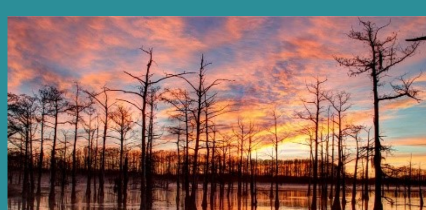
EPA/600/R-20/146 | July 2020 | www.epa.gov/research

United States Environmental Protection Agency

A Deeper Look at the Ouachita River

How investment in Ouachita River infrastructure sustains human well-being in Ouachita Parish, Louisiana




Office of Research and Development
Gulf Ecosystem Measurement and Modeling Division

EPA/600/R-20/146
July 2020

Deeper Look at the Ouachita River

How investment in Ouachita River infrastructure sustains human well-being in Ouachita Parish, Louisiana

By

Richard Fulford[1], William Michaud[2], Joyce Stubblefield[3], Leah Sharpe[1], James Harvey[1]

Office of Research and Development

U.S. Environmental Protection Agency

1. Gulf Ecosystem Measurement and Modeling Division, Center for Ecosystem Measurement and Modeling, Gulf Breeze, FL 32561
2. GDIT, 3434 Washington Blvd, Arlington, VA 22201
3. EPA Region 6, 1201 Elm St., Ste 500, Dallas, TX 75270

Notice and Disclaimer

The U.S. Environmental Protection Agency, through its Office of Research and Development, funded and collaborated in the research described herein. This document has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document. Any mention of trade names, products, or services does not imply an endorsement or recommendation for use.

This is a contribution to the EPA ORD Sustainable and Healthy Communities Research Program.

The citation for this report is:

Fulford, R., Michaud, W., Stubblefield, J., Sharpe, L., & Harvey, J. (2020). *Deeper look at the Ouachita River: How investment in Ouachita River infrastructure sustains human well-being in Ouachita Parish, Louisiana.* U.S. Environmental Protection Agency, Gulf Breeze, FL, EPA/600/R-20/146

Executive Summary

Waterways across the country are facing reduced funding for river maintenance and bank stabilization. These issues affect the ecosystem services that these rivers provide to people, which can have a tremendous impact upon local towns dependent upon the resulting resource benefits. The State of Louisiana experienced severe storms and historic flooding events in both March and August 2016, resulting in 56 of the state's 64 parishes receiving a federal disaster declaration with major impacts to the Ouachita River and neighboring communities. Ouachita Parish (Parish, City of Monroe, City of West Monroe) identified some $91 million in needed flood control projects. The Parish is now in an even more vulnerable state, and if another severe flood event were to occur this would be catastrophic for the entire region. The Ouachita River provides significant economic, infrastructure, and natural benefits to the region and its cities; a region that has struggled economically for some time. Local officials had already seen impacts from the loss of ecosystem services such as clean water supply, recreation opportunities, fishing, etc., and are now concerned that reduced maintenance and current sediment issues will further impede these benefits.

While the social and economic consequences of flooding are clearly understood, it would serve communities to better understand how the benefits they are receiving from ecosystem services are impacted by reduced river maintenance and bank stabilization and the resulting repetitive floods. How is the sustainability of community well-being impacted by the loss of ecosystem services? Complex decisions require clear, measurable objectives for both comparisons of proposed actions and evaluation of the resulting decisions. Structured Decision Making (SDM) is an approach to identify community goals, transform those goals into measurable values, and use these measurable values to define the best consensus options for achieving these community goals. The approach has been called 'organized common sense' and serves to better engage stakeholders in the decision process and make complex decisions like flood control strategies easier to understand. The U.S. Environmental Protection Agency is providing decision support to the cities of Monroe and West Monroe, LA regarding flood control strategies on the Ouachita River to improve stakeholder engagement, increase public understanding of flood control effects on important ecosystem services, and better integrate flood control options into the strategic planning processes of both cities.

The SDM process has three primary steps for developing and evaluating decision options for local flood control: 1) Identify and prioritize community fundamental objectives (e.g., improve health); 2) Convert these fundamental objectives into measures of success for achieving them; and 3) Use all available data on these measures of success to evaluate decision options for flood control and to communicate to stakeholders the consequences of proposed actions regarding ecosystem benefits from the River and community health and well-being. The use of SDM and associated tools and applications show promise in assisting the assessment and choosing among alternatives for flood mitigation based on benefits identified by stakeholders, such as flood protection, clean water, and opportunities for recreation or fishing. For this project, the three steps were separated into two parallel parts:

1) Stakeholder engagement to:
    a. Establish fundamental objectives for the cities of Monroe and West Monroe.

   b. Use these fundamental objectives to evaluate current decision options for flood control.
   c. Communicate the relative value of these decision options for achieving community fundamental objectives.
2) The application of data and analytical tools to provide information to stakeholders for the first part.

The two parts occurred in overlapping fashion: the engagement occurred primarily during two face-to-face workshops and one webinar, and the analysis occurred primarily in between these stakeholder events. The analytical objective was to link proposed community actions to ecosystem services and community well-being based on five stepping stones: 1) Action categories; 2) River attributes; 3) Beneficiaries; 4) Ecosystem services; and 5) Domains of human well-being.

Action categories were developed to compile the list of proposed community actions, such as stormwater projects or river dredging into groups for analysis. Proposed community actions were identified during Workshop 1 and in consultation with community leaders. The groups helped simplify the analysis by binning actions with similar effects on people as opposed to analyzing each project separately. Four action categories were identified by stakeholders for this study:

i. River navigation projects – All identified projects that promote or maintain the river for navigation. Examples are dredging and lock/dam maintenance.
ii. Stormwater projects – All identified projects that facilitate the safe disposal or diversion of stormwater from areas surrounding the river. Examples are installation or maintenance of pump stations.
iii. Levee maintenance – All identified projects that preserve the integrity of existing Parish levees and protective walls around the city.
iv. Greenspace projects – All identified projects that increase or preserve public access to greenspace in the community. An example is park development and these projects are often associated with projects in the first three action categories.

River attributes were identified during Workshop 1 and include characteristics of the river that are most likely to be impacted by each action category. These river attributes include water depth, water quality and quantity, and risk of flooding. A full list is given in Table 3.4.

Beneficiaries are user groups that can be specifically connected to a service. Beneficiaries of river services were identified during Workshop 2 and as a part of EPA data analysis. They included anglers, residential property owners, and industrial users of the river. A full list of Beneficiaries used in this analysis can be found in Table 3.4.

Ecosystem services are those services of the river that are directly enjoyed by beneficiaries such as harvestable fish, navigable waterways, and community identity. Each service can be linked to one or more specific beneficiaries making them final ecosystem services. Services of the river were identified and linked to beneficiaries as a part of Workshop 2. A full list of services identified for this study can be found in Table 3.3.

Domains of human well-being represent ways services impact the community as a whole. This is a step beyond a beneficiary group to collective community objectives such as Work-life Balance, Education, and Health. Domains of well-being were defined based on the Human Well-being Index (HWBI) and linked to river services as a part of the post-workshop analysis. A full description of the domains of human well-being is given in Table 2.1. The Human Well-being Index can be used both to summarize the current state of a community and to predict how changes in services resulting from actions will alter community well-being.

Well-being in Ouachita Parish is slightly lower than neighboring parishes and the state of Louisiana as a whole (Table 3.8). Well-being is highest in Ouachita Parish for the Connection to Nature and Health. It was lowest for Social Cohesion and Education. These well-being values are consistent with characteristics of a rural parish based on a national comparison (Smith et al. 2013). During Workshop 1, the community gave the highest weight to the Safety domain, which generated a median overall score. However, this value was also well below the state average so represents a domain with room for improvement. A full description of well-being scores for Ouachita Parish can be found in Tables 3.7 and 3.8. In examining the effect of actions on community well-being, focus was given to the domains given high weight by the stakeholders.

River navigation projects were predicted to positively affect Living Standards, Safety, and Connection to Nature. They are also predicted to have some negative impacts on Education, Work-life Balance, and Social Cohesion. Navigation has some direct economic impacts reflected here but also some social impact related to altering the river and trade-offs with industry.

Stormwater projects were predicted to have positive effects on Social Cohesion, Safety, and Education. These actions were also predicted to have negative effects on Living Standards. These effects are largely connected to improvements in property protection and community stability.

Levee maintenance actions were predicted to positively impact Living Standards and Safety. Negative effects were predicted for Education and Social Cohesion. Overall well-being effects of levee projects were lower than other action categories, but that is related to the status quo nature of this category as action on these projects is intended to maintain services and loss of these services would have larger negative effects on well-being in all domains. The impact of levee projects on overall well-being is predicted to be diverse with a broader range of impacts than for other action categories.

Greenspace/Green infrastructure projects were predicted to have positive effects on Social Cohesion and Work-life Balance, and negative effects on Safety and Connection to Nature. These negative effects are related to spending time in public parks and the idea that outdoor time is limited so parks reduce the amount of time spent in more natural settings like forests. One key aspect of greenspace projects is that they are often integrated with other action categories such as stormwater projects. Our analysis suggests that this inclusion will ameliorate some of the negative effects of these other projects, particularly those that involve the loss of access to public land.

The results of our ecosystem services analysis can support these priority action categories by providing important guidance on how resilience plans should account for community fundamental objectives regarding important ecosystem goods and services, and how those services interact with built infrastructure to support community well-being. The stakeholder input obtained for this report and its analysis support the following recommendations:

- Use the findings of this report to integrate ecosystem service priorities and human well-being endpoints into the planning process as targets for resilience and recovery actions.
- Consider trade-offs between economic, social, and environmental services present in major action categories in developing specific actions, such as stormwater projects, so as to maximize the well-being improvements.
- Invest in critical infrastructure, such as levee maintenance, that supports ecosystem services of the Ouachita River and highlight these services to stakeholders.
- Recognize the impact of direct service enhancements, such as the creation of greenspace, as a critical element of resilience and community identity and broaden the impact of actions on well-being.
- Identify all river ecosystem services as vital community resources that require support and should be considered in measuring restoration success.

These findings and recommendations should be viewed as a part of a larger discussion on the services to stakeholders from combinations of ecosystem services and built infrastructure intended to maximize human benefit from the Ouachita River. The combination of findings will allow for a comprehensive communication of services from the Ouachita River. This will greatly facilitate decision making where the goal is the collective well-being of all citizens and the sustainability of all services.

Foreword

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

EPA's Center for Environmental Measurement & Modeling conducts research to advance EPA's ability to measure and model contaminants in the environment, including research to provide fundamental methods and models needed to implement environmental statutes. Specifically, the Center characterizes the occurrence, movement, and transformation of contaminants in the natural environment through the application of measurement and modeling-based approaches. The Center for Environmental Measurement & Modeling's scientists develop, evaluate, and apply laboratory and field-based methods and approaches for use by EPA and its state, local, and tribal partners to characterize environmental conditions in direct support of implementation of EPA programs. Center scientists also provide scientific expertise and leadership related to the development and application of complex computational models that provide precise and detailed predictions of the fate and transport of priority contaminants in the environment to inform the environmental policies and programs at the EPA, state, local and tribal level. The methods and models developed by the Center are typically applied at the airshed, watershed, and ecosystem levels.

The following report provides information and guidance on increasing community flood resilience to the cities of Monroe and West Monroe, LA based on the sustainability of ecosystem services of the Ouachita River. This information and guidance support sustainable decision making and provides a comprehensive valuation of the river's contribution to human well-being.

Tim Watkins, Director
Center for Environmental Measurement & Modeling

Table of Contents

Figures

Tables

Exhibits

Abbreviations and Acronyms

EGS	Ecosystem Goods and Services
EPA	U. S. Environmental Protection Agency
FEGS	Final Ecosystem Goods and Services
FEMA	Federal Emergency Management Agency
FFF	Food-Fiber-Fuel
GOHSEP	Governor’s Office of Homeland Security and Emergency Preparedness
HWBI	Human Well-being Index
LTRC	Long-term Recovery Committees
NDRF	National Disaster Recovery Framework
OCOG	Ouachita Council of Governments
RSF	Recovery Support Function
SDM	Structured Decision Making
ULM	University of Louisiana at Monroe
USACE	U.S. Army Corps of Engineers

Acknowledgments

EPA would like to acknowledge the significant efforts of the local leaders who participated in this project, including Tracy Hilburn, Neal Brown, and Tom Malmay. Without their contributions, this project would not have been possible. EPA would also like to acknowledge all those who participated in the community workshops (full list in Appendix D). Their insights regarding the fundamental goals of the community and important relationships between the Ouachita River and community well-being were invaluable. EPA would also like to acknowledge Dr. Patricia Taylor and Dr. Robert Eisenstadt for providing a technical review of the report.

Cover photo credits: Discover Monroe/West Monroe

1 Introduction

Figure 1.1 River Rat Paddle Challenge Race on the Ouachita River, Saturday, September 28, 2019. Photo credit: Ouachita Parish Sheriff's Office.

Waterways across the country are facing reduced funding for river maintenance (dredging) and bank stabilization. These issues affect the ecosystem services that these rivers provide to people, which can have a tremendous impact upon local towns dependent upon the resulting resource benefits. The state of Louisiana experienced severe storms and historic flooding events in both March and August 2016, resulting in 56 of the state's 64 parishes receiving a federal disaster declaration (Congressional Briefing) with major impacts to the Ouachita River and neighboring communities. Ouachita Parish (Parish, City of Monroe, City of West Monroe) identified some $91 million in needed flood control projects (Ouachita Projects List). The Parish is now in an even more vulnerable state, and if another severe flood event were to occur this would be catastrophic for the entire region. From January 2018 to August 2019, the U.S. Environmental Protection Agency engaged with leaders from Ouachita Parish, Louisiana, in a participatory study of the contributions of the Ouachita River to the well-being of the Ouachita Parish community. The study employed the concept of ecosystem services to develop information and tools—tailored to the needs of Ouachita Parish—that can be used to support existing planning processes. This study represents one aspect of the larger engagement between EPA and Ouachita Parish following the floods of 2016 to support the Parish's efforts to improve community resiliency.

The following section introduces the concept of ecosystem services as it applies to river communities and provides background regarding the Ouachita River and Ouachita Parish, including existing planning efforts and studies. The section also describes the purpose and organization of the report and acknowledges the contributions of community leaders to the study. Sections 2 through 5 of the report describe the study in more detail and present the results.

1.1 River Communities and Infrastructure

River communities are an integral part of our national history, economy, and culture. Rivers are a critical part of the nation's transportation system, connecting farms and industries throughout the country to markets around the world. Over the course of the nation's history, many small towns founded to support river commerce have evolved into thriving cities and communities. Over this same period, river infrastructure, including ports, locks, dams, channels, and levees, has been built to support river navigation and protect communities from flooding.

Currently, there are 12,000 miles of commercially active inland and intracoastal waterways directly serving 38 states in the Midwest, Ohio Valley, Gulf Coast, Atlantic seaboard, and Pacific Northwest. About 630 million tons of cargo, valued at over $73 billion, are shipped over these waterways annually. The U.S. Army Corps of Engineers (USACE) maintains 191 commercially active lock sites with 237 lock chambers on U.S. inland waterways (USACE 2009). There are nearly 28,000 miles of levees along the nation's commercially active and other inland waterways, including 2,200 levee systems totaling approximately 14,150 miles in the USACE levee portfolio (USACE 2018).

Figure 1.2 Ouachita River Levee. Photo credit: Ouachita Parish Police Jury

The character of many river communities is fundamentally defined by their connections to rivers and river infrastructure. Locks and dams affect river pool stage, navigation, stormwater hydrology, surface water supply (e.g., for drinking or irrigation water), and wastewater discharge. River pool stage also affects recreational opportunities and wildlife habitat in and around the river and upstream waterbodies. Levees protect communities from flooding by creating a hydrological barrier between the community and the river. Levees also create barriers for water to flow out of communities and into the river, which affects the need for stormwater infrastructure.

