded reach, and interbasin water transfers. And we join FWS's comments outlining its concerns regarding the Project's potential impacts on aquatic habitat. *See* FWS Comments at 3. These impacts to not just aquatic, but also wildlife and plant, species and their habitats will extend beyond the Project boundary: "Because many of the potentially impacted species are mobile, their ranges and movement exceed the initial research area, there is viable habitat beyond the initial townships searched, and land use/land cover dynamics can have cascading effects in adjacent areas." Letter from Todd D. Fagin, Ph.D. ("Fagin Letter"; Attachment 4), p. 2.

The Nations are also concerned about hydrologic alterations at the intake structure and lower reservoir spillway proposed to be located on the Kiamichi River. The Project's withdrawals from and discharges to the Kiamichi River could have significant impacts on freshwater mussel species.[72] Mussels have historically played important roles in the Kiamichi River watershed though their presence has declined in recent years:

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[72] In addition to direct withdrawals, the Project would alter hydraulic gradients in the KMGB and redirect subsurface flows that would otherwise contribute to baseflow in the Kiamichi River. Schuth Report ¶ 19. Reductions in groundwater contributions to Kiamichi River instream flows would impact water quality and suitability of aquatic habitat. *See* Shannon K. Brewer et al., "Understanding the impacts of surface-groundwater conditions on stream fishes under altered baseflow conditions," U.S. Department of Interior, Fish and Wildlife Service, Cooperator Science Series FWS/CSS-136-2020, Washington, D.C., *available at* https://doi.org/10.3996/css49046075 (last accessed Nov. 4, 2024) (Attachment 10) p. 28 (describing influence of groundwater replenishment on instream flows and thermal regime of the river).

> There are 29 species of mussels recorded as occurring in the Kiamichi basin, and are regarded as keystones in the watershed's ecosystem.[73] Many species are endemic to the Ouachita range, including the federal and state endangered *Arkansia wheeleri* (Ouachita rock-pocketbook). However, recent research shows that the populations of these rare and endangered species have declined significantly. For instance, *Arkansia wheeleri* was not found at any of the historically monitored sites. Removal of riparian habitat, gravel mining, and the impoundments of Jack Fork Creek and the Kiamichi River have been cited as sources threatening mussel communities.[74]

We fear that changes to Kiamichi River hydrology wrought by the Project will threaten these reduced mussel populations, which are under other sources of stress. "Hydrologic alterations impact mussels both directly through physical stress, such as temperature, siltation, and scour, and indirectly through changes in habitat, food, and fish-host availability." Among other things, "[f]luctuating discharge alters the transport of the particulate material in the water column that is the primary food source for mussels."[75] Also, "[d]ischarge that is either low during the wrong season or abnormally low for extended periods of time also negatively impacts mussels." *Id.*

The PAD does not adequately describe the ecological significance of imperiled freshwater mussel species in the Kiamichi and Little Rivers that would be impacted by the Project. Continued protection of mussels in the Kiamichi and Little Rivers is not just important to these local populations, but may be key to conserving entire species:

> … the four rivers of far southeastern Oklahoma (Kiamichi, Little, Glover and Mountain Fork) continue to harbor a rich and overall healthy mussel fauna. There are approximately 52 extant unionid mussel species known to presently occur in

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[73] According to Dr. Caryn C. Vaughn, there are thirty-one (31) species of freshwater mussels. *See* letter from Caryn C. Vaughn, Ph.D. to FERC, eLibrary no. 20241104-5061 (Sept. 3, 2024), p, 1.

[74] D. Russell Sanford II and Susy Boyd, Draft Watershed Assessment for the Kiamichi Watershed of Oklahoma Hydrological Unit Code (HUC): 11140105 (2012), *available at* https://www.researchgate.net/publication/254558602_Watershed_Assessment_of_the_Kiamichi_River_Watershed_Oklahoma (last accessed Nov. 4, 2024), p. 10 (internal citations omitted).

[75] Caryn C. Vaughn, "Freshwater Mussel Populations in Southeastern Oklahoma: Population Trends and Ecosystem Services," Proceedings of Oklahoma Water 2005, Tulsa, OK, September 27 and 28, Paper #18, Oklahoma Water Resources Research Institute, Stillwater, OK (Vaughn 2005) (Attachment 12), p. 4.

> Oklahoma waters (Williams et al. 1992b), and 41 of these (80%) occur in these rivers. In 1998, *The Nature Conservancy identified the Interior Highlands (which includes the four rivers in question) as one of the most critical regions in the U.S. for protecting freshwater biodiversity, based on its rich fish and mussel fauna. Based on a comprehensive national assessment of available data, The Nature Conservancy determined that all of the at-risk freshwater fish and mussel species in the U.S. could be conserved by protecting and restoring 327 watersheds (15% of total US watersheds) across the country; the Kiamichi and Little River watersheds were included in this highly select group* (Master et al. 1998).[76]

More generally, the Nations are concerned that the proposed Project might cause further declines to all aquatic populations:

> [A] relationship between species richness and upstream distance from reservoir impoundments as a result of reservoir construction, noting a decrease in abundance of three fish species (*Fundulus olivaceus, Notropis atherinoides*, and *Labidesthes sicculus*) in the time period following dam construction in fish declines in other parts of the watershed.

Id. at 11 (internal citations omitted).

The PAD (p. 4-51) also reports resource agencies' concerns regarding the impacts of human-caused land use changes in the Kiamichi River on several darter and shiner species. The Nations share those concerns and are further concerned that impacts from construction and operation of the proposed Project would further imperil these and other freshwater species. We note that some of these species are host fish for mussel species in the Kiamichi River, making their protection necessary to protection of mussels in the Project area. SEOPC's studies and the Commission's NEPA analysis should reflect the Project's potential impacts on the host of species present in the Kiamichi and explain the Project's impacts in the broader ecological context.

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[76] *Id.* (emphasis added); *see also* Heather S. Galbraith et al., "Status of Rare and Endangered Freshwater Mussels in Southeastern Oklahoma," The Southwestern Naturalist 53(1):45–50 (Mar. 2008) (Galbraith et al. 2008) (Attachment 11), p. 1 ("One river basin, the Kiamichi-Little River Basin, supports about 80% of all species of mussels that can be found in Oklahoma ...."); *see also* D. Russell Sanford II and Susy Boyd, Draft Watershed Assessment for the Kiamichi Watershed of Oklahoma Hydrological Unit Code (HUC): 11140105 (2012), *available at* https://www.researchgate.net/publication/254558602_Watershed_Assessment_of_the_Kiamichi_River_Watershed_Oklahoma (last accessed Nov. 4, 2024), p. 10 (internal citations omitted).

Section 4.5 Wildlife Resources

The PAD (p. 4-56) briefly summarizes habitat types and general wildlife occurring within the Project boundary based on document review. It essentially acknowledges that wildlife resources are a known data gap:

> To date, no wildlife studies have been conducted within the proposed Project boundary. SEOPC is proposing a Terrestrial Resources Study to conduct a habitat assessment within the proposed Project area (proposed Project boundary plus a 0.5-mile buffer) to ground truth LANDFIRE data (USGS 2019), which will provide a more accurate assessment of habitat type and quality. Incidental wildlife sightings will be recorded during the habitat assessment to provide a more complete list of general wildlife and invasive species present within the Project area.

The data gaps are greater than the PAD indicates and will require more extensive studies and analysis to close. In particular, the assumption that Project impacts will be limited to lands located within the Project boundary is unreasonable. For example, to the extent the construction and operation of Project facilities may interfere with wildlife corridors for White-tailed deer and mule deer located within Project boundaries—an issue that SEOPC should study, as it is nearly certain (given the size of the Project area), that such corridors exist—as it will also affect the off-site portion of such corridors, which will have to follow a different route or be abandoned.

Further, FWS's comments regarding potential Project impacts on special status wildlife species would also apply to non-special status wildlife species:

> The clearing of trees and other vegetation on thousands of acres to facilitate the proposed construction and maintenance of dams and for placement of over 76 miles of transmission lines has potential to adversely impact species …. [that] utilize soil and vegetation in the action area as habitat. Additional construction related effects to wildlife species would occur through ground excavation and clearing of vegetation for the reservoirs, conveyance tunnels, powerhouse, transmission line and general grading of facility sites, staging areas, and road improvements. The extent and magnitude of impacts could vary greatly depending on steps taken to manage alteration of water, sediment, and organic debris.[77]

[77] FWS Comments, p. 2.

SEOPC's studies and the Commission's NEPA analysis need to fully consider the Project's potential impacts on wildlife resources. That will require extending the geographic scope of study beyond the Project boundary. It will also require greater attention to the temporal scope of wildlife studies. For example, habitat assessments should be scheduled during seasons or periods when wildlife are expected to be in the area, rather than just relying on "incidental wildlife sightings" that might be recorded (e.g., assessments of nesting habitat would be deliberately scheduled during the nesting season).

Section 4.6 Botanical Resources

The PAD (p. 4-59) describes vegetation habitat types known to occur within the Project boundary based on SEOPC's document review. Similar to the discussion of wildlife resources, this discussion acknowledges but does little to resolve existing data gaps: "[t]o date, no botanical resources surveys have been conducted within the proposed boundary. SEOPC proposes a Wetlands, Riparian, and Botanical Resources Study to catalogue the botanical species, associated habitats, invasive species, and wetland resources." *Id.* at 4-62. The PAD's treatment of Special Status Plants at Section 4.7.2 is substantially the same. It acknowledges that lands within the proposed Project boundary have not been surveyed (*id.* at 4-67) and restates SEOPC's intention to undertake a Wetlands, Riparian, and Botanical Resources Study (p. 4-76). While we agree with the PAD's determination that the lands within the Project area have not yet been systematically surveyed, we find the PAD's summary of existing data and proposed study to be incomplete.

The PAD (p. 4-67) reports that there are two federally listed plant species in Oklahoma that have the potential to occur within the Project boundary: western prairie fringed orchid (*Platanthera praeclara*) and harperella (*Ptilimnium nodosum*). It notes that harperella is also a state-listed species. That is a *vast* understatement of the number of rare, imperiled, and/or culturally significant plant species that potentially occur in the Project area and could be impacted by the Project.[78]

Based on the Nations' expert analysis, there are seventy-nine (79) vascular plant species that are classified as rare or tracked by the Oklahoma Natural Heritage Inventory ("ONHI")[79] and/or designated by the USFS as Proposed, Endangered, Threatened, and Sensitive ("PETS") species,[80] which have the potential to occur within approximately five (5) miles of the Project boundary.[81] *See* Expert Report of Amy Kathleen Buthod ("Buthod Report"; Attachment 1) ¶ 11, Table 2.

There are also several "globally critically imperiled, imperiled, and vulnerable vegetation associations" that occur within the Project boundary:

> Approximately 21% (7,474 acres) of the project boundary area is located in the habitat known as the Ozark-Ouachita Dry-Mesic Oak Forest System.…
>
> Approximately 21% (7,235 acres) of the project will be located in the habitat known as the Ozark-Ouachita Shortleaf Pine-Bluestem Woodland System.…
>
> [And] [a]pproximately 5% (1,674 acres) of the project will be located in the Ozark-Ouachita Dry Oak Woodland System.

[78] *See also* Fagin Letter, p. 1 (describing Project area as "both biologically and ecologically diverse," and as supporting several of Oklahoma's rare and vulnerable species).

[79] "NatureServe—the authoritative source for biodiversity data throughout North America for over 50 years—and its associated Natural Heritage programs use a global and subnational ranking system to assign conservation priorities. Species are assigned both a global (G) and subnational (S) rank on a scale of 1 to 5. For instance, a rank of G1 indicates critical imperilment on a global scale, while an S1 rank indicates critical imperilment within a subnational (state or province) area. … In Oklahoma, the species with ranks of SX, SH, S1, S2, and S3 are *tracked* by the Oklahoma Natural Heritage Inventory (ONHI). ONHI maintains a centralized database of species occurrence data which is used for determining the subnational ranks for the state." Buthod Report ¶ 9.

[80] "PETS species include those that are listed as Threatened or Endangered by the [FWS], species that are proposed to be listed, and sensitive species—those with special management needs required to maintain and improve their status and prevent a need for listing." Buthod Report ¶ 10.

[81] *See also* Fagin Letter, p. 2 (describing Project's potential "cascading effects in adjacent areas" to the Project boundary).

Id. ¶ 12 – 14. Each of these vegetation associations includes one or more of the individual special status plant species that are tracked in OHNI's database, as described above. *Id.*

Based on our expert analysis, there are also forty-four (44) plant species that are culturally significant to the Choctaw Nation that occur within the Project boundary. *Id.* ¶ 15, Table 3. The PAD does not identify any of these culturally significant plant species.

Project construction, operation, and maintenance would have unavoidable adverse impacts on botanical resources in the Project area. Construction activities would cause temporary and permanent destruction of plant species and their habitat. Pumped storage operations would cause hydrologic changes in the Kiamichi River, which would reduce habitat availability and quality, and lead to less successful reproduction and loss of biodiversity. *Id.* ¶ 16. Changes in the hydraulic gradients in the KMGB could also alter existing plant habitats. Davis Report ¶ 20.

Construction and maintenance of the Project transmission line could also result in introduction or spread of invasive species within the Project area:

> The Oklahoma Invasive Plant Council Watch List lists forty-three species of exotic species that already occur in McCurtain County (Oklahoma Invasive Plant Council 2024, TORCH Portal 2024). The disturbance created during construction of the transmission line could result in the introduction and/or spread of these and other invasive plants species into the unexplored areas within the project boundary area (Dalu et al. 2023). Habitat loss, habitat fragmentation, and edge effects may occur because of the forest clearing activity during construction and right-of-way maintenance. Installation of transmission may result in an increase of fire events, which also can be accelerated by the presence of invasive plants (Biasotto and Kindel 2018).

Id. ¶ 17; *see also* Ehat Report ¶¶ 22-23.

SEOPC's vague proposal to conduct a Wetlands, Riparian, and Botanical Resources Study is inadequate to ensure a comprehensive investigation of plant species occurring in the Project boundary and accurate documentation of baseline conditions. SEOPC's pre-construction study obligation should not be limited to "cataloguing" existing species. Rather, FERC should direct SEOPC to conduct rigorous plant surveys, focused on species that are designated as PETS, tracked by ONHI, or considered culturally significant species, "throughout one or more growing seasons (May through October), with trips made to the site/sites each month." Buthod Report ¶ 18. As with wildlife studies, the geographic extent of plant surveys should not be arbitrarily limited to the Project boundary but should extend to at least 5 miles outside of that boundary.

Section 4.7 Rare, Threatened, and Endangered Species

Sections 4.7.1 and 4.7.2

The PAD (pp. 4-62, 4-67) describes "various special status wildlife [and plant] species [that] have the potential to occur given habitat availability (*see* Section 4.6.1) and USFWS Information for Planning and Consultation (IPac) queries." The Nations are concerned by SEOPC's failure to undertake even preliminary field studies in the five (5) years it has held a preliminary permit, and the limited scope of SEOPC's document review in the absence of field studies. We are further concerned by the indications in the PAD that SEOPC has not yet secured permissions to undertake these studies. As discussed above, field studies may not be deferred to post-license issuance.

The Nations support FWS's comments, which are more direct and informative than the PAD in describing the terrestrial (and aquatic species) that would be impacted by the proposed Project.

Section 4.7.3 Special Status Aquatic Species

The PAD (p. 4-70) describes the Kiamichi River as supporting listed mussel species: "The Kiamichi River above Hugo Reservoir is designated as area that contains both ESA-listed scaleshell and Ouachita rock pocketbook mussels by OWRB (OWRB 2020). It also acknowledges that, "[a]ll federally listed mussels in the region appear to be declining, largely due to impoundment, sedimentation, and increasing droughts …." *Id.*

The PAD's discussion of listed mussel species and how they could be impacted by the Project is perfunctory at best. While the PAD describes certain impacts causing mussel decline, it does not adequately describe how specific these species' habitat preferences are or how sensitive they are to any alterations in hydrology.

It is well-established that freshwater mussels are highly sensitive to anthropogenic impacts, like hydropower development, and considered critically impaired throughout the United States:

> One of the most critically imperiled freshwater groups in the United States is freshwater mussels (Family Unionidae; Strayer et al., 2004). The United States Fish and Wildlife Service recognizes 12% of native freshwater mussels to be extinct and 23% as threatened or endangered, while the Nature Conservancy considers 68% of native mussels to be at risk (Biggins and Butler, 2000). Mussels are long-lived, iteroparous, and spend a portion of their lives as obligate ectoparasites on a fish host (McMahon and Bogan, 2001). These life-history characteristics have made them particularly susceptible to anthropogenic impacts.[82]

There are at least three federally endangered mussel species that are recorded to occur in the Kiamichi and Little Rivers, and a subpopulation of at least one species is located just upstream of the proposed Project's intake structure:

> Three federally endangered species occur in these rivers, the Ouachita rock pocketbook, the winged mapleleaf, and the scaleshell. *Arkansia wheeleri*, the Ouachita rock pocketbook mussel, occurs in only three rivers in the world, the Kiamichi and Little rivers in Oklahoma, and in the Ouachita River in Arkansas (Vaughn *et al.* 1993; Vaughn 1994; Vaughn & Pyron 1995; Vaughn *et al.* 1995; Vaughn *et al.* 2004b). The Kiamichi population is considered the most viable; subpopulations are patchily located over a 128 km stretch of the river from near Whitesboro to directly above Lake Hugo. Within these subpopulations, the species is quite rare. Vaughn & Pyron (1995) found that in the Kiamichi River, *A. wheeleri* occurs only in the largest, most species-rich mussel beds. Even its optimal habitat the species was always rare; mean relative abundance varied from 0.2 to 0.7% and

[82] Galbraith et al. 2008 (Attachment 11).

> the mean density within large mussel beds was 0.27 individuals / m2. The youngest individual *A. wheeleri* encountered was approximately 12 years of age, indicating that recruitment is low (Vaughn & Pyron 1995). One of the *A. wheeleri* subpopulations in the Kiamichi is located near the proposed [City's] water outtake at Moyers (Vaughn *et al.* 2004b). Two subpopulations of *A. wheeleri* have been identified in the Little River; both of these are located on the U.S. Fish and Wildlife Service Little River Wildlife Refuge (Vaughn *et al.* 1995).[83]

Although several populations of listed mussels have survived on the Kiamichi and Little Rivers, they are declining (as acknowledged in the PAD), and would very likely be put at elevated risk by additional water development projects, like the Project:

> … although rare and endangered species of mussels are still present in southeastern Oklahoma, populations in both the Kiamichi and Little rivers are declining. This is troubling information, particularly for *A. wheeleri*, whose global distribution is limited to these two rivers and the Ouachita River in Arkansas. Given the declines in populations of *A. wheeleri* and *Q. cylindrica* and the recent discovery of *Q. fragosa* in this region, it is imperative that further efforts be made to minimize impacts on these already threatened populations. Further construction of reservoirs in this area as recently has been proposed could be detrimental to the remaining populations of both rare and common species of mussels.[84]

SEOPC's studies and the Commission's NEPA analysis should reflect the Project's potential impacts in this broader, ecological context. Further, the Commission should require SEOPC to consult with the FWS in designing its proposed "biological surveys for special status and Threatened/Endangered wildlife, plants, and aquatic species," aquatic habitat studies, and hydrologic studies. PAD, p. 4-76.

The PAD (pp. 4-70 – 4-71) also mentions the potential occurrence of the federally-listed threatened leopard darter, and that the Project transmission line would cross designated critical

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[83] Vaughn 2005 (Attachment 12); *see also* Galbraith et al. 2008 ((Attachment 11) "Historically, both of these rivers also have been home to a number of rare and endangered species of mussels including the Ouachita rock pocketbook, *Arkansia wheeleri*, scaleshell, *Leptodea leptodon*, winged mapleleaf, *Quadrula fragosa*, and rabbitsfoot, *Quadrula cylindrica*.").

[84] Galbraith et al. 2008 (Attachment 11).

habitat. The PAD's cursory discussion of the leopard darter does not present an accurate picture of its current status and threats it faces, which include road construction, increased water demand, and climate change:

> Impacts to water quality from agriculture, industry, gravel mining, and road construction continue to act as a stressor on the species. Poultry operations continue to operate within the watershed, as well as timber extraction and gravel mining. Roads and related sediment run-off and low water crossings that affect the darter's ability to move upstream are potentially significant threats to the leopard darter. More recently identified threats such as climate change and increased water demands further exacerbate potential impacts to the species.[85]

It is reasonable to expect that the proposed Project, if licensed, would exacerbate these threats. However, as commented by FWS, SEOPC must provide additional information regarding proposed Project facilities and operations to evaluate the full extent of the Project's potential impacts.[86]

<u>Section 4.8 Wetland, Riparian, and Littoral Habitats</u>

The PAD's discussion of "floodplain, wetland, riparian, and littoral habitats that have the potential to occur within the proposed Project boundary," relies on limited document review: "[n]o aquatic resource delineations or inventories within the proposed Project boundary have been conducted. Given this, wetland, riparian, and littoral habitat descriptions provided in this section were based on existing [USFWS National Wetlands Inventory (NWI)] data gathered within the proposed Project boundary." PAD, p. 4-77. As discussed above, the proposed Project description and maps are inadequate to determine whether SEOPC has accurately quantified the habitats that could be impacted by Project construction. Further, because SEOPC has not yet provided specific

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[85] FWS Oklahoma Ecological Services Office Tulsa, Oklahoma, "Leopard Darter (*Percina pantherina*) 5-Year Review: Summary and Evaluation (Aug. 30, 2023), *available at* https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/9318.pdf (last accessed Nov. 4, 2024).

[86] FWS Comments, p. 3.

information regarding proposed Project operations, it is not yet clear whether the Project's operational impacts would be limited to those habitats located within the Project boundary.

According to the Nations' expert analysis, the Project's impacts on hydrogeologic resources could to the regional KMGB, which extends beyond the Project boundary. Schuth Report ¶ 2. Impacts to hydrogeologic resources would likely have attendant impacts on wetland habitats. Davis Report ¶ 21. Accordingly, the Nations request Commission staff require that SEOPC's Wetlands, Riparian, and Botanical Resources Study include technical evaluation of the potential geographic scope of Project impacts on wetland, riparian, and littoral habitats, rather than assume that such impacts would be limited to within the Project boundary.

The Nations' share and support FWS's concerns and recommendations regarding the proposed Project's potential impacts on wetlands.[87]

<u>Section 4.9 Recreation Resources</u>

The PAD (p. 4-86) states that, "there are no recreation facilities or opportunities identified within the Project area (defined above as the proposed Project boundary plus a 0.5-mile buffer)." This statement is based on SEOPC's false assumption that recreation only occurs on public lands at formally designated recreation areas or facilities. As described in our comments regarding Section 4.1.3, dispersed recreation is more common in this region and occurs on private lands, not just public access areas. Further, SEOPC has provided no basis for its claim that Project impacts on recreational uses will be limited to within 0.5-miles of the Project boundary.

The PAD fails to disclose potential Project impacts on water-dependent recreation on the Kiamichi River at the intake location. Based on our review, it appears that SEOPC is proposing to

[87] FWS Comments, p. 3.

locate the 40-foot-wide concrete intake structure and appurtenant facilities at a popular swimming hole which supports numerous recreation visits during the spring and summer.

The PAD also fails to disclose potential Project impacts on water-dependent recreation downstream of the intake structure. Given that SEOPC has not yet disclosed volume, timing, and other information regarding its proposed withdrawals from the Kiamichi to fill and recharge Project reservoirs, there is currently no basis to evaluate the severity and extent of those withdrawals on recreational uses downstream of the intake.

As described above, the proposed Project intake would be located upstream of the City's water supply intake. The Project's withdrawals could contribute to depletion of instream flow downstream at the City's intake, which would, in turn, impair the City's ability to exercise its water right without releasing additional water from storage in Sardis Lake. Increased or more frequent releases from storage could interfere with the City's ability to maintain certain Sardis Lake levels for the benefit of fish and wildlife *and recreational uses*, as required under the Settlement Agreement and Act. Thus, the geographic scope of potential Project impacts on recreation could extend to Sardis Lake.

Section 4.10 Land Use

See comments regarding road access and the ONEOK natural gas pipeline in Section 4.1.3, *supra.*

Section 4.11 Aesthetic and Visual Resources

Section 4.11.1.1 Oklahoma

The PAD (pp. 4-106 – 4-107) summarizes the rural and undeveloped visual character of Oklahoma in the Project vicinity.

The PAD (PAD, p. 4-107 to 4-111) provides a few photographs of viewpoints within the proposed Project boundary, apparently randomly selected from Google Earth rather than taken during a site visit. But the PAD also includes error messages – "Error! Reference source not found" – that suggest other photographs may be missing.

The photographs selected by SEOPC fail to show the natural beauty of the Kiamichi River valley, including the undeveloped, verdant viewsheds, the dirt roads shaded by stands of trees, and flowing river itself. *See, e.g.,* Drowned Land documentary trailer.

Section 4.12 Cultural Resources

The PAD's discussion of cultural resources incomprehensibly renders the Nations a historical bump in the road, even though the Project would be located within the Choctaw Reservation and relies on the resources of the Choctaw and Chickasaw Nations. The PAD (pp. 4-144 – 4-152) summarizes the history of the Indian Removal Act, creation of Indian Territory, Choctaw and Chickasaw removal (which SEOPC euphemistically calls "Relocation and Settlement"), and U.S. Development in Texas, the Indian Territory and Oklahoma. It only mentions treaties signed by the U.S. government and Choctaw and Chickasaw Nations to describe the historical cession of Choctaw lands – not the fact that the Choctaw Nation was promised and continues to hold extensive powers of self-government under those treaties on its modern-day reservation. The PAD's reference to the Chickasaw Nation's history and interests in the reservation is extremely limited and gives little indication that the Chickasaw might have any present-day interests in any part of Oklahoma. *See* PAD p.4-147. The PAD's consideration of the Choctaw Nation's interests in the Project site ends in 1907, at Oklahoma statehood. *See* PAD, p. 4-149.

There is no discussion of the Nations' continuing sovereign authority, Treaty rights, and governance of their respective Reservations under their constitutions.[88]

As discussed above, SEOPC cannot fulfill the Commission's obligations under NHPA section 106 to consider the Project's effects on historic, cultural, and other Tribal resources. *See* 36 C.F.R. § 800.2(a).[89] SEOPC's conduct to date only confirms that it lacks the knowledge, experience, or ability to properly consider the Nation's interests here. SEOPC has not adequately performed even its limited role of preparing information for the Commission's use in Section 106 consultation, *see* 36 C.F.R. § 800.2(a)(3). For example, the PAD neglects the interconnection of natural and cultural resources, effectively ignoring that the Project's environmental impacts would have a corresponding impact on cultural resources. "[W]hile the [PAD] briefly touches on various aspects of environmental and cultural services, it does not take into account interactions between cultural and environmental resources, nor does it consider the diversity of cultural services, mainly emphasizing important historical sites (on the National Historic Registrar) or sites in national databases in the proposed project area (which is defined as a 3-mile buffer). Given the flow of common-goods through space … the 3-mile buffer does not provide an adequate understanding of the potential impacts on the complex bundle of ecosystem services" and does not acknowledge the value of the "cultural services provided by nature…" Vadjunec Letter, p. 2.

Further, as stated in Section 2.2, *supra*, SEOPC and its consultants have not provided basic information that the CNHPD has requested to preliminarily identify historical and cultural sites

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[88] *See* Constitution of the Chickasaw Nation, *available at* https://chickasaw.net/getattachment/Our-Nation/Government/Chickasaw-Constitution/CN_Constituion_Amended2002.pdf.aspx?lang=en-US (last accessed Nov. 4, 2024); *see also* Constitution of the Choctaw Nation of Oklahoma, *available at* https://www.choctawnation.com/wp-content/uploads/2022/03/constitution.pdf (last accessed Nov. 4, 2024).

[89] The PAD (p. 4-116) briefly acknowledges that FERC is "the lead federal agency responsible for Section 106 compliance,…."

that could be impacted. The CNHPD commented on the difficulties presented by the ambiguity in the PAD's description of the Project boundary:

> Ambiguity in the project boundary (or APE) has made it difficult to capture exactly which cultural resources could be adversely affected by this project. Aside from construction, CNHPD shares concern regarding spillway drainages, dr[o]ught conditions, and any other unanticipated effects of this project that could adversely affect previously recorded cultural resources located along the Kiamichi River to the east and to the west of the proposed pump facilities.[90]

Based on its preliminary analysis and initial field work,[91] the CNHPD found differences between the information in the PAD as compared to the information maintained in the Choctaw Register of Historic Places and Oklahoma Archaeological Survey. The CNHPD's "search identified thirty-six (36) [known] historic archaeological sites, including fourteen (14) Choctaw Cemeteries, in addition to Twelve (12) possible 1898 BLM GLO Structures in or adjacent to the project area." *Id.* at 3.

While the exact Project location remains unclear, the CNHPD has concluded that there are many more cultural resources located in the Project area than are disclosed in the PAD. A major discrepancy exists between the number of cultural resources listed in the PAD as within the proposed project boundary and the *actual* number of cultural resources encompassed by the proposed project boundary as defined by the project shapefiles. The majority of archaeological resources listed in the PAD as within the proposed project boundary are currently unevaluated for the National Register of Historic Places. CNHPD is of the opinion that many of these

[90] CNHPD Comments (Attachment 9), p. 3; *see also* CNDHP Comments (Attachment 8), p. 2.

[91] In advance of receiving shapefiles from SEOPC, the CNHPD conducted a "preliminary review of the Choctaw Register of Historic Places for sites located within a 5-mile radius of the project area. CNHPD also requested and received site files pertaining to this project from the Oklahoma Archaeological Survey (OAS)." CNHPD Comments (Attachment 9), p. 2.

archaeological sites are, in fact, eligible for the National Register, individually or possibly as a District, *see* 36 C.F.R. § 60.3(d) (definition of "district").

In addition to reviewing the existing site files, the CNHPD has also undertaken initial fieldwork within the project boundary identified in the PAD. A few days of effort resulted in the identification of many unrecorded archaeological sites within the potential APE, including one historic Choctaw Cemetery (with approximately fifteen (15) to twenty (20) internments) and one pre-contact period rock art site that has not been fully surveyed.

SEOPC has not provided timely or adequate information to allow the Nations and other potential consulting parties to prepare for the Section 106 consultation or NEPA processes.[92] It also underscores the need for the Commission's direct administration of the Section 106 consultation process.

The Nations reiterate the requests of their respective historic preservation offices that the Commission require completion of a cultural survey report that meets current professional standards:

> It is highly probable that most of the project area has not received a cultural resources survey up to modern standards. It is likely to contain a number of archaeological sites that are culturally affiliated with the Caddo, Choctaw, and other groups. Given the number of structures shown on maps dating to the first decade of the 1900s, the project areas is likely to contain several Choctaw homestead sites, which our office considers potentially eligible for the NRHP for significance under Criteria A and D. The project area also has a high potential for containing additional Choctaw cemeteries and unmarked, isolated burial places.
>
> If this undertaking is to proceed, CNHPD is requiring a Phase I cultural resources survey of the entire APE by a reputable cultural resource management firm with experience in the area.… FERC will need to engage in a meaningful consultation process with the Choctaw Nation of Oklahoma, [Chickasaw Nation], other

[92] The Chickasaw Nation Division of Historic Preservation separately described deficiencies in the information provided by SEOPC regarding potential impacts to NRHP designated or eligible sites. *See* CNDHP Comments (Attachment 8), p. 2.

> federally recognized Tribes with a historic interest in the area, the Oklahoma State Historic Preservation Officer, and the Oklahoma Archaeological Survey under the [NHPA].… The Tribal cemetery that has been located within the APE is of utmost concern to the Choctaw Nation. FERC must consult with Choctaw Nation under the Native American Graves Protection and Repatriation Act.[93]

The Nations remains very concerned by the presence of historic cemeteries in the Project area, which would trigger additional, unacceptable impacts to the Nations, as well as obligations for the Commission and other federal agencies under the Native American Graves Protection and Repatriation Act.[94,95] The Commission must fully evaluate cemeteries that are known to be or have the potential to be located in the Project area and explain how the Project would avoid disturbing them, or how it would relocate or repatriate human remains in areas where soil disturbance is unavoidable.

Section 4.13 Tribal Resources

This section should be one of the most significant elements of the PAD, given that the Project would be constructed within the Choctaw Reservation and most of the resources that would be impacted are within the Reservation, which is by definition "tribal." Instead, this section contains but a brief discussion of the Choctaw Reservation, which is the only time the PAD ever

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[93] CNHPD Comments (Attachment 9) p. 3. The CNDHP Comments made a substantially similar request: "Archaeological standards have changed throughout the years, and a Phase I cultural resource survey of the entire APE must be completed and provided to us for review followed by formal government-to-government consultation.… [O]ur office is requested a cultural resource **survey** report be completed meeting the current professional standards." CNDHP Comments (Attachment 8), p. 2 (emphasis in original).

[94] *See* CNHPD Comments (Attachment 9), p. 3 ("Sites 34PU244, 34PU257, 34PU263, and 34PU275 are known to contain 'historic native' or Choctaw burials. Wall Cemetery and the Maytubby Cemetery are also located within 5-miles of the proposed pump facilities."). *See also* CNDHP Comments (Attachment 8), p. 2 ("This area encompasses significant sites with Caddoan occupation of approximately 4,000 years and known sites including mounds, evidence of houses, burials, midden soil deposits and hearths.").

[95] The Town of Albion has separately commented that the proposed "project must account for the impact on Albion Cemetery, where 472 memorials are located. Due to the undiscernible maps provided by the prospective applicant, we cannot determine the full effect on Albion Cemetery, where numerous Veterans and Choctaw are buried." (Albion Comments, p. 2).

acknowledges the Reservation's continued existence: "[t]he proposed Project's pumped storage site is adjacent [*sic*] the Choctaw Nation Reservation, of which special consideration and attention to the Choctaw Nation's jurisdiction has been afforded in this section." PAD, p. 4-154. That is incorrect; the pumped storage site and a significant portion of the transmission line would be located *within* the Choctaw Nation Reservation.

Further, SEOPC's claim to "special consideration and attention to the Choctaw Nation's jurisdiction," is blatantly false, as the PAD does not discuss the Nation's jurisdiction at all. And as discussed in Section II, *supra,* the PAD also fails to disclose that the Project would be located in the "Settlement Area" and rely on "Settlement Area Waters," as defined in the Settlement Agreement and Settlement Act.

As described throughout, the Project would have *significant* impacts on the resources of both Nations without providing any protections, mitigation, or enhancement benefits. Contrary to SEOPC's suggestion in the PAD (p. 4-152), these impacts include, but are not limited to, impacts on previously identified cultural sites. In addition to the Nations' comments, several individual Choctaw Nation members have filed comments describing how the Project would deplete natural resources that their families rely upon for the exclusive benefit of non-Tribal communities. For example, a community member from Hugo, Oklahoma provided the following comments:

> We Choctaw hunt and fish this land. We southeastern Oklahomans drink from this basin. It is not for you to take what we have built our communities on. We cannot afford to see higher water rates. My father raises cattle, just as his father and his father. They need the water to live My brother and his wife's family will have the land taken to build this line. Many of my neighbors will suffer. Water rates will go up. Our own ability to have drinking water will be diminished. Why must our water be taken for something that will never benefit us? I say no to this stealing of our land, resources, and heritage.[96]

[96] Comment by Amanda L. Underwood, eLibrary no. 20240828-5003 (Aug. 28, 2024).

The proposed Project is reminiscent of dam building in the northwest in the early 20th century, which extracted wealth from Tribal resources and transferred it away from the Tribes to other communities. The Department of Interior ("Interior") recently published a report documenting the historic, ongoing and cumulative impacts of hydropower development on Columbia River Basin Tribes, which describes this transfer of wealth as being a "persistent environmental injustice."[97] According to Interior,

> The federal and non-federal dams on the Columbia River and lower Snake River transformed the river functions from those the Tribes rely on to those serving other economic ends, transferring wealth away from the Tribes…. Together with commercial activities and other consequences from settlement of the region by non-Indigenous people, the construction and operation of federal dams impacted salmon, steelhead, and other species in the Columbia River Basin, thus impeding the Tribes' ability to realize the benefits of their reserved rights…. Because these impacts continue today and face new threats from climate change, upholding the federal government's treaty and trust responsibilities to the Tribes includes working to protect these reserved rights and restore associated resources; improving the spiritual, cultural, physical, and economic wellbeing of Tribes; and advancing environmental justice.

Interior's assessment of the impacts of hydropower development on Tribes, and its statements regarding the federal government's responsibility to avoid the mistakes of the past when undertaking or licensing projects that would degrade and deplete Tribal resources, are highly relevant to the Commission's and other federal agencies' consideration of this Project. And while the Commission and other federal agencies are ultimately responsible, it is SEOPC's responsibility, as the applicant, to provide all information the agencies deem necessary for their consideration of Tribal Resources in accordance with the law.

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[97] Interior, "Historic and Ongoing Impacts of Federal Dams on the Columbia River Basin Tribes," (June 2024), p. 53, *available at* https://www.doi.gov/media/document/tribal-circumstances-analysis (last accessed Nov. 4, 2024).

<u>Section 4.14 Socioeconomic Resources</u>

The PAD (p. 4-170) represents that SEOPC has been proactive in reaching out to Tribes to discuss potential economic benefits of the Project:

> SEOPC has initiated an open dialogue with local Tribal leaders to explore potential areas of Project-related collaboration. The aim of this early outreach has been to facilitate Project construction and implementation, thereby contributing to local employment and economic benefits for the Tribal communities and other neighboring communities. As of today, collaboration is ongoing and further information pertaining to economic and employment benefits has been sought out.

The PAD overstates SEOPC's Tribal outreach, at least with respect to the Nations. Although the Nations' representatives attended a meeting convened by SEOPC in late 2023, there has been no "open dialogue" or ongoing collaboration between SEOPC and the Nations about providing Project benefits for the Nations. The Nations are interested in pursuing responsible economic development opportunities, but there is nothing in SEOPC's proposal for the local communities.

The PAD states the local workforce and housing supply is inadequate to meet demand during Project construction, and generally indicates the Project would be burdensome rather than beneficial to local economies:

> It is possible that during proposed Project construction the labor workforce would need to be outsourced from outside the Project vicinity. In part, this is due to the relative low population of noted communities within the Project vicinity; additionally, it is due to the low level of vacant (available) housing and short-term lodging. Accommodation and lodging arrangements for Project-related workers during the construction phase would need to be further evaluated, including the relative proportion of within-Project vicinity workforce versus outsourced workforce; the number of existing housing units; the number of vacant housing units; and hotels within a reasonable commuting distance to the proposed Project. An initial evaluation of lodging arrangements revealed that there are approximately two hotels or lodging options within the Project vicinity in Pushmataha County.

The PAD does not estimate the number of workers that would be required at the various stages of the Project, but it is reasonable to expect it would be in the hundreds for several years. Given the limited size of the local workforce, we anticipate the majority of workers will not be local and instead will require housing and other services. The potential need for "temporary" housing over a multi-year construction period would present a significant challenge given that existing housing supply is very limited.

The Project's workforce could also increase demand for emergency, safety, and health services. Given Project construction would occur over several years, it is possible workers would bring their families, which would also increase demand for educational and health services.

However, the massive influx of workers would be relatively short-lived as the Project would create few permanent jobs. This boom-and-bust cycle would be very disruptive to local communities. SEOPC's socioeconomics studies should address these potential impacts.

<u>Section 4.15 Environmental Justice</u>

The PAD (p. 4-185) states, "[g]iven the demographic characteristics, socioeconomic factors, and environmental considerations of these EJ communities, it is possible that the proposed Project could have a disproportionate impact on EJ communities. SEOPC recognizes the importance of equitable treatment and meaningful engagement of local communities." As described above, it is certain, not just "possible" that the Project would impact the Nations. The PAD's summary discussion only scratches the surface of what will be required to address the environmental justice concerns raised by the Project.

> While analysis of demographic characteristics of the proposed site area … and vulnerability … is a start to understanding important socio-environmental dimensions, this approach fails to attend to dimensions of distributive, procedural, and corrective justice and the complex, interactive, and long-standing historical

> dynamics of the peoples, waters, and land in the Kiamichi River Basin which will be impacted by the [Project].

Expert Report of Tamara L. Mix, Ph.D. ("Mix Report"; Attachment 5) ¶ 7 (internal citations omitted).

Fundamentally, the Project involves providing benefits to people outside of the Nations, while imposing most of its costs on the Nations. SEOPC and its out-of-state investors will reap financial benefits from the Project, and consumers in Texas will get electrical power. All the damage to Reservation resources and the risk of further damage to those resources, will be borne by the Nations in order to generate money for SEOPC's investors, wherever they may be. SEOPC will likely use electricity from the local grid to pump water into the upper reservoir, raising demand and costs for local people. The burdens of years of reservoir construction will be felt on the Reservation, not in Texas or by SEOPC. The ecology of the Reservation will be permanently changed in ways that threaten rare and irreplaceable species, which SEOPC is only vaguely aware of. The lands of the Reservation, which SEOPC apparently has not visited, will be seized and inundated. Recreational and cultural use of those lands, of which SEOPC appears ignorant, will be lost to the community. All the risks of stacking two new massive bodies of water in the Jackfork and Stanley formations, which SEOPC never acknowledges, will be borne by the Choctaw Nation and its residents.

This is the very definition of environmental injustice:

> Environmental justice is characterized by systemic exclusion of people from environmental decision-making processes as well as inequitable distribution of environmental "bads," including hazards and risks like pollution, exposure to natural and technological harms, and effects of climate change/disruption, combined with lack of access to environmental "goods," like clean water, air, and affordable, safe food.[98]

[98] Mix Report ¶ 7.

Mix Report ¶ 7. In short, the PAD does not describe the environmental justice impacts of SEOPC's proposal, and those impacts require full study, explanation, and appropriate avoidance, minimization, or mitigation measures.

And that study cannot be artificially cabined to ignore parts of the Nations that will bear costs from the Project, as that would only replicate the erasure that environmental justice policies is meant to undo. The PAD (p. 4-172) proposes that the geographic scope for its EJ analysis will be limited to EJ communities located "within a 5-mile radius around the proposed Project boundary pumped storage site and 75-mile transmission line leading to Paris, Texas." This is inadequate. The entire Choctaw Nation will be affected by this Project because the Nation is responsible for governing and protecting the people and resources of its Reservation, and the resources of the Reservation are valued by, and important to, the entire Nation. And this analysis cannot ignore the Chickasaw Nation's and Choctaw Nation's interests in the use of Settlement Area waters pursuant to the Settlement Agreement. Therefore, the scope of EJ study and analysis must be expanded to include all potentially impacted EJ communities, not just those located within 5 miles of the Project boundary.

In addition to broadening the geographic scope, such study must include the following elements:

a. Quantitative and qualitative research methodologies to address breadth and depth/nuance of Environmental Justice implications related to siting.
b. Analysis of foraging/subsistence dimensions for local populations.
c. Implications of water quality and quantity for local populations.
d. Displacement and land implications for local populations.
e. Downstream impacts related to water quality/quantity and land use changes.
f. Implications for cultural meaning of space and place due to changing land/water access and natural/built landscape changes.
g. Consideration of Environmental Justice impacts broader than immediate site and transmission line right-of-way due to integrated socio-cultural and

> environmental dimensions (migration patterns, seasonal forage, place/space use and meaning, etc.).

Mix Report ¶ 9.

Section 5.1 Known or Potential Adverse Effects and Issues

Despite the title, this section of the PAD does not list any known or potential adverse effects and issues. The idea that a major infrastructure project could have *no* known or potential adverse effects and issues is obviously ridiculous. This is another omission that makes it more difficult for stakeholders to understand the Project and its potential impacts.

At a minimum, the Nations' representatives identified several potential adverse effects prior to SEOPC's filing of the PAD that should be listed in this section. For example, Choctaw Nation representatives raised concerns regarding the Project's potential impacts on the local economy and lifestyle and quality of life for local communities. *See* PAD, Appendix A, Session 1 - Webvtt - **Unedited Zoom Transcript** (Dec. 11, 2023), p. 18 of 27. The Nations have identified many more potential adverse effects in these comments.

Table 5-1. Proposed Studies

The PAD (p. 5-1) lists several proposed studies but does not provide specific information about SEOPC's proposed scope or methodologies for such studies. This incomplete information increases the burden on licensing participants to develop specific study requests in a vacuum. The Nations have nevertheless made a considerable effort to develop additional study requests for inclusion in SEOPC's proposed study plan, as described in Section VI, *infra*.

V. COMMENTS ON SCOPING DOCUMENT 1

SD1 largely relies on the information contained in the PAD. Accordingly, the Nations request Commission Staff consider the comments in Section IV, *supra*, in considering revisions to SD1 and the scope of environmental analysis.

The Nations generally organize our comments according to the headings in SD1 for ease of reference.

Section 1.0 Introduction

According to SD1 Section 1, Commission Staff will determine whether to prepare an Environmental Impact Statement ("EIS") or an Environmental Assessment ("EA") under NEPA based, in part, on scoping comments.

The Commission's regulations establish a presumption that an EIS will be prepared for licenses issued under the FPA Part I "for construction of any unconstructed water power projects." 18 C.F.R. § 380.6(a). The Commission can overcome this presumption, but only if it "believes that a proposed action … may not be a major Federal action significantly affecting the quality of the human environment …." 18 C.F.R. § 380.6(b). Given the scope and significance of the Project's impacts, there is no rational basis for such a belief. Accordingly, the Commission should prepare an EIS for the proposed Project.

Section 2.2 Scoping Comments, Scoping Meetings, and Site Review

Under NEPA regulations, federal agencies are required to engage the public for the "purpose of inform[ing] the public of an agency's proposed action, allow[ing] for meaningful engagement during the NEPA process, and ensur[ing] decision makers are informed by the views of the public."40 C.F.R. § 1501.9. The regulations further direct a federal agency to consider the needs of the affected community when deciding how best to reach the public. *See* 40 C.F.R. § 1501.9.

The Scoping Notice (p. 4) indicated the scoping meetings would provide an opportunity for meaningful public input, consistent with NEPA regulations:

> Commission staff will hold five public scoping meetings to receive input on the scope of the environmental issues that should be analyzed in the NEPA document …. We invite all interested agencies, Native American Tribes, NGOs, and individuals to attend one of these meetings to assist us in identifying the scope of environmental issues that should be analyzed in the NEPA document. Additionally, each meeting will include a virtual review of the proposed project site.

The Notice (pp. 2-3) also referred to the Commission's inclusive approach to public engagement:

> The Commission's Office of Public Participation (OPP) supports meaningful public engagement and participation in Commission proceedings. OPP can help members of the public, including landowners, environmental justice communities, Tribal members and others, access publicly available information and navigate Commission processes.

Chief Gary Batton of the Choctaw Nation attended the scoping meeting on August 9 because of the Project's proposed location within the Choctaw Reservation and seriousness of potential impacts on Tribal resources and communities. Several representatives from the Nations also attended the meetings in Paris and Talihina. Given the regulatory standards for meaningful public engagement and the Notice's descriptions, those that attended were taken aback by the format and content of the meetings.

The applicant's presentation was not designed to inform, and the applicant did not appear prepared to respond constructively to the community members' questions about the proposed Project. Indeed, a representative of SEOPC attacked a member of the public who asked questions about the source of SEOPC's funding by shouting an expletive at him. Further, Commission staff provided little actionable information about the Commission's NEPA scoping and administrative hearing process to the many community members in attendance who likely have never participated in a proceeding for a major energy infrastructure project proposed in their backyard.

Perhaps most concerning was the Commission's procedure for receiving public comments. Rather than allowing community members to provide comments during the open meeting, each commenter was assigned a number and when their number was called, they were sent to a private room to provide their comments to a court reporter.[99] Comments provided in this format are, obviously, not public comments as no one except the court reporter hears them. This deprived commenters the opportunity to speak directly to Commission Staff and SEOPC's representative, and also prevented community members from hearing each other's comments, questions, and concerns. This procedure blocked the exchange of ideas and prevented meaningful public engagement for which the Commission is solely responsible. That error should be corrected.

<u>Section 3.0 Proposed Action and Alternatives</u>

The Nations request the Commission thoroughly consider the No-Action Alternative.

<u>Sections 3.2.1 and 3.2.2 Proposed Project Facilities</u>

As described above, the PAD's descriptions of the proposed Project facilities and operations are too vague and incomplete to permit fully and accurate study of the Project's potential environmental impacts and the availability of any alternatives or measures to avoid, minimize or mitigate those impacts. The Commission should direct SEOPC to provide additional information and undertake studies that are necessary for the Commission and other federal

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[99] *See* FERC Staff, "Handout and slide presentation from the in-person scoping meetings for the proposed Pushmataha Project (P-14890-005) held on August 7-9, 2024," eLibrary no. 20240823-3066 (Aug. 23, 2024).

permitting agencies to comply with their trust responsibilities to the Nations and their responsibilities under NEPA.

Section 3.2.3 Proposed Environmental Measures

SD1 (p. 11) confirms that SEOPC has not proposed "any environmental protection, mitigation, and enhancement (PM&E) measures at this time." The Nations do not understand the basis for Commission Staff's acceptance of a PAD that does not include any proposed mitigation measures for a major, new pumped storage project that would permanently inundate 1530 acres, divert vast quantities of water from the Kiamichi River for years into the future, alter the hydrogeology of the regional groundwater basin, construct 100 miles of new transmission lines, and have attendant impacts on fish and wildlife, recreation, and other beneficial uses.

Section 3.3 Alternatives to the Proposed Action

SD1 (p. 12) states, "Commission staff will consider and assess all alternative recommendations for operational or facility modifications, as well as PM&E measures identified by Commission staff, resource agencies, Native American Tribes, NGOs, and the public." The Commission is obligated to undertake thorough study of alternatives to the proposed Project under NEPA section 102, 42 U.S.C. § 4332(2)(C), (E), and FPA section 10(a)(1), 18 C.F.R. § 803(a)(1). SD2 should acknowledge the Commission's obligations to develop alternatives for consideration, not simply rely on SEOPC's proposals.[100]

Section 4.1.1 Resources that Could Be Cumulatively Affected

The Nations support the proposed inclusion of "water quantity (i.e., area hydrology), water quality (i.e., dissolved oxygen [DO] and water temperature), fisheries, and rare, threatened, and

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[100] *Scenic Hudson Preservation Conference v. FPC*, 354 F.2d 608, 612 (2d Cir. 1965). "In viewing the public interest, the Commission's vision is not to be limited to the horizons of the private parties to the proceeding." *Id.*

endangered (RTE) species … as having the potential to be cumulatively affected by the proposed construction, operation, and maintenance of the project." SD1, p. 12. The Commission should also study the proposed Project's cumulative effects on geologic resources and soil resources, hydrogeologic resources, aquatic resources (including non-listed mussels and host fish), terrestrial resources, recreation resources, land use and aesthetic resources, cultural and historic resources, environmental justice, socioeconomics, noise, air quality, and traffic, and developmental resources.

Section 4.1.2 Geographic Scope

The geographic scope of the EIS should be broad enough to identify and consider the Project's potential indirect and cumulative impacts. We expect the geographic scope to be large given the extensive size of the Project facilities and length of the proposed transmission line.

Section 4.2 Resource Issues

SD1 lists resources (pp. 13-17) that would be affected by the proposed Project and lists specific issues the Commission proposes to analyze in the NEPA document for each resource category. We support consideration of the effects already listed *and* request the Commission *also* include the *additional* issues and/or considerations identified in underlined text, *infra*, and discussed in Section III, *supra*.

Section 4.2.1 Geologic and Soil Resources

- Effects of construction, operation, and maintenance of project structures, access roads, and transmission facilities on soil erosion and sedimentation.
- Effects of spoil disposal on soil erosion and sedimentation.
- Effects of construction, filling, and operation of the upper, lower, and re-regulating reservoirs on groundwater levels and wells in the surrounding area, groundwater flows and groundwater quality.
- Effects of project operation on riverbank and sediment conditions (i.e., stability, erosion and sedimentation, and sediment transport, and rate and

volume of deposition) in the Kiamichi River, Long Creek, and shorelines of the upper, lower, and re-regulating reservoirs.

- Effects of the proposed water intake on erosion and sedimentation in the Kiamichi River.
- Effects of project construction and operation on geologic stability, including but not limited to more specific inventory of soil types, geological formations, and geologic hazards in the project area.
- Effects related to potential disposal or reuse of excavated materials during construction.

Section 4.2.2 Water Resources

- Effects of project construction, operation, and maintenance on aquifers underlying the Latimer, Le Flore, upper Atoka, Pushmataha and McCurtain Counties.
- Effects of seepage on groundwater levels, groundwater quality and on reservoir refill requirements.
- Effects of project water withdrawals (e.g., during initial fill of the lower reservoir and for filling the re-regulating reservoir during high flows to provide maintenance flows for the project reservoirs) on water quantity in the Kiamichi River.
- Effects of project construction, operation, and maintenance on the hydrology (e.g., changes in flow and water velocities) of the Kiamichi River, Long Creek, and the Pushmataha Project watershed area.
- Effects of project construction, operation, and maintenance on water quality in the project area.
- Effects of project construction, operation, and maintenance on surface water quality and drainage patterns across the watershed of the proposed Project area.
- Effects of project construction, operation, and maintenance on long-term water quality and water quantity in the reservoirs of the Kiamichi River Basin.
- Effects of potential spillway discharges to the Long Creek, and the potential erosion and sedimentation impacts (*see* Section III, Section 3.2.1.1 Upper Reservoir Facilities, *supra*).
- Effects on hydrogeologic resources (*id.*).
- Effects of potential spillway discharges to the Kiamichi River (banks, channel and bed), and the potential erosion and sedimentation impacts of those discharges (*see* Section III, Section 3.2.1.2 Lower Reservoir Facilities, *supra*).
- Effects on water quality, and attendant aquatic habitat impacts, of any potential spillway discharges, including the likely water quality parameters (e.g., turbidity, pH, and dissolved oxygen, of spillway discharges from the lower reservoir) (*id.*).

- Effects of the spillway tunnel on avoiding or mitigating downstream flooding in the event of spillway operation or potential dam failure under emergency conditions (*id*.).
- Effects of the proposed withdrawals (including timing, volume, and rate) on unnecessary discharges from the regulating or lower reservoirs back into the Kiamichi River (*see* Section III, Section 3.2.1.3 Regulating Reservoir Facilities, *supra*).
- Effects from the discharges on impact water quality, aquatic resources, and existing water rights holders (*id*.).
- Effects of evaporative losses over the Project lifetime with a warming climate (*see* Section III, Section 4.1.2 Climate, *supra*).
- Effects of evaporative losses on climatic conditions that cause severe thunderstorms, tornadoes, and other extreme weather events (*id*.).
- Effects of reservoir construction and leakage on hydraulic gradients in the KMGB and potential effects of potential changes in hydraulic gradients.
- Effects of project construction and operation on existing water rights.

Section 4.2.3 Aquatic Resources

- Effects of project construction, operation, and maintenance on aquatic habitat and biota (i.e., fish, vertebrates, micro-invertebrates, and macroinvertebrates), including the quantity, timing, and duration of available effective habitat in the Kiamichi River, Black Fork River, and Long Creek, across the range of proposed project operations.
- Effects of project water withdrawals from the Kiamichi River during high-flow periods for initial fill of the lower and re-regulating reservoirs and supplemental refills for reservoir maintenance and storage for evaporative losses, on aquatic habitat and biota in the Kiamichi River.
- Effects of project impingement, entrainment, and turbine mortality on fish populations in Kiamichi River and the lower project reservoir.
- Effects of project operation on fish species that are caught and consumed as part of any subsistence fishery in the project area (e.g., sunfish, catfish, bluegill, etc.).

Section 4.2.4 Terrestrial Resources

- Effects of project construction, operation, and maintenance activities, including maintenance for roads and transmission facilities on native and/or sensitive-plant communities (in wetlands and uplands), including a) vegetation species tracked by the Oklahoma Natural Heritage Inventory, b) USFS Proposed, Endangered, Threatened, and Sensitive Species, and c) vegetation species that are culturally significant to Tribal Nations (*see* Buthod Report ¶¶ 9-15), and the spread and control of non-native invasive plants, and the disruption of wildlife migration corridors and creation of edge habitat.

- Effects of vegetation clearing, grubbing, and other construction activities on the availability and continuity of upland and wetland habitat, including for special status plants and wildlife.
- Effects of construction, operation, and maintenance of transmission line facilities on vegetation and wildlife, including electrocution and collision hazards for raptors and other birds including the bald eagle.
- Effects of noise, lighting, vehicular traffic, and human presence during project construction, operation, and maintenance activities on wildlife, especially during sensitive periods (e.g., migrating or breeding).
- Effects of project construction, operation, and maintenance activities on subsistence farming and harvesting.

Section 4.2.5 Threatened and Endangered Species

- Effects of project construction, operation, and maintenance on the following tentatively identified federally listed threatened and endangered species in Oklahoma and Texas: Indiana bat, northern long-eared bat, piping plover, red-cockaded woodpecker, rufa red knot, American burying beetle, American alligator (similarity of appearance threatened [SAT]), leopard darter, Ouachita rock-pocketbook, rabbitsfoot, scaleshell mussel, and winged mapleleaf.
- Effects of project construction, operation, and maintenance on the proposed endangered tricolored bat and proposed threatened alligator snapping turtle.
- Effects of project construction, operation, and maintenance on designated critical habitat for the leopard darter.
- Effects of project construction, operation, and maintenance on the monarch butterfly, a candidate species for listing under the Endangered Species Act.

Section 4.2.6 Recreation Resources

- Effects of project construction, operation and maintenance on recreational use, access, and resources in the 20-mile radius of the project-affected area, including Kiamichi River, Long Creek, Little River, Red River, Cedar Creek, and the Kiamichi Mountains.
- Effects of project construction, operation, and maintenance on recreational flows of the Kiamichi River.
- Effects on camping, hiking, fishing, gathering and other cultural and recreational activities provided by the Ouachita National Forest Ranger District and federal lands administered by the Bureau of Land Management (*see* Section III, Section 4.1.3 Major Land Uses, *supra*).
- Effects of project construction and operation on quality of various recreational uses and opportunities, e.g., fishing, hunting, wildlife observation.

- Effects of project and construction and operation on number and duration of recreational visits in the Project area, including private and public (e.g., Ouachita National Forest) lands.

Section 4.2.7 Land Use and Aesthetic Resources

- Effects of project construction, operation and maintenance on existing land uses in the project-affected area.
- Effects of project construction, operation, and maintenance on project-affected area roadways (e.g., vehicular traffic).
- Effects of project construction, operation, and maintenance (including the presence of project facilities) on visual resources, including the Kiamichi Mountains, and culturally or historically significant landscapes whether within outside of the Project boundary.
- Effects of project construction, operation, and maintenance on light pollution.
- Effects of project construction, operation, and maintenance on farming and grazing uses, not limited to permanent conversion of farmland to developed land.

Section 4.2.8 Cultural Resources

- Effects of project construction, operation, and maintenance on properties that are included in, or eligible for inclusion in, the National Register of Historic Places, and traditional cultural properties, features, and landscapes.
- Effects of continued project operation and maintenance on properties of traditional religious and cultural importance to Native-American Tribe(s), including but not limited to the Grobin Davis Mound site, Wall and Maytubby Cemeteries, and the Duke family farmstead.
- Effects of project construction, operation, and maintenance on historic trails, including the Kiamichi Trail (K-Trail), the Wildhorse Trail, Uphilly Bowers Trail, the Nolia Trail, and the Stevens Trail.

Section 4.2.9 Environmental Justice

- Effects of project construction, operation and maintenance on minority and low-income communities in the project-affected area.
- Effects of the project on human health and environmental effects currently present in the project-affected area.
- Effects that could be disproportionate, adverse, and significant on minority and low-income populations.
- Effects of project water withdrawals associated with (a) initially filling the lower reservoir; and (b) supplemental withdrawals from the Kiamichi River

during high flow periods on the sustenance of minority and low-income populations.

- Effects of project construction, operation, and maintenance within the Choctaw Nation Reservation on the Choctaw Nation, including impacts to tribal policing, infrastructure construction and maintenance, the providing of services to tribal members, environmental monitoring and protection, economic development, cultural resource cataloging and protection, protecting and fostering cultural and traditional practices, tribal education, tourism, and recreational programs.
- Effects of project's consumptive withdrawal of water resources within the Choctaw and Chickasaw Nations' Reservations.
- Consistency with the goals and requirements of federal executive policies on environmental justice, including those implemented pursuant to Executive Order 14008, Sections 219-20.
- Consistency of agency decision making with all applicable agency and executive policies, guidelines, rules, and regulations regarding tribal consultation.

Section 4.2.10 Socioeconomics

- Effects of project construction and operation activities on local roads (including traffic), housing, businesses, employment opportunities, and government services.
- Effects of project construction, operation, and maintenance activities on human health or the environment.
- Effects of project construction, maintenance, and operation on local infrastructure and government and other emergency, educational, and health services.
- Effects of project construction on public safety, including but not limited to crime, vehicular traffic, and blasting impacts.
- Effects of permanent conversion of rural farmland, grasslands, and forested lands to developed lands.
- Effects (temporary and long-term) of Project construction and operation on *local* employment opportunities.
- Effects of Project construction and operation on local property values and insurance costs.
- Effects of project construction and operation on local and regional recreational and tourist economies.

Section 4.2.11 Noise, Air Quality, and Traffic

- Effects of project construction and operation on noise levels in the Pushmataha Project area.

- Effects of project construction activities (including windblown dust) on air quality.
- Effects of project construction on traffic and road networks in the Pushmataha Project area during and after construction.
- Effects of project construction, operation, and maintenance on the generation of greenhouse gasses.

<u>Section 4.2.12 Developmental Resources</u>

- Effects of proposed or recommended environmental measures on project generation and economics.
- Adequacy of proposed fill and refill resources and the effects on generation.

<u>Section 5.0 Proposed Studies</u>

SEOPC's list of Proposed Studies is incomplete and will produce inadequate data for purposes of the Commission's environmental analysis under NEPA and comprehensive planning under the FPA. SEOPC should be required to undertake additional and/or modified studies as requested in Section VI, *infra*, and any studies requested by FWS, Bureau of Indian Affairs, USACE, and other state and federal resource agencies, parties to the Settlement Agreement, and local governments and agencies.

VI. <u>STUDY REQUESTS</u>

The license applicant must evaluate its proposal and reasonable alternatives using reliable data. Specifically, the license applicant must

> (1) Provide all necessary or relevant information to the Commission; [and]
>
> (2) Conduct any studies that the Commission staff considers necessary or relevant to determine the impact of the proposal on the human environment and natural resources….[101]

Reliable data requires studies, and the approved study plan should characterize and evaluate the potential Project effects listed in Section IV, *supra*, based on reliable data, and then

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[101] 18 C.F.R. § 380.3(b)(1)-(2).

develop and compare alternatives, including the No Action Alternative. This work is necessary to the Nations' meaningful participation in this proceeding and the Commission's fulfillment of its trust responsibility to the Nations, and essential to provide an adequate record for the Commission's and other agencies' environmental analysis under NEPA and ultimate decision-making under authorizing statutes. To fulfill these duties, the Nations request that the Commission direct SEOPC to undertake the studies listed in SD1, subject to the clarifications and modifications described below and as requested by FWS, BIA, and other resource agencies, and conduct the additional studies described below.

A. Geological and Soil Resources

1. Geological and Soils Study

Criterion (1) – Describe the goals and objectives of each study proposal and the information to be obtained.

The goals of this study are to define the existing geological and soils conditions at the site for use in the environmental analysis of the proposed Project and to assess the feasibility of the proposed Project features. Its specific objectives include describing:

a) The geologic and soil characteristics within proposed Project boundary, including any potential borrow areas and quarry sites;

b) How the physical characteristics of the geology and soil would react to the construction and operation of the Project, including the construction of a dam at the upper reservoir site, the inundation of the lower, upper and regulating reservoirs, and the daily transfer of enormous volumes of water between and among them;

c) The risk of static liquefaction, and an analysis of the factors that create that risk, including the steep slopes the project works traverse, and the weight of the water the reservoirs carry and hold;

d) The issues associated with the excavation, disposal, and storage of these materials, whether on or off site;

e) The hydrogeologic characteristics to obtain an understanding of groundwater movement and expected quantities, and their potential to destabilize the soil on which the reservoirs and other project works are built; and

f) The soils and geologic information to be used in the preparation of a supporting design report that fully meets existing dam safety standards.

Criterion (2) – If applicable, explain the relevant resource management goals of the agencies or Indian tribes with jurisdiction over the resource to be studied.

The Choctaw Reservation will be directly affected by the proposed Project, and a thorough understanding of the geologic characteristics involved is critical to ensuring that SEOPC does not cause damage to the natural environment or harm to the people who live and rely on it, particularly where such damage is avoidable. An incomplete or otherwise inadequate understanding of the site's geology could undermine findings regarding the feasibility of the proposed Project and cause significant risks to public safety and the environment, including from dam failure.

Criterion (3) – If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study.

See response to Criterion (2).

Criterion (4) – Describe existing information concerning the subject of the study proposal, and the need for additional information.

While the PAD gives an overview of the geology and soils (*Section 4.2 Geology and Soils*), site specifics have yet to be studied. Incredibly, the PAD admits (p. 4-26) that: "site-specific geologic and soil studies have not yet been conducted in the Project area," and at the same time states that "SEOPC plans to undertake a geomorphic analysis and sampling study to gather *additional* information." (Emphasis added.) Obviously, SEOPC cannot add to what it has not done. Site-specific rock and soil information is needed for Commission staff to adequately assess potential Project effects to soil and geology resources resulting from Project construction, operation, and maintenance; and to assess the adequacy of the proposed Project features, given the properties of the specific rock and soil units at the proposed Project site.

Criterion (5) – Explain any nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements.

Project construction, operation, and maintenance activities have the potential to be affected by, and to affect, geologic formations, soils, and hydrogeology in the project area. This study would assist in identifying specific areas within the Project area where the condition or nature of the geology or soils are such that siting the Project at this location is not feasible or safe, or measures would have to be proposed to avoid, minimize, or mitigate potential effects from project construction, operation, and/or maintenance. The proposed project includes the construction of a concrete-faced rockfill upper dam, with a 599.55-acre upper reservoir; an earthen lower dam, with an 887.37-acre lower reservoir; an earthen/concrete embankment, with a 40-acre re-regulating reservoir; a concrete pump station/powerhouse, and a transmission line. All such facilities would require extensive geologic information to be obtained for the project to advance through the design phase. The study would indicate whether the near complete destruction of the existing geologic and soils conditions at the Project area can support its replacement with the Project works, and any special design and construction measures that would need to be incorporated into the project design based on the results of the geologic investigations.

Criterion (6) – Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge.

The study plan should address how the following specific information would be gathered by SEOPC:

a) A comprehensive review and preliminary analysis of existing geologic and soil resources using existing geologic and soil survey maps, available well logs/records, available records from proximate infrastructure development, aerial photography, etc.;

b) An analysis of regional stratigraphy and geologic structure based on a review of existing literature;

c) Field investigations to ground truth existing information and to determine the properties of rock and soil units, including their occurrence and distribution within the proposed Project area. Consideration should be given to studying:
   1. The fault mapped in the vicinity of the proposed powerhouse location;
   2. Determination of shear wave velocities in the soils and rock to support the seismic hazard study; and
   3. The response of soil and rock units to stress changes, particularly in light of the relative softness and anisotropy of the mapped rock units;

d) A preliminary analysis of the effect of the composition of soils in the Project area on the construction, operation, and maintenance of the proposed Project, including the potential for static liquefaction.

These methods are consistent with standard practices and generally accepted methods used by applicants and relied upon by Commission staff in other hydroelectric licensing proceedings to assess geological and soil resources. *See, e.g.,* FERC, Letter to Terry Wolf (Western Minnesota Municipal Power Agency) Dated October 26, 2022 re: Comments on Preliminary Study Plans, Request for Studies, and Additional Information (Oct. 26, 2022), eLibrary no. 20221026-3007, pp. A-1 – A-4 (GCPSP FERC Study Requests). These methods are also necessary to protect public safety.

In the initial study report, SEOPC should include the results of the surveys and field investigations and identify, describe, and assess the extent to which Project-related actions and activities may be affected by, or may affect, local geology and soils. SEOPC should describe all methods used; discuss regional geology and soils distribution; describe the lithologies, stratigraphy, and material types present in the construction zones; and include maps showing the areas investigated.

The Preliminary Licensing Proposal ("PLP") (or draft license application ("DLA")) should clearly describe any proposed measures to reduce any potential adverse effects associated with Project construction, operation, and maintenance to or from soil, geologic and hydrogeologic resources, the effectiveness of any such proposed measures in reducing potential adverse effects, and the adverse effects that cannot reliably be avoided. The information gathered during this analysis should also be used to advance project design and inform the development of SEOPC's supporting design report, which is a requirement of any final license application filed for the project (*see* 18 C.F.R. § 4.41(g)(3)).

Criterion (7) – Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

The estimated cost of this work is approximately \$200,000 to \$00,000. *See* GCPSP FERC Study Requests, p. A-4.

2. <u>Slope Stability Study</u>

Criterion (1) – Describe the goals and objectives of each study proposal and the information to be obtained.

The goal of this study is to conduct stability and stress analyses for all existing and proposed slopes with the potential to be affected by Project facilities (e.g., upper, lower, and regulating reservoirs, powerhouse, access road, transmission structures, etc.), under all probable loading conditions, which includes seismic and hydrostatic forces. The specific objectives of this study are to assess:

a) The steepness of slopes in the Project area, and the weight to be loaded onto those slopes;

b) stability of all existing and proposed slopes during project construction as well as when subject to loading associated with the constructed project works and their operation;

c) The seismic stability of critical slopes;

d) The contribution of slope steepness to the static liquefaction risk at the Project area;

e) The deformation response of the underlying and adjacent materials during project construction as well as when subject to loading associated with the constructed project works and their operation; and

f) The effect of rock weathering and bedding on all existing and proposed slopes and how that would affect their temporary and long-term stability.

Criterion (2) – If applicable, explain the relevant resource management goals of the agencies or Indian tribes with jurisdiction over the resource to be studied.

The Nations have considerable interest in ensuring that the proposed Project's effects do not cause landslides or other detrimental impacts on their lands, or threats to the people who live and work there. Project construction, operation, and maintenance activities have the potential to be affected by, and to affect, slope conditions and geological hazards in the vicinity. Describing these effects is necessary to fulfill the Commission's trust responsibilities to the Nations and its responsibilities under the NEPA. Ensuring that potential measures associated with minimizing these impacts are analyzed is relevant to the Commission's public interest determination, as well as to the Nations.

Criterion (3) – If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study.

In addition to the Nations' interests described under Criterion (2), the Commission has explained the relevant public interest considerations in requesting slope stability studies:

> Section 4(e) and 10(a) of the FPA require that the Commission give equal consideration to all uses of the waterway on which a project is located. When reviewing a proposed action, the Commission must consider the environmental,

> recreational, fish and wildlife, and other non-developmental values of the project, as well as power generation and other developmental values.
>
> Project construction, operation, and maintenance activities have the potential to be affected by, and to affect, slope conditions and geological hazards in the vicinity. Describing these effects is necessary to fulfill the Commission's responsibilities under the NEPA. Ensuring that potential measures associated with minimizing these impacts are analyzed is relevant to the Commission's public interest determination.
>
> Additionally, the Commission must decide whether to issue a license for the project. In making that decision, the Commission must review the adequacy of the proposed project facilities. Accordingly, 18 C.F.R. § 4.41(g)(3) requires that an applicant furnish stability and stress analyses for all major structures and critical abutment slopes under all probable loading conditions, including seismic and hydrostatic forces induced by water loads up to the Probable Maximum Flood to demonstrate that proposed structures are safe and adequate to fulfill their stated functions.

GCPSP FERC Study Requests, pp. A-4 – A-5.

Criterion (4) – Describe existing information concerning the subject of the study proposal, and the need for additional information.

The PAD only offers an overview of the geology and soils (*Section 4.2 Geology and Soils*), and fails to directly address geological hazards, including the potential for unstable slope conditions.

Stability analyses to assess the potentially unstable slopes and stress analyses would be needed to understand the response of soil and rock units to embankment and reservoir loading. This information is needed for Commission staff to conduct its environmental analysis under NEPA, assess slope stability hazards/constraints, and assess the adequacy of proposed project features given the properties of the specific rock, soil units, and seismicity at the proposed project site.

Criterion (5) – Explain any nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements.

Project construction, operation, and maintenance activities have the potential to be affected by, and to affect, slope conditions, and geological and soils hazards in the vicinity. This study would assist in identifying specific areas within the project area where the condition or nature of the geology or soils is such that measures would have to be proposed to avoid, minimize, or mitigate potential effects from project construction, operation, and/or maintenance.

Criterion (6) – Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge.

The study plan should address how the following specific information would be evaluated by SEOPC:

a) Permanent (e.g., embankment loading) and transient (e.g., seismic, reservoir cycling) ground deformations at the upper, lower, and regulating reservoir sites, their potential to cause or contribute to the impact of seismic seiches, and their potential effect on the feasibility of the proposed project configuration and potential reservoir lining types;

b) Potential for block-type translation and/or shallow slope failure along planes beneath the proposed upper, lower, and regulating reservoir embankments, particularly when subject to hydrostatic and potential earthquake loading;

c) Depending on the findings of a Geological and Soils Study, the local susceptibility to liquefaction during an earthquake event; and

d) The potential for any deep-seated failures that could directly affect the spillway tunnel or powerhouse in the vicinity of project infrastructure.

To complete this study, SEOPC should:

a) Use data obtained during the Geological and Soils Study;

b) Use records available from local agencies documenting slope conditions and slope response to construction works;

c) Visual observation of site conditions;

d) Review publicly available LiDAR data to identify existing slide locations and, if warranted, acquire new data to assess changes in conditions; and

e) If indication of large-scale instabilities or ground movements are found, use InSAR5 or similar satellite-based ground deformation monitoring approaches to understand the magnitude and distribution of the deformations and assess the potential effects on the project.

These methods are consistent with standard practices and generally accepted methods used by applicants and relied upon by Commission staff in other hydroelectric licensing proceedings to assess slope stability and geological hazards.

SEOPC's initial study report should include study results, data analysis, and a description of field investigation activities and methods. The PLP (or DLA) should clearly describe any proposed measures to reduce any potential adverse effects associated with project construction, operation and maintenance, and recommend project design details based on the findings of the analyses conducted as part of this study. The information gathered during this analysis should also be used to advance project design and inform the development of the supporting design report, which is a requirement of any final license application filed for the project (*see* 18 C.F.R. § 4.41(g)(3)).

Criterion (7) – Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

The estimated cost of this work is approximately $50,000 to $75,000. *See* GCPSP FERC Study Requests, p. A-7.

3. Site-Specific Seismic Hazard Study

Criterion (1) – Describe the goals and objectives of each study proposal and the information to be obtained.

The goal of this study is to conduct a deterministic and probabilistic seismic hazard evaluation in accordance with Chapter 13 of the FERC Engineering Guidelines for the Evaluation of Hydropower Projects to define earthquake ground motion parameters at the project site, assess the seismic risk for the project during and following seismic loading, and propose design criteria for project components considering the risk level. The specific objectives of this study are to:

a) Compile and document available information on geology and historical seismicity of the region in which any proposed project facilities would be located, including any existing geologic and seismic characterization studies and critical review of local, non-technical data sources, such as newspaper publications;

b) Identify the seismic sources along which future earthquakes are likely to occur, including the potential for upper reservoir-triggered seismicity;

c) Define the magnitude and frequency of the possible earthquakes on each seismic source;

d) Define the location of each seismic source with respect to the site;

e) Develop earthquake ground motion parameters at the proposed project site to be utilized in:
   1. Slope stability assessments;
   2. Transient and permanent deformation assessments, with consideration of potential failure modes and allowable deformation tolerances; and
   3. An assessment of the effects of earthquakes on proposed project structures;

f) Compare study results with the U.S. Geological Survey seismic hazard in terms of hazard curves, deaggregation, etc.; and

g) Define seismic design criteria for the project.

Criterion (2) – If applicable, explain the relevant resource management goals of the agencies or Indian tribes with jurisdiction over the resource to be studied.

The Nations have considerable interest in avoiding seismic hazards on their lands and thus in ensuring that the proposed project's effects do not increase those risks. Project construction, operation, and maintenance activities have the potential to be affected by, and to affect, seismic conditions and geological hazards in the vicinity. Describing these effects is necessary to fulfill the Commission's trust responsibilities to the Nations and its responsibilities under the NEPA. Ensuring that potential measures associated with minimizing these impacts are analyzed is relevant to the Commission's public interest determination. 18 C.F.R. § 4.41(g)(3) of the Commission's regulations require that an applicant furnish, at a minimum, the bases for determination of seismic loading in sufficient detail to permit independent staff evaluation.

***Criterion (3) – If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study*.**

In addition to the Nations' interests described under Criterion (2), FERC has explained the relevant public interest considerations in requesting seismic risk studies:

> Section 4(e) and 10(a) of the FPA require that the Commission give equal consideration to all uses of the waterway on which a project is located. When reviewing a proposed action, the Commission must consider the environmental, recreational, fish and wildlife, and other non-developmental values of the project, as well as power generation and other developmental values.
>
> Project construction, operation, and maintenance activities have the potential to be affected by, and to affect, seismic conditions and geological hazards in the vicinity. Describing these effects is necessary to fulfill the Commission's responsibilities under the NEPA. Ensuring that potential measures associated with minimizing these impacts are analyzed is relevant to the Commission's public interest determination.
>
> The Commission is responsible for ensuring, through monitoring and investigation, that actions necessary to protect life, health, and property, and the environment are properly taken by licensees. This responsibility includes assessing the effects of earthquakes at hydropower facilities. The ability of the proposed project facilities to perform satisfactorily (e.g., limit embankment deformations such that critical damage to the liner system is not sustained) when subject to a design seismic event is considered a basic element of a comprehensive dam safety program under the

> Commission's 18 CFR Part 12 regulations. 18 C.F.R. § 4.41(g)(3) of the Commission's regulations require that an applicant furnish, at a minimum, the bases for determination of seismic loading in sufficient detail to permit independent staff evaluation.

GCPSP FERC Study Requests, p. A-8.

Criterion (4) – Describe existing information concerning the subject of the study proposal, and the need for additional information.

The PAD provides a brief overview of the regional geology and seismicity. Although the PAD includes Figure 4.4, *Fault Zone and Seismic Activity Map*, this map cannot be considered site-specific. A better understanding of the regional seismicity should be incorporated in the design of the project structures. Accordingly, a site-specific seismic hazard evaluation per the FERC Engineering Guidelines for the Evaluation of Hydropower Projects should be conducted for the project.

Criterion (5) – Explain any nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements.

Project construction, operation, and maintenance activities have the potential to be affected by, and to affect, seismic activity in the project area. Detailed knowledge of the local geology and seismology is necessary to determine project feasibility and understand what measures are needed to prevent or address potential damage from earthquakes to the project or critical ancillary facilities or access routes, and associated costs.

Criterion (6) – Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge.

The ground motion parameters for the project should be defined and evaluated according to Chapter 13 of the FERC Engineering Guidelines for the Evaluation of Hydropower Projects and the latest available scientific information on the seismicity of this region.

SEOPC's initial study report should include study results, data analysis, and a description of field investigation activities and methods. The initial study report should also discuss how the design of the proposed project features would address seismic loading and what types of analysis would be performed. The PLP (or DLA) should clearly describe any proposed measures to reduce any potential adverse effects associated with project construction, operation and maintenance, and recommend project design details based on the findings of the analyses conducted as part of this study. The information gathered during this analysis should also be used to advance project design and inform the development of the supporting design report, which is a requirement of any final license application filed for the project (*see* 18 C.F.R. § 4.41(g)(3)).

Criterion (7) – Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

The estimated cost of this work is approximately $150,000 to $200,000. *See* GCPSP FERC Study Requests, p. A-9.

B. <u>Visual and Aesthetic Resources</u>

Criterion (1) – Describe the goals and objectives of each study proposal and the information to be obtained.

This study would characterize the potential effects of the Project construction, operation, and maintenance activities on the existing visual and aesthetic quality of key viewing areas, including those of historic or cultural significance, of Project lands and the surrounding area. The specific objectives of the study and subsequent report are to:

a) To characterize the existing visual and aesthetic resources of Project lands, document the associated visual quality and management objectives; and

b) Document the existing visual and aesthetic character of Project facilities and features from affected viewsheds and representative Key Observation Points ("KOPs").

Criterion (2) – If applicable, explain the relevant resource management goals of the agencies or Indian tribes with jurisdiction over the resource to be studied.

The Nations' goal is to protect their Reservations' lands, waters, and communities, which includes safeguarding the sites and areas of historic and cultural significance to the Nations. Project construction, operation, and maintenance activities have the potential to affect visual and aesthetic resources and, subsequently, cultural (including spiritual), social, and recreational activities in the vicinity. Describing these effects is necessary to fulfill the Commission's trust responsibilities to the Nations and its responsibilities under the NEPA. Ensuring that potential measures associated with minimizing these impacts are analyzed is also relevant to the Commission's public interest determination.

Criterion (3) – If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study.

See response to Criterion (2).

Criterion (4) – Describe existing information concerning the subject of the study proposal, and the need for additional information.

The PAD only mentions some potential Project impacts in Section 4.11.1 Visual Character of Project Vicinity (pp. 4-106 – 4-114), and incredibly denies Project operations will affect aesthetic and visual resources within the Project vicinity, stating:

> [A]lthough potential impacts to designated aesthetic and visual resources within the Project vicinity during Project operations are not anticipated, and any impacts during Project construction would likely be temporary and intermittent, the construction of the proposed Project would alter the aesthetic of the existing landscape. Thus, SEOPC proposes further investigation, including the preparation

> of detailed viewshed analyses and visual simulations from designated resources in a Visual Resources Study.

Id. at 4-114.

The Nations are concerned that SEOPC considers the Project's location and operation to have no negative visual or aesthetic effect. That may result from its lack of knowledge or understanding of how the Project area is seen, used, and relied on by those who live and work in the Project's vicinity and others who visit the area for cultural, social, or recreational reasons and from SEOPC's apparent reliance on Google Maps for information about aesthetic or visual resources. Both of which may explain why SEOPC focuses on the Project's visual and aesthetic effects from roads, which provides only a limited picture of potential aesthetic or visual impacts. In addition, given the scale of the proposed Project and its normal maximum elevation over a thousand feet above the Kiamichi River, *see* SD1, pp. 8-9. the Project will be visible at a considerable distance from the Project area and may therefore threaten and directly affect, and even dominate, the aesthetic and visual values of the landscape in a large area, including from KOPs located on private lands. Further information is needed regarding the Project's visual impacts from which to gauge potential adverse effects of Project-generated visual and aesthetic changes on the landscape, as well as cultural, social, and recreational practices.

Criterion (5) – Explain any nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements.

As SEOPC describes in the PAD (p. 4-114), the Project could have a variety of visual effects:

> During Project construction the rural, forested aesthetic character would be altered by the removal of fields and woodlands and introduction of the approximately 1.4-square-mile, uniformly shaped lower reservoir and visible energy infrastructure rising along the north facing slopes of the Kiamichi Mountains…. Project

> construction may impact the visual character of the Project vicinity due to mobilized construction equipment and increased traffic concentrates on adjacent local roads and highways, namely US 271 and Indian Highway in Oklahoma, and highways and county roads crossed by the Project's associated transmission line in Texas. Dust may also become intermittently present within the Project area during tree clearing and excavation activities that could be seen by residents. Although not anticipated, if Project construction at night is necessary, safety construction lights may be visible as a discreet glow to residents.

The Nations need an understanding of these visual and aesthetic impacts, evaluated from the perspective SEOPC now lacks, as described in Criterion (4) above, to assess how the proposed Project may affect land, cultural, and recreational uses and to identify potential mitigation measures.

Criterion (6) – Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge.