Connections between communities, rivers, and river infrastructure can be fundamentally altered by changes in watershed hydrology and river conditions (e.g., changes in land use and greater duration and frequency of extreme storms), as well as infrastructure degradation. Levee failures due to unanticipated, extreme weather events are a vivid example of how hydrological changes and/or levee degradation can affect the relationships between communities and rivers. While other changes, such as incremental degradation of stormwater management infrastructure or lack of channel dredging, may be less visible, their long-term impacts on a community can be significant.

1.2 Understanding Community-River-Infrastructure Relationships

Local, state, and federal agencies evaluate the potential impacts of changes in watershed hydrology and the condition of river infrastructure to inform their planning and funding decisions. These assessments and decisions typically focus on risks to human life and property and the economic consequences of different actions. For example, the costs of investments in stormwater management infrastructure, bank stabilization, and/or levee maintenance are weighed against the potential loss of human life and amount of property damage that could occur in the absence of those investments. Costs of lock maintenance and river channel dredging are justified by the economic benefits derived from river navigation—including jobs, wages, and overall economic activity (Eisenstadt and Nelson 2017).

A deeper look at the relationships between communities and rivers reveals that communities can be affected in other ways not usually considered in more traditional risk and economic impact assessments. For example, loss of a reliable river pool depth could adversely affect recreational opportunities that rely on the river and upstream waterbodies. Loss of these opportunities could consequently impact the community health and well-being derived from outdoor recreation. Additionally, concerns about flood risk and safety can cause anxiety and affect mental health (Smith et al. 2013).

These types of well-being impacts can have cascading effects. For example, they can affect community demographics, including loss of middle-income residents and erosion of the community's economic base. This can have wide-ranging consequences for the quality of community services (e.g., educational services, public works, etc.) with further consequences for demographic change. Communities that experience loss of quality of life (e.g., higher incidence of disease from lack of physical exercise or anxiety) and/or erosion of the economic base are less resilient and less capable of dealing with natural hazards when they occur (USEPA 2014).

This broad view of the relationships between communities and rivers can be captured through the lens of "ecosystem services." This concept allows for the systematic examination of human relationships with nature, reveals the complexity of these relationships, and helps inform actions that could affect these relationships. In river settings, ecosystem services describe the ways in which the river "serves the needs" of the community. For example, a river can support commercial navigation, provide water for irrigation and public drinking water supply, provide a means for draining stormwater and wastewater, and support recreational activity. In these ways, the river serves the economic, public health, and other well-being needs of the community.

1.3 Ouachita River and River Infrastructure

The Ouachita River originates in the Ouachita Mountains of western Arkansas and flows 600 miles through Arkansas and northern Louisiana where it converges with the Tensas and Little Rivers to form the Black River at Jonesville, Louisiana. The Black River flows to the Red River which connects the river system to the Gulf of Mexico via the Atchafalaya and Mississippi

Rivers. The USACE maintains the Ouachita-Black Rivers Navigation Project, a 337-mile long waterway from Camden, Arkansas to the convergence of the Ouachita River with the Black River (USACE 2019a). The navigation project contains four locks and dams and provides a 9-foot deep, 100-foot wide channel over this stretch of the river (USACE 2019b).

Beginning about 20 miles south of the Arkansas border, the Ouachita River flows through Ouachita Parish, Louisiana, passing through the towns of Richwood and Sterlington, cities of Monroe and West Monroe, and unincorporated areas of the Parish. Bayou Bartholomew, Bayou de Loutre, and Bayou D'Arbonne, three major tributaries of the Ouachita River, enter the Parish near its northern boundary. Bayou Desiard, another tributary of the river, is dammed just north of the city of Monroe and forms Black Bayou Lake, which is used as a source for the city's public water supply (LSU 2017).

A system of levees extends from just north of Ouachita Parish through Ouachita and Caldwell Parishes to about 74 miles south of Monroe and West Monroe. The levee at Monroe includes about 2 miles of floodwall, with a unique fold-down floodwall near its center. West Monroe is protected by a loop system consisting of 5.5 miles of levee and 1.6 miles of floodwall (USACE 1993). The Ouachita River levee system is under the jurisdiction of the USACE Vicksburg District and is maintained by the Tensas Basin Levee District.

The east and west areas of Ouachita Parish constitute separate drainage basins, both of which drain to the Ouachita River. During normal river stage, most areas of the parish drain by gravity flow through natural bayous and drainage canals to the Ouachita River. When the river level rises to the point that the flood gates need to be closed, pump stations are used to transfer floodwater from drainage canals to the river. Some areas of the Parish east of the river rely completely on gravity flow to the east to Bayou LaFourche, which flows south and eventually into the Ouachita River (LSU 2017).

1.3.1 Ouachita Parish, Louisiana

Ouachita Parish (Figure 1.3) was established in 1807 as one of 19 parishes created by dividing the territory of New Orleans. The parish was later divided into nine smaller parishes spanning northeast Louisiana. The city of Monroe began its history as a trading post in the late eighteenth century and was incorporated in 1819 (OPPJ 2019). Two former river towns opposite Monroe were combined and incorporated as the city of West Monroe in 1880 (OPPJ 2019). At the time of the 2010 decennial census, Ouachita Parish had a population of about 154,000, with about 56% of the population in unincorporated areas. The cities of Monroe and West Monroe had populations of 49,000 and 13,000, respectively (LSU 2017).

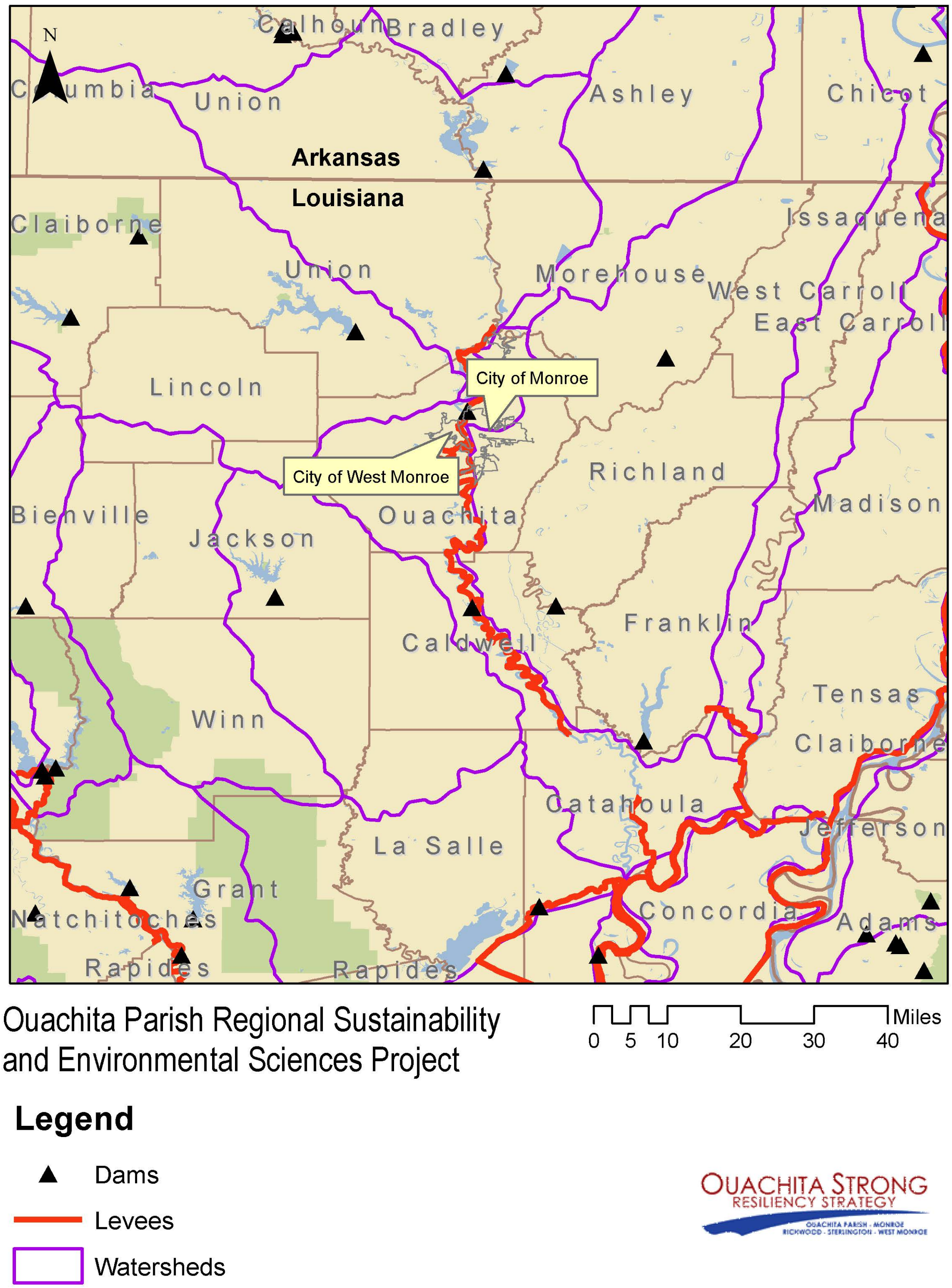


Figure 1.3 Map of northeastern Louisiana showing location of Ouachita parish, cities of Monroe/West Monroe, and associated infrastructure addressed in this report. See legend for details. Photo credit: Tom Malmay, Ouachita Strong.

Located between Shreveport, Louisiana, and Vicksburg, Mississippi, Ouachita Parish is considered the population center and economic hub for northeast Louisiana. Over time, the region has transitioned from a natural resource economy (i.e., agriculture and wood/timber) to a relatively diverse economy supporting a broad range of industries, including primary manufacturing, warehousing/distribution, and telecommunications (LSU 2017). The University of Louisiana at Monroe (ULM) and Louisiana Delta Community College are located in Monroe. Louisiana Tech University and Grambling State University are located about 30 miles west of Monroe and West Monroe (OPSB 2019).

1.3.2 Current Ouachita River and River Infrastructure Conditions

The USACE operates four locks on the Ouachita-Black Rivers Navigation Project, including the Jonesville and Columbia locks downstream of Ouachita Parish and the Felsenthal and Thatcher locks upstream of the Parish in Arkansas. From 2012 to November 2015, the lower two locks were operated less than 24 hours a day. Since November 2015, the locks have operated on a 24/7/365 basis (Eisenstadt and Nelson 2017). The upper two locks are operated 5-10 hours per day on weekdays with no weekend service. In 2015, total tonnage shipped on the navigation project dropped below 1 million tons, a critical threshold for determining access to federal funds for operation and maintenance of the navigation project (Eisenstadt and Nelson 2017). Columbia Lock was closed in July 2018 for emergency repairs and was reopened on August 1, 2019, allowing dredging operations and commercial shipping to return to normal.

From 1990-2019, the Ouachita River reached the flood stage of 40 feet in eight different years. The river reached major flood stage of 45 feet in 1991, 2009, and three of the past four years: 2016, 2018, and 2019 (USACE 2019a). The Ouachita River floodwall and levee network have held back the floodwaters, experiencing no failures during this period. However, areas of the Parish, including parts of Monroe and West Monroe, are subject to backwater flooding during major rainfall events. Since 1990, the Parish has experienced more than 80 flooding events, including the historic flooding event in March 2016 that resulted in a federal disaster declaration. The March 2016 flooding event overwhelmed drainage systems and damaged over 10,000 residential and 640 commercial structures in Ouachita Parish (RLTF 2016).

The number of significant flooding events over the past decade have caused bank erosion and, in some cases, damage to the levee system. Portions of the Ouachita River levee system are included in the Mississippi River & Tributaries Project and are eligible for federal funding. However, recent federal budgets have not included funding for the system. The Tensas Basin Levee District has addressed critical repairs within its funding limits. The Ouachita River levee system (Figure 1.3) currently has provisional accreditation. The Tensas Basin Levee District is working with USACE to obtain full accreditation for the parish levee system. Loss of accreditation would change flood control maps with significant consequences for insurance rates, cost of living, and land-use planning in the parish.

1.3.3 Existing Planning Efforts and Studies

Since 2005, Ouachita Parish has engaged in detailed hazard mitigation planning to improve disaster resiliency of the community. The parish published its first Hazard Mitigation Plan in

2006 and updated the plan in 2010 and 2016. The Hazard Mitigation Plan represents a collaboration between Parish and local governments and includes a parish-wide hazard identification and risk assessment and hazard mitigation strategy.

Following the flood of 2016, local Parish leaders partnered with the Federal Emergency Management Agency and the Louisiana Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP) and created the Ouachita Strong Resiliency Strategy. The strategy established a steering committee to work with the Ouachita Council of Governments (OCOG) and six Long-term Recovery Committees (LTRCs), each focused on a different Recovery Support Function (RSF) aligned with the functional areas of the National Disaster Recovery Framework (NDRF). *Ouachita Strong* provides a key organizational framework for improving community resiliency and engaging effectively in other efforts, such as the Louisiana Watershed Initiative.

In 2017, ULM completed a study entitled "The Economic Impact on Arkansas and Louisiana of the Ouachita River" (Eisenstadt and Nelson 2017), which focused on the portion of the river covered by the Ouachita-Black Rivers Navigation Project, including areas in Arkansas upstream of Ouachita Parish. The study applied a traditional definition of "economic impact" and focused on the impacts from commercial navigation, industrial water use, municipal water use, agriculture, recreation, and wastewater treatment. Their analysis indicated that commercial use of the Ouachita River generates nearly $5.7 billion annually and is linked to nearly 21,000 full-time jobs in Louisiana and Arkansas. It concluded that commercial activities have returned $1.2 billion to household incomes throughout the region.

1.4 Purpose and Organization of Report

The purpose of this report is to document the participatory study between EPA and leaders of Ouachita Parish, Louisiana, to develop tailored information and tools to evaluate contributions of the Ouachita River to Ouachita Parish community well-being. Section 2 of this report defines the concepts used to frame the study and describes community engagement activities and analyses conducted by EPA to complete the study. Section 3 presents the results of the study. Section 4 discusses how the study can be used to inform existing planning processes. Section 5 presents recommendations for next steps for using the information and tools developed through this study.

1.4.1 How the information can be used

The information can be used to help set priorities and evaluate alternatives for infrastructure projects. The methods and results presented herein provide insights into approaches that can be used and criteria that can be considered, along with engineering and cost criteria. The study sheds light on relationships between different project types and community well-being to help deepen understanding of these relationships and ensure that well-being factors are considered in planning decisions. The information can also be used to justify funding requests and communicate the rationale for investment decisions to stakeholders.

1.4.2 Who is the target audience?

This report is primarily intended for local and regional officials responsible for infrastructure planning, investment, and operational decisions, including officials engaged in hazard mitigation and community resilience planning efforts in Ouachita Parish. However, it is also written with a broader range of stakeholders in mind and could be used by leaders in other communities to better understand the complex relationships between the river, river infrastructure, and the lives of community residents, thereby improving community leaders' ability to engage in planning processes and decisions. The approach is transferable to other communities facing complex resilience issues.

1.4.3 What is and is not included in the report

The report and analyses described herein focus on information and tools for analyzing the relationships between infrastructure project types and the ways in which decisions regarding different project types could affect ecosystem services and human well-being. The report and analyses are not intended to evaluate specific projects. They are intended to provide information and describe an approach that can be used by the community to support project evaluation. The report does not provide recommendations regarding project priorities or decisions. These decisions are best made by the community through existing planning processes.

2 Study Approach

The following section describes the approach used to engage leaders from Ouachita Parish, Louisiana in a participatory study of the contributions of the Ouachita River to the well-being of the Ouachita Parish community. The study was designed to incorporate community input into a structured framework, enabling the EPA research team to quantify how community decisions related to the Ouachita River could affect community well-being.

2.1 Overview

The participatory study involved several discrete steps, including community workshops and modeling activities. The study involved extensive community engagement to help ensure that conceptual models reflected community values and knowledge and that the results were responsive to community needs. The EPA research team worked with local community leaders in an iterative fashion throughout the study, convening two community workshops as well as multiple consultation points before and after those workshops, such as a working webinar. Individual study components can be described as follows:

1. *Develop study framework* to identify information needs and guide community engagement and subsequent modeling activities (Section 2.2).
2. *Engage the community* to obtain input to help scope the study and inform conceptual models connecting community actions, ecosystem services, and community well-being (Section 2.3).
3. *Develop conceptual models* identifying and quantifying connections between project types, ecosystem services, and community well-being domains (Section 2.4).
4. *Apply and refine the conceptual models* to evaluate the community well-being value of the Ouachita River (Section 2.5).

The basic framework was defined in terms of five core elements – Actions, River Attributes, Ecosystem Services, Beneficiaries and Human Well-being Domains – linked via “concept maps.” Researchers from EPA provided a “blank” framework and guidance (Figure 2.1), and the community “filled in the blanks” by participating in community workshops and information exchange activities. The result is a conceptual model supported by empirical research and tailored to the decision context and values of the Ouachita Parish community that allows for quantitative and qualitative evaluation of the potential effects of river-related decisions on community well-being.

The remainder of this section describes the steps completed for the study, basic analytical framework and core elements, and steps taken to develop the conceptual model for Ouachita Parish. Section 3 presents the results of these actions, including summaries of community input at different phases of the study, conceptual maps, and findings obtained for different action categories.

2.2 Framing the Analysis

The five core elements in the conceptual framework for analyzing potential well-being outcomes were Action Categories, River Attributes, Ecosystem Services, Beneficiaries, and Human Well-being Domains. Each of these elements and how they are linked are described below.

2.2.1 Project Types

A key step in framing the analysis was defining the decision context. Ouachita Parish is engaged in substantial efforts to mitigate hazards and improve community resilience to natural hazards, including flooding. A key goal of these local efforts is to sustain and/or enhance community well-being. The community has identified dozens of actions associated with hazard mitigation and community resilience, ranging from stakeholder engagement and information gathering to specific projects that could physically alter the Ouachita River watershed and river infrastructure.

For the purposes of this study, the "action" element of the basic framework was defined in terms of types of projects that could have a direct, physical impact on the Ouachita River. The project types most relevant to the community were defined by community leaders engaged in the study and reflect the focus of current hazard mitigation and resilience planning. They include projects that could affect watershed hydrology (e.g., stormwater drainage and green infrastructure projects), levee performance, and river pool depth and navigation. As the goal of this report is to examine impacts on community well-being and not to judge specific actions, general action categories were used rather than specific, individual proposed projects in the analysis. Focal action categories are described in more detail in Section 3.

2.2.2 Ecosystem Services, Attributes, and Beneficiaries

To help evaluate relationships between community actions and well-being outcomes, the conceptual framework included ecosystem services and two related elements: beneficiaries of ecosystem services and ecosystem attributes linking ecosystem services and beneficiaries. Each of these elements and their relationships are described below.

Natural ecosystems provide the clean air we breathe, water we drink, and fertile soil that we use to grow food. The term "ecosystem services" can be used to describe these and other ways that natural ecosystems support human health and well-being. The term conveys the idea that healthy and intact natural systems serve human needs (i.e., benefits from nature).

Ecosystem services can be defined in different ways (Nahlik et al. 2012). For the purposes of this study, EPA focused on final ecosystem goods and services (FEGS)[1], defined as those "components of nature that are directly enjoyed, consumed, or used to yield human well-being" (Boyd and Banzhaf 2007). Using the concept of FEGS helps focus the conversation on the aspects of nature that are most immediate and meaningful to the community (see Exhibit 2-1).

---

[1] In this report, the terms "ecosystem services" and "ecosystem goods and services" are used interchangeably. "Goods" are considered inherent in the term "ecosystem services."

EPA used the Final Ecosystem Goods and Services Classification System (FEGS-CS) developed by Landers and Nahlik (2013) to define ecosystem services for this study.

Exhibit 2-1. Final and Intermediate Ecosystem Goods and Services (EGS)

FEGS are directly enjoyed, consumed, or used by humans. These can include, for example, edible fish in the Ouachita River. Intermediate EGS may be required to support these FEGS. For example, healthy habitat is required to support edible fish. Humans indirectly benefit from the healthy fish habitat, but they do not directly enjoy, consume, or use it. Therefore, the fish habitat is not included as an endpoint for this analysis. This helps avoid ambiguity and minimize double counting in the analysis. See Landers and Nahlik (2013) for further discussion of the distinction between final and intermediate EGS.

In order to be considered a FEGS, there must be both an ecosystem function—something that the ecosystem provides—and a beneficiary, the person or people who benefit from the ecosystem function (e.g., anglers who enjoy fishing). The relationship between ecosystem services and beneficiaries can be further described in terms of the ecosystem attributes associated with the ecosystem service. An attribute is generally something that is observable and/or measurable (e.g., the population of edible fish in a river). Attributes are useful for describing ecosystem service-beneficiary relationships.

2.2.3 Community Well-being

The final element of the study framework is community well-being. The sustenance or enhancement of community well-being is a goal of community hazard mitigation and resilience actions. In terms of the conceptual model for this study, community well-being is the "endpoint" of interest when evaluating how community actions could affect the Ouachita River.

For the purposes of this study, EPA used the definition of human well-being developed by Smith et al. (2013) and incorporated in EPA's Human Well-being Index (USEPA 2014) for the community well-being element of the framework. The Human Well-being Index (HWBI) includes eight independent well-being domains that can be linked to ecosystem services via their relationship to economic, environmental, and societal well-being (Smith et al. 2013).

The HWBI includes metrics focused on individuals, family and friends, and communities. The study assumes that actions that sustain and/or enhance well-being for individuals, groups, and communities will sustain and/or enhance community well-being. Community well-being has been found to differ by community composition and access to ecosystem services (Fulford et al.

2015). Previous studies have found well-being to be an approachable target for ecosystem service assessments (Fulford et al. 2016a, 2016b). Table 2.1 lists and provides brief definitions of the eight domains defined in the HWBI and used in this study. Appendix A presents more detailed definitions of HWBI domains.

Table 2.1. Domains of Human Well-being (Smith et al. 2013, USEPA 2014)

Human Well-being Domain	Goals Associated with Domain
Safety and Security	▪ Being safe ▪ Feeling safe ▪ Resilience to hazards
Health	▪ Reasonable life expectancy ▪ Physical and mental well-being ▪ Emotional well-being ▪ Good quality healthcare ▪ Healthy lifestyle and behavior
Education	▪ Basic educational knowledge and skills ▪ Positive social, emotional, and physical development of children and youth ▪ More advanced knowledge and skills
Social Cohesion	▪ Participation in community activities such as volunteerism and government

Human Well-being Domain	Goals Associated with Domain
Living Standards	▪ Ability to afford basic necessities ▪ Reasonable income ▪ Reasonable wealth ▪ Job stability and satisfaction
Work-life Balance	▪ Enough time available for basic leisure activities ▪ Enough time available for physical activity and vacation ▪ Reasonable balance between leisure time, work, and caring for others
Connection to Nature	▪ Biophilia ▪ Mental connectedness to nature
Cultural Fulfillment	▪ Participation in local cultural/religious activities as a part of normal life

2.2.4 Putting It Together – Conceptual Maps

The connections among elements of the framework (Figure 2.1) were described with conceptual maps. The maps explicitly identified Action Categories, River Attributes, Ecosystem Services, and Human Well-being Domains and illustrated connections between these four elements. Beneficiaries (e.g., people who go fishing) were not shown on conceptual maps but were used to draw connections between the four elements. Figure 2.1 illustrates a “blank” map as well as the starting points used to structure different elements of the overall framework (e.g., FEGS-CS for beneficiaries) and where community input was used to tailor the analysis.

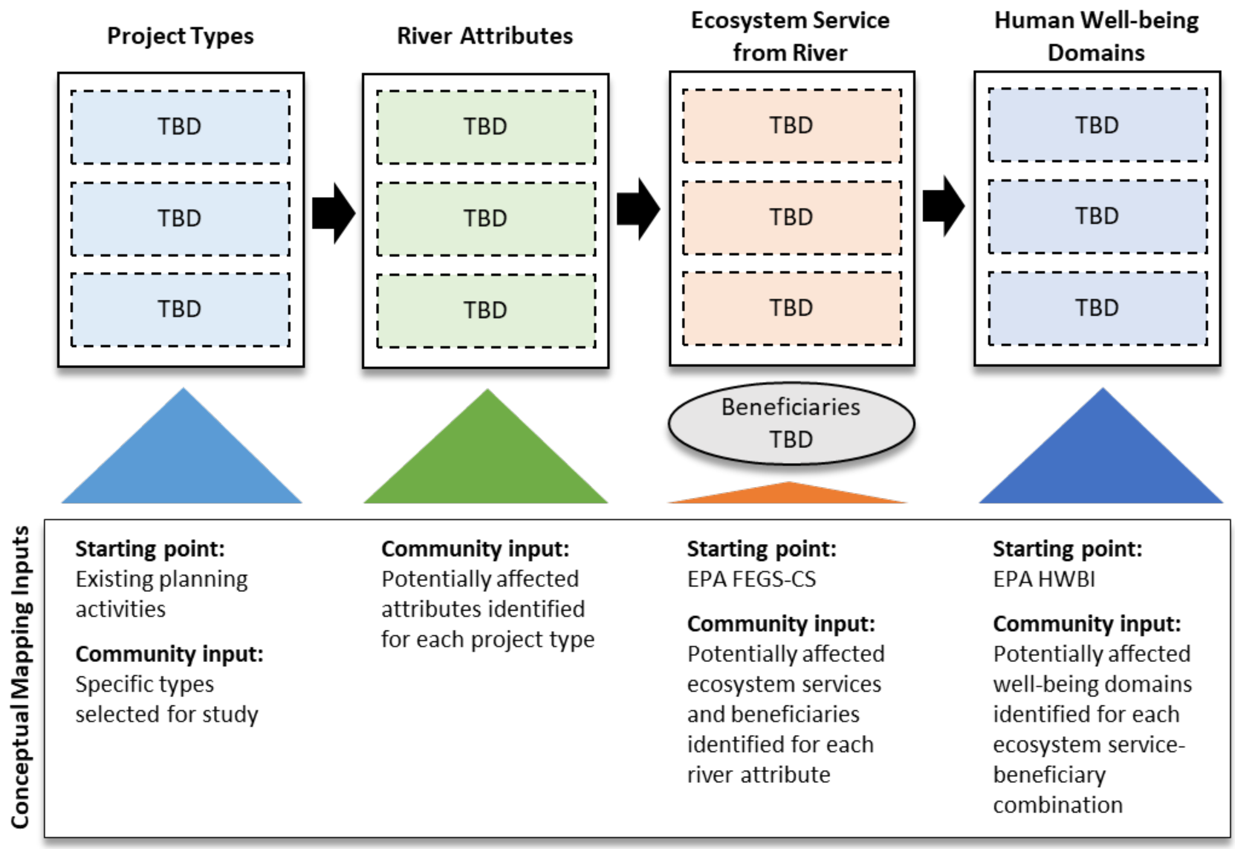


Figure 2.1 Starting points and types of community input used for mapping community actions related to the Ouachita River to potential community well-being outcomes.

2.3 Community Engagement and Conceptual Mapping

The research team worked with local community leaders and convened two community workshops to tailor the basic framework to the decision context and needs of the community. A structured decision making (SDM) approach[2] was used to guide community engagement activities (Bradley et al. 2016). Community input was captured with conceptual maps, as described above. Community engagement and conceptual mapping activities are described below. Please refer to the text boxes in this section (Exhibits 2-2 through 2-5) for an example of how community engagement was used to develop conceptual maps. Results of community engagement activities are described in Section 3.

[2] See Keeney (1992) and Gregory and Keeney (2002) for a description of structured decision making and its application to environmental management decisions.

Exhibit 2-2. Example of Community Engagement and Conceptual Mapping
Anglers on the Ouachita River

The Ouachita River is a popular destination for anglers. Residents enjoy fishing on the river and in upstream bayous. In addition, the Ouachita River near Monroe and West Monroe, Louisiana, is the site of Big Bass Tour tournaments and the annual Ronald McDonald House bass tournament. The ULM Economic Impact study noted that the organized fishing tournaments have a positive economic impact, as they draw visitors from outside the area who spend money on hotels, food, fuel, and general merchandise. The study notes that the river provides quality of life benefits for local anglers but notes that those benefits are beyond the scope of the Economic Impact study. The text boxes in this section describe how these broader benefits of the river to residents (and visitors) were incorporated in the current study.

2.3.1 Workshop 1 – Preliminary Community Input

The first community workshop was held on May 23, 2018. The workshop was hosted in West Monroe, Louisiana by the Tensas Basin Levee District, Ouachita Parish Office of Homeland Security and Emergency Preparedness, and Ouachita Parish Police Jury. The first part of the workshop focused on identifying core values of the Ouachita Parish community, in terms of the human well-being outcomes that the community cares most about. This discussion was held at the outset of the workshop to establish values-focused fundamental objectives prior to addressing the decision context, consistent with the SDM approach.

After the initial discussion, categories of human well-being were introduced and discussed in small groups. These categories were based on the eight domains of the Human Well-being Index (Smith et al. 2013). Once the groups felt comfortable with the categorical definitions, a suite of scoring exercises was employed to assign relative importance to each category and to provide community-specific data for mapping community core values to these well-being categories. The scoring exercises included a large group dot-voting approach, an anonymous individual ranking exercise, and a small group mapping exercise.

Following this initial discussion and exercises, the workshop included an open-ended discussion of the ways the Ouachita River affects core community values. Next, the Tensas Basin Levee District presented information on the Ouachita-Black Rivers Navigation Project and Ouachita River levee system. The workshop concluded with an open discussion of how actions related to the navigation project, levees, and drainage infrastructure affect core community values.

2.3.2 Scoping the Analysis Based on Workshop 1

The community input from Workshop 1 was used to identify project types, ecosystem services, river attributes, and beneficiaries relevant to the decision context, as described below.

2.3.2.1 *Ecosystem Services, Attributes, and Beneficiaries*

The EPA research team reviewed community responses to the open-ended question about how the Ouachita River affects core community values. The team mapped the responses to a list of ecosystem services developed from the FEGS-CS. This approach was designed to allow community members to identify and emphasize ecosystem services most relevant to the community. The FEG-CS framework was applied after-the-fact as a way of capturing (versus guiding) community input.

Exhibit 2-3. Ecosystem Services and Environmental Attributes Relevant for Anglers

Participants in Workshop 1 noted that the Ouachita River provides recreational opportunities for local anglers. Based on this input, EPA identified "recreational opportunities" as an ecosystem service provided by the river and "anglers" as potentially associated beneficiaries. The EPA team identified measures of surface water and fish community characteristics as attributes that could affect the quality of ecosystem services received by anglers.

The resulting list of ecosystem services and other descriptive information provided during Workshop 1 were used as a starting point for identifying community beneficiaries of the services provided by the Ouachita River. The EPA researchers reviewed the community input against the thirty-eight beneficiary sub-categories laid out in FEGS-CS and identified twenty sub-categories as being potentially relevant to the Ouachita River and Ouachita Parish community.

Once potential beneficiaries were identified, the EPA team developed the set of environmental attributes necessary for community members to receive those benefits, focusing on the attributes likely to be impacted by community actions related to the Ouachita River. Exhibit 2-3 presents an example of ecosystem services, beneficiaries, and attributes that were identified based on input from Workshop 1. The lists of potential ecosystem services, attributes, and beneficiaries developed based on Workshop 1 were used to structure discussions in Workshop 2.

2.3.2.2 *Action Categories*

The EPA research team also reviewed the discussions during Workshop 1 regarding community actions that could affect the river and river infrastructure. The team identified action categories and reviewed these categories with a working group of community leaders, including leaders from the Tensas Basin Levee District, Ouachita Parish, cities of Monroe and West Monroe, and LTRC subcommittees. The EPA team and local leaders developed a list of four action categories: river navigation, levees, stormwater management, and community resilience projects. The list of action categories was used to structure community input during Workshop 2 and all resulting analysis.