A systematic study should be conducted to characterize the existing visual and aesthetic resources in the vicinity of the proposed Project and estimate the potential effects from construction, operation, and maintenance of the proposed. The study should include the following steps:

a) Consult with the USFS, BLM, Nations, and other Native American Tribes to identify viewsheds and representative views ("KOPs") and the characteristic and natural features on which they rely, for assessment of the influence of future Project operations, maintenance, or construction activities on those viewsheds and representative views and their use by the Nations and others.

b) Inventory, map, and describe existing Project infrastructure, operation, maintenance and construction activities that may have the potential to affect visual resources of the Project Area.

c) Document existing Protection, Mitigation, and Enhancement measures.

d) Obtain, map (via geographic information system [GIS]) and characterize existing visual resource inventories and management objectives associated with the Project lands.

e) Conduct a viewshed analysis (via GIS) and determine what portion and acreages of the Project lands and associated landscape are potentially visually affected by Project-related activities based on the inventory conducted under Task 2, and to determine the extent of the surrounding area that is so affected.

f) Map and assess the KOP locations to include documentation of the existing scenic character and potential use of the selected KOPs.

g) Prepare a study report that documents the study findings and characterizes the existing visual conditions as they relate to Project facilities and Project-related activities.

These methods are consistent with standard practices and generally accepted methods used by applicants and relied upon by Commission staff in other hydroelectric licensing proceedings to assess visual and aesthetic resources.

Criterion (7) – Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

The estimated cost of this work is approximately $200,000.

C. <u>Phase I Cultural Resources and Tribal Resources Survey</u>

Criterion (1) – Describe the goals and objectives of each study proposal and the information to be obtained.

The goal of this survey is to determine the potential effects of project operation on archaeological, cultural, and historic resources that are included in or eligible for the National Register of Historic Places (National Register or historic properties). The survey and study report, including identification of the APE,[102] and of traditional cultural properties within that area, should

[102] The APE should, at a minimum, include the lands enclosed by the project boundary including both in-water and on-shore project lands and facilities, and lands or properties outside the project boundary where project operation or other project-related activities may cause changes in the character or use of historic properties.

be developed after consultation with the Oklahoma State Historic Preservation Officer ("OK SHPO"), the Nations (including their THPOs) and other federally-recognized tribes who have an active interest in the project, and other interested parties.[103] The specific objectives of the survey and subsequent report are to:

a) Identify the APE;

b) After consultation with the OK SHPO and THPOs, conduct a Phase I pedestrian field inventory within the APE to locate any cultural, historic or archeological resources;

c) Assess the National Register-eligibility of cultural and historic resources, including within the Project area itself, or archaeological resources within the APE;

d) Evaluate the potential effects the project would have on cultural and historic properties; and

e) Assess the condition of the area where any cultural, historic and archaeological sites are located for shoreline stability and evidence of erosion.

Criterion (2) – If applicable, explain the relevant resource management goals of the agencies or Indian tribes with jurisdiction over the resource to be studied.

The Choctaw Reservation will be directly affected by the proposed Project, and a thorough understanding of the cultural and historical resources affected is critical to ensuring that SEOPC does not cause avoidable damage to those resources, which are irreplaceable. An incomplete or otherwise inadequate understanding of the APE's cultural resources could cause irreparable damage.

Criterion (3) – If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study.

In addition to the Nations' interests described under Criterion (2), FERC has explained the relevant public interest considerations in requesting cultural resources studies:

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[103] *Accord* BIA Comments, p. 2 ("The [APE] should be appropriately delineated in consultation with interested Indian Tribes.").

> Sections 4(e) and 10(a) of the FPA require that the Commission give equal consideration to all uses of the waterway on which a project is located. When reviewing a proposed action, the Commission must consider the environmental, recreational, fish and wildlife, and other non-developmental values of the project, as well as power generation and other developmental values.
>
> Cultural resources are resources of particular interests to the public. Preserving and protecting cultural resources provides a venue for understanding our Nation's past and respecting the various cultures of this country. Project operation and maintenance may affect the value and integrity of National Register-eligible historic properties in the vicinity of the project. Ensuring that potential measures associated with cultural resources are analyzed is relevant to the Commission's public interest determination.
>
> Furthermore, pursuant to section 106 of the National Historic Preservation Act (section 106), the licensing of the proposed project would be a federal undertaking and a license issued by the Commission would permit activities that may "… cause changes in the character or use of historic properties, if any such historic properties exist…" (see 36 CFR part 800.16(d) of the regulations implementing section 106). The Commission must, therefore, comply with section 106, which requires the head of any federal department or independent agency having authority to license an undertaking to take into account the effect of the undertaking on historic properties. In the case of the proposed project, assessment of historic properties would be conducted in consultation with the Commission, the [state] SHPO, any tribes which express an interest in the project, and other interested parties.[104]

Criterion (4) – Describe existing information concerning the subject of the study proposal, and the need for additional information.

The PAD provides some information on archaeological and historic resources identified during previous cultural resources surveys over a multi-decade span. However, there may be presently unknown historical or archeological sites that may be affected by project construction, operation, and/or maintenance. As additional cultural and historic properties are identified, the nature and extent of potential effects and measures that may avoid, lesson, or mitigate adverse effects, or the inadequacy of such measures, can be properly determined.

[104] *See* "Letter to Melissa Sonnleitner re: Study Requests for the French Landing Hydroelectric Project, P-9951," eLibrary no. 20220829-3034 (Aug. 29, 2022), pp. A-15 – A-16 (French Landing FERC Study Requests).

> It is highly probable that most of the project area has not received a cultural resources survey up to modern standards. It is likely to contain a number of unrecorded archaeological sites that are culturally affiliated with the Caddo, Choctaw, and other groups. Given the number of structures shown on maps dating to the first decade of the 1900s, the project area is likely to contain several Choctaw homestead sites, which our office considers potentially eligible for the NRHP for significance under Criteria A and D. The project area also has a high potential for containing unmarked Choctaw cemeteries, isolated Choctaw burial places.[105]

Criterion (5) – Explain any nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements.

NHPA section 106 requires that federal agencies take into account the effect of proposed undertakings on any district, site, building, structure, or object that is included in or eligible for the National Register. Operation and maintenance of project facilities could adversely affect cultural and historic properties through ground-disturbing activities and cause other indirect adverse effects on such properties.

A cultural resources survey would provide information on potential cultural resources located within the APE. The subsequent report would provide information on cultural resources that would be potentially eligible for the National Register and any potential effects on historic properties. If there would be an adverse effect on cultural and historic properties, an applicant-prepared historic properties management plan (“HPMP”), and/or potentially at a Native American Graves Protection and Repatriation Act (“NAGPRA”) Plan of Action, would be necessary to avoid, lessen, or mitigate for adverse effects, both of which should be prepared in consultation with the Nations and other affected tribes.

Criterion (6) – Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted

[105] *See* CNHPD Comments (Attachment 9), p. 3.

practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge.

The cultural resources study must begin with a full desktop review. The desktop review report should include a thorough background section that describes the archaeological, historic, and cultural context of the region. It must include a search of the Oklahoma site files, of relevant historic maps, and of aerial photos. It must, at a minimum, include a list of all previously recorded archaeological sites within the APE, their latitudinal and longitudinal coordinates, dimensions, descriptions of the sites including recovered materials, potential for intact subsurface features, level of disturbance, and an indication of the sites' National Register eligibility status. It must also list all historic structures and significant landscape features located within the APE on the historic maps and aerials. These sites need to be shown on detailed maps in the desktop review report.

The report must list all previous cultural resources surveys conducted within the APE, provide a brief description of their methodologies, and show their geographic extent on the detailed site map. This information must be compiled into a report shared with OK SHPO and THPOs. The report will serve as a reference point for the OK SHPO, THPOs, and applicant to work out a phase I cultural resources survey methodology.

The phase 1 cultural resources survey methodology will be based on the desktop review and consultation with the OK SHPO and THPOs. Phase I work will be designed to locate all sites within the APE that are potentially eligible for the National Register. It will involve an archaeological component including shovel testing in areas identified in consultation with SHPO and SHPOs. It will also include a historic structure survey. The results of the phase I survey will go into a report to guide consultation with the OK SHPO and THPOs in determining the need for a phase II cultural resources survey. The report should also be kept confidential, and filed with the Commission and other consulting parties as "privileged," as a non-public document, and subject to redactions or other protections deemed necessary by the Nations.

Sites and structures deemed to be potentially eligible for the National Register will receive phase II work following methodologies agreed upon with the OK SHPO and THPOs. The purpose of phase II is to determine the eligibility for the National Register of the sites and structures that have been identified as potentially eligible in phase I. The results of the phase II work will be presented in a report to the OK SHPO, THPOs. The evaluation of project effects on cultural resources should include both site-specific effects and indirect effects and informed by an understanding of the role of those resources in the history and culture of the Nations. Together, the parties will agree on a mitigation plan for each identified National Register eligible site and structure that is located within the APE. Mitigation can consist of avoidance, excavation, alternative mitigation (such as producing museum exhibits, publications, or educational materials), or the case of structures documentation through photography and Historic American Buildings ("HABS") survey. A Memorandum of Agreement will have to be completed between the applicant, the Commission, OK SHPO, and THPOs for any mitigation measures excluding avoidance.

Incorporating the results of the phase I and II cultural resources work, the applicant, OK SHPO, THPOs, and Commission will draft a Programmatic Agreement for complying with the NHPA during Project implementation. This would specify site avoidance measures (e.g., work exclusion areas and construction buffers), treatment measures (e.g., construction mats), and lay out a legally binding plan for inadvertent discovery.

Based on the results of the cultural resources survey work, the Commission must prepare a NAGPRA Plan of action with consulting Tribes that lays out what measures will be taken to avoid impacting Native American burials, what measures will be taken to protect them if they are inadvertently disturbed, how Tribes will be notified, and what format consultation will take from there, and what will be the ultimate disposition of any ancestors encountered.

An HPMP of cultural and historic properties that would be adversely affected by proposed operation or maintenance of the Project or from Project-related activities should be developed in full consultation with the OK SHPO, THPOs, and other interested parties. When developing an HPMP the generally acceptable practice is to use the "Archeology and Historic Preservation: Secretary of the Interior's Standards and Guidelines" (Fed. Reg., September 29, 1983, Vol. 48, No. 190, Part IV, pp. 44716-44740) and the Advisory Council on Historic Preservation and Commission's "Guidelines for the Development of Historic Properties Management Plans for FERC Hydroelectric Projects" (issued May 20, 2002), and consider and/or address the following items:

a) Completion, if necessary, of identification of cultural and historic properties, within the project's APE;

b) Continued use and maintenance of cultural and historic properties;

c) Maintenance and operation of the hydroelectric project according to the Secretary of Interior's "Standards for the Treatment of Historic Properties" (36 C.F.R. Part 68) and applicable National Park Service Preservation Briefs;

d) Treatment of cultural and historic properties threatened by project-induced shoreline erosion, other project-related ground-disturbing activities, and vandalism;

e) Identification and evaluation of cultural and historic properties, determination of effects, and ways to avoid, minimize, or mitigate adverse effects;

f) Consideration and implementation of appropriate treatment that would minimize or mitigate unavoidable adverse effects on cultural and historic properties;

g) Identification and evaluation of adverse effects on cultural and historic properties that cannot be minimized or mitigated;

h) Treatment and disposition of any human remains that may be discovered, taking into account and in compliance with any applicable Nation, state, and federal laws (including but not limited to NAGPRA) and the Advisory Council on Historic Preservation's "Policy Statement Regarding Treatment of Human Remains and Grave Goods" (September 27, 1988, Gallup, NM);

i) Protocols for the discovery of previously unidentified cultural and historic properties during project operation;

j) Public interpretation of the cultural, historic and archaeological values of the project, and the Nations' interpretation of such values;

k) List of activities, including routine repair, maintenance, and replacement in kind at the project not requiring consultation with the OK SHPO or THPOs; since these activities would have little or no potential to affect cultural and historic properties;

l) Procedures to address effects during project emergencies; and

m) Coordination with the OK SHPO and THPOs, and any other identified parties during implementation of the HPMP.

These methods are consistent with cultural resources studies used by applicants and licensees and relied upon by Commission staff in other hydroelectric licensing proceedings.

Criterion (7) – Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

The anticipated cost for the literature review and phase I and phase II archeological survey is estimated to be > $1 million.

D. <u>Road and Trail Access</u>

Criterion (1) – Describe the goals and objectives of each study proposal and the information to be obtained.

The goals of this study are to conduct an assessment to define which roads will need to be constructed or improved for construction, operation, and maintenance for the proposed Project and to assess the feasibility of the proposed Project features on current and future road and trail access.

The specific objectives of this study include:

a) Inventory and assess condition of Project access roads and trails, including all Project access roads and trails that are used for operation and/or maintenance of the Project.

b) Characterize SEOPC's use of Project access roads and trails, including season of use and level of use.

c) Characterize SEOPC's current maintenance practices and responsibilities.

d) Identify existing agreements related to Project access roads and trails (e.g., maintenance agreements, easements, rights of way, special use permits).

Criterion (2) – If applicable, explain the relevant resource management goals of the agencies or Indian tribes with jurisdiction over the resource to be studied.

The Nations' goal is to protect their Reservations' lands, waters, natural resources, and communities. Project construction, operation, and maintenance will directly impact the Choctaw Reservation and Tribal members who own or use lands within the proposed Project area. A thorough understanding of the potential changes to road and trail access is critical to ensuring that SEOPC does not cause avoidable damage to these lands and culturally significant resources and sites located there. An inadequate or otherwise incomplete understanding of the Project area's roads and trails could undermine findings regarding the feasibility of the proposed Project and result in adverse impacts to natural and cultural resources, public safety, and human health, (e.g., harmful air quality, storm water runoff, flooding, disruption of wildlife habitat and migration) from poorly placed access roads.

Criterion (3) – If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study.

See Response to Criterion (2).

Criterion (4) – Describe existing information concerning the subject of the study proposal, and the need for additional information.

The PAD (p. 3-7) states:

> SEOPC does not anticipate the need to construct or improve existing access roads to conduct studies associated with the proposed Project. However, SEOPC will continue to consult with local authorities and landowners to determine which access roads may need to be constructed or improved for either construction or operation and maintenance of the proposed Project during the term of an original license.

The Nations are concerned that without further study, the potential environmental impacts of Project construction and maintenance on the roads and trails will not be adequately analyzed, disclosed, or effectively avoided, minimized, or mitigated.

Criterion (5) – Explain any nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements.

With the current dearth of information on SEOPC's detailed plans for the proposed Project route (*supra* PAD Section 3.1), SEOPC's assurance in the PAD that it will consult with local authorities and landowners on road access is inadequate. A 3- to 4-year Project construction period has great potential to cause runoff, dust, flooding, and road access issues. An understanding of current roads/trails and projected environmental impacts is needed to assess how the proposed Project may affect these uses and to identify potential mitigation measures.

Criterion (6) – Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge.

To complete this study, SEOPC should collect data on the following:

a) Length, general width, and terrain characteristics of Project access roads and trails;

b) Use, frequency, and speed of vehicles on Project access roads and trails, and their propensity for dust generation;

c) Type and/or changes in surface treatment (e.g., paved, aggregate, native) and condition;

d) Location, size, and condition of culverts and other drainage features;

e) Location and condition of bridge crossings;

f) Location and condition of erosion control features;

g) Location and condition of safety, traffic control, and information signs and access control features such as gates and other closure methods;

h) Identification of potential traffic safety concerns such as blind spots, poor sight distance, inadequate signage, and hazard trees;

i) Identification of potential natural resource issues that may occur along Project access roads and trails, such as stream crossings and riparian areas;

j) Conduct pedestrian surveys looking for and recording features on or adjacent to the Project access roads and trails with a minimum of two individuals, and follow the other requirements of the Bureau of Land Management's H-9113-2 – Road Inventory and Condition Assessment Guidance and Instructions (May 4, 2015);

k) Assign feature codes to specific road features observed during the survey, consistent with the U.S. Forest Service protocol;

l) Identify natural resources along Project access roads and trails, such as stream crossings, riparian areas, sensitive biological resources, and noxious weeds; and

m) Conduct research and interviews with local governments, landowners, and Native American tribes to characterize use, maintenance, and agreements associated with Project access roads and trails.

These methods are consistent with standard practices and generally accepted methods used by applicants and relied upon by Commission staff in other hydroelectric licensing proceedings to assess road and trail access.

Criterion (7) – Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

The anticipated cost for the road and trail access study is expected to be about $40,000.

E. Noise

Criterion (1) – Describe the goals and objectives of each study proposal and the information to be obtained.

The goal of this study is to characterize the existing ambient sound environment in the vicinity of the proposed Project and estimate the potential impacts associated with construction and operational activities. The specific objectives of the study and subsequent report are to:

a) Define existing noise levels in identified sensitive wildlife habitat, recreation and cultural areas within the Choctaw reservation, Ouachita National Forest/Talimena State Park, Sardis Lake, fishing and hunting areas, and areas used for subsistence and other traditional cultural practices.

b) Describe, through the use of sound models, the expected noise levels, including low decibel sound and vibration, in the identified sensitive areas during project construction and operation.

c) Develop measures to avoid or lessen sound impacts during project construction and operation.

Criterion (2) – If applicable, explain the relevant resource management goals of the agencies or Indian tribes with jurisdiction over the resource to be studied.

The Nations' goal is to protect their Reservations' lands (including their quietude), waters, natural resources, and communities. Project construction, operation, and maintenance activities have the potential to affect noise levels and, subsequently, cultural and recreational activities in the vicinity. Describing these effects is necessary to fulfill the Commission's trust responsibilities to the Nations and its responsibilities under the NEPA. Ensuring that potential measures associated with minimizing these impacts are analyzed is relevant to the Commission's public interest determination.

Criterion (3) – if the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study.

In addition to the Nations' interests described under Criterion (2), FERC has explained the relevant public interest considerations in requesting noise studies:

> Section 4(e) and 10(a) of the Federal Power Act require that the Commission give equal consideration to all uses of the waterway on which a project is located. When reviewing a proposed action, the Commission must consider the environmental, recreational, fish and wildlife, and other non-developmental values of the project, as well as power generation and other developmental values.
>
> Project-generated noise during construction or operation, if not properly controlled, could have a negative effect on wildlife and the public in the surrounding area; therefore, it is important to understand the existing ambient noise levels in the project vicinity and possible noise effects from project-related activities. Ensuring that potential measures associated with minimizing noise impacts are analyzed is relevant to the Commission's public interest determination.

See FERC, Letter to Bobby Armstrong (Nushagak Electric & Telephone Cooperative, Inc.) Dated January 23, 2020 re: Study Requests (Jan. 23, 2020), eLibrary no. 20200123-3011, pp. 1-2 (Nushagak FERC Study Requests).

Criterion (4) – Describe existing information concerning the subject of the study proposal, and the need for additional information.

The only mention of noise in the PAD (p. 4-98) is conclusory and wholly insufficient to assess Project impacts on noise levels:

> Potential impacts as it relates to recreation may include construction-related traffic delays or noise, which may indirectly affect recreationists traveling along US 271 to either the Ouachita National Forest/Talimena State Park (20-minute drive to the east) or Sardis Lake (15-minute drive to the west).

The Nations have concerns about Project-generated noise during construction and operation disrupting wildlife and visitor uses for cultural, social, and recreational purposes within the Choctaw Reservation, including at nearby recreation (including hunting and fishing) areas. Further information is needed regarding ambient noise levels from which to gauge potential adverse effects of Project-generated noise on existing uses.

Criterion (5) - Explain any nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements.

Construction is planned to take place over a 3- to 4-year period and would include the use of noise-generating equipment to carry out activities such as drilling, boring, blasting, and compaction. Each of these sources of noise has the potential to disrupt wildlife and their uses of adjoining habitats or degrade visitor recreation and cultural experiences and practices. An understanding of ambient noise levels and projected noise generation is needed to assess how Project-generated noise may affect these uses and to identify potential mitigation measures.

Criterion (6) – Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge.

A systematic sound study should be conducted to characterize the existing ambient sound environment in the vicinity of the proposed Project and estimate the potential noise effects from construction, operation, and maintenance of the proposed. The study should include the following steps:

a) Review the most current project description, operating and construction equipment rosters, construction schedules, and construction methods to identify the types of excavation or blasting expected to occur, its timing and frequency, volume, where project noise is likely to be heard by the public, and the requirements of applicable law with respect to excavation and blasting;

b) Identify the type and expected frequency of maintenance activities that would generate noise in the project vicinity (e.g., helicopter or airplane use);

c) Identify sensitive noise receptor areas (i.e., wildlife habitat, recreation and cultural areas) where sound data needs to be collected;

d) Collect ambient sound level measurements at the identified noise receptor sites and document observations of perceived and identifiable sources of sound contributing to ambient sound levels at these sites;

e) Use an acoustic model to predict sound levels during project construction, operation, and maintenance at the noise receptor sites, estimated in A-weighted decibels (dBA), and indicate the duration of these sound levels;

f) Superimpose predicted sound level isopleths or "sound contours" on aerial photographs or maps of the project area and include specific sound level predictions at the selected measurement locations; and

g) Develop measures to avoid or lessen project-generated sound effects.

The study should be developed in consultation with the Oklahoma Department of Wildlife Conservation, the Choctaw Nation Wildlife Conservation Department, the Chickasaw Nation Fish and Wildlife Service, local outfitters, and Native American tribes, including the Nations, that use the project area for subsistence or other traditional cultural practices. The initial Study Report should include study results, data analysis, a description of field investigation activities and methods, and documentation of consultation with the above-named stakeholders.

These methods are consistent with sound analyses used by applicants and licensees and relied upon by Commission staff in other hydroelectric licensing proceedings.

Criterion (7) – Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

The anticipated cost for the noise study is estimated to be about $45,000. *See* Nushagak FERC Study Requests, p. 3.

F. <u>Environmental Justice Study</u>

To assist Commission staff with its analysis under NEPA, SEOPC should conduct an Environmental Justice Study ("EJ Study") for the Project. Pursuant to section 5.9 of the Commission's regulations, we address the seven study request criteria below.

Criterion (1) – Describe the goals and objectives of each study proposal and the information to be obtained.

The proposed EJ Study has five objectives:

(1) to identify the presence of environmental justice communities that may be affected by the licensing of the project and identify outreach strategies to engage the identified environmental justice communities in the pre-licensing and licensing process, if present;
(2) to identify the presence of non-English speaking populations that may be affected by the project and identify outreach strategies to reach and engage non-English speaking populations in the licensing process, if present;
(3) to discuss effects of licensing the project on any identified environmental justice communities and identify any effects that are disproportionately high and adverse;
(4) to identify mitigation measures to avoid or minimize project effects on environmental-justice communities; and
(5) to identify sensitive receptor locations within the project area and identify potential effects and measures taken to avoid or minimize the effects to such locations, if they are present.

Criterion (2) – If applicable, explain the relevant resource management goals of the agencies or Indian tribes with jurisdiction over the resource to be studied.

See Criterion (2) response to the Phase I Cultural Resources and Tribal Resources Survey, *supra*.

Criterion (3) – If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study.

Executive Order 14008, *Tackling the Climate Crisis at Home and Abroad*, and Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations*, as amended, require federal agencies to determine whether impacts on human health or the environment would be disproportionately high and adverse for environmental justice communities in the surrounding community as a result of the programs, policies, or activities of federal agencies.

Further, sections 4(e) and 10(a) of the FPA require the Commission to give equal consideration to all uses of the waterway on which a project is located, and what conditions should be placed on any license that may be issued. In making its license decision, the Commission must equally consider the environmental, recreational, fish and wildlife, and other non-developmental values of the project, as well as power and developmental values.

Criterion (4) – Describe existing information concerning the subject of the study proposal, and the need for additional information.

The information necessary to conduct an identification of environmental justice communities near the project is available through the U.S. Census Bureau's American Community Survey; however, such information must be aggregated and compared in order to make determinations about the presence of environmental justice communities within the project area. The nature of effects of the Project on any communities present, e.g., the Nations, must be determined through consultation with the Nations and any other environmental justice communities, and are dependent on SEOPC's licensing proposal.

Criterion (5) – Explain any nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements.

Construction and operation of the project has the potential to affect human health or the environment in environmental justice communities. Examples of resource impacts may include, but are not necessarily limited to, project-related effects on: erosion or sedimentation of private properties; groundwater or other drinking water sources; fishing, hunting, or plant gathering; access for cultural, social, and recreational activities; housing or industries of importance to environmental justice communities; and construction-or operation-related air quality, noise, and traffic.

Criterion (6) – Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted

practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge.

Below, we provide the methodology that Commission staff has adopted for collecting environmental justice data for hydroelectric projects. This methodology has been employed previously and is consistent with guidance from the Environmental Protection Agency's *Promising Practices for EJ Methodologies in NEPA Reviews* (2016), which are also described in the context of the Project in the Mix Report (Attachment 5). The Nations request the Commission require an EJ Study Report that provides the following:

(1) A table of racial, ethnic, and poverty statistics for each state, county, and census block group within the geographic scope of analysis. For the project, the geographic scope of analysis is the area encompassed within 5 miles of the project boundary. The table should include the following information from the U.S. Census Bureau's most recently available *American Community Survey* 5-Year Estimates for each state, county, and block group (wholly or partially) within the geographic scope of analysis:
  a. Total population;
  b. Total population of each racial and ethnic group (i.e., White Alone Not Hispanic, Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, some other race, two or more races, Hispanic or Latino origin [of any race]) (count for each group);
  c. Minority population including individuals of Hispanic or Latino origin as a percentage of total population; and
  d. Total population below poverty level as a percentage.

(2) The data should be collected from the most recent *American Community Survey* files available, using table #B03002 for race and ethnicity data and table #B17017 for low-income households.

(3) Identification of environmental justice populations by block group, using the data obtained in response to part a above, by applying the following methods included in EPA's *Promising Practices for EJ Methodologies in NEPA Reviews* (2016).
  a. To identify environmental justice communities based on the presence of minority populations, use the "50-percent" and the "meaningfully greater" analysis methods. To use the "50-percent" analysis method, determine whether the total percent minority population of any block group in the affected area exceeds 50%. To

use the "meaningfully greater" analysis, determine whether any affected block group affected is 10% greater than the minority population percent in the county using the following process:

1. Calculate the percent minority in the reference population (county);
2. To the reference population's percent minority, add 10% (i.e., multiply the percent minority in the reference population by 1.1); and
3. This new percentage is the threshold that a block group's percent minority would need to exceed to qualify as an environmental justice community under the meaningfully greater analysis method.

b. To identify environmental justice communities based on the presence of low-income populations, use the "low-income threshold criteria" method. To use the "low-income threshold criteria," the percent of the population below the poverty level in the identified block group must be equal to or greater than that of the reference population (county).

(4) A map showing the project boundary and location(s) of any proposed project-related construction in relation to any identified environmental justice communities within the geographic scope. Denote on the map if the block group is identified as an environmental justice community based on the presence of minority population, low-income population, or both.

(5) A discussion of anticipated project-related effects on any environmental justice communities for all resources where there is a potential nexus between the effect and the environmental justice community. For any identified effects, please also describe whether or not any of the effects would be disproportionately high and adverse. Anticipated project-related effects here include, but are not limited to, the following:

a. Quantitative and qualitative research methodologies to address breadth and depth/nuance of Environmental Justice implications related to siting.
b. Analysis of foraging/subsistence dimensions for local populations.
c. Implications of water quality and quantity for local populations.
d. Displacement and land implications for local populations.
e. Downstream impacts related to water quality/quantity and land use changes.
f. Implications for cultural meaning of space and place due to changing land/water access and natural/built landscape changes.
g. Consideration of Environmental Justice impacts broader than immediate site and transmission line right-of-way due to integrated

socio-cultural and environmental dimensions (migration patterns, seasonal forage, place/space use and meaning, etc.).

(6) A description of SEOPC's outreach efforts regarding the project, including:

(7) A summary of any outreach to environmental justice communities conducted prior to filing the application (include the date, time, and location of any public meetings beyond those required by the regulations);
   a. a summary of comments received from members of environmental justice communities or organizations representing the communities;
   b. a description of information provided to environmental justice communities; and
   c. planned future outreach activities and methods specific to working with the identified communities.

(8) A description of any mitigation measures proposed to avoid and / or minimize project effects on environmental justice communities.

(9) Identification of any non-English speaking groups, within the geographic scope of analysis, that would be affected by the project (regardless of whether the group is part of an identified environmental justice community).

(10) Identification of sensitive receptor locations within the Project area and geographic scope of NEPA analysis. Show these locations on the map generated in step (4). Provide a table that includes their distances from project facilities and any project-related effects on these locations, including measures taken to avoid or minimize project-related effects.

SEOPC should engage with the Nations' technical staff and consultants in further planning and implementation of this study. SEOPC's initial study report should include documentation of any outreach it conducted with the Nations and other stakeholders that expressed interest in environmental justice, copies of their comments, and an explanation of how SEOPC addressed their comments in the study report.

Criterion (7) – Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

The estimated cost of all efforts to complete this study is > $50,000. *See, e.g.,* GCPSP FERC Study Requests, p. A-7.

G. Economic Feasibility Study

SEOPC does not claim to now operate any power generating or transmitting facilities, and as a result any assessment SEOPC offers of the Project's feasibility, including its economic feasibility, is conjectural. Nevertheless, SEOPC says it "it will continue to refine the Project design based on landowner input, economic and financial modeling, cost-benefit analysis, geologic, and environmental considerations" (PAD, p. 3-3). However, it does not list these studies in Table 5-1. The Nations request that Commission staff direct SEOPC to include details in the PSP on the specific cost-benefit analysis methods that SEOPC proposes to use for this study, as well as consultation on the economic, financial, and environmental considerations.

It generally takes seven to ten years to complete the regulatory process for a pumped storage project.[106] SEOPC anticipates it will take 3-4 years to complete Project construction, and an additional 2-3 years to fill the Project's lower and regulating reservoirs. *See* PAD, p. 3-8. In other words, it will likely be a decade or more before the Project is operational. There will likely be considerable changes to energy markets and energy storage technologies within this time that may affect the comparative benefits and competitiveness of the proposed Project as compared to alternatives. Accordingly, SEOPC's proposed economic and financial modeling and cost-benefit analysis should provide information regarding alternatives to the Project that could potentially meet ERCOT's power needs in light of predicted market and technological changes while avoiding significant, irreversible impacts on the Nations' lands, natural resources, and communities.

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[106] National Hydropower Association, "Pumped Storage Report" (2021), p. 11, *available at* https://www.hydro.org/wp-content/uploads/2021/09/2021-Pumped-Storage-Report-NHA.pdf (last accessed Nov. 4, 2024).

VII. REQUEST FOR FURTHER PROCEDURES

A. Commission Staff Should Direct SEOPC to File a Revised PAD or Supplement to the PAD Before Continuing with NEPA Scoping.

The Council on Environmental Quality's NEPA regulations provide that, "scoping should begin as soon as practicable *after the proposal for action is sufficiently developed for agency consideration*." 40 C.F.R. § 1502.4 (emphasis added).

In enacting the ILP regulations, the Commission intended for the PAD to state the applicant's proposal in sufficient detail to permit scoping under NEPA:

> The PAD should include all engineering, economic, and environmental information relevant to licensing the project that is reasonably available when the NOI is filed. It is a tool for identifying issues and information needs, including NEPA scoping, developing study requests and study plans, and providing information for the Commission's NEPA document.[107]

As described in the foregoing comments, SEOPC has not complied with its obligation under Section 5.6(b)(2) of the Commission's regulations to use due diligence in obtaining the information it provided to the Commission and, as a result, the PAD does not comply with the minimum content requirements of Section 5.6(d). This includes, in part, failure to describe the proposed Project:

> (2) Project location, facilities, and operations. The potential applicant must include in the pre-application document:…
>
>> (ii) *Detailed* maps showing lands and waters within the project boundary by township, range, and section, as well as by state, county, river, river mile, and closest town, and also showing the specific location of any Federal and tribal lands, and the location of proposed project facilities, including roads, transmission lines, and any other appurtenant facilities;

[107] 68 Fed. Reg. at 51075.

> (iii) A *detailed* description of all existing and proposed project facilities and components ….

Id. at § 5.6(d)(2)(ii)-(iii) (emphasis added).

SEOPC's proposal is not sufficiently developed to support the NEPA scoping process, and the Commission's issuance of SD1 was premature. To avoid errors in the Commission's NEPA document, which we expect the Commission will also rely on for its comprehensive planning analysis under FPA section 10(a)(1), the Commission should require SEOPC to file a revised PAD or a supplement to the PAD before continuing with the scoping process.

B. The Commission Must Undertake Government-to-Government Consultation with the Nations.

The Nations request the Chair and Commissioners meet with representatives of both Nations to ensure that the Commission understands the potential harms posed by the proposed Project to assets held in trust by the United States for the benefit of both Nations, the need for the Commission to meaningfully engage with both Nations throughout this proceeding, and the inadequacy of the applicant's PAD as the basis for initiating scoping and other aspects of the ILP.

VIII. REQUEST FOR SERVICE

The Nations request that the following representatives be added to the Commission's official service list for this proceeding.

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IX. CONCLUSION

The Choctaw and Chickasaw Nations are federally recognized sovereign nations with rights and obligations to protect their homelands, including its lands, waters, and natural, cultural, and ecological resources, which sustain the Nations' existence. Both Nations, by treaty, retain and exercise rights that would be impacted by this Project. The Nations continue to oppose the Project as proposed by SEOPC because it would contravene those sovereign interests and risk direct harm to the Nations' rights.

The Nations urge the Commission to consider these comments and requests before moving forward with this ILP. The Commission should not allow SEOPC to proceed based on the inadequate information it has presented in the PAD because doing so would prevent the Nations from fully exercising their sovereign rights to address the full range of resource issues the applicant is required to disclose under § 5.6. The Commission's approval without SEOPC's full regulatory compliance and due diligence would be unfair, reflecting historical practices of exploiting tribal resources without due process. The Commission should instead act to ensure its decisions safeguard the Nations' tribal trust resources and treaty rights under 18 C.F.R. § 2.1c.

Respectfully submitted,

____

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Attachments:

1. Expert Report of Amy Kathleen Buthod.
2. Expert Report of Arden D. Davis, Ph.D., P.E.
3. Expert Report of Fred P. Ehat, P.E.
4. Letter from Todd D. Fagin, Ph.D.
5. Expert Report of Tamara L. Mix, Ph.D.
6. Expert Report of Ethan Schuth.
7. Letter from Jacqueline Vadjunec, Ph.D.
8. Chickasaw Nation Division of Historic Preservation (CNDHP) to Acting Sec'y Reese, eLibrary no. 20240905-5175 (Sept. 5, 2024).
9. Choctaw Nation of Oklahoma Historic Preservation Department, Letter to FERC Docket, eLibrary no. 20240906-5006 (Sept. 6, 2024).
10. Shannon K. Brewer et al., "Understanding the impacts of surface-groundwater conditions on stream fishes under altered baseflow conditions," U.S. Department of Interior, Fish and Wildlife Service, Cooperator Science Series FWS/CSS-136-2020, Washington, D.C. https://doi.org/10.3996/css49046075 (2020).
11. Heather S. Galbraith et al., "Status of Rare and Endangered Freshwater Mussels in Southeastern Oklahoma," The Southwestern Naturalist 53(1):45–50 (Mar. 2008).
12. Caryn C. Vaughn, "Freshwater Mussel Populations in Southeastern Oklahoma: Population Trends and Ecosystem Services," Proceedings of Oklahoma Water 2005, Tulsa, OK, September 27 and 28, Paper #18, Oklahoma Water Resources Research Institute, Stillwater, OK (Sept. 2005).

DECLARATION OF SERVICE

Southeast Oklahoma Power Corporation's Pushmataha County Pumped Storage Hydroelectric Project (P-14890-005)

I, Emma Roos-Collins, declare that I today served the attached "The Chickasaw Nation and Choctaw Nation of Oklahoma's Comments on Pre-Application Document and Scoping Document 1 and Study Requests (P-14890-005)," by electronic mail, or by first-class mail if no e-mail address is provided, to each person on the official service list compiled by the Secretary in this proceeding.

Dated: November 5, 2024

By: Emma Roos Collins

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Attachment 1

Expert Report of Amy Kathleen Buthod

I, Amy Kathleen Buthod, hereby declare the following:

1. I submit this report in response to Southeast Oklahoma Power Corporation's (SEOPC) Filing of Notice of Intent to File an Application for an Original License and Pre-Application Document, and Request to be Designated as FERC's Non-Federal Representative for the Purposes of Informal Consultation under Section 106 and Section 7 for the Pushmataha County Pumped Storage Project (P-14890), eLibrary no. 20240507-5119 (May 7, 2024), as noticed by the Federal Energy Regulatory Commission (FERC or Commission) on July 8, 2024. *See* eLibrary no. 20240708-3054.

2. This report is organized as follows: Section I states my experience and qualifications; Section II states the documents I reviewed in preparing this report; Sections III – VI describe the potential impacts of the project on the plant life in the area; Section VII states my conclusions and recommendations.

I. Experience and Qualifications

3. My educational credentials include a Bachelor of Science degree in Zoology from the University of Oklahoma, Norman, Oklahoma in 1994 and a Master of Science degree in Botany from the University of Oklahoma, 2001.

4. From 2000 through the present, I have worked as a Botanical Specialist at the Oklahoma Biological Survey, a state agency/research unit at the University of Oklahoma. As Botanical Specialist, I am the Collections Manager for the Robert Bebb Herbarium, the state's largest research collection of preserved plant specimens. I am also the Heritage Botanist for Oklahoma, where I am responsible for conducting floristic inventories throughout the state and for

monitoring and tracking rare plant species. I am also the current Past President of the Oklahoma Invasive Plant council.

5. I am providing these comments in my personal capacity as a professional botanist and concerned citizen, not in my capacity as an employee of the University of Oklahoma.

6. My curriculum vitae is provided as an attachment.

II. Documents Reviewed

7. In preparing this report, I reviewed the following resources:

a. Bastarache, R. 2023. Forest Service PETS. *Personal communication*.

b. Biasotta, L.D. and A. Kindel. 2018. Power lines and impacts on biodiversity: A Systematic Review. *Environmental Impact Assessment Review* 71:110-119. https://www.sciencedirect.com/science/article/abs/pii/S0195925517304432?via%3Dihub.

c. Bipa, N.J., G. Stradiotti, M. Righetti, G.R. Pisaturo 2024. Impacts of hydropeaking: A systematic review. *Science of the Total Environment* 912. https://www.sciencedirect.com/science/article/pii/S0048969723078816.

d. Dalu, T., E.M. Stram, M.O. Ligege, R.N. Cuthbert. 2023. Highways to invasion: Powerline servitudes as corridors for alien plant invasions. *African Journal of Ecology* 61(2): 379-388. https://onlinelibrary.wiley.com/doi/abs/10.1111/aje.13121.

e. Greimerl, F. L. Schülting, W. Graf, E. Bondar-Kunze, S. Auer, B. Zeiringer and C. Hauer. 2018. Hydropeaking Impacts and Mitigation. Riverine Ecosystem Management vol 8. Springer, Cham., Switzerland. https://library.oapen.org/bitstream/handle/20.500.12657/27726/1/1002280.pdf#page=95.

f. Hoagland, B.W. and A.K. Buthod. 2004. Vascular flora of Hugo Lake Wildlife Management Area, Choctaw County, Oklahoma. *Southeastern Naturalist* 3(4):701-714. https://bioone.org/journals/southeastern-naturalist/volume-3/issue-4/1528-7092(2004)003[0701:VFOHLW]2.0.CO;2/Vascular-Flora-of-Hugo-Lake-Wildlife-Management-Area-Choctaw-County/10.1656/1528-7092(2004)003[0701:VFOHLW]2.0.CO;2.short.

g. Hoagland, B.W. and A. Buthod. 2009. The vascular flora of Cucumber Creek Nature Preserve, LeFlore County, Oklahoma. *Castanea* 74(1): 78-87. https://bioone.org/journals/castanea/volume-74/issue-1/07-35.1/The-Vascular-Flora-of-The-Cucumber-Creek-Nature-Preserve-Leflore/10.2179/07-35.1.short.

h. Hoagland, B.W. and A.K. Buthod. 2010. The vascular flora of Hale Scout Reservation, LeFlore County, Oklahoma. *Oklahoma Native Plant Record* 10:34-54. https://ojs.library.okstate.edu/osu/index.php/ONPR/article/download/8193/7532#page=35.

i. L.G. Clark. 2011. Survey of the vascular flora of Boehler Seeps and Sandhills Preserve. *Oklahoma Native Plant Record* 11:4-21. https://ojs.library.okstate.edu/osu/index.php/ONPR/article/view/444/415.

j. NatureServe. 2024. NatureServe Explorer. http://www.natureserve.org/explorer. (8 Oct 2024).

k. Oklahoma Invasive Plant Council. 2024. Oklahoma Invasive Plant Database https://www.okinvasives.org/plants-database. (8 Oct 2024).

l. Oklahoma Natural Heritage Inventory. 2024. Oklahoma Biodiversity Information System. http://obis.ou.edu/#/collaborators/search/main. (8 Oct 2024).

m. Rahman, A. O. Farrok., M.M. Hague. 2022. Environmental impact of renewable energy source based electrical power plants: Solar, wind, hydroelectric, biomass, geothermal, tidal, ocean, and osmotic. *Renewable and Sustainable Energy Reviews* 161. https://www.sciencedirect.com/science/article/abs/pii/S136403212200199X.

n. SEOPC's Pre-Application Document (May 7, 2024).

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https://www.saveamericasforests.org/congress/ASAF/Parks/EPA-Ecoregion-Map.pdf

III. The Area within the Project Boundary Has Not Been Systematically Surveyed for Rare and Sensitive Species and Vegetation Types. Reservoir and Powerhouse Construction Will Destroy Native Habitat for the Rare and Sensitive Plants and Vegetation Types Potentially Found within this Portion of the Project Boundary.

8. No systematic botanical studies have occurred within the project boundary; any plant specimens/data collected within the boundary have been random and sporadic. The closest complete botanical inventories include those of The Nature Conservancy's Cucumber Creek Nature Preserve (northern LeFlore county; Hoagland and Buthod 2009), The Nature Conservancy's Boehler Seeps and Sandhills Preserve (southeastern Atoka County; Clark 2011), and The Boy Scouts of America's Hale Scout Reservation (southern LeFlore County; Hoagland and Buthod 2010), and the Oklahoma Department of Wildlife Conservation's Hugo Lake Wildlife Management Area (eastern Choctaw County; Hoagland and Buthod 2004). Reservoir and powerhouse construction would severely impact or even eliminate the native vegetation of approximately 1,500 unexplored acres in Pushmataha County.

9. There is the potential for species that are rare or *tracked* by the Oklahoma Natural Heritage Inventory to occur within the project boundary. NatureServe—the authoritative source for biodiversity data throughout North America for over 50 years—and its associated Natural Heritage programs use a global and subnational ranking system to assign conservation priorities. Species are assigned both a global (G) and subnational (S) rank on a scale of 1 to 5. For instance, a rank of G1 indicates critical imperilment on a global scale, while an S1 rank indicates critical imperilment within a subnational (state or province) area. Factors including a) global population size and range, b) number of extant sites, and c) threats to the species contribute to the assignment of G and S ranks (NatureServe 2024). In Oklahoma, the species with ranks of SX, SH, S1, S2, and

S3 are *tracked* by the Oklahoma Natural Heritage Inventory (ONHI). ONHI maintains a centralized database of species occurrence data which is used for determining the subnational ranks for the state.

Table 1. An explanation of some Heritage Status Ranks (NatureServe 2024).

Rank	**Definition**
GX/SX	Presumed extinct or eliminated; virtually no likelihood of rediscovery
GH/SH	Possibly extinct or eliminated; known only from historical (>20-40 years) records
G1/S1	Critically imperiled; at very high risk of extinction or elimination
G2/S2	Imperiled; at high risk of extinction or elimination
G3/S3	Vulnerable; at moderate risk of extinction or elimination

10. U.S. Forest Service Proposed, Endangered, Threatened, and Sensitive Species (PETS) are likely to occur within the project boundary. PETS species include those that are listed as Threatened or Endangered by the U.S. Fish and Wildlife Service, species that are proposed to be listed, and sensitive species—those with special management needs required to maintain and improve their status and prevent a need for listing. Some of these species have been found at the sites referenced in Paragraph 8 of this report or found within 5 miles of the project boundary according to the Oklahoma Natural Heritage Inventory's database of rare species occurrences (Bastarache *personal communication*, Oklahoma Natural Heritage Inventory 2024).

11. Table 2, below, includes tracked vascular plant species found in the studies cited in Paragraph 8 of this report, U.S. Forest Service PETS, and tracked species known to occur within approximately five miles of the project boundary according to the ONHI database (2024).

Table 2. Tracked species and PETS, their Heritage Status Ranks, and information source. BS=Boehler Seeps, CC=Cucumber Creek, HL=Hugo Lake, HSR=Hale Scout Reservation, ONHI=Oklahoma Natural Heritage Inventory database, PETS=Forest Service sensitive species

Species	**G Rank**	**S Rank**	**Location/Source**
Actaea pachypoda	G5	S1	CC
Amorpha ouachitensis	G3	S3	HSR, ONHI, PETS
Aristolochia serpentaria	G4	S1	HSR
Asplenium bradleyi	G4	S1	ONHI
Baptisia nuttalliana	G5	S3	HSR
Brachyelytrum erectum	G5	S3	HSR
Calamovilfa arcuata	G2	S2	ONHI, PETS
Callirhoe bushii	G3	S2	ONHI, PETS
Carex latebracteata	G3	S3	CC, ONHI, PETS
Carex ouachitana	G4	S2	CC, HSR
Carex oxylepis	G5	S2	HL
Carex striatula	G5	S1	CC
Carex swanii	G5	S1	ONHI
Carex typhina	G5	S1	ONHI
Carya myristiciformis	G4	S1	HL, ONHI
Castanea pumila var. *ozarkensis*	GNR	S2	CC
Chionanthus virginicus	G5	S3	CC, HSR
Clematis crispa	G5	S1	HSR
Corallorhiza odontorhiza	G5	S1	ONHI
Cypripedium kentuckiense	G3	S1	ONHI, PETS
Diarrhena americana	G4	S1	HL
Didiplis diandra	G5	S1	HSR, ONHI
Dirca palustris	G4	S1	CC
Drosera brevifolia	G5	S1	BS
Eriocualon koernickianum	G2	S1	BS, PETS
Fagus grandifolia	G5	S1	ONHI
Fraxinus quadrangulata	G4	S1	CC
Galium arkansanum	G5	S2	CC, HSR
Hamamelis vernalis	G4	S3	CC
Hamamelis virginiana	G5	S2	CC
Houstonia ouachitana	G3	S3	HSR
Hypericum gentianoides	G6	S1	CC
Hypericum lobocarpum	G5	S1	ONHI
Ilex ambigua	G5	S1	ONHI
Iris cristata	G5	S3	CC
Iris virginica	G5	S1	HL
Isotria verticillata	G5	S1	ONHI
Juncus repens	G5	S1	HSR, ONHI
Leavenworthia aurea	G5	S1	ONHI, PETS

Species	G Rank	S Rank	Location/Source
Lycopodiella appressa	G5	S1	BS
Lyonia ligustrina	G5	S1	ONHI
Malaxis unifolia	G5	S1	ONHI
Magnolia tripetala	G5	S1	CC
Matelea baldwyniana	G5	S1	ONHI
Monotropa hypopithys	G5	S1	HSR, BS
Muhlenbergia bushii	G5	S1	HSR
Oenothera demareei	G5	S1	ONHI
Panax quinquefolius	G3	S1	CC
Panicum brachyanthum	G5	S2	HL
Paronychia drummondii	G4	S1	BS
Peltandra virginica	G5	S1	ONHI
Penstemon murrayanus	G4	S1	BS
Penstemon oklahomensis	G3	S3	ONHI
Phyllanthopsis phyllanthoides	G4	S1	ONHI
Physaria angustifolia	G5	S1	ONHI, PETS
Piptochaetum avenaceum	G5	S2	CC
Planera aquatica	G5	S2	HL
Platanthera ciliaris	G5	S1	ONHI
Platanthera flava	G2	S2	ONHI
Platanthera lacera	G2	S2	ONHI
Polygala polygama	G5	S2	CC
Polygonella americana	G5	S1	BS
Rhododendron viscosum	G2	S2	ONHI
Rhynchospora capillacea	G2	S2	ONHI
Ribes curvatum	G3	S2	ONHI
Ribes cynosbati	G5	S2	CC, HSR
Saccioplepis striata	G5	S3	HL
Sagittaria ambigua	G3	S2	ONHI
Smilax smallii	G5	S2	HL
Stachys eplingii	G5	S2	CC
Thalia dealbata	G4	S3	HL
Thalictrum arksansanum	G3	S2	ONHI, PETS
Tradescantia ozarkana	G3	S2	HL, ONHI, PETS
Triphora trianthophoros	G3	S3	ONHI
Urtica chamaedryoides	G4	S3	HL
Utricularia radiata	G3	S3	ONHI
Uvularia grandiflora	G5	S2	CC
Vernonia lettermannii	G3	S3	ONHI, PETS
Vernonia missurica	G4	S2	HL

12. In Oklahoma, the project boundary area falls within the South Central Plains and Ouachita Mountain Level III Ecosystems (U.S. Environmental Protection Agency 2007). Globally critically imperiled, imperiled, and vulnerable vegetation associations occur within the project boundary. Approximately 21% (7,474 acres) of the project boundary area is located in the habitat known as the Ozark-Ouachita Dry-Mesic Oak Forest System. The Globally Vulnerable (G3) species *Tradescantia ozarkensis* (Ozark spiderwort) may be found in this system. Component associations of the Ozark-Ouachita Dry-Mesic Oak Forest System include the a) Globally Imperiled (G2) *Acer saccharum - Quercus muehlenbergii / Cotinus obovatus* Forest, b) the Globally Vulnerable (G3) *Quercus alba - Carya tomentosa / Ostrya virginiana / Carex pensylvanica - Schizachyrium scoparium* Woodland, c) the G3 *Quercus alba - Quercus rubra - Carya tomentosa / Cornus florida* Acidic Forest, d) the G3 *Quercus falcata - Carya tomentosa - Carya ovata* Forest, and e) the G3 *Quercus muehlenbergii - Quercus shumardii* Forest (NatureServe 2024).

13. Approximately 21% (7,235 acres) of the project will be located in the habitat known as the Ozark-Ouachita Shortleaf Pine-Bluestem Woodland System. Component associations of the Ozark-Ouachita Shortleaf Pine-Bluestem Woodland System include a) the Globally Imperiled (G1) *Pinus echinata / Schizachyrium scoparium - Solidago ulmifolia - Monarda russeliana - Echinacea pallida* Woodland, b) the Globally Imperiled (G2) *Pinus echinata - Quercus stellata - Quercus marilandica / Schizachyrium scoparium* Woodland and *Pinus echinata* / Rock Outcrop Interior Highland Woodland, and c) the Globally Vulnerable (G3) *Pinus echinata - Quercus alba / Schizachyrium scoparium* Woodland (NatureServe 2024).

14. Approximately 5% (1,674 acres) of the project will be located in the Ozark-Ouachita Dry Oak Woodland System. A component of this system is the globally Imperiled (G2)

Quercus stellata - Quercus marilandica - Quercus velutina - Carya texana / Schizachyrium scoparium Woodland association (NatureServe 2024).

IV. The Area within the Project Boundary Includes Habitat for Plant Species that Are Culturally Significant/Important to the Choctaw Nation.

15. Wild populations of plant species that are traditionally important to the Choctaw people are likely to occur within in the project boundary. According to the TORCH Data Portal (2024), an online database which provides access to herbarium specimen data for the purposes of conservation, management, and education, the following culturally significant species could be found within the project boundary area (Thompson 2019, TORCH Portal 2024):

Table 3. Culturally Significant Species within the Project Boundary.

Species (Latin)	**Species (Choctaw)**
Acer rubrum	Chukchu
Acer saccharum	Chukchu Lusa
Achillea millefolium	Ibikoa Ikhish Fvni/ Hasimbish Holba
Allium canadense	Hatofvlaha/Shachuna
Alnus serrulata	Itukawiloha
Andropogon virginicus	Hashuk Basi
Arundinaria gigantea	Uski
Asimina triloba	Umbi
Baptisia sp.	Poafvchi
Betula nigra	Opahaksun
Callicarpa americana	Shoklapa/Ani Humma/Wak Impatvlhpo
Carpinus caroliniana	Oka Hiloha/Chukvpishvno
Carya texana	Uksak Vpi
Castanea sp.	Hachofaktvpi/Otvpi Osi/ Otvpi Chimponta
Cornus florida	Hakchopilhkupvpi/Hakchulhkvpi
Fagus grandifolia	Hatonbvlaha
Fraxinus sp.	Shinvp
Helenium amarum	Nukhlatili Napakanli Lvkna
Helianthus hirsutus	Okhish Chito
Ilex opaca	Iti Hishi Halupa
Liquidambar styraciflua	Hika/Iti Tokwasali
Morus rubra	Bihvpi
Nyssa sylvatica	Itvni/Hushvpa
Ostrya virginiana	Iyanvbi

Species (Latin)	Species (Choctaw)
Phytolacca americana	Koshiba
Pinus echinata	Tiak Hvta/Tiak Tohbi
Poa sp.	Hashuk Okchamali
Podophyllum peltatum	Fvla Imisito/Fvla Intanchi/Fvlaknimushi/Sitosila
Pseudognaphalium obtusifolium	Bashukchak
Quercus alba	Baii
Quercus marilandica	Chiskilik
Quercus nigra	Chilhpvtha/Nusi Shauiya
Quercus stellata	Chisha
Quercus velutina	Nuslaknvpi
Rhus glabra	Bvti/Bashankchi/Bashochi
Sabatia campestris	Napakanli Pisachukma
Smilax bona-nox	Halupa
Smilax glauca	Bisakchakinna
Smilax smallii	Halupa Chito
Spigelia marilandica	Pakanli Homma/Lvpchvbi/Vla Imokhish
Symphoricarpos orbiculatus	Imvllusak/Issimvllusak
Tilia americana	Pishvnnuk/Balop
Vaccinium arboreum	Hvshtula Sepha/Sepha Chaha/Oksak Okchi
Vitis rotundifolia	Suko

V. Reservoir Construction Could Alter Plant Communities and Habitats Downstream from the Water Intake Structure Site.

16. The Kiamichi River's natural flow regime will be impacted depending on the amount, rate, and timing of water withdrawals and potential discharges. The project's operations, particularly operation of the intake structure to be located on the river, will cause hydrologic changes, which will in turn cause fluctuations in environmental factors such as water depth, temperature, and flow rate (Greimel et al. 2018, Bipa et al. 2024). Artificial hydrologic changes can reduce habitat availability and quality for plants and animals. Consequently, this leads to less successful reproduction and, ultimately, loss of biodiversity (Greimel at al. 2018). Water quality is also a concern. Hydrologic changes can also lead to erosion, loss of riparian vegetation, and increased sedimentation, which can impact terrestrial vegetation communities (Bipa et al. 2024).

Other possible impacts of hydroelectric power plant construction include greenhouse gas emissions, water toxification, eutrophication, soil desiccation, and noise pollution (Rahman et al. 2022).

VI. Transmission Line Construction Will Impact Nearly 25 Square Miles of Un-Surveyed Habitat.

17. The Oklahoma Invasive Plant Council Watch List lists forty-three species of exotic species that already occur in McCurtain County (Oklahoma Invasive Plant Council 2024, TORCH Portal 2024). The disturbance created during construction of the transmission line could result in the introduction and/or spread of these and other invasive plants species into the unexplored areas within the project boundary area (Dalu et al. 2023). Habitat loss, habitat fragmentation, and edge effects may occur because of the forest clearing activity during construction and right-of-way maintenance. Installation of transmission may result in an increase of fire events, which also can be accelerated by the presence of invasive plants (Biasotto and Kindel 2018).

Table 4. Invasive plant species on the Oklahoma Invasive Plant Council's Watch List that are already found in McCurtain County.

Species name	
1. *Anthemis cotula*	23. *Melilotus officinalis*
2. *Arctium minus*	24. *Morus alba*
3. *Bromus catharticus*	25. *Paspalum dilatatum*
4. *Bromus japonicus*	26. *Phyllostachys aurea*
5. *Bromus secalinus*	27. *Polygonum aviculare*
6. *Bromus sterilis*	28. *Ranunculus sardous*
7. *Broussonetia papyrifera*	29. *Rosa multiflora*
8. *Cardiospermum halicacabum*	30. *Rumex acetosella*
9. *Cirsium vulgare*	31. *Rumex crispus*
10. *Dactylis glomerata*	32. *Rumex obtusifolius*
11. *Daucus carota*	33. *Sonchus asper*
12. *Dianthus armeria*	34. *Sonchus oleraceus*
13. *Dysphania ambrosioides*	35. *Stellaria media*
14. *Echinochloa crus-galli*	36. *Thlaspi arvense*
15. *Elaeagnus angustifolia*	37. *Trifolium incarnatum*
16. *Erodium cicutarium*	38. *Trifolium reflexum*

17. *Fatoua villosa*	39. *Trifolium resupinatum*
18. *Lolium perenne*	40. *Verbascum thapsus*
19. *Lygodium japonicum*	41. *Verbena brasiliensis*
20. *Medicago lupulina*	42. *Vicia villosa*
21. *Melia azedarach*	43. *Vinca major*
22. *Melilotus albus*	

VII. Conclusions and Recommendations.

18. Surveys for species tracked by the Oklahoma Natural Heritage Inventory and Forest Service PETS should be conducted to thoroughly evaluate the potential impacts of the SEOPC project. Plant surveys, specifically surveys for species tracked by the Oklahoma Natural Heritage Inventory and PETS, should be conducted throughout the project area boundary before any construction commences. A typical vegetation inventory is conducted throughout the growing season (March through October), with trips made to the site/sites each month. The trips vary in length depending on the size of the survey area, the type of habitat, and the time of the year. Usually, one of every plant species encountered within the survey area is collected and prepared as an herbarium voucher. Following completion of the fieldwork, the plants are identified, labeled, and a species list for the survey area is prepared.

19. Vegetation inventories are costly and time-consuming, and there are few botanists available in Oklahoma that are qualified to do this work. Despite this, I think it is necessary to conduct a complete survey of the reservoir and powerhouse sites within the project boundary area, since these areas will most likely be completely altered or destroyed. Considering the scope of this project, it would be impossible to survey the entire length of the transmission line, but multiple areas within the path should be selected (randomly or targeting certain areas/habitats using aerial photos) for surveys.

I declare under penalty of perjury of the laws of the State of Oklahoma and the United States of America that the foregoing is a true and correct statement of my expert opinion, and that this report was executed this 30th day of October 2024, at 2115 E Robinson, Norman, OK, 73071.

Respectfully submitted,

s/ *Amy Kathleen Buthod*
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CURRICULUM VITAE

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Education:

2001	**The University of Oklahoma**, Norman, OK **M.S.** in Botany
1994	**The University of Oklahoma**, Norman, OK B.S. in Zoology

Teaching:

1998	**The University of Oklahoma,** Norman, OK **Teaching Assistant,** Department of Botany and Microbiology. Lectured for weekly laboratory section of general botany course. Prepared instructional material and experiments for laboratory sessions.

Related Experience:

2000-present	**The University of Oklahoma,** Norman, OK **Botanical Specialist/Scientist/Researcher III, Herbarium Collections Manager and Oklahoma Heritage Botanist**, Oklahoma Biological Survey. Managing the operation of the Robert Bebb Herbarium and its collections. Conducting floristic inventories throughout the state of Oklahoma. Monitoring and tracking rare species. Preparing manuscripts, grant applications, and project reports.
1999-2000	**The University of Oklahoma,** Norman, OK **Research Assistant,** Robert Bebb Herbarium. Maintained and managed the Robert Bebb Herbarium and its collections.
1998	**The University of Oklahoma,** Norman, OK **Curatorial Assistant,** Robert Bebb Herbarium. Assisted collections manager with herbarium operations and maintenance.
1990-1992	**The University of Oklahoma,** Norman, OK **Student Research Assistant,** Oklahoma Museum of Natural History. Prepared fossil specimens for vertebrate paleontology collections.

Grants:

2024	Principal Investigator for "Tishomingo National Wildlife Refuge FY23 Invasive Species". Funded by the U.S. Fish and Wildlife Service
	Principal Investigator for "The Status of *Geocarpon minimum* and *Ptilimnium nodosum* in Oklahoma. Funded by the U.S. Fish and Wildlife Service
	Principal Investigator for "Task Agreement to Support Floristics Projects in Southern Plains Network National Parks". Funded by the National Park Service
2023	Principal Investigator for "The Status of *Geocarpon minimum* in Oklahoma". Funded by the U.S. Fish and Wildlife Service
2022	Principal Investigator for *Schoenoplectiella hallii* in Oklahoma". Funded by the U.S. Fish and Wildlife Service
	Principal Investigator for "Implementing and Conducting Monitoring for the Ozark Plateau National Wildlife Refuge Restoration Pilot Project". Funded by the U.S. Fish and Wildlife Service
2020	Principal Investigator for "The Status and Reintroduction Potential of *Eriocaulon koernickianum* in Oklahoma". Funded by the U.S. Fish and Wildlife Service
2019	Principal Investigator for "Status of *Valerianella nuttallii* in Oklahoma". Funded by the U.S. Fish and Wildlife Service
2017	Principal Investigator for "The Nature Conservancy's Blue River Mitigation Project". Funded by the Nature Conservancy
	Principal Investigator for "Status of *Silene regia* and *Ptilimnium nodosum* in Oklahoma". Funded by the U.S. Fish and Wildlife Service
2016	Principal Investigator for "A Floristic Inventory of the Nature Conservancy's Hottonia Bottoms Preserve". Funded by The Nature Conservancy
	Principal Investigator for" A Floristic Inventory of the Nature Conservancy's Oka' Yanahli Preserve: Year 2". Funded by the Nature Conservancy
	Principal Investigator for "Status of *Agalinis auriculata, Agalinis skinneriana, Phlox oklahomensis*, and *Ptilimnium nodosum"*. Funded by the U.S. Fish and Wildlife Service
2015	Principal Investigator for "The Federally Endangered *Ptilimnium nodosum* in the State of Oklahoma: Year 2". Funded by the U.S. Fish and Wildlife Service
2014	Principal investigator for "The Federally Endangered *Ptilimnium nodosum* in the state of Oklahoma". Funded by the U.S. Fish and Wildlife Service
	Principal investigator for "An Updated Floristic Inventory of the Nature Conservancy's Pontotoc Ridge Preserve, The Nature Conservancy". Funded by

	The Nature Conservancy
	Principal investigator for "A Floristic Inventory of the Nature Conservancy's Oka' Yanahli Preserve, The Nature Conservancy". Funded by The Nature Conservancy
2012	Principal investigator for "Status of the Tracked Vascular Plants of the Black Mesa Area, Cimarron County, Oklahoma". Funded by the U.S. Fish and Wildlife Service
2011	Principal investigator for "Status of the Oklahoma endemics *Leavenworthia aurea* var. *aurea* and *Phlox pilosa* var. *longipilosa*". Funded by the U.S. Fish and Wildlife Service
2010	Co-investigator for "Floristic inventory of Red Slough Wildlife Management Area." Funded by U.S. Department of Agriculture, Forestry Service
2009	Principal investigator for "*Calopogon oklahomensis* in the state of Oklahoma". Funded by the U.S. Fish and Wildlife Service
2008	Co-investigator for "A Survey for Invasive Plant Species at the Wildfire Site Near Brantley Cabin". Funded by U.S. Department of Agriculture, Forestry Service
	Co-investigator for "Bogs of Southeastern Oklahoma, Year 2". Funded by the U.S. Fish and Wildlife Service
2007	Co-investigator for "Floristic Inventory of the Little River National Wildlife Refuge". Funded by the U.S. Fish and Wildlife Service
	Co-investigator for "Bogs of Southeastern Oklahoma, Year 1". Funded by the U.S. Fish and Wildlife Service
2006	
	Co-investigator for "Woody Vegetation of Four Canyons". Funded by The Nature Conservancy
	Co-investigator for "Establishment of Monitoring Protocols for *Stanhopea tigrina, Euchile mariae*, and *Laelia speciosa* (Orchidaceae) in the El Cielo Biosphere Reserve, Tamaulipas, Mexico". Funded by the Association of Zoological Horticulture
2005	Principal investigator for "*Platanthera praeclara* and *Asclepias uncialis* in Oklahoma". Funded by the U.S. Fish and Wildlife Service
	Co-investigator for "Floristic Inventory of the Four Canyons Preserve, Ellis County, Oklahoma". Funded by the Nature Conservancy
	Co-investigator for "Floristic Inventory of the Cucumber Creek Nature Preserve, Le Flore County, Oklahoma". Funded by the Nature Conservancy

2004 Principal investigator for "Monitoring Vascular Plants of Federal Concern: *Asclepias uncialis* and *Trillium pusillum* var. *ozarkanum*". Funded by the U.S. Fish and Wildlife Service

2003 Co-investigator for "Development of the Oklahoma Vascular Plants Database and website". Funded by the National Science Foundation

Principal investigator for "Utilizing Standardized Protocols for Monitoring Vascular Plants of Federal Concern: A Continuing Study with *Castanea pumila* var. *ozarkensis*". Funded by the U.S. Fish and Wildlife Service

2002 Principal investigator for "Utilizing Standardized Protocols for Monitoring Vascular Plants of Federal Concern: A Study with *Castanea Pumila* var. *Ozarkensis*". Funded by the U.S. Fish and Wildlife Service

Co-investigator for "Floristic Survey of the Keystone Wildlife Management Area". Funded by the Oklahoma Department of Wildlife Conservation

Co-investigator for "Floristic Inventory of the Washita National Battlefield Historic Site". Funded by the National Park Service

2001 Principal Investigator for "Developing Standardized Protocols for Monitoring Vascular Plants of Federal Concern: A Case Study with *Silene regia* and *Cypripedium kentuckiense*". U.S. Fish and Wildlife Service

Co-investigator for "A Floristic Survey of the Hugo Wildlife Management Area". Funded by the Oklahoma Department of Wildlife Conservation

Selected Publications:

2024 Buthod, A.K. 2024. A Floristic Inventory of the Oklahoma Department of Wildlife Conservation's Lexington Wildlife Management Area, Cleveland County, Oklahoma. *Oklahoma Native Plant Record* 22(1):4-25.

2023 Buthod, A.K. and L. Miller. 2023. Geocarpon minimum, New to Oklahoma, U.S.A. *J.Bot.Res.Inst.Texas* 17(2):535-529

2020 Buthod, A.K. and B.W. Hoagland. 2020. A Floristic Inventory of the Nature Conservancy's Oka' Yanahli Preserve, Johnston County, Oklahoma, *Oklahoma Native Plant Record* 20(1): 24-52.

Buthod, A.K. and B.W. Hoagland. 2020. A Floristic Inventory of the Nature Conservancy's Hottonia Bottoms Preserve, Atoka, Choctaw, and Bryan Counties, Oklahoma, *Oklahoma Native Plant Record* 20(1): 4-23.

2019 Buthod, A.K., B.W. Hoagland, and D. Arbour. 2019. New to Oklahoma: *Triadica sebifera* (Euphorbiaceae). *Phytoneuron* 2019-61: 1-5.

2017 Buthod, A.K. and B.W. Hoagland. 2016. A Floristic Inventory of the University

	of Oklahoma's Kessler Atmospheric and Ecological Field Station, McClain County, Oklahoma. Oklahoma Native Plant Record 1(16): 45-63.
2015	Buthod, A.K. and B.W. Hoagland. 2015. Contributions to the Flora of Cimarron County and the Black Mesa Area. *Oklahoma Native Plant Record* 15 (1), pp. 49-60.
2014	Buthod, A.K. and J.J. Skvarla. 2014. Pollen morphology of the Oklahoma endemic plants *Leavenworthia aurea* (Brassicaceae/Cruciferae) and *Phlox pilosa* subsp. *longipilosa* (Polemoniaceae), with special reference to their natural history. Rhodora 116(965):41-62.
	Buthod, A.K. and J.J. Skvarla. 2014. Pollen morphology of the Oklahoma narrowly endemic plants *Physaria angustifolia* (Brassicaceae/Cruciferae) and *Penstemon oklahomensis* (Plantaginaceae), with special reference to their natural history. Rhodora 116(965):63-82.
2013	Buthod, A. K. 2013. A checklist of the vascular plants of the Mary K. Oxley Nature Center, Tulsa County, Oklahoma. *Oklahoma Native Plant Record* 13(1): 29-47.
	Buthod, A. K. and B.W. Hoagland. 2013. An occurrence of the federally endangered Harperella (*Harperella nodosa* Rose; Apiaceae) in Oklahoma. *Castanea* 78(3): 213-215.
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2001	Buthod, A. Infrageneric Relationships of *Bulbophyllum* (Orchidaceae) Based on Nuclear *ITS* DNA. Master's thesis.

Awards:

1992	Barry M. Goldwater Scholarship for Excellence in Science and Mathematics, The University of Oklahoma

Attachment 2

Technical Report:

Geotechnical and Hydrologic Problems Associated with the Proposed Pushmataha County Pumped Storage Hydroelectric Project near Albion, Oklahoma

by

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Prepared for

Chickasaw Nation and Choctaw Nation of Oklahoma

November 1, 2024

I. EXECUTIVE SUMMARY

1. The proposed Pushmataha County Pumped Storage Hydroelectric Project ("Project") would be constructed near the Kiamichi River in southeastern Oklahoma. The planned upper reservoir for the project is proposed to be located on the Jackfork Group, which consists mainly of sandstone with some interbedded shale. These sandstone deposits are permeable and would allow water to seep into underlying bedrock at the site. The proposed lower reservoir would be located partly on shale of the Stanley Group and partly on alluvial terrace deposits in the valley of the Kiamichi River. A proposed regulating reservoir also would be located on terrace deposits. The alluvial terrace deposits are permeable and would allow seepage of water from the lower reservoir and the regulating reservoir. Sandstone of the Jackfork Group is exposed on a steep slope and ridge in the southern part of the proposed site. Infrastructure proposed for construction in these sandstones and shales, including tunnels, inlets, and outlets, would be susceptible to

landslides and related rock failures. Leakage from the proposed reservoirs and associated infrastructure could contribute to the likelihood of landslides. Loss of water by leakage and evaporation from reservoirs for the proposed project is a related concern because water resources in the basin currently are stressed. A rise in the water table also could cause environmental and ecological damage. Activation of landslides poses additional risks for the area besides safety, including potential damage to cultural and archeological resources. It is crucial that geotechnical and hydrologic studies be completed before issuance of a license for the project.

2. This report is organized as follows: Section II states my experience and qualifications; Section III is an introduction; Sections IV – VI describe the geotechnical and hydrologic considerations of the project; Section VII summarizes my report; Section VIII provides my references cited, and Section IX provides figures.

II. EXPERIENCE AND QUALIFICATIONS

3. My curriculum vitae is provided as an attachment.

III. INTRODUCTION

4. I submit this report in response to Southeast Oklahoma Power Corporation's ("SEOPC") Filing of Notice of Intent to File an Application for an Original License and Pre-Application Document ("PAD"), and Request to be Designated as FERC's Non-Federal Representative for the Purposes of Informal Consultation under Section 106 and Section 7 for the Pushmataha County Pumped Storage Project (P-14890), eLibrary no. 20240507-5119 (May 7, 2024), as noticed by the Federal Energy Regulatory Commission ("FERC" or "Commission") on July 8, 2024. *See* eLibrary no. 20240708-3054.

5. Figure 1 shows the location of the proposed site of the Project. The planned Project, including an upper reservoir, lower reservoir, and regulating reservoir, would be constructed near

the Kiamichi River. Figure 2 shows planned facilities for the Project. The proposed Project boundaries are shown superimposed on a Google Earth image in Figure 3. This upper reservoir is proposed to be located in a valley south of a steep ridge near the southern end of the site, about 1000 feet above the elevation of the lower reservoir and regulating reservoir.

6. The purpose of this report is to examine the geotechnical and hydrologic conditions of the proposed project area and to discuss the probability of disrupting landslides as well as associated environmental damage from potential leaks in the reservoirs. Leaks from the reservoirs or related facilities south of the Kiamichi River could contribute to the likelihood of landslides in the steep slopes above the river valley. Leaking water from the proposed reservoirs also could have adverse impacts on existing water resources, along with potential damage to cultural and archeological resources. This report was based on information provided by SEOPC's PAD, and other sources, as cited in the references.

IV. GEOLOGY

7. Figure 4 shows part of a geologic map of Pushmataha County and surrounding areas in southeastern Oklahoma (from Marcher and Bergman, 1983). The proposed project site is in the Ouachita Mountains, about three miles south of Albion, Oklahoma. The Stanley Group, of Mississippian age, is shown by the dark blue color and the symbol, Mst. It consists mainly of shale with some sandstone beds. The Jackfork Group, of Pennsylvanian age, is shown by the lighter blue color and the symbol, ℙjf. It consists mainly of sandstone with interbedded shales. Quaternary alluvial terrace deposits are shown by the stippled, dark yellow color. The terrace deposits consist of gravel, sand, silt, clay, and volcanic ash. Quaternary alluvium is shown by the lighter yellow color and the symbol, Qal, along the Kiamichi River. The alluvium consists of gravel, sand, silt, and clay. Figure 5 shows stratigraphic sections of the Jackfork Group.

8. Figure 6 shows the area of the geologic map from Figure 4, with the proposed project boundary and reservoirs superimposed. The proposed upper reservoir for the Project is in a valley underlain by erodible shale and adjacent sandstone of the Jackfork Group. Figure 7 shows a description of this material and the rocks of the Stanley Group, from the geologic map of Marcher and Bergman (1983). The area of the proposed lower reservoir is underlain partly by shale of the Stanley Group (*see* Figure 6) and partly by alluvial terrace material. The area of the proposed regulating reservoir is underlain by alluvial terrace material. Rainfall and snowmelt that infiltrate into permeable deposits of sandstone and alluvial material are a source of recharge to groundwater in the area.

V. GEOTECHNICAL CONSIDERATIONS AND THE POTENTIAL FOR LANDSLIDES

9. The proposed upper reservoir for the Project would be located on rocks of the Jackfork Group (Figures 4 and 6), which could contain swelling clays within the rocks or in weathered soils. In addition, the sandstone deposits are permeable and would allow water to seep into bedrock at the site. The proposed lower reservoir is underlain partly by rocks of the Stanley Group, which also could contain swelling clays in the rocks or in weathered soils derived from the rocks.

10. The Ouachita Mountains of southeastern Oklahoma are a region of high landslide potential, according to the U.S. Geological Survey (2024a). Figure 8 shows a map of landslide potential in the United States, with areas of greatest likelihood shown in dark red. An enlargement of the region near the proposed project is shown on Figure 9. Regmi and Walter (2020) described landslide hazards in eastern Oklahoma. The steep slopes above the Kiamichi River south of the proposed lower reservoir site appear to be extremely susceptible to slope failures. The soils in this

area are potentially unstable, especially if they contain unstable soils *and* swelling clays. Landslides often are initiated along a clay layer within a rock formation.

11. The potential effects of landslides are of crucial importance. Future landslides and reactivation of old landslides pose a serious risk for the area. Slope failures such as landslides are a common risk in the Ouachita Mountains. For example, Nevels (2010) described a landslide that damaged U.S. Highway 271 in Pushmataha County, about twelve miles southwest of the proposed pumped storage site. Nevels (2010) stated that the underlying bedrock at the site of this landslide is the Stanley Group, and that the surface soils at that site were mapped as the Carnasaw-Pirum-Clebit association, with 12 to 20 percent slopes. Figure 10 shows the location of this landslide on the geologic map by Marcher and Bergman (1983), in soils and geologic material similar to that of the proposed pumped storage site. Figure 11 shows a recent slope failure within the proposed Pushmataha Pumped Storage Hydroelectric Project area.

12. Regmi and Walter (2020) of the Oklahoma Geological Survey reported that the frequency of shallow landslides in eastern Oklahoma has increased since 2005. They stated that the landslides could have been caused by earthquakes or intense storms, which are considered triggers for mass slope failures. Seismic events in Oklahoma such as earthquakes have increased during the past decade. Regmi and Walter (2020) observed the chronology of recent landslides from 1995 to 2016, and they determined the approximate ages of 137 landslides in eastern Oklahoma. They noted that 25 of these occurred before 2000, 4 occurred during 2000 to 2005, 46 occurred during 2005 to 2010, and 62 occurred during 2010 to 2016. They concluded by stressing the importance of considering the characteristics of the shale and sandstone rocks in the Ouachita Mountains, when making decisions about planning for landslide mitigation and managing hillslopes.

13. SEOPC's PAD states that about 9% of the proposed project area contains soils of the Clebit-Carnasaw-Stapp association, with 12 to 20 percent slopes. About 8.2% of the project area contains soils of the Clebit-Pirum-Carnasaw association, with 20 to 45 percent slopes. About 5.5% of the project area contains soils of the Clebit-Carnasaw-Stapp association, with 20 to 40 percent slopes. An additional 3.7% of the project area contains soils of the Carnasaw-Pirum-Clebit association, with 12 to 20 percent slopes. Thus, more than 25% of the proposed project area contains these potentially troublesome soils, with their correspondingly steep slopes.

14. Smectite, montmorillonite, or other expansive clays that could exist in the Stanley Group, Jackfork Group, or weathered soils from these rocks would be especially troublesome because they can absorb a large amount of water, causing swelling of the soil and leading to instability. If present, these swelling clays should be identified by soil borings and other appropriate methods in a thorough, complete geotechnical investigation. SEOPC's PAD states that expansive soils occur in 75% of Oklahoma, including the northern part of Pushmataha County, citing the Oklahoma Geological Survey (2008). It also states that smectite and montmorillonite could be present in clay-rich shales or weathered shales, again citing the Oklahoma Geological Survey (2008). Expansive soils can develop great pressure in the presence of moisture (Rahn, 1996). Alternatively, expansive clays can shrink drastically when they dry out, causing additional instability. The moisture content (or water content) of a soil is defined as the weight of water in a soil sample, divided by the weight of the dry soil (Gonzales de Vallejo and Ferrer, 2011; Das, 1983). As an example, montmorillonite can swell more than 1.5 to 2 times its original volume and can have a moisture content greater than 150% when it reaches the liquid limit, at which it passes from a plastic state to a liquid state (Rahn, 1996). Landslides and swelling soils regularly produce the greatest annual economic loss of all geologic hazards (Rahn, 1996).

15. Landslides are part of the natural erosional processes that operate in the Ouachita Mountains. Landslides from previous slope failures are present in the area, and more are predicted to occur in the future. Older slope failures also could be reactivated, especially during wet periods. Landslides can be initiated by heavy rain, prolonged wet periods, or human activities. Leaking water and increased pore-water pressure can cause landslides by increasing the weight of the sliding mass, and by decreasing the frictional resistance between grains of the soil. High water-table levels can be a major contributor to slope failures. Average annual precipitation in the Ouachita Mountains of southeastern Oklahoma is about 45 to 50 inches (Southeast Oklahoma Power Corporation, 2024; Oklahoma Climatological Survey, 2024), and the area is humid and subtropical, so abundant moisture in the soils will contribute to instability, especially during wet periods.

16. Leakage from the proposed upper reservoir and associated facilities could cause instability and lead to landslides in the area. SEOPC's PAD indicates that the proposed upper reservoir would have a volume of 68,269 acre-feet of water and a surface area of about 600 acres. The average depth of the reservoir thus would be about 114 feet. At that depth, the hydrostatic pressure would be about 7100 lb/ft^2 (about 49 lb/in^2). SEOPC's PAD also states that the height of the dam for the proposed upper reservoir would be 282 ft. If the water depth near the dam is assumed to be about 250 feet, the hydrostatic pressure at that depth would be about 15,600 lb/ft^2 (108 lb/in^2). The PAD does not mention a membrane liner, and it is doubtful that natural soils or artificial fill could withstand such pressures without substantial leakage. Leaking water thus could saturate material under the reservoir and adjacent to it, causing instability of the adjacent soils and rocks.

17. Similar calculations for the proposed lower reservoir show that its average depth could be about 55 feet. At this depth, the hydrostatic pressure would be about 3425 lb/ft^2 (about 23.8 lb/in^2). Because the proposed lower reservoir would be located partly on permeable alluvial terrace material and partly on shale of the Stanley Group, this could lead to serious leakage of water and could cause instability problems, including landslides.

18. Large-scale landslides could occur, especially in the southern part of the proposed project site. Other facilities for the proposed project, such as tunnels, spillways, and outlet works, could cause difficulties because of leakage or erosion. For example, if the emergency spillway for the upper reservoir discharged water during a large rainfall event, it could cause erosion of shales in the Jackfork Group and potentially could contribute to a large slope failure. Construction during the project, especially on steep slopes, could pose special problems for slope stability.

VI. HYDROLOGIC CONSIDERATIONS

19. Leakage of water from the proposed upper reservoir and associated facilities could have adverse impacts on groundwater and surface water. Water resources in the basin currently are stressed, according to SEOPC's PAD. Three streamflow gaging stations on the Kiamichi River (near Big Cedar, Oklahoma – station 07335700; near Clayton, Oklahoma – station 07335790; and near Antlers, Oklahoma – station 07336200) currently show zero discharge in October 2024 (U.S. Geological Survey, 2024b). The PAD indicates that the reservoir system would be filled by diverting water from the Kiamichi River. If the river could have periods of no discharge in the future, this raises critical questions about the viability of the proposed Project. Figure 12 shows a hydrograph for the Kiamichi River near Clayton, Oklahoma, from October 2023 to October 2024. The PAD also states that lake evaporation exceeds annual rainfall and ranges between 45 and 55 inches. Evaporation from the large surface-water exposures of the proposed reservoirs, along with

leakage of water from the bottom of the reservoirs, would exacerbate this problem. A thorough hydrologic analysis should be completed to determine potential effects, including the changing climate.

20. The proposed reservoirs could cause environmental and ecological damage. A higher water table could cause wetlands to appear, changing animal and plant habitat and causing difficulties because of saturated, muddy soils. Landslides in the steep slopes above the Kiamichi River, aggravated by leakage from the reservoirs, could destroy shallow archeological sites and cultural resources that currently are at or near the surface.

VII. SUMMARY

21. The planned upper reservoir for the proposed Project would be located on sandstones and shales of the Jackfork Group. The proposed lower reservoir would be located on permeable terrace alluvium and on shales of the Stanley Group. These geologic formations and their associated weathered soils are potentially unstable, making them extremely susceptible to failure. Landslides from slope failures are a geotechnical risk in the Ouachita Mountains. Leakage from the proposed upper and lower reservoirs could allow saturation of the underlying material and contribute to the likelihood of landslides. Potential leakage from associated facilities for the proposed project, including tunnels and other infrastructure, also is a concern.

22. Evaporation and leakage from the proposed reservoirs would cause losses of available water in a basin where water resources currently are stressed. A rise in the water table also could cause environmental and ecological damage. Future landslides and reactivation of old landslides pose a serious risk for the area, not only because of safety concerns for human life and property, but also for archeological and cultural resources.

23. An acceptable site is a basic requirement for a major undertaking such as the Project. SEOPC's PAD states that geotechnical investigations would be conducted following issuance of a license. However, geotechnical investigations and hydrologic analysis should be completed before issuance of a license for the proposed project. The investigations should explain the potential impacts of leaks from the proposed upper and lower reservoir as well as associated facilities, and should outline mitigation procedures in the event of leaks, landslides, and related problems. Issuance of a license before determining potential effects associated with these concerns is an unacceptable risk.