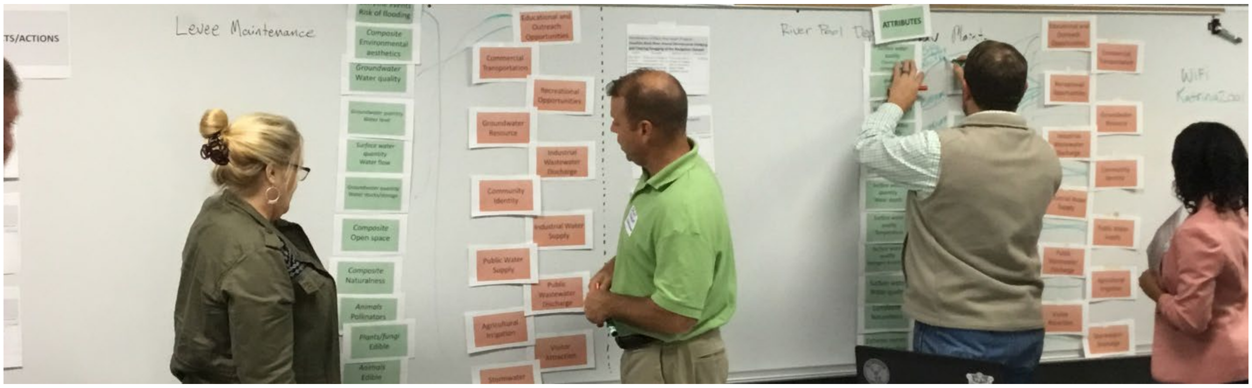


Figure 2.2 Photo from second stakeholder workshop – making connections. Photo credit: Anisa Pjetrovic USEPA.

2.3.3 Workshop 2 – Making Connections

Workshop 2 was held on November 8, 2018. The workshop was hosted in West Monroe, Louisiana by the Tensas Basin Levee District and Ouachita Parish Office of Homeland Security and Emergency Preparedness. The purpose of Workshop 2 was to:

- Review and refine the elements of the conceptual framework, especially the ecosystem services and action categories identified by the community.
- Obtain community input, for each action category, on the connections between the five core elements of the conceptual framework: Action Categories, River Attributes, Beneficiaries, Ecosystem Services, and Human Well-being Domains.
- Explain how EPA planned to use this input to develop conceptual models linking community actions to well-being outcomes via ecosystem services from the river.

Participants broke into four working groups, each focused on a different action category. Each group was first asked to identify project types within the broader action categories to align with existing planning activities and/or illuminate differences in action-river attribute relationships. Following this initial exercise, participants completed the follow activities:

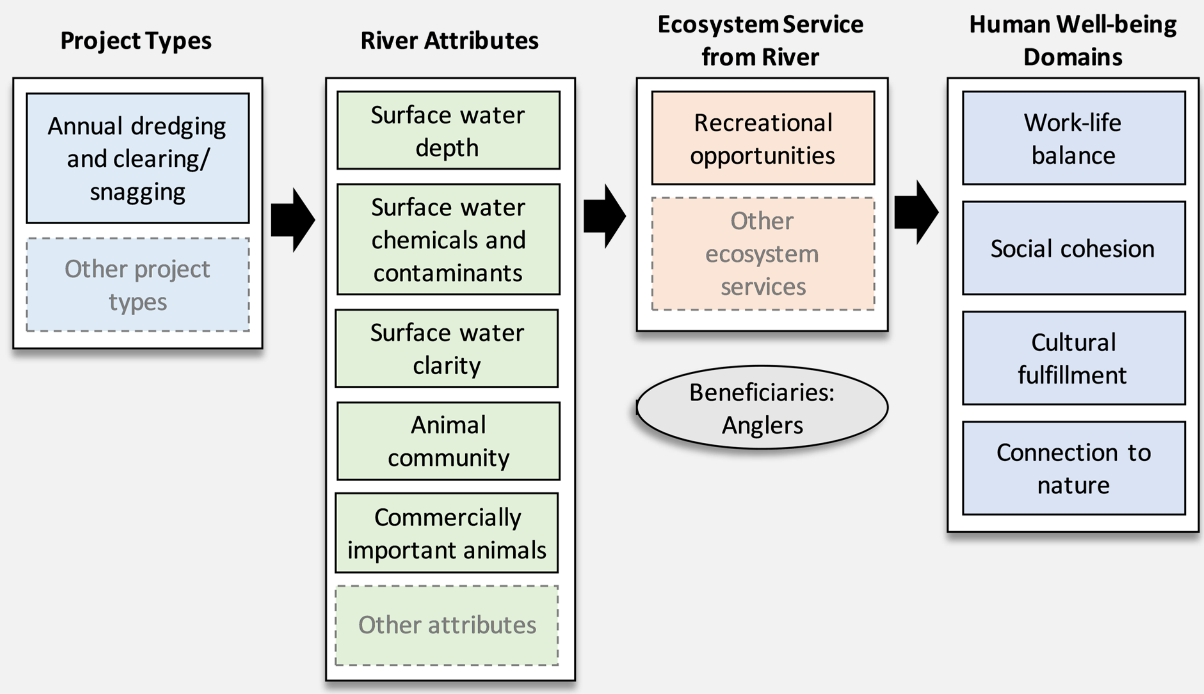
- *Identified river attributes* that could be affected by each specific project type and drew connections between project types and associated river attributes.
- *Identified beneficiaries* associated with the attributes identified in the previous exercise.
- *Identified ecosystem services* that rely on the river attributes, considering the attribute-beneficiary relationships identified in the previous exercise, and draw connections between the attributes and ecosystem services.
- *Identified well-being domains* that are affected by the ecosystem services highlighted in the previous exercise and drew connections between ecosystem services and well-being domains.

To structure the exercises, EPA provided community participants with lists of potential river attributes, beneficiaries, and ecosystem services developed based on input from Workshop 1. Participants were instructed to use these as a starting point but were encouraged to expand upon these lists as necessary to capture their input. When making connections between different elements, participants were not asked about the direction or strength of relationships (i.e., whether a project type would have a positive or negative impact on an attribute or the potential magnitude of the impact).

At the conclusion of the workshop, each group developed a series of complete conceptual maps linking action categories to environmental attributes, attributes to ecosystem services, and ecosystem services to well-being domains. The input from Workshop 2 was used to develop conceptual models for quantifying the relationships between project types, ecosystem services, and community well-being. These subsequent activities are described below. Exhibit 2-4 presents an example of the exercises completed and output from Workshop 2.

Exhibit 2-4. Example of Workshop 2 Conceptual Mapping Exercise:
How Could Anglers be Affected by Ouachita River Dredging and Clearing/Snagging Projects?

The Workshop 2 River Pool/Navigation working group identified the following specific project types within the broader project type category: annual dredging and clearing/snagging, operation and maintenance of locks and dams, and Columbia Lock chamber repairs. The group noted that dredging and clearing/snagging could affect surface water depth, surface water chemicals and contaminants, surface water clarity, commercially important animals (i.e., fish), and the animal community (in general) associated with the river. The group noted that effects on these attributes could affect anglers (among other beneficiaries) and the ecosystem service of recreational opportunities. They concluded that this could affect the well-being outcomes of Work-life Balance, Social Cohesion, Cultural Fulfillment, and Connection to Nature. At the end of the workshop, the River Pool/Navigation group had completed the following conceptual map capturing this input:



2.4 Ecosystem Services Analysis

Based on the input from the two community workshops and intervening analyses and information exchange with community leaders, EPA researchers developed conceptual models of community-wide ecosystem services associated with different project types using the following steps:

1. *Conceptual mapping:* Refined workshop conceptual maps to reflect community input received during Workshop 2 and help guide subsequent analyses.
2. *Beneficiary analysis:* Identified beneficiary groups based on assessed relationships between project types, river attributes, ecosystem services, and beneficiaries. Developed scores representing the strength and direction of project type-beneficiary relationships.
3. *Composite ecosystems services analysis:* Developed composite scores of ecosystem services affected by different project types at the community (versus beneficiary) level.

These activities are described below. Results of the conceptual modeling are presented in Section 3.

2.4.1 Conceptual Mapping

The research team refined conceptual maps for each project category and project type based on the scope of relevant attributes and ecosystem services and connections identified by the community during Workshop 2. For each action category, the conceptual map showed the river attributes that community participants identified as potentially affected by one or more action categories, relationships between these attributes and ecosystem services identified as a result of Workshop 1, and relationships between ecosystem services and well-being outcomes.

2.4.2 Scoring Project Type-Beneficiary Relationships

The EPA researchers reviewed each of the connections between action categories and attributes identified in Workshop 2 and assigned a strength-directionality value using a scale ranging from strongly negative to strongly positive. In some cases, EPA researchers could not find supporting scientific justification for an action category-attribute connection or concluded that the connection was indirect (i.e., completion of a stormwater management plan does not directly affect watershed hydrology; its effects are indirect and experienced only when specific projects outlined in the stormwater management plan are implemented). In these cases, connections were scored as neutral. Neutral connections were retained on the conceptual maps (to accurately reflect community input) but were not included in subsequent analyses.

Once connections between action categories and attributes were assessed, beneficiaries were incorporated into the picture. For each attribute impacted by a project type, all beneficiaries who rely on that attribute to receive the benefit of an ecosystem service were listed. The result was a list of many-to-many relationships, where each beneficiary could potentially be associated with multiple attributes and services, and likewise each attribute or service could potentially be associated with multiple beneficiaries. The importance of each attribute-beneficiary relationship was ranked on a scale of 1 to 3. On this scale, a score of 3 meant that the attribute was critical for the benefit to occur, whereas a score of 1 meant that the benefit was nice to have but not necessary.

These two scores—action category-attribute relationship strength score and importance to beneficiary score—were combined with a scaling factor to produce a composite measure of the strength and direction of the impact of each action category on beneficiaries. The scaling factor was used to quantify the relative influence of action category-attribute relationship strength on beneficiary impact. The resulting analysis provides a measure of the overall impact of each project type on beneficiaries in the Ouachita Parish community of ecosystem services provided by the Ouachita River.

During the beneficiary analysis, EPA researchers reviewed input from workshop discussions to clarify the ecosystem services provided by the Ouachita River and add transparency to the analysis. For example, the ecosystem service "navigable waterways" was substituted for "commercial transportation" to reflect the repeated mention of the former term during workshop discussions. Similarly, "catchable fish" was substituted for "commercially important animals" to allow for a more transparent link between anglers as a beneficiary group and the fish in the Ouachita River that are prized by anglers. Exhibit 2-5 presents an example of how action category-beneficiary relationships were mapped and scored.

Exhibit 2-5. Example of Project Type-Beneficiary Analysis:
How Could Anglers be Affected by Ouachita River Dredging and Clearing/Snagging Projects? *

Action - Attribute Relationship. Relationships between dredging and clearing/snagging projects and the attributes identified by community participants in Workshop 2 (see Exhibit 2-4) were assessed and rated on a scale of strongly positive (+3) to strongly negative (-3), as shown in the table to the right. The assessment identified, for example, a direct and strongly positive relationship with the attribute of surface water depth and a moderately negative connection with surface water clarity. Dredging and clearing/snagging maintain channel and river pool depth and affect surface water clarity during active operations.

Beneficiary Impact and Combined Relationship-Impact Score. Potential effects of dredging and clearing/snagging on anglers were incorporated in the model by evaluating the importance of attributes potentially affected by dredging and clearing/snagging to anglers. For example, catchable fish are critical for anglers to receive the benefits of recreational opportunities afforded by the river. Importance of the attributes affected by dredging and clearing/snagging were rated on a scale of 1 to 3 (3 being most important) as shown in the table to the right. Combined scores on each attribute were calculated by multiplying the relationship strength/direction (top table) by the importance score. Combined scores are shown in the table to the right and suggest that dredging and clearing/snagging project types are likely to have mixed positive and negative effects on recreational opportunities for anglers.

Example Attribute Relationship Strength Scores for Dredging and Clearing Snagging Project Type

River attribute	Relationship direction and strength
Surface water depth	+3
Surface water chemicals and contaminants	-2
Surface water clarity	-2
Animal community	-1
Catchable fish	+1

Example of Beneficiary Impact Scores Linking Anglers (Beneficiary), Attributes, and Dredging Action Category

River attribute	Importance to anglers	#Combined score
Surface water depth	1	+3
Surface water chemicals and contaminants	2	-4
Surface water clarity	2	-4
Animal community	3	-3
Catchable fish	3	+3

* **Note:** This example is for illustration and does not include all action category-beneficiary relationships identified for dredging and clearing/snagging projects and anglers. Please refer to Section 3 for a more complete analysis.
# Combined score example: surface water depth to anglers: 1 * +3 = +3

2.4.3 Scoring Final Ecosystem Service Impacts

Final ecosystem services are a combination of river attribute and beneficiary. Important FEGS were identified via beneficiary analysis (see previous section). These final services were given weight based on the combination of impact scores (see Exhibit 2-5) across the beneficiary groups connected to each service. These connections were taken directly from the concept maps built during the second workshop (see Section 2.3.3). This weight was assigned to each beneficiary-attribute link (e.g., surface water flow – recreational anglers) and then allocated to services connected to that link (e.g., surface water flow – recreational anglers – navigable waterways). Impact score allocation to final services was simply the addition of all beneficiary impact scores that were linked to a service. Scores were allocated across the three ecosystem service categories: economic, social, and environmental. The beneficiary-impact score was allocated to each service category separately so that an individual beneficiary-impact score could be used in all three service categories if it was linked to services spread across those categories. However, if an impact score was not linked to a service in a service category, then that category received no score from that impact score. All score allocations to services were validated by reverse mapping back to the proper beneficiary and river attribute.

2.4.4 Results Validation and Model Refinement

The results of the beneficiary impact score calculations and the allocation of those scores to final services were presented to community leaders during a webinar on August 19, 2019. After the webinar, EPA researchers reviewed component parts of the analysis (e.g., conceptual maps, river attribute-beneficiary relationships) with community leaders to check for completeness and accuracy in representing community input. The EPA researchers also presented overall results to check whether they resonated with the community's experience of the ecosystem services provided by the river. No significant changes to the conceptual models were identified based on this final community review.

2.5 Quantifying Well-being Impacts

The final step in the calculation was to link final ecosystem services to metrics of human well-being, quantified based on the HWBI (Smith et al. 2013). This index combines indicator scores in eight independent well-being domains (Table 2.1) and then combines these domain scores into a composite well-being score based on a weighted average of the eight domain scores. The HWBI is intended to describe value to beneficiaries comprehensively across social, economic, and environmental service categories. It is a broader index of service value, but comparable in function to economic valuation (Eisenstadt and Nelson 2017). The study first calculated a baseline value of HWBI for Ouachita Parish and then used known links between final ecosystem services and the HWBI as a tool to examine how projected changes in final ecosystem services (resulting from the action-attribute-service connections like those described in Exhibit 2-4 and scored in Exhibit 2-5) predict change in HWBI baseline scores for the Ouachita Parish community as a whole. The eight domains of HWBI were individually weighted (1-5) based on community scoring exercises that took place during Workshop 1.

2.5.1 Human Well-being Index baseline value

Human well-being can be measured by an index comprised of eight domains intended to describe all economic, social, and environmental aspects of human well-being. The Human Well-being Index (Smith et al. 2013) can be used at the county level, but compared to nationwide data, provides a comparative tool for Ouachita Parish as a way of developing a meaningful benchmark for strategic planning. This baseline value was available for all counties (parishes) in the conterminous 48 U.S. states based on an existing set of metrics included in a standard HWBI tool (Summers et al. 2016).

2.5.2 Linking Services to Human Well-being Endpoints

Final ecosystem services scores resulting from the impact and beneficiary analysis were normalized to proportional change in service delivery that will result from proposed actions. These were then used to build scenarios of service change that could be used to project changes in human well-being (Summers et al. 2016). Existing regression relationships between service scores and the eight domains of human well-being were used to project change in service scores onto changes in the HWBI. The domains were also assigned weight in the HWBI calculation based on ranking data collected during Workshop 1. This mapping of service scores onto HWBI scores was conducted in an existing EPA county comparison tool (Summers et al. 2016).

2.5.3 Capturing the Well-being Value of the River

Well-being impacts associated with each project type category were developed based on proportional changes in domains of human well-being from the county-specific baseline HWBI scores for Ouachita Parish (Smith et al. 2013). These baseline values were calculated as a part of a national comparison of U.S. counties and allowed for local calculation of chosen metrics for each human well-being domain. Change from the baseline value was calculated with an existing regression relationship between final ecosystem service scores and the HWBI. The regression was conducted for each HWBI domain independently.

3 Results

The following section summarizes the results of community engagement activities, including community input on fundamental objectives, action categories, and ecosystem services from the Ouachita River, and subsequent analyses completed by EPA to develop conceptual models and scores for evaluating relationships between action categories, ecosystem services, and community human well-being.

3.1 Fundamental Objectives

The discussion of the human well-being outcomes that the community cares most about during Workshop 1 highlighted the following fundamental objectives:

- The community values fundamental goals, including good basic educational knowledge and skills, being safe, and having access to good quality healthcare.
- When these fundamental goals are supported, other goals—including a good job, college education, and enough time for leisure activities—are attainable. Without good basic education, being safe, and good quality healthcare, it is harder to achieve other, more advanced goals.
- These fundamental goals are closely tied to, and dependent upon, other goals, including a supportive network of family and friends and ability to achieve a reasonable balance between leisure time, work, and caring for others.
- The benefits of living in Ouachita Parish are not shared equally by all. Poverty is a problem. The route to opportunity is different for the poor. Poverty can hinder one's ability to attain even the most fundamental goals. More advanced goals, including a stable job, college education, and broader participation in the community, are often out of reach for community members in poverty.

Table 3.1 presents the results of the Workshop 1 exercise where participants were asked to vote on the most important community-wide goals.

Table 3.1. Results of Workshop 1 Prioritization Exercise: Which community-wide goals do you view as most important to Ouachita Parish?[3] Goals are listed in rank order based on number of votes with the most important at the top. Voting is based on 180 dots voted by 25 community participants.

Goal category	Goal	Participant votes	
		Number	Percent
Education	Basic educational knowledge and skills	19	11%
Safety and Security	Being safe	18	10%
Health	Good quality healthcare	17	10%
Social Cohesion	Supportive network of friends and family	13	7%
Work-life Balance	Reasonable balance between leisure time, work, and caring for others	13	7%
Living Standards	Job stability and satisfaction	11	6%
Education	More advanced knowledge and skills	10	6%
Living Standards	Reasonable income	8	5%
Work-life Balance	Enough time available for basic leisure activities	8	5%
Connection to Nature	Connectedness to nature	7	4%
Health	Physical and mental well-being	6	3%
Living Standards	Reasonable wealth	6	3%
Education	Positive social, emotional, and physical development of children and youth	5	3%
Safety and Security	Feeling safe	5	3%
Safety and Security	Resilience to hazards	5	3%
Cultural Fulfillment	Cultural fulfillment	4	2%
Living Standards	Ability to afford basic necessities	3	2%
Social Cohesion	Responsible engagement in our democracy	3	2%
Social Cohesion	Healthy family bonding	3	2%
Social Cohesion	Satisfaction with others and the community	3	2%
Work-life Balance	Enough time available for physical activity and vacation	3	2%
Health	Reasonable life expectancy	2	1%
Health	Healthy lifestyle and behavior	1	1%
Social Cohesion	Regular participation in social community activities	1	1%
Health	Emotional well-being	0	0%

3.2 Action Categories and Types

After Workshop 1 and prior to Workshop 2, EPA and local leaders developed a list of four action categories: river navigation, levees, stormwater management, and community resilience projects. During Workshop 2, groups assigned to each action category were asked to identify project types within the broader action categories. The EPA team combined similar project types (i.e., regional levee repairs versus repairs to specific levee reaches) and identified those action categories that

[3] Participants were presented with a list of goals reflected in the HWBI (see Appendix A). Participants "voted" on the goals that they felt were most important for the community using seven "dots" that they could apply to one or more goals. Workshop participants were selected as a broad cross-section of community interests.

most directly affect ecosystem services for further analysis. Table 3.2 presents the project types identified by the community, and the subset of actions selected by EPA, for the analysis of community actions that could affect ecosystem services of the Ouachita River. Relative impact of the selected action categories on the selected river attributes is described in Table 3.5. In each case a most important impact was identified, and all other impacts were scored relative to the most important impact.

Table 3.2. Project Types Included in the Study

Action category	Project type	Conceptual model development	
		Included?	Rationale
Stormwater management	Pump stations	Yes	Direct relationship to ecosystem services
	Drainage improvements	Yes	Direct relationship to ecosystem services
	Local levee projects and repairs	Yes	Captured in regional levees
	Miscellaneous projects	No	Too imprecise to be illustrative
Regional levees	Levee maintenance	Yes	Direct relationship to ecosystem services
River pool depth/ navigation	Annual dredging and clearing/snagging	Yes	Direct relationship to ecosystem services
	O&M of locks and dams	Yes	Direct relationship to ecosystem services
	Columbia Lock chamber repair	No	Captured in operation and maintenance of locks and dams
	Boat ramps and recreation sites	No	Indirect relationship to ecosystem services
Community resilience	Master drainage plan	No	Indirect relationship to ecosystem services
	Regional watershed studies	No	Indirect relationship to ecosystem services
	Neighborhood drainage districts	No	Indirect relationship to ecosystem services
	Greenspace development in floodplain	Yes	Direct relationship to ecosystem services
	Green infrastructure	Yes	Direct relationship to ecosystem services
	Inventory of all resources	No	Indirect relationship to ecosystem services
	Critical infrastructure inspection	No	Indirect relationship to ecosystem services

3.3 *Ecosystem Services of the River*

The EPA research team reviewed community responses to the open-ended discussion in Workshop 1 regarding the ways the Ouachita River affects core community values and mapped discussion points to a provided list of ecosystem goods and services. Table 3.3 summarizes the final ecosystem goods and services identified by the community and included in the analysis of how community actions relative to specific project types could affect ecosystem services of the Ouachita River.

Table 3.3. Ecosystem Services Included in the Study

Ecosystem service category	Ecosystem service	Description of ecosystem in Ouachita River context[4]
Water supply	Public water supply	The river is used for public water supply.
	Industrial water supply	The river is used by local industries as a source of water supply.
	Agricultural irrigation	The river is an important source of irrigation water for agriculture.
	Groundwater resource	Availability of water supply from the river mitigates pressure on the groundwater aquifer as a water supply source.
Stormwater/ wastewater management	Stormwater discharge	The river is the principal means of draining stormwater from the cities and other areas of the parish.
	Public wastewater discharge	The river is used for direct discharge from municipal wastewater treatment plants.
	Industrial wastewater discharge	The river is used by local industries for permitted direct wastewater discharge.
	Reduce property damage/loss	The river, and associated infrastructure, helps reduce flood risk on adjacent land.
	Maintain property value	The river and associated infrastructure reduce risk and increase value of near river land.
Transportation	Navigable waterways	The river is used to import petroleum products to the region and to ship chemicals, grain and other goods produced in the region.
Recreation	Recreational opportunities	The river is used for boating, fishing, hunting, camping, photography, and other outdoor recreation.
Visitors	Visitor attraction	The river attracts visitors for fishing and water-skiing tournaments and other outdoor recreation.
Education	Education and outreach	The river is a destination for school field trips and is used by local colleges and universities for education and research.
Identity	Community identity	The river is fundamental to the identity of Ouachita Parish and the cities of Monroe and West Monroe. More broadly, the river “shapes the person” and their relationship to water.
Important animals and plants	Catchable fish	The river is used to catch fish either commercially or recreationally.
	Harvestable animals	The river creates habitat for other harvestable animals such as birds.
	Harvestable food	The river creates habitat for other harvestable food such as edible plants.
	Crop growth	The river promotes agricultural crop growth via sediment deposition or maintenance of farmland.

	Prevent crop damage/loss	The river and associated infrastructure prevent flood damage.
	Tree/Forest growth	The river promotes growth of forestry products.

[4] The Ouachita River context includes the river itself as well as bayous and other waterbodies, riparian areas, floodplain areas, and groundwater aquifers associated with the river.

Table 3.4. List of River Attributes and Beneficiary Groups Included in the Analysis

*River attributes	*Beneficiary groups
Flood risk Surface water contaminants Surface water clarity Surface water depth Surface water flow Surface water pathogens Groundwater level Groundwater quality Groundwater storage Naturalness Open space Pest predators Pollinators Commercially important fauna Edible fauna Edible plants/fungi Environmental aesthetics Faunal community	Residential property owners Industrial processors Industrial dischargers Drinking water consumers Municipal waste dischargers Transporters of goods Transporters of people Farmers Foresters Hunters Anglers Boaters Wader/swimmer/divers Experiencer/viewers Food picker/gatherers Ceremonial participants Artists Educators People who care
*Two lists are for introduction and are not linked in this table	

Table 3.5. Action Category-River Attribute Impact Scores - Impact weights assigned to action category identified as important for the Ouachita River. Impact scores describe the relative importance of the action category (e.g., pump station maintenance) on an attribute of the river (e.g., surface water flow). Relative importance is scaled to the most important (grey/bolded below) attribute as determined by expert opinion for each action (score = 1, 2, 3), and impact can be positive or negative, which reflects positive or negative impacts on stakeholders. Weights were estimated based on consultation with state/local experts. The 'most important' label below allows for other attributes to be given the same score (3).

River attributes	Pump station maintenance	Drainage projects	Levee maintenance	Channel dredging	Lock/dam maintenance	Green-space
Surface water flow	1	1	3	3	3	0
Surface water depth	1	1	3	**3**	**3**	0
Surface water clarity	-1	1	0	-2	1	0
Surface water chemicals and contaminants	-1	1	0	-2	1	0
Surface water pathogens and parasites	-2	1	0	0	0	0
Risk of flooding	**3**	**3**	**3**	2	3	0
Naturalness	0	0	-1	-1	1	0
Ground water quality	0	0	1	0	0	0
Ground water storage	0	0	1	0	0	0
Ground water level	0	0	1	0	0	0
Edible plants/fungi	0	0	2	0	0	0
Edible fauna	0	0	2	0	0	0
Pollinators	0	0	2	0	0	0
Environmental aesthetics	0	0	2	0	0	0
Open space	0	0	2	0	0	**3**
Faunal community	0	0	0	-1	1	0
Commercially important fauna	0	0	0	1	1	0
Pest predators	0	0	0	1	1	0
Flora/fungi community	0	0	0	0	0	2

3.4 Beneficiary Importance Analysis

The research team created conceptual maps for each project category and project type based on the scope of relevant river attributes and ecosystem services and connections identified by the community during Workshop 2. The list of included river attributes and beneficiary groups are described in Table 3-4. The two-step weighting process began by weighting the impact of the action categories on river attributes (Table 3.5). This weighting ranged from -3 to 3 and is scaled by the strongest link for each action category. The goal here is to score the likely impact of an action on each attribute of the river. The second step in the weighting process measured impact on each beneficiary group. The beneficiary importance ranged from 1 to 3 with 3 being highly important, 2 being important but not critical, and 1 being desired but of lower importance. The goal here is to extend the impact of an action on the river to an estimated impact on specific beneficiary groups. An example of beneficiary importance scores is given in Table 3.6 for the action category "Greenspace." The two scores were combined for every action category-river attribute – beneficiary combination as described in Exhibit 2-5 and these combined scores were used to measure the importance of ecosystem services. Conceptual maps developed based on community input regarding links between river attributes-beneficiary groups-ecosystem services are included in Appendix B. The weighting results are described in Section 3.6 divided by action category.

NOTE: BECAUSE OF THE NEED TO NOT SPLIT TABLES ACROSS PAGES, THIS MIGHT BE AN OPEN SPACE WHERE WE CAN PUT IN GRAPHICS OR OTHER ITEMS TO CUT DOWN ON BLANK SPACE

Table 3.6 Beneficiary Importance Scores - These scores are an example from the action category Greenspace projects. Scores are ordered alphabetically by beneficiary group. The use of the score is demonstrated in Exhibit 2-5 and the full suite of importance scores across all action categories are given in Appendix C. Beneficiary scores were compiled for the associated services to estimate effects of actions on services.

Greenspace projects			
River attributes	**Beneficiaries**	**Services**	**Importance to beneficiary (out of 3)**
Open space	Anglers	Recreational opportunities	2
Flora/fungi community	Artists	Visitor attraction	2
Open space	Boaters	Recreational opportunities	2
Flora/fungi community	Ceremonial participants	Community identity	2
Open space	Ceremonial participants	Community identity	3
Open space	Educators/students/researchers	Education and outreach	2
Flora/fungi community	Educators/students/researchers	Community identity	3
Flora/fungi community	Experiencers/viewers	Visitor attraction	2
Open space	Experiencers/viewers	Recreational opportunities	3
Open space	Farmers	Crop growth	3
Open space	Food pickers/gatherers	Recreational opportunities	1
Open space	Foresters	Tree growth	2
Open space	Hunters	Recreational opportunities	2
Open space	People who care	Community identity	3
Open space	Residential property owners	Property value	1
Open space	Transporters of people	Commercial transportation	1
Open space	Waders, swimmers, divers, skiers	Recreational opportunities	1

3.5 Domains of Human Well-being and HWBI

The well-being analysis involved two steps: (Step 1) calculation of a baseline HWBI value for Ouachita Parish and a change analysis predicting impacts of ecosystem services on HWBI domains. Results for Step 2 are described by action category in Section 3.6. The overall baseline HWBI value for Ouachita Parish based on HWBI scoring of all U.S. counties (parishes) in the conterminous 48 states (Smith et al. 2013) is 47. This overall value is below the national average of 52.8 and the Louisiana state average of 49.9 (USEPA 2014).

Across the individual HWBI domains, the highest scores in Ouachita Parish were for Connection to Nature and Work-life Balance, and the lowest were for Education and Social Cohesion (Table 3.7). Meaningful individual Connection to Nature is high compared to other domains but low in comparison to surrounding parishes and about average for Louisiana, so this is a generally high HWB Domain for this region. Education and Social Cohesion are lowest and below average across the board, so these are domains worth focusing on for improvement. The community also gave high weight to this domain during the first workshop.

Table 3.7 Baseline HWBI Scores for Ouachita Parish, LA - Scores are given separately for each HWBI domain. Weights assigned to each domain in calculating overall HWBI score were calculated from Workshop 1 results based on multiple scoring exercises described in Section 2.3.1. Mean domain scores for the six neighboring parishes are described in detail in Table 3.8.

HWBI domain	Domain description	Ouachita parish wt. (1-5)	Ouachita parish score	Neighboring parish Avg. (n=6; Table 3.8)
Connection to Nature	Perception of nature and how it affects people	2	57.4	78.4
Health	Healthy behavior, access to healthy lifestyle, illness, morbidity	4	56.7	56.8
Work-life Balance	Work-life balance in activity choices	2	53.7	54.6
Safety and Security	Perceived and actual safety; exposure to danger	5	50.2	59.4
Living Standards	Basic necessities, wealth, relative income levels	5	48.1	46.8
Cultural Fulfillment	Participation and importance of arts and spiritual activities	2	42.8	40.4
Social Cohesion	Involvement in family, democracy, and community activities	4	39.8	39.7
Education	Acquisition of basic skills through education	4	36.6	36.1
HWBI	**Weighted geometric mean of eight domain scores**	**n/a**	**47.0**	**49.6**

Table 3.8 HWBI scores for six adjacent parishes to Ouachita Parish, Louisiana - These values are summarized in Table 3.7 as a neighboring parish average.