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IX. FIGURES

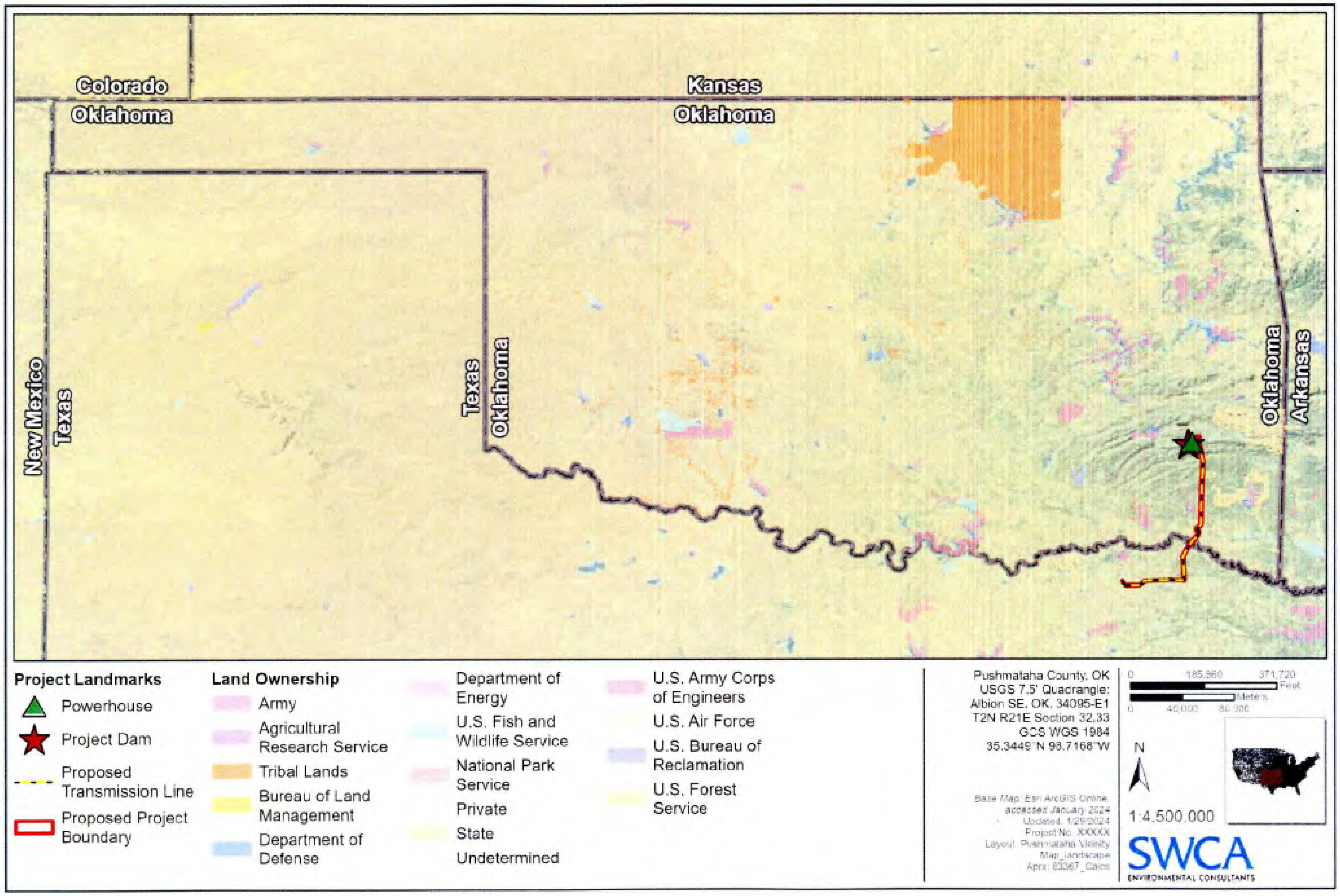


Figure 1. Location of the proposed Pushmataha County Pumped Storage Hydroelectric Project (from Southeast Oklahoma Power Corporation, 2024).

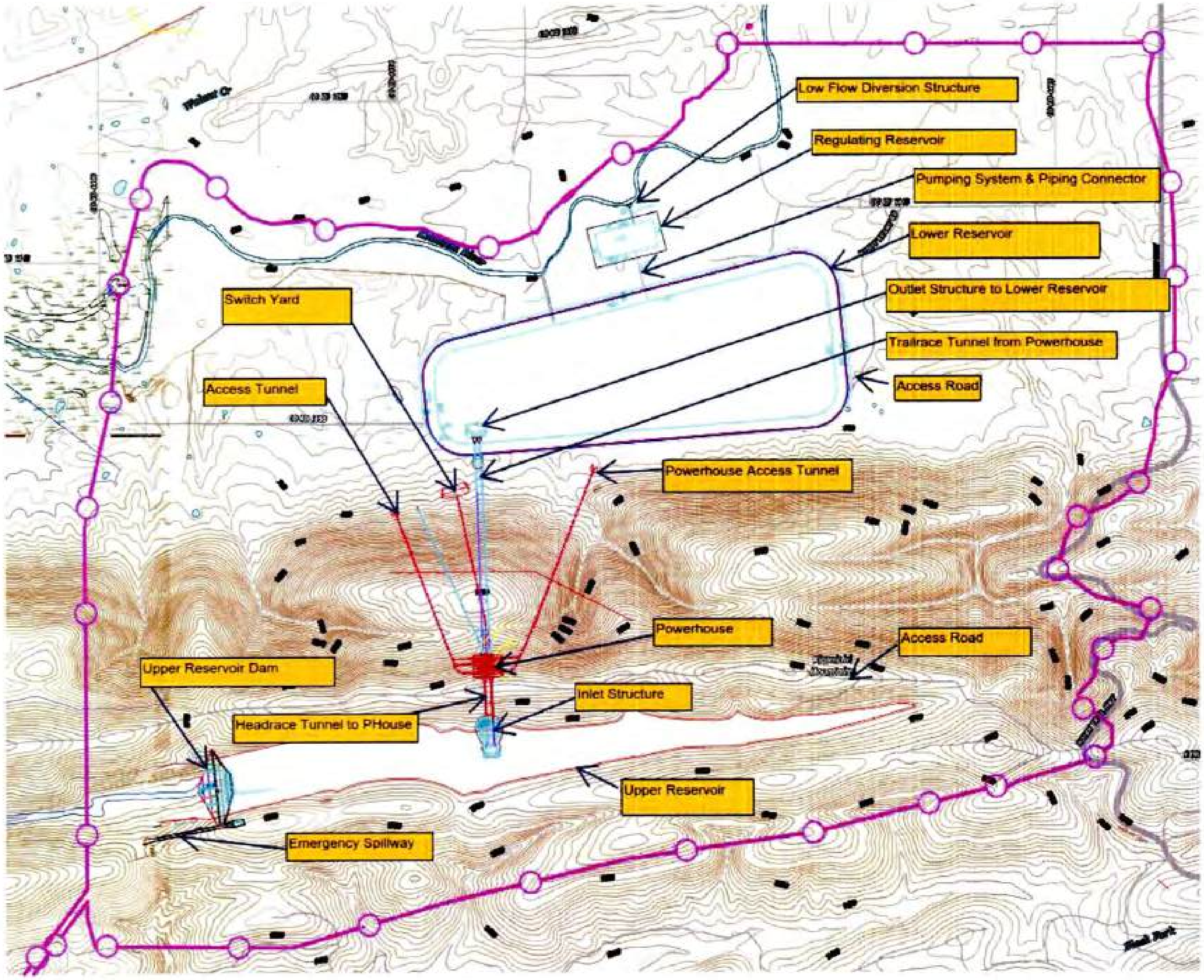


Figure 2. Planned facilities for the proposed Pushmataha County Pumped Storage Hydroelectric Project (from Southeast Oklahoma Power Corporation, 2024).

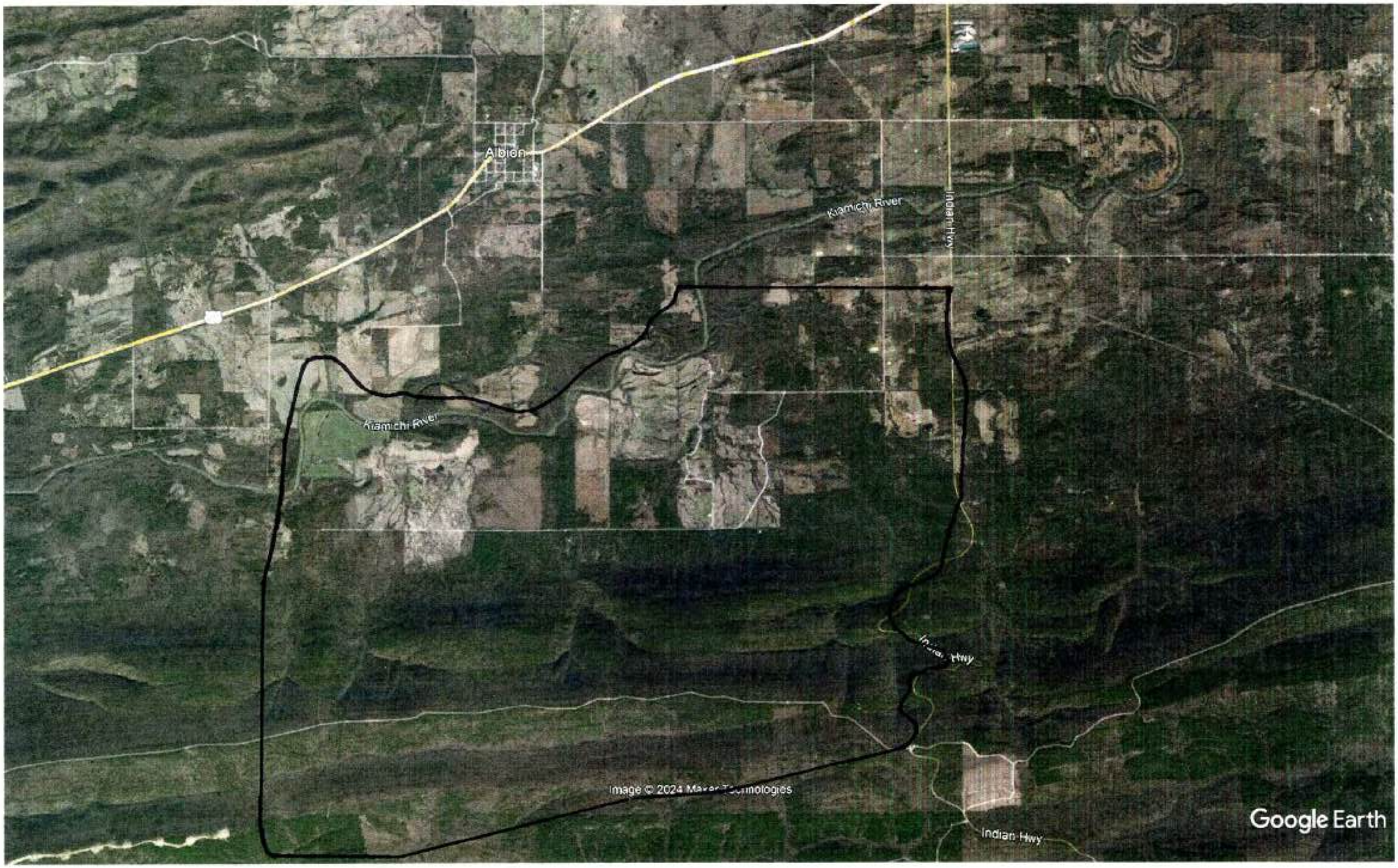


Figure 3. Google Earth image of the proposed Project area, with the approximate outline of the project boundary shown in black.

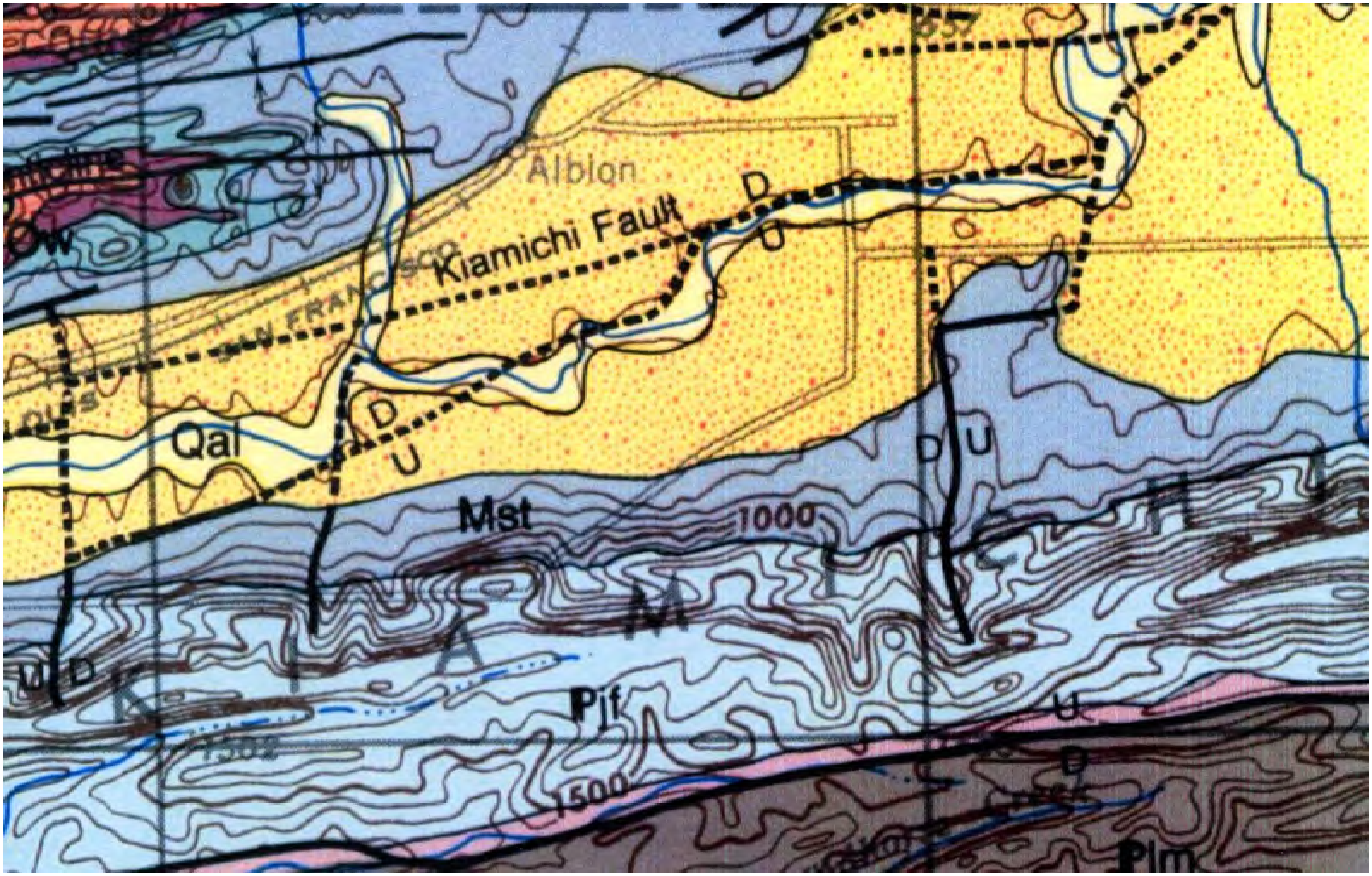
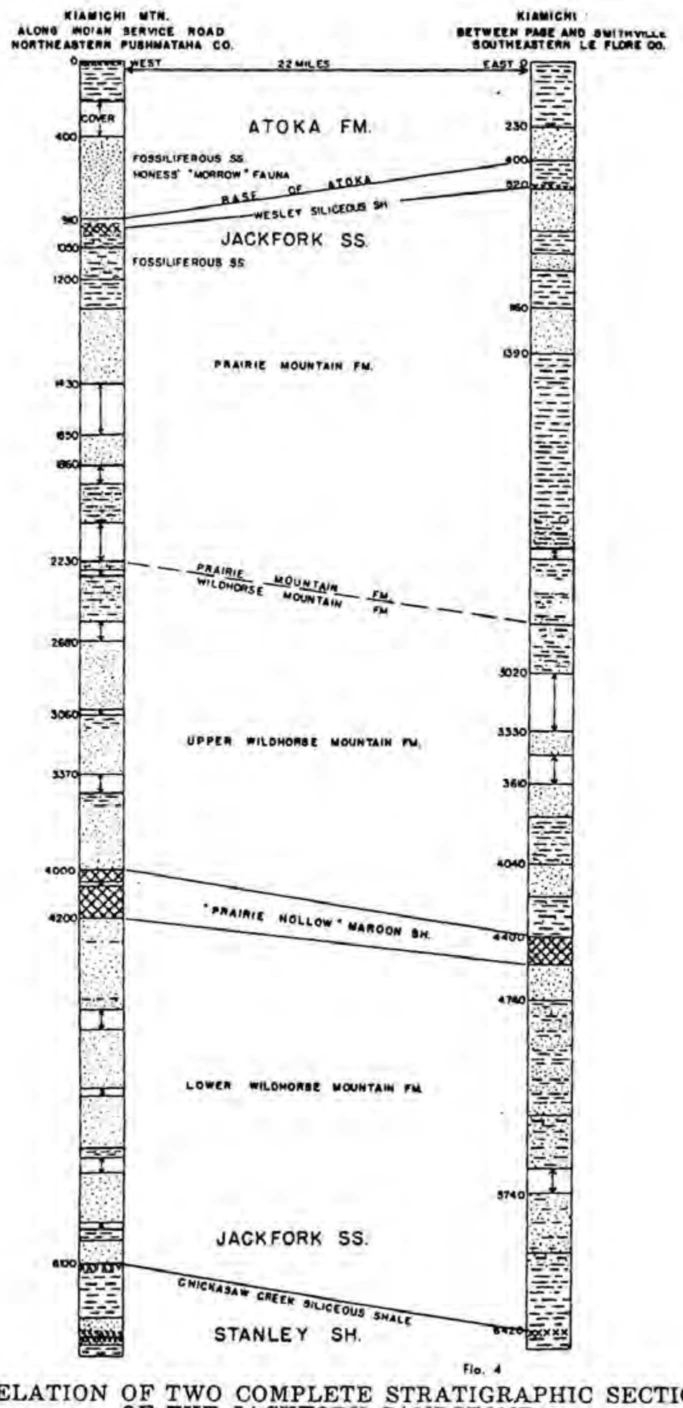


Figure 4. Part of the geologic map of Pushmataha County and surrounding areas (from Marcher and Bergman, 1983). The area of the map where the Stanley Group is exposed is shown by the symbol, Mst. The area where the Jackfork Group is exposed is shown by the symbol ℙjf. Terrace alluvium is shown by the stippled dark yellow color, and Quaternary alluvium (Qal) is shown in light yellow.



CORRELATION OF TWO COMPLETE STRATIGRAPHIC SECTIONS
OF THE JACKFORK SANDSTONE
Cropping Out In Kiamichi Mountain in the
East-Central Ouachita Province, Oklahoma
By L. M. CLINE and FRANK MORETTI; Described April, 1955

Figure 5. Measured stratigraphic sections of the Jackfork Group near the proposed site of the Pushmataha County Pumped Storage Hydroelectric Project in southeastern Oklahoma (from Cline and Moretti, 1956).

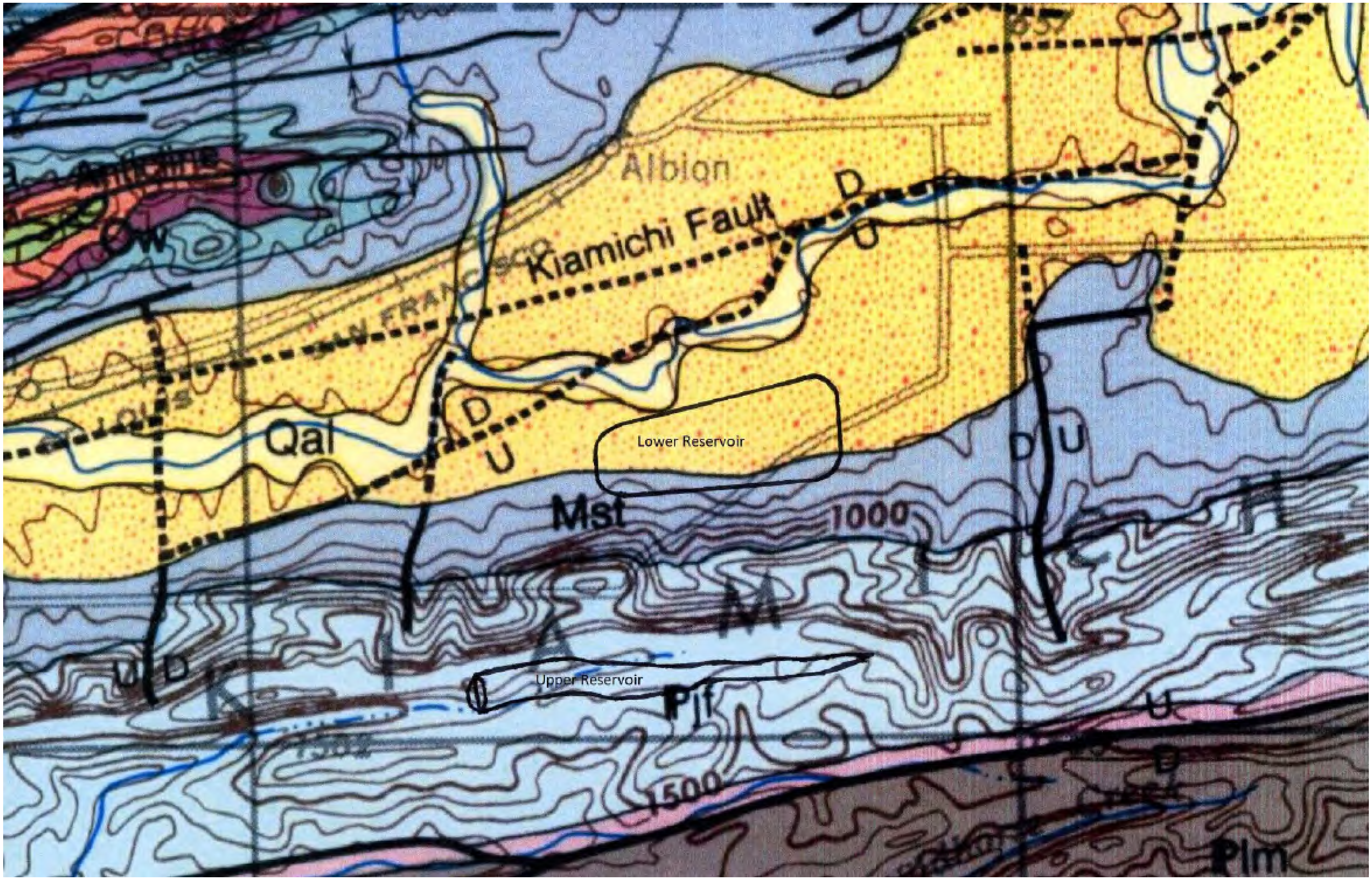
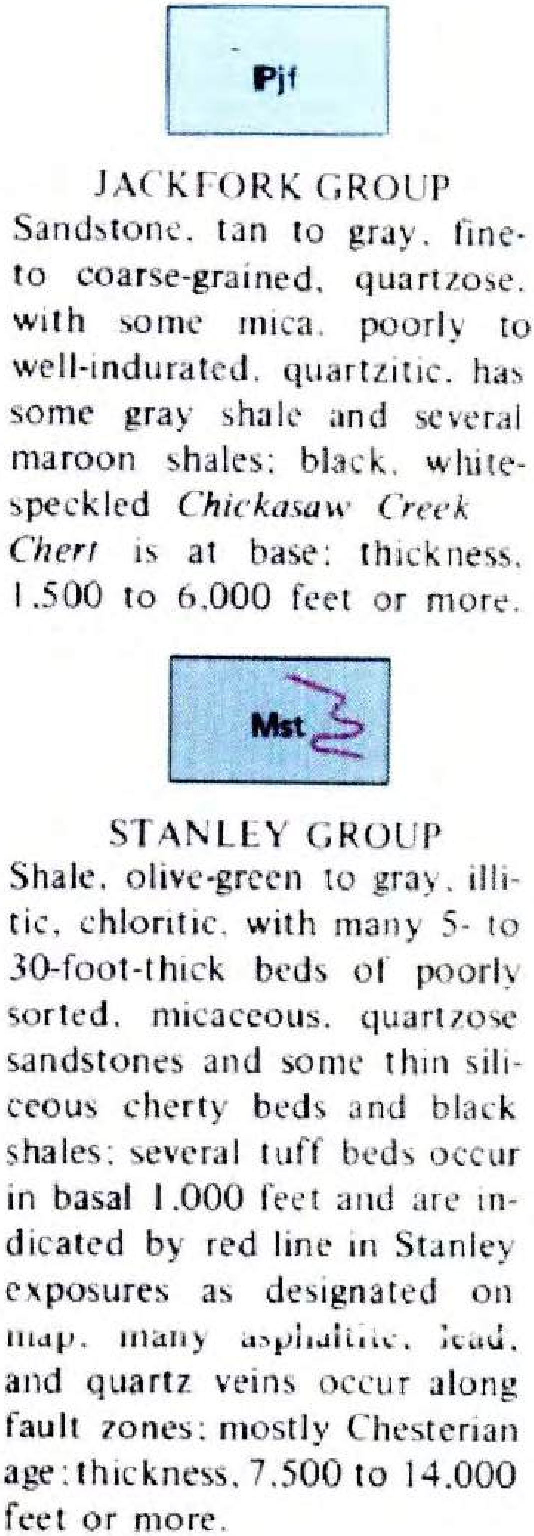


Figure 6. Part of the geologic map of Pushmataha County and surrounding areas by Marcher and Bergman (1983), with the approximate areas of the proposed upper and lower reservoirs shown by superimposed black lines.


Pjf

JACKFORK GROUP
Sandstone, tan to gray, fine- to coarse-grained, quartzose, with some mica, poorly to well-indurated, quartzitic, has some gray shale and several maroon shales; black, white-speckled *Chickasaw Creek Chert* is at base; thickness, 1,500 to 6,000 feet or more.

Mst

STANLEY GROUP
Shale, olive-green to gray, illitic, chloritic, with many 5- to 30-foot-thick beds of poorly sorted, micaceous, quartzose sandstones and some thin siliceous cherty beds and black shales; several tuff beds occur in basal 1,000 feet and are indicated by red line in Stanley exposures as designated on map. many asphaltic, lead, and quartz veins occur along fault zones; mostly Chesterian age; thickness, 7,500 to 14,000 feet or more.

Figure 7. Geologic descriptions of the Stanley Group and Jackfork Group (from Marcher and Bergman, 1983).

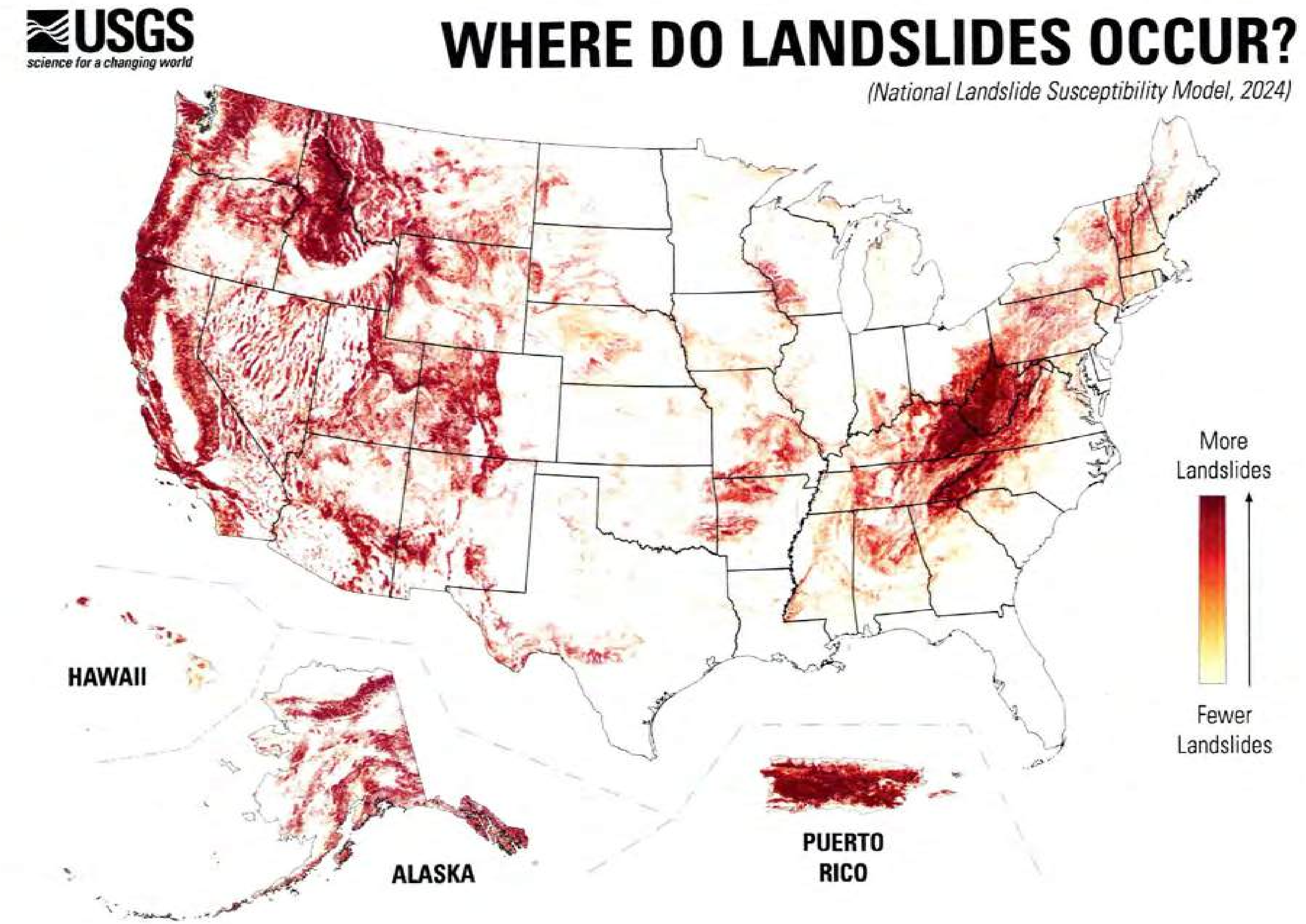


Figure 8. Map of landslide susceptibility in the United States (from U.S. Geological Survey, 2024a).

Figure 9. Enlargement of part of the map of landslide susceptibility shown on Figure 9, with the general area of the proposed Pushmataha County Pumped Storage Hydroelectric Project shown by the black circle. Areas of dark red denote greatest landslide susceptibility (from U.S. Geological Survey, 2024a).

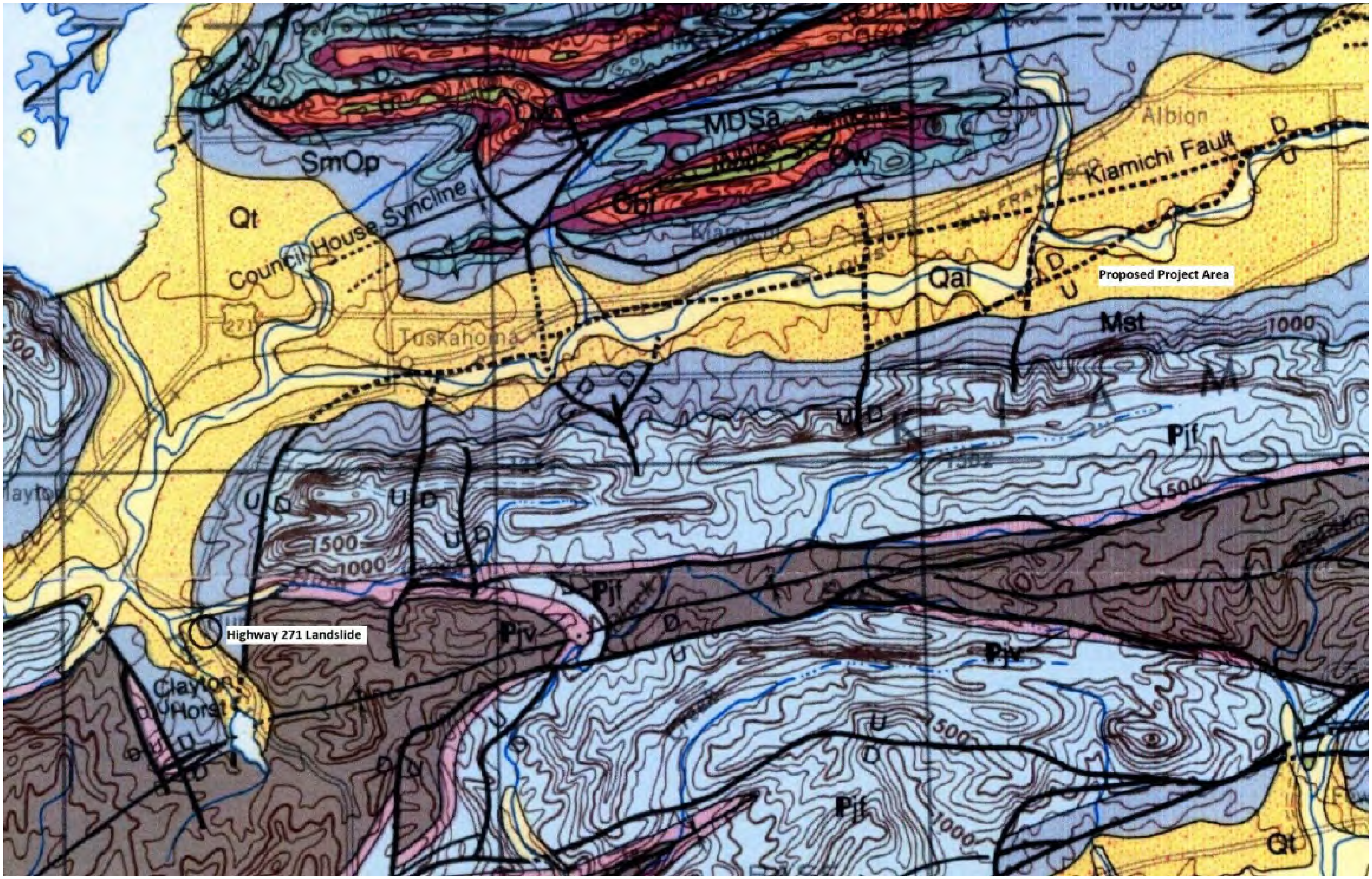


Figure 10. Part of the geologic map of Pushmataha County and surrounding areas by Marcher and Bergman (1983), with the area of the landslide along U.S. Highway 271 described by Nevels (2010) shown by the small black circle in the lower left-hand part of the figure. The area of the proposed Project is south of the town of Albion and the Kiamichi River in the upper right.

Figure 11. Google Earth image, looking southward, of a recent slope failure within the proposed site of the Pushmataha County Pumped Storage Hydroelectric Project, about 1½ miles south of the Kiamichi River and about 3½ miles south of the town of Albion. The failed slope is about 80 feet wide, from west to east, and about 180 feet long.

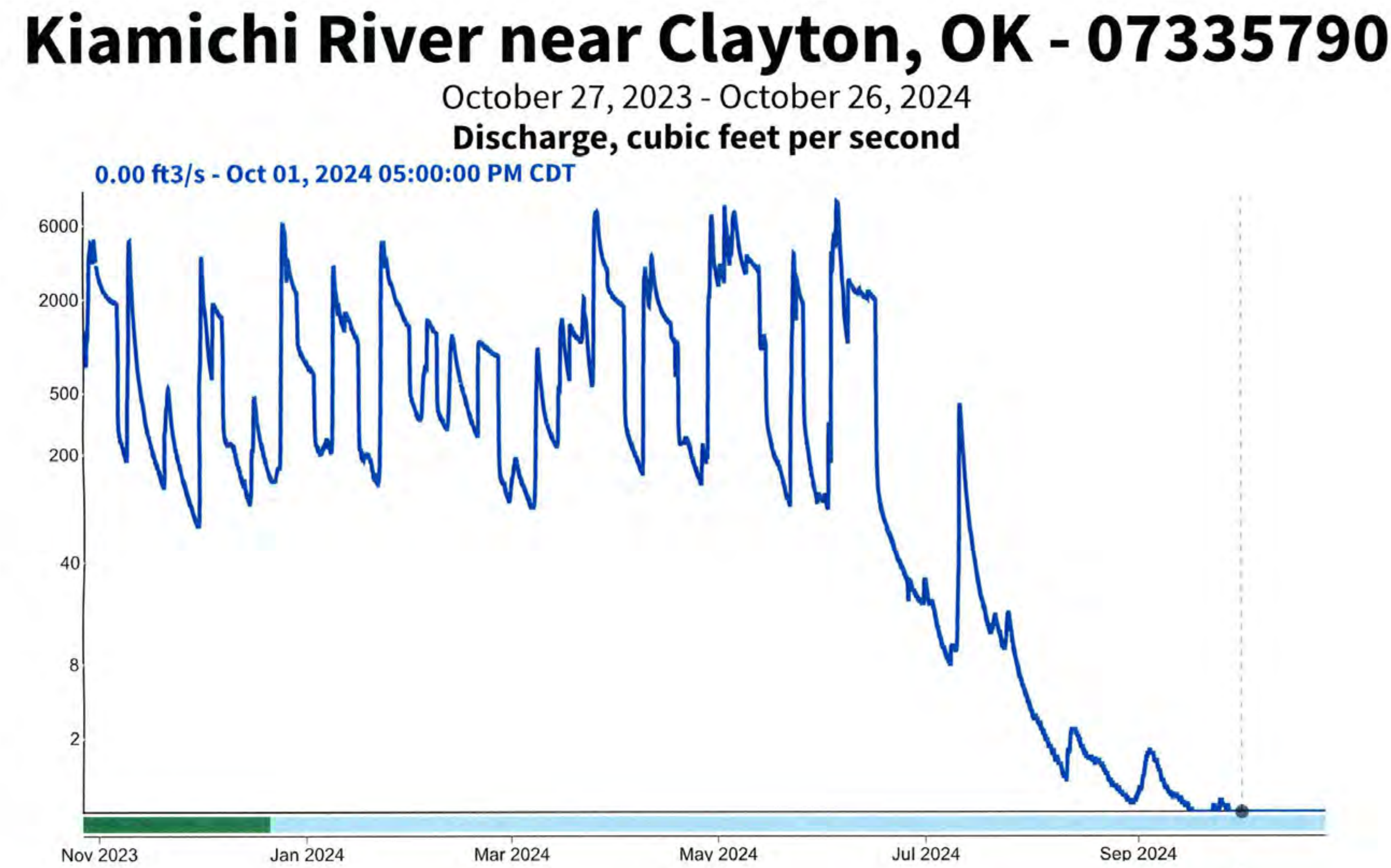


Figure 12. Hydrograph of discharge vs. time for the Kiamichi River near Clayton, Oklahoma (from U.S. Geological Survey, 2024b). Note that the discharge was zero in October 2024.

Arden D. Davis

Arden Davis received a B.A. degree in geology from the University of Minnesota and M.S. and Ph.D. degrees in geological engineering from South Dakota School of Mines and Technology. Dr. Davis currently is Professor Emeritus in the Department of Geology and Geological Engineering at South Dakota School of Mines and Technology. Since 1982 he has served as Instructor, Assistant Professor, Associate Professor, Professor, and Chairman of the Department of Geology and Geological Engineering. During that time he worked on modeling of ground-water flow as well as transport and dispersion of subsurface contaminants. He taught courses in ground water, digital modeling of ground-water flow and contaminant transport, ground-water geochemistry, analytical methods in ground water, engineering and environmental geology, and geological engineering design.

Dr. Davis is a Registered Professional Engineer in South Dakota. He has served as associate editor and reviewer for the journal of Ground Water, and as a book reviewer for the Bulletin of the Association of Engineering Geologists. He also was chairman of the Council of Education and the Accreditation and Curricular Issues Committee of the Society for Mining, Metallurgy, and Exploration. From 2002 to 2007, Dr. Davis served on the Engineering Accreditation Commission of ABET. In 2007, he was appointed to the ABET Board of Directors and served a three-year term. In 2010, he was re-appointed to the ABET Board of Directors for a second three-year term.

During his career at South Dakota School of Mines and Technology, Dr. Davis worked extensively on ground-water projects and geological engineering site evaluations. He has been an investigator in more than fifty funded research projects. He also has given technical assistance to the South Dakota Department of Environment and Natural Resources in the review of mining plans and ground-water contamination problems, including Superfund sites. He and his co-researchers hold a U.S. patent for removal of arsenic from water, and they have applied for a second patent for removal of metals from water. As a consultant he has provided expert witness testimony in cases involving water quality, environmental contamination, disposal of waste, and slope stability. He gave expert witness testimony in regard to the Bakken Pipeline in Wyoming, the TransCanada Keystone Pipeline in eastern South Dakota, and the Keystone XL Pipeline in western South Dakota.

In his service to South Dakota School of Mines and Technology, Dr. Davis has acted as Geological Engineering Program Coordinator and ABET Coordinator for geological engineering accreditation. This included revision of the geological engineering curriculum, origination and teaching of new engineering design courses, and preparation of ABET reports. He also is active in ground-water protection efforts, and in 1998 received the Virginia Simpson Award for community service in the area of environmental protection. In 2007, he received the Ennenga Award for Excellence in Teaching. In 2014 he received the Ivan Rahn Education Award from SME, and in 2015 he was given the Distinguished Service Award of the Environmental Division of SME. South Dakota School of Mines and Technology presented him with the Presidential Award for Outstanding Professor in 2015.

Arden D. Davis

Academic rank:	Professor Emeritus of Geological Engineering

Education:	B.A. - 1971	University of Minnesota (Geology)
	M.S. - 1979	South Dakota School of Mines and Technology (Geological Engineering)
	Ph.D. - 1983	South Dakota School of Mines and Technology (Geological Engineering)

Registered Professional Engineer (South Dakota; No. 4663)

Experience:	2015 - present	Professor Emeritus
	2006 - 2015	Professor
	2002 - 2006	Chairman Dept. of Geology and Geological Engineering S.D. School of Mines and Technology
	1995 - 2002	Professor S.D. School of Mines and Technology
	1989 - 1994	Associate Professor S.D. School of Mines and Technology
	1984 - 1989	Assistant Professor S.D. School of Mines and Technology
	1982	Instructor
	1976-1982	Teaching and Research Assistant
	1978	Shell Development (Shell Oil Company)

Teaching: Digital Modeling of Ground-Water Flow Systems, Ground Water, Ground-Water Geochemistry, Geochemistry, Analytical Methods in Ground Water, Advanced Ground Water, Engineering and Environmental Geology, Engineering Field Geology, Geological Engineering Design Project I

Consulting: Ground-water hydrologist and geological engineering consultant for numerous projects over past thirty years involving ground-water contamination, aquifer evaluation, slope stability, pipeline routing, low-level radioactive waste site evaluation, spring-flow measurements, and mine site development.

Funded research: Projects involving ground-water contamination, ground-water resource evaluation, aquifer vulnerability, water quality, and mine waste.

Community service: Ground-water protection efforts (see following pages).

Theses: Fifty two M.S. theses and twelve Ph.D. dissertations supervised.

Consulting:

2024	Slope stability; water resources
2022	Slope stability; engineering accreditation
2021	Water supply; aquifer suitability; engineering accreditation
2020	Water supply; drilling depths; suitability of geologic material for aggregate
2019	Water supply; well locations
2018	Water supply; routing of pipeline
2017	Routing of pipeline
2016	Water rights application
2015	Siting of pipeline; expert witness testimony; water rights application
2014	Spring discharges
2013	Spring discharges
2012	Expert witness testimony – proposed pipeline
2011	Spring discharges
2010	Madison aquifer well for municipal water supply.
2009	Expert witness testimony: springs and potential effects of nearby wells.
2008	Ground-water model for permit application.
2007	Siting of new Madison wells for public water supplies in the Black Hills.
2006	Modeling of ground-water flow and biodegradation of benzene.
2005	Modeling of ground-water flow and gasoline contamination.
2004	Ethylene dibromide contamination; expert witness.
2003	Alliance of Architects and Engineers; expert witness.
2002	Alliance of Architects and Engineers; expert witness.
2001	Consolidated Engineers & Materials Testing; GeoTek; expert witness.
2000	Hillcrest Spring Water; Rapid City Landfill; expert witness.
1999	Boyd County LLW Monitoring Committee; Gill Landfill modeling.
1998	Boyd County LLW Monitoring Committee; Rapid City Landfill.
1997	Boyd County LLW Monitoring Committee; Terra, Inc., modeling.
1996	Terra, Inc., modeling; Boyd County LLW Monitoring Committee.
1995	Terra, Inc.; modeling for City of Ida Grove, Iowa; Vogel Paint and Wax.
1994	Keystone Gold Project, Keystone, South Dakota. Dunbar Resort: proposed railroad grade, Deadwood, South Dakota. Vogel Paint and Wax Superfund Site, Maurice, Iowa.
1993	Keystone Gold Project, Keystone, South Dakota. Vogel Paint and Wax Superfund Site, Maurice, Iowa. Low-level radioactive waste site evaluation and modeling.
1992	City of Rapid City: criteria for private wastewater disposal facilities. Nitrate contamination from mine waste.
1991	Corrosion problems during geothermal heating.
1990	Low-level radioactive waste site evaluation. South Dakota Department of Environment and Natural Resources: cyanide contamination.
1989	Wastewater facility site evaluation. South Dakota Department of Environment and Natural Resources: review of mine plan, northern Black Hills.

1988 Expert witness testimony: gasoline contamination of ground water.
1987 South Dakota Department of Environment and Natural Resources: modeling of gasoline contamination.
Utility Engineering Company: aquifer test evaluation.
Gasoline contamination of ground water.
1986 South Dakota Department of Environment and Natural Resources.
1985 South Dakota Department of Environment and Natural Resources: ground-water contamination.
1983 Rosebud Sioux Tribe: aquifer evaluation.
1981 Save Wyoming Water: drawdown calculations.
South Dakota Public Utilities Commission: aquifer evaluation.
1981 Evans Plunge, Hot Springs, South Dakota: spring discharges.
1979 U.S. Environmental Protection Agency; Engineering Science, Inc.

Community Service:

Assisted City of Rapid City and Pennington County in determining aquifer vulnerability in the Rapid City area. Assisted U.S. Environmental Protection Agency and South Dakota Department of Environment and Natural Resources as member of Technical Advisory Team, Gilt Edge Superfund Site.

Selected Publications:

Davis, A.D., 1986, Deterministic modeling of dispersion in heterogeneous permeable media: Ground Water, v. 24, no. 5, p. 609-615.

Davis, A.D., 1987, Determination of mean transmissivity values in the modeling of ground water flow, in Proceedings of International Conference on Solving Ground Water Problems with Models: National Ground Water Association, Dublin, Ohio, p. 1162-1174.

Davis, A.D., and Riding, D.R., 1989, A three-dimensional model of ground-water flow in the Madison aquifer at Annie Creek mine, northern Black Hills, South Dakota, in Proceedings of International Conference on Solving Ground Water Problems with Models: National Ground Water Association, Dublin, Ohio, p. 409-423.

Rizk, Z.S., and Davis, A.D., 1991, Impact of the proposed Qattara Reservoir on the Moghra aquifer of northwestern Egypt: Ground Water, v. 29, no. 2, p. 232-238.

Davis, A.D., 1992, Review of "Finite Element Techniques in Ground Water Flow Studies," in Bulletin of the Association of Engineering Geologists, v. 29, no. 4, p. 431-432.

Davis, A.D., 1994, Education of future ground-water professionals: Ground Water, v. 32, no. 5, p. 706-707.

Rahn, P.H., Davis, A.D., Webb, C.J., and Nichols, A.D., 1996, Water quality impacts from mining in the Black Hills, South Dakota, USA: Environmental Geology, v. 27, no. 1, p. 38-53.

Rahn, P.H., and Davis, A.D., 1996, An educational and research well field: Journal of Geoscience Education, v. 44, p. 506-517.

Rahn, P.H., and Davis, A.D., 1996, Gypsum foundation problems in the Black Hills area, South Dakota: Environmental and Engineering Geoscience, v. II, no. 2, p. 213-223.

Davis, A.D., Heriba, A., and Webb, C.J., 1996, Prediction of nitrate concentrations in effluent from spent ore: Mining Engineering, v. 48, no. 2, p. 79-83.

Davis, A.D., and Zabolotney, G.A., 1996, Ground-water flow simulations for the determination of post-mining recharge rates at the Belle Ayr Mine: Mining Engineering, v. 48, no. 11, p. 80-83.

Davis, A.D., and Rahn, P.H., 1997, Karstic gypsum problems at wastewater stabilization sites in the Black Hills of South Dakota: Carbonates and Evaporites, v. 12, no. 1, p. 73-80.

Webb, C.J., Davis, A.D., and Paterson, C.J., 1998, Comprehensive inventory of known abandoned mine lands in the Black Hills of South Dakota: Mining Engineering, v. 50, no. 7, p. 84-86.

Davis, A.D., Webb, C.J., and Durkin, T.V., 1999, A watershed approach to evaluating impacts of abandoned mines in the Bear Butte Creek basin of the Black Hills: Mining Engineering, v. 51, no. 9, p. 49-56.

Davis, A.D., Long, A.J., and Wireman, M., 2000, Sensitivity of the Madison aquifer to contamination in the Rapid City area of the Black Hills, in Strobel, M.L., and Davis, A.D., eds., Hydrology of the Black Hills: South Dakota School of Mines and Technology Bulletin No. 20, p. 12-19.

Davis, A.D., Capehart, W.J., Hjelmfelt, M.R., Kenner, S.J., Johnson, C.S., and Naus, C.A., 2000, Coupling of a ground-water model to atmospheric and surface-water models in the complex terrain of the Black Hills, in Strobel, M.L., and Davis, A.D., eds., Hydrology of the Black Hills: South Dakota School of Mines and Technology Bulletin No. 20, p. 65-72.

Davis, A.D., Long, A.J., and Wireman, M., 2002, KARSTIC: a sensitivity method for carbonate aquifers in karst terrain: Environmental Geology and Water Science, v. 42, no. 1, p. 65-72.

Davis, A.D., and Webb, C.J., and Beaver, F.W., 2003, Hydrology of the proposed National Underground Science Laboratory at the Homestake Mine in Lead, South Dakota: Preprint 03-59, Society for Mining, Metallurgy, and Exploration, Littleton, Colorado.

Webb, C.J., Davis, A.D., and Johnson, C.S., Environmental evaluation of the Belle Eldridge Mine near Deadwood, South Dakota: Mining Engineering.

Davis, A.D., Beaver, F.W., and Stetler, L.D., 2003, Engineering problems of gypsum karst along the Interstate 90 development corridor in the Black Hills of South Dakota, in Johnson, K., and Neal, J., eds., Evaporite Karst and Engineering Problems in the United States: Oklahoma Geological Survey Circular 109, p. 255-261.

Webb, C.J., and Davis, A.D., 2003, Arsenic remediation of drinking water using modified limestone: ACS Paper 726161, American Chemical Society.

Davis, A.D., Webb, C.J., and Nelson, K.C., 2004, Acid rock drainage and the potential for impacts at selected abandoned mine sites in the Black Hills National Forest: Preprint 04-49, Society for Mining, Metallurgy, and Exploration, Littleton, Colorado, 3 p.

Davis, A.D., and Webb, C.J., 2005, Progress toward a National Underground Science and Engineering Laboratory at the Homestake Mine in Lead, South Dakota: Preprint 05-33, Society for Mining, Metallurgy, and Exploration, Littleton, Colorado, 3 p.

Miller, S.L., Kenner, S.J., Davis, A.D., and Silva, A.J., 2005, Characterization of naturally occurring acid rock drainage and impacts to the North Forks of Rapid Creek and Castle Creek in the Black Hills near Rochford, South Dakota: Proceedings, South Dakota Academy of Science, v. 83, p. 83-89.

Davis, A.D., and Webb, C.J., Progress toward a Deep Underground Science and Engineering Laboratory at the Homestake Mine in Lead, South Dakota: Mining Engineering.

Miller, S.L., Davis, A.D., and Lisenbee, A.L., 2005, Vulnerability (risk) mapping of the Madison aquifer near Rapid City, South Dakota (abstract), in Kuniansky, E.L., ed., U.S. Geological Survey Karst Interest Group Proceedings: U.S. Geological Survey Scientific Investigations Report 2005-5160, p. 163.

Stetler, L.D., and Davis, A.D., 2005, Gypsum and carbonate karst along the I-90 development corridor, Black Hills, South Dakota (abstract), in Kuniansky, E.L., ed., U.S. Geological Survey Karst Interest Group Proceedings: U.S. Geological Survey Scientific Investigations Report 2005-5160, p. 134.

Epstein, J.B., Davis, A.D., Long, A.J., Putnam, L.D., and Sawyer, J.F., 2005, Field Trip Guide 2, Karst features of the northern Black Hills, South Dakota and Wyoming, in Kuniansky, E.L., ed., U.S. Geological Survey Karst Interest Group Proceedings: U.S. Geological Survey Scientific Investigations Report 2005-5160, p. 232-282.

Davis, A.D., Webb, C.J., Dixon, D.J., Sorensen, J.L., and Dawadi, S., 2006, Arsenic removal from drinking water by limestone-based material: Preprint 06-034, Society for Mining, Metallurgy, and Exploration, Littleton, Colorado, 3 p.

Davis, A.D., Webb, C.J., Dixon, D.J., Sorensen, J.L., and Dawadi, S., 2007, Arsenic removal from drinking water by limestone-based material: Mining Engineering, v. 59, no. 2, p. 71-74.

Davis, A.D., Webb, C.J., and Sorensen, J.L., 2007, Environmental reclamation and monitoring of the abandoned Belle Eldridge Mine near Deadwood, South Dakota: Preprint 07-39, Society for Mining, Metallurgy, and Exploration, Littleton, Colorado, 3 p.

Webb, C.J., Campbell, C., Davis, A.D., Dawadi, S., Dixon, D.J., and Sorensen, J.L., 2006, Arsenic remediation of drinking water using limestone-based material: American Chemical Society, Division of Environmental Chemistry, ACS Symposia Paper 941321.

Davis, A.D., 2006, Case 4: Geological engineer, in Baura, G.D., Engineering ethics: an industrial perspective, Chapter 16, Case studies: Elsevier Academic Press, Burlington, Massachusetts, 220 p.

Davis, A.D., Webb, C.J., Dixon, D.J., Sorensen, J.L., and Dawadi, S., 2007, Arsenic removal from drinking water by limestone-based material: Mining Engineering, v. 59, no. 2, p. 71-74.

Davis, A.D., Webb, C.J., Sorensen, J.L., and Valder, J.F., 2007, Environmental monitoring of the abandoned Belle Eldridge Mine near Deadwood, South Dakota: Preprint 07-39, Society for Mining, Metallurgy, and Exploration, Littleton, Colorado, 3 p.

Chintalapati, P.K., Davis, A.D., Hansen, M.R., Sorensen, J.L., and Dixon, D.J., 2009, Encapsulation of limestone waste in concrete after arsenic removal from drinking water: Environmental Earth Science, v. 59, no. 1, p. 185-190.

Davis, A.D., Roggenthen, W.M., Stetler, L.D., Hladysz, Z., and Johnson, C.S., 2009, Post-closure flooding of the Homestake Mine at Lead, South Dakota: Mining Engineering, v. 61, no. 3, p. 43-47.

Davis, A.D., Dixon, D.J., and Webb, C.J., 2010, Arsenic in water from mine workings and wells of the Keystone area in the Black Hills of South Dakota: Preprint 10-020, Society for Mining, Metallurgy, and Exploration, Littleton, Colorado, 5 p.

Davis, A.D., Dixon, D.J., Webb, C.J., and Betemariam, H., 2010, Removal of arsenic and heavy metals from mine drainage and ground water in the Black Hills of South Dakota: Manuscript TP-10-039, Society for Mining, Metallurgy, and Exploration, Littleton, Colorado, 4 p.

Davis, A.D., and Elifrits, C.D., 2010, The importance of ABET engineering accreditation to SME: Mining Engineering, v. 62, no. 5, p. 77.

Davis, A.D., Dixon, D.J., Webb, C.J., and Betemariam, H., 2011, Removal of arsenic and heavy metals from mine drainage and ground water in the Black Hills of South Dakota: Technical Paper 11-022, Society for Mining, Metallurgy, and Exploration, Littleton, Colorado, 4 p.

Valder, J.F., Long, A.J., Davis, A.D., and Kenner, S.J., 2012, Multivariate statistical approach to estimate mixing proportions for unknown end members: Journal of Hydrology, v. 460-461, p. 65-76.

Davis, A.D., Webb, C.J., Sorensen, J.L., Dixon, D.J., and Betemariam, H., 2013, Laboratory testing of arsenic and heavy metals removal from mine drainage and ground water in the Black Hills of South Dakota: Environmental Earth Sciences, DOI 10.1007/s12665-013-2956-0, Springer, published online 06 December 2013.

Davis, A.D., Webb, C.J., Sorensen, J.L., and Dixon, D.J., Thermodynamic constraints on arsenic and heavy metals removal from water with limestone-based material: Technical paper13-035, Society for Mining, Metallurgy, and Exploration, Littleton, Colorado, 4 p.

Betemariam, H., Stone, J.J., McCutcheon, C., Penn, M.R., DeSutter, T., Davis, A.D., and Stetler, L.D., 2013, Geochemical behavior and watershed influences associated with sediment-bound mercury for South Dakota lakes and impoundments: Journal of Water, Air, and Soul Pollution, v. 224, no. 4.

Davis, A.D., Webb, C.J., Sorensen, J.L., Dixon, D.J., and Betemariam, H., 2014, Laboratory testing of arsenic and heavy metals removal from mine drainage and ground water in the Black Hills of South Dakota: Environmental Earth Sciences, v. 72, no. 2, p. 355-361 (previously published online by Springer, 06 December 2013).

Webb, C.J., and Davis, A.D., 2017, Remediation of arsenic in drinking water (Chapter 3), in States, J.C., ed., Arsenic: Exposure Sources, Health Risks and Mechanisms of Toxicity: John Wiley and Sons.

Rahn, P.H., Detwiler, A.G., and Davis, A.D., 2017, Tritium in groundwater in the Black Hills of South Dakota: Environmental Earth Sciences, 76: 762. https://doi.org/10.1007/s12665-017-7082-y

Davis, A.D., Webb, C.J., Sorensen, J.L., and Dixon, D.J., 2018, Thermodynamic constraints on limestone-based arsenic removal from water: Environmental Earth Sciences, 77:33, 7 p.
https://doi.org/10.1007/s12665-017-7204-6

Davis, A.D., Webb, C.J., Sorensen, J.L., Dixon, D.J., and Hudson, R., 2018, Geochemical thermodynamics of cadmium removal from water with limestone: Environmental Earth Sciences, 77:37, 5 p.
https://doi.org/10.1007/s12665-017-7205-5

Davis, A.D., Webb, C.J., Sorensen, J.L., Dixon, D.J., and Hudson, R., 2018, Geochemical thermodynamics of lead removal from water with limestone: Water, Air, and Soil Pollution, 229:177, 7 p.
https://doi.org/10.1007/s11270-018-3824-z

Li, L., Stetler, L., Cao, Z., and Davis, A., 2018, An iterative normal-score ensemble smoother for dealing with non-Gaussianity in data assimilation: Journal of Hydrology, v. 567, p. 759-766. doi.org/10.1016/j.jhydrol.2018.01.038
https://doi.org/10.1016/j.jhydrol.2018.01.038

Li, L., Puzel, R., and Davis, A., 2018, Data assimilation in groundwater modeling: ensemble Kalman filter versus ensemble smoothers: Hydrological Processes, v. 32, no. 13, p. 2020-2029. doi.org/10.1002/hyp.13127
https://doi.org/10.1002/hyp.13127

Bao, J., Li, L., and Davis, A., 2022, Variational autoencoder or generative adversarial networks? A comparison of two deep learning methods for flow and transport data assimilation: Mathematical Geosciences, v. 54, no. 6, p. 1017-1042.
https://doi.org/10.1007/s11004-022-10003-3

Li, L., and Davis, A.D., 2022, Teaching groundwater flow and contaminant transport modeling via a sand-tank model: Mathematical Geosciences, published online.
https://doi.org/10.1007/s11004-022-10012-2

Selected Presentations:

Rahn, P.H., and Davis, A.D., 1991, Hydrogeology of a proposed low-level radioactive waste disposal site near Butte, Nebraska: Association of Engineering Geologists, Proceedings of 34th Annual Meeting, Chicago, Illinois.

Wang, J., Hjelmfelt, M.R., Capehart, W.J., Kenner, S.J., and Davis, A.D., 1998, Coupled atmospheric-hydrologic numerical simulation of a flash flood event: Part 1. Atmospheric simulation: American Meteorological Society, Hydrology Conference, Phoenix, Arizona.

Davis, A.D., and Long, A.J., 1998, Ground-water issues in the coupling of a subsurface flow model to atmospheric and surface-water models in complex terrain: GEWEX Continental-Scale International Project, Annual Meeting, St. Louis, Missouri.

Davis, A.D., Webb, C.J., and Nelson, K.C., 2004, Acid rock drainage and the potential for impacts at selected abandoned mine sites in the Black Hills National Forest. Presented at 2004 SME Annual Meeting, Denver, Colorado.

Webb, C.J., and Davis, A.D., Arsenic remediation of drinking water using modified limestone: American Chemical Society, Anaheim, California.

Miller, S.L., Davis, A.D., and Lisenbee, A.L., Long, A.J., Putnam, L.D., Lester, J.D., and Hargrave, R.G., 2004, Vulnerability mapping of the Madison aquifer near Rapid City area, South Dakota: Western South Dakota Hydrology Conference, Rapid City, South Dakota, April, 2004.

Lisenbee, A.L., Davis, A.D., Paterson, C.J., Stetler, L.D., Miller, S.L., and Hargrave, R.G., 2004, Geologic atlas of the Rapid City West 7.5-minute quadrangle: Western South Dakota Hydrology Conference, Rapid City, South Dakota, April, 2004.

Davis, A.D., and Webb, C.J., 2005, Progress toward a National Underground Science and Engineering Laboratory at the Homestake Mine in Lead, South Dakota: Annual Meeting, Society for Mining, Metallurgy, and Exploration, Salt Lake City, Utah, February, 2005.

Davis, A.D., Webb, C.J., Dixon, D.J., and Sorensen, J.L., 2006, Arsenic removal from drinking water by limestone-based material: SME Annual Meeting, Technical Program: Limestone – Nature's Miracle Rock; March, 2006, St. Louis, Missouri.

Davis, A.D., 2006, Modeling of natural biodegradation of gasoline contamination at a site in eastern South Dakota: Presented at 18th Annual Environmental and Ground Water Quality Conference, March, 2006, Pierre, South Dakota.

Sorensen, J.L., Davis, A.D., Dixon, D.J., and Webb, C.J., 2006, Development of an agglomeration process to increase the efficiency of limestone-based material for removing metals from drinking water: Presented at 18th Annual South Dakota Ground-Water Quality Conference, March, 2006, Pierre, South Dakota.

Sorensen, J.L., Davis, A.D., Dixon, D.J., and Webb, C.J., Controlling factors on arsenic removal from water by limestone-based material: Western South Dakota Hydrology Conference, April, 2006, Rapid City, South Dakota.

Webb, C.J., Campbell, C., Davis, A.D., Dawadi, S., Dixon, D.J., and Sorensen, J.L., 2006, Arsenic remediation of drinking water using limestone-based material: American Chemical Society, Division of Environmental Chemistry, Symposium on Current Status of Research on Arsenic Remediation, 231st National Meeting, March 26-30, Atlanta, Georgia.

Davis, A.D., Dixon, D.J., and Sorensen, J.L., 2006, Fixed-bed adsorption column studies and engineering scale-up design of a limestone-based metals removal technology: Eastern South Dakota Water Conference, Brookings, South Dakota, November, 2006.

Valder, J.F., and Davis, A.D., 2006, Pumping test and assessment of the Deadwood aquifer at Jewel Cave National Monument, Custer County, South Dakota: Geological Society of America, Annual Meeting, October, 2006, Philadelphia, Pennsylvania.

Hocking, C.M., Lisenbee, A.L., and Davis, A.D., 2007, Vulnerability of the Madison aquifer, Hayward quadrangle, South Dakota: Western South Dakota Hydrology Conference, April 19, 2007, Rapid City, South Dakota.

Johnson, D., Lisenbee, A.L., and Davis, A.D., 2007, Aquifer characteristics of Precambrian basement rocks in the Pactola Dam quadrangle, South Dakota: Western South Dakota Hydrology Conference, April 19, 2007, Rapid City, South Dakota.

Lisenbee, A.L., Francisco, E.M., Davis, A.D., and Pellowski, C., 2007, Vulnerability of the Inyan Kara aquifer, Hermosa and Hermosa NW quadrangles, Black Hills Development Corridor: Western South Dakota Hydrology Conference, April 19, 2007, Rapid City, South Dakota.

Francisco, E.M., Lisenbee, A.L., and Davis, A.D., 2007, Aquifer vulnerability in the Blackhawk quadrangle, South Dakota: Western South Dakota Hydrology Conference, April 19, 2007, Rapid City, South Dakota.

Davis, A.D., Webb, C.J., Sorensen, J.L., and Valder, J.F., 2007, Environmental monitoring of the abandoned Belle Eldridge Mine near Deadwood, South Dakota: Western South Dakota Hydrology Conference, April 19, 2007, Rapid City, South Dakota.

Valder, J.F., and Davis, A.D., 2007, Pumping tests in the Deadwood aquifer at Jewel Cave National Monument, Custer County, South Dakota: Western South Dakota Hydrology Conference, April 19, 2007, Rapid City, South Dakota.

Davis, A.D., and Elifrits, C.D., 2011, ABET Geological Engineering and Mining Engineering Criteria Training: Society for Mining, Metallurgy, and Exploration, February 26, 2011, Denver, Colorado.

Davis, A.D., Webb, C.J., Sorensen, J.L., and Dixon, D.J., 2013, Thermodynamic constraints on arsenic and heavy-metals removal from water with limestone-based material: Annual Meeting, Society for Mining, Metallurgy and Exploration, Denver, Colorado, February, 2013.

Davis, A.D., Lisenbee, A.L., Price, M.H., Aurand, A., Bednar, J., and Tekle, M., 2013, Water-quality sampling of Precambrian crystalline aquifers in the central Black Hills: Western South Dakota Hydrology Conference, Rapid City, South Dakota, April 18, 2013.

Davis, A.D., and Elifrits, C.D., The importance of ABET engineering accreditation to SME: Presented to the SME Board of Directors, February, 2013.

Davis, A.D., Elifrits, C.D., Keaton, J.R., and Sweigard, R., SME Program Evaluator Training: Presented to geological engineering and mining engineering program evaluators, SME Annual Meeting, Denver, Colorado, February, 2013.

Davis, A.D., Lisenbee, A.L., and Price, M.H., Smith, G.R., Walega, E.A., and Tiruneh, H.W., Groundwater quality in Precambrian crystalline aquifers of the central Black Hills: Western South Dakota Hydrology Conference, Rapid City, South Dakota, April, 2014.

Davis, A.D., Groundwater resources and potential issues in northwestern South Dakota: New Horizons Oil and Gas Conference, Rapid City, South Dakota, April, 2014.

Davis, A.D., Elifrits, C.D., Skaggs, G.L., and Sweigard, R., SME Program Evaluator Training: Presented to geological engineering and mining engineering program evaluators, SME Annual Meeting, Denver, Colorado, February, 2014.

U.S. Patent:

Webb, Cathleen Joyce, Arden Duane Davis, and David John Dixon, "Method and composition to reduce the amounts of arsenic in water," United States Patent 7,790,653, 7 September 2010.

Application for U.S. Patent:

Webb, Cathleen Joyce, Arden Duane Davis, and David John Dixon, "Method and composition to reduce the amounts of heavy metal in water," United States Patent and Trademark Office, Provisional application for patent, SDSM-1064434, Serial no. 61/393,806.

Related research:

Grainger Prize for Sustainability: HydroTech Engineering and Rohm & Haas (collaboration): Limestone-based arsenic-removal method; selected for Round II of competition.

Recent Research Funding:

National Science Foundation: SGER: Characterization of the Precambrian Aquifer at the Homestake DUSEL: Dr. Larry D. Stetler, Dr. Arden D. Davis, and Dr. Rohit Salve (Lawrence Berkeley Laboratory), $75,000.

U.S. Geological Survey 104b Grant Program / South Dakota Water Resources Institute: Acidic Leaching Tests to Determine Arsenic Mobility from Concrete-Encapsulated Limestone Waste: Dr. Arden D. Davis, Dr. M.R. Hansen, and Dr. David J. Dixon, $12,131.

U.S. Geological Survey 104b Grant Program / South Dakota Water Resources Institute: Investigation of Arsenic Removal from Water by Microbiologically Induced Calcite Precipitation: Dr. Arden D. Davis, Dr. Sookie S. Bang, and Dr. David J. Dixon, $13,983.

U.S. Bureau of Land Management: Belle Eldridge Mine Sampling and Monitoring, Phase III, $4,500 (additional); Arden D. Davis, Principal Investigator.

U.S. Geological Survey 104b Grant Program / South Dakota Water Resources Institute: Development of an agglomeration process to increase the efficiency of limestone-based material to remove metals from drinking water: Dr. Arden D. Davis and Dr. David J. Dixon, $10,897.

U.S. Geological Survey 104b Grant Program / South Dakota Water Resources Institute: Fixed-bed adsorption column studies and engineering scale-up design of a limestone-based metals removal technology for small water supply systems: Dr. Arden D. Davis and Dr. David J. Dixon, $12,918.

U.S. Geological Survey 104b Grant Program / South Dakota Water Resources Institute: Leaching tests for encapsulation of waste after arsenic removal from drinking water: Dr. Arden D. Davis, Dr. David J. Dixon, and Dr. M.R. Hansen; $11,873.

U.S. Department of the Interior, National Park Service; Jewel Cave Pumping Test; Dr. Arden D. Davis, Principal Investigator; $8,800.

U.S. Bureau of Land Management: Belle Eldridge Mine Sampling and Monitoring, Phase III, $4,500 (additional); Arden D. Davis, Principal Investigator.

West Dakota Water Development District: Determination of historic ground water pollution problems, Part II: Pactola Dam, Rapid City West, and the North One-Half of Rockerville quadrangles; $9,162; Dr. Alvis L. Lisenbee, Principal Investigator; Dr. Arden D. Davis, Co-Principal Investigator.

West Dakota Water Development District: Aquifer susceptibility study of the Pactola Dam quadrangle, South Dakota: Part II – Precambrian: $9,112; Dr. Alvis L. Lisenbee, Principal Investigator; Dr. Arden D. Davis, Co-Principal Investigator.

West Dakota Water Development District: Aquifer mapping (1:24,000) of the Hermosa NW quadrangle; $13,538; Dr. Alvis L. Lisenbee, Principal Investigator; Dr. Arden D. Davis and Dr. Larry Dr. Stetler, Co-Principal Investigators.

West Dakota Water Development District: Preliminary aquifer vulnerability and susceptibility study of the Blackhawk quadrangle; $15,988; Dr. Alvis Lisenbee, Principal Investigator; Dr. Arden D. Davis, Co-Principal Investigator.

West Dakota Water Development District: Geologic mapping of the Mt. Rushmore quadrangle, South Dakota; $14,970; Dr. Alvis Lisenbee, Principal Investigator; Dr. Arden D. Davis, Co-Principal Investigator.

West Dakota Water Development District: Aquifer vulnerability study of the Rockerville quadrangle, South Dakota; $14,763; Dr. Alvis Lisenbee, Principal Investigator; Dr. Arden D. Davis, Co-Principal Investigator.

Phase I Small Business Innovation Research Grant, U.S. Environmental Protection Agency, Limestone-Based Material for Arsenic Removal from Drinking Water: Dr. Cathleen J. Webb, Dr. Arden D. Davis, Dr. David J. Dixon, and Dr. Terrence L. Williamson; $100,000.

Phase II Small Business Innovation Research Grant, U.S. Environmental Protection Agency, Limestone-Based Material for Arsenic Removal from Drinking Water: Dr. Cathleen J. Webb, Dr. Arden D. Davis, Dr. David J. Dixon, and Dr. Terrence L. Williamson; $225,000.

National Science Foundation, Statewide Partnership to Support Technology Innovation and Entrepreneurship in South Dakota (PFI), University of South Dakota: Arsenic Removal from Drinking Water; John C. Lofberg, Dr. Arden D. Davis, and Dr. David J. Dixon; $35,826.

West Dakota Water Development District: Crystalline Aquifers of the Central Black Hills, South Dakota: Phase IV: Dr. Alvis L. Lisenbee, Dr. Arden D. Davis, and Dr. Maribeth Price; $44,000.

West Dakota Water Development District: Crystalline Aquifers of the Central Black Hills, South Dakota: Phase III: Dr. Alvis L. Lisenbee, Dr. Arden D. Davis, and Dr. Maribeth Price; $41,000.

U.S. Geological Survey 104b Grant Program / South Dakota Water Resources Institute: Investigation of the Contribution of Coliform Contamination in Runoff from Scoured Bed Sediments: Dr. Jennifer L. Benning, Dr. Scott J. Kenner, and Dr. Arden Davis, $14,913.

West Dakota Water Development District: Crystalline Aquifers of the Central Black Hills, South Dakota: Phase II; Dr. Laurie Anderson, Principal Investigator; Dr. Alvis L. Lisenbee, Dr. Arden D. Davis, and Dr. Maribeth H. Price, Co-Principal Investigators; $33, 020.

Pete Lien and Sons, Inc: Optimization and characterization of iron-loaded limestone as a medium for the removal of arsenic from drinking water; Dr. Arden D. Davis, Principal Investigator; Dr. David J. Dixon, Co-Principal Investigator; $8,800.

City of Custer, South Dakota: Water Sampling of Crystalline and Alluvial Aquifers at Custer, South Dakota: Dr. Arden D. Davis, Principal Investigator; Dr. J. Foster Sawyer, Dr. Alvis L. Lisenbee, and Dr. Maribeth H. Price, Co-Principal Investigators; $25,000.

U.S. Department of the Interior, Bureau of Land Management: Environmental Monitoring of the Belle Eldridge Mine: Dr. Arden D. Davis, Principal Investigator; $5,000.

West Dakota Water Development District: Missouri River Water Allotment Study for Future Use Water Permit 1443-2; Dr. Alvis L. Lisenbee, Dr. Arden D. Davis, Dr. Kurt W. Katzenstein, and Dr. Scott J. Kenner, Co-Principal Investigators; $37,341.

Attachment 3

<u>Expert Report of Fred P. Ehat, P.E.</u>

I, Fred P. Ehat, hereby declare the following:

1. I submit this report in response to Southeast Oklahoma Power Corporation's (SEOPC) Filing of Notice of Intent to File an Application for an Original License and Pre-Application Document, and Request to be Designated as FERC's Non-Federal Representative for the Purposes of Informal Consultation under Section 106 and Section 7 for the Pushmataha County Pumped Storage Project (P-14890), eLibrary no. 20240507-5119 (May 7, 2024), as noticed by the Federal Energy Regulatory Commission (FERC or Commission) on July 8, 2024. *See* eLibrary no. 20240708-3054.

2. This report is organized as follows: Section I states my experience and qualifications; Section II states the documents I reviewed in preparing this report; Section III provides my comments on the project proposal described in the Pre-Application Document; Section IV states my conclusions and recommendations.

I. EXPERIENCE AND QUALIFICATIONS

1. My educational credentials include a Bachelor of Science in Civil Engineering, San Jose State University, 1976 and Master of Science in Construction/Soil Mechanics, San Jose State University, 1978.

2. I am a registered professional engineer with more than 40 years of experience in the design, management, and risk assessment for construction of large embankment dams, power and pumping facilities, tunnels and shafts. I also have extensive experience with performing safety of dam's quality reviews for the U.S. Army Corps of Engineer's risk-based evaluation system. I am experienced in performing constructability, schedule, cost estimate, construction and project management reviews. I am the recipient of U.S. Society on Dams' "Excellence in Constructed

Project" Award (2011) for Ridges Basin Dam, a member of the American Society of Civil Engineers, and a recipient of the U.S. Bureau of Reclamation's "John Keys Customer Collaboration Award" (2008 and 2009).

3. My curriculum vitae is provided as an attachment.

II. DOCUMENTS REVIEWED

4. In preparing this report, I reviewed the following documents:

a. SEOPC's Pre-Application Document (May 7, 2024) (PAD); and

b. Challenges in execution of Concrete Face Rock-Fill Dams In Emerging Economies, ICOLD Symposium on Sustainable Development of Dams and River Basins, 24th - 27th February 2021, New Delhi by S.C. Mittal, Imran Sayeed, U.V. Hegde and Senthil Raja.

c. FERC Taum Sauk Investigation Team. (2006). Report of Findings on the Overtopping and Embankment Breach of the Upper Dam – Taum Sauk Pumped Storage Project, FERC No. 2277.

III. COMMENTS

A. THE PAD IS MISSING MANY CRITICAL AREAS OF STUDY.

5. The Project Description and Operation is missing key information. Because the data gaps could impact the feasibility of the endeavor, I recommend they be thoroughly explored and analyzed during the study phase, as described below.

6. SEOPC has not yet developed a detailed construction schedule. In the PAD, it is stated that construction is planned to be 3 to 4 years. While this may be possible assuming ideal conditions, it should be considered optimistic given that construction of a project of this scale requires multiple complex steps, including:

- Significant tunneling – the logistics and time alone for driving five (5) or six (6) tunnels and the pump/generating house chamber will require significant coordination and planning;

- Material processing;
- Common excavation;
- Foundation treatment;
- Reinforced concrete placement;
- Power equipment and controls manufacturing;
- Pump/generator fabrication;
- Conductor installation;
- Switchyard equipment fabrication and installation;
- Testing; and
- Creation, review, and approval of thousands of design and fabrication detailed engineering documents for all of the aforementioned activities prior to installation and/or fabrication.

7. I describe in more detail some of the additional considerations regarding constructability that are missing from the PAD, below.

1. <u>Construction Activities and Project Safety</u>

8. The PAD states all of the facilities, including the 100-mile-long transmission line, will be on private land. This needs to be verified. Nevertheless, SEOPC will have to identify and initiate discussions with many property owners to negotiate the numerous easements and agreements that will have to be accomplished to construct the project. If the necessary property rights are not completed prior to licensing, it could cause significant delays and associated increase in costs.

9. A thorough geotechnical investigation will have to be performed that includes evaluating each dam's foundation for seepage potential, each reservoir's holding capability, dam foundation settlement potential, groundwater issues, rock foundation treatment, seismic loading, landslide potential, as well as identifying acceptable borrow areas for engineered fill zoning and waste areas. It is recognized that the tunnel muck may provide for some required rockfill, however there will be many other required embankment material needs.

10. The PAD includes a Concrete Faced Rockfill dam for the impoundment of the upper reservoir. The document does not provide reasoning for such a selection. Such a structure will require a solid foundation for placement of the plinth and treatment for adequate seepage cutoff. It also will require similar sound abutment contact for the concrete face as well as minimal settlement of the rockfill. It should be required that extensive investigation during the study phase to confirm such amenable rock conditions exist.

11. Site investigations should determine the feasibility of favorable ground conditions for such a large expanse of tunneling. Investigations should account for potential for naturally occurring toxic and explosive gas, running or squeezing ground, and ground water infiltration.

12. Each embankment will likely require an engineered filter and drain system. The feasibility of manufacturing these critical materials needs to be investigated to determine potential sources quality and durability compliance for handling and compaction breakdown, degree of cementation potential, and quantity.

13. It is noted in the PAD that expansive soil will likely be encountered in the clay and clayey shale. The engineering properties of such materials will require careful and perhaps special requirements for use in the dam's embankments and/or structural fill. It is possible such material may not be satisfactory for impervious Zone 1 type material.

14. There appears to be no spillway envisioned, at this time, on the Regulating Reservoir. There needs to be an engineered fail-safe system incorporated for all project reservoirs, as appropriate, to prevent the potential for overtopping to avoid a similar situation which took place at Taum Sauk.

15. In addition, first fill loading against the dam embankments is a critical dam safety operation and could easily be required to take more than a year.

2. Project Operations and Economic Feasibility

16. Margins on pump generating systems can be very tight with respect to cost recovery. The economics associated with the project as a whole should be clearly explained. An overall system hydraulic and hydrologic analysis needs to be performed taking into account operation requirements of the pump systems, pump/generating systems, river fluctuation, estimates of seepage, station service needs, cavitation potential, accounting for water rights, seasonal effects, evaporation, hydrology, etc. to verify the economic and engineering assumptions being made.

17. The PAD states that the pump/generator units will be variable speed. This will require a power harmonics study to assure equipment is designed to avoid operational issues.

18. The PAD describes a future plan for operation and maintenance. This plan should include provisions for replacement as well. Mechanical and electrical machinery will break and there should be a plan for funding that eventuality.

3. Environmental Impacts and Mitigation

19. A reality today is there will be certain restrictions upon completion of environmental review under the National Environmental Policy Act and consultation under the National Historic Preservation Act, which will impact when certain surface construction activities may occur. Such restrictions should be factored into the construction schedule because they will likely impact a construction contractor's ability to fast track activities, adding to the overall project completion period.

20. During operation, changes will occur to the river water temperature, oxygen content and sediment loads. These changes need to be addressed with its impacts to environmental and project operation planning.

21. Noise from Pump and Pump/Generating units during operation should be addressed during the study phase.

22. A plan needs to be provided to deal with potential invasive species, i.e., Mussels, weeds, etc.

23. Non-native species of fish may be introduced during future operations and recreation activities and provisions should be included to prevent their introduction into the Kiamichi River. Also, a study should be conducted to assure native fish survival potential in the reservoirs. Engineering features may be required to address these potentials.

24. Many modern water projects, such as this, require land or resources be provided as mitigation for losing the existing resources. The PAD does not appear to account for such an eventuality.

25. There will be significant quantities of structural concrete required. This likely will lead to an on-site temporary batch plant and aggregate processing operation. The alternative is to batch offsite and haul the material into the job. The study phase should account for such operations using multiple shifts/day and associated dust, noise, emissions, light pollution, and traffic.

26. A plan should be made to include maintenance during operations for wildfire mitigation along the transmission lines.

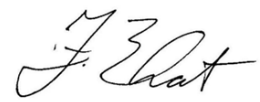
IV. CONCLUSION

27. In sum, a project of this size and complexity requires detailed design and engineering studies to evaluate the feasibility of and develop specific plans for construction and operations. The PAD does not show the applicant has given sufficient consideration to the types of studies that will be needed or to the development of a complete and coherent approach for

accomplishing such studies prior to construction. These issues will need to be addressed for the project to advance in a safe and responsible manner.

I declare under penalty of perjury of the laws of the State of Colorado and the United States of America that the foregoing is a true and correct statement of my expert opinion, and that this report was executed this 30th day of October, 2024, at 34 Ophir Drive, Durango, Colorado, 81301.

Respectfully submitted,



Fred P. Ehat

Frederick (Rick) Ehat, MSCE, PE

Senior Construction Specialist – Water Resource Engineering – Large Civil Works Projects

EDUCATION
Master of Science in Construction/Soil Mechanics, San Jose State University
Bachelor of Science in Civil Engineering, San Jose State University

REGISTRATION/CERTIFICATION
Registered Professional Engineer in California

AFFILIATIONS
Member USSD (United States Society on Dams, Construction Committee)
Senior Construction Specialist Member, American Society of Civil Engineers

PROFESSIONAL EXPERIENCE
January 2012 to Present, Consultant, Construction Specialist – Intermittent

Serve as member of Consultant Review Board for the seismic retrofit of Reclamation's Conconully Dam in Washington.

Reviewed status of the San Juan Headwaters Project in Pagosa Springs, CO, to provide "next step" advice to construct an off-stream embankment dam.

Participated in constructability review for Reclamation for the seismic retrofit work for B.F. Sisk embankment dam and the Delta Mendota Canal gate rehab projects in California.

Dispute Resolution Team member for the owner (Western Minnesota Municipal Power Agency) for hydroelectric power plant installation on the USACE Red Rock Dam.

Provided expert construction engineering advice for seven U.S. Corps of Engineers Safety of Dams projects (Addicks, Barker, Isabella, Zoar Levee and Diversion Dam, Moose Creek, Cherry Creek, and Pipestem Dams) and a Value Engineering Study for J.T. Myers Lock and Dam.

Provided expert construction engineering and management advice to Reclamation on large water resources projects for Indian Water Rights Settlements: including the Tule River Indian Tribe Settlement, Navajo Nation Utah Settlement and Crow Tribe Settlement.

Provided Reclamation a Construction Management Cost Estimate for the Arkansas Valley Conduit near Pueblo Colorado, a $300M potable water line, treatment plant and pumping plants.

Provided expert construction engineering advice to the U.S. Corps of Engineers in drafting official guidance for conducting constructability reviews.

2012 to 2014, Construction Manager for Water District, Hesperus, Colorado
District's Long Hollow Dam (Currently in operation). Owner's representative overseeing the construction contract and the design engineering consultant contract.