Parish Domains	Caldwell	Jackson	Lincoln	Morehouse	Richland	Union
Connection to Nature	90	57.9	84.8	90	90	57.4
Health	52.5	54.6	54.5	59.6	59.6	59.9
Work-life Balance	55.8	54.8	56.4	51.2	56.4	53.2
Safety and Security	65.7	70.8	54.4	45.4	57.7	62.5
Living Standards	47.1	50.8	46.1	43.4	45.2	48.3
Cultural Fulfillment	23.3	46.3	40.9	40.9	44.6	46.3
Social Cohesion	39.3	45.5	39.9	35.9	36.8	41
Education	37.5	40.1	30.8	35.2	35.3	37.5
HWBI score	**48**	**51.9**	**48.8**	**48.0**	**51.0**	**50.0**

3.6 Assigning Weight to Linkages from Action Category to EGS to HWBI

The impact of each action category on services was estimated based on impact score of actions on river attributes and importance score of those impacts to specific beneficiaries (See Exhibit 2-5 for an example). Beneficiary choice was based on stakeholder input and expert judgement to include all important categories but should not be considered comprehensive. The results are given by action category and separated into three phases (Impact, Beneficiary, and Service).

3.6.1 Stormwater Projects

3.6.1.1 Impact Analysis

The largest impact of stormwater projects was a reduction in the risk of flooding. This impact was scored as high (3) and all other impacts were scaled from this maximum (Table 3.5). Other river impacts considered were surface water flow and depth, and water quality impacts such as water clarity, chemicals, and pathogens. Impacts on surface water flow and depth were positive but weak in that stormwater drainage occurs mainly when river stage is high limiting stormwater impacts on the river. Impacts on water quality were negative for pumping stations that remove water from impervious areas directly to the river. They were positive for drainage projects that divert water and allow it to seep into the ground—but weak in both cases for the reasons stated above.

3.6.1.2 Beneficiary Analysis

Stormwater projects were linked to beneficiaries based on the perceived importance of river attributes to beneficiary groups. River attributes impacted by stormwater projects were most important to residential property owners and those beneficiaries who use the river for commercial purposes such as transporters and industrial dischargers (Figure 3.1). The most important attribute-beneficiary connections were between river depth/flow and transporters, and risk of flooding and residential property owners. Medium importance values were identified for river flow/depth/water quality and farmers, as well as water quality and industrial users. These medium importance values are associated with beneficiaries removing water for a specific purpose. Other significant attribute-beneficiary connections identified included river flow/depth and recreational users such as anglers, boaters, and swimmers.

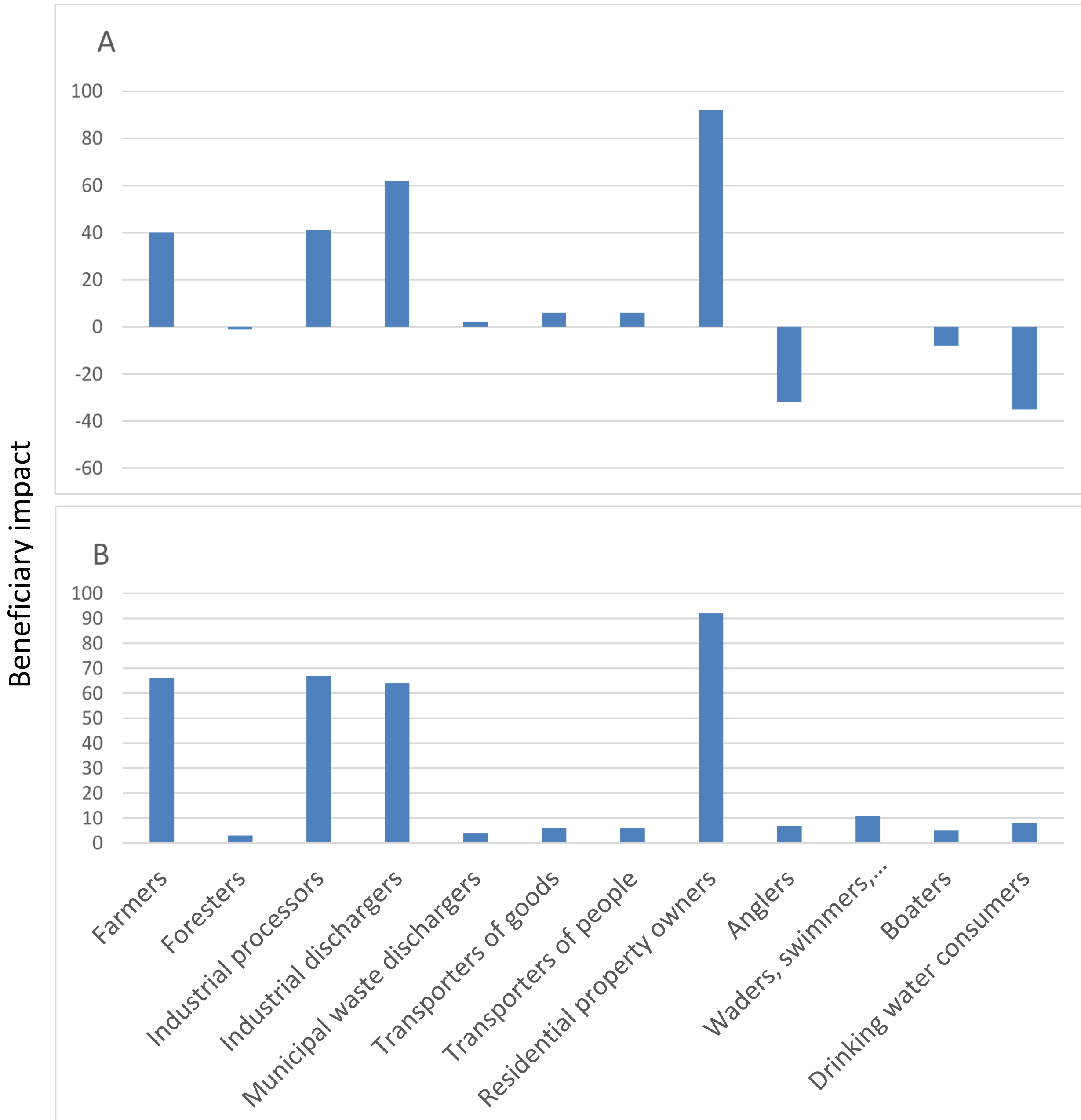


Figure 3.1 Combined impact and beneficiary importance scores for stormwater projects: Pump station repair (A) and drainage projects (B). All beneficiary groups with a non-zero combined score indicating significant impact are shown (x-axis). Combined scores range from -100 to 100 with zero indicating no impact.

3.6.1.3 *Services Analysis*

Stormwater projects are principally implemented to reduce the risk of flooding in the river floodplain. Services most strongly impacted by these types of projects are capital investment and emergency preparedness, reflecting a higher confidence in infrastructure safety (Figure 3.2). Smaller impacts on public works services as well as economic production and consumption reflect the difference between the operating cost of drainage and pump station projects. Impacts on ecosystem services were smaller—but important—with the largest being impacts on greenspace and water quantity in the river. Greenspace is created by drainage projects and generally removed by pump stations, which may require the use of public land for the pumping.

NOTE: BECAUSE OF THE NEED TO NOT SPLIT GRAPHICS ACROSS PAGES, THIS MIGHT BE AN OPEN SPACE WHERE WE CAN PUT IN GRAPHICS OR OTHER ITEMS TO CUT DOWN ON BLANK SPACE

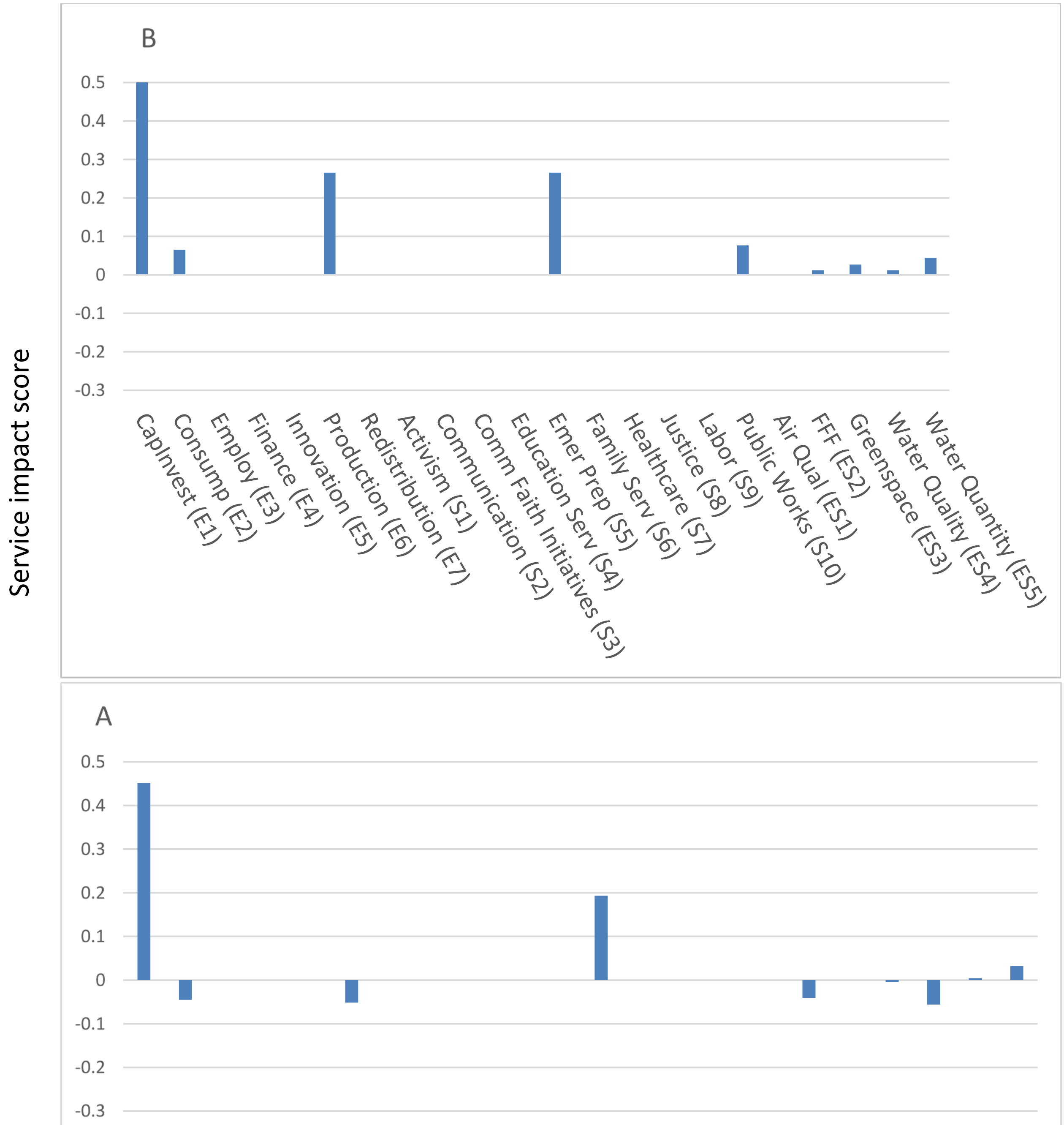


Figure 3.2 Service scores for stormwater projects: Pump station repair (A) and drainage projects (B). Service categories listed in the x-axis are grouped by type: Economic (E1), Social (S1), and Ecosystem (ES1) services. All services with a score contribute to the impact on community well-being. Service scores range from -0.5 to 0.5 with zero indicating no impact of this action category on a service.

3.6.2 Levee Maintenance

3.6.2.1 Impact Analysis

The largest impact of levee maintenance and repair was thought to be a reduction in the risk of flooding and maintenance of river depth and flow rate (Table 3.5). Effect scores of 2 (medium) were given to impacts on open space, environmental aesthetics, pollinators, and edible fauna based largely on the impact of the levee surface as habitat. An impact score of 1 was given to groundwater storage based on the impact of levees on water entering the river from the floodplain. All impacts of levees were rated as positive.

3.6.2.2 Beneficiary Analysis

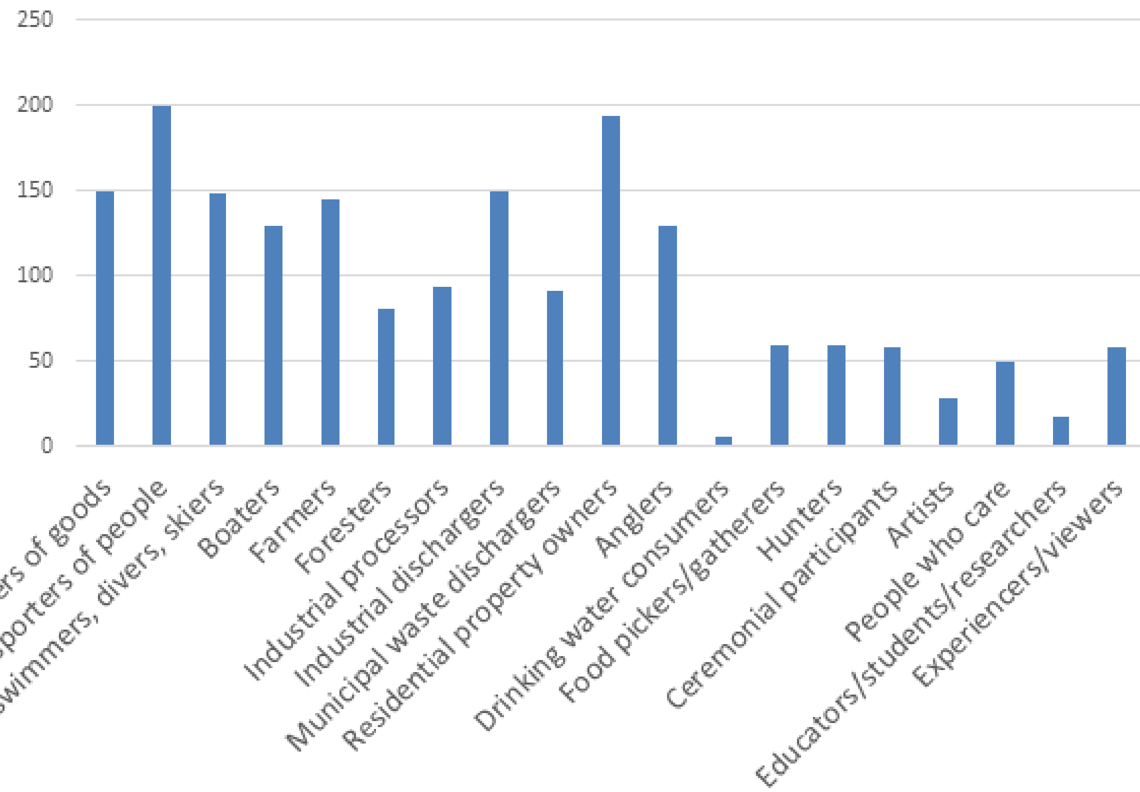


Figure 3.3 Combined impact and beneficiary importance scores for levee maintenance projects. All beneficiary groups with a non-zero combined score indicating significant impact are shown (x-axis). Combined scores range from -100 to 100 with zero indicating no impact.

Similar to stormwater projects, the most important attribute-beneficiary links were between river depth/flow and transporters, residential property owners, and industrial users of the river (Figure 3.3). Levees impact a broader set of river attributes than stormwater projects so added to this list are medium impacts of open space/naturalness on recreational users and property owners, ceremonial participants, and wildlife viewers. Medium importance also included the impact of groundwater on farmers and drinking water consumers. Low importance was assigned to the impact of naturalness/open space on recreational users of the river such as waders/swimmers based on access, as well as the impact of improved aesthetics on transportation of people based on an improved view. Overall, levee projects had the most attribute-beneficiary links of any project type.

3.6.2.3 Services Analysis

Levee maintenance projects had the most diverse impacts on services for the community reflecting their broad importance to multiple beneficiary groups. The largest service impacts were for economic production, consumption, and capital investment (Figure 3.4). Equally important were the impact of levee maintenance on the social services for public works, community/faith-based initiatives, and labor. Ecosystem services impacted were water quantity and quality in the river, greenspace, and provision of food-fiber-fuel. Levees create open space which can be used as publicly available land, river access, or as habitat for flora and fauna.