2009 to December 31, 2011, Navajo San Juan Settlement Implementation Program Manager
Reclamation, Durango, Colorado. Oversaw ~ 8 settlement agreements and the design and planning for the $995M potable Navajo Gallup Water Supply project. Interactions with 14 entities (including 2 Tribes).

2002 to 2009, Project Construction Engineer
Reclamation, Durango, Colorado. Manager of $500M Animas-La Plata Project in Southwest Colorado, and Northwestern New Mexico. Includes 5.2M CY embankment dam, outlet works tunnel, pumping plant, roads, storage tanks, and pipelines. Reported to 9 organizations (including 3 Tribes) and managed ~80 employees.

1990 to 2002, Construction Liaison Engineer
Construction Management Group, Technical Service Center, U.S. Bureau of Reclamation, Denver, CO. Provided technical advice on construction projects for California Dams at Folsom, Friant, Shasta, Mormon Island Auxiliary Dam, Bradbury, O'Neill Forebay, Casitas, and Buckhorn and several other dams in Nevada, Washington, Utah, and Montana.

1995 to Present, Construction Specialist
Reclamation Technical Advisory Team member to the Taiwan Provincial Water Conservancy Bureau. Technical Advisor to government of Pakistan through the State Department providing remediation options for a massive landslide across a river.

1978 to 1990, Construction Inspector and Resident Engineer
Construction of San Felipe and Central Arizona Projects Reclamation in California and Arizona (Dams, power and pumping plants, canals, pipelines, siphons, shafts, and tunnels.)

STATEMENT OR QUALIFICATIONS

Construction/Project Management
- Project implementation and development
- Independent field assessments of CM/PM
- Scheduling
- Evaluation of construction management and contractor performance
- Construction Management Readiness Reviews

Construction Methods
- Constructability Evaluations
- Risk Assessments

Solicitations, Plans and Specifications
- Comprehensive Independent Evaluations
- Value Planning and Value Engineering Review Participation
- Claims Avoidance Advice
- Procurement Selection Assistance
- Proposal Preparation Assistance

Indian Water Rights Settlement Implementation
• Collaborative Process Development
• Fast Track Implementation Methods

Project Implementation and Development

- Consult on organizational skill sets required to be commensurate with the size, complexity, and risk associated with managing a project.
- Assist in budget development for Projects.
- Independent Field Assessments of CM/PM
- Perform independent assessments of ongoing construction management services and provide counsel on preparing for future operations, including contract administration and quality assurance activities.
- Provide technical assistance to construction engineers on problem solving and construction methods.
- Scheduling
- Assist in preparing project schedules and in evaluating construction contractor's schedules.
- Evaluation of Construction Contractor Performance
- Perform field assessment of a contractor's overall performance gauged against the contract documents and my experience.
- Assist in resolving disputes and evaluate risk to the owner regarding possible issues resolution options.
- Construction Management Readiness Reviews
- Assist field personnel and design staffs in preparing for initiation of construction or new and complex construction operations.

References: Provided upon request

Recognitions

United States Society of Dams Award of Excellence in Constructed Project for Ridges Basin Dam, 2011.

John W. Keys, III Award for Building Partnership and Strengthening Relationships, 2009

John W. Keys, III Award for Building Partnership and Strengthening Relationships, 2008

Honorary Recognition for Outstanding Technical and Administrative Leadership of the Animas-La Plata Project by the Project Sponsors, 2008

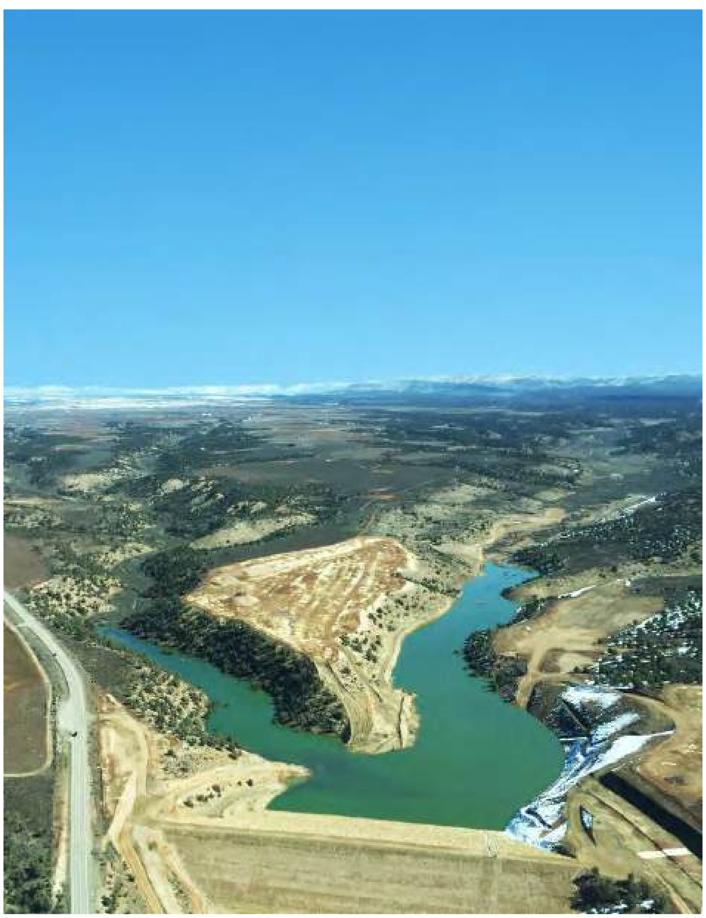
Meritorious Service Honor Award, Department of Interior, 2008

Superior Service Honor Award, Reclamation , 2005

Engineer of the Year for Reclamation, National Society of Professional Engineers, 2001

SEE SAMPLE OF PROJECTS PHOTOS BELOW:

Long Hollow Dam embankment nearing completion - Spring 2014



Long Hollow Dam and Bobby K. Taylor Reservoir under first filling, March, 2015

Right abutment grouting operation, Ridges Basin Dam, Colorado

Ridges Basin Dam embankment construction, Colorado

Durango Pumping Plant excavation and initial concrete placement,Colorado

Durango Pumping Plant construction, Colorado

Completed Durango Pumping Plant, Colorado

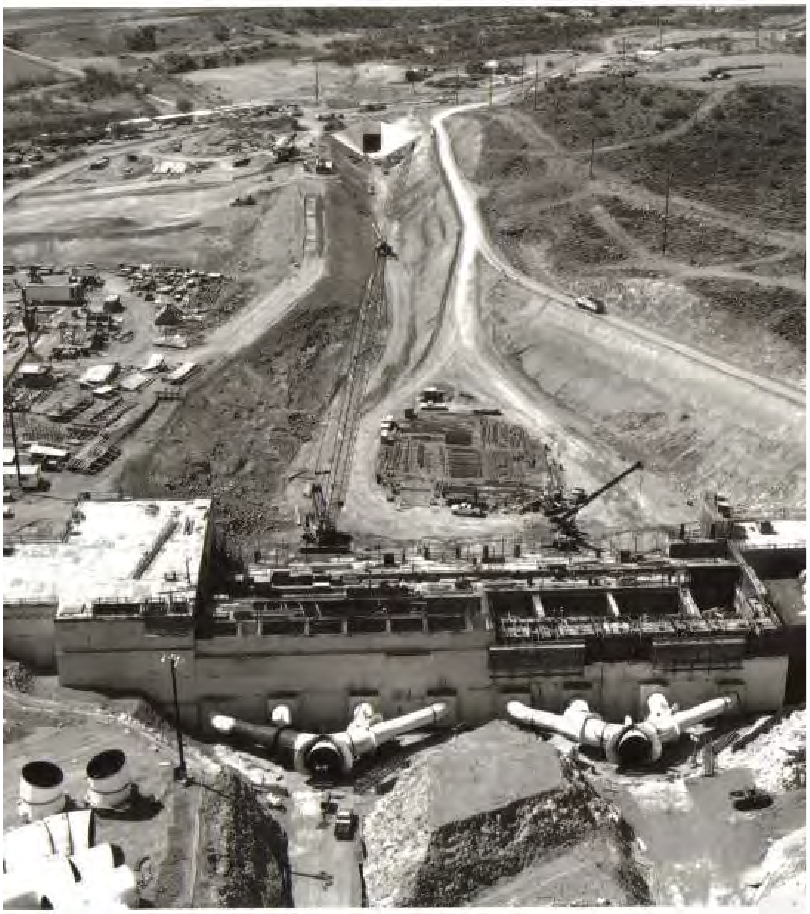
Upstream Outlet Works tunnel excavation, Ridges Basin Dam,Colorado

Ridges Basin Dam and full Lake Nighthorse, Colorado

Pump intake liner installation, Pacheco Pumping Plant,California

Pre-assembly of Shasta Dam Temperature Control Device, California

Red Bluff Fish Demonstration Pumping Plant, Sacramento River, California



New Waddell Pump-Generating Plant construction, Arizona

New Waddell Dam and Pump-Generating Plant in operation, Arizona

Attachment 4

Todd D. Fagin, PhD.

2708 Fairfield Dr. Norman, OK 73072 · 405.740.4324 · spruce0230@gmail.com

re: Pushmataha County Pumped Storage Project (FERC Project No. 14890)

To whom it may concern, October 16, 2024

My name is Todd Fagin and I currently serve as the Executive Associate Director at the Center for Spatial Analysis at the University of Oklahoma. However, the letter I write today is not in my official capacity, rather it is my expert opinion as a public citizen with over two decades of experience on the topics addressed here. Though I am a geospatial scientist, the majority of my career has involved maintaining and analyzing data related to the distributions of species, including vulnerable and rare species; land use/land cover change dynamics; and the effects of these dynamics on said species distributions. Indeed, prior to my current position, I served as the conservation data manager at the Oklahoma Natural Heritage Inventory; I worked on the Oklahoma ecological systems mapping project; and was (and remain) a project lead on the Oklahoma Biodiversity Information System (OBIS). The information I provide in this letter related to biodiversity and ecological factors associated with the Pushmataha County Pumped Storage Project (FERC Project No. 14890) is largely based on this work.

The proposed project boundary occurs within two southeastern Oklahoma counties, Pushmataha and McCurtain, as well as two northern Texas counties, Red River and Lamar. Due to the jurisdictional limitations of the datasets, my analysis focuses solely on the Oklahoma portion of the project.

This project area is both biologically and ecologically diverse. Within the project footprint (which commences at the Kiamichi River in T2N-R21E/T2N-R22E IM and runs primarily southerly near the McCurtain/Pushmataha boundary to the state line in T7S-R21E), I have identified multiple ecological systems, including several West Gulf Coastal Plain, Ozark-Ouachita Mesic Hardwood, and South Central Interior Bottomland types. Within Oklahoma, these systems are primarily restricted to the southeastern/eastern portions of the state and our home to several of the state's rare and vulnerable species.

OBIS contains records for seven federally listed and one state listed species in the townships through which the proposed will run. These are summarized in the table below.

Species Name	Common Name	Category	Status
Arcidens wheeleri	Ouachita rock pocketbook	Mussel	Federally Endangered
Quadrula fragosa	winged mapleleaf	Mussel	Federally Endangered
Theliderma cylindrica	rabbitsfoot	Mussel	Federally Threatened
Myotis sodalis	Indiana Bat	Mammal	Federally Endangered
Perimyotis subflavus	Tricolored Bat	Mammal	Proposed Endangered
Percina pantherina	leopard darter	Fish	Federally Threatened
Percina maculata	blackside darter	Fish	State Threatened
Nicrophorus americanus	American burying beetle	Insect	Federally Threatened

Because many of the potentially impacted species are mobile, their ranges and movement exceed the initial search area, there is viable habitat beyond the initial townships searched, and land use/land cover dynamics can have cascading effects in adjacent areas, I expanded the search radius by several miles. This resulted in an additional 12 federally list species in the project vicinity, as summarized below:

Species Name	Common Name	Category	Status
Lampsilis rafinesqueana	Neosha Mucket	Mussel	Federally Endangered
Potamilus leptodon	Scaleshell Mussel	Mussel	Federally Endangered
Theliderma cylindrica	Rabbitsfoot	Mussel	Federally Threatened
Potamilus amphichaenus	Texas heelsplitter	Mussel	Proposed Endangered
Myotis septentrionalis	Northern Long-eared Bat	Mammal	Federally Endangered
Picoides borealis	Red-cockaded Woodpecker	Bird	Federally Endangered
Laterallus jamaicensis	Eastern Black Rail	Bird	Federally Threatened
Ptilimnium nodosum	harperella	Plant	Federally Endangered
Notropis girardi	Arkansas River shiner	Fish	Federally Threatened
Scaphirhynchus platorynchus	Shovelnose sturgeon	Fish	Federally Threatened
Macrochelys temminckii	alligator snapping turtle	Reptile	Proposed Threatened

In addition to federal and state protected species, an analysis of OBIS records indicates that there are six Tier 1 species of greatest conservation need (SGCN); 13 Tier 2 SCGN species; and 11 Tier 3 SGCN species within the vicinity of the proposed project footprint. Moreover, 33 of the species found within the project footprint vicinity are ranked S1 (critically imperiled), while 50 are ranked as S2 (imperiled). Please note, though, these ranks are not mutually exclusive (e.g. a species can be federally listed, Tier 1, and S1).

Given the presence of a number of federally listed, SGCN, and other vulnerable species in the project area, I recommend studies that could determine the potential biological and ecological impacts of this project. In particular, the project has the potential to disrupt surface flow of the Kiamichi River and its tributaries, which could adversely impact the seven vulnerable freshwater mussel species in the project vicinity. Additionally, a determination of the presence/absence of bat hibernacula and/or maternity roost trees in the project area is incumbent to ensure the protection of these vulnerable species.

I hope that the information I have provided in this letter will be factored in the permitting decisions related to the Pushmataha County Pumped Storage Project. If you have any questions regarding my assessment, please contact me at spruce0230@gmail.com.

Sincerely,

Todd Fagin, PhD.

Attachment 5

Expert Report of Tamara L. Mix, Ph.D.

I, Tamara L. Mix, Ph.D. hereby declare the following:

1. I submit this report in response to Southeast Oklahoma Power Corporation's (SEOPC) Filing of Notice of Intent to File an Application for an Original License and Pre-Application Document for the Pushmataha County Pumped Storage Project (P-14890), eLibrary no. 20240507-5119 (May 7, 2024), as noticed by the Federal Energy Regulatory Commission (FERC or Commission) on July 8, 2024. *See* eLibrary no. 20240708-3054.

2. This report is organized as follows: Section I states my experience and qualifications; Section II states the documents I reviewed in preparing this report; Section III describes my assessment of the extant Environmental Justice discussions in the documents; Section IV states my conclusions and recommendations.

I. EXPERIENCE AND QUALIFICATIONS

3. My educational credentials include a Bachelor of Arts in Sociology (1995) from James Madison University and a Master of Science (1998) and Doctor of Philosophy (2002) in Sociology with an emphasis in Environmental Sociology from the University of Tennessee at Knoxville. I have been engaged in research on issues of Environmental Justice since 1996. A qualitative researcher, I have conducted projects involving a diverse range of stakeholders to address topics including environmental and community contamination, water access and quality, food justice and security, and resource inequalities. I have experience with participatory research strategies, building projects with applied components and integrating the perspectives and voices of impacted and underserved populations.

4. I am currently a Professor of Sociology at Oklahoma State University (OSU). I provide these comments in my personal capacity as an Environmental Sociologist and

Environmental Justice scholar and concerned citizen and not in my capacity as an employee of OSU.

5. My curriculum vitae is attached.

II. DOCUMENTS REVIEWED

6. In preparing this report, I reviewed the following documents:

a. SEOPC's Pre-Application Document (May 7, 2024);

b. Other

III. Definition and Clarification of Scope of Environmental Justice.

7. Environmental justice focuses on a range of environmental inequalities rooted in social and political dynamics that results in uneven exposure to environmental risks and hazards for communities and people of color, poor communities, and otherwise minoritized groups (1, 2). Environmental justice is characterized by systemic exclusion of people from environmental decision-making processes as well as inequitable distribution of environmental 'bads,' including hazards and risks like pollution, exposure to natural and technological harms, and effects of climate change/disruption, combined with lack of access to environmental 'goods,' like clean water, air, and affordable, safe food (3, 4). While analysis of demographic characteristics of the proposed site area (including race/ethnicity and socio-economic status) and vulnerability (including wildfire risk and presence of food deserts, among others) is a start to understanding important socio-environmental dimensions, this approach fails to attend to dimensions of distributive, procedural, and corrective justice (5) and the complex, interactive, and long-standing historical dynamics (6, 7) of the peoples, waters, and land in the Kiamichi River Basin which will be impacted by the Pushmataha County Pumped Storage Project.

IV. Reaffirmation of need for additional Environmental Justice research related to siting.

8. Given that a high rate of census tracts and block groups outlined as part of or adjacent to the Pushmataha County Pumped Storage Project site/transmission lines are identified as Environmental Justice communities and a majority of census tracts and block groups also are identified as maintaining Environmental Justice concerns linked to vulnerability for environmental risks, additional research on Environmental Justice impacts is warranted. While a Socioeconomic and Environmental Justice Study is a start, such research efforts must include:

   a. Quantitative and qualitative research methodologies to address breadth and depth/nuance of Environmental Justice implications related to siting.

   b. Analysis of foraging/subsistence dimensions for local populations.

   c. Implications of water quality and quantity for local populations.

   d. Displacement and land implications for local populations.

   e. Downstream impacts related to water quality/quantity and land use changes.

   f. Implications for cultural meaning of space and place due to changing land/water access and natural/built landscape changes.

   g. Consideration of Environmental Justice impacts broader than immediate site and transmission line right-of-way due to integrated socio-cultural and environmental dimensions (migration patterns, seasonal forage, place/space use and meaning, etc.).

V. CONCLUSIONS AND RECOMMENDATIONS

While the Notice of Intent to File does attend to limited Socioeconomic and Environmental Justice dimensions related to the Pushmataha County Pumped Storage Project, extant discussion lacks depth and nuance of interactions related to the socio-cultural and environmental dimensions of Environmental Justice unique to the region and important for determining the broader impacts of this proposed project.

I declare under penalty of perjury of the laws of the State of Oklahoma and the United States of America that the foregoing is a true and correct statement of my expert opinion, and that this report was executed this 14th day of October, 2024, in Stillwater, Oklahoma, 74074.

Respectfully submitted,

Tamara L. Mix, Ph.D.

Literature Referenced

1. Roberts, J.T., D.N. Pellow, and R. Mohai. 2018. “Environmental Justice.” *Environment and Society: Concepts and Challenges*, 233-255.
2. Malin, S. 2024. “Environmental Justice”.” In the *Encyclopedia of Technological Hazards and Disasters in the Social Sciences*, edited by D.A. Gill, L.A. Ritchie and N. Campbell. London: Edward Elgar.
3. Mohai, P., D.N. Pellow and J. T. Roberts. 2009. “Environmental Justice.” *Annual Review of Environment and Resources*, 34 (1):405-430
4. Pellow, D.N. 2017. *What is critical environmental justice?* John Wiley & Sons.
5. Kuehn, R. 2000. “A Taxonomy of Environmental Justice Issues.” *Environmental Law Repor*t, 30:10681-703.
6. Pellow, D.N. 2004. “The Politics of Illegal dumping: An Environmental Justice Framework.” *Qualitative Sociology*, 27(4): 511-525.
7. MacGregor, D. 2020. “Indigenous Environmental Justice: Towards an Ethical and Sustainable Future.” In *Routledge Handbook of Critical Indigenous Studies*, 405-419. Routledge.

TAMARA L. MIX

October 2024

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Stillwater, OK 74078, (405) 744-6104
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EDUCATION

Ph.D.	2002	Sociology, University of Tennessee, Knoxville – Knoxville, TN.
MA	1998	Sociology, University of Tennessee, Knoxville – Knoxville, TN.
BA	1995	Sociology, James Madison University – Harrisonburg, VA.

PROFESSIONAL EXPERIENCE

2019-	Department Head, Sociology, Oklahoma State University.
2018-	Professor, Sociology, Oklahoma State University.
2017-	Laurence L. and Georgia Ina Dresser Professor in Rural Sociology, Oklahoma State University.
2014-2018	Graduate Program Director, Sociology, Oklahoma State University.
2010-2018	Associate Professor, Sociology, Oklahoma State University.
2007-	Affiliate Faculty, Environmental Science Program.
2006-	Affiliate Faculty, Gender, Women's, and Sexuality Studies Program.
2006-	Affiliate Faculty, School of International Studies.
2005-2010	Assistant Professor, Sociology, Oklahoma State University.
2002-2005	Assistant Professor, Sociology, University of Alaska Fairbanks.

RESEARCH AND TEACHING INTERESTS

Environmental Sociology
Environmental Justice
Race, Class, and Gender Inequality
Social Movements
Social Justice
Qualitative Methods

HONORS AND AWARDS

2024	Awardee. Lead the Change: Consciousness of Self in Leadership Award. Hargis Leadership Institute, Oklahoma State University.
2023	Awardee. University Service Award, Oklahoma State University.
2022	Nominee. Eminent Faculty Award, Oklahoma State University.
2019	Awardee. Regent's Distinguished Teaching Award, Oklahoma State University.
2017	Nominee. Eminent Faculty Award, Oklahoma State University.
2013	Awardee. Outstanding Sociology Professor, Department of Sociology, Oklahoma State University.
2011	Awardee. The Allen Schnaiberg Outstanding Publication Award by the Section on Environment and Technology of the American Sociological Association (ASA) for "Risk Society and Contested Illness: The Case of Nuclear Weapons Workers."
2005	Awardee. Dean's Award of Faculty Recognition & Appreciation, College of Liberal Arts, University of Alaska Fairbanks.
2005	Awardee. Teaching Excellence Award, College of Liberal Arts, University of Alaska Fairbanks.
2001	Awardee. Yates Dissertation Fellowship, Graduate College, University of Tennessee.
2001	Awardee. Sociology Graduate Student Research Award, Department of Sociology, University of Tennessee, Knoxville.

2001 Awardee. Cole Franklin Scholarship, Graduate College, University of Tennessee, Knoxville.

PUBLICATIONS

(For all publications, authorship is listed in order of contribution unless noted)
(*Publication with a current or former graduate student)

BOOKS

2019 Norwood, F. Bailey and Mix, Tamara L. *Meet the Food Radicals*. Oxford University Press.

REFEREED JOURNAL ARTICLES

2024 Schweitzer, Julie*, Tamara L. Mix, and Fleming, Olivia*. "'We will continue to fight for our lands… it is Mother Nature that we value': Idle No More, Anti-Capitalist Ecologist Discourse, and the Rights of Nature Social Movement Frame." *Globalizations*. (Online first 2024: DOI: 10.1080/14747731.2024.2366326).

2024 Fleming, Olivia* and Tamara L. Mix. "Oklahoma Foragers' Pathways, Practices, and Interactions with Local Wild Foods and Foodscapes." *Sustainability*, 16(10): 4175 (DOI: 10.3390/su16104175 "Wild Food for Healthy, Sustainable, and Equitable Local Food Systems")**.**

2024 Schweitzer, Julie* and Tamara L. Mix. "'People always think it's going to explode': Emotions and Power Relations in the French Nuclear Debate." *Energy Research & Social Science*. 113: 103534 (https://doi.org/10.1016/j.erss.2024.103534).

2024 Du, Juan*, John Chung-En Liu, and Tamara L. Mix. "China deserves its hamburger: The Controversy over WildAid's 'Shu Shi' Campaign in China." *Environmental Sociology*. (https://doi.org/10.1080/23251042.2024.2319370).

2024 Schweitzer, Julie*, Tamara L. Mix, and Jimmy J. Esquibel*. "Negotiating Dignity and Social Justice in Community Food Access Spaces." *Journal of Safer Communities* 23(2): 171-186.

2023 Karki, Srijana* and Tamara L. Mix. "Navigating the Patriarchal Bargain: Compliance with and Negotiation of Menstrual Customs in Kathmandu, Nepal." *Women's Studies International Forum*.(https://doi.org/10.1016/j.wsif.2023.102767)

[Winner of the Arlene Kaplan Daniels Paper Award for the best paper on women and social justice locally, nationally, and globally by the Society for the Study of Social Problems (SSSP). 2024.]

2023 Schweitzer, Julie*, Tamara L. Mix and Olivia Fleming*. "'We must work…toward justice in action': Social Movement Spillover and the Idle No More Movement." *Social Currents* 10(1):84-102. (Online first 2022: https://doi.org/10.1177/23294965221109167).

2022 Karki, Srijana* and Tamara L. Mix. "Social Control in Women's Pursuit of Secondary Education in Kathmandu, Nepal: 'If I can't sign my name, I can't maintain my privacy.'" *Journal of Gender Studies* 31(4): 413-426.

2022 Schweitzer, Julie* and Tamara L. Mix. "'Personally, it does not bother me all that much': Risk Perceptions among Normative and Oppositional Stakeholders in Post-Fukushima France." *Sociological Focus* 54(4). (Online first 2021 https://doi.org/10.1080/00380237.2021.1970063).

2021 Karki, Srijana* and Tamara L. Mix. "A Yam Between Two Rocks": A Comparative Analysis of Disaster Coverage and Geopolitical Dynamics in Nepali and Indian News Reporting of the 2015 Gorkha (Nepal) Earthquake." *International Journal of Mass Emergencies and Disasters*. 33(3):346-370.

2021 Schweitzer, Julie* and Tamara L. Mix. ""It's a Tradition in the Nuclear Industry. . . Secrecy": Political Opportunity Structures and Nuclear Knowledge Production in France." *Sociological Research Online.* (https://doi.org/10.1177/13607804211025052).

2021 Herrington, Amy* and Tamara L. Mix. "Invisible and Insecure in Rural America: Cultivating Dignity in Local Food Security Initiatives." *Sustainability*. *13*(6): 3109. (https://doi.org/10.3390/su13063109).

2021 Raridon, Andrew*, Tamara L. Mix, and Rachel L. Einwohner. "'Workarounds and Roadblocks'": Co-existence, Challenge, and Resistance among Sustainable Food Activists." *Social Currents* 8(2): 182-198. (Online first 2020: https://doi.org/10.1177/2329496520965627).

2020 Herrington, Amy* and Tamara L. Mix. "Building a Bigger Table: Mobilizing Social Capital to Develop a Community Food Justice Initiative." *Sociological Inquiry.* 90(4):74-822.

2018 Karki, Srijana* and Tamara L. Mix. "'My Family are Supportive … But People in My Village Mock Me': Bonding and Bridging Capital among Women Pursuing Secondary Education in Kathmandu, Nepal." *Sociological Perspectives*. 61(5): 711-727.

2018 Schweitzer, Julie* and Tamara L. Mix. "Risk Normalization in a Nuclear Reliant Society: The Construction of Risk in French Media Narratives Pre and Post Fukushima." *Environmental Sociology* 4(2): 264-274.

2016 Raynes, Dakota K. T.*, Tamara L. Mix, Angela Spotts, and Ariel Ross. "An Emotional Landscape of Place-Based Activism: Exploring the Dynamics of Place and Emotion in Anti-Fracking Actions" *Humanity & Society* 40(4): 401-423.

2016 Caniglia, Beth Shafer, Beatrice Frank, Bridget Kerner* and Tamara L. Mix. "Water Policy and Governance Networks: A Pathway to Enhance Resilience Toward Climate Change" *Sociological Forum* 31(S1): 828-845.

2016 Raridon, Andrew* and Tamara L. Mix. "'That's Not Grassfed!' Identity Formation, Maintenance, and Co-Optation in Oklahoma's Grassfed Livestock Movement." *Sociological Inquiry* 86(2): 141-165.

2015 Gurney, Rachel M.*, Beth Schaefer Caniglia, Tamara L. Mix, and Kristen A. Baum. "Native American Food Security & Traditional Foods: A Review of the Literature." *Sociology Compass* 9/8: 681–693.

2015 Mix, Tamara L. and Kristin G. Waldo*. "Know(ing) Your Power: Risk Society, Astroturf Campaigns and the Battle Over The Red Rock Coal-Fired Plant." *The Sociological Quarterly* 56(1): 125-151.

2013 Ross, Kathryn Worman* and Tamara L. Mix. "I Wanted Empowerment, Healing and Respect": Homebirth as Challenge to Medical Hegemony." *Sociological Spectrum* 33: 453-481.

2011 Mix, Tamara L. "Rally the People: Building Local-Environmental Justice Grassroots Coalitions and Enhancing Social Capital." *Sociological Inquiry* 81(2): 174-194.

2009 Mix, Tamara L. "The Greening of White Separatism: Use of Environmental Themes to Elaborate and Legitimize Extremist Discourse." *Nature & Culture* 4(2): 138-166.

2009 Mix, Tamara L, Sherry Cable and Thomas E. Shriver. "Social Control and Contested Environmental Illness: The Repression of Ill Nuclear Weapons Workers." *Human Ecology Review* 16(2): 172-183.

2008 Cable, Sherry, Thomas E. Shriver and Tamara L. Mix. "Risk Society and Contested Illness: The Case of Nuclear Weapons Workers." *American Sociological Review* 73(3): 380-401.

[Winner of The Allen Schnaiberg Outstanding Publication Award by the Section on Environment and Technology of the American Sociological Association (ASA) 2011].

Reprinted in *Environmental Sociology: From Analysis to Action*, 2nd and 3rd Edition, Pp. 267-286. Edited by Leslie King and Deborah McCarthy. Lanham, MD: Rowman and Littlefield, 2009, 2014.

2007 Mix, Tamara L. and Thomas E. Shriver. "Neighbors, Nuisances and Noxious Releases: Conflicting Perceptions of Environmental Hazards in the Atomic City." *The Social Science Journal* 44(4): 630-644.

2006 Anahita, Sine and Tamara L. Mix. "Retrofitting Frontier Masculinity for Alaska's War Against Wolves." *Gender & Society* 20(3): 332-353 [Co-authored Manuscript – Author order is Alphabetical].

Reprinted in *Exploring Masculinities: Identity, Inequality, Continuity and Change*, 1st Edition, Pp. 145-154. Edited by C.J. Pascoe and Tristan Bridges. New York: Oxford University Press, 2015.

Reprinted in *Men's Lives*, 8th Edition. Edited by Michael S. Kimmel and Michael S. Messner. Boston, MA: Allyn & Bacon, 2010.

2006 Mix, Tamara L. and Sherry Cable. "Condescension and Cross-Class Coalitions: Working Class Activists' Perspectives on the Role of Social Status." *Sociological Focus* 39(2): 99-114.

2003 Cable, Sherry and Tamara L. Mix. "Economic Imperatives and Race Relations: The Rise and Fall of the American Apartheid System." *Journal of Black Studies* 34(2): 183-203.

Reprinted in *Race in an Era of Change: A Reader*, 1st Edition. Edited by Heather Dalmage and Barbara Katz Rothman. New York: Oxford University Press, 2011.

2002 Cable, Sherry, Donald W. Hastings and Tamara L. Mix. "Different Voices, Different Venues: Environmental Racism Claims by Activists, Researchers and Lawyers." *Human Ecology Review* 9(1): 26-42.

REFEREED BOOK CHAPTERS

2023 Schweitzer, Julie*, Olivia Fleming*, and Tamara L. Mix "Environmental Inequality and Rights of Nature Among North American Indigenous Peoples." *Handbook of Inequality and the Environment*.

2020 Dakota K. T. Raynes* and Tamara L. Mix. "Induced Seismicity, Quotidian Disruption, and Challenges to Extractivist Ecocultural Identity." *The Routledge Handbook of Ecocultural Identity,* Routledge Press.

[*Routledge Handbook of Ecocultural Identity* awarded the Tarla Rai Peterson Book Award for Outstanding Environmental Scholarship in Environmental Communication by the National Communication Association. 2020].

2020 Mix, Tamara L. and Duane A. Gill. "'Dear People of Flint': Environmental Justice in Community Context, the Case of Water Contamination in Flint, Michigan." *Introduction to Interdisciplinary Toxicology*, Elsevier.

2020 Gill, Duane A. and Tamara L. Mix. "Love Canal: A Classic Case Study of a Contaminated Community." *Introduction to Interdisciplinary Toxicology*, Elsevier.

2018 Mix, Tamara L. and Dakota K.T. Raynes*. "Denial, Disinformation, and Delay: Recreancy and Induced Seismicity in Oklahoma's Shale Plays" Pp. 173-197 in *Fractured Communities: Risk, Impacts, and the Mobilization of Protest Against Hydraulic Fracking in U.S. Shale Regions*, edited by A. Ladd. New Brunswick, NJ: Rutgers University Press.

2017 Mix, Tamara L., Andrew Raridon,* and Julie M. Croff. "'There is Just a Stigma Here:' Historical Legacies, Food Justice, and Solutions-Based Approaches Toward Urban Community Resilience." Pp. 79-96 in *Resilience, Environmental Justice and the City,* edited by B.S. Caniglia, M. Vallee, and B. Frank. New York: Routledge Press.

2005 Cable, Sherry, Tamara L. Mix and Donald W. Hastings. "Mission Impossible? Environmental Justice Activists' Collaboration with Professional Environmentalists and with Academics." Pp. 55-76 in *Power, Justice and the Environment: A Critical Appraisal of the Environmental Justice Movement* edited by in D. N. Pellow and R. J. Brulle. Cambridge, MA: MIT Press.

OTHER PUBLICATIONS

2008 Mix, Tamara L. "Toxic Burn: The Grassroots Struggle against the WTI Incinerator." By Thomas Shevory. *Mobilization* 13(1): 123-124. (Book Review).

2007 Mix, Tamara L. "Environmental Inequality." Syllabus published in *Teaching Environmental Sociology* (6th edition) Edited by Michael Mascarenhas. Washington DC: American Sociological Association.

2007 Mix, Tamara L. "Environmental Sociology." Syllabus published in *Teaching Environmental Sociology* (6th edition) Edited by Michael Mascarenhas. Washington DC: American Sociological Association.

2007 Mix, Tamara L. "Community Response to Environmental Hazards: Sources of Resilience and Vulnerability." Conference proceedings of the International Workshop on Natural and Human Induced Hazards and Disasters in Africa, 21-22 July 2007, Kampala, Uganda.

MATERIALS UNDER REVIEW

Karki, Srijana* and Tamara L. Mix. "Efforts to Create Neutral Bodied Female Students: Schools and the Menstrual Mandate in Nepal." Revise and Resubmit with *Gender and Education*.

Karki, Srijana* and Tamara L. Mix. "'Nepali Women at Work: Menstruation in Informal and Formal Workplaces." In review with *Gender, Work & Organization*.

Esquibel, Jimmy J.* and Tamara L. Mix. "Using Spatial Analysis to Determine Food Assistance Accessibility in Rural Oklahoma." In review with *Rural Sociology*.

WORK IN PROGRESS

Karki, Srijana* and Tamara L. Mix. "Negotiating Diverse Positionalities: Nepali Immigrants' Lived Experiences and Perceptions of Race and Racism in the United States."

Schweitzer, Julie* and Tamara L. Mix. "France Appears Exemplary: Nuclear Energy and National Pride in Energy Transition Disputes."

Schweitzer, Julie and Tamara L. Mix. "The Atom as National Heritage": National Energy Identity and Energy Justice/Injustice in French Media Narratives."

Schweitzer, Julie and Tamara L. Mix. "'It's the Stupid Food System Here': Emotions, Solidarity, and Community Building in Food Access Spaces."

Schweitzer, Julie*, Olivia Fleming* and Tamara L. Mix. "We Want to Tell the World": Grievance Construction and Political Opportunity Structures in Idle No More and Wet'suwet'en Narratives about Missing and Murdered Indigenous Women."

EXTERNAL GRANTS

Funded (Total grant dollars awarded $95,000)

2012 United States Department of Agriculture. "Oklahoma State University Planning for OSU-Native American Partnership Summit." Co-Principal Investigator with B. Caniglia and R. Sheehan. Awarded $50,000.

2007 International Research Experience for Students (IRES) NSF-OISE "IRES: Research Opportunity in Botswana and Zambia." Sub-awardee under E. Atekwana, OSU Department of Geology. Awarded travel to the International Workshop on Natural and Human Induced Hazards and Disasters in Africa, 21-22 July 2007, Kampala, Uganda.

2004 National Science Foundation (NSF) Experimental Program to Stimulate Competitive Research (EPSCoR) Regional Resilience and Adaptation (RAP) "Regional Resilience and Predator Control in Interior Alaska." Sub-awardee, 2004-2007. Awarded $20,000 [Awarded June 2004. Funding ended June 2005 due to institutional move].

2003 National Science Foundation (NSF) Experimental Program to Stimulate Competitive Research (EPSCoR) Regional Resilience and Adaptation (RAP) "Urban Sprawl and Commuting in the Anchorage and Fairbanks Metropolitan Areas." Sub-awardee and Co-Principal Investigators with N. Edwards (UAA) and P. Fix (UAF), 2003-2004. Awarded $20,000.

Not Funded

2023 United States Department of Energy Full Application in response to DOE FOA-0002779. "HALO Hydrogen Hub - Regional Clean Hydrogen Hubs" Co-Principal Investigator with M. Long.

2021 United States Department of Agriculture 2021 AFRI Sustainable Agriculture Systems (SAS) A9201 program area. “Enhancing the Efficiencies and Robustness of Beef Production Systems.” Primary PI Ranjith Ramanathan. Sociology budget $354,741. [Ranked high priority, not funded].

2018 INFEWS/T2 “Food, Energy and Water for the Future: Innovative Technology and its Influence on Agriculture and Perceptions of Produced Water Reuse.” Co-Principal Investigators with K. Sallam, P. Sarin, D.Y. Kim, L. Ritchie, D. Gill, S. Taghvaeian, B. Dunn, and P. Alderman. Total funding requested $2.498 million. Sociology request $375,000.

2018 HIBAR. “Social Policy Engagement & Research (SPER) Institute: Data Driven Solutions to (Em)Power People and Policy” In collaboration with F. Jalalzai, M. Payton, and C. Freeman. Total funding requested: $10,000 for proposal development.

2015 EPA STAR. “Non-Use Values of Water Quality Improvements and Aquatic Ecosystem Services in Rural versus Urbanizing Watersheds.” In collaboration with R. Melstom (PI), T. Boyer, S. Brewer, G. Fox, A. Teague, W. Kellogg. Total funding requested $789,320; Sociology portion $20,313.

2015 NSF Hazards SEES. “Hazard SEES: Causes of the Increased Seismicity and Seismic Hazard in Oklahoma: Understanding the Role of Fluids in Generating Seismicity.” In collaboration with R. Evans (PI), E.A. Atekwana, H. Savage, B. Dugan, M. Abdelsalam, K. Keranen, J. Puckette and T. Ivey. Total Funding requested for 3 years $3,000,000; Sociology portion $251,472.

2014 EPA. “Cooperative Training Partnerships in Toxicology.” In collaboration with C. Pope (PI), J. Grzywacz, S. Hartson, L. Maxwell, P. Hoyt, D. Brunson, M. Payton, J. Belden, D. Gill. Total Funding Requested $2,000,000; Sociology portion $20,000.

2014 South Central CSC Funding Opportunity 2015: Statement of Interest. “Climate Change: Incorporating Land Owner Decisions and Perceptions into a Scientific Framework” In collaboration with K. Baum (PI), D. Elmore, K. Giles, and J. Warren. Total Funding Requested $220,658; Sociology portion $35,000.

2009 FY 2010 Water Resources Research Grant Program – OWRRI Grant Proposal “Private Property and Water Rights in Oklahoma’s Comprehensive Water Plan: A Stakeholder Assessment.” Co-Principal Investigators with B. Caniglia. Total Funding Requested: $15,000.

2006 National Science Foundation Dynamics of Coupled Natural and Human Systems (CNH) FY2007 Grant Proposal “Interactive Effects of Current Land Use and Legacy Pollution: Environmental, Economic and Sociological Drivers of Watershed Change.” Co-Principal Investigators with R. Nairn, (OU) K. Strevett (OU), M. Yuan (OU), C. Kellogg, (OU), T. Boyer (OSU) and T. Mix (OSU). Total Funding Requested: $1,300,000.00; Sociology portion $90,000.

2004 National Science Foundation Human Social Dynamics Grant Proposal, “The Social Dimensions of Arctic and Sub-Arctic System Changes in Alaska Native Communities.” Co-Principal Investigator with S. Anahita. Total Funding Requested: $600,000.

INTERNAL GRANTS

Funded

2016 College of Arts and Sciences Community Engagement Grant. Mix, Tamara L. and Amy Herrington. “‘Relational, Responsible, and Redemptive’: A Community Engaged Approach to the Development of a Local Food Resource Center.” $2500.00.

2010 Institute for Sustainable Environments Proposal Development Grant. Boyer, Tracy, Tamara L. Mix, Dan Storm, Garey Fox, and Jason Vogel. "Assessing and Adapting to Socio-Economic and Bio-physical Components of Bacterial Water Contamination in the Illinois River, OK." Awarded $5000.00 for proposal development.

2007 College of Arts and Sciences Summer Research Award. "Environmental Inequality and Regional Resilience: Impacts of Energy, Resource and Environmental Hazards on Indigenous Peoples and Communities." Awarded one month's salary.

2007 College of Arts and Sciences Dean's Incentive Grant. "Environmental Justice Organizations and Contaminated Communities: Continuing Work on Environmental Inequalities." Awarded $3000.

2006 College of Arts and Sciences Summer Research Award. "The Impact of Broad Social Forces on Regional Resilience: The Case of Interior Alaska's Predator Control Program" Awarded one month's salary.

2006 Honors College Summer Course Preparation Award. "Contemporary Cultures of the United States New Course Preparation Designed for Diversity Requirements." Awarded one month partial salary.

2006 College of Arts and Sciences Travel Grant. "The Oak Ridge Project: Life, Work and Illness in a Contaminated Community." Awarded $1000.

2006 College of Arts and Sciences Dean's Incentive Grant. "The Impact of Broad Social Forces on Regional Resilience: The Case of Interior Alaska's Predator Control Program." Awarded $3000.

CONFERENCE AND INVITED PRESENTATIONS

Invited Lectures

2019 Invited speaker**.** "Race, Class, and Campus Housing Staff." Diversity Training for OSU Residence Life, Oklahoma State University.

2018 Invited Lecture with F. Bailey Norwood. "Understanding the Scientific and Political Realms of Genetically Modified Organisms (GMOs)." Stillwater Science Café, Oklahoma State University.

2017 Invited Lecture with Duane A. Gill. "Environmental Sociology and Extreme Events." Stillwater Science Café, Oklahoma State University.

2017 Invited speaker. "Environmental Inequality and Food Justice." Food and Culture, Department of History, Oklahoma State University.

2016 Invited speaker with Dakota K. T. Raynes. "Contested Knowledge, Conflicting Reactions." Sustainability Ethics Entrepreneurship Seminar, Natural Hazards Center, University of Colorado-Boulder.

2014 Invited speaker. "Persistence and Change in Environmental Issues: 40 Years of the Environment and Technology Division." Society for the Study of Social Problems Environment and Technology Division, San Francisco, CA.

2012 Invited speaker. "Social Movements: Networking in Action." Emerson-Wier Liberal Arts Symposium at the University of Science and Arts of Oklahoma (USAO).

2000 Roundtable Session. "Navigating the Maze: Women's Graduate School Strategies for Success." Annual meetings of the Mid-South Sociological Association, Knoxville, TN.

International Workshops and Conferences

2007 Mix, Tamara L. "Community Response to Environmental Hazards: Sources of Resilience and Vulnerability." International Workshop on Natural and Human-induced Hazards and Disasters in Africa. Kampala, Uganda.

Conference Presentations

2024 Karki, Srijana* and Tamara L. Mix. "Negotiating Diverse Positionalities: Nepali Immigrants' Lived Experiences and Perceptions of Race and Racism in the United States" American Sociological Association (ASA) Montreal, Quebec Canada.

2024 Schweitzer, Julie and Tamara L. Mix. "The Atom as National Heritage": National Energy Identity and Energy Justice/Injustice in French Media Narratives" American Sociological Association (ASA) Montreal, Quebec Canada.

2024 Schweitzer, Julie and Tamara L. Mix. "'It's the Stupid Food System Here': Emotions, Solidarity, and Community Building in Food Access Spaces" Society for the Study of Social Problems (SSSP), Montreal, Quebec Canada.

2024 Fleming, Olivia* and Tamara L. Mix. "Oklahoma Foragers' Pathways, Practices, and Interactions with Local Wild Foods and Foodscapes." Southern Sociological Society, New Orleans, LA.

2024 Schweitzer, Julie and Tamara L. Mix. "France Appears Exemplary: Nuclear Energy and National Pride in Energy Transition Disputes" Southern Sociological Society, New Orleans, LA.

2023 Esquibel, Jimmy J.* and Tamara L. Mix. "Utilizing Spatial Analysis to Determine Food Pantry Accessibility in Oklahoma." Mid-South Sociological Association, New Orleans, LA.

2023 Fleming, Olivia* and Tamara L. Mix. "Is Access to Food a Right?: Exploring Predictions on the Future of Food Among Oklahoma Foragers" Southern Sociological Society (SSS), Myrtle Beach, SC.

2023 Karki, Srijana* and Tamara L. Mix. "Creating an Ideal Worker: Menstruation in Formal and Informal Workplaces in Kathmandu, Nepal" Southern Sociological Society (SSS), Myrtle Beach, SC.

2020 León-Corwin, Maggie* and Tamara L. Mix. "'An Attack on One of Us is an Attack on All of Us': Intersectional Coalition Building and the Influence of Political Opportunity Structures in Student Organizing." Accepted to the Society for the Study of Social Problems (SSSP), San Francisco, CA. [Cancelled due to COVID].

2020 Karki, Srijana* and Tamara L. Mix. "'Everyone has a monthly cycle! We will not excuse you': Menstrual Taboos within and Beyond the Household, A Qualitative Study Conducted in Kathmandu, Nepal." Accepted to the Society for the Study of Social Problems (SSSP), San Francisco, CA. [Cancelled due to COVID].

2020 Du, Juan*, John Chung-En Liu, and Tamara L. Mix. "China deserves its hamburger: The Controversy over WildAid's 'Shu Shi' Campaign in China." American Sociological Association (ASA), San Francisco, CA.

2019 Karki, Srijana* and Tamara L. Mix. "Menstrual Taboos and Social Norms in an Urban Center." Society for the Study of Social Problems (SSSP), New York.

2019 León-Corwin, Maggie* and Tamara L. Mix. "Student Social Movement Groups, Social Media Use, and Employment of an Intersectional Frame." Southern Sociological Society (SSS), Atlanta GA.

2018 Karki, Srijana* and Tamara L. Mix. "If I can't sign my name, I can't maintain my privacy": Education as a mechanism to resist social control among women pursuing secondary education in Kathmandu, Nepal." Southern Sociological Society (SSS), New Orleans, LA.

2017 Schweitzer, Julie* and Tamara L. Mix. "'Personally, it does not bother me all that much': Risk Perception among Pro-Nuclear and Anti-Nuclear Stakeholders in Post-Fukushima France." Energy Impacts Symposium, Columbus, Ohio.

2017 Karki, Srijana* and Tamara L. Mix. "Types of Social Capital Influencing Women's Education in Kathmandu, Nepal." Southwestern Social Science Association (SSSA), Austin, TX.

2017 Herrington, Amy* and Tamara L. Mix. "Building a Bigger Table: Food Justice, Community Engagement and Social Capital." Southwestern Social Science Association (SSSA), Austin, TX.

2016 Mix, Tamara L. and Dakota K. T. Raynes*. "Emotional Engagement and Organizational Response: Environmental Justice Activism, Induced Seismicity, and the Contentious Politics of Innovative Hydrocarbon Extraction in Oklahoma." Association for Humanist Sociology (AHS), Denver, CO.

2016 Mix, Tamara L. "We Need a Social Scientist Right Now!: Maneuvering the Benefits and Challenges of Interdisciplinary Work in Environmental Studies." Society for the Study of Social Problems (SSSP), Seattle, WA.

2016 Schweitzer, Julie* and Tamara L. Mix. "We Want to Tell the World: Grievance Construction and Tactical Choice in the Idle No More Movement's Missing and Exploited Indigenous Women Narratives." Southern Sociological Society (SSS), Atlanta, GA.

2015 Mix, Tamara L. and Raridon, Andrew*. "Co-existence, Challenge, and Resistance: Mobilizing Alternative Local Food Proponents to Build Resilient Communities." Association for Humanist Sociology (AHS), Portland, OR.

2015 Raridon, Andrew*, Tamara L. Mix and Julie Croff. "'Community Based, Not Community Placed': Using a Community Capacity Approach to Develop a Food Justice Project in North Tulsa, Oklahoma." Society for the Study of Social Problems (SSSP), Chicago, IL.

2015 Caniglia, Beth Shafer, Dakota K.T. Raynes*, Tamara L. Mix and Todd Hallihan. "Stop Fracking Payne County! Understanding the Phases of Early Social Movement Formation." American Sociological Association (ASA), Chicago, IL.

2014 Raridon, Andrew*, Rachel L. Einwohner, and Tamara L. Mix "'Workarounds and Roadblocks': Framing Risk in Local Pasture-Based Livestock Operations in Oklahoma." American Sociological Association (ASA), San Francisco, CA.

2014 Mix, Tamara L. and Kelley Sittner Hartshorn. "'We Will Be Idle No More': Legacies of Protest, Political Opportunity, and Claims Making in the Social Media Narratives of a Canadian First Peoples Social Movement." Society for the Study of Social Problems (SSSP), San Francisco, CA.

2014 Schweitzer, Julie* and Tamara L. Mix. "Keeping the Larzac Plateau: French Activists against Social Control." Society for the Study of Social Problems (SSSP), San Francisco, CA.

2014 Facci, Anna C.*, Solida Kolasinac*, Kelley J Sittner Hartshorn, and Tamara L. Mix, "Giving Voice to Left Behind Communities: The Use of Social Media in Understanding the Idle No More Movement." Midwest Sociological Society (MSS), Lincoln, Nebraska.

2014 Mataic, Dane R.*, Tamara L. Mix, and Kelley J Sittner Hartshorn "Environmental Justice and Indigenous Identity in the Idle No More Movement." Midwest Sociological Society (MSS), Lincoln, Nebraska.

2013 Elsasser, Shaun W.* and Tamara L. Mix. "'You're Calling Me What?': Historical Context, Exclusion and Misnaming of the GLBTQ Community in Social Science Survey Research." Society for the Study of Social Problems (SSSP) Annual Meetings, New York, NY.

2012 Tucker-Trainum, Tess* and Tamara L. Mix "Building a Garden, Shaping Space and Place: Narratives and Meanings in a Newly Emergent Garden Community." Society for the Study of Social Problems (SSSP) Annual Meetings, Denver, CO.

2012 Tamara L. Mix. "From 'Cowboys and Indians' to 'Water Warriors': Building Unlikely Alliances and Social Capital in a Water Resource Controversy." Society for the Study of Social Problems (SSSP) Annual Meetings, Denver, CO.

2008 Mix, Tamara L. "Building Networks and Creating Alliances: Environmental Justice Organizations and the Use of Coalitions." Society for the Study of Social Problems (SSSP) Annual Meetings, Boston, MA.

2008 Mix, Tamara L. and Sine Anahita. "Stakeholder Dynamics in Wildlife Conflicts: The Case of Alaska's Predator Control Controversy." Midwest Sociological Association (MSS) Annual Meetings, St. Louis, MO.

2007 Cable, Sherry, Thomas E. Shriver and Tamara L. Mix. "Invisible Injuries of the Risk Society: Contested Illness among Nuclear Weapons Workers." American Sociological Association (ASA) Annual Meetings, New York, NY.

2007 Mix, Tamara L. and Sine Anahita. "Crafting Environmental Conflict: Media Representation in Alaska's 'War' on Wolves." Midwest Sociological Association (MSS) Annual Meetings, Chicago, IL.

2006 Mix, Tamara L., Thomas E. Shriver and Sherry Cable. "The Story of CHE: Environmental Challenges in the Atomic City." American Sociological Association (ASA) Annual Meetings, Montreal, Quebec, Canada.

2006 Cable, Sherry, Thomas E. Shriver and Tamara L. Mix. "Invisible Injuries: Contested Illness among Oak Ridge Nuclear Workers." Pacific Sociological Association (PSA) Annual Meetings, Hollywood, CA.

2005 Anahita, Sine and Tamara L. Mix. "Meat for Our Table: Retro Frontier Masculinity and the War against Alaska's Wolves." American Sociological Association Annual Meetings, Philadelphia, PA.

2005 Anahita, Sine and Tamara L. Mix. "Wolves, Posey Sniffers, and Alaskan Men: Competing Public Masculinities." Midwest Sociological Society (MSS) Annual Meetings, Minneapolis, MN.

2005 Mix, Tamara L. and Sine Anahita. "Flying Fur: An Analysis of Power and Politics among Stakeholders in the Interior Alaska Aerial Wolf Control Controversy." Pacific Sociological Association (PSA) Annual Meetings, Portland, OR.

2005 Anahita, Sine and Tamara L. Mix. "Wolf Control as Toxic Masculinity." Pacific Sociological Association (PSA) Annual Meetings, Portland, OR.

2004 Mix, Tamara L. and Sine Anahita. "Power and Politics: A Content Analysis of the Aerial Wolf Control Controversy in Interior Alaska." Society for the Study of Social Problems (SSSP) Annual Meetings, San Francisco, CA.

2004 Mix, Tamara L. and Sherry Cable "'How They See Us Makes A Difference': Social Class and Coalition Building in the Contemporary Environmental Movement." Society for the Study of Social Problems (SSSP) Annual Meetings, San Francisco, CA.

2004 Nelta M. Edwards, Tamara L. Mix and Peter J. Fix "Wide Open Spaces: Comparisons and Contradictions of Sprawl in Small Cities." Society for the Study of Social Problems (SSSP) Annual Meetings, San Francisco, CA.

2004 Anahita, Sine and Tamara L. Mix. "Stifled Howls: The Politics of Wolf Control in Alaska." Rural Sociological Society (RSS) Annual Meetings, Sacramento, CA.

2003 Cable, Sherry and Tamara L. Mix. "Economic Imperatives and Race Relations: The Rise and Fall of the American Apartheid System." American Sociological Association (ASA) Annual Meetings, Atlanta, GA.

2003 Mix, Tamara L. "Strangers in the Plight: Class Perceptions and Coalitions in the Contemporary Environmental Movement." Society for the Study of Social Problems (SSSP) Annual Meetings, Atlanta, GA.

2002 Cable, Sherry, Tamara L. Mix and Donald W. Hastings "Mission Impossible? Environmental Justice Movement Collaboration with Environmentalists and Academics." American Sociological Association (ASA) Annual Meetings. Chicago, IL.

2001 Cable, Sherry, Donald W. Hastings and Tamara L. Mix "Different Voices, Different Venues: Environmental Racism Claims by Activists, Researchers and Lawyers." Southern Sociological Society (SSS) Annual Meetings, Atlanta, GA.

2000 Mix, Tamara L. "Symbolic Sickness: Activism and Identity in a Worker Health Movement." Mid-South Sociological Association (MSSA) Annual Meetings, Knoxville, TN.

2000 Mix, Tamara L. "Differential Perceptions of Risk and Recreancy: Community Conflict in the Atomic City." American Sociological Association (ASA) Annual Meetings, Washington, DC.

2000 Mix, Tamara L. "Contamination, Trust, Risk and Recreancy: Divisions in the Oak Ridge Community." Southern Sociological Society (SSS) Annual Meetings, New Orleans, LA.

1998 Mix, Tamara L. "Environmental Racism by Design? The Case of the Scarboro Community." Society for the Study of Social Problems (SSSP) Annual Meetings, San Francisco, CA.

1998 Mix, Tamara L. "Toxic Contamination from Behind the Fence: A Legacy of Environmental Racism." Southern Sociological Society (SSS) Annual Meetings, Atlanta, GA.

Poster Presentations

2017 Raynes, Dakota K. T.* and Tamara L. Mix. "Rigging the Risk Game?: Manufacturing Consent and Delimiting Dissent in an Unconventional Resource Extraction Case." Energy Impacts Symposium, Columbus, OH.

2014 Croff, Julie M., Tamara L. Mix and Andrew Raridon*. "Planning and Implementation of a Mobile Market: Examining Community Capacity." American Academy of Health Behavior, Charleston, SC.

2004 Mix, Tamara L., Nelta M. Edwards and Peter J. Fix. "Tracing the Patterns of Urban Sprawl: An Analysis of Two Cities in the Far North." American Association for the Advancement of Science (AAAS)/EPSCoR poster session, Anchorage, AK.

2004 Anahita, Sine and Tamara L. Mix. "Wolves as Political Problems: Shifts in Wolf Control Policies in the US & Alaska." Poster Session of the Rural Sociological Society (RSS) Annual Meetings, Sacramento, CA.

2004 Anahita, Sine and Tamara L. Mix. "The Politics of Wolf Control: Tracing the Shifting Patterns of Wolf Control in Alaska." Poster session of the International Arctic Social Sciences Association Meetings, Fairbanks, AK.

COURSES TAUGHT

<u>Undergraduate</u>

SOC 1113	Introductory Sociology (S)
SOC 2123	Social Problems (DS)
SOC 2890	Honors Experience in Sociology
SOC 3223	Social Psychology (S)
SOC 3323	Collective Behavior and Social Movements
SOC 4383	Social Stratification (S)
SOC 4433	Environmental Sociology (S)
SOC 4453	Environmental Inequality (S)
HONR 3043	Contemporary Cultures of the United States (DS)

<u>Graduate</u>

SOC 5001	Graduate Proseminar
SOC 5063	Seminar in Social Inequality and Stratification
SOC 5273	Qualitative Research Methods
SOC 5283	Advanced Qualitative Sociological Research
SOC 5323	Seminar on Collective Behavior and Social Movements
SOC 5493	Seminar in Environmental Justice

SERVICE TO THE PROFESSION

Elected Professional Positions

2012-2014 Chair. Publications Committee, Section on Environmental Sociology of the American Sociological Association.
2010-2011 Chair. Erwin O. Smigel Award Committee for the Society for the Study of Social Problems.
2009-2010 Chair-Elect. Erwin O. Smigel Award Committee for the Society for the Study of Social Problems.
2004-2006 Chair. Environment and Technology Division of Society for the Study of Social Problems.

Appointed Professional Positions

2024-2027 Editorial Board Member. *Social Problems*.
2019-2020 Member. Charles Tilly Distinguished Contribution to Scholarship Book Award Committee, Collective Behavior and Social Movements Section of the American Sociological Association.
2016 Member. Brent K. Marshall Student Paper Competition Committee, Environment and Technology Division of the Society for the Study of Social Problems.
2006 Chair. Environment and Technology Division Student Paper Competition, Society for the Study of Social Problems.
2005 Co-Chair. Environment and Technology Division Student Paper Competition, Society for the Study of Social Problems.
2003 Interim Chair. Environment and Technology Division, Society for the Study of Social Problems.
2000 Co-Chair. Environment and Technology Division Student Paper Competition, Society for the Study of Social Problems.
1999 Co-Chair. Environment and Technology Division Student Paper Competition, Society for the Study of Social Problems.

Conference Organizing

2024 Presider. "Section on Environmental Sociology Roundtables/Table 17: Media Frames and Narratives." American Sociological Association, Montreal, Quebec, Canada.
2014 Organizer. "Persistence and Change in Environmental Issues: 40 Years of the Environment and Technology Division." Environment and Technology Division, Society for the Study of Social Problems, San Francisco, CA.
2013 Organizer. "Environmental Privilege: Wealth, Waste, and Inequality." Environment and Technology Division, Society for the Study of Social Problems, New York, NY.
2012 Organizer. "Community Gardens, Parks, and Public Places: Inclusion and Exclusion and the Meaning of Space." Environment and Technology Division, Society for the Study of Social Problems, Denver, CO.
2010 Organizer. "Issues in Environmental Sociology – Roundtable." Environment and Technology Division, Society for the Study of Social Problems, Atlanta, GA.
2009 Organizer. "Issues in Environmental Sociology." Environment and Technology Division, Society for the Study of Social Problems San Francisco, CA.
2008 Organizer. "Activist Scholarship, Symbolic Politics and Environmental Struggles." Environment and Technology Division, Society for the Study of Social Problems Boston, MA.

2007 Rapporteur. "Tectonic, Subsidence and Denudation Analysis." International Conference on the East African Rift System, Kampala, Uganda.
2006 Organizer. "Is the Global Local? Implications of Globalization on the Environment." Environment and Technology Division, Society for the Study of Social Problems, Montreal, Quebec, Canada.
2005 Organizer. "From Environmental Policy to Environmental Justice: Current Issues in Environment and Technology." Environment and Technology Division, Society for the Study of Social Problems Philadelphia, PA.
2004 Organizer. "Communities, Coalitions and the Environment." Environment and Technology Division, Society for the Study of Social Problems, San Francisco, CA.
2004 Presider and Discussant. "Power in Words: Changing Representations of Animals." Environment and Technology Division, Society for the Study of Social Problems, San Francisco, CA.
2004 Presider and Discussant. "Power, People and Animals: Historical Reflections and Contemporary Insights." Environment and Technology Division, Society for the Study of Social Problems, San Francisco, CA.
2004 Member. Organizing Committee. International Conference of Arctic Social Sciences V (ICASS V), International Arctic Social Sciences Association (IASSA), Fairbanks, AK.
2004 Poster session organizer. International Conference of Arctic Social Sciences V (ICASS V), International Arctic Social Sciences Association (IASSA), Fairbanks, AK.
2003 Organizer. "Environment and Technology General Session." Society for the Study of Social Problems, Atlanta, GA.
2000 Member. Local Arrangements Committee. Mid-South Sociological Association, Knoxville, TN.
2000 Co-Organizer. "Environment and Technology General Session." Environment and Technology Division, Society for the Study of Social Problems, Washington, DC.
1999 Co-Organizer. "Environment and Technology General Session." Environment and Technology Division, Society for the Study of Social Problems, Chicago, IL.

Reviewer for: *American Sociological Review*, *American Journal of Sociology*, *Social Problems*, *Gender & Society, The Sociological Quarterly, Social Science Quarterly, Mobilization, Human Ecology Review, Social Forces, Sociological Perspectives, Nature & Culture, Social Currents, Environmental Sociology, Environmental Politics, Journal of Social Issues, Organization & Environment, Sociological Forum, Journal of Rural Studies, Law & Society Review, Rural Sociology; Social Science & Medicine.*

SERVICE TO THE DEPARTMENT

2015-2020 Chair. Social Movements Graduate Concentration Area.
2014-2018 Director. Sociology Graduate Program.
2014-2018 Chair. Graduate Program Committee.
2017-2018 Chair. Faculty Search Committee.
2017-2019 Member. Personnel Committee.
2015-2017
2013-2015
2006-2008
2007- 2019 Member. Graduate Program Committee.
2011-2017 Member (ex-officio). Assessment Committee.
2005- Member. Doctoral Specialty Area Comprehensive Exam Committee Pool.
2005-2015 Member. Methods Preliminary Doctoral Exam Committee.
2014-2015 Member. Department Head Search Committee.
2007-2008
2005-2014 Faculty Advisor. Alpha Kappa Delta International Sociology Honor Society.
2007-2011 Chair. Assessment Committee.
2006-2007 Member. Undergraduate Program Committee.
2006-2007 Co-Chair. Ad-hoc Committee for Departmental Assessment.

2005-2006	Member. Ad-hoc Committee for Departmental Assessment.
2003-2004	Member. Curriculum Revision Committee, University of Alaska Fairbanks.
2003-2005	Faculty Advisor. Alpha Kappa Delta, University of Alaska Fairbanks.
2002-2003	Member. Sociology Search Committee, University of Alaska Fairbanks.

SERVICE TO THE COLLEGE AND UNIVERSITY

2024-2026	Member. HLC Institutional Accreditation Subcommittee 3.
2023-2025	Faculty Fellow for General Education Reform. OSU University-wide Strategy Planning.
2023-2024	Member. Political Science RPT Committee.
2021-2022	Chair. General Education Task Force – OSU University-wide Strategy Planning.
2022	Returning Officer. Department of English Department Head Search.
2021-2022	Chair. Political Science Department Head Search Committee.
2021-2022	Member. 2021 OSU Regents Distinguished Research Award Committee.
2019-	Member. NOC Behavioral Sciences Advisory Board.
2018-2024	Member. General Education Advisory Council (GEAC).
2018-2019	Member. CAS RPT Committee.
2018-2019	Member. Political Science RPT Committee.
2016-	Alternate. Institutional Review Board (IRB).
2013-2016	Vice Chair. Institutional Review Board (IRB).
2014-2017	Member. University Scholarship Committee.
2007-2016	Member. Institutional Review Board (IRB).
2014	Interim Chair. Institutional Review Board (IRB) (7/2014 - 8/2014).
2013-2014	Member. Honors College Dean Search Committee.
2006-2014	Academic Integrity Facilitator.
2011-2013	Co-Facilitator. University Assessment and Testing Workshop Series: "Teaching and Assessing Diversity in your Class."
2008-2011	Member. Arts and Sciences Curriculum Committee.
2006	Blind Reviewer. Arts and Sciences FY07 Travel Grant Round Two Program.
2005-2008	Co-Advisor. ECO-OSU student environmental organization.
2005	Member. Center for Global Change Steering Committee, University of Alaska Fairbanks.
2004-2005	Member. Social Science Conference Committee, University of Alaska Fairbanks.
2004-2005	Member. Global Studies/International Studies Minor Committee, University of Alaska Fairbanks.

SERVICE TO THE COMMUNITY

2017	Adviser to OSU Department of Art Studio Methods course for creation of the Loclahoma Grown Mural appearing in Food Pyramid, Stillwater, OK.
2015-2016	Member. Stillwater City Charter Review Committee.
2015	Speaker. Stillwater Planning Commission, Stillwater City Council, Payne County Commission.
2015	Speaker. Science Café Norman. "Well, you *do* live on an oilfield…": An Environmental Sociology Perspective on Hydraulic Fracturing." Norman, OK.
2014	Panel Member. Science Café: A Stillwater Community Program. "Oil and Gas Exploration Updates." Stillwater, OK. [Series winner of the Excellence in Library Programming Award from the American Library Association].
2011	Panel member. Sociology Graduate Student Organization film series "Tapped."
2005	Speaker. Lecture to Environmental Science undergraduate organization on "Environmental Sociology."
2005	Panel member. ECO-OSU film series "Oil on Ice."

2005	Unpaid consultant. Provided Tulsa Partner's Inc. assistance in development of an education plan and early assessment measure for an EPA Education Grant for the "EcoSafe Home," a sustainable and disaster aware home to be built at the Tulsa Zoo.
2004	Speaker. Americorp Vista Training Session. Topic: Grassroots Organizing. Fairbanks, AK.
2000	Speaker. Keep America Beautiful Regional Forum. Gatlinburg, TN.

SELECT MEDIA COVERAGE OF RESEARCH

Luther, Tanner and Oklahoma Oral History Research Program. 2018. "Christmas on the Farm." Amplified Oklahoma, Episode 32 (https://soundcloud.com/amplified-oklahoma/ao-e32).

Buhl, Larry. 2016. "Fracking-linked Earthquakes Open Sociopolitical Rifts in Oklahoma." Free Speech Radio News, March 24 "(http://fsrn.org/2016/03/fracking-linked-earthquakes-open-sociopolitical-rifts-in-oklahoma/#).

Wertz, Joe. 2015. "Oklahoma Lawmakers Pass Measure Preventing Local Fracking Bans" *NPR Morning Edition*, May 26 (http://www.npr.org/2015/05/26/409671989/oklahoma-lawmakers-pass-measure-preventing-local-fracking-bans).

Wertz, Joe. 2015. "Stillwater Approves New Oil and Gas Rules, Industry Says They Might Violate New Law" *State Impact*, July 21 (https://stateimpact.npr.org/oklahoma/2015/07/21/stillwater-approves-new-oil-and-gas-rules-industry-says-they-might-violate-new-law/).

Charles, Michelle. 2015. "City pushes oil and gas ordinance to mid-June." *Stillwater News Press,* May 19 (http://www.stwnewspress.com/news/city-pushes-oil-and-gas-ordinance-to-mid-june/article_ea5f3a40-fdd9-11e4-ab72-5b8ea0b52443.html).

Wertz, Joe. 2015. "City Officials Reconsider Drilling Ordinances as Anti-Frack Ban Legislation Moves Forward." State Impact, April 30 (https://stateimpact.npr.org/oklahoma/2015/04/30/city-officials-reconsider-oil-and-gas-ordinances-as-anti-frack-ban-legislation-moves-forward/).

Overall, Michael. 2015. "Too Close to Home: An Oil Well in Stillwater Pumps up Controversy Statewide." Tulsa World, April 18 (http://www.tulsaworld.com/news/state/too-close-to-home-an-oil-well-in-stillwater-pumps/article_ee022d9c-246e-508f-862d-e46316650ba9.html).

Charles, Michelle. 2015. "Stillwater City Councilors Don't Ban Drilling." *Stillwater News Press,* January 23 (http://www.stwnewspress.com/news/stillwater-city-councilors-don-t-ban-drilling/article_2e93d1b6-a2be-11e4-9208-2ff445dd953f.html.

Sando, Megan. 2014. "TOP STORIES OF 2014 – No. 3: Cause of Quakes Still in Debate." *Stillwater News Press*, December 28 (http://www.stwnewspress.com/news/top-stories-of-no-cause-of-quakes-still-in-debate/article_8e1eeada-8e3c-11e4-8569-ef789bf7681f.html).

Sando, Megan. 2014. "Fracking and Earthquakes Hot Topics at Science Café." *Stillwater News Press*, November 21 (http://www.stwnewspress.com/news/fracking-and-earthquakes-hot-topics-at-science-cafe/article_7060f44e-713a-11e4-b93d-576b2817c27f.html).

GRADUATE STUDENT COMMITTEES

Ph.D. Committee Chair or Co-Chair

Katie Ross (Co-Chair with S. Perkins, 2013)
Kristin Waldo (2013)
Dakota Raynes (2018)
Julie Schweitzer (2019)
Grisha Rawal (2019)
Jamie Du (2021)
Srijana Karki (2021)
Olivia Fleming (2023)
Jimmy Esquibel (2025)

Ph.D. Committee Member
Dennis Kennedy (2008)
Collin Davidson (Psychology, 2010)
James Mason (2011)
Vicky Elias (2011)
Paul Stermer (Psychology, 2012)
Jeremy Ross (2012)
Basudhara Sen (2013)
Barb Russo (Fire and Emergency Management, 2013)
Andrea Moore (Environmental Science, 2013)
Natalee Tucker (December 2014)
Valerie Settles (Design, Housing and Merchandising, 2014)
Rich Ellefritz (2014)
Angela Andrade (Psychology, 2014)
Yano Procipio (Counseling Psychology, 2015)
Robert Drinkwater (Counseling Psychology, 2016)
Shari Zimmerman (School of Education, 2017)
Julianne Richard (School of Education, 2017)
Colton Brown (Counseling Psychology, 2017)
Jerrod Yarosh (2017)
Andrew Raridon (Sociology at Purdue University, 2017)
Shaun Peevesasser (2020)
Donna Sharp (School of Education, 2020)
Christina Lane (English, 2021)
Michelle Estes (2021)
Christine Fuston (Community Health and Counseling Psychology, 2022)
Adam Straub (2022)
Christine Thomas (2022)
Ashley Knoch (Integrative Biology, 2022)
Dhruba Sinha (2023)
Jessica Schachle (2024)
Sarah Hileman (Integrative Biology, 2025)
Belal Hossain (2025)
William Smith (Rhetoric and Writing Studies, 2025)
Kristen Bailey (School of Education, 2025)
Pavithra Selvakumar (Environmental Science, 2025)
Kamala Shrestha (2026)

MS Committee Chair or Co- Chair
Kathryn Freeman Anderson (Co-chair with A. Fullerton, 2011)
Candace Moore (2011, Creative Component)
Tess Tucker-Trainum (2012)
Andrew Raridon (2013)
Sonni Kolasinac (2014, Creative Component)
Dane Mataic (2014)
Anna Facci (2014)
Samantha West (2015)
Srijana Karki (2016)
Mark Beaven (2016)
Erin Moore (2016)
Amy Herrington (2017)

Afra Sayara Rahman (2025)

MS Committee Member
Wendy Brame (2006)
Vicki Elias (2007)
Cara Adney (2007)
Rachel Gurney (2012)
Tina Dicks (2013)
Alma Garza (2013)
Sarah Kosmicki (2013)
Jenny Nguyen (2013)
Julie Schweitzer (2013)
Cassidy Ladd (International Studies, 2014)
Laken Pruitt (2015)
Bridget Kerner (2015)
Don Adkins (2016)
Alli Holmes (2016)
Grant Samms (2016)
Kathleen Reddick (2017)
Dhruba Sinha (2017)
Adam Straub (2017)
Jake DeFlitch (2018)
Asger Ali (2019)
Jesse Lane (2019)
Lara Goncalves (2021)
Kugbeme Isumonah (2023)
Aishwarya Ahmed (2025)

Undergraduate Honors Thesis Students and Research Scholars
Erica Hurley (Member, 2006)
Lacey Ponder (Chair, 2007)
Hannah Haiken (Member, 2011)
Jourdan Johnson (Member, 2013)
Kevin Gonzales (Member, 2014)
Emily Bjorklund (Research Advisor, 2016)

PROFESSIONAL MEMBERSHIPS

American Sociological Association
Alpha Kappa Delta
Society for the Study of Social Problems
Oklahoma Sociological Association

REFERENCES

Available upon request.

Attachment 6

Technical Report: Geologic and Hydrogeologic Concerns Associated with the Proposed Pushmataha County Pumped Storage Hydroelectric Project on the Kiamichi River near Albion, Oklahoma

by
Ethan Schuth, P.G. (Texas; No. 15122) & President of ES Environmental LLC

Prepared for
Chickasaw Nation and the Choctaw Nation of Oklahoma

October 29, 2024

I. EXECUTIVE SUMMARY

1. I submit this report in response to Southeast Oklahoma Power Corporation's ("SEOPC") Filing of Notice of Intent to File an Application for an Original License and Pre-Application Document, and Request to be Designated as FERC's Non-Federal Representative for the Purposes of Informal Consultation under Section 106 and Section 7 for the Pushmataha County Pumped Storage Project (P-14890), eLibrary no. 20240507-5119 (May 7, 2024), as noticed by the Federal Energy Regulatory Commission ("FERC" or "Commission") on July 8, 2024. *See* eLibrary no. 20240708-3054. I am providing this report solely in my capacity as President of ES Environmental LLC, on behalf of the Chickasaw Nation and Choctaw Nation of Oklahoma. My curriculum vitae is attached.

2. The Pushmataha County Pumped Storage Hydroelectric Project's ("project") proposed to be located in the Kiamichi and Little River Basins requires further in-depth and site-specific geotechnical, hydrogeological, and geoengineering analyses to identify the full scope and significance of potential project impacts. These analyses need to evaluate the project's impact on groundwater levels, preferential flow

and recharge pathways, and water quality in the localized Kiamichi River-associated alluvium and terrace deposits and the regional Kiamichi Minor Groundwater Basin ("KMGB"). A specialized geoengineering analysis of the structural competency of the Stanley and Jackfork Groups, which will house the main components of the Project, needs to be evaluated appropriately since both Groups are known flysch deposits with low strength attributes. Additionally, a comprehensive site-specific seismicity survey should be conducted to identify unknown or blind faults occurring at the location since the Oklahoma Geologic Survey has identified multiple faults near the Project with optimal and moderately optimal fault orientations susceptible to natural and triggered seismicity.

II. INTRODUCTION

3. SEOPC has proposed the development of a 1,200-megawatt pumped storage hydroelectric facility near the community of Albion, Oklahoma. This report identifies geologic and hydrogeologic concerns within the proposed project area that require additional site-specific evaluations.

4. This Project's primary facilities will span 10,659.72 acres across the Kiamichi and Little River Basins of southeastern Oklahoma in the Choctaw Nation of Oklahoma's Reservation. The Pre-Application Document (SEOPC, 2024) estimates the facility will require 68,269 acre-feet ("AF") of water withdrawn over a 24- to 36-month period from the Kiamichi River to initially fill the project's reservoirs. The project will have an estimated annual replacement need of approximately 20,000 AF to account for system leakage and evaporative losses. The project's lower reservoir, regulating pond,

water intake system, powerhouse/pump house, and over half of the underground tunnels utilized for moving water between the proposed reservoirs are located in the Kiamichi River Basin, with only the upper reservoir and associated appurtenances located in the Little River Basin. The proposed location of the Project is shown in Figure 1 (SEOPC, 2024).

5. Geologic characteristics of the formations within the project area could contribute to structural integrity concerns represented as geohazards due to formation competency and the potential occurrence of unknown and blind faults within or immediately adjacent to the project area. Hydrogeologic impacts from the project's anticipated large-scale excavation and high-elevation reservoir location could significantly impact surface and groundwater levels, disrupt groundwater flow and recharge pathways, and impact water quality in local aquifer systems. The geologic and hydrogeologic attributes of the project's location significantly increase the likelihood of underestimated leakage rates from all the proposed reservoirs, which would require increased annual replacement water withdrawals from the Kiamichi River.

III. GEOLOGY AND HYDROGEOLOGY IN THE PROJECT AREA

6. The project's primary pumped storage facilities are located across four (4) distinct geologic formations: the Stanley Group, the Jackfork Group, the Kiamichi River-associated terrace deposits, and the Kiamichi River-associated alluvium deposits. Each formation or deposit has its own unique lithological, structural, and stratigraphic characteristics and competencies that will need to be evaluated prior to the construction of the facilities. This Project also spans the KMGB, which usually includes the smaller

and more localized Quaternary terrace and alluvium deposits associated with the Kiamichi River Valley (Wilkins, 2001). These deposits have vastly different porosity and permeability characteristics than the other predominate Mississippian and Pennsylvanian aged strata that comprise most of the KMGB. For this report, the alluvium and terrace deposits have been separated.

7. The Stanley Group is Mississippian in age and composed of two formations: the basal Tenmile Creek Formation and the upper Moyer Formation. This group "consists of mostly non-resistant olive-green to gray shales," with thin sporadic beds of massive fine to very fine-grained wacke sandstones, and interbedded siltstones. This formation is easily weathered and forms valleys within the Ouachita Mountain system (Pitts et al., 1982).

8. The Jackfork Group is a Pennsylvanian-aged deposit composed of multiple interbedded sandstone and shale sequences with some laterally unmapped units across the region. The lithology of the Jackfork Group is considered to have a 3 to 2 ratio of massively bedded fine-grained sandstones to darker fissile shales. The increase in alternating lithology within the Jackfork Group promotes surface water infiltration into the KMGB along the contacts of the sandstone and shale beds (Wilkins, 2001). However, it can vary greatly throughout the Kiamichi River Valley. The Jackfork and the Stanley Groups have been identified as flysch deposits, deep-sea depositional environments with deep-marine turbidite sandstones and shale sequences. The Stanley Group is a more distal facies (farther from the source of sedimentation) due to its increased shale content. The Jackfork Group is considered a more intermediate to proximal facies (closer to the

sediment source) due to its increased sandstone content (Niem, 1976). Sandstone units within the Jackfork Group tend to be more resistant to weathering than the shales. Though the Jackfork Group sandstones are more resistant, faulting within both Groups has been documented (Pitt et al., 1982).

9. The Kiamichi River-associated Quaternary-aged terrace deposits are composed of clay, sand, silt, and gravel up to 30 feet thick (Figure 2). These deposits are generally located 20 to 25 feet above the floodplain of the Kiamichi River. The contacts between the alluvium deposits can be gradational, making differentiating between the deposits difficult in some areas (Pitt et al., 1982). Due to their primarily unconsolidated nature, terrace deposits can have high porosity and permeability. Groundwater wells screened within terrace deposits can produce variable quantities of water ranging from 10 to 500 gallons per minute, dependent on localized deposit characteristics such as sand and silt content. This range allows for these deposits to potentially provide substantial groundwater volumes for domestic and commercial users (Johnson, 1983).

10. The Kiamichi River-associated Quaternary-aged alluvium deposits are the most recent deposits within the Kiamichi River Valley and consist primarily of sand, silt, clays, and gravels, usually having a thickness of 30 feet or less (Figure 2) (Pitt et al., 1982). Alluvium deposits share similar characteristics with terrace deposits, which have high porosity and permeability allowing them to transmit water readily throughout the deposit. "Special care must be taken in the utilization of lands underlain by these deposits," as their water quality can be significantly impacted by contaminants (Johnson, 1983). Due to both high porosity and permeability characteristics of the Kiamichi River-

associated alluvium and terrace deposits, water quality and quantity could be greatly impacted by overlying construction activities. Site-specific geotechnical analyses should be conducted to identify characteristics of the underlying deposits to prevent any introduction of contaminants associated with construction or development of land from occurring. Degradation of any alluvial or terrace groundwater has a high likelihood of negatively impacting surface water quality and flows. This is due to the innate nature of alluvium groundwater systems having direct and continual interactions with surface waters that provide base flows to rivers (Winter, 2013).

11. The KMGB covers approximately 3,020,000 acres of southeastern Oklahoma and includes the Stanley and Jackfork Groups that are located on the proposed project site. The availability of groundwater resources is controlled by the "lateral and vertical distribution of rock units, the geologic structures, and physical characteristics, particularly permeability" (Wilkins, 2001). The KMGB's principal mechanism for recharge and water movement throughout the system is both through the "exposed bedding planes between the layers of sandstone and partings between laminae of shale, in addition to any faults, fractures, or formation jointing," occurring within the system (Wilkins, 2001). The faults, fractures, and jointing plane can act as "water conduits," allowing the movement of water through the system and providing usable amounts of water for domestic uses (Wilkins, 2001). The extent of structural deformation and proximity to faults within the KMGB at the proposed project's location could substantially change groundwater availability and potential yields if preliminary hydrogeologic evaluations are not conducted (Wilkins, 2001).

12. The faulting and folding of geologic formations in Pushmataha County and on the project site can be attributed to large-scale compressional forces that created the Ouachita Mountains. Though faulting can be difficult to observe due to the covered nature of the Ouachita Mountains, it does occur in abundance throughout the region and across most formations in the Kiamichi River Valley. Faults identified within this region are usually high-angle reverse faults (Pitt et al., 1982). The Oklahoma Geological Survey has identified multiple faults with optimal and moderately optimal orientations occurring in the Ouachita Mountains that could rupture naturally or from triggered seismicity (Darold & Holland, 2015).

IV. GEOLOGIC AND HYDROLOGIC CONCERNS

13. The geological and hydrological conditions in the proposed project area make the potential for unaccounted water losses due to leakage from project reservoirs more likely. The proposed Project's regulating pond and the lower reservoir would be located within the unconsolidated-undifferentiated alluvium and terrace deposits within the Kiamichi River Valley floor. Those deposits can have much higher porosity and permeability than the underlying KMGB strata of the Jackfork and Stanley Groups, potentially causing large volumes of water to leak into or out of the regulating pond and lower reservoir from a change in hydraulic gradients (Johnson, 1983).

14. The development of the regulating pond and lower reservoir would initially create an area of void space within the deposit causing subsurface flow paths to be redirected into them. Afterwards, with increases in the water level of both features from surface water pumping, those subsurface flows paths would be reversed pushing

water into the deposits along with any potential contaminants. This would also increase the need of additional surface water pumping because the previously pumped and captured water would be pushed into the deposits from an increased hydraulic gradient from elevated water levels in the regulating ponds and the lower reservoir. The regulating pond and lower reservoir would also be partially sited within the Stanley Group, which is primarily recharged via faults, fractures, and jointing planes that occur sporadically throughout the group.

15. The upper reservoir would be located in the Jackfork Group, which has multiple alternating sandstone and shale layers potentially acting as recharge zones in addition to any fault or fracture planes (Wilkins, 2001). Both the alternating layers of sandstone and shale, along with the faults, fractures, and jointing planes could significantly contribute to unaccounted water loss or gain into the proposed Project with unknown impacts on localized groundwater levels from changes in hydraulic gradient differentials, regional surface water flow rates, and water quality. If unaccounted water loss from the Project reservoirs occurs, it will require more than the estimated 20,000 AFY annual replacement amount. Unaccounted losses from reservoir leakage could impact localized groundwater levels by artificially increasing them and potentially transferring any contaminates from the project's features into the groundwater systems.

16. The structural competence of the Stanley Group is dramatically lower than that of the overlying Jackfork Group due to its high shale content, non-resistant, and easily erodible nature (Pitt et al., 1982). Any construction project developing underground facilities or tunneling in known flysch deposits (Stanley and Jackfork

Groups) should undergo specialized geoengineering characterization due to the general nature of these deposits being "low strength and tectonically disturbed" (Marinos, 2014). Flysch deposits can also "produce heavily sheared and chaotic masses," making additional geotechnical and geoengineering evaluations necessary to avoid or identify potential points of failure, geohazards, and supplementary construction mitigation measures (Marinos, 2014).

17. Additional considerations must be given to the potential seismic activity in the proximity of the proposed Project. While earthquakes within the Ouachita Mountains are rare, the Oklahoma Geologic Survey has identified multiple faults in the vicinity with optimal and moderate optimal fault orientations that could pose a major risk for naturally occurring and triggered seismicity (Darold & Holland, 2015). *See* Figure 3. Due to the extensive faulting and folding throughout the Ouachita Mountains and the proposed project location, a comprehensive seismic survey is highly recommended to ensure any unknown or blind faults are identified, documented, and taken into account prior to the development of the Project.

18. Due to the general scope of the proposed Project, site-specific baseline hydrogeologic evaluations need to be conducted and subsequent long-term monitoring plans of the Kiamichi River-associated terrace and alluvium deposits and underlying KMGB need to be developed. The baseline data and long-term monitoring plan would be important to preventing the project's pumped storage facilities from adversely impacting groundwater levels and water quality, or impeding preferential groundwater flow paths that provide supplementary base flows to the Kiamichi River. The withdrawal of water

from moderately high flow events that are just above the 1.5 foot weir could impact alluvium deposit recharge rates and would need to be fully evaluated to avoid potential impacts to this resource. Baseline hydrogeologic evaluations prior to the full design and construction of the project are paramount for preventing adverse long-term impacts on the Kiamichi River's geomorphological characteristics, water quality, and seasonally variable flow rates.

V. SUMMARY

19. The proposed regulating pond and lower reservoir of the proposed project would be located in alluvium and terrace deposits with higher porosity and permeability, making unaccounted water loss or gains from the system likely. The regulating pond, upper reservoir, and lower reservoir would be located in or on top of the KMGB system, causing impacts related to changes in hydraulic gradient. The hydraulic gradient changes would impact the local groundwater levels, leading to impacts on supplemental base flow rates in the Kiamichi River from groundwater discharges, especially during drought events. Water quality could be impacted if unidentified faults, fractures, jointing, and bedding planes are not properly accounted for and their flow paths identified.

20. Site-specific baseline hydrogeologic evaluations from all potential water bearing zones (Kiamichi River associated alluvium and terrace deposit, the Stanley Group and the Jackfork Group), including water quality, preferential flow paths, general hydraulic gradients, and local groundwater levels. The evaluation should be sufficient to develop a comprehensive long-term monitoring plan for post-construction and the operational life of the project. Such monitoring plan should include implementation

timelines and frameworks to proactively identify and minimize or mitigate potentially significant hydrogeologic impacts from the project's and its operation.

21. Specialized geoengineering evaluations of the Stanley and Jackfork Groups' structural competency need to be conducted to identify geohazards and other potential points of failure stemming from the project's development within known flysch deposits.

22. The proposed project would be located near multiple known faults identified by the Oklahoma Geologic Survey with optimal and moderately optimal fault orientations that could pose a significant risk for naturally occurring and triggered seismicity (Darold & Holland, 2015). This highlights the need for a comprehensive seismic survey of the Project's location to identify any unknown or blind faults that could impact the project or the hydrogeology of the surrounding area.

I declare under penalty of perjury of the laws of the State of Oklahoma and the United States of America that the foregoing is a true and correct statement of my expert opinion, and that this report was executed this 29th day of October 2024, at 9039 Olive Street Kingston, Oklahoma 73439.

Respectfully submitted,

s/ Ethan Schuth

____

Ethan Schuth

VI. REFERENCES CITED

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VII. FIGURES

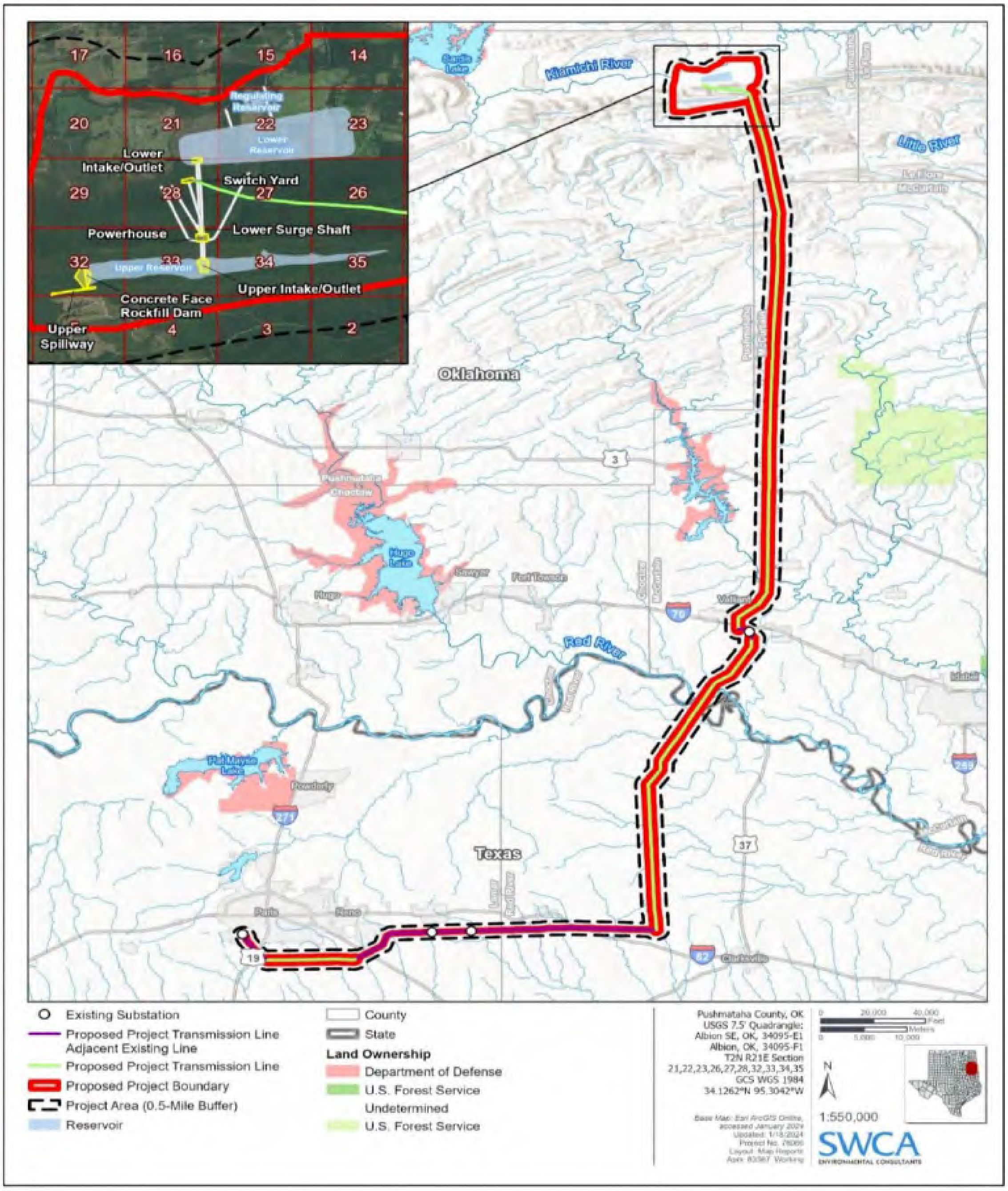
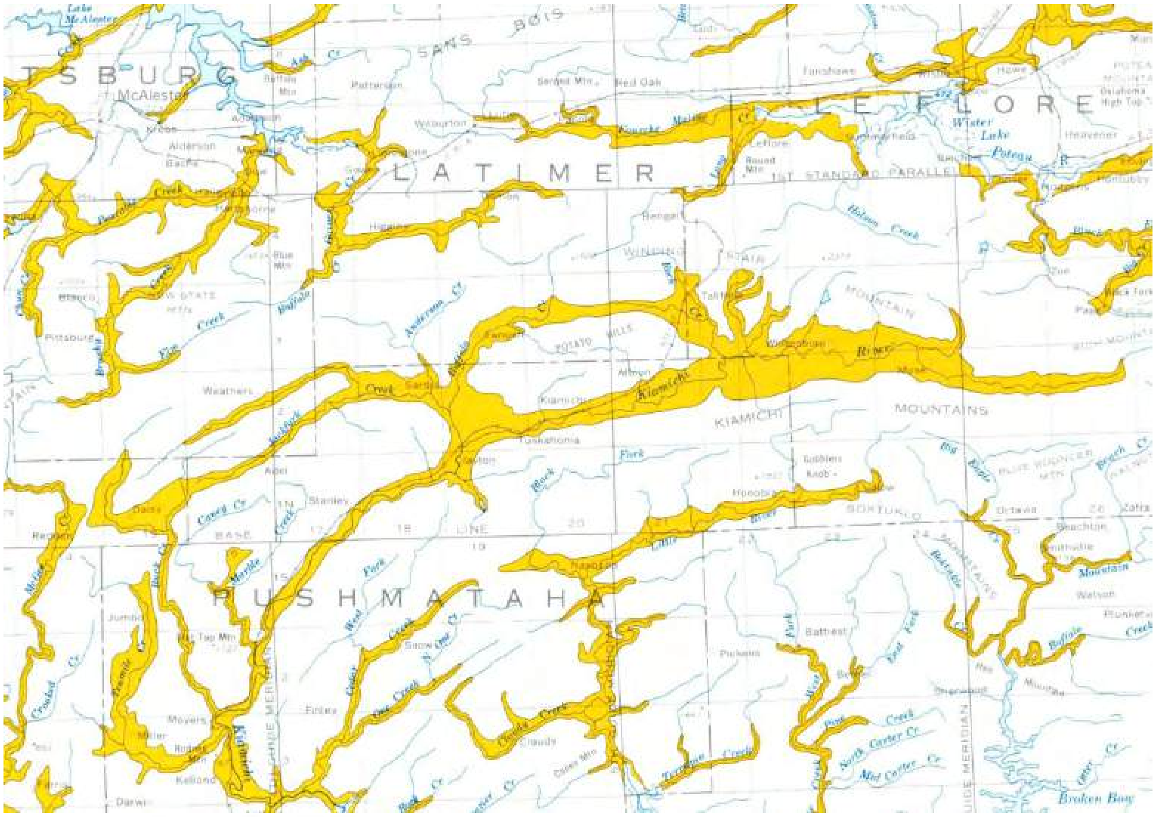


Figure 1. Location of the proposed Pushmataha County Pumped Storage Project. (Source: Pre-Application Document, 14890 (FERC, 2024))



EXPLANATION

Alluvium and Terrace Deposits (Quaternary in age). Unconsolidated deposits of sand, silt, clay, and gravel that occur along or adjacent to modern and ancient rivers and streams. Thickness generally ranges from 10 to 50 ft. (locally as much as 100 ft.). Wells generally yield 10 to 500 gpm of water (locally several thousand gpm), and most water is of good quality (less than 1,000 mg/L). Recharge areas are essentially the same as distribution of the alluvium and terrace deposits.

Figure 2. Alluvium and Terrace Deposit of Oklahoma (Source: Johnson, 1983)

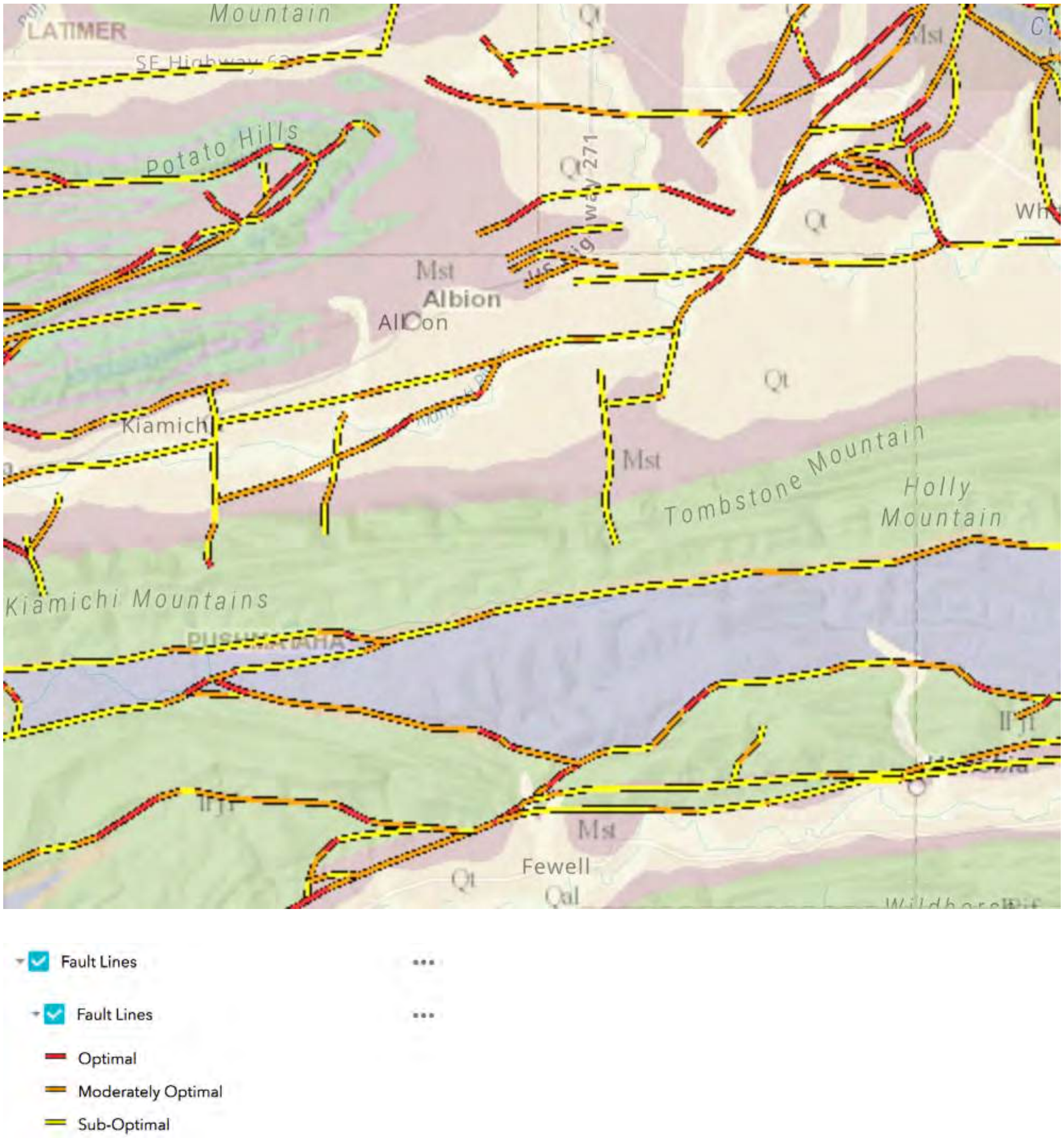


Figure 3. Faults within the Kiamichi River Valley near Albion, Oklahoma.
(Source: Oklahoma Water Resource Board, Interactive Mapper General Viewer, 2024)

Ethan Schuth, P.G.

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Cell: 580-380-9943 – ethanschuth@gmail.com

Results focused Professional Geologist, water resource professional, and environmental consultant business owner with experience in project management, problem solving, technical data analysis, and grant management. Proactive leader adept in communication and collaboration with both technical and non-technical entities to provide science-based solutions to complex geologic and hydrogeologic issues.

PROFESSIONAL LICENSES & CERTIFICATIONS

Professional Geologist (TX #15122)

EDUCATION

Master of Science: Geosciences May 2020
Texas A&M University – College Station, Texas
Overall GPA: 3.80

Bachelor of Science: Geology May 2013
University of Oklahoma – Norman, Oklahoma
Overall GPA: 3.30

EXPERIENCE

Owner/Operator September 2024 – Present
ES Environmental LLC – Kingston, OK

- Provided technical expertise on geologic and hydrogeological issues.
- Conducted technical evaluations of geologic and hydrogeologic information for clients.
- Provided a collaborative environment for the development of specialized technical reports.

Hydrologist June 2023 – Present
Department of the Interior,
Office of Surface Mining Reclamation and Enforcement – Tulsa, OK

- Managed all coal mining related water quality data across the Tulsa Field Office territory of Arkansas, Kansas, Oklahoma, and Texas.
- Developed mitigation and reclamation plans for coal mining impacted lands in Oklahoma.
- Provided technical assistance to the primacy states of Arkansas, Kansas, and Texas.
- Provided technical review and evaluations of coal mining permits, permit revisions, abandoned coal mining sites, and associated reclamation plans.
- Facilitated information exchanges between technical and non-technical entities to provide increased project collaboration and execution.

Sr. Water Resource Manager April 2021 – June 2023
Choctaw Nation of Oklahoma – Durant, OK

- Managed and coordinated multiple water resource grant projects and tribal programs including surface water quality monitoring, hydraulic basin modeling, regional water supply, infrastructure

planning, drinking water evaluations, climate change resiliency and mitigation, and water resource economic evaluations.
- Developed evaluation criteria to ensure grant-funding opportunities aligned with internal strategic plans.
- Managed multiple grant and tribal budgets to ensure objectives were completed.
- Assigned work and monitored performance of staff and contractors.
- Worked successfully with diverse groups of coworkers to accomplish goals and address issues related to our objectives.
- Prioritized and organized multiple tasks to efficiently accomplish strategic goals and address issues related to our objective.
- Liaised between employees and senior leadership to address inquiries, complete strategic goals, and roster problem resolution.

Water Resource Manager January 2018 – March 2021
Choctaw Nation of Oklahoma – Durant, OK

- Responsible for developing job descriptions to address technical staffing needs for development of the Office of Water Resource Management.
- Conducted interviews to ensure solid cultural alignment between applicants and potential job positions.
- Developed a master plan and subsequent strategic work plans to advance technical knowledge of tribal water resources.
- Managed tribal staff and consultants to ensure relevant water resource data was captured for further analysis and data dap identification.
- Provided technical expertise on groundwater projects and potential impacts of water-related legislation.
- Oversaw numerous projects to ensure high quality, timely deliverables.

Geosteering Analyst January 2017 – January 2018
Hoss Geosciences – Oklahoma City, OK

- Developed comprehensive knowledge of oil and gas drilling operations.
- Geosteered multiple horizontal wells through complex geologic formations in the SCOOP and STACK.
- Worked directly with directional drillers, MWDs, and mudloggers to ensure geologic interpretations of real-time geologic data and information acquired from mudlogging grab sample analysis.
- Advised company men and directional drillers on well plan changes based on technical interpretations of real-time geologic data and information acquired from mudlogging grab sample analysis.
- Created reports detailing findings and recommendations.

Operational Geology Intern May 2015 – August 2015
Devon Energy – Oklahoma City, OK
- Worked on summer interdisciplinary project to find potential correlations between geologic and engineering parameters that could increase hydrocarbon production and recovery.
- Researched geological formations and applied regional context to determination of data.
- Shadowed active drilling of two 2nd Bone Spring Sand horizontal wells in the Delaware Basin.
- Mapped preferential drilling targets utilizing surrounding well log data.
- Presented geological and engineering completion report findings to upper management.

Geology Intern May 2014 – August 2014

Samson Resources – Tulsa, OK

- Correlated fluvial sands in the Douglas Formation across the Anadarko Basin.
- Created average porosity, water saturation, isopach, gross and net maps.
- Produced Pickett plots, calculated water saturations and average porosity curves.
- Provided technical review of correlated well logs to upper management for consideration.
- Analyzed geochemical and geophysical data to predict potential new drilling targets in the Douglas Formation.

Geology Intern May 2013 – August 2013

Mewbourne Oil Company – Midland, TX

- Researched geological formations and applied regional context determining potential new targets and correlated the Cline Shale over 9 counties in the Midland Basin.
- Created structural maps along with stratigraphic and structural cross sections.
- Developed potential target locations for future acquisition and drilling.
- Conducted meetings with upper management to discuss potential geologic targets.

PROFESSIONAL ORGANIZATIONS

American Water Work Association, National Environmental Banking Association, Oka Institute, Chickasaw-Choctaw Regional Water Planning Subcommittee, Oklahoma Kill Response Management Team (OKKRT), Texoma Rock Hound, Dallas Paleontological Society,

Attachment 7

10/18/2024

RE: PUSHMATAHA COUNTY PUMPED STORAGE PROJECT (FERC PROJECT NO. 14890)

TO WHOM IT MAY CONCERN:

Greetings. My name is Jacqueline Vadjunec. I am a human-environment geographer (PhD) who has lived and worked as a university professor and researcher in Oklahoma since 2007 (first at Oklahoma State University and now at the University of Oklahoma). I also had the privilege of serving my country as a visiting scientist at the National Science Foundation (NSF) from 2018-2020, for which I was honored by receiving a National Special Service Award. I specialize in socio-ecological systems (SES) resilience, mixed and participatory methodologies, sustainable agriculture and forestry, and the sustainable management of common-pooled and mixed property resources (mainly, land and water). At the University of Oklahoma, I currently serve as the Associate Director of the Institute for Resilient Environmental and Energy Systems (IREES) and as a full professor in the Department of Geography and Environmental Sustainability (DGES). However, today I am writing as a concerned citizen, rather than as a university employee, with over 20 years of experience related to sustainable and equitable development, agriculture, and land use. Much of my work also focuses on win-win conservation and sustainable development practices, with Traditional Peoples in the Americas, mainly in the Brazilian Amazon.

The proposed project boundary occurs within two southeastern Oklahoma counties, Pushmataha and McCurtain, as well as two northern Texas counties, Red River and Lamar. Further, the proposed project would have impacts on the Kiamichi River. For the purposes of this letter, I focus expert comments predominantly on the Oklahoma portion of the project. My concerns regarding an assessment of the proposed project center around the critical need for more studies on the cultural and environmental services that would likely be impacted by the proposed project. More specifically, there is a lack of research on how the project would impact the Kiamichi River within and beyond the (narrowly defined) proposed site, especially the interwoven lifeways of the potentially impacted Tribes, such as the Choctaw and Chickasaw, who have a long and mutually supportive human-environmental relationship with the Kiamichi. Impacts of the proposed pumped storage project to related natural resource Tribal sovereignty issues have not been adequately explored in the current study, the importance of which are well known in light of the more recent water rights settlement.

While the proposed project report emphasizes that the project will be carried out on private property, there are multiple considerations to take into account when considering the potential impacts of the project, especially beyond the private landowners, necessitating further studies. First, experts familiar with common-property and/or mixed property resources, (for instance, the

112 Olde Brook Court, Norman, OK 73072

complex mosaic of Tribal lands and the private lands contained within them), recognize that the crisp binary logic (of Tribal-non-Tribal, private-public, etc.) becomes easily fuzzy given the complex history of Tribal land sovereignty and dispossession (by powerful, historic forces such as theft, corruption, marginalization, cultural genocide etc.). Second, several common-pool resources flow through space which make them hard to environmentally regulate (for instance, flora, fauna, water etc.). Therefore, in judging the impact of the proposed project, more studies would need to be done beyond the footprint of the actual project in order to properly access potential impacts on both people and nature regionally. Third, while the proposed project report briefly touches on various aspects of environmental and cultural resources, it does not take into account interactions between cultural and environmental services, nor does it consider the diversity of cultural services, mainly emphasizing important historical sites (on the National Historic Registrar) or sites in national databases in the proposed project area (which is defined as a 3-mile buffer). Given the flow of common-goods through space (addressed above), the 3-mile buffer does not provide an adequate understanding of the potential impacts on the complex bundle of ecosystem services (see figure, below). In particular, the internationally adopted, United Nations developed Millennial Ecosystem Assessment acknowledges the value and often neglected history of the cultural services provided by nature and therefore, bundles cultural and ecosystem services together as follows:

ECOSYSTEM SERVICES

PROVISIONING SERVICES	REGULATING SERVICES	CULTURAL SERVICES
Products obtained from ecosystems	Benefits obtained from the regulation of ecosystem processes	Nonmaterial benefits obtained from ecosystems
FOOD&FRESHWATER WOOD&FIBER BIOCHEMICALS GENETIC RESOURCES FUEL	CLIMATE REGULATION FLOOD REGULATION EROSION CONTROL DISEASE REGULATION WATER PURIFICATION	AESTHETIC SPIRITUAL EDUCATIONAL RECREATIONAL CULTURAL HERITAGE SENSE OF PLACE

SUPPORTING SERVICES	
Services necessary for the production of all other ecosystem services	NUTRIENT CYCLING SOIL FORMATION PRIMARY PRODUCTION

Adapted by the author from: The Millennium Ecosystem Assessment (see ensia.com)

According to the proposed project report, the site can potentially impact 31 Tribal Nations. Therefore, “SEOPC is proposing to conduct a cultural and tribal resources study, which will include an archaeological survey of all known proposed Project disturbance areas” (*SEOPC- 4-153).* From my experience and expertise in this area, in order to properly judge the efficacy of the project more studies are needed to look at the potential impacts of the cultural and ecosystem services across potentially affected Tribes. It should also be recognized that cultural services cannot be easily untangled from environmental services, and must include more than an emphapsis on historically documented sites and government databases. Further, to judge real impacts of the proposed project, the studies need to focus on a much broader region (as discussed above). It is important to recognize that many sites, such as sacred sites, as well as sacred plants, etc. are often seemingly "undocumented" to the outside observer/researcher exactly because they are closely held, protected, and respected by Native people.

Lastly, additional studies regarding the impact across a greater extent of cultural services needs to be closely studied to better understand the true impact of the proposed project. For instance, many rural and Native people in Oklahoma rely on fishing, hunting, and foraging (food, arts and crafts, medicinals, etc.) as part of subsistence and provisioning environmental services. Yet, these activities are also connected to diverse cultural services which can also be spiritual, recreational, and/or part of one's cultural heritage, sense of place, etc. To fully grasp the potential impacts of the proposed project on potentially affected Tribes, more studies need to be done to fully understand such impacts as complex, holistic human – environmental interactions, in a way more congruent with the lifeways of Traditional People. For me, this requires more on the ground, ethnographic, and ecological studies that would capture how residents of the region access and reply upon cultural and ecosystem services in the proposed study region across time and space (for instance, at the county level, the Tribal level, the watershed level, etc). Unless such studies are carried out recognizing Tribal sovereignty, with potentially impacted Tribal Nations leading their own impact assessments, there is reason to doubt the efficacy of more data collection by SEOPC, especially around the impact of the project on cultural heritage, let alone diverse, holistic environmental and cultural services, particulalry given aspects such as sacred nature and places, the cultural sensitivity of such knowledge, not to mention the complex historical legacies and relationships among diverse stakeholders.

In sum, I hope the information I provided in this letter will be taken into account regarding permitting decisions and/or the need for additional studies related to potential impacts from the Pushmataha County Pumped Storage Project. I write this letter as an expert and a private citizen. As stated above, my opinion is my own, based on 20+ years of research experience in this area. My opinion does not represent the opinions of my employer or any funding agency. If you have any questions regarding my assessment, please contact me at jvadjunec@gmail.com.

SINCERELY,

Jacqueline M. Vadjunec

JACQUELINE M. VADJUNEC, PHD
112 OLDE BROOK COURT
NORMAN, OK, 73072
JVADJUNEC@GMAIL.COM
(405) 334-6788

Attachment 8

Bill Anoatubby
Governor
Chris Anoatubby
Lt. Governor

the Chickasaw Nation DEPARTMENT OF CULTURE AND HUMANITIES

OFFICE OF THE SECRETARY | POST OFFICE BOX 1548 | ADA, OK 74821-1548 | (580) 436-7258

September 5, 2024

Ms. Debbie-Anne A. Reese
Acting Secretary
Federal Energy Regulatory Commission
888 First Street, NE, Room 1A
Washington, D.C. 20426

Dear Acting Secretary Reese:

Your letter of June 6, 2024, invited the Chickasaw Nation to participate in the license application review process for the proposed Pushmataha County Pumped Storage Project No. 14890-005. Your letter was forwarded to the Chickasaw Nation Division of Historic Preservation, as well as other departments within the Nation's government, for preliminary review. As indicated in Chickasaw Nation Governor Bill Anoatubby's July 2, 2024, letter to the Commission, which is included for your convenient reference, the Chickasaw Nation has substantive concerns with this project as proposed. This letter pertains to this Division's review and will be supplemented by additional comments, which will be filed prior to the Commission's recently extended November 5, 2024, deadline.

Based on our preliminary review, we understand that the Commission designated the applicant, i.e., Southeast Oklahoma Power Corporation, LLC (SEOPC), to serve as its non-federal representative for purposes of consultations. We further learned SEOPC allegedly invited Tribal participation in early engagement. The Chickasaw Nation's government-to-government relationship is with the United States, and we believe it would be inappropriate for the Commission to delegate its Tribal relations responsibility to a private company. We believe it would be particularly inappropriate to delegate such role to the private company that is the applicant for the project that would be the subject of the consultation, which company may be unfamiliar with the unique federal / tribal relationship, which company may not have the authority or ability to comply with relevant laws, and which company may not reasonably be expected to be a neutral arbiter of the concerns the Nation may have. We believe such a delegation would be inconsistent with good practice as well as the Commission's own regulations. Those regulations acknowledge "that, as an independent agency of the federal government, it has a trust responsibility to Indian tribes and this historic relationship requires it to adhere to certain fiduciary standards in its dealings with Indian tribes" and further provides that "consultation should involve *direct contact between agencies and tribes and should recognize the status of the tribes as governmental sovereigns*." 18 C.F.R. § 2.1c(a) & (b) (emphasis added). Those regulations further express a belief "that the hydroelectric licensing process will benefit by *more direct and substantial consultation between the Commission staff and Indian tribes*" and a pledge to "increase direct communications with tribal representatives," as appropriate. 18 C.F.R. § 2.1c(i) (emphasis added).

We would look forward to working with the Federal trustee in accord with these regulations. We further believe this particular application—which proposes the construction of a massive project in the middle of the reservation of the Choctaw Nation of Oklahoma, an area of cultural significance to numerous Tribal peoples, and the treaty region that is the subject of the Chickasaw Nation's and Choctaw Nation of Oklahoma's water settlement with the United States and Oklahoma—would provide the Commission a critical subject that is appropriate for meaningful engagement and consultation. To date, however, the Commission has not provided a meaningful opportunity for consultation, with respect to the National Historic Preservation Act or otherwise. ***Accordingly, given our sovereign status and the nature of confidential information shared in government-to-government consultation (which information may need protections provided by federal law), we request all project correspondence with the Chickasaw Nation concerning historic and cultural resources come from the Commission, itself.*** This request should be understood as consistent with Governor Bill Anoatubby's earlier letter.

Further, we understand that FERC will define the area of potential effect (APE), and the plan is that cultural resources which have not been previously evaluated for National Register of Historic Places (NRHP) eligibility will be documented and evaluated under the NRHP criteria and previously identified properties that have not been evaluated within five years will be reassessed. However, upon review of the table of previously recorded archaeological resources within the proposed project boundary we see that numerous cultural resources have been previously recorded within portions of the proposed project boundary and surveys were conducted by avocational and academic archaeologists, primarily from 1939 through the early 1990's. Archaeological standards have changed throughout the years, and a Phase I cultural resources survey of the entire APE must be completed and provided to us for review followed by formal government-to-government consultation. To clarify, later in the document SEOPC proposed to conduct a cultural and tribal resource **study**; our office is requesting a cultural resource **survey** report be completed meeting the current professional standards.

The proposed project covers an enormous area of land including a 99.96-mile-long transmission line, an 886-foot-long upper dam impounding 599.55 acres, a 13,615-foot-long lower dam impounding 887.37 acres of reservoir, a 40-acre re-regulating reservoir, and a concrete intake channel on the Kiamichi River for initial fill and make-up water. This area encompasses significant sites with Caddoan occupation of approximately 4,000 years and known sites including mounds, evidence of houses, burials, midden soil deposits and hearths. The area is significant to the Chickasaw people as we used the historic trail through this area during our forced Removal from our homeland to what is now Oklahoma.

The applicant's documentation shows the importance of applying NRHP significance criteria of the resources located within the area of potential effect to assess if the proposed project would result in adverse effects. However, four resources were evaluated but the results of the testing were not found during data gathering. Its documentation also indicates that not all previously recorded archeological resource information has been received but has been requested and will be provided in subsequent licensing documentation. ***Our office requests to be provided copies of the information upon it being located.***

Finally, as noted, the Chickasaw Nation is working on a broader set of comments on the proposed project. We are working on this response in coordination with the Choctaw Nation and will be submitting them by the November 5, 2024, deadline. In the meantime, the Choctaw Nation and the Chickasaw Nation intend to seek broader direct and jointly convened government-to-government consultations with the Commission for purposes of addressing numerous areas of our concerns.. Until then, our request for consultation and documentation in this letter today pertains specifically to NHPA Section 106.

We appreciate your efforts to preserve and protect significant historic properties. If you have any questions concerning the NHPA, please contact Ms. Amber Hood, director of historic preservation and repatriation, at (580) 559-0825 or by email at amber.hood@chickasaw.net.

Sincerely,

Lisa John, Secretary
Department of Culture and Humanities

Cc: catherine.roberts@ferc.gov; eComment system
Stephen Greetham, Special Counsel, Chickasaw Nation

Document Content(s)

Attachment 9

Choctaw Nation of Oklahoma

Historic Preservation

PO. Box 1210 • Durant, OK 74702-1210

Gary Batton
Chief

Jack Austin, Jr.
Assistant Chief

September 5th, 2024

Re: Pushmataha County Pumped Storage Hydroelectric Project (FERC Project No. 14890)

To whom it may concern,

The Choctaw Nation of Oklahoma Historic Preservation Department (CNHPD) has reviewed the Pumped Storage Hydroelectric Project (FERC Project No. 14890) in Pushmataha and McCurtain Counties, Oklahoma, and Red River and Lamar Counties, Texas. Southeast Oklahoma Power Corporation (SEOPC) proposes to construct a 1,200-megawatt (MW) closed loop hydroelectric facility including upper and lower dams and spillways, upper, lower, and regulating reservoirs, upper and lower concrete intake/outlet structures, headrace and tailrace tunnels, an underground pumping station/powerhouse, two pumping systems, a 99.96-mile transmission line that will extend from the facilities in Pushmataha County, Oklahoma, to Paris, Texas, and appurtenant facilities. The project area includes 10,660-acres of land that will surround the primary pumped storage facilities and 24,576-acres of land for the right-of-way that will surround the proposed transmission line. The total Area of Potential Effect (APE) is 35,235-acres.

The project area is within lands ceded by the Quapaw Tribe to the United States and subsequently reserved for the Choctaw Nation through the Treaty of Doak's Stand in 1820. Following the Treaty of Dancing Rabbit Creek in 1830, bands of Choctaw were forcibly relocated into what is now the Choctaw Nation of Oklahoma from their homelands in Alabama, Louisiana, and Mississippi. In 1837, the Chickasaw were moved into the Choctaw reservation, upon removal from their homelands in parts of Alabama, Kentucky, Mississippi, and Tennessee.

The Choctaw Nation of Oklahoma Historic Preservation Department (CNHPD) received a copy of the transmittal letter from Indya Messier, Project Manager with SWCA Environmental Consultants, on February 1, 2024. CNHPD requested additional information on March 1, 2024, but no additional information was provided. CNHPD received a copy of the pre-application document from the Choctaw Nation Environmental Protection Service on April 2, 2024. CNHPD attempted to contact Randa Horton (SWCA), the tribal liaison listed in the pre-application document, on June 7, 2024, but the phone line was disconnected. Without the materials from FERC or the project applicant necessary to review this project as required by the NHPA, and without knowing the precise project location, CNHPD conducted a preliminary review of the Choctaw Register of Historic Places for sites located within a 5-mile radius of the project area. CNHPD also requested and received site files pertaining to this project from the Oklahoma Archeological Survey (OAS). This search identified thirty-six (36) historic archaeological sites, including fourteen (14) Choctaw Cemeteries, in addition to twelve (12) possible 1898 BLM GLO Structures in or adjacent to the project area.

CNHPD received copies of the shapefiles for this project on August 2, 2024. CNHPD has consulted historic maps, aerial photographs, LiDAR, and the Choctaw Register of Historic Places, a database containing Choctaw sites, place names, trails, and other pertinent historic information. Examination of a historic Bureau of Land Management (BLM) map (circa 1898) indicates the presence of at least five (5) late nineteenth century historic sites within the APE including three (3) historic structures in the area proposed for the pumped storage facilities (1 labeled "Church"), and two (2) structures located in the transmission ROW. Other historic maps consulted during review include the Alikchi (1901), Tuskahoma, IT (1901), Tuskahoma, OK (1909), McAlester, OK (1950), and Millerton, OK (1951) topographic maps. Aerial photographs dating to the following years were examined: 1955, 1954, 1980, 1995, 2003, 2008, 2010, 2013, 2015, 2017, 2019, and 2021. The Tuskahoma map dated to 1901 indicates at least six (6) structures within the APE, and the Tuskahoma map dated to 1909 indicates eighteen (18) structures within the APE. Historic allotment maps show at least fifty percent (50 percent) of the APE is located on lands originally allotted to Choctaws (Figures 1 and 2). A brief site visit by Choctaw Nation Historic Preservation Department staff located a Choctaw cemetery within the APE. This cemetery includes approximately 18 marked burials.

The Pre-Application Document (PAD) lists at least forty (40) previously recorded pre-contact period archaeological sites within the project area, these archaeological sites are representative of the region's deep history spanning the archaic period to early contact period. One National Register of Historic Places Property, the Grobin Davis Mound Group (NR 84002637), falls within the proposed transmission line ROW (Figure 4). The Grobin Davis Mound site is an approximately 25-acre ancestral Caddo mound center. The site was listed on the National Register of Historic Places in 1984 and is currently owned by the Archaeological Conservancy.

Lands reserved for the pumped storage facilities are intersected by the historic Kiamichi Trail (K-Trail) (Figure 3). The trail was likely constructed during the early twentieth century for access to the fire lookout tower, built between 1926 and 1928 under the auspices of the Oklahoma Forestry Commission. The proposed transmission line will likely destroy 2.5-miles of the existing trail. The transmission line Right-of-Way (ROW) will also intersect several other trails of unknown age including, but not limited to, the Wildhorse Trail, Uphilly Bowers Trail, the Nolia Trail, and the Stevens Trail. Many of these trails continue to be used today, mostly for recreational purposes.

A major discrepancy exists between the number of cultural resources listed in the PAD as within the proposed project boundary and the actual number of cultural resources encompassed by the proposed project boundary as defined by the project shapefiles. The PAD lists sixteen (16) previously recorded historic archaeological sites within the proposed project boundary; however, of these sixteen (16) sites, only one (1) historic archaeological site (Site 34PU281) falls within the proposed project boundary as defined by the shapefiles (Figure 5). Site 34PU281 is a multi-component habitation site with both historic and pre-contact period occupations. The site is currently unevaluated for the National Register of Historic Places (NRHP).

Ambiguity in the project boundary (or APE) has made it difficult to capture exactly which cultural resources could be adversely affected by this project. Aside from construction, CNHPD shares concern regarding spillway drainages, draught conditions, and any other unanticipated effects of this project that could adversely affect previously recorded cultural resources located along the Kiamichi River to the east and to the west of the proposed pump facilities. Previously recorded historic archaeological sites outside the project boundary shapefile but listed in the PAD as within the project boundary include: 34PU244, 34PU253, 34PU257, 34PU263, 34PU264, 34PU267, 34PU272, 34PU275, 34PU285, 34PU286, 34PU292, and 34PU294. Sites 34PU244, 34PU257, 34PU263, and 34PU275 are known to contain "historic native" or Choctaw burials. Wall Cemetery and the Maytubby Cemetery are also located within 5-miles of the proposed pump facilities. Site 34PU264 is the Dukes' family farmstead. Gilbert Dukes served as Principal Chief of Choctaw Nation between 1900 and 1902. Most of these historic sites have been determined culturally affiliated with Choctaw Nation but have not been assessed for the NRHP.

It is highly probable that most of the project area has not received a cultural resources survey up to modern standards. It is likely to contain a number of archaeological sites that are culturally affiliated with the Caddo, Choctaw, and other groups. Given the number of structures shown on maps dating to the first decade of the 1900s, the project area is likely to contain several Choctaw homestead sites, which our office considers potentially eligible for the NRHP for significance under Criteria A and D. The project area also has a high potential for containing additional Choctaw cemeteries and unmarked, isolated Choctaw burial places.

If this undertaking proceeds, CNHPD is requiring a Phase I cultural resources survey of the entire APE by a reputable cultural resource management firm with experience in the area. For this undertaking to comply with the NHPA, FERC will need to engage in a meaningful consultation process with the Choctaw Nation of Oklahoma, other federally recognized Tribes with a historic interest in the area, the Oklahoma State Historic Preservation Officer, and the Oklahoma Archaeological Survey under the National Historic Preservation Act. FERC will need to work out a formal plan with these parties to mitigate adverse effects to any properties identified within the APE that are eligible or potentially eligible for inclusion on the National Register of Historic Places. The Tribal cemetery that has been located within the APE is of utmost concern to the Choctaw Nation. FERC must consult with Choctaw Nation under the Native American Graves Protection and Repatriation Act.

Most sincerely,

Ian Thompson PhD, RPA
Tribal Historic Preservation Officer

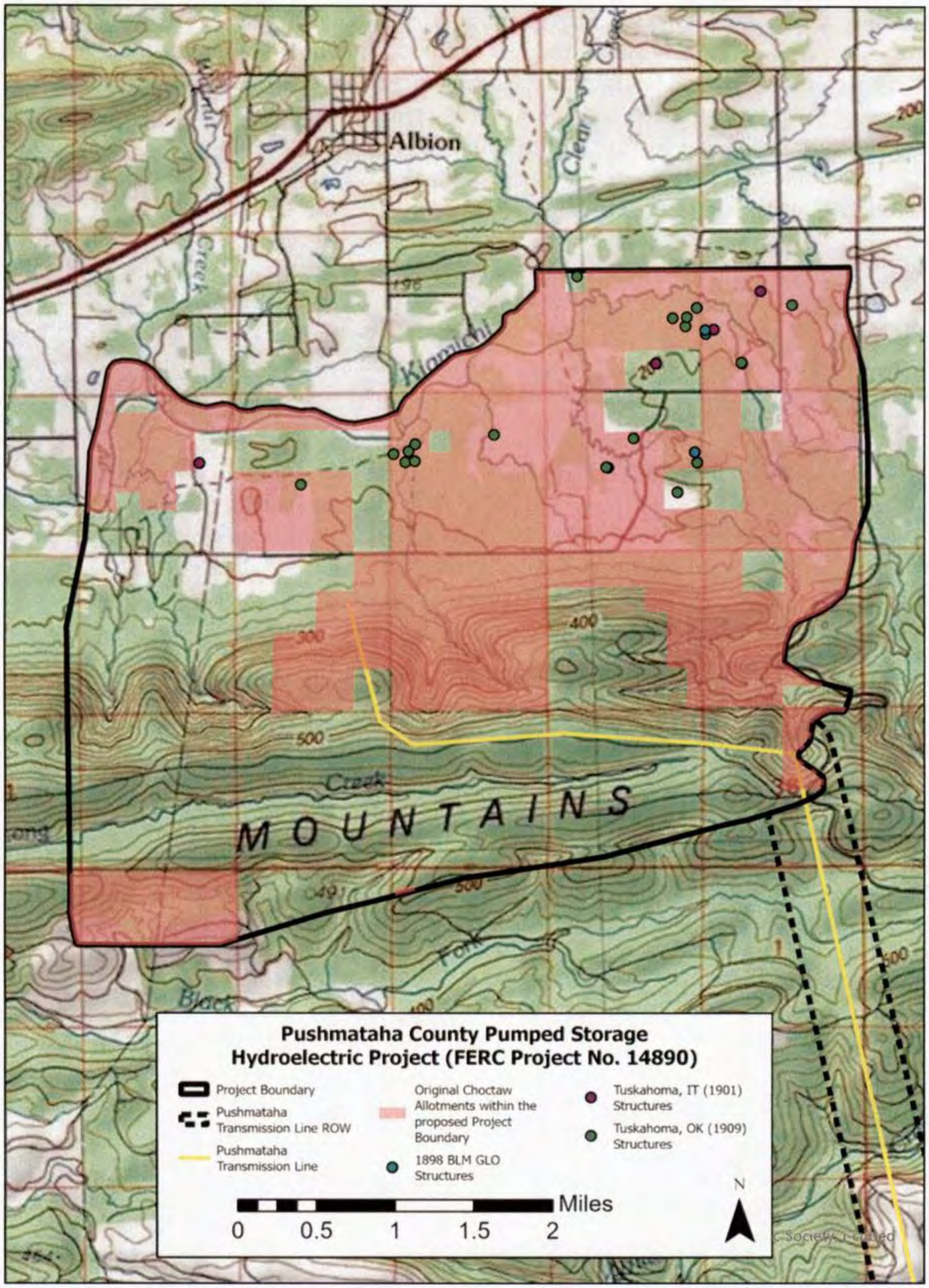

Figure 1: Map showing Choctaw allotted lands and historic sites within the project area.

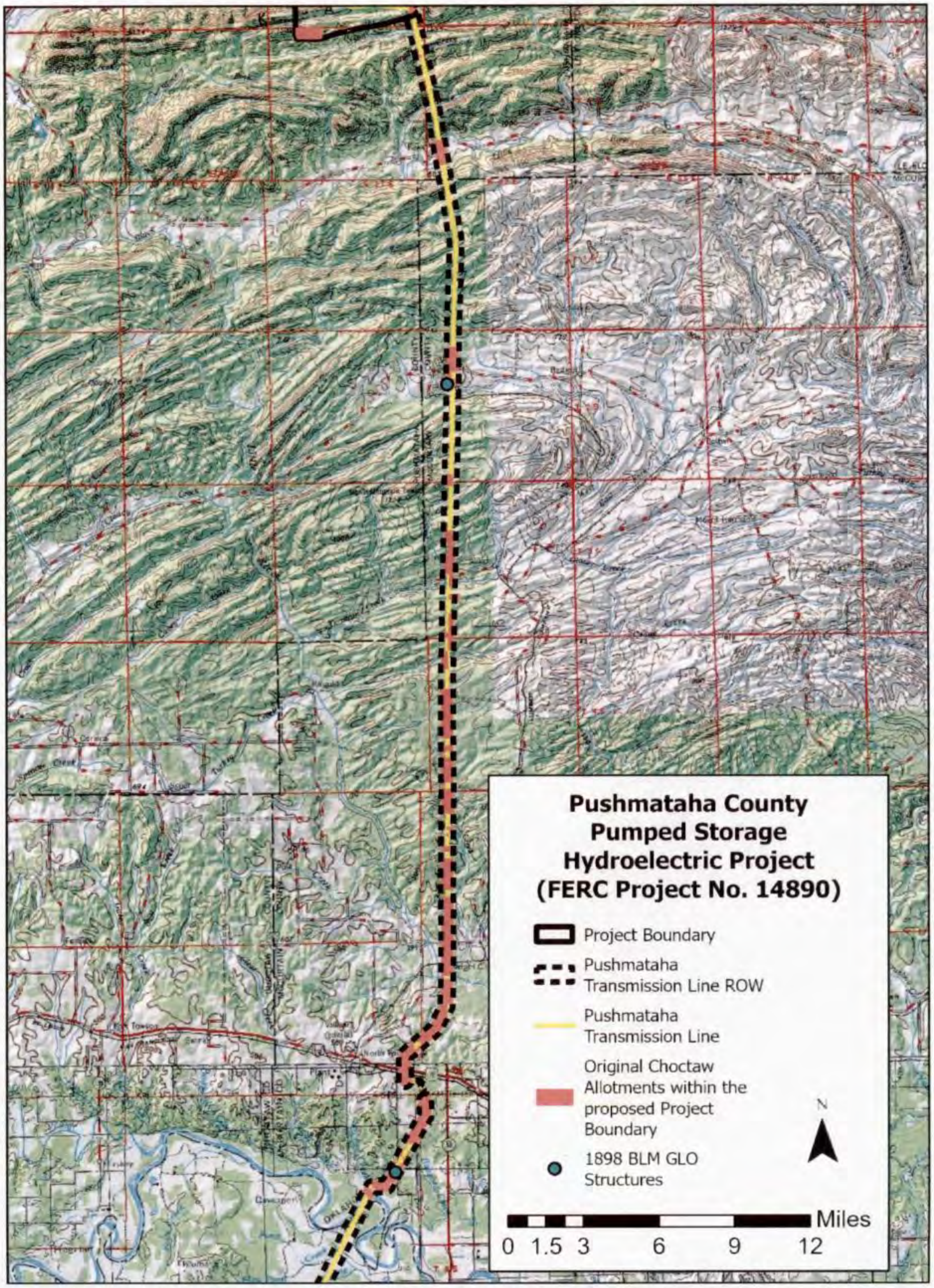

Figure 2: Map showing Choctaw allotted lands and historic sites within the ROW.

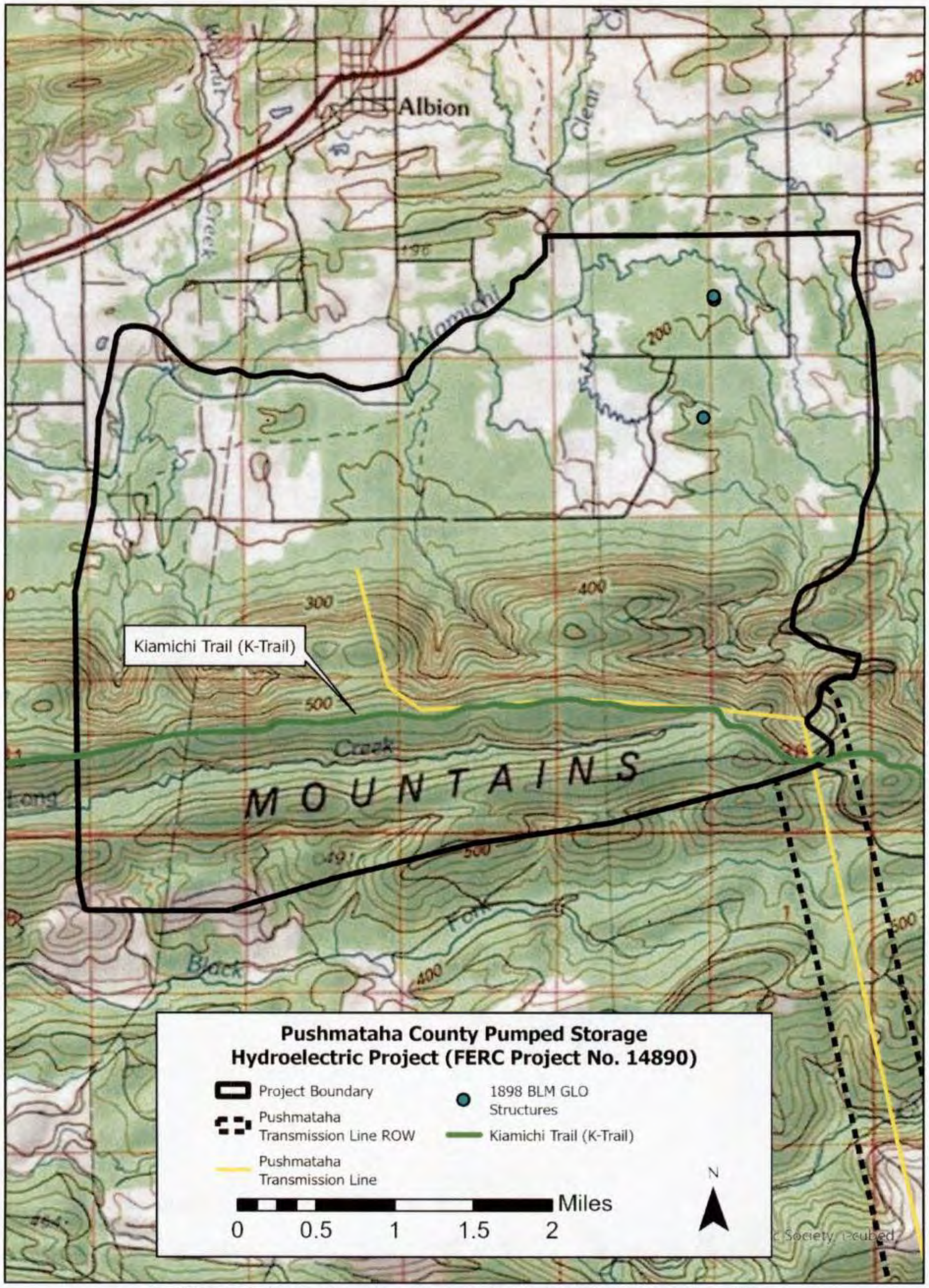

Figure 3: Map showing the location of the historic K-Trail.

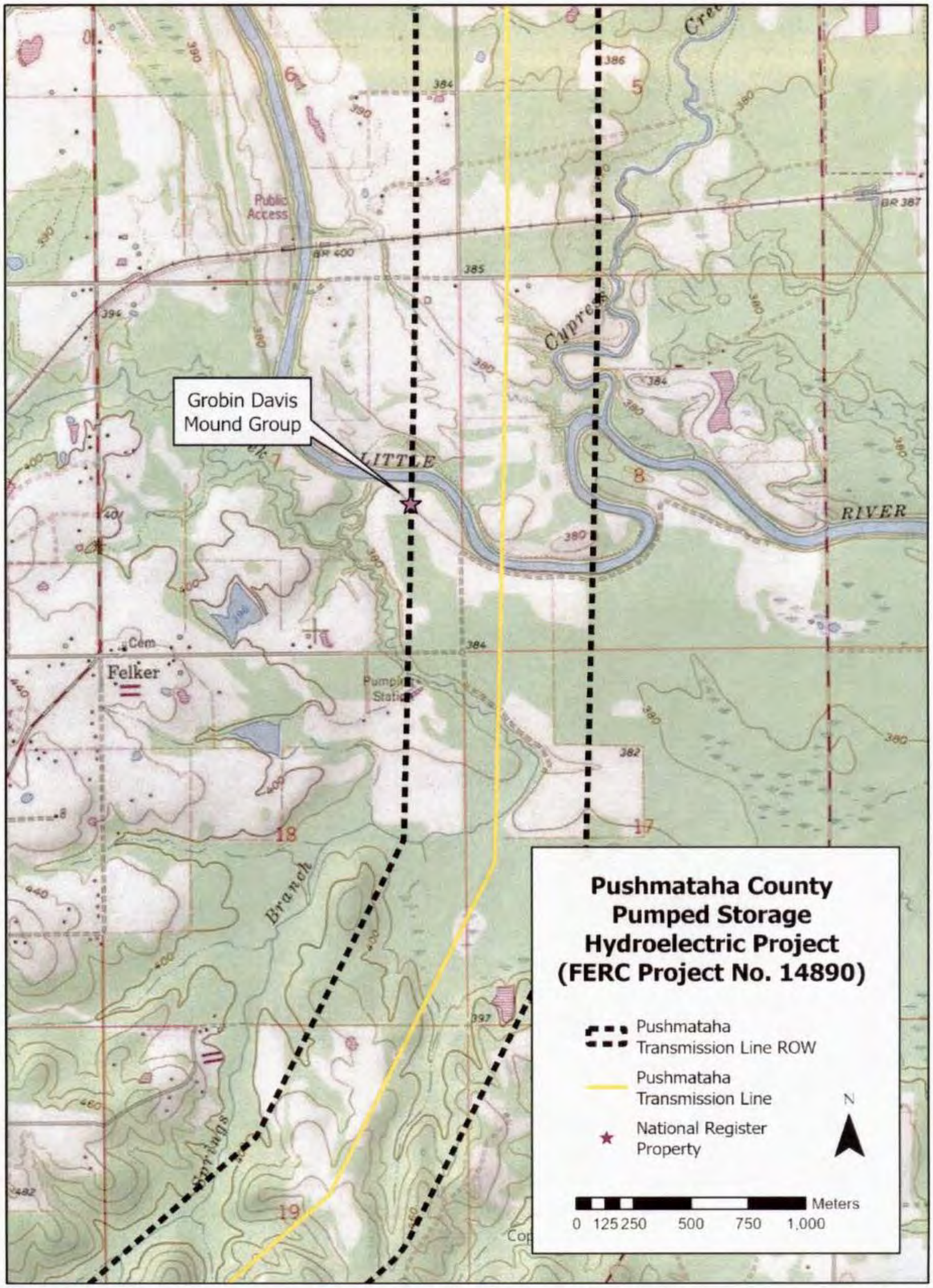

Figure 4: Map showing the location of the Grobin Davis Mound Group site, a NRHP listed property.

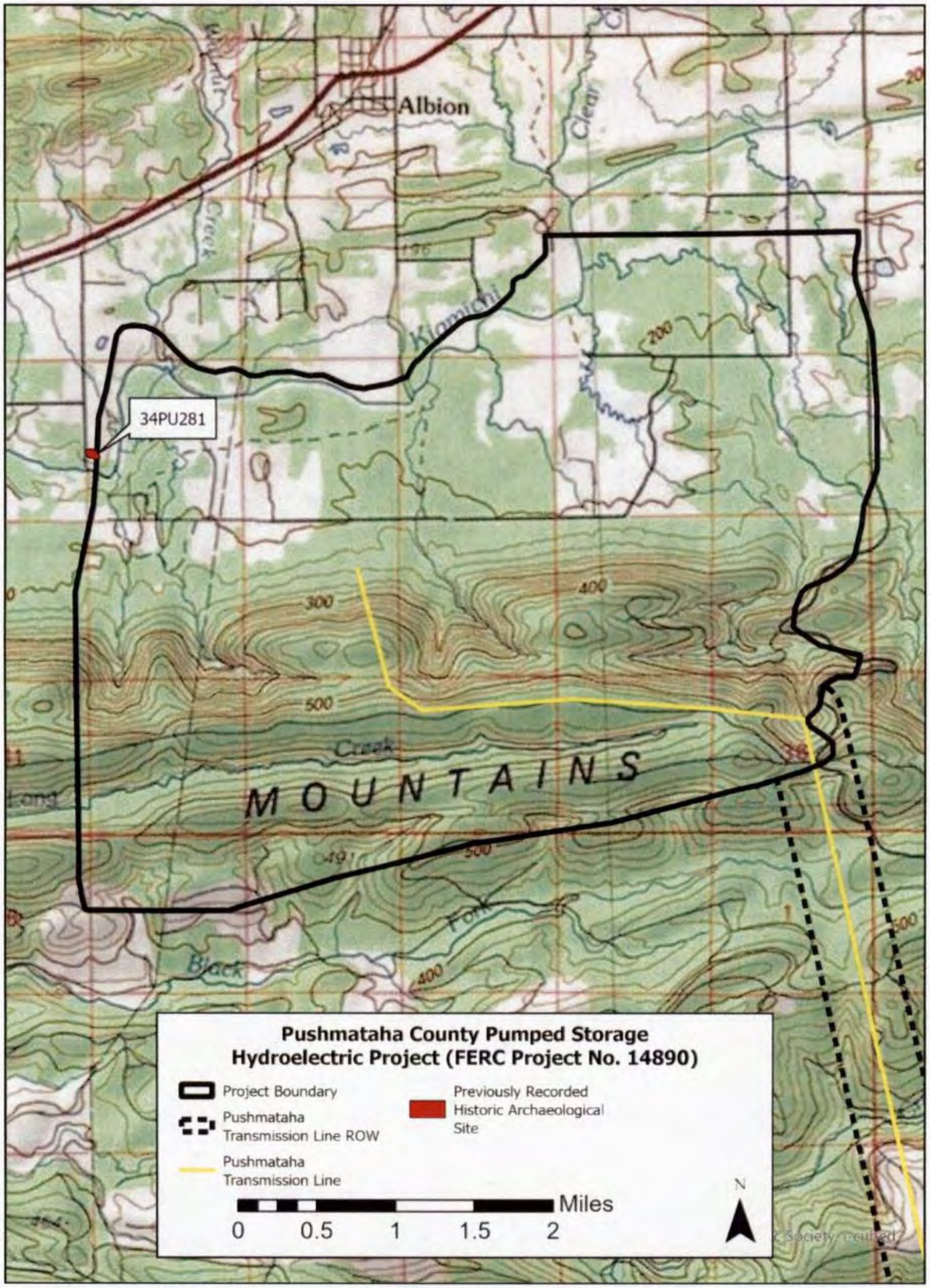

Figure 5: Map showing previously recorded historic sites within the project area.

Document Content(s)

Attachment 10

Understanding the impacts of surface-groundwater conditions on stream fishes under altered baseflow conditions

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Understanding the impacts of surface-groundwater conditions on stream fishes under altered baseflow conditions

Photograph obtained from smug mug

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EXECUTIVE SUMMARY

Persistence of aquatic fauna depends on the conditions and connectivity of surface water and groundwater. In light of altered baseflows and both current and future predicted increases in stream temperatures, it is important to assess current thermal conditions, examine thermal responses of aquatic fauna, and evaluate water-management practices. Our study objectives were to determine (1) how changes in baseflow levels in the Kiamichi River influence hyporheic exchange, which correspondingly influences temperature at the reach scale; (2) temperature tolerances of stream fishes as a means for predicting how habitat complexity influences stream-fish populations; and (3) assess how dam releases influence the downstream temperature and dissolved oxygen regime during the low-flow period. We quantified hyporheic exchange at four reaches and, as expected, found higher groundwater exchange via transient storage occurred at the upstream sites. The net groundwater flux estimation was negative for the majority of reaches indicating that surface water is lost to groundwater during summer (i.e., losing), baseflow conditions. We determined critical thermal maximum (CTMax) for 17 stream fishes and thermal tolerances ranged 32-38°C. We determined the average thermal tolerance for two habitat fish guilds to calculate changes in thermal stress due to hypothetical reservoir release scenarios. We developed a process-based Water Quality Analysis Simulation Program model to predict downstream temperature conditions over 74-km of river in response to reservoir releases that corresponded to discharges of 0.00 (control), 0.34, 0.59, 0.76, 1.13, and 1.50 m^3/s. Based on the dissolved oxygen conditions observed in 2015 and 2017 and biological oxygen demand sampling results, reservoir releases did not directly reduce dissolved oxygen concentrations in the Kiamichi River (though dissolved oxygen concentrations are limited to current water-release strategies by the managing agency). We simulated three scenarios using three water-release temperatures: 27.64°C, 26.00°C and 24.07°C that corresponded to average reservoir temperatures at gate locations on the dam. We compared the predicted temperature time series with CTMax of two fish-habitat guilds to quantify the cumulative time when stream fishes experienced severe thermal stress downstream from Sardis Reservoir. According to our simulations, reservoir releases would be capable of regulating downstream water temperature during

the summer baseflow period. The 0.00 m^3/s scenario resulted in 130 h of thermal stress for benthic fishes, and 73 h for mid-column fishes. As expected, thermal relief increased with increasing release magnitude and decreasing release water temperature. The 0.34 m^3/s release scenario reduced thermal stress (range is simulations from the top and bottom gate) by 11-18% for mid-column fishes and 8-12% for benthic fishes with an effective distance (where the cumulative time above CTMax was reduced by half) of 1-2 km for both guilds. The 0.59 m^3/s release scenario reduced thermal stress by 18-25% for mid-column fishes and 12-20% for benthic fishes with effective distances of 4-8 km and 2-7 km, respectively. Three releases representing pre-dam flow magnitudes (0.76, 1.13 and 1.50 m^3/s released from top gate) reduced thermal stress up to 46% for mid-column fishes and 41% for benthic fishes with an effective distance of 13-16 km, respectively. Lastly, we quantified temperature-induced stress via whole-body cortisol concentration of six stream fishes in response to prolonged thermal exposure at two temperatures (27°C and 32°C). We found no difference in cortisol levels between temperatures for any of the six species, indicating acclimation to elevated temperatures during the test period. However, Highland Stoneroller *Campostoma spadiceum* expressed cortisol concentrations greater than typical basal levels at both temperatures, suggesting stress from factors other than temperature (i.e., captivity). Our results suggest different reservoir-release options could improve downstream thermal-fish habitat during the summer baseflow period.

BACKGROUND

Human modifications of rivers, particularly flow modifications, are resulting in the loss of aquatic organisms. Aquatic systems are channelized, dammed, dredged, leveed, and pumped to maximize flood protection, maintain and expand water supplies, and generate power (Wootton, 1990). Across much of Europe, Asia, the United States, and Mexico, the prevalence of stressors on freshwater resources put human water security and biodiversity at risk (Vörösmarty et al., 2010). Water resource development that fragments rivers is a prominent stressor on biodiversity (Vörösmarty et al., 2010). Flows and habitat are fragmented by dams in more than 50% of the world's large rivers (Nilsson et al., 2005) thereby affecting the persistence of downriver organisms (Olden and Naiman, 2010). In addition to river fragmentation, dams affect instream habitat by degrading water quality (Olden and Naimen, 2010), disrupting natural flows (Poff et al., 1997), and altering thermal (Olden and Naimen, 2010) and sediment regimes (Wohl et al., 2015). Reservoirs are typically operated to focus on our growing human water demands despite the importance of natural flow patterns to biota (Poff, 1997).

Efforts to improve conditions in rivers regulated by impoundments have increased in recent years (Tharme, 2003). In fact, more than 30 scientific approaches have been documented to facilitate environmental flow efforts (Annear et al., 2002; McManamay et al., 2016) and many efforts have been ecologically successful. For example, implementation of environmental flows for over 13 years in the Upper Nepean River system, Sydney, Australia, improved macroinvertebrate assemblages at restored sites (Growns, 2016), and Kiernan et al. (2012) show that restoration of seasonal high discharge events in Putah Creek, California, created favorable spawning and rearing habitat. However, the flow-biota relationships observed in many regulated rivers reflects the water-quality conditions of the discharging reservoir (Olden and Naiman, 2010), and consequently there are many examples of environmental flow efforts failing to provide the perceived benefits due to other release-related factors such as sediment (Yarnell et al. 2015), temperature (McManamay et al. 2013), or contaminants (Schwindt et al. 2014). Thus, improving flow conditions without consideration of reservoir water quality or other limiting factors may maintain or improve river hydrologic connectivity, but do little to improve or may even worsen environmental conditions (Krause et al., 2005; Poff et al., 2017).

Though research efforts to improve downriver conditions have focused primarily on hydrologic alteration (Bunn and Arthington, 2002), the significance of riverine water quality on biota, especially temperature, is widely acknowledged (Magnuson et al., 1979; Poole and Berman, 2001; Caissie, 2006). Water releases from dams and diversions often alter the thermal gradients for an extensive distance downstream (Ellis and Jones, 2013) thereby affecting species' phenology (e.g., Sockeye Salmon *Oncorhynchus nerka*, Quinn et al., 1997), decreasing growth (e.g., Brown Trout *Salmo trutta*, Saltveit, 1990; Murray cod *Maccullochella peelii*, Nick et al. 2017), reducing reproduction rate (e.g., Rainbow Trout *Oncorhynchus mykiss*, Pankhurst, 1997), and even resulting in species' extirpation (e.g., freshwater mussels, Vaughn and Taylor, 1999; fishes, Olden and Naiman, 2010).

Given the coupling between the water quantity and quality, it is critical to identify environmental flow solutions that balance both human and ecological needs (Brewer et al., 2016) and to begin to address the multiple limiting factors affecting some ecosystems (Poff et al. 2017). The specific study objectives were to determine (1) how changes in baseflow levels in the Kiamichi River influence hyporheic exchange, which correspondingly influence temperature at the reach scale; (2) temperature tolerances of stream fishes as a means to predicting how habitat complexity influences stream-fish populations; and (3) how dam releases influence the downstream temperature and dissolved oxygen regime during the low-flow period.

METHODS

Study Area

The Ouachita Mountain Ecoregion is located in southeast Oklahoma. The ecoregion comprises pine, oak, and hickory forest and land use in the region consists primarily of agriculture, logging, ranching, and recreation (Woods 2005). Streams within the region have steep valleys and primarily bolder and cobble substrates (Splinter et al. 2011). The Kiamichi River, a tributary of the Red River, originates near Pine Mountain in the Ouachita Mountains near the Arkansas border. From its source in LeFlore County, Oklahoma, the Kiamichi River flows approximately 285 km (177 miles) to its confluence with the Red River south of Hugo, Oklahoma.

Hyporheic exchange and stream temperatures

We quantified hyporheic exchange and the thermal profile of reaches across the study area. We used transient storage tracer tests with Rhodamine WT tracers under varying baseflow levels to quantify total transient groundwater storage. Water level and temperature loggers were positioned in the stream for measuring temperature gradients. Cross-section surveys were performed at numerous transects within each reach to document changes in bed topography and channel morphology. Direct push piezometers were used for monitoring pressures in the near-streambed shallow groundwater in an attempt to separate surface and hyporheic storage following Stofleth et al. (2008). Rhodamine WT concentrations were measured using a fluorometer.

Seepage Runs

Seepage run is a field technique used for estimating net water fluxes between surface water and groundwater (see Zhou et al. 2018). The seepage run consists of measuring streamflow at multiple transects along the river. The discharge difference between transects is assumed to be the result of groundwater discharge to the stream or loss of stream water to groundwater.

Tracer Test and OTIS-P

Tracer tests were performed using Rhodamine WT tracers to quantify the transient storage characteristics. For each site, a tracer was injected at one upstream location and sampled at three downstream monitoring locations. The collected samples were read using a fluorometer and the collected concentration data analyzed using the OTIS-P model to quantify the transient storage characteristics.

OTIS (One-Dimensional Transport with Inflow and Storage) is a model used to characterize the rate of transport of water-borne solutes in stream and river systems that simultaneously solves equations (1) and (2) given the appropriate parameters of the model (Runkel, 1998).

$$\frac{\partial C}{\partial t} = -\frac{Q}{A}\frac{\partial C}{\partial x} + D\frac{\partial^2 C}{\partial x^2} + \alpha_s \left(C_S - C\right) \quad (1)$$

$$\frac{dC_S}{dt} = \alpha_s \frac{A}{A_S}\left(C - C_S\right) \quad (2)$$

where A is the main channel cross-sectional area (L^2), A_s is the storage zone cross-sectional area (L^2), C is the main channel solute concentration ($M\ L^{-3}$), C_s is the storage zone solute concentration ($M\ L^{-3}$), D is the dispersion coefficient in the main channel ($L^2\ T^{-1}$), Q is the flow rate in the main channel ($L^3\ T^{-1}$), and α_s is the storage zone exchange coefficient (T^{-1}) (Runkel, 1998).

In this research, OTIS was inversely (known as OTIS-P) used to estimate main channel and transient storage zone parameters based on data collected from soil pipe tracer tests of Wilson et al. (2015) described below. Typically, for a conservative tracer and constant flow rate the A, D, A_s and α_s are inversely estimated from tracer breakthrough curves (Stofleth et al., 2008). OTIS-P uses a nonlinear regression method in fitting the advection–dispersion equations (equations 1 and 2) to observed data by minimizing the squared error between observed and modeled concentrations where A is the main channel cross-sectional area (L^2), A_s is the storage zone cross-sectional area (L^2), C is the main channel solute concentration ($M\ L^{-3}$), C_s is the storage zone solute concentration ($M\ L^{-3}$), D is the dispersion coefficient in the main channel ($L^2\ T^{-1}$), Q is the flow rate in the main channel ($L^3\ T^{-1}$), and α_s is the storage zone exchange coefficient (T^{-1}) (Runkel, 1998).

<u>Influence of dam releases on stream temperatures and dissolved oxygen</u>

WASP Modeling

We modeled the thermal regime of an extensive segment of the Kiamichi River (Figure 1) using the Water Quality Analysis Simulation Program (WASP).
Hourly averaged weather data for 2013 were obtained from the Oklahoma Mesonet for three nearby sites (Talihina, Clayton and Antlers), including air temperature, dew point,

net solar radiation and wind speed. Data were obtained from two existing gages (Clayton and Antlers, U.S. Geological Survey (USGS) gages 07335790 and 07336200, respectively) including hourly averaged gage height and flow rate data for 2013. River water temperature data were collected at four sites on the Kiamichi River via the Oklahoma Department of Wildlife Conservation, at sites designated as Payne Riffle, Pine Spur Riffle, Robins Riffle and NDN Riffle (Figure 1). These data included hourly averaged temperature data from 4/1/2013 to 9/1/2013.

The WASP is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos. The time-varying processes of advection, dispersion, point and diffuse mass loading, and boundary exchange are represented in the basic program. The WASP Temperature Module can be used to predict water column temperature based upon atmospheric conditions and heat exchange between the surface, subsurface and benthic layers of the water body. We began using WASP to predict temperature at four observation sites (Payne Riffle, Pine Spur Riffle, Robins Riffle and NDN Riffle) based on weather data, flow data and boundary temperature data (i.e., the observed water temperature data at Payne Riffle and NDN Riffle sites).

In the WASP Temperature Module, the stream water temperature is computed based on the following 1D advection-diffusion equation:

$$\frac{\partial T_s}{\partial t} = -\frac{\partial}{\partial x}(V_x T_s) + \frac{\partial}{\partial x}\left(D_x \frac{\partial T_s}{\partial x}\right) + \frac{H_n A_s}{\rho_w C_p V} + S \qquad (3)$$

where T_s is the stream water temperature (°C), V_x is the advective velocities (m/s), D_x is the diffusion coefficients (m^2/s), V is the segment volume (m^3), A_s is the segment surface area (m^2), ρ_w is the density of water (997 kg/m^3), C_p is the specific heat of water (4179 J/kg °C), H_n is the net surface heat flux (W/m^2), S is the loading rate include boundary, direct and diffuse loading (°C /s).

The net surface heat flux includes the effects of a number of processes (Cole et al., 1994) computed as:

$$H_n = H_s + H_a + H_e + H_c - (H_{sr} + H_{ar} + H_{br}) \qquad (4)$$

where H_n is the net heat flux across the water surface (W/m^2), H_s is the incident short wave solar radiation (W/m^2), H_a is the incident long wave atmospheric radiation (W/m^2), H_{sr} is the reflected short wave solar radiation (W/m^2), H_{ar} is the reflected long wave radiation (W/m^2), H_{br} is the back radiation from the water surface (W/m^2), H_e is the evaporative heat loss (W/m^2), H_c is the heat conduction (W/m^2).

The WASP model used a one-dimensional kinematic wave flow option where flow velocity, depth and width were calculated as an exponential function of flow rate, with their multipliers and exponents specified by user. Based on Acoustic Doppler Current Profiler (ADCP, SonTek RiverSurveyor M9) transect measurements, a set of multipliers and exponents was estimated based on the least sum of square of standard error approach to obtain the optimal and realistic flow dynamics. The regression equations are displayed below and plotted in Figure 2.

$$Velocity = 0.0389Q^{0.4000} \quad (5)$$

$$Depth = 0.7034Q^{0.1638} \quad (6)$$

$$Width = 36.528Q^{0.4362} \quad (7)$$

We represented the river within WASP by 74, 1-km segments. Because weather conditions were similar across the study area, we used meteorological data from one mesonet site (Clayton, OK) to calibrate our WASP model. Discharge monitored at USGS gage near Clayton (07335790) was used as hydrology input. Monitored stream water temperature data at Indian Highway (NDN, Figure 1) were used as the upstream boundary. The completed WASP model structure is illustrated in Figure 3.

Reservoir Release Simulation

The validated WASP model was used to predict downstream temperature in response to hypothetical reservoir operations during the validation period: 7/22/2017 to 9/1/2017. We first simulated stream water temperature without a release. This simulation served as a control and evaluated the thermal stress that would have been experienced by fishes in the absence of any water release. Next, multiple realistic release scenarios were simulated to assess their effects on both downstream water temperatures and fish-habitat guilds (Table 1). Five constant release levels were chosen: (1) 0.34 m^3/s represented the current longer-term release that was previously provided by the U.S. Army Corps of Engineers and the Oklahoma Water Resources Board (OWRB) to provide limited relief to sensitive freshwater mussels during a drought (note, this release does not provide connectivity from Sardis Reservoir to Lake Hugo); (2) 0.59 m^3/s represented the release that was hypothesized to adequately restore wetted primary mussel habitat (i.e., provide connectivity and coverage of primary beds) at Clayton; (3) 0.76 m^3/s (~26 cfs), 1.13 m^3/s (~40 cfs)and 1.50 m^3/s (~53 cfs) were chosen to represent the pre-dam median flows of August, September and July, respectively (Fisher et al. 2012). Three water temperatures, 27.64 ºC, 26.00 ºC and 24.07 ºC, were applied in simulations as the lateral thermal boundary condition to represent releases from three gates at different depths of the reservoir (5, 10 and 20 m). Beginning water-release scenario temperatures were estimated by averaging summertime water temperature data for depths corresponding to the gates located at 5 m, 10 m and 20 m when the conservation pool is full (lake profile data from 1999 to 2015, Oklahoma Water Resources Board, 2016,).

To evaluate the benefits of the reservoir release on the receiving stream, we developed two metrics. Releases were aimed at keeping the stream temperatures below a thermal tolerance for fishes. For these initial simulations, the initial thermal tolerances (T^*) of organisms were assumed to be 30°C (until the thermal experiments were completed). The metrics were based on the principle of average excessive heat energy and average heat flux:

Time averaged excessive heat energy:

$$h_e(m) = \frac{1}{n}\sum_{i=1}^{n}\left[V(n,m) * \rho * \Delta T(n,m) * C_p\right] \qquad (8)$$

Time averaged excessive heat flux:

$$h_{ef}(m) = \frac{1}{n}\sum_{i=1}^{n}\left[Q(n,m) * \rho * \Delta T(n,m) * C_p\right] \qquad (9)$$

Time averaged reservoir release heat flux:

$$h_{if}(m) = \frac{1}{n}\sum_{i=1}^{n}\left[Q_r(n,m) * \rho * \Delta T(n,m) * C_p\right] \qquad (10)$$

Where $Q = Q_n + Q_r$ (11)

n is time step during the experiment period, m is the segment number, V is volume of water in the segment, Q is the flow rate in the stream (subscript n indicates natural flow and subscript r indicates reservoir release), ρ is the water density, C_p is the specific heat capacity of water, and ΔT is a temperature difference.

The first metric, called the energy reduction percentage (ER), was based on the reduction of excessive heat energy above this thermal tolerance (i.e., to what extent is the excessive temperature or heat energy in the stream reduced). The excessive heat energy was calculated using equation (8) for the no reservoir release or base scenario, defined as h_{e0}, and for the scenarios with a reservoir release, defined as h_{er}, based on times when the temperature in the stream exceeded the thermal tolerance (i.e., $\Delta T = T_s - T^*$). The ER was then calculated as:

$$\text{ER}\ (m) = (h_{e0} - h_{er}) / h_{e0} \qquad (12)$$

The second metric, called the energy reduction efficiency (ERE), was used to evaluate the relative benefit of the temperature reduction due to specific reservoir releases relative to the heat flux invested into the stream from the reservoir. For this metric, the invested heat flux from the reservoir (h_{if}) was calculated using equation (10) based on the temperature difference between the stream and the reservoir release temperature (i.e., $\Delta T = T_s - T_r$) and then compared to excessive flux reduction. The ERE was calculated as:

$$\text{ERE}\ (m) = (h_{ef0} - h_{efr}) / h_{if} \qquad (13)$$

Predicted temperature time series were contrasted against CTMax to identify the time when stream fishes from different habitat guilds (Table 1) experienced severe thermal stress. A cumulative time when stream fish experienced severe thermal stress (hereafter cumulative time above CTMax) was calculated for each fish-habitat guild in every 1-km segment simulated in the Kiamichi River WASP temperature model. The results were plotted as a function of distance from the Sardis Reservoir confluence and cumulative time above CTMax. The areas bounded by the curve of cumulative time above CTMax (km•h) were calculated to quantify the thermal stress experienced by the two fish guilds downstream of Sardis Reservoir. The reduction rates of thermal stress against that of the control were calculated to quantify the 'cooling effect' of each release scenario. The distance where the cumulative time above CTMax was reduced by half was calculated as the effective distance indicating the dissipation of the cooling effect. This metric is intended to provide a conservative approach to examining the tradeoff of water use versus cooling as we acknowledge that cooler water pockets exist within the stream and our model is predicting at the one-dimensional scale.

Stream Temperature and Dissolved Oxygen Data Collection, and DO Modeling

Stream temperature and dissolved oxygen (DO) concentration data were collected using 10 temperature data loggers (HOBO U22 Water Temperature Pro v2 Data Logger) and 10 DO data loggers (HOBO U26 Dissolved Oxygen Data Logger) deployed along the river (Figure 4). Temperature loggers were placed in approximately 1-m deep water in areas of pools that would receive adequate mixing of stream water (i.e., main channel). Loggers were anchored to the stream bottom on a paving stone attached via a cable. The HOBO logger was contained within a white polyvinyl chloride (PCV) housing to prevent any direct solar radiation. Prior to use, holes were drilled in the PCV to allow flow through while deployed. DO data loggers were calibrated initially in the laboratory using a 0% oxygen solution and 100% oxygen saturation and calibrated in the field, monthly, according to the factory recommendation. Briefly, a pre-calibrated DO meter, barometer, and thermometer (YSI Pro 2030) were used to record current conditions at each logger's location. These data were recorded and used as a correction factor when offloading data into HOBOware Pro v. 3.7.4.

The WASP model was set up based on the Streeter-Phelps BOD (biochemical oxygen demand)-DO equations to predict downstream DO concentration.

$$\frac{\partial D}{\partial t} = k_1 L_t - k_2 D \qquad (14)$$

$$D = \frac{k_1 L_a}{k_2 - k_1}\left(e^{-k_1 t} - e^{-k_2 t}\right) + D_a e^{-k_2 t} \qquad (15)$$

Where D is the saturation deficit, $D = DO_{sat} - DO$ (mg/L), k_1 is the deoxygenation rate (s^{-1}) , k_2 is the reaeration rate (s^{-1}), L_a is the initial oxygen demand also called ultimate BOD (mg/L), L_t is the oxygen demand at time t, $L_t = L_a e^{-k_1 t}$ (mg/L), D_a is the initial oxygen deficit (mg/L).

Temperature tolerances of stream fishes

CTMax is a useful technique to assess thermal tolerances in fishes. It was originally developed by Cowles and Bogert (1944) on lizards and later adapted for use on freshwater fishes (Becker and Genoway 1979). CTMax is an accepted method for measuring temperature tolerance in fishes (Lutterschmidt and Hutchison 1997). During

CTMax studies, the water temperature increases at a fast-enough rate (1°C per min - 1°C per h, Becker and Genoway 1979) to prevent acclimation and continues to increase until the fish reaches loss of equilibrium (LOE), onset of spasms (OS), or death (D) (Lutterschmidt and Hutchinson 1997). Given the time to acclimate to rising temperatures, stream fishes may tolerate higher temperature than many CTMax studies suggest (Becker and Genoway 1979). Also, streams experience diel temperature fluctuations where stream temperature decreases during the evening, which could allow fish to better cope with an overall thermal increase (i.e., a nocturnal thermal refuge). A study that both increases temperature at a natural rate and incorporates a diel component would simulate a more realistic physiological response to temperature. Therefore, we also performed a longer-term temperature stress study that mimics a natural stream environment and measured cortisol as an indicator of stress (see *Long-term Thermal Stress*).

Fish Collection and Acclimation

Fishes were collected 2015-2018, transported to, and acclimated to laboratory conditions. We collected fishes using a seine (2.44 m in length, 1.83 m in height, with 0.3175 cm diameter mesh) that was pre-soaked in VidaLife (Western Chemical Inc., Ferndale, WA) to minimize handling stress (i.e., reduces friction on the fish). Collected fish were transported in stream water treated with non-iodized salt to 1% (10 g/L) to reduce stress (Swann and Fitzgerald 1992). Fishes remained in hauling containers for up to 12 h until the temperature of the hauling water reached that of the holding tanks, approximately 20.0°C. Fishes were then transferred to 190-L holding tanks covered with a screen on the top. We added airstones to all holding tanks to maintain dissolved oxygen >5 mg/L. Over the first 96 h, fishes were left undisturbed to recover from transportation stress. Brown Trout *Salmo trutta* and Rainbow Trout *Oncorhynchus mykiss* recover from acute emersion and confinement within 24-48 h (Pickering and Pottinger 1989). Fishes remained in holding tanks where they were acclimated to laboratory conditions over a 2-week period.