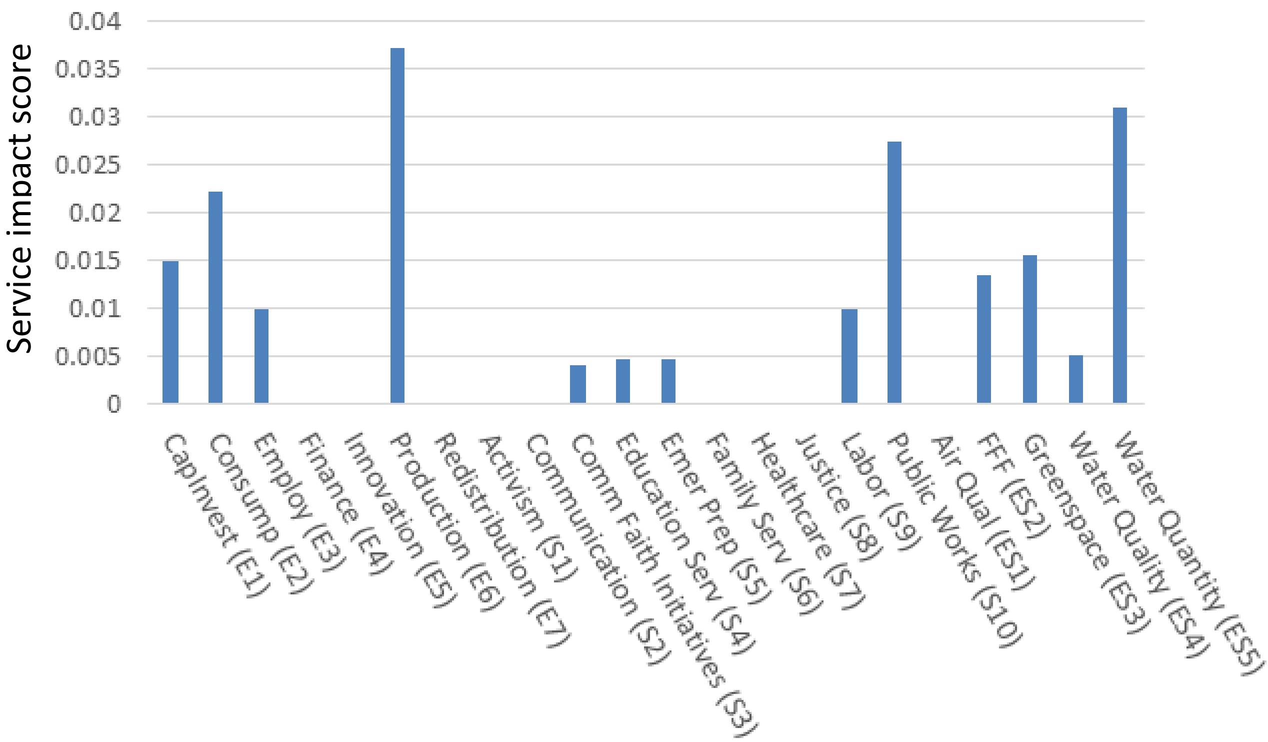


Figure 3.4 Service impact scores for levee maintenance projects. Service categories listed in the x-axis are grouped by type: Economic (E1), Social (S1), and Ecosystem (ES1) services. All services with a score contribute to the impact on community well-being. Service scores range from -0.5 to 0.5 with zero indicating no impact of this action category on a service.

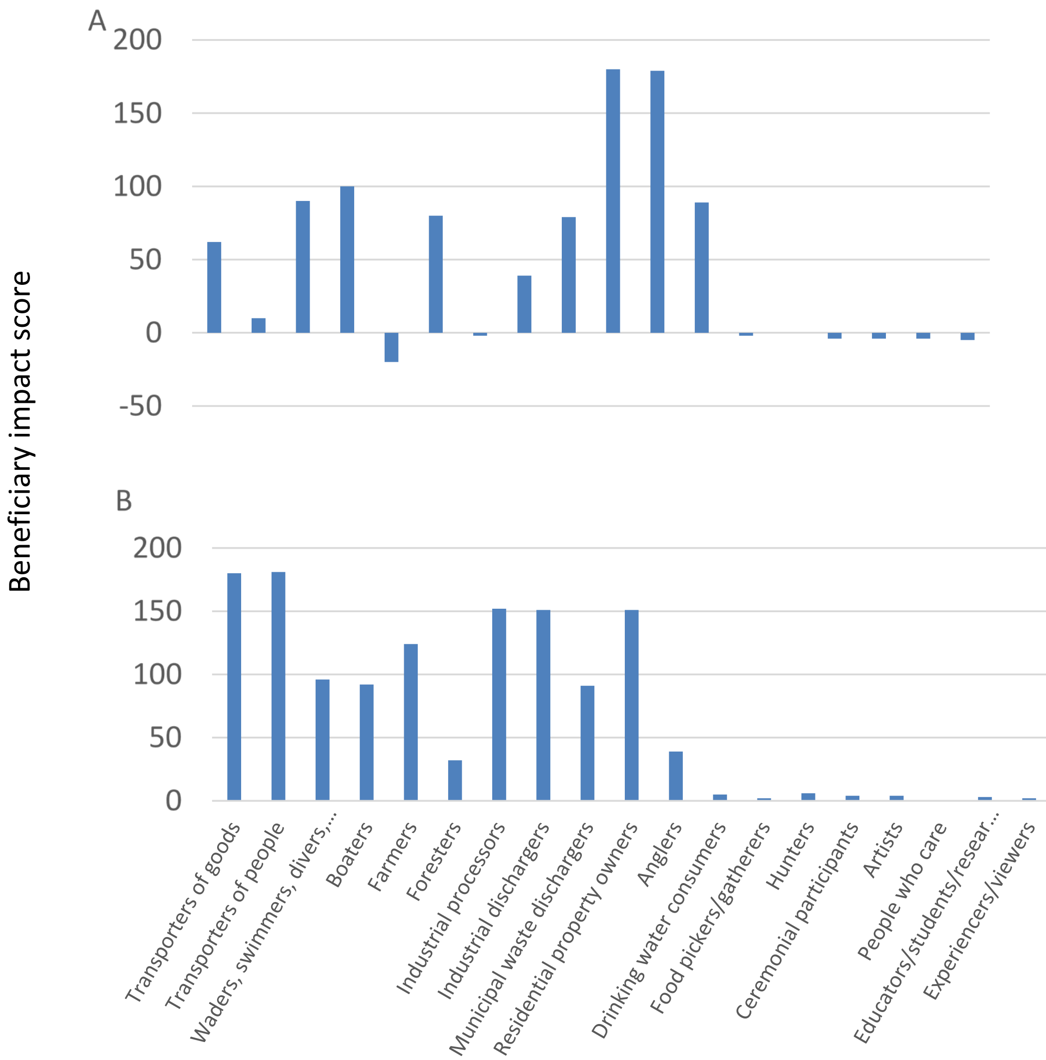


Figure 3.5 Combined impact and beneficiary scores for river pool/navigation projects: Dredging projects (A) and Lock/Dam maintenance projects (B). All beneficiary groups with a non-zero combined score indicating significant impact are shown (x-axis). Combined scores range from -100 to 100 with zero indicating no impact.

3.6.3 River Pool/Navigation

3.6.3.1 Impact Analysis

River pool navigation included two major types of projects: river dredging and maintenance of locks and dams. Both project types had the highest impact on surface water depth and flow. Locks/dams also had a score of 3 for reduction in flood risk (Table 3.5). Dredging had medium positive impacts on reduction in flood risk and medium negative impact on water quality metrics. Dredging also had a low negative relationship on naturalness based on deposition of dredge spoil, as well as on the fauna community of the river. In contrast, lock/dam projects create lentic habitat so have a smaller positive relationship on naturalness, fauna community (including commercially important species), and water quality.

3.6.3.2 *Beneficiary Analysis*

The most important attribute-beneficiary links for river pool/navigation projects are river depth/flow and industrial users of the river such as transporters and industrial processors (Figure 3.5). The flood risk-residential property owner link was also rated high importance as was the catchable fish-angler link based on increased habitat. Medium importance links included naturalness/habitat to farmers, experience viewers, and ceremonial participants. Medium links were also included for river water quality-industrial water users. Low importance links included naturalness-foresters and recreational users, as well as river flow/depth to foresters.

3.6.3.3 *Services Analysis*

Maintenance of river pool/navigation via dredging and lock/dam maintenance has its highest service impact on public works, economic production, and consumption reflecting the primary goal of supporting river navigation as an economic tool (Figure 3.6). Ecosystem services were also affected in the category of water quantity/quality in the river, and creation of greenspace. In this case the greenspace is in the river itself and reflects increased access and use of the river for recreational/experiential purposes.

3.6.4 Greenspace/Green Infrastructure

3.6.4.1 *Impact Analysis*

Community resilience projects were limited for analysis to development of greenspace and green infrastructure such as riparian/wetland buffer. These projects had a high impact score for creation of open space and a medium impact score for positive influence on flora and fauna via habitat (Table 3.5).

3.6.4.2 *Beneficiary Analysis*

These projects had the shortest list of attribute-beneficiary links among the four project types. Important links included open space-ceremonial participants, educators, experience viewers, and farmers (Figure 3.7). Medium importance was assigned to open space and flora links to anglers, artists, and hunters.

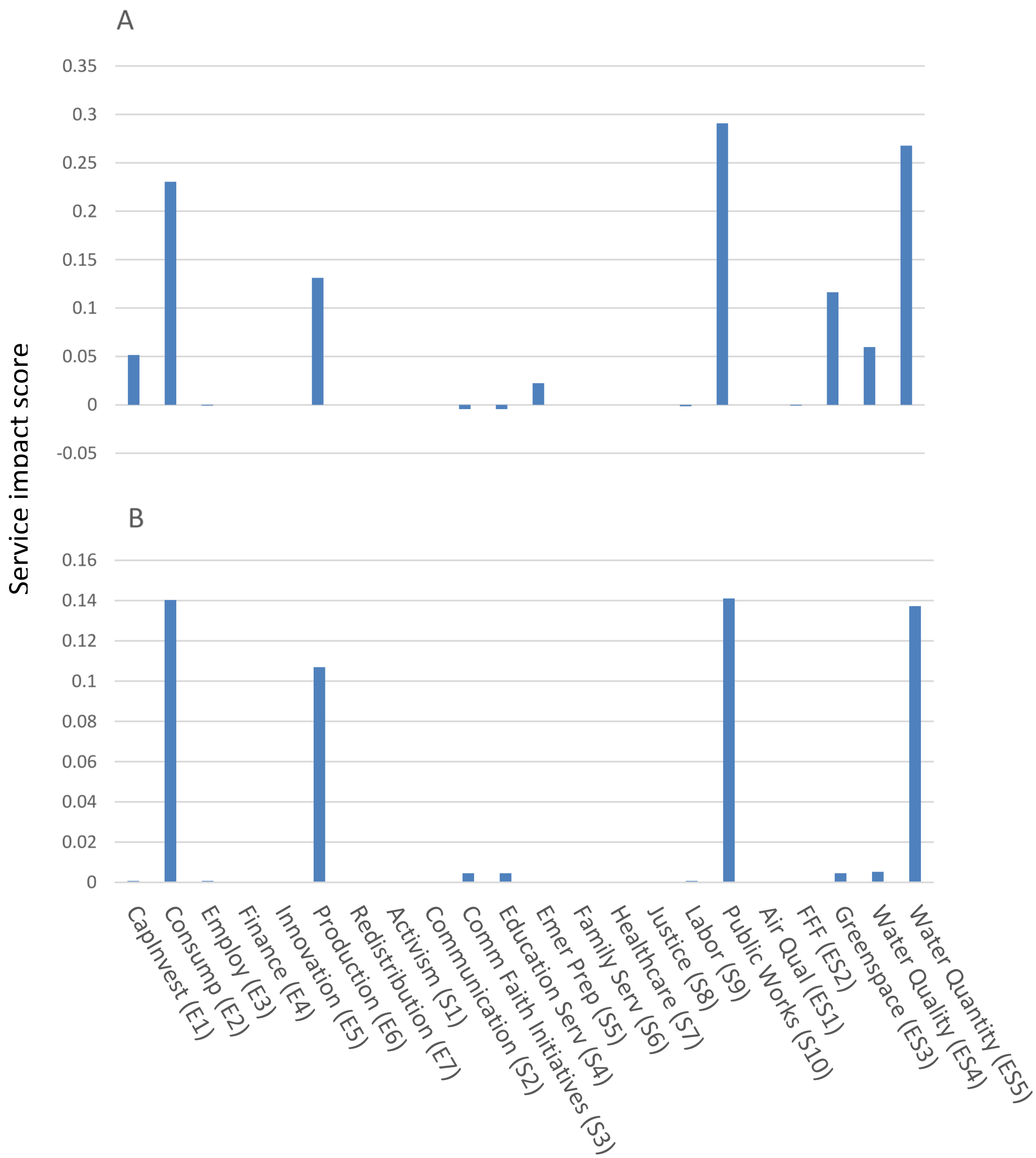


Figure 3.6 Service impact scores for river pool/navigation projects. Charts describe impacts of dredging (A) and Lock/Dam maintenance (B). Note change in scale of y-axis between (A) and (B). Service categories listed in the x-axis are grouped by type: Economic (E1), Social (S1), and Ecosystem (ES1) services. All services with a score contribute to the impact on community well-being. Service scores range from -0.5 to 0.5 with zero indicating no impact of this action category on a service.

Lower importance was assigned to open space-residential property owners, swimmers, and transporters of people. It is important to note that this discussion of greenspace projects is limited to those associated with the river.

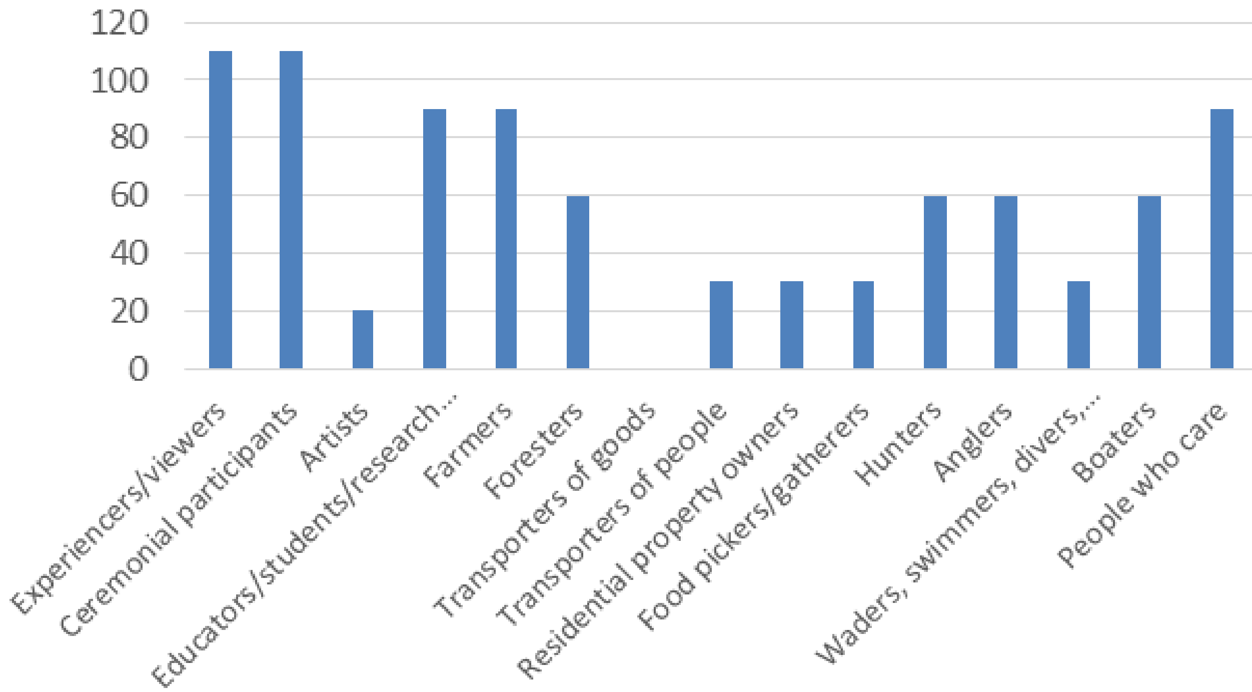


Figure 3.7 Combined impact and beneficiary scores for greenspace projects. All beneficiary groups with a non-zero combined score indicating significant impact are shown (x-axis). Combined scores range from -100 to 100 with zero indicating no impact.