Following the initial 96 h, fish were fed and water-quality conditions were checked daily. We fed fish flakes (Wardley Advanced Nutrition Perfect Protein Tropical Fish Flake Food, Hartz Mountain Corporation, Secaucus, NJ) and bloodworms (Fish

Gum Drops Floating Fish Food Bloodworms, San Francisco Bay Brand, Newark, CA) once daily to satiation (i.e., until fishes ceased eating). Unconsumed food was removed from aquaria daily via siphon. Ammonia, pH, and chloramine were checked twice daily. The temperature of the holding tanks was maintained at approximately 20.0°C. Ammonia was maintained <0.5 ppm. This level was only observed when new fish were added to the holding tanks, and for the first few days of lab acclimation. For the duration of acclimation and experimentation, ammonia was <0.25 ppm, pH was 8-8.5, and chloramine was zero. Water changes of approximately 30% were performed daily after the first 96 h of acclimation.

Critical Thermal Maximum of Fish-Habitat Guilds used in WASP Modeling

Each of 10 stream fishes was assigned to one of three habitat guilds and CTMax was averaged for that guild (Alexander 2017). Habitat guilds were assigned as benthic, mid-column or surface occupants (Pflieger, 1997; Miller and Robison, 2004; Cashner et al., 2010) (Table 1). The benthic guild consisted of five species that typically used habitat on the stream bottom. The mid-column guild consisted of four pelagic species that typically occupied the water column. The surface guild was represented by one species which occupied the surface of slackwater habitats. The CTMax for each guild ranged from 34.0 °C to 38.3°C for the thermally sensitive benthic guild and more tolerant surface guild, respectively (Table 1). The CTMax of the 10 species assigned to habitat guilds was determined following the methods outlined below for the Kiamichi River Assemblage. The species were chosen based on 1) abundance, 2) conservation status (i.e., Orangebelly Darter *Etheostoma radiosum*, Blackside Darter *Percina maculata*, Oklahoma's Comprehensive Wildlife Conservation Strategy 2005), and 3) data gaps. We used these fishes, rather than all species where CTMax was determined because we needed to develop the reservoir scenarios for the WASP model in conjunction with this effort. We continued our CTMax efforts in parallel to have a more robust species-thermal profile for the Kiamichi River.

Critical Thermal Maximum of the Kiamichi Assemblage

We determined the CTMax of 17 stream fishes (Table 2) using an incomplete block design with an associated survival control (i.e., the control was not included in the final analyses). Each block consisted of up to six species, each represented by one individual fish. Our goal was to replicate the experiment ten times for each species. We set up a system that routed water from a 189.27-L sump to six 37.85-L acrylic aquaria (Figure 5). Two airstones were added to the sump system to maintain dissolved oxygen above 5 mg/L. Water in the sump system was heated with a 5000-W Smartone heater (OEM Heaters, Saint Paul, MN). We randomly assigned species to aquaria, but haphazardly assigned individual fish to each aquarium (one fish per aquarium). We maintained a survival control using a separate sump system where fish experienced the same handling as the treatment fish but were held at their acclimation temperature for the duration of each trial. Most fishes were held at 20.0°C for 24 h prior to the start of the experiment to allow acclimation to testing conditions and recovery from handling stress (Hutchison and Maness 1979; Pickering and Pottinger 1989). We primarily focused on adult, small-bodied fishes because they are often less tolerant of higher temperatures (Pörtner and Farrell 2008) and would be more likely to represent thermal population bottlenecks. However, we did include juveniles of two subspecies/unique strains of Smallmouth Bass *Micropterus dolomieu* in our trials. Although we have information on the thermal tolerances of the nominal subspecies (Northern Smallmouth Bass), we lack information on these bass lineages and thus, included them in our trials. We recognize that neither species occupies the Kiamichi River, but the Ouachita strain is endemic to the Ouachita Mountain ecoregion and is of interest to the Oklahoma Department of Wildlife Conservation. The Neosho subspecies (endemic to the Ozark Highlands and Boston Mountains) was also included as a comparison. The two juvenile basses were acclimated to both 25°C and 20°C because they would be anticipated to tolerate warmer temperatures and they hatch/develop under warmer-water conditions (but also completing trials at 20 °C allowed them to also be directly compared to the other species).

All CTMax trials were completed using one critical endpoint, loss of equilibrium (LOE) (Becker and Genoway 1979; Lutterschmidt and Hutchison 1997; Beitinger et al. 2000). During our trials, we increased water temperature 2°C/h until fish experienced LOE. We defined LOE as the point at which an individual lost the ability to maintain dorso-ventral orientation (Becker and Genoway 1979). None of our control fish experienced LOE.

We used robust Bayesian estimation (Kruschke 2013) to estimate CTMax values among the assemblage of stream fishes (17 fishes) where CTMax was determined (Table 2). We fit a single-factor linear model with a covariate in a hierarchical framework, where species was the factor j and total length was the covariate x. This model structure is a Bayesian generalization of an analysis of covariance that imposes sum-to-zero constraints on group-level parameters (Kruschke 2015). Species CTMax were modeled as deflections around the group mean, where we used broad normal priors for both group-level parameters and the total length slope. For these data, we used a t distribution with a shifted exponential prior on the normality parameter ν (Kruschke 2013) to accommodate heavy tails in CTM observations i. Because an equal-variance among groups assumption was not reasonable, we modeled each species standard deviation (SD) j separately. We also included a grouping factor for trial k to account for correlated CTM observations using a broad normal prior (Gelman and Hill 2007).

We used a set of contrasts (Kruschke 2015) to compare differences in CTMs based on both thermal groupings and taxonomy (Table 3). Initially, we divided the stream fishes into two thermal groups, low and high, based on their rank relative to the estimated group mean CTM. We then further divided stream fishes into four subgroups (low-low, low-high, high-low, and high-high) based on the mean estimated CTM of the initial groupings. For the contrasts, we compared the low and high groups and their associated subgroups (i.e. low-low versus low-high; low-high versus high-high). We also compared both the two darter genera (*Etheostoma* and *Percina*) and darters to minnows (Highland Stoneroller, *Notropis*, *Pimephales*, and Steelcolor Shiner; Table 2). Lastly, we compared each species individually to all other members of their genera when applicable (Table 3). The differences in CTMs were evaluated using 90% highest density intervals (HDIs), where we considered the difference important if the interval did not overlap zero.

We performed the analysis using the program JAGS (Plummer 2003) called from the statistical software R (version 3.5.1, R Core Team, 2018) with the package runjags (Denwood and Plummer 2016). Posterior distributions for parameters were estimated with Markov chain Monte Carlo methods using 50,000 iterations after a 10,000-iteration burn-in phase. We assessed convergence using both the Brooks-Gelman-Rubin statistic ($\hat{R}$; Gelman and Rubin 1992) and effective sample size (ESS; Kruschke 2015), where values <1.1 and >15,000, respectively, indicate adequate mixing of chains. Total length was standardized to a mean of zero and a variance of one such that group-level deflections are interpreted as estimated species CTM at mean total length, and the total length slope represents the estimated change in CTM with a one SD change in total length.

Long-term Thermal Stress

We determined whole-body cortisol concentration of six stream fishes (Table 4) in response to thermal exposure using a split-plot design that was blocked by trial. We used a 2x6 factorial treatment structure with two levels of temperature (27.0°C and 32.0°C) and six levels of species (Table 2). We set up four identical sump systems that routed water from a 189.27-L sump to six 37.85-L acrylic aquaria (Figure 5). Two airstones were added to each sump system to maintain dissolved oxygen above 5 mg/L. Water in each sump system was heated with a 1700 W Smartone heater (OEM Heaters, Saint Paul, MN). We randomly assigned temperature treatments to sumps (whole plots). Within each sump, we randomly assigned species to aquaria (our sub-plots). We used 27.0°C as the control temperature because it commonly occurs in our study area during the summer. The control temperature was below the thermal tolerance of our initial group of species whose CTMax was tested (Table 1). We used 32.0°C as the experimental temperature because it was 2.0°C less than CTMax of the most thermally-sensitive species initially tested, but this temperature was anticipated to be stressful to stream fishes. Each temperature-species combination was replicated 10 times.

Fishes were assigned to treatment aquaria, and then acclimated to the new conditions prior to starting each trial. We randomly assigned species to each of six aquaria in each sump system for each trial, and then we haphazardly selected three individual adult fish (pseudoreplicates) to place in each aquarium. We only used adults in these trials because they are often less tolerant of higher temperatures (Pörtner and Farrell, 2008). All fishes were held at 20.0°C for 24 h prior to the start of the experiment to allow acclimation to testing conditions and recovery from handling stress (Hutchison and Maness, 1979; Pickering and Pottinger, 1989).

We used a 12h:12h diel cycle to gradually heat each sump to its treatment temperature and maintained a 2.5°C nightly refuge during the trials. During each trial, we increased water temperature 2.5°C over 12 h (0700-1900), daily, and decreased water temperature 1.5°C over 12 h (1900-0700), nightly. The net water temperature increase was 1.0°C/d until the treatment temperature of 27.0°C (control) or 32.0°C (experimental) was reached. All sumps were provided with a 2.5°C nightly (1900-0700) thermal refuge but returned to the treatment temperature each day. We maintained each sump at this thermal regime for 14 d. After 14 d at the treatment temperatures, we sacrificed all fishes by freezing them in liquid nitrogen. The fish samples were then stored at -80°C until homogenization.

Whole-body Cortisol Concentration

To quantify whole-body cortisol, we weighed and homogenized individuals, extracted cortisol, and performed an enzyme-linked immunosorbent assay (ELISA). We measured whole-body cortisol because sampling blood in my study fishes was impractical and holding water was shared among species in each trial (Belanger et al., 2016; Zuberi et al., 2014). Fish samples were weighed (0.001 g), partially thawed, and homogenized in 1x phosphate buffered saline (PBS) (1-part fish tissue, 5-parts 1x PBS). We combined 1 mL of homogenate with 5 mL diethyl ether in a glass centrifuge tube and vortexed for 1 min to extract cortisol. We then centrifuged samples at 3,500 rpm for 5 min and removed the organic layer containing cortisol. We repeated the extraction process three times for each sample. Following extraction, diethyl ether was allowed to evaporate overnight in a fume hood, leaving behind only proteins. We reconstituted samples with 1 mL of 1x PBS and incubated them overnight at 4°C. We performed ELISAs according to manufacturer's instructions to determine cortisol concentrations using a human salivary cortisol kit (Salimetrics LLC, College Station, PA). Each kit included cortisol standards, blanks, and high and low controls. We assayed samples in triplicate. We used a Cytation 5 cell imaging multi-mode reader (Biotek U.S., Winooski, VT) with Gen5 software (version 3.03, Biotek U.S., Winooski, VT) to measure sample optical density. We quantified whole-body cortisol concentrations of our samples using a 4-parameter sigmoid minus curve fit based on optical density of cortisol standards. High and low controls included in the kit verified values for standards. Cortisol concentrations were normalized by weight of the whole-body sample and reported as absolute cortisol concentrations (ng/g body weight). Values of pseudoreplicates were averaged to represent conditions in each aquarium.

We used a generalized linear mixed model (GLMM) to analyze the whole-body cortisol concentrations following a split-plot design with trial as a blocking factor, sump as the whole plot and aquarium as the subplot. In our model, whole-body cortisol concentration was the dependent variable, and temperature, species, and the temperature-species interaction were fixed effects. We checked for homogeneity of variance of the fixed effects. We used sump and trial as random effects in our model to control for differences among sumps and trials that were not directly of interest. The random effects, sump and trial, were assumed normally distributed as $N(0, \tau^2)$, where τ^2 was the population variance among levels of sump and $N(0, \beta^2)$, where β^2 was the population variance among levels of trial. We performed a Tukey Kramer Honest Significant Difference (HSD) post hoc test when an effect was significant. We assessed significance at $\alpha \leq 0.05$. These analyses were performed in SAS (version 9.4, SAS Institute, Cary, NC).

RESULTS

Hyporheic exchange and stream temperatures

Seepage Runs

The distance and number of transects were chosen to minimize error, accommodate access points, and avoid tributary confluences. ADCP error was minimized at $\leq \pm$ 0.015 m^3/s). We found using three transects was sufficient to minimize error (error $\leq \pm$ 1.5E-5 m^2/s) in groundwater flux across sites, while allowing us to avoid tributary inflows.

We completed six seepage runs on the Kiamichi River at six locations (Figure 4: Indian Riffle, Robins Riffle, Confupstrm, Confdownstrm, Pine Spur, and Payne Riffle).

At each reach, we measured discharge using an ADCP at three transects spaced 500-m apart. We established a discharge-distance relationship and the slope of the regression represented the net flux between surface water and groundwater at each reach. According to groundwater flux estimations, the upstream reaches tended to have a higher recharge rate than downstream reaches (Table 5). The net groundwater flux estimation was negative for most of the reaches, indicating loss of stream water (surface waters) to groundwater (losing reaches).

Tracer Test and OTIS-P

We performed tracer tests at 4 locations along the river between Pine Spur Riffle, and Robins Riffle (Figure 1) to quantify hyporheic exchange longitudinally. We finished data analyses and model fitting for data collected at Pine Spur Riffle (PS). Model predictions via OTIS-P were contrasted to monitored concentration (Figure 6). Parameter estimates via the OTIS-P simulations indicated model convergence was successful for both the first (PS2) and second reaches (PS3). The maximum residual sum of squares (i.e., describes the quality of the estimator) had a mean square error (MSE) < 0.2 suggesting good model fit of the breakthrough curve (i.e., concentration curve versus time). The fraction of median travel time due to storage (F_{med200}) of PS2 was higher than PS3 (70.23 > 63.56), indicating the groundwater exchange through transient storage was higher upstream.

<u>Influence of dam releases on stream temperatures and dissolved oxygen</u>

WASP model

Predicted values of velocity, depth, and width were confirmed to be within a realistic range when compared to data collected using an ADCP at riverine locations. Because of minor differences in the weather between the four sites, the weather data were set constant along the river using observations from the Clayton Mesonet site in the middle of the modeled reach.

Simulated temperatures simulated by the WASP model more closely matched measured values after accounting for groundwater (Figure 7 and 8). The model tended to predict cooler than expected temperatures during warmer periods (Figure 7) until groundwater inflow was incorporated in the model (Figure 8). Specifically, we introduced a dispersive groundwater exchange process to the model. We set groundwater temperature at 15°C (average air temperature during the research period). The modeled predictions were closer to measured values at the upstream sites and the error increased in the downstream direction. The model was improved at all sites by including a surrogate for groundwater in the model (Tables 6 and 7).

Reservoir Release Simulation

According to our initial simulation results, a reservoir release has a significant effect of regulating downstream water temperature during the summer baseflow period (i.e., also known as drought flow, referencing the portion of streamflow that comes from the sum of deep subsurface flow and delayed shallow subsurface flow) (Figure 9).

The WASP predicted temperatures were used to calculate energy reduction (ER) and energy reduction efficiency (ERE) with respect to spatial distance downstream from the Indian HWY site (Figures 10-12). We show excess energy is reduced at various release temperatures, and as expected, with the coolest release temperature reducing the most excess energy. However, the temperatures generally converge regardless of temperature release at approximately 100-km downstream (due to other heat processes). The trend is the same across figures but is represented by different processes (Figures 10-12).

In the absence of a reservoir release (i.e., the control scenario), downstream fishes were expected to experience an approximately uniform thermal stress throughout the simulated reach of Kiamichi River (Figure 13). The control scenario indicated the benthic guild was expected to experience 130 h of thermal stress, while mid-column guild was expected to experience 73 h thermal stress. The surface guild never experienced temperatures exceeding their CTMax; thus, temperatures were expected to be tolerated by that fish guild so that guild was not investigated further.

As expected, the thermal relief increased as indicated by thermal stress (Table 8), reduction rate of thermal stress (Table 9) and effective distance (Table 10) with the increase of the release magnitude and the depth of the release location (i.e., the lower release locations had cooler water, Figure 14). In recent years, the only time a release has been provided for ecological purposes, only 0.34 m^3/s was released from the top gate (Gates et al., 2015). This release scenario only reduced thermal stress by 11% for mid-column fishes and 8% for benthic fishes. The effective distance (i.e., distance where cumulative time above CTMax was reduced by half) of the release was only 1 km for both guilds. A release hypothesized in the literature (0.59 m^3/s released from the top gate) to provide relief for downstream mussel habitat (Spooner et al., 2005) reduced thermal stress by 18% for mid-column fishes and 12% for benthic fishes. The effective distance increased to 4 and 2 km for mid-column fishes and benthic fishes, respectively. Three releases that represented pre-dam flow magnitudes (0.76, 1.13 and 1.50 m^3/s released from top gate) reduced thermal stress up to 33% for mid-column fishes and 29% for benthic fishes. The effective distance increased to approximately 10 km for both fish guilds. In comparison, the 0.34 m^3/s release was expected to cause an increase in thermal stress of up to 20% for both guilds. Consideration of different release locations (and access to cooler water) improved the cooling results and downstream effects considerably (Figure 14). Surface releases resulted in ~30% reduction rate in thermal stress at the highest modeled flow release. Similar results could be achieved at half that flow volume if the lowest available gate on the dam was used to initiate the release. The three release scenarios that represented pre-dam flow magnitudes (0.76, 1.13 and 1.50 m^3/s) reduced thermal stress by 21-46% for mid-column fishes and 15-41% for benthic fishes, depending on water temperatures associated with the gate location on the dam. The effective distance (i.e., where thermal stress was reduced by 50%) extended to 16-km downriver of the Jack Fork Creek confluence if releases were made from the deepest gate on the dam and the greatest flow magnitude simulated (1.50 m^3/s). The other pre-dam flow magnitudes (0.76, 1.13 m^3/s) increased the effective distance to 5-12 km for the mid-column guild, and 5-10 km for the benthic guild, depending on release temperature (i.e., gate location).

Stream Water Temperature and Dissolved Oxygen Data Collection

The DO time series observed in 2015 represented summer conditions of a relatively warm year with few water releases (Figure 15). The DO concentrations observed at the confluence were above 5 mg/L uniformly more than 95% time. The DO concentrations observed at the sites located downstream of the dam influence were above 5 mg/L during releases, except for the most downriver site. At Payne, DO had a major shift where variances increased substantially during a low-flow period starting 10/13/2017. Because there were no dam releases during that period, and the site immediately upstream (Pine Spur) showed suitable DO conditions, it seems the low DO (near 2 mg/L) at night were likely related to an algae bloom. Algae blooms are relatively common from May through October and negatively affect the DO conditions at night when the plants experience high rates of respiration (i.e., use oxygen). Another possible explanation is that the loggers fouled at that location, which is a common limitation of polarographic membrane-type sensors (Wagner et al., 2000).

The DO concentration time series observed in 2017 represented DO patterns during a higher-flow period because of considerable water releases from Sardis Reservoir due to repeated storm events (Figure 16). The DO concentrations observed at the Jack Fork-Kiamichi rivers confluence were above 5 mg/L during these release scenarios but dropped significantly following releases.

The BOD sampling also supported our findings that DO was only low immediately following discharge events. BOD samples reflected low values (less than 2 mg/L) during the decreasing of discharge (while discharge was above 1.0 m^3/s) and higher values (2.9 mg/L and 3.8 mg/L observed at most upstream and downstream sites, respectively) immediately following the return to low-flow conditions (when discharge dropped below detectable limit).

Temperature tolerances of stream fishes

We summarized CTMax values from the existing literature (Table S1). Most studies focused on sport fish and common species. However, a few studies did determine thermal tolerances of diminutive fishes (e.g., Johnny Darter *Etheostoma nigrum* and Southern Redbelly Dace *Chrosomus erythrogaster*).

Critical Thermal Maximum of the Kiamichi River Assemblage

CTMax values differed significantly between thermal groupings, between taxonomic groups, and between species and subspecies of the same genera. The estimated group mean CTMax was 34.72 °C (90% HDI: 34.60, 34.83), and estimated CTM among the stream fishes ranged from 32.43 to 38.26 °C (Table 2). Kiamichi Shiner *Notropis ortenburgeri* had the lowest estimated thermal tolerance, and Blackspotted Topminnow *Fundulus olivaceus* had the highest. Although darters tended to have a lower thermal tolerance than minnows, the difference in estimated CTMax values was not significant (Table 2 and Table 3). Similarly, 4 of 10 stream fishes, along with six darters, in the low thermal guild (raw mean CTMax ± SD: 34.09 ± 0.66 °C) were minnows, and Logperch *Percina caprodes* was included in the high thermal guild (raw mean CTMax ± SD: 35.71 ± 1.24 °C) along with three minnows, both Smallmouth Bass subspecies/genetic lineages, and Blackspotted Topminnow (Table 2). The difference in estimated CTMax values between the low and high thermal guilds was significant (Table 3). When broken into four different thermal guilds, the low-low guild comprised Kiamichi Shiner, Etheostoma, Blackside Darter, and Channel Darter (Table 2), and the low-high guild comprised Dusky Darter, Bigeye Shiner, Emerald Shiner, Slenderhead Darter, and Steelcolor Shiner (Table 3). The high-low guild comprised Pimephales, Neosho Smallmouth Bass, Highland Stoneroller, and Logperch, and the high-high group comprised Ouachita Smallmouth Bass and Blackspotted Topminnow. Thermal tolerances were significantly different between the four thermal guilds, where the magnitude of the difference in estimated CTMax was ~1°C higher between the guilds in the high thermal group compared to the low thermal group. Among all darter species, *Etheostoma* had a significantly lower thermal tolerance than *Percina*. Among members of *Percina*, Blackside Darter *Percina maculate* and Channel Darter *Percina copelandi* had a significantly lower thermal tolerance, and Logperch had a significantly higher thermal tolerance. Estimated CTMax did not differ significantly between Johnny Darter *Etheostoma nigrum* and Orangebelly Darter *Etheostoma radiosum*. Among members of *Notropis*, Bigeye Shiner *Notropis boops* and Emerald Shiner *Notropis atherinoides* had a significantly higher thermal tolerance, and Kiamichi Shiner had a significantly lower thermal tolerance. Estimated CTMax did not differ significantly between Bluntnose Minnow *Pimephales notatus* and Bullhead Minnow *Pimephales vigilax*. As expected, estimated CTMax was higher for both genetically-distinct Smallmouth Bass populations at the higher acclimation temperature (Table 2). Neosho Smallmouth Bass had a significantly lower thermal tolerance than Ouachita Smallmouth Bass at both acclimation temperatures; however, the magnitude of the difference was ~0.5 °C higher at the higher acclimation temperature. Estimated CTMax decreased with increasing total length in the assemblage-level analysis (slope: -0.31, 90% HDI: -0.47, -0.15). The 90% HDI for the total length slope in the Smallmouth Bass analysis overlapped zero and was subsequently removed.

Model diagnostics indicated adequate mixing of chains and good fit. $\hat{R}$ was 1.0 and ESS was >15,000 for all model coefficients in both analyses. Posterior predictive plots indicated good fit using a t-distribution ($\nu = 11.2$ and $\nu = 9.5$ for the assemblage analysis and Smallmouth Bass-only analysis, respectively).

Whole-body Cortisol Concentration

Assumptions of normality and homoscedasticity were not met by our model. Natural-log transformation of whole-body cortisol concentrations improved skewness. However, unequal variances of the fixed effects were still apparent; thus, were modeled to account for heteroscedasticity.

Whole-body cortisol concentrations varied among the species we examined, but not between the two treatment temperatures. The fixed effect of species was significant in our model ($F_{5, 36.86} = 62.46$, P <0.01) indicating a significant difference in stress response for at least one species. Interestingly, the fixed effect of temperature ($F_{1, 17.57} = 0.84$, P = 0.37), and the interaction of the fixed effects were not significant ($F_{5, 36.86} = 0.55$, P = 0.74). Results from Tukey Kramer HSD indicated there were differences in whole-body cortisol concentrations among species (Figure 17). Highland Stoneroller *Campostoma spadiceum* had the highest cortisol concentration (67.61 ng/g body weight at the treatment temperature, 56.38 ng/g body weight at the control temperature) regardless of temperature (P <0.01). Channel Darter had the lowest cortisol concentration (1.64 ng/g body weight at the treatment temperature, 2.07 ng/g body weight at the control temperature), significantly different from Steelcolor Shiner (P = 0.02) and Bluntnose Minnow (P = 0.04), but not significantly different from Orangebelly Darter (P = 0.79) or Blackspotted Topminnow (P = 0.46). Cortisol concentrations in all other species were statistically similar among one another (Figure 17) and ranged 3.45-9.12 ng/g body weight in treatment fishes and 3.04-5.55 ng/g body weight in control fishes.

DISCUSSION & RECOMMENDATIONS

The impoundment of Sardis Lake significantly altered the downstream thermal regime of the Kiamichi River and increased thermal stress by up to 20% for benthic and mid-column fish species. However, we show the only flow released to benefit biota in recent years (0.34 m^3/s, Gates et al. 2015) was insufficient to recover the downstream thermal regime to even near pre-dam conditions, and that flow does not connect the entire length of river between Sardis Reservoir and Lake Hugo. In addition to providing little improvement to thermal conditions, this scenario also prevents fish movement via lack of connectivity across the riverscape. If the desired outcome is to improve habitat for fishes and freshwater mussels, flow releases would benefit from consideration of the results presented in this report. We demonstrate that thermal improvements via flow releases could improve conditions for fishes for a considerable distance downriver of the confluence. The benefits of thermal improvement via cooling is observed across the entire 74-km river segment but providing a 50% reduction in thermal stress for fishes varied by volume of water released and release location. Monitoring of dissolved oxygen is recommended to establish better relationships with water releases as there have not been any releases of water at those locations to sufficiently evaluate the resulting dissolved oxygen conditions. Specifically, the water-management agency does not currently make water releases from the lower gates so the dissolved oxygen conditions we observed cannot account for that uncertainty.

Dissolved oxygen concentration is also an essential component of aquatic ecosystems that are affected by the magnitude of release. However, based on the in-stream DO concentrations observed in 2015 and 2017 and BOD sampling results, the observed reservoir releases did not directly reduce DO concentrations in the Kiamichi River. DO concentration of reservoir water tended to decrease with depth (Townsend, 1999), as shown in existing lake profile data (Oklahoma Water Resources Board, 2016, unpublished data 1999-2015). As a result, hypolimnetic release with low DO concentration may degrade fish habitat by reducing DO concentration downstream of the dam (Hoback and Barnhart, 1996; Marshall et al., 2006), especially when releases are made continuously during extremely hot years. In this study, the reservoir was likely to have released water from the upper gate expected to have the highest DO, which did not introduce any moderate or severe DO stress. However, DO conditions at depth may change (e.g., climate change, different use of water volumes over time), and releases of larger magnitudes can affect downstream DO concentrations by causing resuspension of oxygen demanding materials. DO monitoring efforts are recommended to ensure suboptimal conditions are not created if hypolimnetic releases are used as a management option.

The DO observations revealed some unexpected patterns at certain sites. For example, the DO variances increased substantially during a low-flow period at the Payne site starting 10/13/2015 (Figure 15). Because there were no dam releases during that period, and the site immediately upstream (Pine Spur) showed suitable DO conditions, it seems the low DO at Payne (near 2 mg/L) at night were likely related to local conditions such as an algae bloom (Jacobsen and Marín, 2008) (see page 23). In 2017, the DO at the confluence dropped to less than 1 mg/L following releases while the sites upstream and downstream of the confluence were less effected. Possible causes for these changes in DO include aquatic ecosystems disturbed by high flows causing reduced capacity for photosynthesis, or dam releases transporting or resuspending oxygen demanding materials whose effects are felt after the flood crest (Graczyk and Sonzogni 1991).

The DO concentrations observed at the Jack Fork-Kiamichi rivers confluence were above 5 mg/L during these release scenarios but dropped significantly following releases. This was likely to result from disturbed aquatic ecosystems by high flows with reduced capacity of photosynthesis and influx or resuspension of oxygen demanding materials as a result of the storm water input (Graczyk and Sonzogni 1991). This pattern was also observed on upstream sites but dissipated downstream and was not observed at the downstream sites.

The WASP model offered a more comprehensive method to predict water temperature (compared to published regression equations, Spooner et al. 2005), taking into account the heat transfer mechanisms (i.e., solar radiation, bottom heat conduction and evaporation), which we then used to simulate reservoir releases. However, we found a continued discrepancy between the predicted and observed water temperatures when discharge decreased to base-flow conditions in the summer months, and two processes may be responsible. First, as discharge decreased, groundwater replenishment accounted for much of the available water source. As a result, the thermal regime of the river was also largely influenced by groundwater temperature. Second, the WASP model did not account for the heating of bank and bottom sediments when the water level was low. In the model, the bank temperature was set to a constant value. Yet, when discharge was low, the temperature of the surrounding river bank and bottom was likely higher due to more bank area being directly exposed to solar radiation. As a result, more heat exchange than simulated will occur on the river bank and bottom interface that may replenish the heat loss that occurred in the current simulation. This missing process could not be added to the current model, but we compensated by using a higher stream bottom temperature and that provided much more accurate temperature comparisons.

The root mean square errors (RMSE, difference between predicted and observed values) representing the prediction modeled temperature discrepancy averaged about 1.6 °C and were similar to other research using deterministic thermal models (e.g., Caissie et al., 2007); therefore, we believe our model performance is acceptable based on the research objective. The WASP model is one dimensional and represents *average water temperature* of each model segment, but the actual thermal heterogeneity within the stream would offer some patches of warmer or cooler water (Ebersole et al., 2001). Thus, although the error associated with the thermal predictions could be problematic for fishes during extremely hot periods if absolute (i.e., there was no thermal patchiness), it was expected to be less than the spatial variance created by fine-scale thermal heterogeneity (Kanno et al., 2014) that provides thermal refugia for fishes. Moreover, the importance of our WASP model was to understand the magnitude of effect that could be achieved with different reservoir releases (i.e., what is the net gain for stream fishes from using a certain volume of water and a certain release gate).

The predicted stream water temperature time series initially had greater diurnal variance when compared to the observed temperatures. Two main factors may have contributed to the prediction discrepancy. The first potential source of bias was associated with the stream water temperature being monitored at the bottom of the river while the Kiamichi temperature model predicted average stream water temperature across the entire stream segment volume due to the one-dimensional simplification. An additional contributing factor is the model limitation in accounting for the buffering effect of stream bottom in response to atmospheric heating conditions. For a shallow stream, a portion of the incoming radiation heat is absorbed by the stream bottom, which in turn heats up the stream water slowly, creating a heat buffer. In contrast, the model only allowed incoming radiation heat to be absorbed only by water column. To try to account for the incoming radiation heat absorbed by stream bottom, we used a high light extinction coefficient, allowing the water column to absorb a larger portion of incoming radiation heat. One consequence of this solution was increased diurnal variance due to faster heat transfer. However, for this research, the absolute accuracy of the temperatures was less critical than the relative differences across the water-release scenarios (i.e., the effect of different release options), and for the scenarios modeled, the error rate was acceptable. Evaluating the effects of dam releases was completed to examine how thermal conditions could be improved under different release scenarios.

The 1-D WASP model predicts water temperature as an average over a model segment, and to provide decision-making tools to evaluate dam releases over a 74-km reach consisting of 1 km stream segments, a one-dimensional model is probably the preferred option because of its high data efficiency. The model predictions are likely conservative as the thermal conditions predicted do not account for the patchy stream environment. This is probably beneficial given CTMax represents morbid conditions for fishes that does not allow fishes to acclimate and, of course, all models have some inherent error. It is important to recognize that even when CTMax values are not exceeded, fish may still experience reduced growth and survival due to exposure to suboptimal temperatures (Coutant, 1976). From the perspective of fish habitat, there may still be cooler-water patches available that provide refuge during thermally-stressful conditions and predicting those is not possible with a 1-D model. This study used a 1-D model, but if improved resolution of thermal conditions is desired, a two-dimensional model could be developed. However, significantly higher data requirement (e.g., vertical temperature stratification profiles) and computational cost is expected for 2-D models. Use of a 2-D model would likely be most beneficial for identifying greater resolution of thermal conditions at freshwater mussel beds, as an example, where organisms are generally sessile. A 2-D model would also be useful if there is interest in examining thermal refugia related to other land-use practices (i.e., maintaining riparian corridors, fencing cattle to prevent DO decreases). Lastly, increased thermal resolution of some stream segments might be useful to agencies developing monitoring strategies to target areas during severe drought or other thermally-stressful periods.

Interestingly, none of the fishes in this study showed increased cortisol concentrations resulting from the experimental temperature. Disregarding Highland Stoneroller, which is specifically discussed below, whole-body cortisol levels among the species in this study ranged from 3.4-7.1 ng/g body weight in response to control temperature and 2.2-10.1 ng/g body weight in response to treatment conditions. Sutherland et al. (2008) found similar basal whole-body cortisol values for Whitetail Shiner *Cyprinella galactura* (5-20 ng/g body weight, depending on age) and Spotfin Chub *Erimonax monachus* (10 ng/g body weight). Li et al. (2009) found whole-body cortisol levels of 6.3 ng/g body weight in Golden Shiner *Notemigonus crysoleucas* immediately sacrificed after seining from aquaculture ponds. The similarity of cortisol concentrations in our study to previous studies implies only a basal stress response at each temperature. The lack of significant temperature effect to acclimation to water temperatures may relate to a slow rate of temperature increase. Slower rates of temperature increase allow acclimation to occur (Lutterschmidt and Hutchison 1997). The net increase in temperature of 1°C/d that we used likely allowed acclimation to occur. A stress response may not be elicited until much higher temperatures.

Cortisol concentrations found in Highland Stoneroller in this study (70.8 ng/g body weight in response to control temperature, 75.8 ng/g body weight in response to experimental temperature) imply that individuals of this species were exhibiting stress response higher than basal levels and equal in magnitude at each treatment level. This level of stress appears to relate to species-specific intolerance of confinement in the laboratory setting. Confinement can cause increased levels of plasma cortisol (Clearwater and Pankhurst 1997, Murray et al. 2017). Due to their exaggerated stress response in captivity, it may be advisable to avoid using Highland Stoneroller to determine sources of stress in a laboratory setting. For the same reason, it may also be advisable to question the validity of lab-determined CTMax for Highland Stoneroller and Central Stoneroller *Campostoma anomalum*, a closely related species.

A variety of factors relates to species-specific thermal tolerances (e.g., life history, dispersal ability); however, at the most basic level, we lack information on the thermal tolerances of many warmwater stream fishes (Smale and Rabeni 1995, Lutterschmidt and Hutchison 1997, Beitinger et al. 2000). Understanding the thermal tolerances of species and assemblages will allow improved predictions of how species persist or thrive under changing stream temperatures. With water temperatures currently approaching the CTM of multiple species, further increases may threaten the health and persistence of many stream fishes. Increasing atmospheric temperatures will cause a 2-3°C water temperature increase in the south-central United States over the next 50-100 years (Morrill et al., 2005; van Vliet et al., 2013). Dewatering of streams also causes water temperature increases and reduction of suitable habitat for stream fishes (Luttrell et al., 1999; Bonner and Wilde, 2000). Dewatering can occur as a result of limited reservoir releases, overexploitation of groundwater and surface water, or extended drought (Muehlbauer et al., 2011). The resulting increases in water temperature stress fish and put them at risk for reduced or delayed reproduction (Tveiten and Johnsen, 1999; Auer, 2004), increased susceptibility to disease (Yin et al., 1995), weight loss (Whitledge et al., 2002), and even death (Allan & Castillo, 2007).

Because stream fishes have different thermal tolerances, it is difficult to evaluate assemblage-level responses to thermal changes in aquatic systems. A fundamental challenge is to reduce assemblage data in a way that is meaningful to detect patterns among fish assemblage members or groups. An increasingly common approach for simplifying assemblage data is to group species information based on common traits. Although useful for allowing generalization of ecological relationships and reducing data dimensionality, use of guilds or traits can be arbitrary and result in classifications that may not be ecologically meaningful. Fish exhibit behaviors, physiological characteristics, and life-history strategies which correspond to their sensitivity to and exploitation of water temperatures. For example, temperature influences reproductive effort (e.g., Pumpkinseed Sunfish *Lepomis gibbosus*, Masson et al. 2015), egg size, and the timing of ovulation in some fishes (e.g., Common Wolffish *Anarhichas lupus*, Tveiten and Johnsen 1999). Whereas general patterns in how fishes respond to changing temperatures are evident, different populations exhibit differences in these and other traits. Generalization of thermal sensitivity based on shared habitat (such as used in our WASP model), surrogate-species relationships, proxies to estimate the fundamental thermal niche (e.g., swimming performance, aerobic scope, Allen-Ankins and Stoffels 2017), or other estimated field-based parameters (e.g., realized thermal maxima, Stuart-Smith et al. 2017; Day et al. 2018) may not best represent similar thermal responses among species assemblages. Although multiple techniques may be useful for estimating species responses to changing thermal environments, laboratory estimates of thermal tolerances are useful because they isolate the species' response due specifically to changing temperature. It is surprising that our CTMax values covered such a broad range (32-38 ˚C) suggesting sensitivity of some assemblage members is much higher than others. This information may be useful for determining which species may be useful in monitoring for thermal stresses (e.g., minnow) including those associated with water releases (or lack thereof) and climate change. We found a mix of minnows and darters in the lowest thermal guild suggesting taxonomy is generally not a good way to examine thermal responses by fishes.

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Table 1. Critical thermal maxima (CTMax) was obtained from Alexander (2017). CTMax was determined by increasing temperature 2 °C/h above acclimated temperature (20.0°C) for 10 fish species that occupied the Ouachita Mountain ecoregion. The average value of species within each of three habitat guilds was used to determine a fish-habitat guild. Species were assigned to each habitat guild using existing ecological information (references provided). The CTMax for each guild was used to determine when fish will experience thermal stress as part of our WASP model simulations.

Habitat Guild	Guild CTMax (°C)	Common Name	Scientific Name	n	CTMax (°C)	Typical Habitat	Reference
Surface	38.30	Blackspotted topminnow	*Fundulus olivaceus*	10	38.30	Surface water, backwaters, edgewaters	Pflieger, 1997
Mid-column	34.72	Bigeye shiner	*Notropis boops*	10	34.42	Mid-column, run, pool	Pflieger, 1997
		Bluntnose minnow	*Pimephales notatus*	10	35.26	Mid-column, backwaters, pools	Miller and Robison, 2004
		Highland stoneroller	*Campostoma spadiceum*	10	34.78	Mid-column, riffle, run, pool	Cashner et al., 2010
		Steelcolor shiner	*Cyprinella whipplei*	10	34.42	Mid-column, riffle, run, pool	Pflieger, 1997
Benthic	34.34	Channel darter	*Percina copelandi*	10	34.09	Benthic, riffle, run, pool	Miller and Robison, 2004
		Common logperch	*Percina caprodes*	10	35.00	Benthic, riffle, run, pool	Miller and Robison, 2004

	Dusky darter	*Percina sciera*	10	34.30	Benthic, riffle, run, pool	Miller and Robison, 2004
	Orangebelly darter	*Etheostoma radiosum*	10	33.97	Benthic, riffle, run, pool	Miller and Robison, 2004
	Slenderhead darter	*Percina phoxocephala*	10	34.32	Benthic, riffle, run, pool	Miller and Robison, 2004

Table 2. Critical thermal maxima (CTMax) of 17 stream fishes that occupy Ouachita Mountain streams. Most fishes were acclimated to 20.0°C and exposed to a 2.0°C/h increase in temperature until loss of equilibrium. *The two unique strains of Smallmouth Bass (SMB) were also acclimated to 25.0°C because tested individuals were juveniles and more tolerant of thermal stress.

Scientific name	Common name	CTM (˚C), 90% HDI	Thermal group	Thermal subgroup
Notropis ortenburgeri	Kiamichi Shiner	32.50 (32.04, 33.02)	Low	Low-low
Etheostoma nigrum	Johnny Darter	33.52 (33.09, 33.91)	Low	Low-low
Etheostoma radiosum	Orangebelly Darter	33.84 (33.60, 34.08)	Low	Low-low
Percina maculata	Blackside Darter	33.87 (33.49, 34.32)	Low	Low-low
Percina copelandi	Channel Darter	33.98 (33.61, 34.34)	Low	Low-low
Percina sciera	Dusky Darter	34.36 (34.02, 34.70)	Low	Low-high
Notropis boops	Bigeye Shiner	34.43 (33.95, 34.91)	Low	Low-high
Notropis atherinoides	Emerald Shiner	34.49 (34.09, 34.88)	Low	Low-high
Percina phoxocephala	Slenderhead Darter	34.55 (34.28. 34.83)	Low	Low-high
Cyprinella whipplei	Steelcolor Shiner	34.71 (34.11, 35.24)	Low	Low-high
Pimephales vigilax	Bullhead Minnow	34.73 (34.22, 35.21)	High	High-low

Micropterus dolomieu velox	Neosho Smallmouth Bass	34.92 (34.40, 35.50)	High	High-low
Campostoma spadiceum	Highland Stoneroller	35.08 (34.71, 35.42)	High	High-low
Pimephales notatus	Bluntnose Minnow	35.13 (34.90, 35.41)	High	High-low
Percina caprodes	Logperch	35.61 (35.14, 36.06)	High	High-low
Micropterus dolomieu	Ouachita Smallmouth Bass	36.24 (35.64, 36.77)	High	High-high
**Micropterus dolomieu velox*	Neosho Smallmouth Bass	35.84 (34.93, 36.75)	NA	NA
**Micropterus dolomieu*	Ouachita Smallmouth Bass	37.71 (36.81, 38.63)	NA	NA
Fundulus olivaceus	Blackspotted Topminnow	38.28 (37.82, 38.71)	High	High-high

Table 3. Multiple comparison tests of critical thermal maximums (CTMax) based on thermal groupings and taxonomy, where contrast describes the test (see Methods and Table 2 for a detailed description of contrasts and groupings). The 90% highest-density interval (HDI) represents the posterior distribution of the credible difference (i.e., the effect size) in CTMax (˚C), where asterisks indicate HDIs that do not overlap zero. Most of the stream fishes were acclimated to 20°C, but genetically-distinct populations of Smallmouth Bass (SMB) were acclimated to both 20°C and 25°C (*).

Contrast	90% HDI
Low versus high	*-1.91, -1.45
Low-low versus low-high	*-1.23, -0.68
High-low versus high-high	*-2.55, -1.72
Darters versus minnows	-0.41, 0.03
Etheostoma versus *Percina*	*-1.17, -0.45
Johnny Darter versus Orangebelly Darter	-0.76, 0.11
Blackside Darter versus *Percina*	*-1.18, -0.25
Channel Darter versus *Percina*	*-1.08, -0.18
Dusky Darter versus *Percina*	-0.53, 0.23
Logperch versus *Percina*	*0.95, 1.90
Slenderhead Darter versus *Percina*	-0.23, 0.40
Bigeye Shiner versus *Notropis*	*0.33, 1.52
Emerald Shiner versus *Notropis*	*0.48, 1.55
Kiamichi Shiner versus *Notropis*	*-2.54, -1.34
Bluntnose Minnow versus Bullhead Minnow	-0.15, 1.01
Neosho SMB versus Ouachita SMB	*-2.08, -0.44

*Neosho SMB versus Ouachita SMB	*-2.79, -0.95

Table 4. Whole-body cortisol concentrations from chronic thermal stress trials were measured on six fishes: Blackspotted Topminnow *Fundulus olivaceus*, Bluntnose Minnow *Pimephales notatus*, Channel Darter *Percina copelandi*, Highland Stoneroller *Campostoma spadiceum*, Orangebelly Darter *Etheostoma radiosum*, and Steelcolor Shiner *Cyprinella whipplei*. Fishes were expected to exhibit stress responses associated with habitat guilds defined by documented habitat use. Experimental fishes were collected from the Kiamichi River in autumn 2016 and spring 2017. Fish were acclimated to laboratory conditions of 20.0°C and exposed to a 1.0°C/d increase in temperature until reaching the treatment temperatures (i.e., 27.0°C control; 32.0°C experimental). Fish remained at treatment temperatures for 14 days but were all provide a thermal refuge of 2.5°C each night during trials.

Common Name	Scientific Name	Habitat Guild	Typical Habitat	Reference
Blackspotted Topminnow	*Fundulus olivaceus*	Surface	Surface water, backwaters, edgewaters	Pflieger, 1997
Bluntnose Minnow	*Pimephales notatus*	Mid-column	Mid-column, backwaters, pools	Miller and Robison, 2004
Channel Darter	*Percina copelandi*	Benthic	Benthic, riffle, run, pool	Miller and Robison, 2004
Highland Stoneroller	*Campostoma spadiceum*	Mid-column	Mid-column, riffle, run, pool	Cashner et al., 2010
Orangebelly Darter[1]	*Etheostoma radiosum*	Benthic	Benthic, riffle, run, pool	Miller and Robison, 2004
Steelcolor Shiner	*Cyprinella whipplei*	Mid-column	Mid-column, riffle, run, pool	Pflieger, 1997

[1]Oklahoma Species of Greatest Conservation Concern

Table 5. Estimated groundwater fluxes from our seepage run data. Sites are listed in downstream order and the distance downstream was measured from the start of the reach in interest (i.e., Indian).

Reach	Downstream distance (km)	Net Groundwater Flux (m^2/s)
Indian	0.00	-4.45E-05
Robins	9.69	-6.42E-05
ConfUpstrm	34.28	3.76E-05
ConfDwnstrm	34.28	-3.00E-06
Pine Spur	59.88	-4.82E-05
Payne	73.34	-5.10E-06

Table 6. Statistics evaluating the predicted versus observed water temperatures using the WASP model without conceptualized groundwater inflow: sample size (n), R squared (R^2), squared errors of prediction (SSE), mean squared error (MSE), and Nash-Sutcliffe model efficiency coefficient (NSE). Statistics for each of four sites are included in the table.

	Indian HWY Pool	Robins Pool	Pine Spur Pool	Payne Pool
n	3696	3696	3696	3696
R^2	0.911	0.896	0.628	0.643
SSE	10516.398	19746.481	108988.067	104742.476
MSE	2.8E+00	5.3E+00	2.9E+01	2.8E+01
NSE	0.906	0.829	0.201	0.173

Table 7. Statistics evaluating predicted versus observed water temperatures using the WASP model with conceptualized groundwater inflow**:** sample size (n), R squared (R^2), squared errors of prediction (SSE), mean squared error (MSE), and Nash-Sutcliffe model efficiency coefficient (NSE). Statistics for each of four sites are included in the table.

	Indian HWY Pool	Robins Pool	Pine Spur Pool	Payne Pool
n	3673	3673	3673	3673
R^2	0.999	0.942	0.817	0.786
SSE	170.048	8819.775	41059.483	48092.314
MSE	0.05	2.40	11.18	13.09
NSE	0.999	0.933	0.710	0.641

Table 8. Thermal stress of fishes was evaluated by calculating the area under the curve of cumulative time above CTMax downstream of the release (km•h). The CTMax used to represent the thermal tolerances of a mid-column fish habitat guild was 34.72°C and the value used to represent the thermal tolerances of the benthic guild was 34.34°C. The thermal tolerances of fishes included in each guild were: mid column- Bigeye Shiner, Bluntnose Minnow, Highland Stoneroller, and Steelcolor Shiner; benthic- Channel Darter, Common Logperch, Dusky Darter, Orangebelly Darter, and Slenderhead Darter. Release scenarios were simulated based on the combination of five different release magnitude (0.34, 0.59, 0.76, 1.13 and 1.50 m^3/s) and three gate levels (5, 10 and 20 m deep representing release water temperature of 27.64°C, 26.00°C, and 24.07°C, respectively).

	Mid-column Guild				Benthic Guild			
Depth of water release from dam (m)	Control	5	10	20	Control	5	10	20
Discharge (m^3/s)	2914				5206			
0.34		2607	2516	2401		4808	4679	4557
0.59		2392	2290	2197		4579	4360	4153
0.76		2309	2214	2118		4401	4162	3949
1.13		2119	1980	1831		4027	3776	3534
1.50		1953	1785	1583		3698	3409	3077

Table 9. The reduction rate of thermal stress compared to the control with no release (calculated as the ratio of thermal stress reduction to the thermal stress of the control). The CTMax used to represent the thermal tolerances of a mid-column fish habitat guild was 34.72°C and the value used to represent the thermal tolerances of the benthic guild was 34.34°C The thermal tolerances of fishes included in each guild are provided in Table 8. Release scenarios were simulated based on the combination of five different release magnitude (0.34, 0.59, 0.76, 1.13 and 1.50 m^3/s) and three gate levels (5, 10 and 20 m deep representing release water temperature of 27.64°C, 26.00°C and 24.07°C, respectively).

	Mid-column Guild			Benthic Guild		
Depth of water release from dam (m)	5	10	20	5	10	20
Discharge (m^3/s)						
0.34	11%	14%	18%	8%	10%	12%
0.59	18%	21%	25%	12%	16%	20%
0.76	21%	24%	27%	15%	20%	24%
1.13	27%	32%	37%	23%	27%	32%
1.50	33%	39%	46%	29%	35%	41%

Table 10. The distance downstream of the Jack Fork Creek and Kiamichi River where the cumulative time above CTMax was reduced by half (provided in km). The CTMax used to represent the thermal tolerances of a mid-column fish habitat guild was 34.72°C and the value used to represent the thermal tolerances of the benthic guild was 34.34°C. The thermal tolerances of fishes included in each guild are provided in Table 8. Release scenarios were simulated based on the combination of five different release magnitude (0.34, 0.59, 0.76, 1.13 and 1.50 m^3/s) and three gate levels (5, 10 and 20 m deep representing release water temperature of 27.64°C, 26.00°C and 24.07°C, respectively).

	Mid-column Guild			Benthic Guild		
Depth of water release from dam (m)	5	10	20	5	10	20
Discharge (m^3/s)						
0.34	1	1	2	1	1	2
0.59	4	6	8	2	5	7
0.76	5	7	8	5	7	7
1.13	9	11	12	8	9	10
1.50	10	13	16	10	11	13

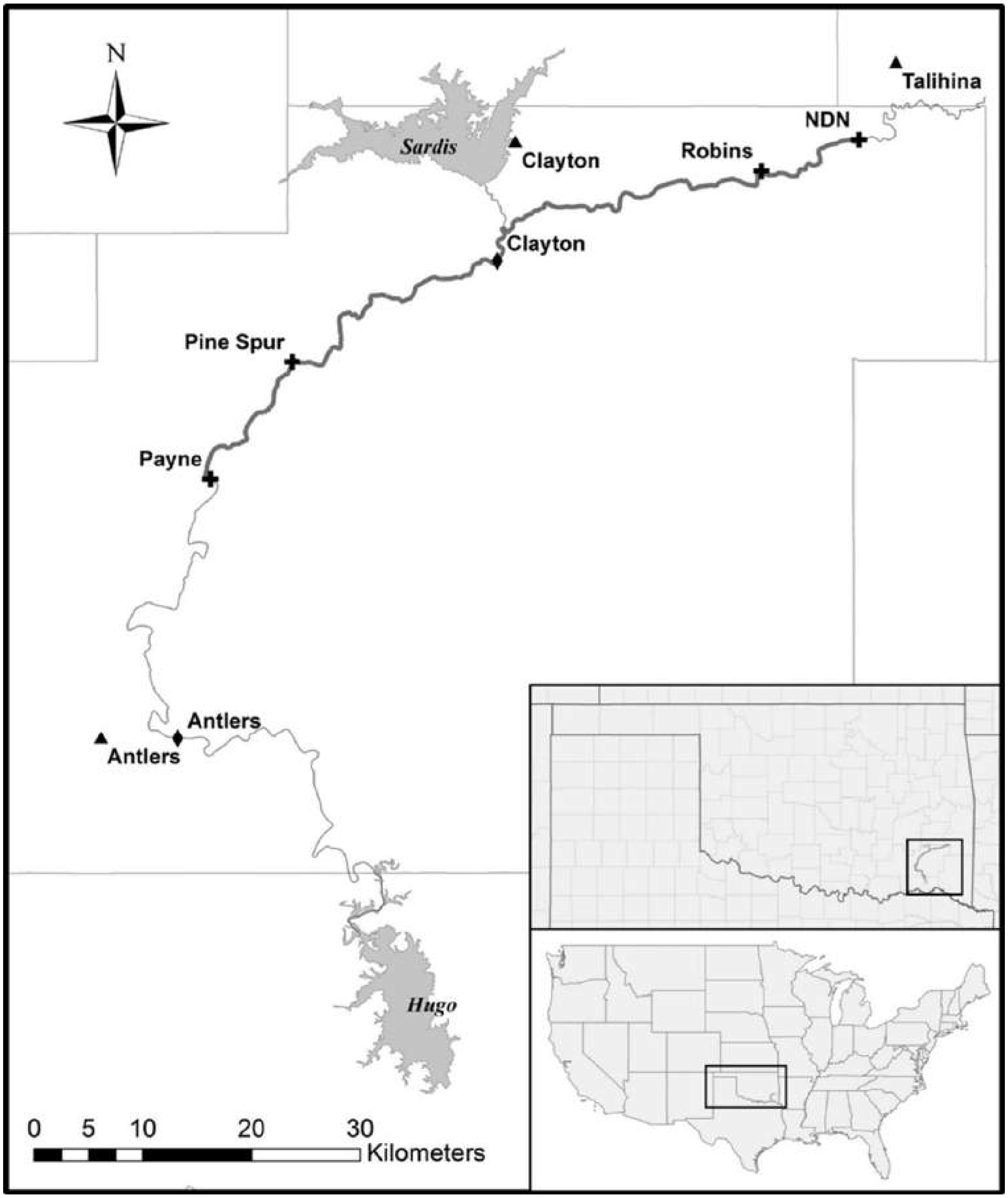

Figure 1. Map of the Kiamichi River showing our study reach (thick gray line). Mesonet stations and U.S. Geological Survey (USGS) stream gages are represented by triangle and diamond markers, respectively. Cross markers indicate monitoring sites where stream water temperature data were collected.

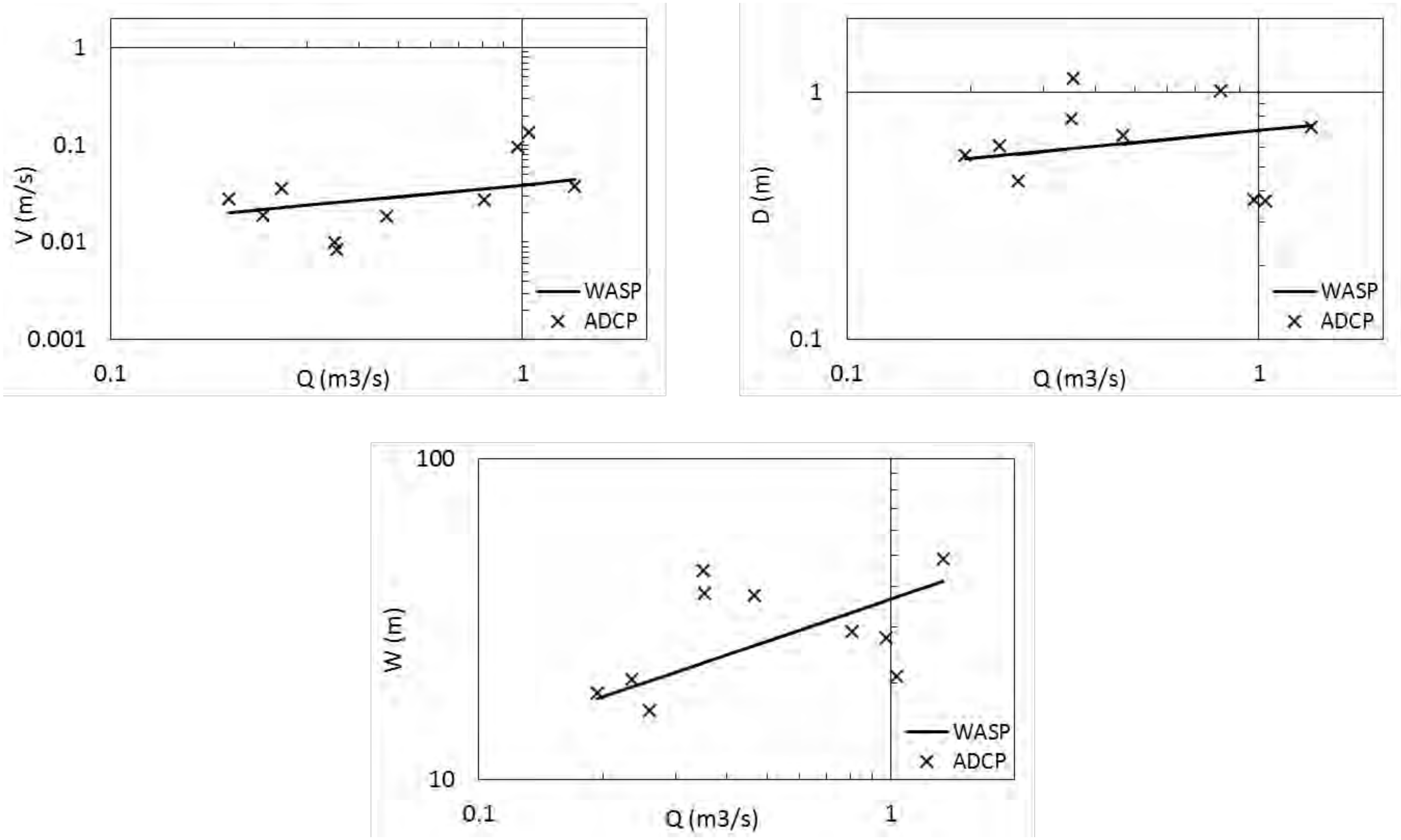

Figure 2. Regression between velocity (V), depth (D) and stream width (W) and discharge (Q). Acoustic Doppler Current Profiler (ADCP) transect measurement results are represented by markers (x) and regression equations are represented by the solid line.

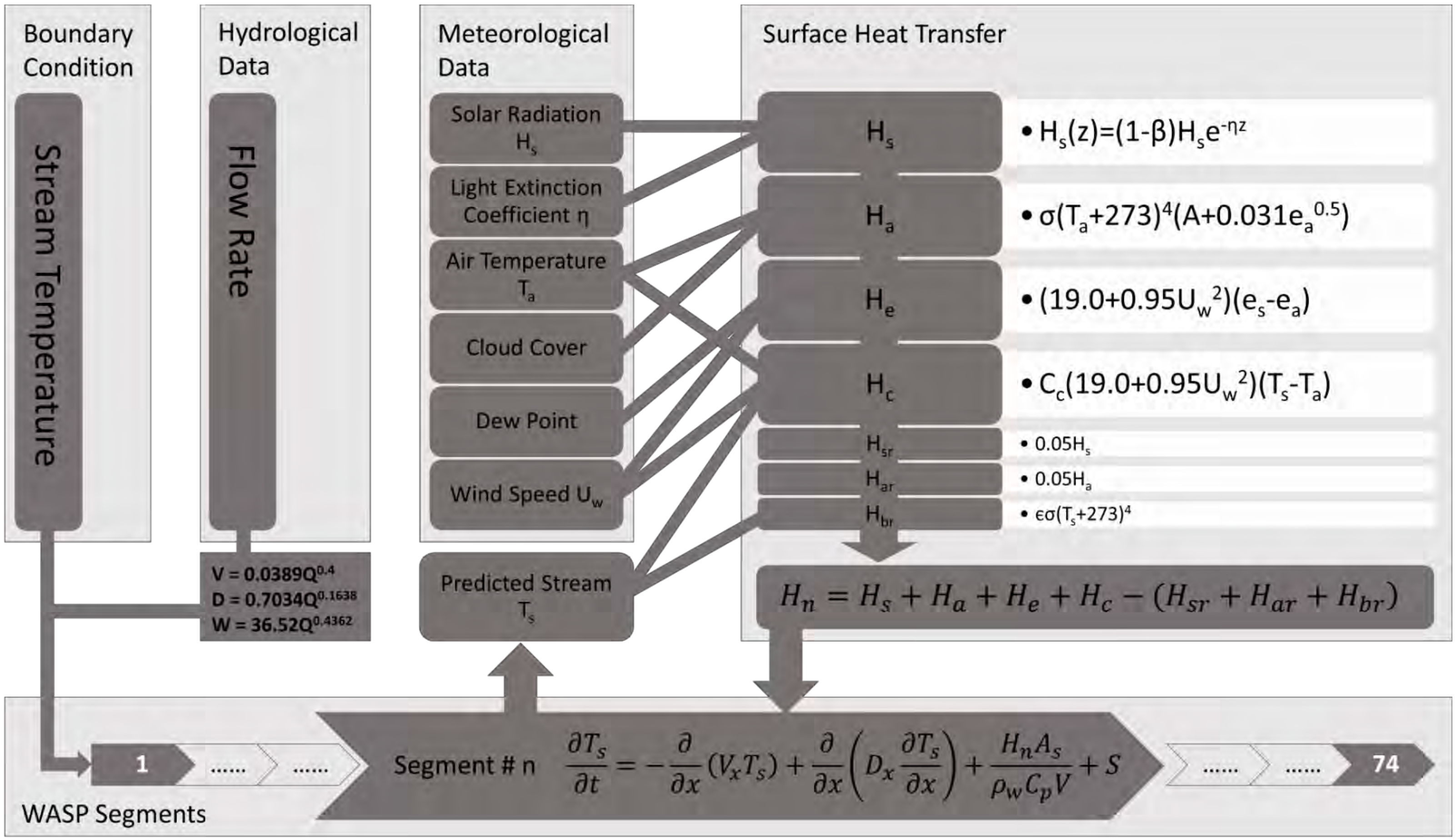

Figure 3. Water Quality Analysis Simulation Program (WASP) Temperature Module Structure. The WASP temperature module uses a partial differential equation (shown in the bottom) to calculate stream water temperature based on upstream boundary condition (shown in the top left) and surface heat transport processes (shown in the top right).

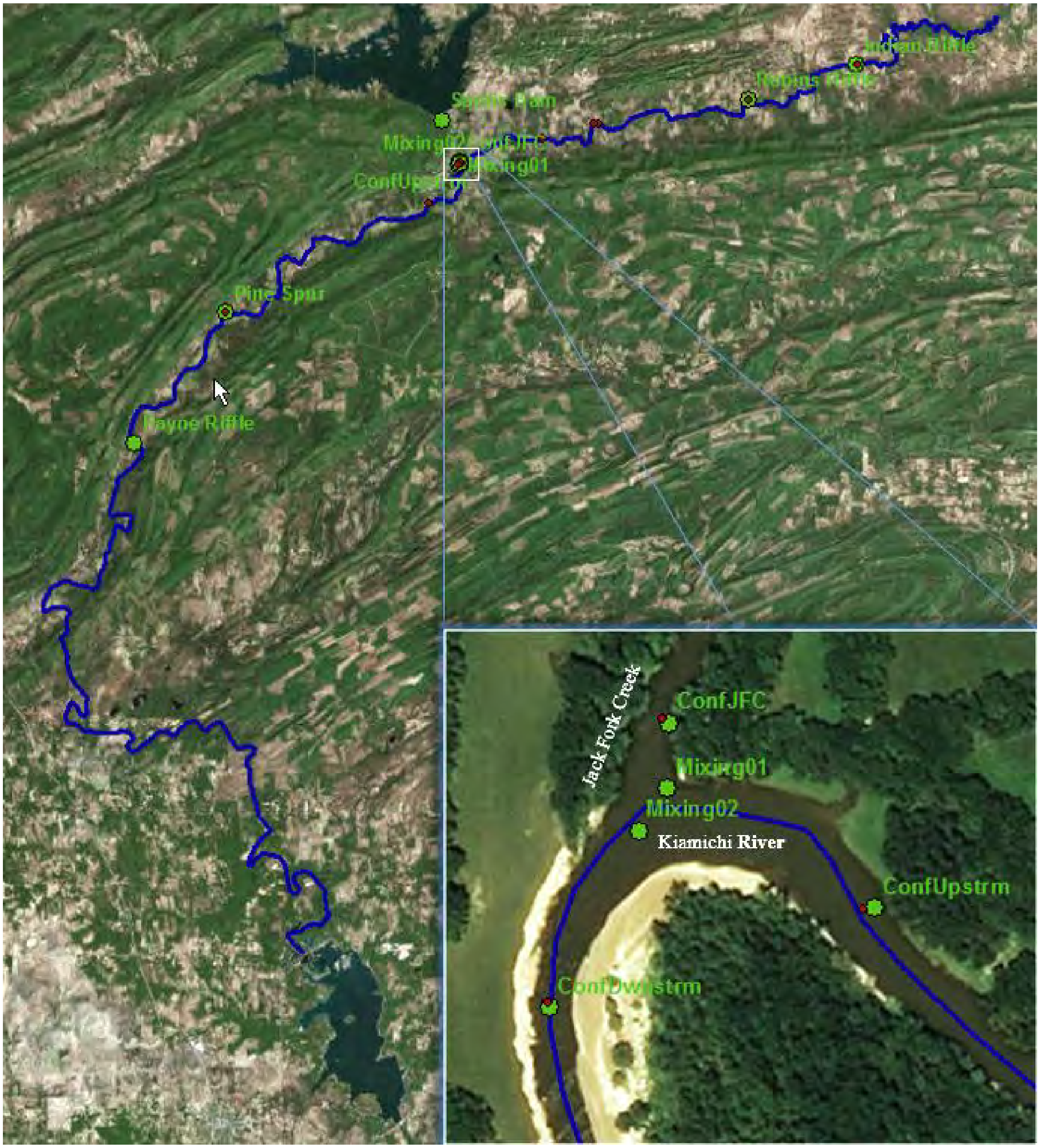

Figure 4. A map of our study area that shows the locations of dissolved oxygen (DO) loggers (green markers) and temperature loggers (red markers). The closely located loggers near the confluence are shown in subfigure (e.g., there are 5 DO data loggers and 3 stream temperature data loggers located just downstream of Sardis Reservoir on Jack Fork Creek).

Figure 5. Sump system for testing critical thermal maximum (CTMax) and long-term thermal stress. A pump discharges water into the 37.85-L aquariums and a gravity fed system discharges water into the 189.27-L sump. During CTMax trials, water is heated in the sump by a 5000-W Smartone heater (OEM Heaters, Saint Paul, MN). During long-term thermal stress trials, water is heated in the sump by a 1700-W Smartone heater (OEM Heaters, Saint Paul, MN).

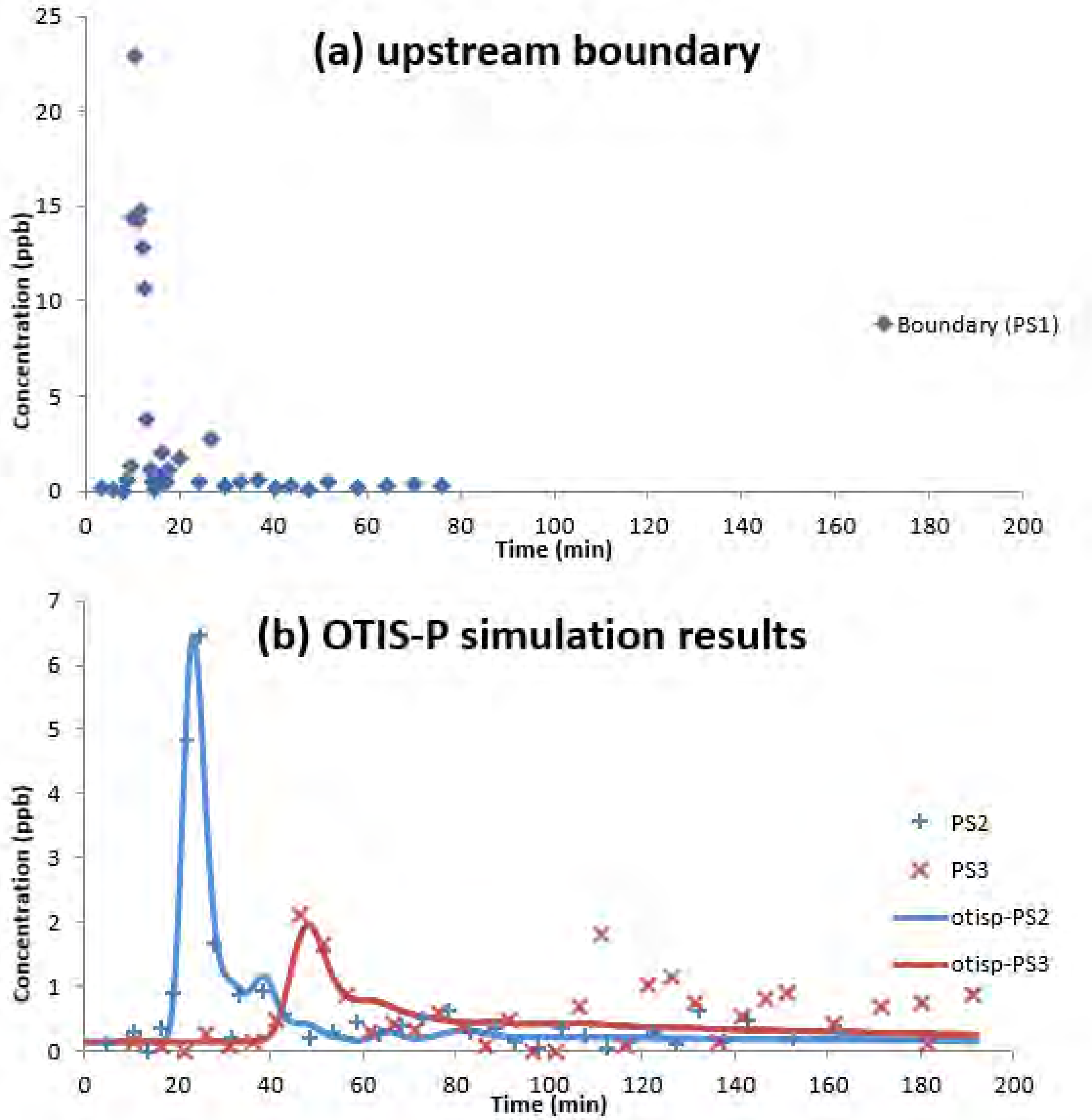

Figure 6. The relationship between tracer concentrations over time. (a) The first location (PS1, blue squares) was used to make predictions at the downstream sites (PS2, PS3) that would account for unknown mixing caused by river characteristics (i.e., hyporheic exchange, flow characteristics). (b) The blue and red crosses represent the actual measured concentration at PS2 and PS3, respectively. The blue and red curves are the corresponding OTIS-P modeled predictions associated with the raw data at each site (PS2 and PS3). These predictions are estimated tracer concentrations after accounting for hyporheic exchange.

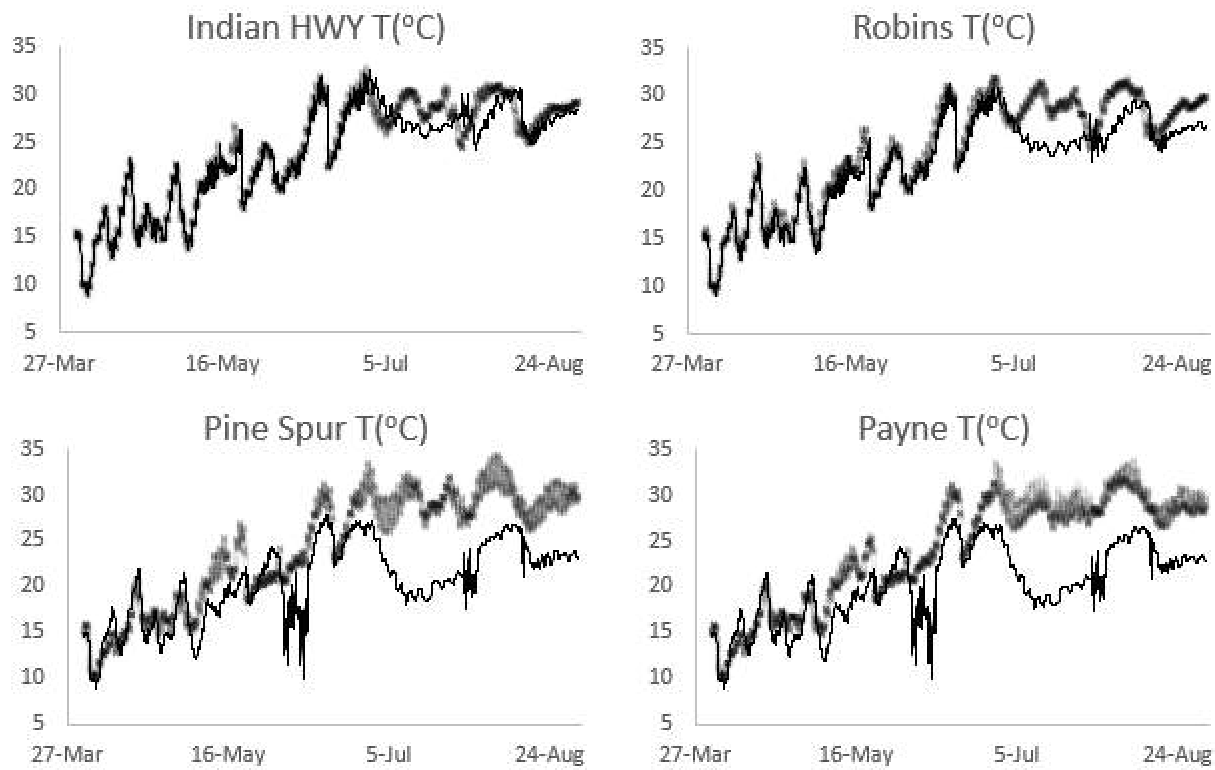

Figure 7. Predicted stream temperature without groundwater inflow using the WASP model. Calibration data are represented by the partly transparent markers whereas the model-predicted stream temperature is represented by the solid line.

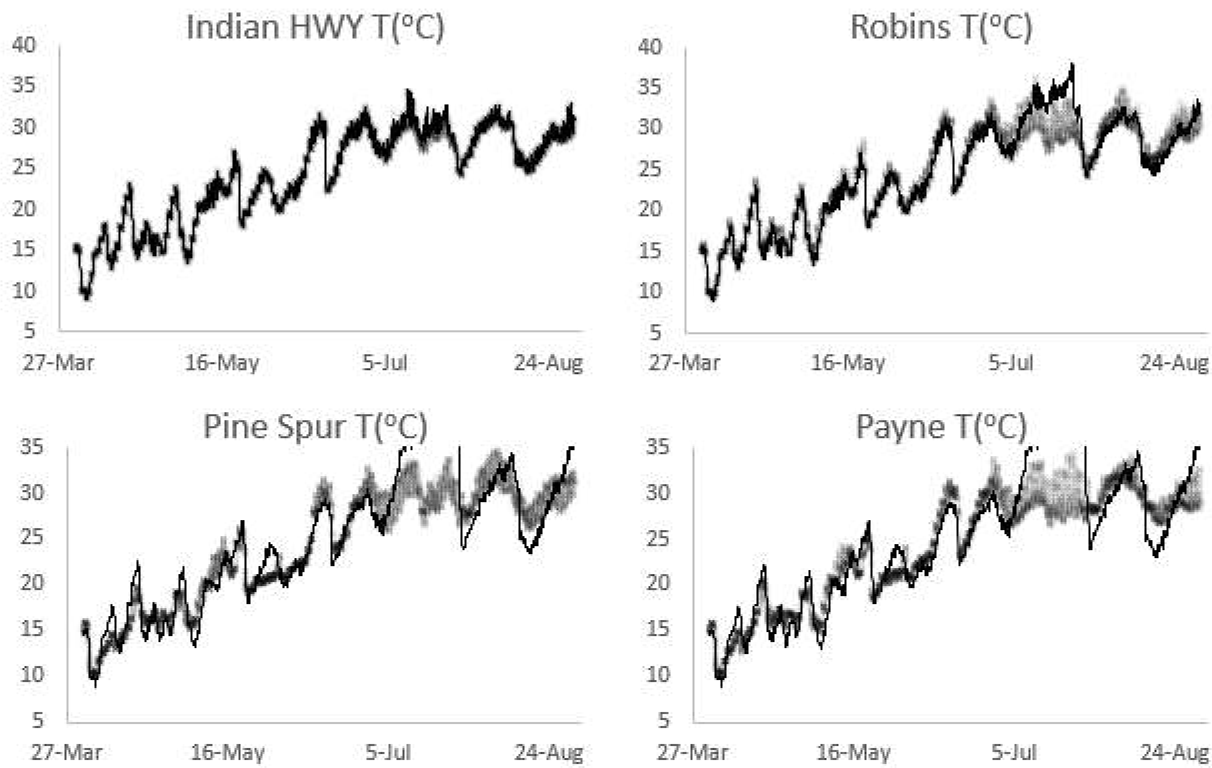

Figure 8. Predicted stream temperature with groundwater inflow using the WASP model. Calibration data are represented by the partly transparent markers whereas the model-predicted stream temperature is represented by the solid line.

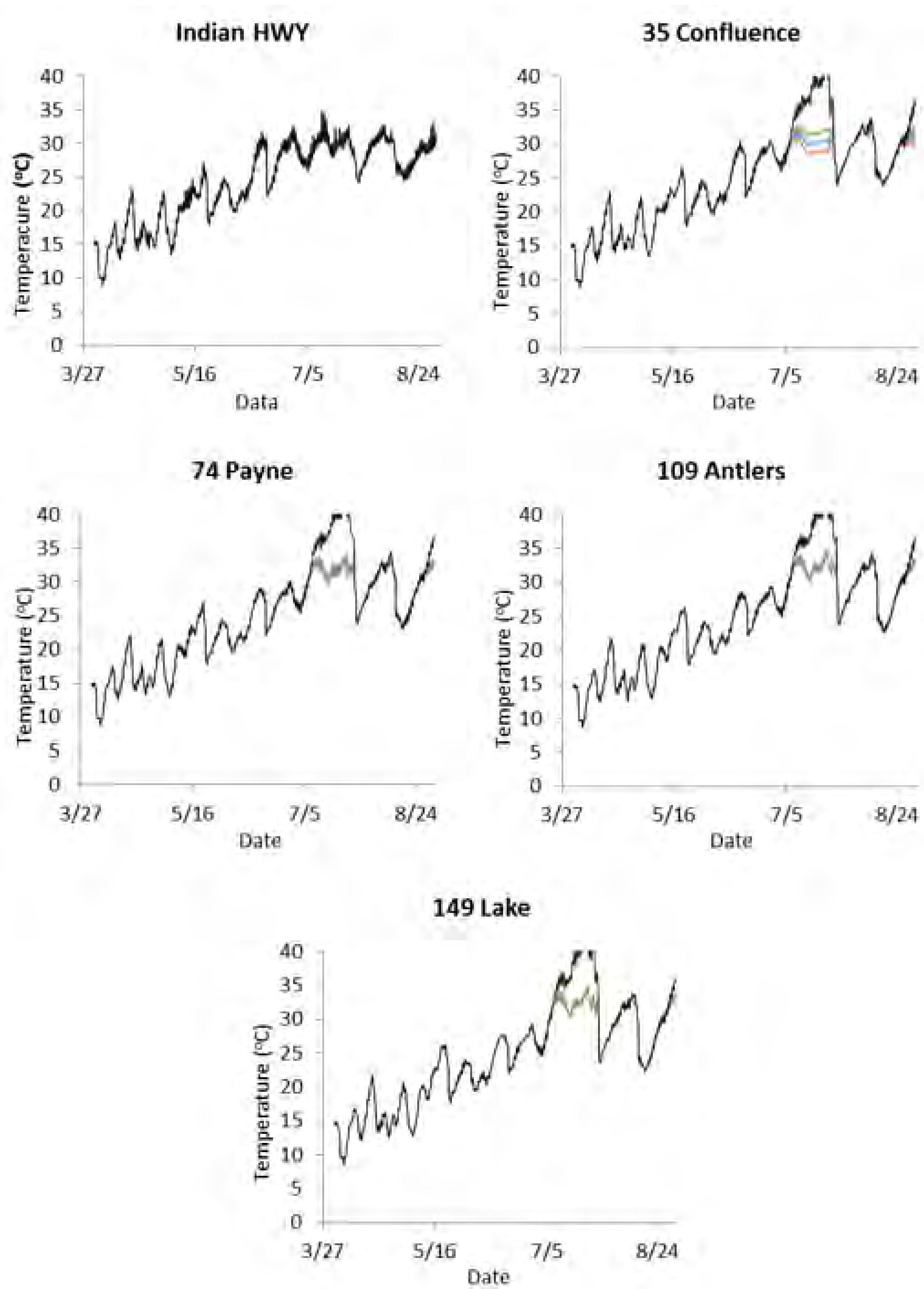

Figure 9. Initial predictions of stream temperature by the WASP model. The control discharge (i.e., without reservoir release) is represented by the black solid line and reservoir releases of 29°C, 27°C, and 25°C are represented by orange, blue, and red lines, respectively. The number before each site name is the distance in km from the start of the research river reach (Indian HWY is located at 0).

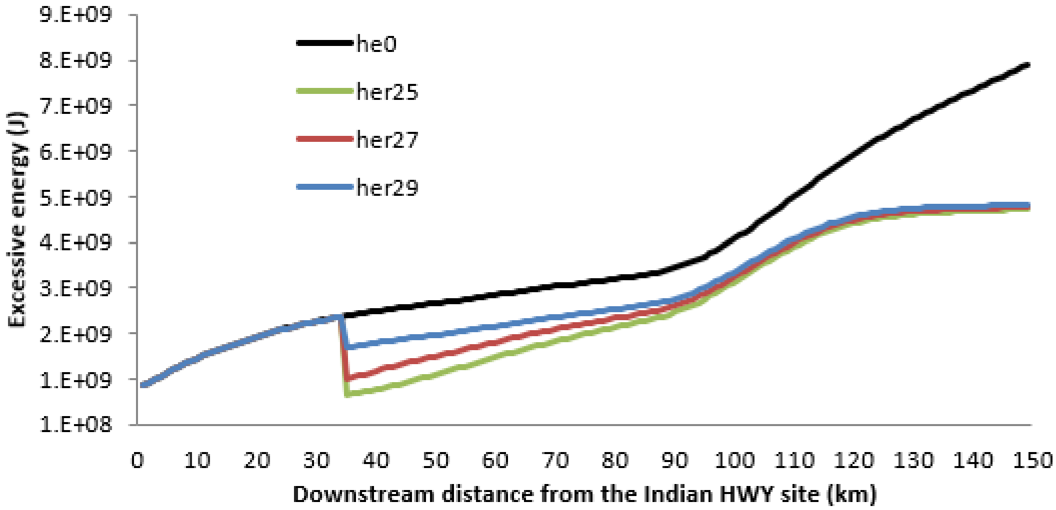

Figure 10. Predicted excessive energy. h_{e0} is initial excessive energy above the target temperature limit; h_{er} is excessive energy after reduction using reservoir release of 25°C, 27°C, and 29°C. He0 indicates no water release. At the reservoir release confluence (x=35), excessive energy was substantially reduced by released water. However, the difference in excessive energy for each temperature of released water diminishes with downstream distance.

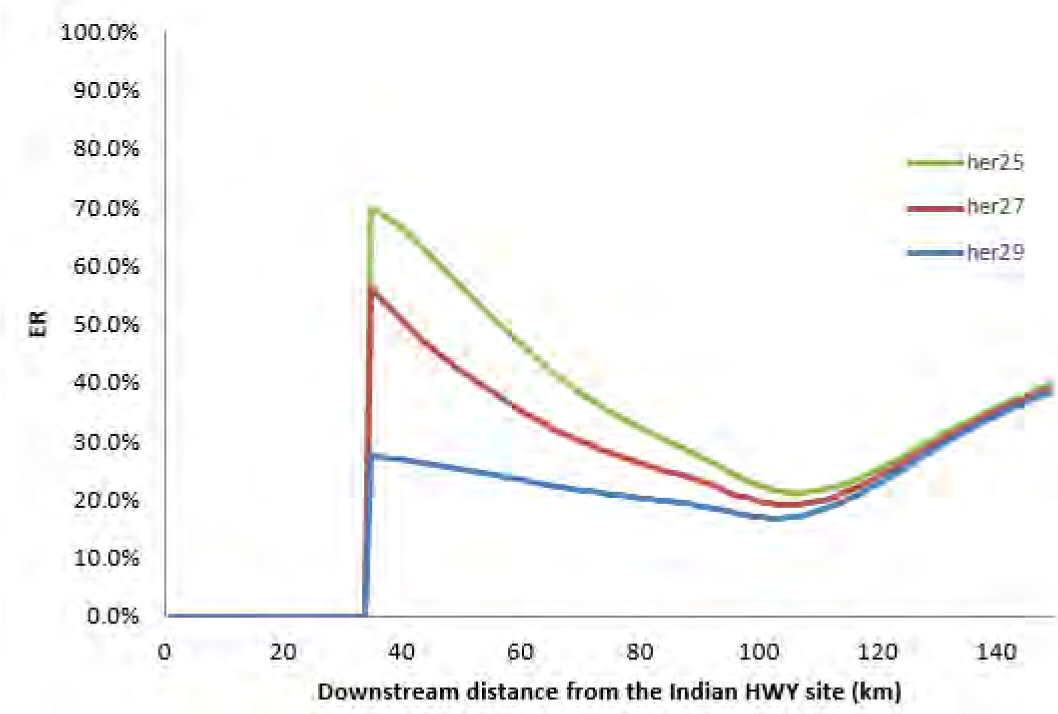

Figure 11. Predicted energy reduction (ER) as a function of distance downstream for a reservoir release temperature of 25°C (her25), 27°C (her27), and 29°C (her29). Similar to the previous figure, energy reduction (ER) happens at the reservoir release confluence (x=35).

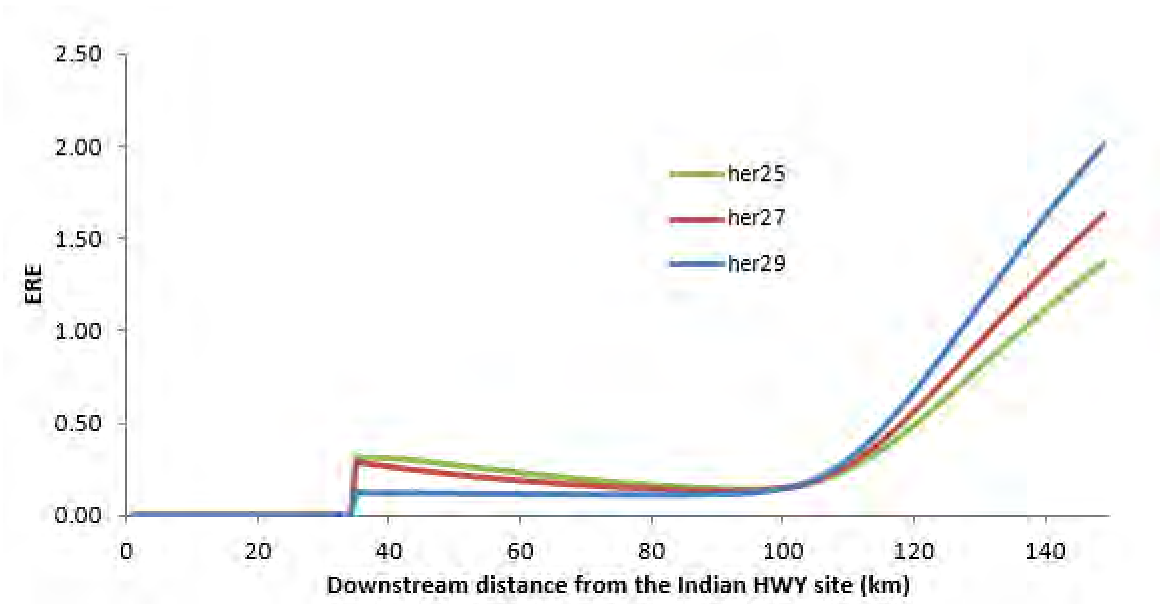

Figure 12. Predicted energy reduction efficiency (ERE) as a function of distance downstream for a reservoir release temperature of 25°C, 27°C, and 29°C. Energy reduction happens at the reservoir release confluence (x=35). Initially, cooler released water results in a higher energy reduction efficiency (ERE) due to greater temperature difference from natural stream water. However, after the intersection point downstream, warmer released water results in a higher ERE because water with less temperature difference from natural stream water was released to reduce excessive energy to a similar level.

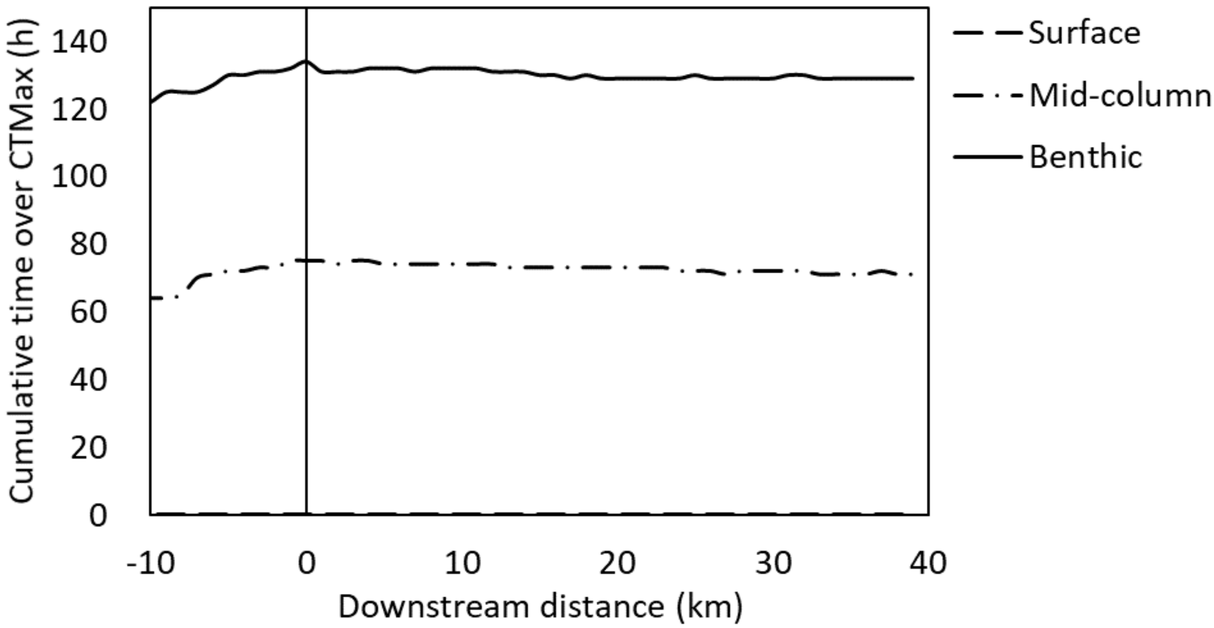

Figure 13. The cumulative time above thermal critical maxima (CTMax) of three fish guilds versus downstream distance from the reservoir confluence calculated with the occurred release removed from the model. This simulation served as a control and evaluated the thermal stress that would have been experienced by fishes in the absence of the water release. The surface guild never experienced temperatures exceeding their CTMax (showing as y = 0 h that overlays with x-axis).

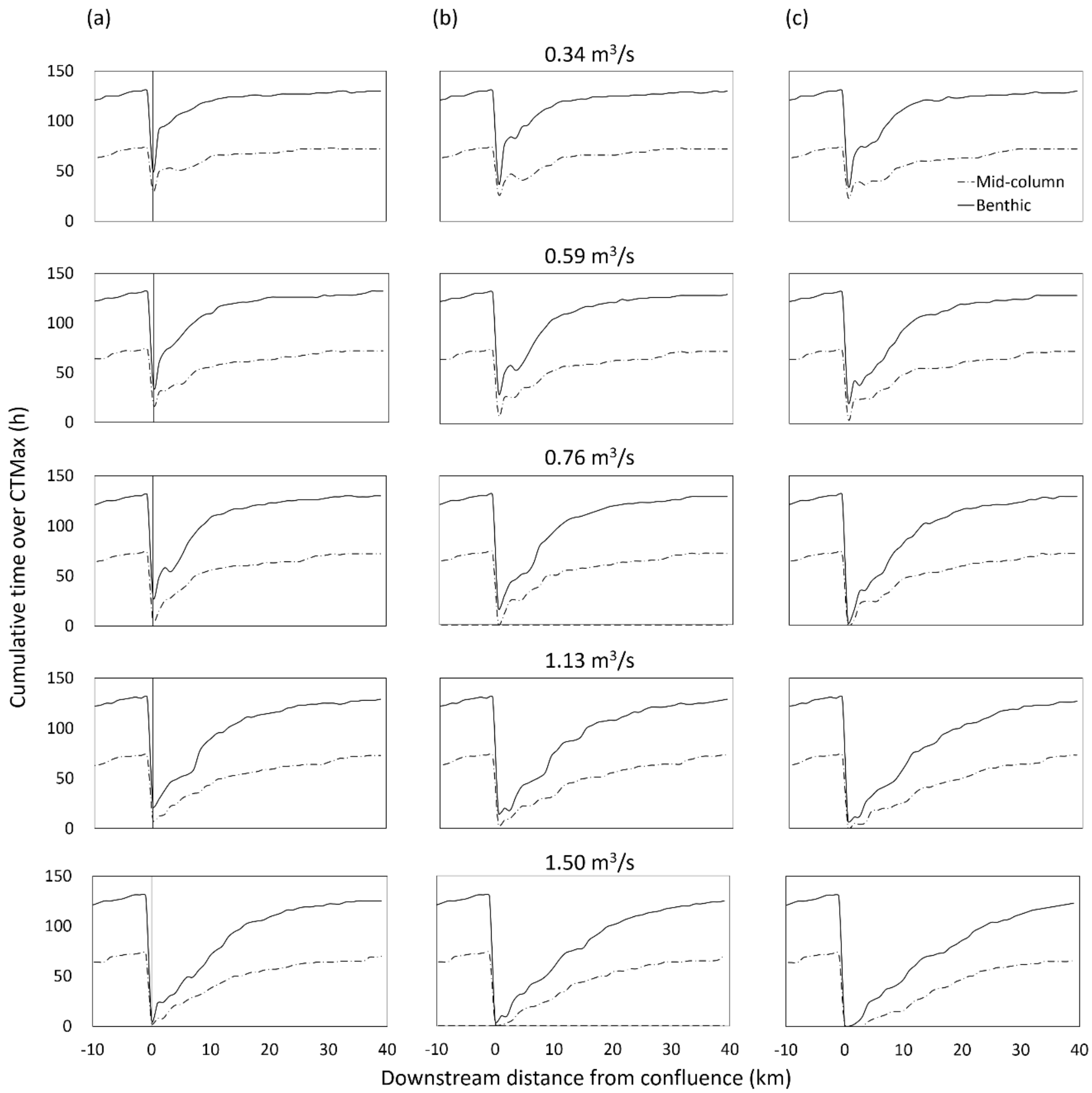

Figure 14. The cumulative time above critical thermal maxima (CTMax) for two fish-habitat guilds: mid-column and benthic guilds. The cumulative time about CTMax is shown 10-km upstream of the Jack Fork Creek and Kiamichi River confluence (indicated as 0 on the X axis). Each water-release scenario (second Y axis) is simulated showing the cumulative time above CTMax from the confluence downriver for 40 km. Each water-release scenario was simulated using three different upstream thermal boundary conditions (i.e., water temperature from the dam) that reflect the gate locations where releases could occur from the dam (5, 10 and 20 m), represented by a, b and c, respectively. The temperatures of simulated water releases at each gate location were: 27.64 °C, 26.00 °C and 24.07 °C, respectively.

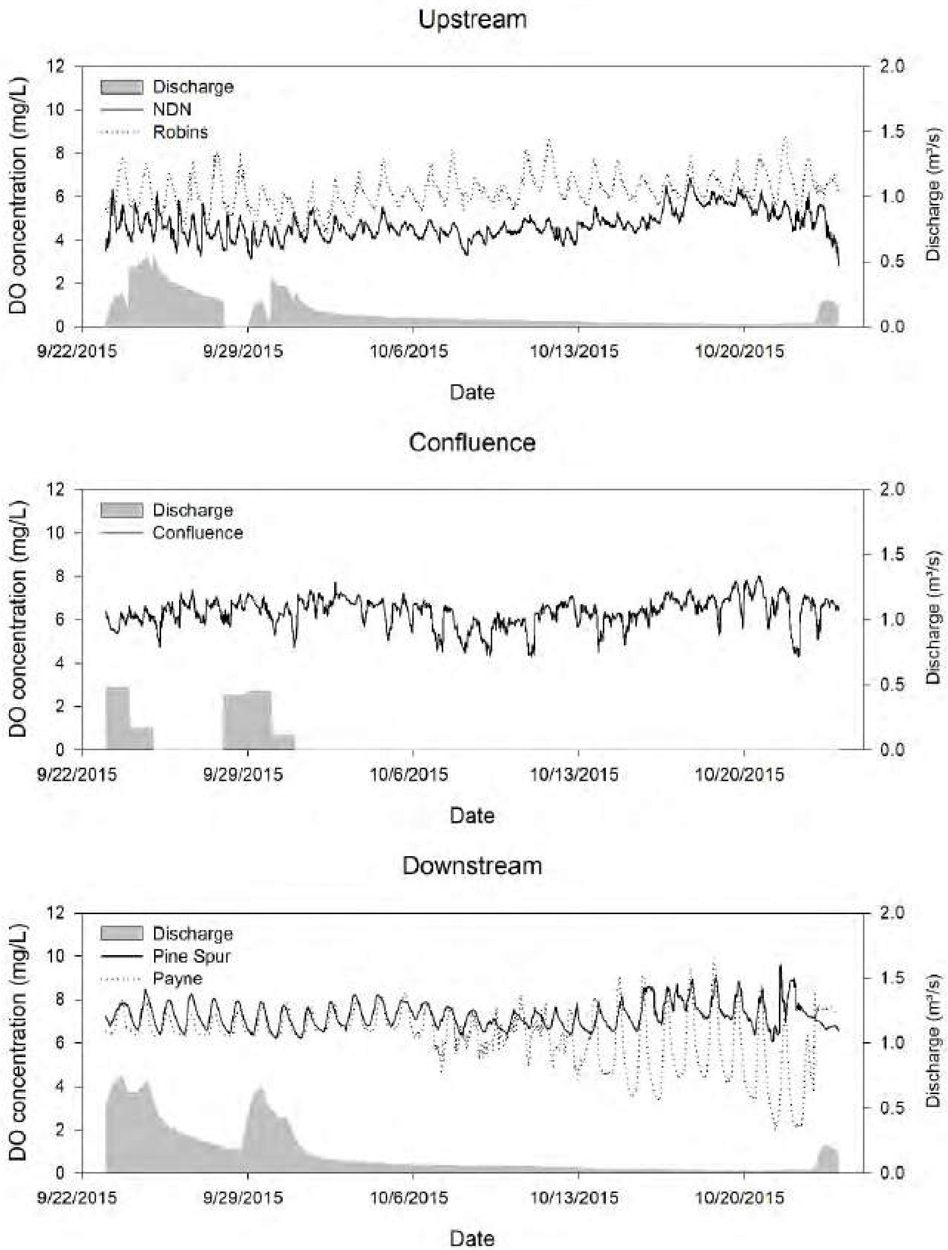

Figure 15. Monitored dissolved oxygen (DO) concentrations at sites upstream of the confluence (Kiamichi River and Jack Fork Creek), at the confluence, and downstream of the confluence. Data were collected during summer 2015 representing DO conditions during a baseflow period with minimal water released from Sardis Dam.

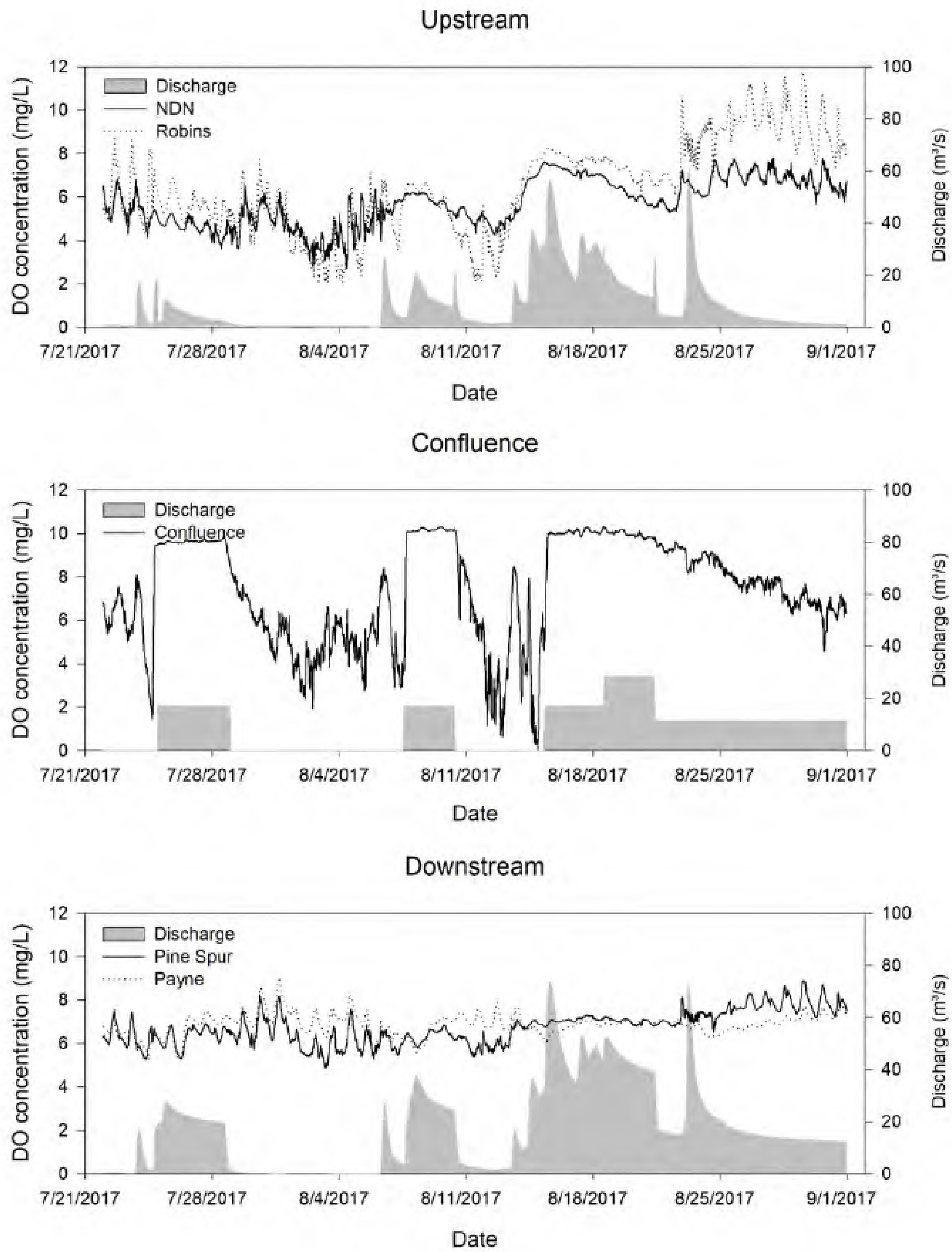

Figure 16. Monitored dissolved oxygen (DO) concentrations at sites upstream of the confluence (Kiamichi River and Jack Fork Creek), at the confluence, and downstream of the confluence. Data were collected during summer 2017 representing DO conditions during a higher flow period with considerable released water from Sardis Dam.

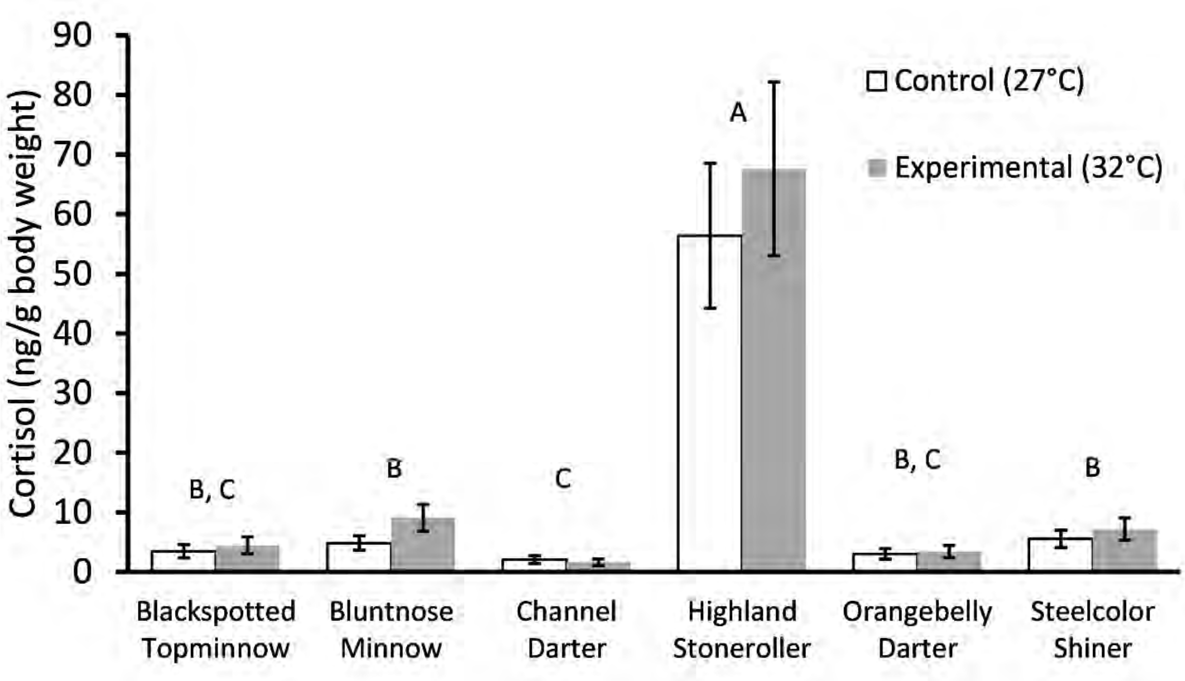

Figure 17. Average (± standard error) whole-body cortisol concentrations from chronic thermal stress trials on six stream fishes: Blackspotted Topminnow *Fundulus olivaceus*, Bluntnose Minnow *Pimephales notatus*, Channel Darter *Percina copelandi*, Highland Stoneroller *Campostoma spadiceum*, Orangebelly Darter *Etheostoma radiosum*, and Steelcolor Shiner *Cyprinella whipplei*. Experimental fishes were collected from the Kiamichi River in autumn 2016 and spring 2017. Fish were acclimated to laboratory conditions of 20.0°C and exposed to a 1.0°C/d increase in temperature until reaching the treatment temperatures (i.e., 27.0°C control; 32.0°C experimental). Fish remained at treatment temperatures for 14 days but were provided a thermal refuge of 2.5°C each night during trials. Letters over each bar indicate species differences in whole-body cortisol concentration from the Tukey Kramer Honest Significant Difference post-hoc analysis.

APPENDIX 1.

Published critical thermal maximum temperature (CTMax; °C), acclimation temperature (°C), optimal temperature (°C), or upper incipient lethal limit (UILL, °C) in fishes that occupy or are closely related to species in the Kiamichi River. Tests in the laboratory (L) or field (F) are reported and "-" indicate this information was not reported.

Table A1. Published critical thermal maximum (CTMax), optimal temperature, or upper incipient lethal limit in fishes that occupy or are closely related to species in the Kiamichi River. Tests in the laboratory (L) or field (F) are reported and blanks indicate this information was not reported.

Species	Life Stage	CTMax (◦C)	Field (F) or Lab (L)	CTMax (◦C)2	Optimal Temp (◦C)	Upper Incipient Lethal (◦C)	References
Creek Chub	*	21-21.9	*	*	*	31.8	Carlander1973; Brett 1944 cited in Carlander 1969
Creek Chub	*	22.8	*	*	*	32.1	Carlander1974; Brett 1944 cited in Carlander 1969
Creek Chub	*	25-26	*	*	*	32.6	Carlander1975; Brett 1944 cited in Carlander 1969
Creek Chub	Adult	*	*	*	*	*	Brett 1944; Hart 1947, as cited in McMahon 1982
Creek Chub	Adult	5	*	*	*	24.7	Brown1974; Hart 1947, as cited in Brown 1974,
Creek Chub	Adult	10	*	*	*	27.3	Brown1974; Hart 1947, as cited in Brown 1974
Creek Chub	Adult	15	*	*	*	29.3	Brown1974
Creek Chub	Adult	20	*	*	*	30.3	Brown1974
Creek Chub	Adult	25	*	*	*	30.3	Brown1974
Creek Chub	Adult	10	*	*	*	27.5	Brown1974
Creek Chub	Adult	15	*	*	*	29	Brown1974
Creek Chub	Adult	20	*	*	*	30.5	Brown1974
Creek Chub	Adult	25	*	*	*	31.5	Brown1974
Creek Chub	Adult	30	*	*	*	31.5	Brown1974
Creek Chub	Adult	7.2	*	*	*	31.1	Brown1974
Creek Chub	Nesting	*	*	*	26.7	*	Brown1974
Creek Chub	Spawning	*	*	*	14	*	Brown1974
Creek Chub	Hatching	*	*	*	*	*	Clark 1943; Moshenko and Gee 1973; Copes 1978
Creek Chub	Adult	5	*	*	*	*	Hart 1947, as cited in NAS/NAE 1973
Creek Chub	Adult	10	*	*	*	*	Hart 1947, as cited in NAS/NAE 1973
Creek Chub	Adult	15	*	*	*	*	Hart 1947, as cited in NAS/NAE 1973
Creek Chub	Adult	20	*	*	*	*	Hart 1947, as cited in NAS/NAE 1973
Creek Chub	Adult	25	*	*	*	*	Hart 1947, as cited in NAS/NAE 1973
Creek Chub	Adult	10	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973

Creek Chub	Adult	15	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Creek Chub	Adult	20	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Creek Chub	Adult	25	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Creek Chub	Adult	30	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Creek Chub	*	*	*	*	*	*	McFarlane et al 1976, as cited in Wismer and Christie1987
Creek Chub	Adult	*	*	*	*	*	Miller 1964; Moshenko and Gee 1973, as cited in McMahon 1982
Creek Chub	Spawning	*	F	*	12.8	*	Scott&Crossman1973
Creek Chub	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
Creek Chub	*	5	*	*	*	24.7	Strawn 1958 cited in Carlander 1969
Creek Chub	*	10	*	*	*	27	Strawn 1958 cited in Carlander 1969
Creek Chub	*	17.1-17.5	*	*	*	30.5	Strawn 1958 cited in Carlander 1969
Creek Chub	*	15	*	*	*	*	Strawn 1958 cited in Carlander 1969
Creek Chub	*	25	*	*	*	*	Strawn 1958 cited in Carlander 1969
Creek Chub	Hatching	*	*	*	*	*	Washburn 1945, as cited in McMahon 1982
Johnny Darter	*	*	*	*	20	*	Floye et al 1984, as cited in Wismer and Christie 1987
Johnny Darter	*	*	F	*	*	*	Hankinson 1919 cited in Carlander 1997
Johnny Darter	*	15	*	*	*	*	Ingersoll and Clauseen 1984, as cited in Beitinger et al. 2000
Johnny Darter	*	15	*	*	*	*	Ingersoll and Clauseen 1984, as cited in Beitinger et al. 2000
Johnny Darter	*	15	L	30.7	*	*	Kowalski1978
Johnny Darter	*	15	L	31.4	*	*	Kowalski1978
Johnny Darter	*	15	*	*	*	*	Kowalski et al. 1978, as cited in Beitinger et al. 2000
Johnny Darter	*	*	F	*	*	*	Lutterbie 1976 cited in Carlander 1997
Johnny Darter	*	20	*	*	*	*	Lydy and Wissing 1988, as cited in Beitinger et al. 2000
Johnny Darter	Hatching	*	F	*	24	*	Scott&Crossman1973
Johnny Darter	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
Johnny Darter	*	20-30	*	*	*	*	Smith and Fausch 1997, as cited in Beitinger et al. 2000
Johnny Darter	*	*	F	*	*	*	Speare 1958 cited in Carlander 1997
Johnny Darter	*	*	F	*	*	*	Speare 1965 cited in Carlander 1997
Johnny Darter	*	*	F	*	*	*	Winn 1958 cited in Carlander 1997

Sauger	*	*	*	*	7.2	*	Brown1974
Sauger	*	*	*	*	21.1	*	Brown1974
Sauger	*	*	*	*	20	*	Brown1974
Sauger	*	*	*	*	*	*	Coutant 1977 cited in Carlander 1997
Sauger	*	*	*	*	*	*	Dendy 1948 cited in Carlander 1997
Sauger	*	*	*	*	19.2	*	Carlander1977
Sauger	*	*	*	*	29	*	EPA 1974, as cited in Wismer and Christie 1987
Sauger	Spawning	*	*	*	10	*	EPA 1974, as cited in Wismer and Christie 1987
Sauger	Incubation	*	*	*	15	*	EPA 1974, as cited in Wismer and Christie 1987
Sauger	Juvenile	26	*	*	*	31	EPA 1974, as cited in Wismer and Christie 1987
Sauger	*	*	*	*	19	*	EPA 1974, as cited in Wismer and Christie 1987
Sauger	Adult	*	*	*	19.2	*	Feruson, 1958 as cited in Hokanson, K.E.F., 1977
Sauger	*	*	*	*	*	*	Gammon 1973 cited in Coutant 1977
Sauger	*	*	F	*	28	*	Gammon 1973, as cited in Yoder and Gammon 1976
Sauger	Adult	*	*	*	28	*	Gammon, 1971 as cited in Hokanson, K.E.F., 1977
Sauger	*	*	*	*	*	*	Hokanson 1977 cited in Carlander 1997
Sauger	*	*	*	*	*	*	Hokanson 1977 cited in Carlander 1997
Sauger	*	*	*	*	*	*	Hokanson 1977 cited in Carlander 1997
Sauger	*	*	F	*	*	*	Hokanson 1977 cited in Carlander 1997
Sauger	*	*	F	*	*	*	Hokanson 1977 cited in Carlander 1997
Sauger	*	*	*	*	*	*	Hokanson 1977 cited in Carlander 1997
Sauger	Juvenile	*	L	*	*	20.9	Hokanson et al 1977
Sauger	Spawning	*	*	*	15	*	Hokanson et al 1977
Sauger	Incubation	*	*	*	15	*	Hokanson et al 1977
Sauger	Spawning	*	*	*	*	*	Hokanson et al 1977, as cited in Wismer and Christie 1987
Sauger	*	*	F	*	*	*	Medlin 1990 cited in Carlander 1997
Sauger	*	*	F	*	*	*	Nelson 1968 cited in Carlander 1997
Sauger	*	*	*	*	*	*	Nelson 1968 cited in Carlander 1997
Sauger	*	*	*	*	*	*	Nelson 1968 cited in Carlander 1997
Sauger	*	*	F	*	*	*	Priegel 1969 cited in Carlander 1997

Sauger	*	*	*	*	22.6	*	Smith and Koenst 1975, as cited in Jobling 1981
Sauger	*	*	*	*	21.3	*	Smith and Koenst 1975, as cited in Jobling 1981
Sauger	Juvenile	10.1	L	*	*	26.36	Smith and Koenst 1975, as cited in Wismer and Christie 1987
Sauger	Juvenile	12	L	*	*	26.7	Smith and Koenst 1975, as cited in Wismer and Christie 1988
Sauger	Juvenile	13.9	L	*	*	28.4	Smith and Koenst 1975, as cited in Wismer and Christie 1989
Sauger	Juvenile	16	L	*	*	28.6	Smith and Koenst 1975, as cited in Wismer and Christie 1990
Sauger	Juvenile	18.3	L	*	*	28.7	Smith and Koenst 1975, as cited in Wismer and Christie 1991
Sauger	Juvenile	19.9	L	*	*	29.5	Smith and Koenst 1975, as cited in Wismer and Christie 1992
Sauger	Juvenile	22	L	*	*	29.9	Smith and Koenst 1975, as cited in Wismer and Christie 1993
Sauger	Juvenile	23.9	L	*	*	30.4	Smith and Koenst 1975, as cited in Wismer and Christie 1994
Sauger	Juvenile	25.8	L	*	*	30.4	Smith and Koenst 1975, as cited in Wismer and Christie 1995
Sauger	Spawning	*	*	*	9	*	Smith and Koenst 1975, as cited in Wismer and Christie 1996
Sauger	Juvenile	*	L	*	*	*	Smith and Koenst 1975, as cited in Wismer and Christie 1997
Sauger	Juvenile	25.8	*	*	*	30.4	Smith, L.L., and Koenst, W.M., 1975
Sauger	*	*	F	*	21	*	Yoder and Gammon 1976
Sauger	*	*	F	*	11	*	Yoder and Gammon 1976
Sauger	*	*	F	*	*	*	Eaton and Scheller 1996
Sauger	Spawning	*	*	*	*	*	Bell 1990
Sauger	*	*	*	*	25	*	U.S. EPA 1976
Sauger	Spawning	*	*	*	12	*	U.S. EPA 1977
Sauger	Embryo Survival	*	*	*	18	*	U.S. EPA 1978
Sauger	*	*	F	31.2	*	*	U.S. EPA 1979
Southern Redbelly Dace	*	26	*	*	*	*	Smale and Rabeni 1995
Spottail Shiner	Adult	*	*	*	20	*	Crowder1981
Spottail Shiner	Adult	*	*	*	18	*	Crowder1981
Spottail Shiner	Spawning	*	F	*	20	*	Carlander1969
Spottail Shiner	*	25	L	*	28.5	*	Kellogg&Gift11983
Spottail Shiner	Juvenile	25	L	*	29.9	*	Kellogg&Gift11983
Spottail Shiner	Juvenile	25	L	*	29	*	Kellogg&Gift11983

Spottail Shiner	6-8 Wk	20	L	*	*	*	Kellogg and Gift 1983
Spottail Shiner	6-8 Wk	22.5	L	*	*	*	Kellogg and Gift 1984
Spottail Shiner	6-8 Wk	25	L	*	*	*	Kellogg and Gift 1985
Spottail Shiner	6-8 Wk	27.3	L	*	*	*	Kellogg and Gift 1986
Spottail Shiner	6-8 Wk	29.6	L	*	*	*	Kellogg and Gift 1987
Spottail Shiner	6-8 Wk	32.2	L	*	*	*	Kellogg and Gift 1988
Spottail Shiner	6-8 Wk	34.7	L	*	*	*	Kellogg and Gift 1989
Spottail Shiner	Juvenile	25	L	*	*	*	Kellogg and Gift 1990
Spottail Shiner	Spawning	none	F	*	18	*	Mansfield 1984
Spottail Shiner	*	*	*	*	14	*	Meldrim and Gift, 1971 as cited in Spotila, J.R., et al., 1979
Spottail Shiner	Adult	*	L	*	9	*	Reutter and Herdendorf 1976
Spottail Shiner	Adult	21.7	L	*	14.3	*	Reutter and Herdendorf 1977
Spottail Shiner	Adult	*	*	*	*	*	Reutter and Herdendorf 1978
Spottail Shiner	Adult	*	*	*	*	*	Reutter and Herdendorf 1979
Spottail Shiner	*	*	*	*	*	*	Reutter and Herdendorf 1980
Spottail Shiner	*	*	F	*	*	*	Trembley 1960 cited in Carlander 1969
Spottail Shiner	Juvenile	*	*	*	20.1	*	Marcy1976
Spottail Shiner	*	*	*	*	13	*	Brandt1980
Spottail Shiner	*	*	*	*	16	*	Brandt1980
Spottail Shiner	*	*	*	*	20	*	Brandt1980
Spottail Shiner	Adult	15	L	*	13.9	*	Brown1974
Spottail Shiner	Hatching	*	F	*	20	*	Wismer and Christie 1987
Spottail Shiner	Fry	*	*	*	*	*	Wismer and Christie 1987
Spottail Shiner	*	*	F	*	*	*	Wismer and Christie 1987
Spottail Shiner	*	*	F	*	*	*	Wismer and Christie 1987
Spottail Shiner	*	7.2	L	*	*	*	Wismer and Christie 1987
Spottail Shiner	*	11.1	L	*	*	*	Wismer and Christie 1987
Spottail Shiner	Juvenile	9	*	*	*	*	Ecological Analysts, Inc. 1978a., as cited in Jinks et al. 1981
Spottail Shiner	Juvenile	17	*	*	*	*	Ecological Analysts, Inc. 1978a., as cited in Jinks et al. 1982
Spottail Shiner	Juvenile	23-24	*	*	*	*	Ecological Analysts, Inc. 1978a., as cited in Jinks et al. 1983

Spottail Shiner	Juvenile	26	*	*	*	*	Ecological Analysts, Inc. 1978a., as cited in Jinks et al. 1984
Spottail Shiner	*	*	*	*	*	*	Prince and Mengel 1981, as cited in Wismer and Christie 9187
Spottail Shiner	Adult	winter	*	*	10.2	*	Reutter and herdendorf 1974, as cited in Houston 1982
Spottail Shiner	Adult	spring	*	*	*	*	Reutter and herdendorf 1974, as cited in Houston 1982
Spottail Shiner	Spawning	*	*	*	*	*	Talmage 1978, as cited in Wismer and Christie 1987
Spottail Shiner	Adult	*	*	*	20	*	Talmage&Coutant1980
Stoneroller	*	7.5	*	*	*	*	Chagnon and Hlohowskyj 1989, as cited in Beitinger et al. 2000
Stoneroller	*	23	*	*	*	*	Chagnon and Hlohowskyj 1989, as cited in Beitinger et al. 2000
Stoneroller	*	*	*	*	29	*	Cherry et al. 1975 cited in Coutant 1975
Stoneroller	*	9	L	*	15.2	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Stoneroller	*	6	L	*	13.4	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1980
Stoneroller	*	24	L	*	25.3	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1981
Stoneroller	*	27	L	*	28.6	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1982
Stoneroller	*	21	L	*	23.6	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1983
Stoneroller	*	12	L	*	20.7	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1984
Stoneroller	*	15	L	*	21.7	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1985
Stoneroller	*	18	L	*	22.3	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1986
Stoneroller	*	12	L	*	16.5	*	Cherry et al., 1977
Stoneroller	*	18	L	*	21	*	Cherry et al., 1978
Stoneroller	*	21	L	*	22.4	*	Cherry et al., 1979
Stoneroller	*	24	L	*	25.1	*	Cherry et al., 1980
Stoneroller	*	27	L	*	28.2	*	Cherry et al., 1981
Stoneroller	*	30	L	*	27.4	*	Cherry et al., 1982
Stoneroller	*	15	L	*	*	*	Cherry et al., 1983
Stoneroller	*	10	*	*	*	*	Lutterschmidt and Hutchison 1997a, as cited in Beitinger 2000
Stoneroller	Spawning	*	*	*	*	*	Miller 1964 cited in Carlander 1969
Stoneroller	*	24	F	*	*	*	Mundahl 1990, as cited in Beitinger et al. 2000
Stoneroller	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
Stoneroller	Spawning	*	*	*	*	*	Smith 1935 cited in Carlander 1969
Stoneroller	*	*	*	*	26.8	*	Stauffer et al. 1975 cited in Coutant 1977

Stoneroller	*	*	*	*	*	*	Stauffer et al. 1975 cited in Coutant 1977
Stoneroller	*	*	*	*	27	*	Stauffer et al., 1974 as cited in Spotila, J.R., et al., 1979
Stoneroller	Spawning	*	*	*	21	*	Carlander 1969
Stoneroller	Hatching	*	*	*	24.3	*	Carmichael 1983, as cited in Wismer and Christie 1987
Stoneroller	Hatching	*	*	*	17.7	*	Carmichael 1983, as cited in Wismer and Christie 1988
Stoneroller	Hatching	*	*	*	13.9	*	Carmichael 1983, as cited in Wismer and Christie 1989
Stoneroller	Spawning	*	*	*	24.3	*	Carmichael 1983, as cited in Wismer and Christie 1990
Stoneroller	Spawning	*	*	*	17.7	*	Carmichael 1983, as cited in Wismer and Christie 1991
Stoneroller	Spawning	*	*	*	13.9	*	Carmichael 1983, as cited in Wismer and Christie 1992
Stoneroller	*	*	*	*	28.5	*	Opuszynski 1971, as cited in Houston 1982
Stoneroller	*	*	*	*	26.2	*	Cherry et al., 1977
White Crappie	*	*	F	*	*	*	Al-Rawi 1971 cited in Carlander 1977
White Crappie	*	*	F	*	*	*	Agersborg 1930, as cited in Brown 1974
White Crappie	*	*	F	*	*	*	Proffitt and Benda 1971, as cited in Brown 1974
White Crappie	*	*	*	*	*	*	Bell 1990
White crappie	Adult	*	*	*	*	*	Biesinger, personal communication, as cited by Edwards et al. 1982
White crappie	Juvenile	29	*	*	*	*	Brungs and Jones 1977, as cited in Edwards et al. 1982
White crappie	Juvenile	27	*	*	*	*	Brungs and Jones 1977, as cited in Edwards et al. 1983
White crappie	Juvenile	*	*	*	*	*	Brungs and Jones 1977, as cited in Edwards et al. 1984
White Crappie	*	*	F	*	*	*	Eaton and Scheller 1996
White Crappie	Juvenile	*	L	*	*	33	Kleiner and Hikanson 1973, as cited in Brown 1974
White Crappie	Spawning	*	*	*	20	*	EPA 1974, as cited in Wismer and Christie 1987
White Crappie	Spawning	*	*	*	20	*	EPA 1974, as cited in Wismer and Christie 1987
White Crappie	*	*	*	*	*	*	Gammon 1973 cited in Coutant 1977
White Crappie	*	*	*	*	*	*	Gammon 1973, as cited in Yoder and Gammon 1976
White Crappie	Nesting	*	F	*	*	*	Hansen 1957 cited in Carlander 1977
White Crappie	Hatching	*	*	*	*	*	Morgan 1954, as cited in Brown 1974
White Crappie	*	*	F	*	23	*	NA
White Crappie	Spawning	*	F	*	16	*	NA

White Crappie	*	*	F	*	24	*	O'Brien et al. 1984
White Crappie	Adult	*	*	*	19.8	*	Reutter and Herdendorf 1974 cited in Coutant 1977
White Crappie	Adult	*	*	*	18.3	*	Reutter and Herdendorf 1974 cited in Coutant 1977
White Crappie	Adult	*	*	*	10.4	*	Reutter and Herdendorf 1974 cited in Coutant 1977
White Crappie	Adult	*	L	32.8	19.4	*	Reutter and Herdendorf 1976
White Crappie	Adult	*	L	*	*	*	Reutter and Herdendorf 1976
White Crappie	Adult	*	L	*	*	*	Reutter and Herdendorf 1976
White Crappie	Adult	*	L	*	*	*	Reutter and Herdendorf 1976
White Crappie	Spawning	*	F	*	*	*	Siefert 1968 cited in Carlander 1977
White Crappie	Hatching	*	*	*	*	*	Siefert 1968 cited in Carlander 1977
White Crappie	Embryo	*	*	*	*	*	Siefert 1968, as cited in Edwards et al. 1982
White Crappie	Hatching	*	*	*	*	*	Swingle 1952 cited in Carlander 1977
White Crappie	*	*	*	*	28	*	U.S. EPA 1976
White Crappie	Spawning	*	*	*	18	*	U.S. EPA 1976
White Crappie	Embryo Survival	*	*	*	23	*	U.S. EPA 1976
White Crappie	*	*	F	*	*	*	Witt 1952 cited in Carlander 1977
White Crappie	*	*	F	*	*	*	Walburg 1969, as cited in Brown 1974
White Crappie	*	summer	F	*	*	*	Yoder and Gammon 1976
White Crappie	*	fall	F	*	*	*	Yoder and Gammon 1976
White Crappie	*	winter	F	*	*	*	Yoder and Gammon 1976
White Crappie	*	*	*	*	*	*	Marcy 1976
White Crappie	*	*	F	32.3	*	*	Marcy 1977
White Crappie	*	*	F	*	*	*	Marcy 1978
White Sucker	*	*	*	*	*	*	Marcy 1979
White Sucker	*	*	F	28	27.8	*	Marcy 1980
White Sucker	1&2 Yr	*	L	*	*	*	Adelman 1980, as cited in Wismer and Christie 1987
White Sucker	Juvenile	5	*	*	*	26	Brown 1974, as cited in Wismer and Christie 1987
White Sucker	Juvenile	10	*	*	*	28	Brown 1974, as cited in Wismer and Christie 1987
White Sucker	Juvenile	15	*	*	*	29	Brown 1974, as cited in Wismer and Christie 1987
White Sucker	Juvenile	20	*	*	*	29	Brown 1974, as cited in Wismer and Christie 1987

White Sucker	Juvenile	25-26	*	*	*	31	Brett 1944, as cited in Brown 1974
White Sucker	1-2Yr	5	*	*	*	26.3	Brett 1944, as cited in Brown 1975
White Sucker	1-2Yr	10	*	*	*	27.7	Brett 1944, as cited in Brown 1976
White Sucker	1-2Yr	15	*	*	*	29.3	Brett 1944, as cited in Brown 1977
White Sucker	1-2Yr	20	*	*	*	29.3	Brett 1944, as cited in Brown 1978
White Sucker	1-2Yr	25	*	*	*	28.3	Brett 1944, as cited in Brown 1979
White Sucker	Juvenile	*	*	*	*	31.4	Huntsman 1946, as cited in Brown 1974
White Sucker	Juvenile	*	*	*	*	33.3	Brown 1974, as cited in Wismer and Christie 1987
White Sucker	Juvenile	32.2	*	*	*	35	Trembley 1961, as cited in Brown 1974
White Sucker	Juvenile	7.2	*	*	*	30	Trembley 1961, as cited in Brown 1974
White Sucker	Juvenile	11.1	*	*	*	31	Trembley 1961, as cited in Brown 1975
White Sucker	*	*	*	*	18.3	*	Cooper and Fuller 1945, as cited in Brown 1974
White Sucker	*	*	F	*	*	*	Hile and Juday 1941, as cited in Brown 1974
White Sucker	*	*	F	*	23.9	*	Trembley 1960, as cited in Brown 1974
White Sucker	Spawning	*	F	*	*	*	Trautman 1957, as cited in Brown 1974
White Sucker	Spawning	*	*	*	*	*	Trautman 1957, as cited in Brown 1974
White Sucker	Spawning	*	*	*	*	*	Webster 1941, as cited in Brown 1974
White Sucker	Larvae	*	*	*	*	*	McCormick et al. 1972, as cited in Brown 1974
White Sucker	Fry	21	F	*	*	*	Trembley 1960, as cited in Brown 1974
White Sucker	Juvenile	*	L	*	*	*	Huntsman 1946, as cited in Brown 1974
White Sucker	Adult	*	F	*	*	*	Horak and Tanner 1964, as cited in Brown 1974
White Sucker	*	*	F	*	18.3	*	Cooper and Fuller 1945, as cited in Coutant 1977
White Sucker	Spawning	*	*	*	*	*	Corbett and Powels 1983, as cited in Wismer and Christie 1987
White Sucker	Larvae	*	*	*	*	*	Corbett and Powels 1983, as cited in Wismer and Christie 1987
White Sucker	Spawning	*	*	*	16.8	*	Corbett and Powles 1983
White Sucker	Larvae	*	*	*	*	*	Corbett and Powles 1983
White Sucker	Larvae	*	*	*	*	30.2	Crippen and Fahmy 1981
White Sucker	*	*	F	*	*	*	Eaton and Scheller 1996
White Sucker	Larvae	15	*	*	*	31	EPA 1974, as cited in Wismer and Christie 1987
White Sucker	Juvenile	15	*	*	*	29	EPA 1974, as cited in Wismer and Christie 1988

White Sucker	Larvae	21	*	*	*	30	EPA 1974, as cited in Wismer and Christie 1989
White Sucker	Spawning	*	*	*	10	*	EPA 1974, as cited in Wismer and Christie 1990
White Sucker	Hatching	*	*	*	15	*	EPA 1974, as cited in Wismer and Christie 1991
White Sucker	*	*	*	*	24	*	EPA 1974, as cited in Wismer and Christie 1992
White Sucker	Juvenile	*	L	*	*	*	EPA 1974, as cited in Wismer and Christie 1993
White Sucker	Spawning	*	*	*	11.16	*	Fuiman 1979, as cited in Wismer and Christie 1987
White Sucker	Adult (1-2Yr)	5	*	*	*	*	Hart 1947, as cited in NAS/NAE 1973
White Sucker	Adult (1-2Yr)	10	*	*	*	*	Hart 1947, as cited in NAS/NAE 1974
White Sucker	Adult (1-2Yr)	15	*	*	*	*	Hart 1947, as cited in NAS/NAE 1975
White Sucker	Adult (1-2Yr)	20	*	*	*	*	Hart 1947, as cited in NAS/NAE 1976
White Sucker	Adult (1-2Yr)	25	*	*	*	*	Hart 1947, as cited in NAS/NAE 1977
White Sucker	*	*	*	*	*	*	Haymes 1984, as cited in Wismer and Christie 1987
White Sucker	*	*	F	*	20.6	*	Hile and Juday 1941, as cited in Coutant 1977
White Sucker	Adult	*	F	*	21.1	*	Horak and Tanner 1964, as cited in Coutant 1977
White Sucker	Larvae	*	*	*	23.8	*	Marcy, B.C., 1976
White Sucker	Spawning	*	*	*	23.4	*	Marcy, B.C., 1976
White Sucker	*	*	L	*	15.2	*	McCormick 1977
White Sucker	Newly Hatched	21.1	L	*	*	28.2	McCormick et al 1977
White Sucker	Swim-Up	21.1	L	*	*	30.5	McCormick et al 1978
White Sucker	Swim-Up	15.8	L	*	*	30.7	McCormick et al 1979
White Sucker	Swim-Up	10	L	*	*	28.1	McCormick et al 1980
White Sucker	Newly Hatched	15.2	L	*	*	30	McCormick et al 1981
White Sucker	Newly Hatched	8.9	L	*	*	28.6	McCormick et al 1982
White Sucker	Newly Hatched	21.1	L	*	*	*	McCormick et al 1983
White Sucker	Newly Hatched	21.1	L	*	*	*	McCormick et al 1984
White Sucker	Newly Hatched	15.2	L	*	*	*	McCormick et al 1985
White Sucker	Newly Hatched	15.2	L	*	*	*	McCormick et al 1986
White Sucker	Newly Hatched	8.9	L	*	*	*	McCormick et al 1987
White Sucker	Newly Hatched	8.9	L	*	*	*	McCormick et al 1988
White Sucker	Newly Hatched	21.1	L	*	*	*	McCormick et al 1989

White Sucker	Newly Hatched	10	L	*	*	*	McCormick et al 1990
White Sucker	Larvae	10-Sep	*	*	*	28.8	McCormick et al 1991
White Sucker	Larvae	15-16	*	*	*	31.1	McCormick et al 1992
White Sucker	Larvae	21	*	*	*	31.7	McCormick et al 1993
White Sucker	*	*	F	*	*	*	Michaud 1981
White Sucker	*	*	*	*	*	*	Michaud 1981, as cited in Wismer and Christie 1987
White Sucker	Spawning	*	*	*	17.8	*	Raney 1943 cited in McCormick 1977
White Sucker	*	23	*	*	24.1	*	Renyolds and Casterlin 1978
White Sucker	Adult	*	L	*	22.4	*	Reutter and Herdendorf 1974, as cited in Coutant 1977
White Sucker	Adult	19	L	*	*	*	Reutter and Herdendorf 1976
White Sucker	Spawning	*	F	*	*	*	Scott and Crossman 1973, p540
White Sucker	Hatching	*	L	*	*	*	Scott and Crossman 1973, p540
White Sucker	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
White Sucker	*	*	*	*	26.7	*	Stauffer et al 1976, as cited in Reynolds and Casterlin 1978
White Sucker	*	*	*	*	28	*	U.S. EPA 1976
White Sucker	Spawning	*	*	*	10	*	U.S. EPA 1976
White Sucker	Embryo Survival	*	*	*	20	*	U.S. EPA 1976
White Sucker	Adult	*	*	*	21	*	Wyman 1981, as cited in Wismer and Christie 1987
White Sucker	*	*	F	*	27	*	Yoder and Gammon 1976
White Sucker	*	*	F	*	19	*	Yoder and Gammon 1976
White Sucker	*	*	*	*	14.4	*	Marcy 1976
White Sucker	Juvenile	*	*	*	*	*	Brown 1974
Bigmouth Shiner	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
Bluegill	*	*	F	36	31.7	*	Smale and Rabeni 1995, as cited in Beitinger et al 2001
Bluegill	*	*	*	36	32.5	*	Smale and Rabeni 1995, as cited in Beitinger et al 2002
Bluegill	*	*	*	*	*	*	Anderson 1958 cited in Carlander 1977
Bluegill	Adult	*	*	*	*	*	Anderson 1959; Emig 1966, as cited in Stuber et al. 1982
Bluegill	*	12.1	*	*	*	*	Banner and Van Arman 1973 cited in Carlander 1977
Bluegill	*	19	*	*	*	*	Banner and Van Arman 1973 cited in Carlander 1977
Bluegill	*	26	*	*	*	*	Banner and Van Arman 1973 cited in Carlander 1977

Bluegill	*	32.9	*	*	*	*	Banner and Van Arman 1973 cited in Carlander 1977
Bluegill	*	26	*	*	*	*	Banner and Van Arman 1973 cited in Carlander 1977
Bluegill	*	*	*	*	*	*	Banner and Van Arman 1973, as cited in Stuber et al. 1982
Bluegill	Embryo	*	*	*	*	*	Banner and Van Arman 1973, as cited in Stuber et al. 1982
Bluegill	Fry	*	*	*	*	*	Banner and Van Arman 1973, as cited in Stuber et al. 1982
Bluegill	*	*	*	*	*	33.8	Banner and Van Arman, 1973 as cited in Spotila, J.R., et al., 1979
Bluegill	*	*	*	*	23.9	*	Banner and Van Arman, 1973 as cited in Spotila, J.R., et al., 1980
Bluegill	*	*	*	*	31.2	*	Beitinger 1974 cited in Coutant 1977
Bluegill	*	*	*	*	*	*	Beitinger 1974 cited in Coutant 1978
Bluegill	*	*	*	*	*	*	Beitinger, T.L., 1974 as cited in Spotila, J.R., et al., 1979
Bluegill	*	*	*	*	*	*	Beitinger, T.L., 1974 as cited in Spotila, J.R., et al., 1980
Bluegill	*	*	*	*	*	*	Bell 1990
Bluegill	Spawning	*	*	*	*	*	Bell 1990
Bluegill	*	15	*	*	*	*	Brett, J.R., 1956 as cited in Spotila, J.R., et al., 1979
Bluegill	*	20	*	*	*	*	Brett, J.R., 1956 as cited in Spotila, J.R., et al., 1979
Bluegill	*	30	*	*	*	*	Brett, J.R., 1956 as cited in Spotila, J.R., et al., 1979
Bluegill	Adult	*	*	*	*	*	Brown 1974, as cited in Wismer and Christie 1987
Bluegill	*	*	*	*	*	*	Anderson 1959,as cited in Brown 1974
Bluegill	*	*	*	*	*	33.8	Brown 1974, as cited in Wismer and Christie 1987
Bluegill	*	*	*	41.4	*	38.3	Brown 1974, as cited in Wismer and Christie 1987
Bluegill	*	*	*	*	30	*	Brown 1974, as cited in Wismer and Christie 1987
Bluegill	*	*	F	*	*	*	Byrd 1951, as cited in Brown 1974
Bluegill	Spawning	*	*	*	*	*	Stevenson et al 1969, as cited in Brown 1974
Bluegill	Spawning	*	*	*	*	*	Clugston 1966, as cited in Brown 1974
Bluegill	Spawning	*	*	*	*	*	Breder 1936, as cited in Brown 1974
Bluegill	*	*	*	*	*	*	Speakmand and Krenkel 1972, as cited in Brown 1974
Bluegill	*	*	*	*	*	*	Proffitt and Benda 1971, as cited in Brown 1974
Bluegill	*	*	*	*	*	*	Buck and Thoits 1970 cited in Carlander 1977
Bluegill	*	*	*	*	*	*	Cairns 1956, as cited in Brown 1974

Bluegill	*	*	*	*	*	35.5	Carlander 1977
Bluegill	*	*	*	*	*	33	Carlander 1977
Bluegill	*	*	*	*	*	33.8	Carlander 1977
Bluegill	*	*	*	*	*	34	Carlander 1977
Bluegill	*	*	*	41.5	*	*	Carlander 1977
Bluegill	*	*	*	*	18.7	*	Carlander 1977
Bluegill	*	*	*	*	19.6	*	Carlander 1977
Bluegill	*	6	*	*	*	*	Cherry et al. 1975 cited in Carlander 1977
Bluegill	*	30	*	*	*	*	Cherry et al. 1975 cited in Carlander 1977
Bluegill	*	*	*	*	32	*	Cherry et al. 1975 cited in Coutant 1975
Bluegill	*	6	*	*	*	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Bluegill	*	9	*	*	*	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Bluegill	*	12	*	*	*	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Bluegill	*	15	*	*	*	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Bluegill	*	18	*	*	*	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Bluegill	*	21	*	*	*	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Bluegill	*	24	*	*	*	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Bluegill	*	27	*	*	*	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Bluegill	*	30	*	*	*	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Bluegill	*	*	*	*	*	36	Cherry et al., 1977
Bluegill	*	*	*	*	*	*	Childers 1967 cited in Carlander 1977
Bluegill	*	*	*	*	*	*	Childers 1967 cited in Carlander 1977
Bluegill	*	26	*	*	*	*	Cox 1974, as cited in Beitinger et al. 2000
Bluegill	*	26	*	*	*	*	Cox 1974, as cited in Beitinger et al. 2000
Bluegill	*	26	*	*	*	*	Cox 1974, as cited in Beitinger et al. 2000
Bluegill	*	*	*	*	*	*	Cravens 1981, as cite in Wismer and Christie 1987
Bluegill	*	*	*	*	*	28.5	Cvancara et al., 1976 as cited in Spotila, J.R., et al., 1979
Bluegill	*	*	*	*	*	*	Durham 1957 cited in Carlander 1977
Bluegill	*	*	F	*	*	*	Eaton and Scheller 1996
Bluegill	Adult	15	*	*	*	31	EPA 1974, as cited in Wismer and Christie 1987

Bluegill	Juvenile	12	*	*	*	27	EPA 1974, as cited in Wismer and Christie 1987
Bluegill	Adult	20	*	*	*	*	EPA 1974, as cited in Wismer and Christie 1987
Bluegill	Adult	25	*	*	*	33	EPA 1974, as cited in Wismer and Christie 1988
Bluegill	Juvenile	26	*	*	*	36	EPA 1974, as cited in Wismer and Christie 1989
Bluegill	Adult	30	*	*	*	34	EPA 1974, as cited in Wismer and Christie 1990
Bluegill	Juvenile	33	*	*	*	37	EPA 1974, as cited in Wismer and Christie 1991
Bluegill	Spawning	*	*	*	25	*	EPA 1974, as cited in Wismer and Christie 1992
Bluegill	Hatching	*	*	*	24	*	EPA 1974, as cited in Wismer and Christie 1993
Bluegill	*	*	*	*	32.3	*	Fry and Pearson 1952 / Ferguson 1958, as cited in
Bluegill	*	*	*	*	*	*	Ferguson, R.G., 1958 as cited in Spotila, J.R., et al., 1979
Bluegill	*	21.5	*	*	*	*	Hallam 1959 cited in Carlander 1977
Bluegill	Fry	*	*	*	*	*	Hardin and Bovee 1978, as cited in Stuber et al. 1982
Bluegill	Adult	15	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Bluegill	*	20	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Bluegill	*	25	*	*	*	*	Hart 1952, as cited in NAS/NAE 1974
Bluegill	*	*	*	37.3	*	*	Hart 1952, as cited in NAS/NAE 1975
	*	*	*	*	*	*	Van Arman, 1973 as cited in Beitinger and Magnuson, 1979
Bluegill	1-2 Yr	22-23	*	*	*	*	Hathaway 1927, as cited in Brown 1974
Bluegill	*	10	*	*	*	*	Hathaway 1928 cited in Carlander 1977
Bluegill	*	30	*	*	*	*	Hathaway 1928 cited in Carlander 1977
Bluegill	*	21.5	*	*	*	*	Hickman and Dewey 1973, as cited in Brown 1974
Bluegill	*	25	*	*	*	*	Holland et al. 1974, as cited in Beitinger et al. 2000
Bluegill	*	30	*	*	*	*	Holland et al. 1974, as cited in Beitinger et al. 2001
Bluegill	*	35	*	*	*	*	Holland et al. 1974, as cited in Beitinger et al. 2002
Bluegill	*	35	*	43.4	*	*	Holland et al. 1974, as cited in Beitinger et al. 2003
Bluegill	*	25	*	37.8	*	*	Holland et al. 1974, as cited in Beitinger et al. 2004
Bluegill	*	30	*	40	*	*	Holland et al. 1974, as cited in Beitinger et al. 2005
Bluegill	*	*	*	*	*	*	Kitchell et al. 1974 cited in Carlander 1977
Bluegill	*	*	*	*	*	*	Kitchell et al. 1974 cited in Carlander 1978
Bluegill	Juvenile	*	*	*	*	*	Lemke 1977, as cited in Stuber et al. 1982

Bluegill	*	10	*	*	*	*	Lutterschmidt and Hutchison 1997a, as cited in Beitinger 2000
Bluegill	Juvenile	*	*	*	*	*	McCauley and Casselman 1980,cited in Wismer and Christie 1987
Bluegill	Subadult	*	*	*	*	*	McCauley and Casselman 1980,cited in Wismer and Christie 1988
Bluegill	*	*	*	*	*	*	McCauley and Casselman 1980,cited in Wismer and Christie 1989
Bluegill	Adult	26	*	*	31	*	Medvick, P.A., et al., 1981 as cited in Cravens 1982
Bluegill	*	16	F	31.5	*	*	Murphy et al. 1976
Bluegill	*	24	F	37.5	*	*	Murphy et al. 1976
Bluegill	*	32	F	41.4	*	*	Murphy et al. 1976
Bluegill	*	16	F	*	*	*	Murphy et al. 1976
Bluegill	*	24	F	*	*	*	Murphy et al. 1976
Bluegill	*	32	F	*	*	*	Murphy et al. 1976
Bluegill	*	*	*	*	31.3	*	Neill 1971 cited in Coutant 1977
Bluegill	*	*	*	*	31.2	*	Neill 1971 cited in Coutant 1977
Bluegill	*	*	*	*	29	*	Neill 1971 cited in Coutant 1977
Bluegill	*	*	*	*	32.6	*	Neill 1971 cited in Coutant 1977
Bluegill	*	*	*	*	29	*	Neill 1971 cited in Coutant 1977
Bluegill	*	*	*	*	30.2	*	Neill 1971 cited in Coutant 1977
Bluegill	*	*	*	*	31.5	*	Neill 1971 cited in Coutant 1977
Bluegill	*	29	*	*	*	*	Neill and Magnuson 1974 cited in Carlander 1977
Bluegill	*	33	*	*	*	*	Neill and Magnuson 1974 cited in Carlander 1977
Bluegill	Young	*	*	*	*	*	Neill and Magnuson 1974, as cited in Brown 1974
Bluegill	*	*	*	*	30.7	*	*
Bluegill	*	*	*	*	24.6	*	*
Bluegill	*	27	L	*	*	35.8	Peterson and Schutsky 1976
Bluegill	*	13	L	*	*	29.3	Peterson and Schutsky 1976
Bluegill	*	1	L	*	*	23.3	Peterson and Schutsky 1976
Bluegill	*	*	*	*	27.4	*	Reutter and Herdendorf 1974 cited in Coutant 1977
Bluegill	*	22.8	L	38.3	*	*	Reutter and Herdendorf 1976
Bluegill	Adult	*	*	*	*	*	Reutter and Herdendorf, 1974 as cited in Spotila, J.R., et al., 1979

Bluegill	*	*	*	*	*	*	Reutter and Herdendorf, 1976 as cited in Spotila, J.R., et al., 1979
Bluegill	*	*	*	*	32.3	*	Reynolds and Casterlin 1976 cited in Coutant 1977
Bluegill	Adult	*	*	*	*	*	Reynolds and Casterlin 1976, as cited in Stuber et al. 1982
Bluegill	*	*	*	*	30.5	*	Reynolds et al. 1976 cited in Coutant 1977
Bluegill	*	*	*	*	*	*	Salmon Research Trust of Ireland 1960 cited in Carlander 1977
Bluegill	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
Bluegill	*	*	*	*	*	*	Stevenson et al. 1969 cited in Carlander 1977
Bluegill	*	15	*	*	*	*	Stevenson et al. 1969 cited in Carlander 1978
Bluegill	*	20	*	*	*	*	Stevenson et al. 1969 cited in Carlander 1979
Bluegill	*	30	*	*	*	*	Stevenson et al. 1969 cited in Carlander 1980
Bluegill	*	*	*	*	*	*	Stuntz and Magnuson 1976, as cited in Wismer and Christie 1987
Bluegill	*	*	*	*	*	*	Swingle 1949 cited in Carlander 1977
Bluegill	*	*	*	*	*	*	Swingle 1949 cited in Carlander 1977
Bluegill	Juvenile	25	*	*	31.2	*	Talmage and Coutant 1978, as cited in Wismer and Christie 1987
Bluegill	*	*	*	*	31	*	Talmage and Coutant 1978, as cited in Wismer and Christie 1987
Bluegill	*	*	*	*	31.4	*	Talmage and Coutant 1978, as cited in Wismer and Christie 1987
Bluegill	Juvenile	25	*	*	*	*	Talmage and Coutant 1978, as cited in Wismer and Christie 1987
Bluegill	*	*	*	*	*	*	Talmage and Coutant 1978, as cited in Wismer and Christie 1987
Bluegill	Juvenile	*	*	*	*	*	Talmage and Coutant 1978, as cited in Wismer and Christie 1987
Bluegill	*	*	*	*	*	*	Trembley 1960 cited in Carlander 1977
Bluegill	*	24.4	*	*	*	*	Trembley 1961, as cited in Brown 1974
Bluegill	*	*	*	35	32	*	U.S. EPA 1976
Bluegill	*	*	*	*	25	*	U.S. EPA 1976
Bluegill	*	*	*	*	34	*	U.S. EPA 1976
Bluegill	*	summer	F	*	*	*	Yoder and Gammon 1976
Bluegill	*	fall	F	*	*	*	Yoder and Gammon 1976
Bluegill	*	winter	F	*	*	*	Yoder and Gammon 1976
Brassy minnow	Spawning	*	F	*	12.8	*	Scott and Crossman 1973, p416
Channel Catfish	*	*	*	35	32.8	*	Scott and Crossman 1973, p417

Channel catfish	Fry	*	*	*	*	*	McMahon and Terrell 1982
Channel Catfish	Juvenile (44-57D)	26	*	*	*	*	Allen and Strawn 1968, as cited in NAS/NAE 1973
Channel Catfish	Juvenile (44-57D)	30	*	*	*	*	Allen and Strawn 1968, as cited in NAS/NAE 1974
Channel Catfish	Juvenile (44-57D)	34	*	*	*	*	Allen and Strawn 1968, as cited in NAS/NAE 1975
Channel Catfish	Juvenile (11.5 Mo)	25	*	*	*	*	Allen and Strawn 1968, as cited in NAS/NAE 1976
Channel Catfish	Juvenile (11.5 Mo)	30	*	*	*	*	Allen and Strawn 1968, as cited in NAS/NAE 1977
Channel Catfish	Juvenile (11.5 Mo)	35	*	*	*	*	Allen and Strawn 1968, as cited in NAS/NAE 1978
Channel Catfish	*	26	*	*	*	*	Allen and Strawn 1968, as cited in NAS/NAE 1979
Channel Catfish	*	30	*	*	*	*	Allen and Strawn 1968, as cited in NAS/NAE 1980
Channel Catfish	*	34	*	*	*	*	Allen and Strawn 1968, as cited in NAS/NAE 1981
Channel catfish	Juvenile	*	*	*	*	*	Andrews et al. 1972; Andrews and Stickney 1972
Channel Catfish	*	*	*	*	*	*	Bell 1990
Channel Catfish	Spawning	*	*	*	*	*	Bell 1990
Channel Catfish	Hatching	*	*	*	*	*	Bell 1990
Channel Catfish	*	10	*	*	*	*	Bennett et al. 1998, as cited in Beitinger et al. 2000
Channel Catfish	*	20	*	*	*	*	Bennett et al. 1998, as cited in Beitinger et al. 2000
Channel Catfish	*	30	*	*	*	*	Bennett et al. 1998, as cited in Beitinger et al. 2000
Channel Catfish	*	35	*	*	*	*	Brown 1942; Clemens and Sneed 1957, as cited in
Channel Catfish	Embryo	*	*	*	*	*	McMahon and Terrell 1982
Channel Catfish	Juvenile	26	*	*	*	36.6	Wismer and Christie 1987
Channel Catfish	Juvenile	34	*	*	*	37.8	Allen and Strawn 1968, as cited in Brown 1974
Channel Catfish	Juvenile	30	*	*	*	38	Brown 1974, as cited in Wismer and Christie 1987
Channel Catfish	Juvenile	25	*	*	*	35.5	Brown 1974, as cited in Wismer and Christie 1988
Channel Catfish	Juvenile	30	*	*	*	37	Brown 1974, as cited in Wismer and Christie 1989
Channel Catfish	Juvenile	35	*	*	*	38	Brown 1974, as cited in Wismer and Christie 1990
Channel Catfish	Adult	15	*	*	*	30.4	Hart 1952, as cited in Brown 1974
Channel Catfish	Adult	20	*	*	*	32.8	Hart 1952, as cited in Brown 1974
Channel Catfish	Adult	25	*	*	*	33.5	Trembley 1961, as cited in Brown 1974
Channel Catfish	*	7.2	*	*	*	32.8	Trembley 1961, as cited in Brown 1974

Channel Catfish	*	11	*	*	*	35	West 1966, as cited in Brown 1974
Channel Catfish	Larvae	*	*	*	*	*	West 1966, as cited in Brown 1974
Channel Catfish	Fry	*	*	*	*	*	West 1966, as cited in Brown 1974
Channel Catfish	Fry	*	*	*	29	*	Drew and Tilton 1970, as cited in Brown 1974
Channel Catfish	Juvenile	*	*	*	*	*	Tiemeir and Deyoe 1967, as cited in Brown 1974
Channel Catfish	Juvenile	*	*	*	*	*	Hokanson 1969, as cited in Brown 1974
Channel Catfish	Juvenile	*	*	*	*	*	Kilambri et al. 1970, as cited in Brown 1974
Channel Catfish	Juvenile	*	*	*	*	*	NTAC 1968, as cited in Brown 1974
Channel Catfish	Fingerling	*	*	*	*	*	Andrews et al. 1972, as cited in Brown 1974
Channel Catfish	Spawning	*	*	*	22	*	Brown 1974, as cited in Wismer and Christie 1987
Channel Catfish	Spawning	*	*	*	*	*	Katz 1954, as cited in Brown 1974
Channel Catfish	Spawning	*	F	*	*	*	McClellan 1954, as cited in Brown
Channel Catfish	Spawning	*	*	*	*	*	Sneed and Hokanson 1969, as cited in Brown 1974
Channel Catfish	Hatching	*	*	*	*	*	Brown 1974, as cited in Wismer and Christie 1987
Channel Catfish	Larvae	*	*	*	*	*	Brown 1974, as cited in Wismer and Christie 1987
Channel Catfish	Juvenile	*	*	*	*	*	Brown 1974, as cited in Wismer and Christie 1987
Channel Catfish	*	12	*	*	17	*	Cheetham et al., 1976 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	16	*	*	21	*	Cheetham et al., 1976 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	20	*	*	22	*	Cheetham et al., 1976 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	24	*	*	28	*	Cheetham et al., 1976 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	28	*	*	26	*	Cheetham et al., 1976 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	12	*	34.5	*	*	Cheetham et al., 1976 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	16	*	34.2	*	*	Cheetham et al., 1976 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	20	*	35.5	*	*	Cheetham et al., 1976 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	24	*	37.7	*	*	Cheetham et al., 1976 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	28	*	39.2	*	*	Cheetham et al., 1976 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	32	*	41	*	*	Cheetham et al., 1976 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	32	*	*	30	*	Cheetham et al., 1976 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	12	*	*	*	*	Cheetham st al. 1976, as cited in Beitinger et al. 2000
Channel Catfish	*	16	*	*	*	*	Cheetham st al. 1976, as cited in Beitinger et al. 2000

Channel Catfish	*	20	*	*	*	*	Cheetham st al. 1976, as cited in Beitinger et al. 2000
Channel Catfish	*	24	*	*	*	*	Cheetham st al. 1976, as cited in Beitinger et al. 2000
Channel Catfish	*	28	*	*	*	*	Cheetham st al. 1976, as cited in Beitinger et al. 2000
Channel Catfish	*	32	*	*	*	*	Cheetham st al. 1976, as cited in Beitinger et al. 2000
Channel Catfish	*	*	*	*	30.5	*	Cherry et al. 1975 cited in Coutant 1975
Channel Catfish	*	30	*	*	30.5	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	6	*	*	18.9	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	9	*	*	20.4	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	12	*	*	19.9	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	15	*	*	21.7	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	18	*	*	22.9	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	21	*	*	26.1	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	24	*	*	29.4	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	27	*	*	29.5	*	Cherry et al., 1975 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	*	*	*	*	*	Cravens 1981, as cite in Wismer and Christie 1987
Channel Catfish	*	20	*	*	*	*	Currie et al. 1998, as cited in Beitinger et al. 2000
Channel Catfish	*	25	*	*	*	*	Currie et al. 1998, as cited in Beitinger et al. 2000
Channel Catfish	*	30	*	*	*	*	Currie et al. 1998, as cited in Beitinger et al. 2000
Channel Catfish	*	*	F	*	*	*	Eaton and Scheller 1996
Channel Catfish	Spawning	*	*	*	27	*	EPA 1974, as cited in Wismer and Christie 1987
Channel Catfish	Spawning	*	*	*	*	*	EPA 1974, as cited in Wismer and Christie 1987
Channel Catfish	*	*	*	*	*	*	Gammon 1973 cited in Coutant 1977
Channel Catfish	*	*	*	*	*	*	Gammon 1973, as cited in Yoder and Gammon 1976
Channel Catfish	Adult	15	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Channel Catfish	Adult	20	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Channel Catfish	Adult	25	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Channel Catfish	*	*	*	*	*	*	Leidy and Jenkins, as cited in Wismer and Christie 1987
Channel Catfish	*	10	*	*	*	*	Lutterschmidt and Hutchison 1997a, as cited in Beitinger 2000
Channel Catfish	*	*	F	*	15.2	*	Marcy 1976
Channel Catfish	*	*	*	*	*	*	McClellan 1954 cited in Carlander 1969

Channel Catfish	*	*	*	*	*	35	Moss and Scott 1961 cited in Carlander 1969
Channel Catfish	*	*	*	*	*	*	Proffitt 1969 cited in Coutant 1977
Channel Catfish	*	*	*	*	25.2	*	Reutter and Herdendorf 1974 cited in Coutant 1977
Channel Catfish	*	*	*	*	25.3	*	Reutter and Herdendorf 1974 cited in Coutant 1977
Channel Catfish	*	22.7	L	*	*	*	Reutter and Herdendorf 1976
Channel Catfish	*	*	L	*	*	*	Reutter and Herdendorf 1976
Channel Catfish	Adult	*	*	*	*	*	Reutter and Herdendorf, 1974 as cited in Spotila, J.R., et al., 1979
Channel Catfish	Adult	*	*	*	*	*	Reutter and Herdendorf, 1974 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	22.7	*	38	*	*	Reutter and Herdendorf, 1976 as cited in Spotila, J.R., et al., 1979
Channel catfish	Adult	*	*	*	*	*	Schrable et al. 1969; Chen 1976
Channel Catfish	Spawning	*	F	*	26.7	*	Scott and Crossman 1973, p 607
Channel Catfish	Hatching	*	F	*	*	*	Scott and Crossman 1973, p 607
Channel Catfish	*	*	*	*	32.5	*	Stauffer et al., 1974 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	*	*	*	32	*	Stauffer et al., 1974 as cited in Spotila, J.R., et al., 1979
Channel Catfish	*	15	*	*	*	30.3	Strawn 1958 cited in Carlander 1969
Channel Catfish	*	20	*	*	*	32.8	Strawn 1958 cited in Carlander 1970
Channel Catfish	*	25	*	*	*	33.5	Strawn 1958 cited in Carlander 1971
Channel Catfish	*	15	*	*	*	*	Strawn 1958 cited in Carlander 1972
Channel Catfish	*	20	*	*	*	*	Strawn 1958 cited in Carlander 1973
Channel Catfish	*	25	*	*	*	*	U.S. EPA 1976
Channel Catfish	*	*	*	32	35	*	U.S. EPA 1976
Channel Catfish	*	*	*	*	27	*	U.S. EPA 1976
Channel Catfish	*	*	*	*	29	*	Watenpaugh and Beitinger 1985, as cited in Beitinger et al. 2000
Channel Catfish	*	20	*	*	*	*	West 1966, as cited in McMahon and Terrell 1982
Channel catfish	Fry	*	*	*	*	*	Yoder and Gammon 1976
Channel Catfish	*	summer	F	*	36	*	Yoder and Gammon 1976
Channel Catfish	*	fall	F	*	32	*	Yoder and Gammon 1976
Channel Catfish	*	winter	F	*	14	*	NA
Channel Catfish	*	*	F	35	32.8	*	NA

Channel Catfish	Spawning	*	*	*	23.9	*	Carlander 1969
Channel Catfish	*	*	*	*	*	36.1	Jinks1981
Channel Catfish	*	*	*	*	*	36.4	Jinks1981
Common Shiner	*	25-26	*	*	*	*	Brett 1944 cited in Carlander 1969
Common Shiner	Adult	10	L	*	29	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	15	L	*	30.5	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	20	L	*	31	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	25	L	*	31	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	25	L	*	31	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	30	L	31	31	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	5	*	*	26.7	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	10	*	*	28.6	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	15	*	*	30.3	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	20	*	*	31	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	25	*	*	31	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	7.2	*	*	30.6	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	11.1	*	*	31.1	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Spawning	*	*	*	25.5	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Spawning	*	*	*	15.6	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Spawning	*	*	*	21.1	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Spawning	*	*	*	28	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Spawning	*	*	*	18	*	Brown 1974, as cited in Wismer and Christie 1987
Common Shiner	Adult	*	*	*	32	*	Carlander 1969, as cited in Wismer and Christie 1987
Common Shiner	Inshore Migration	*	*	*	15.5	*	Dodson and Young 1917, as cited in Wismer and Christie 1987
Common Shiner	Spawning	*	*	*	18	*	Dodson and Young 1917, as cited in Wismer and Christie 1987
Common Shiner	Adult (Mostly 2 Yr)	5	*	*	*	*	Hart 1947, as cited in NAS/NAE 1973
Common Shiner	Adult (Mostly 2 Yr)	10	*	*	*	*	Hart 1947, as cited in NAS/NAE 1973
Common Shiner	Adult (Mostly 2 Yr)	15	*	*	*	*	Hart 1947, as cited in NAS/NAE 1973
Common Shiner	Adult (Mostly 2 Yr)	20	*	*	*	*	Hart 1947, as cited in NAS/NAE 1973

Common Shiner	Adult (Mostly 2 Yr)	25	*	*	*	*	Hart 1947, as cited in NAS/NAE 1973
Common Shiner	Adult	10	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Common Shiner	Adult	15	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Common Shiner	Adult	20	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Common Shiner	Adult	25	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Common Shiner	Adult	25	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Common Shiner	Adult	30	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Common Shiner	Adult	25	*	*	*	*	Hart 1952, as cited in NAS/NAE 1980
Common Shiner	Adult	30	*	*	*	*	Hart 1952, as cited in NAS/NAE 1980
Common Shiner	*	15	L	30.6	*	*	Kowalski et al. 1978, as cited in Beitinger et al. 2000
Common Shiner	*	15	L	31.9	*	*	Kowalski et al. 1978, as cited in Beitinger et al. 2000
Common Shiner	*	15	*	*	*	*	Kowalski et al. 1978, as cited in Beitinger et al. 2000
Common Shiner	*	15	*	*	*	*	Kowalski et al. 1978, as cited in Beitinger et al. 2001
Common Shiner	*	*	*	*	*	*	Miller 1964 cited in Carlander 1969
Common Shiner	*	*	*	*	21	*	Nurnberger 1931 cited in Carlander 1969
Common Shiner	*	15	*	*	*	*	Schubauer et al 1980, as cited in Beitinger et al. 2000
Common Shiner	Spawning	*	F	*	18.3	*	Scott and Crossman 1973, p450
Common Shiner	Spawning	*	F	*	28.3	*	Scott and Crossman 1973, p450
Common Shiner	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
Common Shiner	*	5	*	*	27	*	Strawn 1958 cited in Carlander 1969
Common Shiner	*	10	*	*	29	*	Strawn 1958 cited in Carlander 1969
Common Shiner	*	15	*	*	30.3	*	Strawn 1958 cited in Carlander 1969
Common Shiner	*	20	*	*	32.3	*	Strawn 1958 cited in Carlander 1969
Common Shiner	*	25	*	*	33.5	*	Strawn 1958 cited in Carlander 1969
Largemouth Bass	*	8	*	*	*	*	Fields et al. 1987, as cited in Beitinger et al. 2000
Largemouth Bass	*	16	*	*	*	*	Fields et al. 1987, as cited in Beitinger et al. 2000
Largemouth Bass	*	24	*	*	*	*	Fields et al. 1987, as cited in Beitinger et al. 2000
Largemouth Bass	*	32	*	*	*	*	Fields et al. 1987, as cited in Beitinger et al. 2000
Freshwater Drum	*	*	*	35.3	*	*	Fields et al. 1987, as cited in Beitinger et al. 2001

Freshwater Drum	*	*	*	*	26.1	*	Brown 1974, as cited in Wismer and Christie 1987
Freshwater Drum	*	*	*	*	22	*	Brown 1974, as cited in Wismer and Christie 1987
Freshwater Drum	*	*	*	*	31	*	Brown 1974, as cited in Wismer and Christie 1987
Freshwater Drum	*	*	F	*	*	*	Brown 1974, as cited in Wismer and Christie 1987
Freshwater Drum	Spawning	*	*	*	21	*	Brown 1974, as cited in Wismer and Christie 1987
Freshwater Drum	Spawning	*	*	*	23.9	*	Brown 1974, as cited in Wismer and Christie 1987
Freshwater Drum	*	*	*	*	*	*	Brown 1974, as cited in Wismer and Christie 1987
Freshwater Drum	Hatching	*	*	*	*	*	Brown 1974, as cited in Wismer and Christie 1987
Freshwater Drum	Larvae	*	*	*	28	*	Cada and Hergenrader 1980
Freshwater Drum	*	*	*	*	22.2	*	Dendy 1948 cited in Coutant 1977
Freshwater Drum	*	*	F	*	*	*	Eaton and Scheller 1996
Freshwater Drum	*	*	*	*	21	*	EPA 1974, as cited in Wismer and Christie 1987
Freshwater Drum	Incubation	*	*	*	22	*	EPA 1974, as cited in Wismer and Christie 1987
Freshwater Drum	*	*	*	*	*	*	Gammon 1973 cited in Coutant 1977
Freshwater Drum	*	29-35	*	*	*	32.8	Cvancara et al. 1977
Freshwater Drum	*	*	*	*	30.3	*	Neill 1971 cited in Coutant 1977
Freshwater Drum	*	*	*	*	*	*	Neill 1971 cited in Coutant 1977
Freshwater Drum	Young	*	*	*	31.3	*	Reutter and Herdendorf 1974 cited in Coutant 1977
Freshwater Drum	Adult	*	*	*	26.5	*	Reutter and Herdendorf 1974 cited in Coutant 1977
Freshwater Drum	Adult	*	*	*	19.6	*	Reutter and Herdendorf 1974 cited in Coutant 1977
freshwater drum	Adult	21.2	L	*	*	*	Reutter and Herdendorf 1976
freshwater drum	Adult	*	*	*	*	*	Reutter and Herdendorf 1976
freshwater drum	Yoy	*	*	*	*	*	Reutter and Herdendorf 1976
Freshwater Drum	*	*	F	*	30	*	Yoder and Gammon 1976
Freshwater Drum	*	*	F	*	11	*	Yoder and Gammon 1976
Freshwater Drum	*	*	F	32.6	32.5	*	Jinks1981
Freshwater Drum	*	*	*	*	*	32.8	Jinks1981
Gizzard Shad	*	*	*	35.3	32.3	*	Jinks1981
Gizzard Shad	Spawning	*	F	*	*	*	Bodola 1966, as cited in Scott and Crossman 1973, p135
Gizzard Shad	Underyearling	25	*	*	*	34.5	Brown 1974, as cited in Wismer and Christie 1987

Gizzard Shad	Underyearling	30	*	*	*	36	Brown 1974, as cited in Wismer and Christie 1987
Gizzard Shad	Underyearling	35	*	*	*	36.5	Brown 1974, as cited in Wismer and Christie 1987
Gizzard Shad	Spawning	*	*	31.7	*	*	Brown 1974, as cited in Wismer and Christie 1987
Gizzard Shad	Spawning	*	*	35.7	*	*	Brown 1974, as cited in Wismer and Christie 1987
Gizzard Shad	*	*	*	37.5	*	*	Brown 1974, as cited in Wismer and Christie 1987
Gizzard Shad	*	*	*	*	*	*	Brown 1974, as cited in Wismer and Christie 1987
Gizzard Shad	Adult	*	*	*	*	*	Clark 1969; Brungs and Jones 1977
Gizzard Shad	*	*	F	*	*	*	Eaton and Scheller 1996
Gizzard Shad	*	*	*	*	*	*	Ellis 1984, as cited in Wismer and Christie 1987
Gizzard Shad	Adult	*	*	*	*	*	Gammon 1973, as cited in Williamson and Nelson 1985
Gizzard Shad	*	summer	*	*	*	*	Gammon 1973, as cited in Yoder and Gammon 1976
Gizzard Shad	Underyearling	25	F	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Gizzard Shad	Underyearling	30	F	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Gizzard Shad	Underyearling	35	F	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Gizzard Shad	Underyearling	25	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Gizzard Shad	Underyearling	30	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Gizzard Shad	Underyearling	35	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Gizzard Shad	Adult	*	*	*	*	*	Hart 1952;Strawn 1958, as cited in Williamson and Nelson 1985
Gizzard Shad	Hatching	*	L	*	*	*	Miller 1960,as cited in Scott and Crossman 1973, p135
Gizzard Shad	Adult	*	*	*	*	*	Proffitt and Benda 1971, as cited in Williamson and Nelson 1985
Gizzard Shad	Adult	15.9	*	31.7	*	*	Reutter and Herdendorf 1976
Gizzard Shad	Adult	*	*	*	*	*	Reutter and Herdendorf 1976
Gizzard Shad	*	*	*	*	*	*	Talmage and Coutant 1980, as cited in Wismer and Christie 1987
Gizzard Shad	*	*	*	*	*	*	This Study
Gizzard Shad	*	*	*	*	*	*	This Study
Gizzard Shad	*	*	*	*	*	*	Wyman 1981, as cited in Wismer and Christie 1987
Gizzard shad	*	summer	F	*	*	*	Yoder and Gammon 1976
Gizzard shad	*	fall	F	*	*	*	Yoder and Gammon 1976
Gizzard shad	*	winter	F	*	*	*	Yoder and Gammon 1976
Gizzard Shad	*	*	F	34	32.3	*	Yoder and Gammon 1977

Gizzard Shad	Underyearling	*	*	31	*	*	Talmage 1978, as cited in Wismer and Christie 1987
Golden Shiner	*	*	*	35.3	*	*	Talmage 1978, as cited in Wismer and Christie 1988
Golden Shiner	*	22	*	*	*	40	Beltz et al 1974, as cited in Wismer and Christie 1987
Golden Shiner	*	17.1-17.5	*	*	*	31.6	Brett 1944 cited in Carlander 1969
Golden Shiner	*	22.8	*	*	*	32.7	Brett 1944 cited in Carlander 1970
Golden Shiner	*	25-26	*	*	*	33.2	Brett 1944 cited in Carlander 1971
Golden Shiner	*	*	*	*	*	30.4	Brett 1944 cited in Carlander 1972
Golden Shiner	*	*	*	*	*	31.6	Brett 1944 cited in Carlander 1973
Golden Shiner	*	*	*	*	*	30.3	Brett 1944 cited in Carlander 1974
Golden Shiner	*	*	*	*	*	32.8	Brett 1944 cited in Carlander 1975
Golden Shiner	3.49 In	*	*	*	*	33.4	Brett 1944 cited in Carlander 1976
Golden Shiner	*	*	*	*	*	33.2	Brett 1944 cited in Carlander 1977
Golden Shiner	*	*	*	*	*	31.8	Brett 1944 cited in Carlander 1978
Golden Shiner	*	*	*	*	*	33.5	Brett 1944 cited in Carlander 1979
Golden Shiner	*	10	*	*	*	*	Brett 1944 cited in Carlander 1980
Golden Shiner	*	15	*	*	*	*	Brett 1944 cited in Carlander 1981
Golden Shiner	*	20	*	*	*	*	Brett 1944 cited in Carlander 1982
Golden Shiner	*	25	*	*	*	*	Brett 1944 cited in Carlander 1983
Golden Shiner	*	30	*	*	*	*	Brett 1944 cited in Carlander 1984
Golden Shiner	*	10	L	*	*	29.3	Hart 1952, as cited in Brown 1974
Golden Shiner	*	15	L	*	*	30.5	Hart 1952, as cited in Brown 1974
Golden Shiner	*	20	L	*	*	31.8	Hart 1952, as cited in Brown 1974
Golden Shiner	*	25	L	*	*	33.2	Hart 1952, as cited in Brown 1974
Golden Shiner	*	30	L	*	*	34.7	Hart 1952, as cited in Brown 1974
Golden Shiner	*	22	*	39.5	*	*	Alpaugh 1972, as cited in Brown 1974
Golden Shiner	*	22	*	40	*	*	Alpaugh 1972, as cited in Brown 1974
Golden Shiner	*	*	*	*	*	26.7	Nickum 1966, as cited in Brown 1974
Golden Shiner	*	*	*	*	*	35	Brown 1974, as cited in Wismer and Christie 1987
Golden Shiner	*	*	*	*	*	*	Trembley 1961, as cited in Brown 1974
Golden Shiner	*	*	F	*	*	*	Bailey 1955, as cited in Brown 1974

Golden Shiner	*	*	*	800	*	*	Brown 1974, as cited in Wismer and Christie 1987
Golden Shiner	*	*	*	*	28.9	*	Trembley 1961, as cited in Brown 1974
Golden Shiner	*	*	*	*	15.6	*	Brown 1974, as cited in Wismer and Christie 1987
Golden Shiner	*	*	*	*	*	*	Trembley 1961, as cited in Brown 1974
Golden Shiner	*	*	*	*	*	*	Trembley 1961, as cited in Brown 1974
Golden Shiner	*	*	*	*	*	*	Eaton and Scheller 1996
Golden Shiner	*	*	F	*	*	*	Forney 1957 cited in Carlander 1969
Golden Shiner	*	*	*	*	21	*	Hart 1952, as cited in NAS/NAE 1973
Golden Shiner	Adult	10	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Golden Shiner	Adult	15	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Golden Shiner	Adult	20	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Golden Shiner	Adult	25	*	*	*	*	Hart 1952, as cited in NAS/NAE 1973
Golden Shiner	Adult	30	*	*	*	*	Hutchison 1976
Golden Shiner	*	*	*	33	*	*	Hutchison 1976
Golden Shiner	*	*	*	35	*	*	Hutchison 1976
Golden Shiner	*	*	*	36	*	*	Hutchison 1976
Golden Shiner	*	*	*	38	*	*	Hutchison 1976
Golden Shiner	*	*	*	39	*	*	Hutchison 1977
Golden Shiner	*	*	*	40	*	*	Leidy and Jenkins 1977, as cited in Wismer and Christie 1987
Golden Shiner	*	10	*	*	*	*	Lutterschmidt and Hutchison 1997a, as cited in Beitinger 2000
Golden Shiner	*	*	F	*	24	*	Marcy 1976
Golden Shiner	*	*	*	*	18	*	McAllister
Golden Shiner	*	*	*	30.5	23.9	*	R&R1976
Golden Shiner	*	*	L	*	16.8	*	Reutter and Herdendorf 1976
Golden Shiner	*	*	L	*	23.7	*	Reutter and Herdendorf 1976
Golden Shiner	*	14.4	L	*	22.3	*	Reutter and Herdendorf 1976
Golden Shiner	*	*	L	*	21	*	Reutter and Herdendorf 1976
Golden Shiner	Spawning	*	F	*	20	*	Scott and Crossman 1973, p436
Golden Shiner	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
Golden Shiner	*	15	*	*	*	*	Strawn 1958 cited in Carlander 1969

Golden Shiner	*	20	*	*	*	*	Strawn 1958 cited in Carlander 1970
Golden Shiner	*	25	*	*	*	*	Strawn 1958 cited in Carlander 1971
Golden Shiner	*	30	*	*	*	*	Strawn 1958 cited in Carlander 1972
Golden Shiner	*	*	*	*	20	35	Swingle 1952 cited in Carlander 1969
Golden Shiner	*	*	*	*	27	*	Talmage 1978
Golden Shiner	*	*	*	*	*	35	Trembley 1960 cited in Carlander 1969
Golden Shiner	*	*	F	30.9	*	*	Trembley 1960 cited in Carlander 1970
Golden Shiner	*	10	*	30	*	*	Brown1974
Golden Shiner	*	15	*	15	*	*	Brown1974
Green Sunfish	*	*	*	34	19.8	*	Brown1975
Green Sunfish	*	*	F	34	32.6	*	Brown1976
Green Sunfish	*	*	*	*	28.2	*	Beitinger et al. 1975 cited in Coutant 1977
Green Sunfish	Adult	*	*	*	*	*	Beitinger et al. 1975, as cited in Stuber et al. 1982
Green Sunfish	*	*	*	*	26.8	*	Beltz et al 1974, as cited in Wismer and Christie 1987
Green Sunfish	*	*	*	*	22.7	*	Carlander 1977
Green Sunfish	*	20 (1day)	*	*	*	*	Carrier and Beitinger 1988a, as cited in Beitinger et al. 2000
Green Sunfish	*	20 (5 day)	*	*	*	*	Carrier and Beitinger 1988a, as cited in Beitinger et al. 2000
Green Sunfish	*	20 (10 day)	*	*	*	*	Carrier and Beitinger 1988a, as cited in Beitinger et al. 2000
Green Sunfish	*	6	*	*	15.9	*	Cherry et al. 1975 cited in Carlander 1977
Green Sunfish	*	30	*	*	30.6	*	Cherry et al. 1975 cited in Carlander 1977
Green Sunfish	*	6	*	*	*	*	Cherry et al. 1975 cited in Carlander 1977
Green Sunfish	*	27	*	*	*	*	Cherry et al. 1975 cited in Carlander 1977
Green Sunfish	*	*	*	*	30.6	*	Cherry et al. 1975 cited in Coutant 1975
Green Sunfish	Hatching	*	*	*	*	*	Childers 1967 cited in Carlander 1977
Green Sunfish	Spawning	*	*	*	*	*	Childers 1967, as cited in Stuber et al 1982
Green Sunfish	*	*	F	*	*	*	Eaton and Scheller 1996
Green Sunfish	Spawning	*	F	*	*	*	Hunter 1963, as cited in Brown 1974
Green Sunfish	Spawning	*	*	*	*	*	Hunter 1963, as cited in Stuber et al. 1982
Green Sunfish	*	*	*	*	27.3	*	Jones and Irwin 1965 cited in Coutant 1977
Green Sunfish	*	*	*	*	*	*	Jude 1973 cited in Carlander 1977

Green Sunfish	*	10	*	*	*	*	Lutterschmidt and Hutchison 1997a, as cited in Beitinger 2000
Green Sunfish	*	*	*	*	*	*	Proffitt and Benda 1971 cited in Carlander 1977
Green Sunfish	Spawning	*	*	*	29.1	*	Salyer 1958 cited in Carlander 1977
Green Sunfish	Fry	*	*	*	*	*	Siewert 1973;Soutant 1977
Green Sunfish	*	*	*	*	*	*	Sigler and Miller 1963 cited in Carlander 1977
Green Sunfish	Adult	*	F	*	*	*	Sigler and Miller 1963; Proffitt and Benda 1971
Green Sunfish	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
Green Sunfish	Hatching	*	*	*	*	*	Strawn 1958 cited in Carlander 1977
Green Sunfish	*	20	*	*	*	*	Witford 1970, as cited in Brown 1974
Green Sunfish	*	30	*	*	*	*	Witford 1970, as cited in Brown 1975
Hornyhead Chub	*	26	*	*	*	*	Scott and Crossman 1973, p785
Iowa Darter	Hatching	*	F	*	*	*	Scott and Crossman 1973, p785
Largemouth Bass	*	*	*	35.5	34.7	*	Badenhuizen 1969 cited in Carlander 1977
Largemouth Bass	*	*	F	35.5	34.7	*	Badenhuizen 1969 cited in Carlander 1978
Largemouth Bass	*	*	*	*	*	*	Badenhuizen 1969 cited in Carlander 1979
Largemouth Bass	*	*	*	*	*	*	Badenhuizen 1969 cited in Carlander 1980
Largemouth Bass	*	*	*	*	*	*	Bell 1990
Largemouth Bass	Spawning	*	*	*	*	*	Bell 1990
Largemouth Bass	Hatching	*	*	*	*	*	Bell 1990
Largemouth Bass	*	*	F	*	*	*	Bennett 1954a cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Bennett 1954b cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Bennett, G.W., 1965 as cited in Spotila, J.R., et al., 1979
Largemouth Bass	*	20-21	*	*	*	*	Black 1953
Largemouth Bass	*	20-21	*	*	*	28.9	Black, E.C., 1953 as cited in Spotila, J.R., et al., 1979
Largemouth Bass	*	*	*	*	*	*	Breder 1936 cited in Carlander 1977
Largemouth Bass	*	20	*	*	*	*	Brett, J.R., 1956 as cited in Spotila, J.R., et al., 1979
Largemouth Bass	*	25	*	*	*	*	Brett, J.R., 1956 as cited in Spotila, J.R., et al., 1979
Largemouth Bass	*	30	*	*	*	*	Brett, J.R., 1956 as cited in Spotila, J.R., et al., 1979
Largemouth Bass	9-11 Mo	20	*	*	*	32	Brown 1974, as cited in Wismer and Christie 1987
Largemouth Bass	9-11 Mo	25	*	*	*	33	Brown 1974, as cited in Wismer and Christie 1987

Largemouth Bass	9-11 Mo	30	L	*	*	33.7	Hart 1952, as cited in Brown 1974
Largemouth Bass	*	30	L	*	*	*	Hart 1952, as cited in Brown 1974
Largemouth Bass	Adult	20	L	*	*	32.5	Hart 1952, as cited in Brown 1974
Largemouth Bass	*	20	L	*	*	*	Hart 1952, as cited in Brown 1974
Largemouth Bass	Adult	25	*	*	*	34.5	Brown 1974, as cited in Wismer and Christie 1987
Largemouth Bass	Adult	30	*	*	*	36.4	Brown 1974, as cited in Wismer and Christie 1987
Largemouth Bass	Under Yearling	30	*	*	*	36.4	Brown 1974, as cited in Wismer and Christie 1987
Largemouth Bass	*	35	*	*	*	36.4	Brown 1974, as cited in Wismer and Christie 1987
Largemouth Bass	*	22	*	*	*	31.5	Brown 1974, as cited in Wismer and Christie 1987
Largemouth Bass	*	7.2	L	*	*	30.6	Trembley 1961, as cited in Brown 1974
Largemouth Bass	*	11.1	L	*	*	36	Trembley 1961, as cited in Brown 1974
Largemouth Bass	*	15	*	*	*	35	Brown 1974, as cited in Wismer and Christie 1987
Largemouth Bass	*	*	*	*	29.1	*	*
Largemouth Bass	Fry	*	*	*	*	*	Strawn 1961, as cited in Brown 1974
Largemouth Bass	Eggs	*	*	*	*	32.5	Strawn 1961, as cited in Brown 1974
Largemouth Bass	Spawning	*	*	*	*	*	Clugston 1966, as cited in Brown 1974
Largemouth Bass	Fry	*	*	*	*	*	Fry 1950, as cited in Brown 1974
Largemouth Bass	Juvenile	25	*	*	*	*	Meldrim and Gift 1971, as cited in Brown 1974
Largemouth Bass	*	*	F	*	*	*	Trembley 1960, as cited in Brown 1974
Largemouth Bass	*	*	*	*	*	36.7	Carlander 1977
Largemouth Bass	Spawning	*	*	*	21	*	Carlander 1977
Largemouth Bass	Spawning	*	*	*	20	*	Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Carlson and Hale 1972 cited in Carlander 1977
Largemouth Bass	*	*	*	*	30.4	36	Cherry et al. 1982
Largemouth Bass	*	*	F	*	*	*	Chew 1974 cited in Carlander 1977
Largemouth Bass	*	*	F	*	*	*	Clugston 1966 cited in Carlander 1977
Largemouth Bass	*	*	*	*	30	*	Clugston 1973 cited in Coutant 1977
Largemouth Bass	*	*	*	*	27	*	Coutant 1975 cited in Coutant 1977
Largemouth Bass	*	*	*	*	*	*	Coutant and DeAngelis 1983, as cited in Wismer and Christie 1987

Largemouth Bass	*	*	*	*	*	*	Coutant, C.C., 1975 as cited in Spotila, J.R., et al., 1979
Largemouth Bass	*	*	*	*	*	35.6	Cvancara et al., 1976 as cited in Spotila, J.R., et al., 1979
Largemouth Bass	*	*	*	*	27.7	*	Dendy 1948 cited in Coutant 1977
Largemouth Bass	*	*	F	*	*	*	Eaton and Scheller 1996
Largemouth Bass	*	*	*	*	*	*	Eddy and Surber 1947 cited in Carlander 1977
Largemouth Bass	Subadult	*	*	*	*	*	EPA 1974, as cited in Wismer and Christie 1987
Largemouth Bass	Juvenile	*	*	*	*	*	EPA 1974, as cited in Wismer and Christie 1987
Largemouth Bass	Spawning	*	*	*	*	*	EPA 1974, as cited in Wismer and Christie 1987
Largemouth Bass	Juvenile	20	*	*	*	33	EPA 1974, as cited in Wismer and Christie 1987
Largemouth Bass	Juvenile	25	*	*	*	35	EPA 1974, as cited in Wismer and Christie 1987
Largemouth Bass	Juvenile	30	*	*	*	36	EPA 1974, as cited in Wismer and Christie 1987
Largemouth Bass	Juvenile	35	*	*	*	36	EPA 1974, as cited in Wismer and Christie 1987
Largemouth Bass	Spawning	*	*	*	20	*	EPA 1974, as cited in Wismer and Christie 1987
Largemouth Bass	*	*	*	*	32	*	Ferguson 1958 cited in Coutant 1977
Largemouth Bass	*	*	*	*	*	*	Ferguson 1958 cited in Coutant 1978
Largemouth Bass	*	*	*	*	*	*	Ferguson 1958 cited in Coutant 1979
Largemouth Bass	*	8	*	*	*	*	Fields et al. 1987, as cited in Currie et al. 1998
Largemouth Bass	*	16	*	*	*	*	Fields et al. 1987, as cited in Currie et al. 1998
Largemouth Bass	*	24	*	*	*	*	Fields et al. 1987, as cited in Currie et al. 1998
Largemouth Bass	*	32	*	*	*	*	Fields et al. 1987, as cited in Currie et al. 1998
Largemouth Bass	*	8	*	*	*	*	Fields et al. 1987, as cited in Currie et al. 1998
Largemouth Bass	*	16	*	*	*	*	Fields et al. 1987, as cited in Currie et al. 1998
Largemouth Bass	*	24	*	*	*	*	Fields et al. 1987, as cited in Currie et al. 1998
Largemouth Bass	*	32	*	*	*	*	Fields et al. 1987, as cited in Currie et al. 1998
Largemouth Bass	*	32	*	*	*	*	Fields et al. 1987, as cited in Currie et al. 1998
Largemouth Bass	*	32	*	*	*	*	Fields et al. 1987, as cited in Currie et al. 1998
Largemouth Bass	*	30 or 36	*	*	*	*	Guest 1985, as cited in Currie et al. 1998
Largemouth Bass	*	30 or 36	*	*	*	*	Guest 1985, as cited in Currie et al. 1998
Largemouth Bass	*	10	*	*	*	*	Hart 1952 cited in Carlander 1977
Largemouth Bass	*	20	*	*	*	*	Hart 1952 cited in Carlander 1977

Largemouth Bass	*	20	*	*	*	*	Hart 1952 cited in Carlander 1977
Largemouth Bass	*	20-21.8	*	*	*	*	Hart 1952 cited in Carlander 1977
Largemouth Bass	*	25	*	*	*	*	Hart 1952 cited in Carlander 1977
Largemouth Bass	*	25	*	*	*	*	Hart 1952 cited in Carlander 1977
Largemouth Bass	*	30	*	*	*	*	Hart 1952 cited in Carlander 1977
Largemouth Bass	*	30	*	*	*	*	Hart 1952 cited in Carlander 1977
Largemouth Bass	*	30	*	*	*	*	Hart 1952 cited in Carlander 1977
Largemouth Bass	*	30	*	*	*	*	Hart 1952 cited in Carlander 1977
Largemouth Bass	9-11 Mo Age.	20	*	*	*	*	Hart 1952, as cited in NAS/NAE 1977
Largemouth Bass	*	20	*	*	*	*	Hart 1952, as cited in NAS/NAE 1978
Largemouth Bass	9-11 Mo Age.	25	*	*	*	*	Hart 1952, as cited in NAS/NAE 1979
Largemouth Bass	*	25	*	*	*	*	Hart 1952, as cited in NAS/NAE 1980
Largemouth Bass	9-11 Mo Age.	30	*	*	*	*	Hart 1952, as cited in NAS/NAE 1981
Largemouth Bass	*	30	*	*	*	*	Hart 1952, as cited in NAS/NAE 1982
Largemouth Bass	Under Yearling	30	*	*	*	*	Hart 1952, as cited in NAS/NAE 1983
Largemouth Bass	Under Yearling	35	*	*	*	*	Hart 1952, as cited in NAS/NAE 1984
Largemouth Bass	*	22	*	*	*	*	Hart 1952, as cited in NAS/NAE 1985
Largemouth Bass	*	10	*	*	*	*	Hathaway 1927, as cited in Currie et al 1998
Largemouth Bass	*	22-23	*	*	*	*	Hathaway 1927, as cited in Currie et al 1998
Largemouth Bass	*	30	*	*	*	*	Hathaway 1927, as cited in Currie et al 1998
Largemouth Bass	*	*	*	*	*	*	Johnson 1971 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Jurgens and Brown 1954 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Kramer and Smith 1960, as cited in Brown 1974
Largemouth Bass	*	*	*	*	*	*	Lawrence 1957 cited in Carlander 1977
Largemouth Bass	*	10	*	*	*	*	Lutterschmidt and Hutchison 1997a, as cited in Beitinger 2000
Largemouth Bass	*	*	*	*	21.3	*	Marcy 1976
Largemouth Bass	Juvenile	*	*	*	*	*	McCauley and Casselman 1980, cited in Wismer and Christie 1987
Largemouth Bass	Subadult	*	*	*	*	*	McCauley and Casselman 1980, cited in Wismer and Christie 1987
Largemouth Bass	Spawning	*	*	*	*	32.1	McCormick and Wegner 1981

Largemouth Bass	Spawning	20	L	*	*	*	McCormick and Wegner 1981
Largemouth Bass	Spawning	24	*	*	*	*	McCormick and Wegner 1982
Largemouth Bass	Spawning	27	*	*	*	*	McCormick and Wegner 1983
Largemouth Bass	Spawning	30	*	*	*	*	McCormick and Wegner 1981
Largemouth Bass	*	*	*	*	*	*	Miller and Kramer 1971 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Miller and Kramer 1971 cited in Carlander 1978
Largemouth Bass	*	*	*	*	*	*	Miller and Kramer 1971 cited in Carlander 1979
Largemouth Bass	*	*	*	*	*	*	Mraz 1957 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Mraz 1957 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Mraz 1957 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Mraz 1957 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Mraz 1957 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Neil and Magnnson, as cited in Yoder and Gammon 1976
Largemouth Bass	*	*	*	*	30.9	*	Neill 1971 cited in Coutant 1977
Largemouth Bass	*	*	*	*	32	*	Neill 1971 cited in Coutant 1978
Largemouth Bass	*	*	*	*	29.1	*	Neill 1971 cited in Coutant 1979
Largemouth Bass	*	*	*	*	29	*	Neill 1971 cited in Coutant 1980
Largemouth Bass	*	*	*	*	*	*	Nelson 1974 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Nelson 1974 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Otto 1973, as cited in Yoder and Gammon 1976
Largemouth Bass	*	*	*	*	30	*	Reynolds and Casterlin 1976 cited in Coutant 1977
Largemouth Bass	*	*	*	*	29.5	*	Reynolds and Casterlin, 1978 cited in Talmage and Coutant, 1979
Largemouth Bass	*	*	*	*	30.1	*	Reynolds et al. 1976 cited in Coutant 1977
Largemouth Bass	*	*	*	*	30.2	*	Reynolds et al. 1976 cited in Coutant 1977
Largemouth Bass	*	*	*	*	*	*	Reynolds et al., 1976 as cited in Spotila, J.R., et al., 1979
Largemouth bass	*	22	L	*	*	*	Reynolds, W., and Casterlin, M.E., 1978
Largemouth Bass	*	*	*	*	*	*	Salyer 1958 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Smagula and Adelman 1982, as cited in Wismer and Christie 1987
Largemouth Bass	Fry	*	*	*	*	*	Smagula and Adelman 1982, as cited in Wismer and Christie 1987

Largemouth Bass	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
Largemouth Bass	*	20	*	*	*	*	Smith and Scott 1975, as cited in Beitinger et al. 2000
Largemouth Bass	*	28	*	*	*	*	Smith and Scott 1975, as cited in Beitinger et al. 2000
Largemouth Bass	*	20	*	36.7	*	*	Smith and Scott, 1975 as cited in Spotila, J.R., et al., 1979
Largemouth Bass	*	28	*	40.1	*	*	Smith and Scott, 1975 as cited in Spotila, J.R., et al., 1979
Largemouth Bass	*	*	*	*	*	*	Strawn 1961 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Strawn 1961 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	32.5	Strawn 1961 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Swingle 1952 cited in Carlander 1969
Largemouth Bass	*	*	*	*	*	*	Swingle 1956 cited in Carlander 1977
Largemouth Bass	*	*	*	*	27.1	*	Talmage and Coutant 1979, as cited in Wismer and Christie 1987
Largemouth Bass	*	*	*	*	*	*	Trembley 1960 cited in Carlander 1977
Largemouth Bass	*	*	*	*	*	*	Trembley 1960 cited in Carlander 1977
Largemouth Bass	*	*	*	34	32	*	U.S. EPA 1976
Largemouth Bass	*	*	*	*	21	*	U.S. EPA 1976
Largemouth Bass	*	*	*	*	27	*	U.S. EPA 1976
Largemouth Bass	Fingerling	11.1	L	*	*	35	Venables et al 1978, as cited in Wismer and Christie 1987
Largemouth Bass	Fingerling	15	L	*	*	35	Venables et al 1978, as cited in Wismer and Christie 1987
Largemouth Bass	Fingerling	20	L	*	*	40	Venables et al 1978, as cited in Wismer and Christie 1987
Largemouth Bass	Fingerling	25	L	*	*	40	Venables et al 1978, as cited in Wismer and Christie 1987
Largemouth Bass	Fingerling	30	L	*	*	40	Venables et al 1978, as cited in Wismer and Christie 1987
Largemouth Bass	Spawning	35	L	*	*	26.7	Venables et al 1978, as cited in Wismer and Christie 1987
Largemouth Bass	*	*	*	*	32	*	Venables et al., 1978 as cited in Talmage&Coutant, 1979
Largemouth Bass	*	summer	F	*	*	*	Yoder and Gammon 1976
Largemouth Bass	*	fall	F	*	*	*	Yoder and Gammon 1976
Quillback	Large	*	*	*	*	*	Coutant 1977a, as cited in Wismer and Christie 1987
Quillback	*	24	*	*	*	*	Mundahl 1990, as cited in Beitinger et al. 2000
Quillback	Adult	23.3	L	*	*	*	Reutter and Herdendorf 1976
Quillback	*	*	*	*	*	*	Yoder and Gammon 1976
Quillback	*	*	*	*	*	*	Yoder and Gammon 1976

Red Shiner	*	20 (day 1)	*	*	*	*	Carrier and Beitinger 1988a, as cited in Beitinger et al. 2000
Red Shiner	*	20 (day 5)	*	*	*	*	Carrier and Beitinger 1988a, as cited in Beitinger et al. 2000
Red Shiner	*	20 (day 10)	*	*	*	*	Carrier and Beitinger 1988a, as cited in Beitinger et al. 2000
Red Shiner	*	25	*	*	*	*	King et al. 1985, as cited in Beitinger et al. 2000
Red Shiner	*	10	*	*	*	*	Lutterschmidt and Hutchison 1997a, as cited in Beitinger 2000
Red Shiner	*	15	*	*	*	*	Maness and Hutchinson 1980, as cited in Beitinger et al. 2000
Red Shiner	*	25	*	*	*	*	Matthews and Maness 1979, as cited in Beitinger et al. 2000
Red Shiner	*	30	*	*	*	*	Rutledge and Beitinger 1989, as cited in Beitinger et al. 2000
Red Shiner	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
Red Shiner	*	22	*	*	*	*	Takle et al. 1983, as cited in Beitinger et al. 2000
River Carpsucker	*	summer	*	*	*	*	Gammon 1973, as cited in Yoder and Gammon 1976
River Carpsucker	*	summer	F	*	*	*	Yoder and Gammon 1976
River Carpsucker	*	fall	F	*	*	*	Yoder and Gammon 1976
River Carpsucker	*	winter	F	*	*	*	Yoder and Gammon 1976
Sand Shiner	*	15	*	*	*	*	Kowalski et al. 1978, as cited in Beitinger et al. 2000
Sand Shiner	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
Smallmouth Bass	*	*	*	*	24	*	Barans and Tubb 1973 cited in Coutant 1977
Smallmouth Bass	*	*	*	*	31	*	Barans and Tubb 1973 cited in Coutant 1977
Smallmouth Bass	*	*	*	*	27	*	Barans and Tubb 1973 cited in Coutant 1977
Smallmouth Bass	*	*	*	*	13	*	Barans and Tubb 1973 cited in Coutant 1977
Smallmouth Bass	*	*	*	*	16	*	Barans and Tubb 1973 cited in Coutant 1977
Smallmouth Bass	*	*	*	*	30	*	Barans and Tubb 1973 cited in Coutant 1977
Smallmouth Bass	*	*	*	*	23	*	Barans and Tubb 1973 cited in Coutant 1977
Smallmouth bass	Juvenile	*	*	*	*	*	Barans and Tubb 1973, as cited in Edwards et al. 1983
Smallmouth Bass	*	*	*	*	18	*	Barans and Tubb 1976 cited in Coutant 1977
Smallmouth Bass	*	*	*	*	*	*	Bell 1990
Smallmouth Bass	Spawning	*	*	*	*	*	Bell 1990
Smallmouth Bass	Hatching	*	*	*	*	*	Bell 1990
Smallmouth Bass	*	*	*	*	*	*	Brown 1960 cited in Carlander 1977
Smallmouth Bass	*	*	*	*	*	*	Brown 1960 cited in Carlander 1977

Smallmouth Bass	*	*	*	*	*	*	Brown 1960 cited in Carlander 1977
Smallmouth Bass	*	*	*	*	31.3	*	Cherry et al. 1975 cited in Coutant 1975
Smallmouth bass	*	*	*	*	*	*	Cherry et al. 1975, as cited in Edwards et al. 1983
Smallmouth Bass	*	*	*	*	*	35	Cherry et al., 1977
Smallmouth Bass	*	*	*	*	30.3	*	Cherry et al., 1977
Smallmouth Bass	*	15	L	*	*	*	Cherry et al., 1977
Smallmouth Bass	*	18	L	*	*	*	Cherry et al., 1977
Smallmouth Bass	*	21	L	*	*	*	Cherry et al., 1977
Smallmouth Bass	*	24	L	*	*	*	Cherry et al., 1977
Smallmouth Bass	*	27	L	*	*	*	Cherry et al., 1977
Smallmouth Bass	*	30	L	*	*	*	Cherry et al., 1977
Smallmouth Bass	*	33	L	*	*	*	Cherry et al., 1977
Smallmouth Bass	*	*	*	*	*	*	Christie and Regier 1973 cited in Carlander 1977
Smallmouth bass	Adult	*	F	*	*	*	Clancey 1980, as cited in Edwards et al. 1983
Smallmouth bass	Adult	*	*	*	*	*	Coble 1975, as cited in Edwards et al. 1983
Smallmouth bass	Embryo	*	*	*	*	*	Coble 1975, as cited in Edwards et al. 1983
Smallmouth bass	Juvenile	*	*	*	*	*	Coble 1975, as cited in Edwards et al. 1983
smallmouth bass	*	*	*	*	*	*	Crippen and Fahmy 1981
Smallmouth Bass	*	*	F	*	*	*	Eaton and Scheller 1996
Smallmouth Bass	*	*	*	*	*	*	Emig 1966 cited in Carlander 1977
Smallmouth Bass	*	*	*	*	28	*	Ferguson 1958 cited in Coutant 1977
Smallmouth Bass	*	*	*	*	*	*	Ferguson 1958 cited in Coutant 1977
Smallmouth Bass	*	*	*	*	21.3	*	Hile and Juday 1941, as cited in Brown 9174
Smallmouth bass	Juvenile	*	*	*	*	*	Horning and Pearson 1973, as cited in Brown 1974
Smallmouth Bass	*	*	*	*	*	*	Hubbs and Bailey 1938 cited in Carlander 1977
Smallmouth bass	Fry	*	*	*	*	*	Larimore and Duever 1968, as cited in Edwards et al. 1983
Smallmouth Bass	*	*	*	*	*	*	Lowrey 1958 cited in Carlander 1977
Smallmouth Bass	*	10	*	*	*	*	Lutterschmidt and Hutchison 1997a, as cited in Beitinger 2000
Smallmouth bass	Adult	2.2	*	*	*	*	Mathur et al. 1981, as cited in Edwards et al. 1983
Smallmouth bass	Adult	30	*	*	*	*	Mathur et al. 1981, as cited in Edwards et al. 1983

Smallmouth bass	Fry	*	L	*	*	*	Munther 1970; Shuter et al. 1980, as cited in Edwards et al. 1983
Smallmouth Bass	*	*	*	*	*	*	Neves 1975 cited in Carlander 1977
Smallmouth Bass	*	*	*	*	*	*	Neves 1975 cited in Carlander 1977
Smallmouth bass	Adult	*	L	*	*	*	Peek 1965; Shuter et al. 1980; Wrenn 1980
Smallmouth Bass	*	*	*	*	*	*	Rawson 1945 cited in Carlander 1977
Smallmouth Bass	*	*	*	*	*	*	Rawson 1945 cited in Carlander 1977
Smallmouth Bass	*	*	*	*	26.6	*	Reutter and Herdendorf 1974 cited in Coutant 1977
Smallmouth Bass	*	*	L	*	*	*	Reutter and Herdendorf 1976
Smallmouth Bass	*	*	L	*	*	*	Reutter and Herdendorf 1976
Smallmouth Bass	*	*	L	*	*	*	Reutter and Herdendorf 1976
Smallmouth Bass	*	*	L	*	*	*	Reutter and Herdendorf 1976
Smallmouth Bass	*	*	L	*	*	*	Reutter and Herdendorf 1976
Smallmouth Bass	*	*	L	*	*	*	Reutter and Herdendorf 1976
Smallmouth Bass	*	*	L	*	*	*	Reutter and Herdendorf 1976
Smallmouth Bass	*	*	L	*	*	*	Reutter and Herdendorf 1976
Smallmouth Bass	*	*	*	*	31.1	*	Reynolds and Casterlin 1976 cited in Coutant 1977
Smallmouth Bass	*	none	F	*	*	30	Shuter et al. 1980
Smallmouth Bass	*	none	F	*	29	*	Shuter et al. 1980
Smallmouth Bass	*	none	F	*	18	*	Shuter et al. 1980
Smallmouth Bass	*	none	F	*	21	*	Shuter et al. 1980
Smallmouth Bass	*	none	F	*	*	30	Shuter et al. 1980
Smallmouth Bass	*	26	*	*	*	*	Smale and Rabeni 1995, as cited in Beitinger et al 2000
Smallmouth Bass	*	*	F	*	*	*	Smitherman and Ramsey 1972 cited in Carlander 1977
Smallmouth Bass	*	*	F	*	*	*	Smitherman and Ramsey 1972 cited in Carlander 1977
Smallmouth Bass	*	*	*	*	*	*	Trautman 1957 cited in Carlander 1977
Smallmouth Bass	*	*	*	*	*	*	Trembley 1960 cited in Carlander 1977
Smallmouth Bass	*	12.8	*	*	*	*	Trembley 1960, as cited in Brown 1974
Smallmouth Bass	*	*	F	*	*	*	Trembley 1960, as cited in Brown 1974
Smallmouth Bass	*	*	*	*	*	*	Turner and MacCrimmon 1970 cited in Carlander 1977
Smallmouth bass	Spawning	*	*	*	*	*	Turner and MacCrimmon 1970 cited in Carlander 1977

Smallmouth Bass	*	*	*	*	29	*	U.S. EPA 1976
Smallmouth Bass	*	*	*	*	17	*	U.S. EPA 1976
Smallmouth Bass	*	*	*	*	23	*	U.S. EPA 1976
Smallmouth Bass	*	*	*	*	*	*	Webster 1954 cited in Carlander 1977
Smallmouth Bass	*	*	F	*	*	37	Wrenn 1980
Smallmouth Bass	*	*	F	*	*	38	Wrenn 1980
Smallmouth Bass	*	*	F	*	*	35	Wrenn 1980
Smallmouth Bass	*	*	F	*	31	*	Wrenn 1980
Smallmouth Bass	*	*	F	*	32	*	NA
Smallmouth Bass	*	*	*	35	32.32.2	*	NA
Smallmouth Bass	*	12.8	*	*	*	32.2	Brown 1974
Smallmouth Bass	Egg	19	*	*	*	29	Brown 1974
Smallmouth Bass	Egg	16.1	*	*	*	23.1	Brown 1974
Smallmouth Bass	Spawning	*	*	*	*	*	Henderson and Foster 1956, as cited in Brown 1974
Smallmouth Bass	Egg	12.8	*	*	*	*	Webster 1945, as cited in Brown 1974
Smallmouth Bass	Spawning	*	*	*	*	*	Nesley 1913, as cited in Brown 1974
Smallmouth Bass	Spawning	*	*	*	*	*	Hubbs and Bailey 1938, cited in Brown 1974
Smallmouth Bass	Spawning	*	*	*	*	*	Wiebe 1935, as cited in Brown 1974
Smallmouth Bass	Incubation	*	*	*	*	*	Webster 1945, as cited in Brown 1974
Smallmouth Bass	Juveniles	*	*	*	*	*	Peek 1965, as ctied in Brown 9174
Smallmouth Bass	Juveniles	*	*	*	*	*	Hokanson 1969, as cited in Brown 1974
Smallmouth Bass	*	*	*	*	21.4	*	Carlander 1977
Suckermouth Minnow	*	10	*	*	*	*	Lutterschmidt and Hutchison 1997a, as cited in Beitinger 2000
White Bass	*	*	*	*	*	*	Barans and Tubb 1973 cited in Carlander 1997
White Bass	*	*	*	*	*	*	Barans and Tubb 1973 cited in Carlander 1997
White Bass	*	*	*	*	*	*	Barans and Tubb 1973 cited in Carlander 1997
White Bass	*	*	*	*	*	*	Barans and Tubb 1973 cited in Carlander 1997
White Bass	*	*	*	*	*	*	Barans and Tubb 1973 cited in Carlander 1997
White Bass	*	*	*	*	*	*	Barans and Tubb 1973 cited in Carlander 1997
White Bass	*	*	*	*	*	*	Barans and Tubb 1973 cited in Carlander 1997

White Bass	*	*	*	*	*	*	Barans and Tubb 1973 cited in Carlander 1997
White Bass	*	summer	L	*	*	*	Barans and Tubb 1973, as cited in Joder and Gammon 1976
White Bass	*	fall	L	*	*	*	Barans and Tubb 1973, as cited in Joder and Gammon 1976
White Bass	*	winter	L	*	*	*	Barans and Tubb 1973, as cited in Joder and Gammon 1976
White Bass	*	spring	L	*	*	*	Barans and Tubb 1973, as cited in Joder and Gammon 1976
White Bass	*	*	F	*	*	*	Commercial Fisheries Review 1961 cited in Carlander 1997
White Bass	*	*	F	*	*	*	Eaton and Scheller 1996
White Bass	Adults	*	*	*	*	*	Gammon 1973, as cited in Hamilton and Nelson 1984
White Bass	*	*	*	*	*	*	Gammon 1973, as cited in Yoder and Gammon 1976
White Bass	Adults	*	L	*	*	*	Horrall 1961, as cited in Hamilton and Nelson 1984
White Bass	Hatching	*	L	*	*	*	Horrall 1961; Ruelle 1971; Siefert et al. 1974,
White Bass	*	*	F	*	*	*	McCormick 1978 cited in Carlander 1997
White Bass	*	*	F	*	*	*	McCormick 1978 cited in Carlander 1997
White Bass	*	*	F	*	*	*	McCormick 1978 cited in Carlander 1997
White Bass	*	*	*	*	*	*	McCormick 1978 cited in Carlander 1997
White Bass	*	*	F	*	*	*	Nelson 1980 cited in Carlander 1997
White Bass	*	21.7	L	*	*	*	Reutter and Herdendorf 1976
White Bass	Spawning	*	*	*	*	*	Riggs 1955; Webb and Moss 1968; Ruells 1971
White Bass	*	*	F	*	*	*	Vincent 1967 cited in Carlander 1997
White Bass	Incubation	*	*	*	*	*	Yellayi and Kilambi 1970, as cited in Hamilton and Nelson 1984
White Bass	*	summer	F	*	*	*	Yoder and Gammon 1976
White Bass	*	fall	F	*	*	*	Yoder and Gammon 1976
White Bass	*	winter	F	*	*	*	Yoder and Gammon 1976
White Bass	*	*	F	31.4	29.9	*	Yoder and Gammon 1976

Attachment 11

Status of Rare and Endangered Freshwater Mussels in Southeastern Oklahoma

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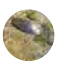
3 authors:



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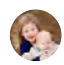

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STATUS OF RARE AND ENDANGERED FRESHWATER MUSSELS IN SOUTHEASTERN OKLAHOMA

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ABSTRACT—We reviewed the conservation status of rare and endangered species of mussels in southeastern Oklahoma by completing surveys of 10 long-term monitoring sites on the Kiamichi River and five sites in the Little River. We found extant populations of the Ouachita rock pocketbook, *Arkansia wheeleri*, scaleshell, *Leptodea leptodon*, winged mapleleaf, *Quadrula fragosa*, and rabbitsfoot, *Quadrula cylindrica cylindrica*. This is the first reported documentation of *Q. fragosa* in the Little River. When our data are compared to historic records, populations, particularly of *A. wheeleri* and *Q. cylindrica*, appear to be declining.

RESUMEN—Revisamos el estado de conservación de las especies raras de mejillones y en peligro de extinción en 10 sitios de muestreo a largo plazo en el río Kiamichi y 5 sitios en el río Little en el sureste de Oklahoma. Encontramos poblaciones existentes de *Arkansia wheeleri*, *Leptodea leptodon*, *Quadrula fragosa* y *Quadrula cylindrica cylindrica*. Reportamos por primera vez a *Q. fragosa* en el río Little. Cuando los resultados son comparados con registros históricos, las poblaciones, particularmente de *A. wheeleri* y *Q. cylindrica*, parecen estar disminuyendo.

One of the most critically imperiled freshwater groups in the United States is freshwater mussels (Family Unionidae; Strayer et al., 2004). The United States Fish and Wildlife Service recognizes 12% of native freshwater mussels to be extinct and 23% as threatened or endangered, while the Nature Conservancy considers 68% of native mussels to be at risk (Biggins and Butler, 2000). Mussels are long-lived, iteroparous, and spend a portion of their lives as obligate ectoparasites on a fish host (McMahon and Bogan, 2001). These life-history characteristics have made them particularly susceptible to anthropogenic impacts.

The highest diversity of freshwater mussels occurs in the southeastern United States, which provides habitat for almost 270 of the about 300 North American species (Williams et al., 1993; Neves et al., 1997). Oklahoma, on the periphery of the highest species richness for mussels, is still home to a diverse and speciose assemblage of freshwater mussels with about 55 species in the state. One river basin, the Kiamichi-Little River Basin, supports about 80% of all species of mussels that can be found in Oklahoma (Table 1; D. E. Spooner et al., in litt.). Historically, both of these rivers also have been home to a number of rare and endangered species of mussels including the Ouachita rock pocketbook, *Arkansia wheeleri*, scaleshell, *Leptodea leptodon*, winged mapleleaf, *Quadrula fragosa*, and rabbitsfoot, *Quadrula cylindrica*.

Arkansia wheeleri (syn. *Arcidens wheeleri*) is a federally listed, endangered species whose historical distribution includes the Kiamichi River and Jackfork Creek (a tributary to the Kiamichi River), the Little River, the Ouachita River in Arkansas, and Pine Creek and Sanders Creek in Texas (Martinez, 2004). As of the early 1990s, the most substantial remaining population occurred in the Kiamichi River within a 123-km stretch upstream of Hugo Reservoir (Vaughn and Pyron, 1995; Martinez, 2004; C. C. Vaughn et al., in litt.). Other smaller populations were known to occur in the Little River in Oklahoma and the Ouachita River in Arkansas (Martinez, 2004; C. C. Vaughn, in litt.; C. C. Vaughn et al., in litt.).

Leptodea leptodon, also a federally listed, endangered species, was known historically from 55 rivers across the United States in Alabama, Arkansas, Illinois, Indiana, Iowa, Kentucky, Minnesota, Missouri, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin (Syzmanski,

TABLE 1—Freshwater species of mussels known from the Kiamichi and Little rivers, Oklahoma (from D. E. Spooner et al., in litt.).

Species	Common name	Kiamichi river	Little river	Federal status	State status
Actinonaias ligamentina	Mucket	X	X		
Amblema plicata	Threeridge	X	X		
Arkansia wheeleri	Ouachita rock pocketbook	X	X	Endangered	Endangered
Ellipsaria lineolata	Butterfly	X	X		
Elliptio dilatata	Spike		X		
Fusconaia flava	Wabash pigtoe	X	X		
Lampsilis cardium	Plain pocketbook	X	X		
Lampsilis satura	Sandbank pocketbook		X		
Lampsilis siliquoidea	Fatmucket	X	X		
Lampsilis teres	Yellow sandshell	X	X		
Lasmigona complanata	White heelsplitter	X	X		
Lasmigona costata	Flutedshell	X	X		
Leptodea fragilis	Fragile papershell	X	X		
Leptodea leptodon	Scaleshell	X		Endangered	Species of special concern
Ligumia subrostrata	Pondmussel	X	X		
Megalonaias nervosa	Washboard	X	X		
Obliquaria reflexa	Threehorn wartyback	X	X		
Obovaria jacksoniana	Southern hickorynut	X			
Plectomerus dombeyanus	Bankclimber		X		
Pleurobema sintoxia	Round pigtoe		X		
Pleurobema rubrum	Pyramid pigtoe	X	X		
Potamilus purpuratus	Bleufer	X	X		
Ptychobranchus occidentalis	Ouachita kidneyshell	X	X		
Pyganodon grandis	Giant floater	X	X		
Quadrula apiculata	Southern mapleleaf		X		
Quadrula fragosa	Winged mapleleaf		X	Endangered	
Quadrula cylindrica	Rabbitsfoot	X			Species of special concern
Quadrula nodulata	Wartyback		X		
Quadrula pustulosa	Pimpleback	X	X		
Quadrula quadrula	Mapleleaf	X	X		
Strophitus undulatus	Creeper	X	X		
Toxolasma parvus	Lilliput	X	X		
Toxolasma texasensis	Texas lilliput		X		
Tritogonia verrucosa	Pistolgrip	X	X		
Truncilla truncata	Deertoe	X	X		
Truncilla donaciformis	Fawnsfoot		X		
Utterbackia imbecillis	Paper pondshell	X			
Villosa arkansasensis	Ouachita creekshell		X		
Villosa iris	Rainbow		X		
Villosa lienosa	Little spectaclecase		X		

1998; Roberts, 2004). Although it always has been considered a rare species, its populations have declined significantly over the past decade such that it has been extirpated from most of its previously known localities. Presently, it is believed to remain in 14 of the original rivers including the Kiamichi River, the Little River, and the Mountain Fork River (a tributary to the Little River; Roberts, 2004; NatureServe, http://www.natureserve.org/explorer/servlet/NatureServe?searchSciOrCommonName=Leptodea+leptodon).

The historical distribution of federally listed, endangered *Q. fragosa* is uncertain because many published records misidentified this species as *Quadrula quadrula*; however, it has been suggested that this species occurred historically throughout the Interior Basin. Currently, the only known viable populations are in the Saint Croix River in Minnesota and Wisconsin, the Bourbeuse River in Missouri, and the Ouachita and Saline rivers in Arkansas (Hornbach et al., 1996; Hove et al., 2003; NatureServe, http://www.natureserve.org/explorer/servlet/NatureServe?searchSciOrCommonName=Quadrula+fragosa&x=7&y=5; C. Davidson and W. R. Posey, pers. comm.).

Quadrula cylindrica cylindrica, although not listed as federally threatened or endangered, has experienced significant population declines across most of its range. This species was found historically in the Great Lakes sub-basin and in the Mississippi River drainage in about 136 rivers across 15 states (R. S. Butler, in litt.; NatureServe, http://www.natureserve.org/explorer/servlet/NatureServe?searchSciOrCommonName=Quadrula+cylindrica+cylindrica). Presently, populations of *Q. cylindrica* are believed to remain in 46 of these streams in 13 states. Most reports on this mussel suggest that it has become rare or extirpated in many regions; however, populations of *Q. cylindrica* in the Little River are considered to be one of the most significant throughout the range of this species. This species is currently under review by the United States Fish and Wildlife Service for possible listing as threatened or endangered (R. S. Butler, in litt.).

Frequent surveys of rare and endangered species are necessary to assess recovery of populations and current and future management practices. During 1990–1992, Vaughn and Pyron (1995) identified and surveyed 10 long-term population monitoring sites for *A. wheeleri* in the Kiamichi River. These sites were all located above a large mainstem impoundment, with four sites above and six sites below a tributary impoundment (Fig. 1). Additionally, during 1993–1995 multiple sites were surveyed along the Little River for *A. wheeleri* (Vaughn and Taylor, 1999; C. C. Vaughn, in litt.). The purpose of the present study was to resurvey the Kiamichi River monitoring sites and survey additional sites in the Little River to determine the status of federally listed and other rare species of mussels in rivers of southeastern Oklahoma.

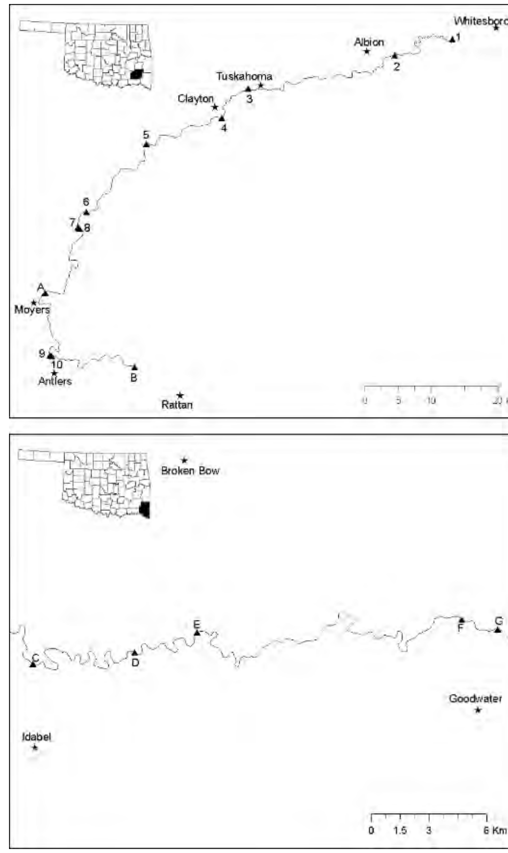

Fig. 1—Sampling sites on the Kiamichi River (top) and Little River (bottom). Monitoring sites established in the 1990s are numbered from upstream to downstream; remaining sites are lettered from upstream to downstream. Towns are indicated by ★.

Materials and Methods—During summers of 2003–2005, we surveyed the 10 monitoring sites in the Kiamichi River and 5 additional sites in the Little River that were believed to harbor dense, diverse communities of mussels (Fig. 1). At each site, we sampled quantitatively with quadrats, followed by qualitative sampling with a timed search (Vaughn et al., 1997; Strayer and Smith, 2003). For each site, we used a stratified-random design and excavated 15 0.25-m^2 quadrats to a depth of about 15 cm. Timed searches consisted of ≥2 h of searching for mussels by hand, snorkel, or SCUBA in deeper areas (>0.75 m). We measured all located endangered species with digital calipers (height, width, length), individually marked each with a Floy® shellfish tag (Floy Tag, Inc., Seattle, Washington) attached with gel-type superglue, and returned mussels to the same location from which they were captured. In beds that were known to have contained *A. wheeleri* in past surveys, we spent additional time searching habitat appropriate for this species (Vaughn and Pyron, 1995) and looking for individuals of *A. wheeleri* that were marked in the early 1990s.

We also canoed a 60-km stretch of the Kiamichi River, between Whitesboro and Moyers, to locate previously unmapped mussel beds and search for rare species of mussels (Fig. 1a). We found mussel beds by conducting visual searches in shallow water and looking for dead shells on the shore. At newly located mussel beds, we recorded universal transverse mercator (UTM) coordinates at each site using a global positioning system (GPS). For most of the newly identified sites, we performed a short timed search (usually 30 min) to obtain a rough estimate of mussel richness. We also searched each new site for potential habitat of *A. wheeleri* so that we might more thoroughly search these sites in the future.

Results—*Arkansia wheeleri*—Historically, *A. wheeleri* was present at 6 of the 10 monitoring sites in the Kiamichi River: sites 1, 2, 3, 5, 6, and 7 (Fig. 1; Vaughn and Pyron, 1995). In our surveys during 2003–2005, we did not find *A. wheeleri* at any of these locations. We found three live *A. wheeleri* at site A, a newly discovered mussel bed near Moyers, Oklahoma (Fig. 1). These individuals (67, 82, and 82 mm) were within the size range of *A. wheeleri* collected in the 1990s (40–100 mm; Vaughn and Pyron, 1995). We also found a relict shell of *A. wheeleri* at a previously unsampled mussel bed located between sites 5 and 6. In 1993, C. C. Vaughn et al. (in litt.) found a live *A. wheeleri* at site B, just upstream of Rattan (Martinez, 2004); we were unable to resample this bed, so the status of this *A. wheeleri* population is unknown.

In the 1990s, *A. wheeleri* was present at site E in the Little River (Martinez, 2004). We did not find *A. wheeleri* at this site in our surveys in 2003–2005. However, we found two individuals (92 and 121 mm) of *A. wheeleri* in the Little River at site F, located <1 km above the confluence of the Mountain Fork River (Fig. 1) on the Little River National Wildlife Refuge where C. C. Vaughn (in litt.) also collected this species historically.

Leptodea leptodon—We found three, fresh dead (i.e., some tissue still attached) shells of *L. leptodon* in the Kiamichi River. One of these shells was at site 2 near Albion, one at site A in the same mussel bed as *A. wheeleri*, and the third at site 10 near Antlers (Fig. 1). One of the shells was small (<5 cm), indicative of either a female or a juvenile.

Quadrula fragosa—We found individuals that genetic analysis confirmed to be *Q. fragosa* (J. Serb, pers. comm.) at sites C, D, E, and F in the Little River. Densities of *Q. fragosa* at each site were 0.13 individuals/m^2 at sites D and E, and 0.53 individuals/m^2 at site F. A single individual was located at site C during our timed search; thus, we do not have a density estimate for this site.

Quadrula cylindrica—We found three substantial populations of *Q. cylindrica* in the Little River at sites D, E, and G, with densities of about 2.4, 1.1, and 0.27 individuals/m^2, respectively. In February of 2006, however, we revisited these sites and found that the population at site D had suffered a large mortality event. We collected >160 fresh dead shells on the bank of this mussel bed; dead individuals spanned the range of sizes for this species from 33 to 103 mm.

Discussion—Extant populations of *A. wheeleri*, *L. leptodon*, and *Q. cylindrica* occur in the Kiamichi and Little rivers. Additionally, this is the first confirmed finding of *Q. fragosa* in Oklahoma. Although it has been suggested that populations of this species exist in the Kiamichi River (P. Mehlhop-Cifelli and E. K. Miller, in litt.; Hove et al., 2003), we have never found this species there in extensive surveys over the past 15 years. Despite finding living individuals of all but *L. leptodon*, we are concerned about the long-term persistence of all of these rare species in southeastern Oklahoma.

In the Kiamichi River, *A. wheeleri* appears to have declined significantly in both number of sites at which it occurs and in abundance. This species tends to be found in the largest, most species-rich mussel beds (Vaughn and Pyron, 1995); however, over the past decade abundance and species richness of mussels have declined throughout the Red River drainage (Vaughn, 2000) and specifically in the Kiamichi River (H. S. Galbraith et al., in litt.). Whatever factors are impacting mussels in the Kiamichi River seem to have had particularly deleterious effects on *A. wheeleri*. The *A. wheeleri* at the newly discovered bed at site A are under severe threat from human activities. Over the past few years, complete removal of riparian habitat and gravel mining within and above the mussel bed have resulted in mass mortality of mussels at this site.

Although we found individuals of *A. wheeleri* in the Little River at localities that previously were unknown, we also have concerns about this population. The water levels over the site-F mussel bed were extremely low at the time we sampled (8 August 2005), and many other mussels were stranded or dead. Both individuals of *A. wheeleri* that we found in our study were stranded out of water; we replaced them in a deeper portion of the mussel bed that was still under water. These individuals were also large: the extent to which recruitment is occurring in this species is assumed to be low (or non-existent) given the large size classes and low densities of individuals that we sampled in both the Little River and Kiamichi River.

The three fresh-dead *L. leptodon* we found suggest that this species remains extant in the Kiamichi River; however, over the past 15 years, no one has sampled a living individual to our knowledge. Our collection at site 2 near Albion is the farthest upstream an individual has been found in the Kiamichi River since at least 1987 (Syzmanski, 1998; Roberts, 2004). Again, we are reluctant to suggest that any populations of *L. leptodon* at the site-A mussel bed will survive the current degradation.

We found large, apparently stable, and reproducing populations of *Q. cylindrica* in the Little River, one of the last places in the United States this species is known to be abundant (R. S. Butler, in litt.). We are uncertain of the cause of mortality in this species at site D, but are troubled over the large number of fresh-dead individuals we observed spanning the range of size classes of this species. This die off was apparently species specific as no other species of mussel was found dead in such high abundance. For southeastern Oklahoma, 2005 was the driest year on record, receiving <50% of the average precipitation (calculated over a 30-year period–Oklahoma Climatological Survey, 2006). High water temperatures (which can exceed 40°C) combined with extensive blooms of filamentous algae may have resulted in extreme physiological stress at site D (D. E. Spooner et al., in litt.), while low water levels may have increased predation pressure at this already shallow bed. Despite the possibility of these factors, we observed no mass mortality prior to November 2005 when the river conditions were most extreme, suggesting the mortality event occurred between November 2005 and February 2006. The Little River is susceptible, however, to inputs of sewage and runoff from poultry plants, which may have been a factor in the mortality of *Q. cylindrica*, although we have no evidence to confirm or refute this hypothesis.

Results of our surveys suggest that, although rare and endangered species of mussels are still present in southeastern Oklahoma, populations in both the Kiamichi and Little rivers are declining. This is troubling information, particularly for *A. wheeleri*, whose global distribution is limited to these two rivers and the Ouachita River in Arkansas. Given the declines in populations of *A. wheeleri* and *Q. cylindrica* and the recent discovery of *Q. fragosa* in this region, it is imperative that further efforts be made to minimize impacts on these already threatened populations. Further construction of reservoirs in this area as recently has been proposed could be detrimental to the remaining populations of both rare and common species of mussels.

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Attachment 12

Proceedings of Oklahoma Water 2005, Tulsa, OK, September 27 and 28, Paper #18
Oklahoma Water Resources Research Institute, Stillwater, OK, 12 pgs.

Freshwater Mussel Populations in Southeastern Oklahoma: Population Trends and Ecosystem Services

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Abstract

Both overall abundance and species richness of freshwater mussels have declined over the past century. Mussels are natural 'biofilters' that provide important ecosystem services in the rivers. Thus, the decline of this fauna may have long-term, negative consequences for the functioning of river ecosystems. The major cause of mussel decline is from the alteration of the natural flow regime of rivers, primarily by impoundments and channelization. Hydrologic alterations impact mussels both directly through physical stress, such as temperature changes, siltation and scour, and indirectly through changes in habitat, food and fish-host availability. There are approximately 52 mussel species that presently occur in Oklahoma waters, with the highest biodiversity and healthiest populations in the southeast. For example, 41/55 species (80%) occur in the Kiamichi and Little River watersheds. Within these watersheds, the number of sites at which species occur and species abundances are declining, and the biological integrity of numerous subpopulations have been greatly decreased by the loss of individuals. Three federally endangered mussel species occur in these rivers, the Ouachita rock pocketbook (*Arkansia wheeleri*), the winged mapleleaf (*Quadrula fragosa*), and the scaleshell (*Leptodea leptodon)*, while a fourth species, *Quadrula cylindrica*, the rabbitsfoot mussel, is being considered for listing.

Introduction

General impacts of hydrologic alterations on unionid mussels

The freshwater mussel (Unionidae) fauna of North America is the most diverse in the world, but is highly threatened (Bogan 1993), with major declines of mussel populations and species diversity occurring over the past century (Neves 1992; Neves *et al.* 1997; Ricciardi *et al.* 1998; Vaughn & Taylor 1999; McMahon & Bogan 2001). Currently, the U.S. Fish and Wildlife Service recognizes 12% of the native mussel fauna as extinct and 23% as threatened or endangered, and The Nature Conservancy considers 68% of the U.S. unionid species at risk, compared to only 17% for mammals and 15% for birds (Biggins & Butler 2000). Recent work has demonstrated that unionid mussels provide important ecosystem services in the rivers where they are abundant (Kasprzak 1986; Welker & Walz 1998; Vaughn *et al.* 2004a). Mussels are natural 'biofilters' that remove algae, bacteria and particulate organic matter from the water

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column. They influence nutrient dynamics in freshwaters through excretion as well as biodeposition of feces and pseudofeces (rejected food particles). By burrowing in the sediment they increase sediment water and oxygen content, and release nutrients from the sediment to the water column. Finally, the physical presence of both living mussels and their spent shells stabilizes sediment and creates habitat for other benthic organisms (Vaughn & Hakenkamp 2001; Spooner 2002; Strayer *et al.* 2004). Thus, the overall decline of this fauna may have long-term, negative consequences for the functioning of river ecosystems (Strayer *et al.* 1999; Vaughn & Hakenkamp 2001; Vaughn *et al.* 2004a).

Table 1. Life history traits of unionid mussels. Modified from McMahon & Bogan (2001) and Mehlhop & Vaughn (1994).

Life span	6 to 100 yr
Age at maturity	6 – 12 yr
Strategy	Iteroparous
Fecundity	200,000 – 17,000,000
Reproductive efforts per year	Typically 1
Juvenile size	50 – 400 um
Relative juvenile survivorship	Very low
Relative adult survivorship	High in undisturbed habitats
Larval habitat	Obligate parasite on fish

Unionid mussels possess a suite of traits that make them highly vulnerable to habitat disturbance (Table 1). Although fecundity is high, the odds of an egg successfully becoming an adult mussel are quite low. Unionids have a complex life history in which the larvae (glochidia) are obligate ectoparasites on the gills and fins of fish. The glochidia of many mussel species can only survive on a narrow range of fish-host species (Kat 1984; Watters 1993; McMahon & Bogan 2001). Once they have metamorphosed from the glochidial stage, juveniles must be deposited in favorable habitat in order to survive. Successful settlement of juveniles appears to be particularly affected by disturbance (Layzer & Madison 1995), and the demography of many mussel populations in disturbed areas is marked by periods when entire year classes are not recruited (Payne & Miller 1989). Because only larvae, attached to fish, can move between mussel beds, and juvenile survival is low (Yeager *et al.* 1994; Sparks & Strayer 1998), potential mussel colonization rates are low (Vaughn 1993). Reproductive maturity of unionid mussels is not reached until at least age 6 and most species live greater than 10 years, with some living as long as 100 years (Imlay 1982; McMahon & Bogan 2001). Once mature, adults in undisturbed habitat exhibit high survivorship (McMahon & Bogan 2001). However, adult mussels are sedentary; movements are seasonal and on a scale of a few to an estimated maximum 100 meters (Green *et al.* 1985; Waller *et al.* 1999). Therefore, unlike many stream organisms such as fish and aquatic insects (Townsend 1989; Matthews 1998), adult mussels have limited refugia from disturbance events in streams. In addition, the filter-feeding habits of mussels make them especially vulnerable to sedimentation and chemical pollution events (Havlik & Marking 1987).

The majority of mussel species are most successful where water velocities are low enough to allow substrate stability but high enough to prevent excessive siltation (Vannote & Minshall 1982; Hartfield & Ebert 1986; Strayer 1993; Strayer 1999). Because of this dependence on appropriate substrate and flow conditions, mussels are naturally patchily distributed in many rivers, often occurring in densely aggregated multi-species "beds" separated by areas where mussels occur sporadically or not at all (Strayer *et al.* 1994; Strayer *et al.* 2004). These habitat characteristics have been difficult to quantify, and mussels are often absent from areas that visually appear to be good habitat (Strayer 1993; Strayer & Ralley 1993; Vaughn *et al.* 1995; Strayer *et al.* 2004). Conventional methods for estimating instream flow preferences for mussels have been largely unsuccessful (Gore et al. 2001). Layzer & Madison

(1995) investigated the use of instream flow incremental methodology (IFIM) for determining microhabitat preferences of mussels in Horse Lick Creek, Kentucky. They found that results were flow conditional; i.e. because mussels are non-mobile and have highly clumped distributions, they appeared to prefer different hydraulic conditions at different stream discharges. However, unlike simple hydraulic variables such a depth and velocity, complex hydraulic characteristics such as shear stress were significantly correlated with mussel abundance (Layzer & Madison 1995). Strayer (1999) found that mussel beds were located in areas protected from high flows and subsequent shear stress and Hardison & Layzer (2001) found that shear velocity varies on a small spatial scale within mussel beds and is negatively correlated with mussel density.

The major cause of mussel decline in the U.S. is from the alteration of the natural flow regime of rivers, primarily by impoundments and channelization (Neves 1992; Allan & Flecker 1993; Bogan 1993; Watters 1996; Neves *et al.* 1997; Master *et al.* 1998; Vaughn & Taylor 1999; Watters 1999). The ways in which impoundments alter existing stream habitat and processes have been extensively described (Baxter 1977; Petts 1984; Yeager 1993; Ligon *et al.* 1995; Sparks 1995). Many mussels do poorly in the altered conditions within impoundments, which include general lack of flow, sedimentation, and frequent anoxic conditions in deeper areas (Haag & Thorp 1991; Watters 1999). Several dozen mussel species have been driven to extinction wholly or in large part by the construction of dams (Layzer *et al.* 1993; Lydeard & Mayden 1995; Watters 1999); nearly without exception impounded rivers have lost or changed their mussel faunas (Blalock & Sickel 1996; Watters 1999). For example, the mussel fauna of the Chickamauga Reservoir portion of the Tennessee River remained essentially unchanged for 2000 years prior to impoundment. After impoundment, over 30 species were extirpated and several are now extinct (Parmalee *et al.* 1982; Watters 1999).

Mussel populations also are impacted up and downstream of impoundments. River sections below impoundments are substantially different than free-flowing rivers (Yeager 1993; Poff *et al.* 1997). Effects include altered seasonality of flow and temperature regimes, changed patterns of sediment scour and deposition (Anderson et al. 1991), and altered transport of particulate organic matter, the food base for mussels (Petts 1984; Frissell *et al.* 1986; Ward & Stanford 1987; Ligon *et al.* 1995). Numerous studies have documented mussel declines below impoundments (Suloway *et al.* 1981; Miller *et al.* 1984; Williams *et al.* 1992a; Layzer *et al.* 1993; Vaughn & Taylor 1999; Garner & McGregor 2001). For example, the Kaskaskia River supported 40 mussel species prior to impoundment; eight years after impoundment the species count was down to 24 species, some sites no longer supported any mussels, and abundance had declined (Suloway *et al.* 1981; Watters 1999).

Hydrologic alterations impact mussels both directly through physical stress, such as temperature, siltation, and scour, and indirectly through changes in habitat, food, and fish-host availability. Fluctuating discharge alters the transport of the particulate material in the water column that is the primary food source for mussels. Depending on season and normal seston loads, this can impact mussels. Releases from impoundments often result in both abnormally high and low flows, sometimes on a daily basis, and these often occur at the “wrong” time of year (Yeager 1993; Poff *et al.* 1997; Richter & Richter 2000). Discharge that is either high during the wrong season or high too frequently can have devastating impacts on mussels. High discharge can displace settling juveniles before they have burrowed into the streambed or attached their byssal threads to sediment (Neves & Widlak 1987; Holland-Bartels 1990; Layzer & Madison 1995; Hardison & Layzer 2001). Increased discharge alters the distribution of sediment through scour, flushing, and deposition of newly eroded material from the banks. Mussels are often killed by sediment scour directly below dams (Layzer et al. 1993) and scour is a major reason for the failure of mussel re-introductions (Layzer & Gordon 1993). Sediment deposition clogs mussel siphons and gills (i.e. smothers them) and interferes with feeding and reproduction (Young & Williams 1983; Dennis 1984; Aldridge *et al.* 1987). Erosion caused by increased discharge at one location in a stream results in deposition of the eroded material further downstream, increasing the width-depth ratio of that portion of the channel and the potential for further bedload transport (Frissell et al. 1986). Therefore, increased discharge can cause habitat loss through both sediment deposition and increased bed mobility. Over time, higher base discharge levels and reduced periods between peak flood events decrease habitat complexity by preventing the formation of areas of stabilized sediments (Frissell et al. 1986). As stated above, sediment stability is a critical habitat requirement for most mussels (Di Maio & Corkum 1995; Strayer 1999; Hardison & Layzer 2001).

Discharge that is either low during the wrong season or abnormally low for extended periods of time also negatively impacts mussels. Extended periods of low flow below impoundments results in the stranding of mussels (Fisher & Lavoy 1972; Spooner & Vaughn 2000); mortality in such cases is usually a result of desiccation and/or thermal stress as the temperature buffering capacity of the water is decreased with reduced water volumes (Watters 1999; Spooner & Vaughn 2000). Numerous mussel dieoffs related to the dewatering of tailwaters below dams and subsequent high water temperatures in the remaining shallow water have been documented (Riggs & Webb 1956; Watters 1999) If stranding does not result in mortality, the associated physiological stress reduces mussel condition and ultimately reproductive potential (McMahon & Bogan 2001). Long periods of excessively reduced discharge often result in the fragmentation of rivers into shallow pools isolated by long reaches of dry riverbed. Within these shallow pools mussel can be exposed to water temperatures exceeding 40ºC. In dry stretches stranded mussels are exposed to air and to solar insolation. Given that mussels are thermo-conformers without the ability to regulate body temperature, these conditions often result in high mortality rates (Spooner & Vaughn 2000). Mussels in shallow, isolated pools are also exposed to hypoxia from algal production. Unionids are typically tolerant of moderate bouts of hypoxia (as low as 2 mg/l) (Chen 1998); however, other bivalves, such as invasive *Corbicula* have reduced anaerobic capacity resulting in massive die-offs (White & White 1977; Milton & McMahon 1999). Ammonia pulses from decaying bivalves kill juvenile unionids and potentially reduce the condition of adult mussels.

Water temperature is especially critical to mussels and they deal with thermal stress in a variety of ways. In the event of dewatering, some species can move either vertically into the sediment or horizontally to deeper areas; this strategy can be energetically costly depending on substrate texture and the distance to cooler water (McMahon & Bogan 2001). A second strategy to contend with emersion is direct transfer of oxygen across the mantle edge exposed to the air, which mussels control by gaping. This approach is limited to environments with high humidity and moderate temperature (Dietz 1974). A third strategy is to close the valves and anaerobically catabalyze stored energy reserves. The success of this strategy depends on the amount of energy reserves available and the duration of dewatering (McMahon & Bogan 2001). The main anaerobic storage pathway for mussels is glycogen catabolism. Glycogen is easily transferred to glucose through glucogenesis and its metabolites are non-toxic (Chen et al. 2001) (unlike catabolism of protein which produces toxic ammonia by products); however, shifts in hemolymph pH due to metabolites produced by glycogen catabolism must be buffered by the sequestration of carbonated from the shell (Byrne et al. 1991). Given that anaerobic catabolism is an underlying mechanism for emersion survival, factors that control glycogen storage capacity should directly influence the ability of mussels to survive drought events.

Reductions in water temperature below hypolimnetic release dams have been shown to reduce and even eliminate mussel populations for long distances (Ahlstedt 1983; Miller *et al.* 1984; Yeager 1993; Lydeard & Mayden 1995; Vaughn & Taylor 1999). Release of cold water during the summer when water temperatures should be warm suppresses mussel metabolic rates during a time of year when growth should be high (McMahon & Bogan 2001) and inhibits reproduction (Layzer et al. 1993). Coldwater releases also may eliminate or inhibit reproduction of some species of warmwater fishes (Layzer *et al.* 1993; Yeager 1993) and increase the success of introduced coldwater species such as trout. Therefore, abnormally cold discharge, particularly in summer, may act as a permanent colonization barrier to mussels (Vaughn & Taylor 1999).

Because mussels are dependent on fish hosts, any effects of hydrologic alterations on fish hosts also impacts mussel populations. Distribution, abundance, and movement patterns of fish hosts have been shown to be critical to the distribution and abundance of mussels (Watters 1993; Vaughn 1997; Haag & Warren 1998; Vaughn & Taylor 2000). The disappearance of mussel species from several rivers has been linked to the disappearance of the appropriate fish host (Kat & Davis 1984), and mussels have re-colonized rivers after their fish hosts were re-introduced (Smith 1985). Lowhead dams have been shown to block fish-host migration and lead to the extirpation of mussels in reaches above the dams (Watters 1996). Altered flow regimes can decrease both the species richness and abundance of fish communities (Gore & Bryant 1986; Kinsolving & Bain 1993; Scheidegger & Bain 1995), potentially eliminating mussel hosts. Impacts likely vary both seasonally and with river microhabitat. For example, a high proportion of nest-building fish species, such a centrarchids, are common mussel hosts (Kat 1984; Watters 1994). Thus, altered hydrology that impacts or prevents nesting could result in mussel glochidia failing to attach to hosts, and reduced mussel recruitment.

Mussels evolved in rivers that typically experienced seasonal periods of low and high flow. Recent studies indicate that instream flow needs are not the same for all mussel species (Hardison & Layzer 2001) and that natural, temporal variability in flows is important to maintaining diverse mussel assemblages. For example, recruitment of some species seems to be greatest at below average discharges, while other species require a more normal flow rate for successful recruitment (Gore et al. 2001). To maintain diverse mussel communities, annual hydrographs may need to vary seasonally and annually to provide optimal flows for different groups of species (Gore et al. 2001).

Mussels of southeastern Oklahoma Rivers

Historical information

Based on archeological evidence, the overall mussel species composition of southeastern Oklahoma rivers has changed little over the last several thousand years. For example, all mussel species identified from a Caddo Indian midden (ca. 3500-1000 B.P.) near the Poteau River, were found in the Poteau River in the last decade (Bell 1953; Wyckoff 1976; White 1977; Vaughn & Spooner 2004). No mussel species are known to be entirely extirpated from either the Kiamichi (Vaughn et al. 1996) or Little Rivers (Vaughn & Taylor 1999), the two rivers in the region that have been studied the most extensively.

While few rivers in the region have lost species outright, within rivers both the number of sites at which species occur and species abundances have declined. The recent fauna was first surveyed by Isely in the early 1900s (Isely 1911, 1914; Isely 1924; Isely 1931). He conducted a comprehensive distributional survey of the mussel fauna of the Red River drainage, focusing on the eastern half of Oklahoma, as part of a nation-wide effort by the U.S. Bureau of Fisheries to find mussel populations to harvest for the pearl-button industry. Isely sampled 20 sites in the Red River drainage from 1910-1912 (Isely 1924); six of these sites are now under impoundments. From 1990-1995 Vaughn (2000) re-sampled 19 sites in the Red River drainage, the majority in southeastern Oklahoma, that had been sampled historically by Isely and Valentine and Stansbery. She found that species richness decreased at 89% of the sites and that 86% of species occurred at fewer sites than in the past. Vaughn used these data to calculate local extinction rates (extinction rate from a local patch or site, not the river as a whole). Local extinction rates were significantly greater than colonization rates, indicating that mortality of mussels is exceeding recruitment in the region (Vaughn 2000).

In the early 1990s Vaughn & Taylor (1999) examined the distribution and abundance of mussels along a 240 km length of the Little River in Oklahoma, from above Pine Creek reservoir to the state line. They observed a mussel extinction gradient downstream from impoundments in the watershed. With increasing distance from Pine Creek Reservoir, an impoundment of the mainstem Little River, there was a gradual, linear increase in mussel species richness and abundance. Rare species only occurred at sites furthest from the reservoir. These same trends were apparent below the inflow from the Mountain Fork River, which is impounded upstream as Lake Broken Bow, and mussel abundance was greatly reduced. In both situations, below reservoir inflows abundance of even common, widespread mussel species was greatly reduced. Thus, even though no species extirpations are known from the Little River, the biological integrity of numerous subpopulations has been greatly decreased by the loss of individuals (Vaughn & Taylor 1999).

The lower Kiamichi River is impounded by Hugo Reservoir. Jackfork Creek, a tributary of the Kiamichi, flows into the river approximately half way down its 180 km length. Jackfork Creek is impounded by Sardis Reservoir. This creek is the largest tributary of the Kiamichi, contributing nearly

30% of the average river flows at the confluence of the two streams. During recent drought years, water that would normally drain into the Kiamichi has been held in Sardis Reservoir, exacerbating drought conditions and causing sections of the Kiamichi to stop flowing and in some cases go completely dry. The summer of 2000 was particularly harsh because of higher than average air temperatures and no rain. During the summer of 2000 Spooner and Vaughn (2000) monitored the effect of these extremely low water levels on a mussel assemblage in the lower Kiamichi near Moyers for which we had two previous years of population data; at this particular site, there was no flow and water temperature during our sampling exceeded 40^{o}C. Mussel mortality was significantly correlated with water depth, with the highest survival in the deepest, coolest water. Mortality was species-specific, with smaller mussels appearing to be hardest hit. Mortalities of federally endangered species were observed (*A. wheeleri* (1 individual) and *L. leptodon* (1 individual)); both individuals were found freshly dead, with tissue still attached, suggesting that the recent mortality was due to the drought and high water temperature. In an effort to minimize mortality, The Army Corps of Engineering released a series of 12 cfs (cubic feet per second) surges of water from Sardis Reservoir resulting in a 4.4 cfs spike in discharge at Clayton and a 1.2 cfs spike at Antlers. Unfortunately, because to the riverbed was already very dry, most of the flow was lost to the water table, and the release was insufficient to reduce water temperature for mussels.

Current mussel fauna

Despite the declines discussed above, the four rivers of far southeastern Oklahoma (Kiamichi, Little, Glover and Mountain Fork) continue to harbor a rich and overall healthy mussel fauna. There are approximately 52 extant unionid mussel species known to presently occur in Oklahoma waters (Williams et al. 1992b), and 41 of these (80%) occur in these rivers. In 1998, The Nature Conservancy identified the Interior Highlands (which includes the four rivers in question) as one of the most critical regions in the U.S. for protecting freshwater biodiversity, based on its rich fish and mussel fauna. Based on a comprehensive national assessment of available data, The Nature Conservancy determined that all of the at-risk freshwater fish and mussel species in the U.S. could be conserved by protecting and restoring 327 watersheds (15% of total US watersheds) across the country; the Kiamichi and Little River watersheds were included in this highly select group (Master et al. 1998).

Three federally endangered species occur in these rivers, the Ouachita rock pocketbook, the winged mapleleaf, and the scaleshell. *Arkansia wheeleri*, the Ouachita rock pocketbook mussel, occurs in only three rivers in the world, the Kiamichi and Little rivers in Oklahoma, and in the Ouachita River in Arkansas (Vaughn *et al.* 1993; Vaughn 1994; Vaughn & Pyron 1995; Vaughn *et al.* 1995; Vaughn *et al.* 2004b). The Kiamichi population is considered the most viable; subpopulations are patchily located over a 128 km stretch of the river from near Whitesboro to directly above Lake Hugo. Within these subpopulations, the species is quite rare. Vaughn & Pyron (1995) found that in the Kiamichi River, *A. wheeleri* occurs only in the largest, most species-rich mussel beds. Even its optimal habitat the species was always rare; mean relative abundance varied from 0.2 to 0.7% and the mean density within large mussel beds was 0.27 individuals / m^2. The youngest individual *A. wheeleri* encountered was approximately 12 years of age, indicating that recruitment is low (Vaughn & Pyron 1995). One of the *A. wheeleri* subpopulations in the Kiamichi is located near the proposed water outtake at Moyers (Vaughn *et al.* 2004b). Two subpopulations of *A. wheeleri* have been identified in the Little River; both of these are located on the U.S. Fish and Wildlife Service Little River Wildlife Refuge (Vaughn *et al.* 1995).

Leptodea leptodon, the scaleshell mussel, was historically distributed throughout much of the Interior Basin but has been extirpated from much of its range. The species is now restricted to 13 streams in the Interior Highlands, including the Kiamichi River, where it is known from several sites (Vaughn *et al.* 2004b).

Quadrula fragosa, the winged mapleleaf, historically occurred in the Interior Basin from Minnesota to Alabama. Currently, the best population is in the St. Croix River in Wisconsin. A viable population is thought to exist in the Ouachita River in Arkansas (Hove *et al.* 2003). *Q. fragosa* have been observed in the Kiamichi River, and in August, 2005, a population of what is believed to be *Q. fragosa* was discovered in the Little River. Genetic studies need to be conducted to determine if these are indeed *Q. fragosa*.

Several of the mussel species occurring in the four rivers are endemic to the Ouachita Highlands or Interior Highlands. These include *Arkansia wheeleri*, discussed above, *Ptychobranchus occidentalis* and *Villosa arkansasensis*. *Ptychobranchus occidentalis*, the Ouachita kidneyshell, occurs sporadically throughout the Kiamichi and Little rivers (Vaughn *et al.* 1996; Vaughn & Taylor 1999), and is a dominant species in the Mountain Fork (Vaughn & Spooner 2000) and Glover rivers (Vaughn 2003b). *Villosa arkansasensis*, the Ouachita creekshell, occurs in the Little, Glover and Mountain Fork rivers (Vaughn & Taylor 1999; Vaughn & Spooner 2000; Vaughn 2003b).

Quadrula cylindrica, the rabbitsfoot mussel, is being considered for listing as an endangered species by the U.S. Fish and Wildlife Service. The range of this species has declined significantly. One of the most viable remaining populations is in the Little River in Oklahoma (USFWS 2005) where at least 5 subpopulations exist from just above Idabel through upper portions of Little River Wildlife Refuge (Vaughn et al., unpublished data). A small population occurs in the Glover River above the Highway 3 crossing (Vaughn 2003b).

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