3.6.4.3 Services Analysis

Creation and maintenance of open space and green infrastructure in association with the river was most influential on social services of community initiatives and education, as well as the ecosystem services of greenspace, and food-fiber-fuel (Figure 3.8). These projects also positively influenced economic production, labor, and employment. Greenspace tends to positively influence opportunities in the adjacent community which a link to growth and cohesion through indirect effects such as community building and property values.

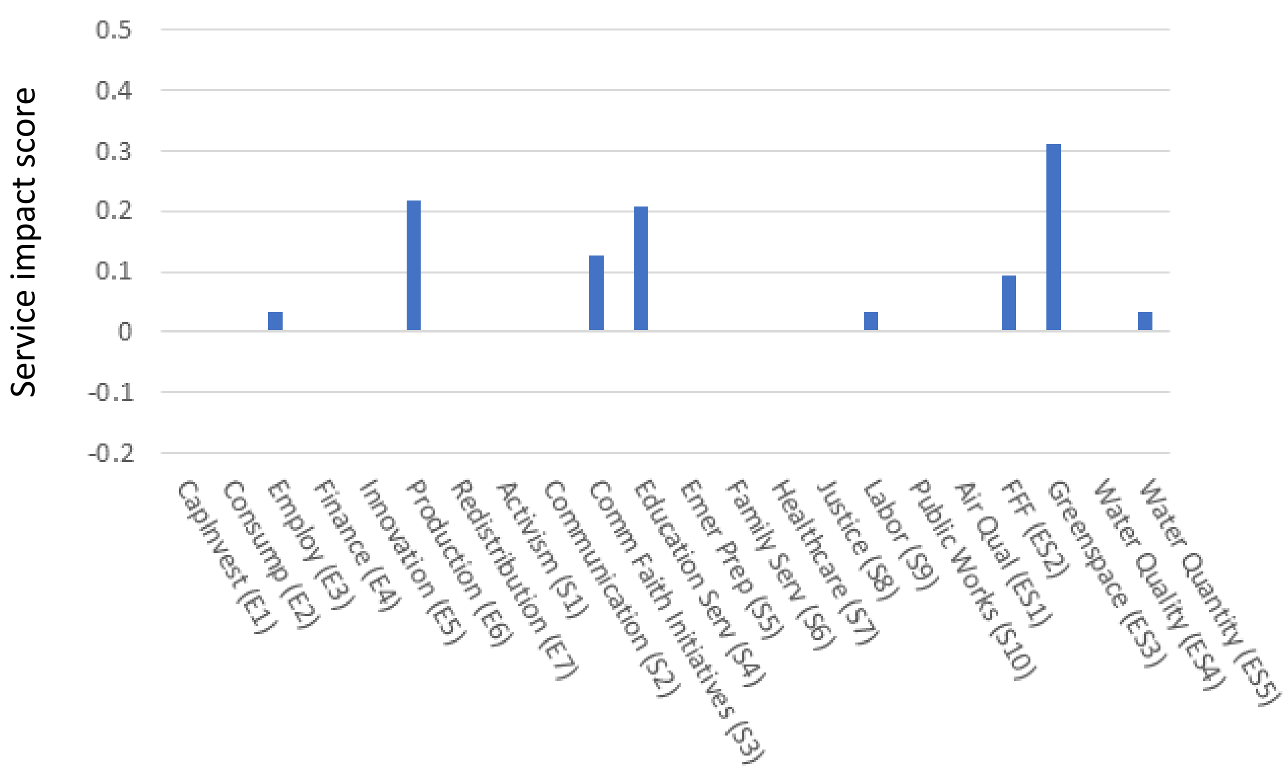


Figure 3.8 Service impact scores for greenspace projects. Service categories listed in the x-axis are grouped by type: Economic (E1), Social (S1), and Ecosystem (ES1) services. All services with a score contribute to the impact on community well-being. Service scores range from -0.5 to 0.5 with zero indicating no impact of this action category on a service.

3.7 Trajectories of Change

The estimated impacts on services described in the previous section were input into a multiple regression analysis linking proportional shift in services to a cumulative shift in domains of well-being (Summers et al. 2016). The proportional shift in services used are described in Table 3.9.

3.7.1 Stormwater Projects

Changes in the domains of human well-being reflect changes in economic, social, and environmental aspects of community well-being. Stormwater projects, such as pump stations and drainage, had a strong positive impact on Social Cohesion, Safety, and Education. Smaller positive impacts were observed for Work-life Balance, Health, and Cultural Fulfillment. Negative impacts were predicted for Living Standards and Connection to Nature (Figure 3.9).

3.7.2 Levee Maintenance

Overall well-being impacts from levee maintenance were smaller than for other project types reflecting the distribution of impact across a wider range of services. Positive impacts were predicted for Living Standards and Safety with a measurable negative impact on Education (Figure 3.9).

3.7.3 River Pool/Navigation

Navigation projects had the highest impact on well-being of the four project types, but several important trade-offs were observed. High positive impacts were predicted for Living Standards and Safety as well as Connection to Nature. Negative impacts were predicted for well-being domains of Work-life Balance, Education, Cultural Fulfillment, and Social Cohesion. These trade-offs reflect the alterations of the river that increase economic production (Figure 3.9).

3.7.4 Greenspace/Green Infrastructure

Greenspace projects such as parks and greenways impacted the most ecosystem services but the fewest overall services of the four project types. Impacts on well-being were generally positive with two key tradeoffs to consider. Negative effects were observed for Safety and Connection to Nature. These reflected the built nature of greenspace (i.e., not natural areas) and the connection of this action category to stakeholder outdoor recreation and social activity. Both of which promote Health and Social Cohesion but can reduce overall safety. Such trade-offs are generally correctable via planning (Figure 3.9).

NOTE: BECAUSE OF THE NEED TO NOT SPLIT GRAPHICS ACROSS PAGES, THIS MIGHT BE AN OPEN SPACE WHERE WE CAN PUT IN GRAPHICS OR OTHER ITEMS TO CUT DOWN ON BLANK SPACE

Table 3.9. Service Change Scenarios for Each Action Category Used to Project Changes in HWBI Domains. Proportional changes in service were calculated based on action category-specific benefit-impact scores. Proportional changes in service in each action category column below were used to inform a regression of service categories on the domains of HWBI. Each column is a set of coefficients for a single regression analysis and these values can be used to understand the relative influence of each service on change in human well-being described in Figure 3.9. All non-zero values are important drivers of well-being.

Action Category	Stormwater Projects		Levee	River Pool/Navigation		Community Resilience
Subcategory	**Pump stations**	**Drainage projects**	**Levee maintenance**	**Dredging projects**	**Lock/Dam maintenance**	**Greenspace**
Service	**Prop. Change**	**Prop. Change**	**Prop. Change**	**Prop. Change**	**Prop. Change**	**Prop. Change**
Capital investment	0.0729	0.1	0.0024	0.0083	0.0001	0
Consumption	-0.0073	0.001	0.0036	0.0372	0.0226	0
Employment	0	0	0.0016	-0.0001	0.0001	0.0054
Finance	0	0	0	0	0	0
Innovation	0	0	0	0	0	0
Production	-0.0083	0.0043	0.006	0.0212	0.0173	0.0341
Re-Distribution	0	0	0	0	0	0
Air quality	0	0	0	0	0	0
Food-fiber-fuel provisioning	-0.0007	0.002	0.0022	-0.0001	0	0.0143
Greenspace	-0.009	0.0043	0.0025	0.0188	0.0007	0.0484
Water quality	0.0007	0.002	0.0008	0.0096	0.0009	0
Water quantity	0.0052	0.007	0.005	0.0432	0.0222	0.0054
Activism	0	0	0	0	0	0
Communication	0	0	0	0	0	0
Community and faith-based initiatives	0	0	0.0007	-0.0007	0.0007	0.0197
Education	0	0	0.0007	-0.0007	0.0007	0.0323
Emergency preparedness	0.0312	0.0043	0.0008	0.0036	0	0
Family services	0	0	0	0	0	0
Healthcare	0	0	0	0	0	0
Justice	0	0	0	0	0	0
Labor	0	0	0.0016	-0.0002	0.0001	0.0054
Public works	-0.0066	0.00124	0.0044	0.0469	0.0228	0

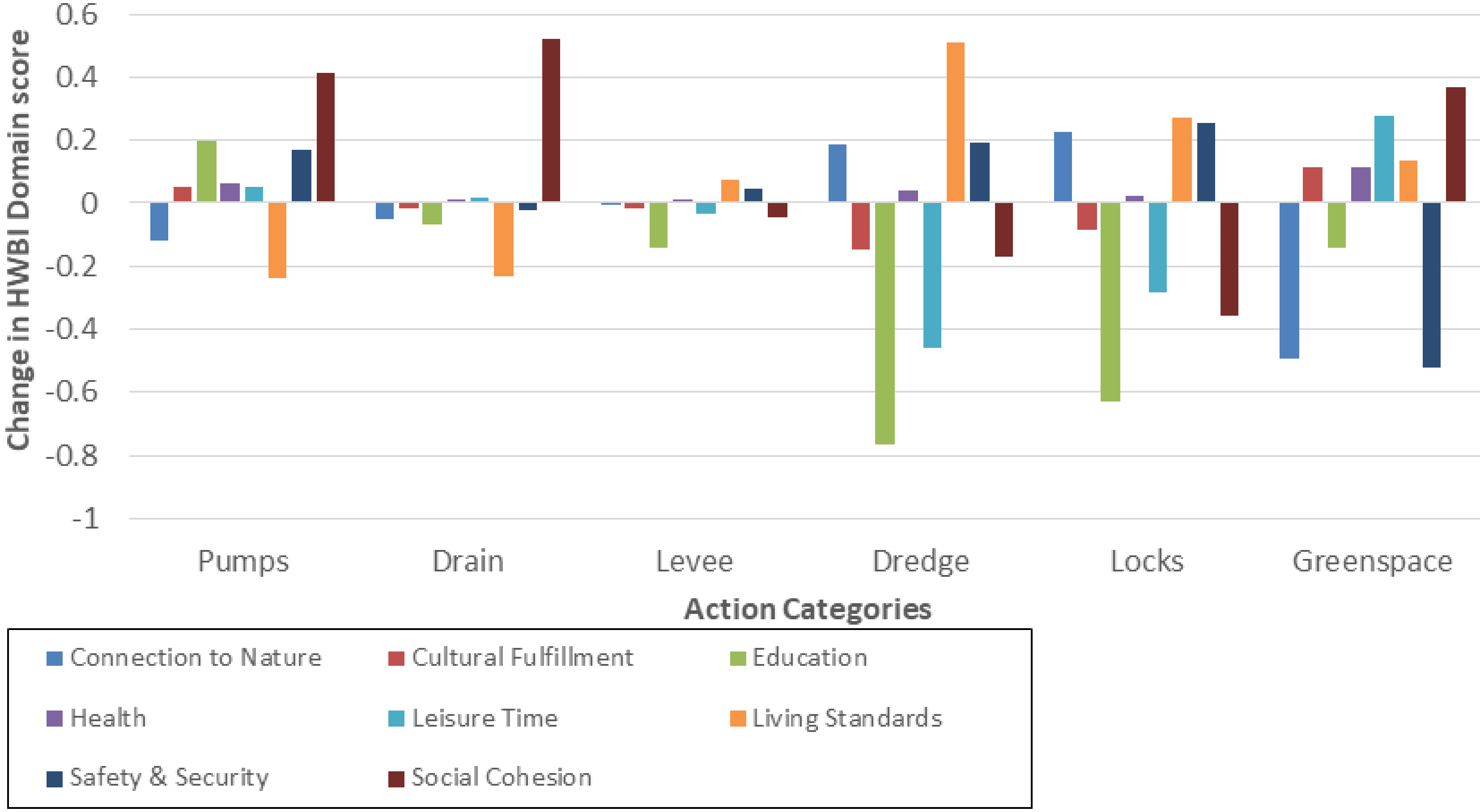


Figure 3.9 Summary of absolute change in HWBI Domain scores based on action category specific scenarios of investment. Baseline domain scores are given in Table 3.1 and described in Section 3.5. The results for each action category are derived from a regression analysis of the percentage changes in service described in Table 3.9.

4 Discussion and Conclusions

4.1 Ecosystem Services of the River

The river provides a wide variety of services to stakeholders including economic impacts like supporting industry and creating jobs. It also provides social services in the form of community identity and social activities like outdoor recreation. A cornerstone of many cultural events that define life in both Ouachita Parish and the cities of Monroe and West Monroe, the river also provides ecosystem services in the form of access to nature, natural resources like water and harvestable fish, and a transportation corridor that is cheap and easy to access. However, these services must be viewed in combination with built infrastructure that both support these services and ameliorate the trade-offs (e.g., the risk of flooding). This analysis considers both natural services and the supporting infrastructure. The findings demonstrate comprehensive value for supporting the combination of nature and infrastructure based on the resulting value-added contribution to human well-being. Some key examples of where this combination is having an important effect are related to river navigation and levees.

River navigation maintained through maintenance of lock/dams and dredging activities is an important economic driver for Ouachita Parish. It contributes to community identity and stability, as well as access to recreational opportunities associated with an optimal river depth (e.g., boating). However, these services come at a cost of increased risk of flooding in riverside communities resulting from more consistent river depth. This risk is reduced by drainage projects, investment in pump stations, and rigorous maintenance of the levee system. In tandem, the natural and built infrastructure greatly increases the well-being benefit of the river, particularly for providing social services.

Levees provide a river channel and create a sharp transition between river and land. This sharp transition creates livable space just behind the levees that would not otherwise be available for use. How this space is used greatly impacts social and ecosystem services of the river to stakeholders. An emphasis on greenspace in this transition area (e.g., on and just outside the levees) greatly increases service to the community and contributes to well-being through recreation, community identity, and attraction of new residents.

Overall, the river and its services, when well-maintained, contribute positively to community well-being, largely in the areas of Social Cohesion and Safety. There is also a significant contribution to Living Standards and Health, which were both ranked as highly important by Parish residents. Economics is often the focus and justification for infrastructure investment, yet when this investment is combined with sustaining and even enhancing ecosystem services, many measurable impacts are social and environmental, and these are important to promoting human well-being.

4.2 Beneficiaries of River Services in Community

The most important beneficiaries of river services are residential property owners, particularly those close to the river, and industrial operators associated with the river. Recreational users are also a large and diverse group that benefit from maintenance of river depth and the creation of habitat along the river for recreational purposes such as boating, fishing, and outdoor enthusiasts. The beneficiaries and associated services under consideration were assembled based on Workshop 1 data and a beneficiary analysis completed by ORD scientists and based on local expert knowledge of Ouachita Parish. These data were presented for comment during Workshop 2. The full list of Beneficiaries is in Table 3.1. It is important to note that beneficiaries are not individual people but interests that overlap across people and groups. A person may fit multiple beneficiary groups and they all collectively support that person's well-being. This means the effect on the beneficiary categories of an action, such as levee maintenance, are not independent of each other but collective in their impact on well-being.

4.2.1 Stormwater Projects

4.2.1.1 Pump Station Projects

The primary beneficiaries are residential property owners, and industrial concerns near the river. Benefits to farmers are also high. Positive, benefits are also predicted for foresters, river transporters, and beneficiaries of waste discharge. Anglers, boaters, and drinking water consumers are predicted to experience small negative effects resulting from pumping stormwater into the river.

Services that affect these beneficiaries are concentrated in economic categories for Capital Investment and the social category of Emergency Preparedness. Ecosystem services of the river affected by pump stations are availability of greenspace (negative) and quantity of water in the river (negative) but these effects were minor and associated with land used for pump stations and stormwater in the river.

4.2.1.2 Drainage Projects

The primary beneficiaries affected by drainage projects are residential property owners, industrial facilities near the river, and farmers in the flood plain. Positive benefits were also estimated for river transporters, waste dischargers, foresters, recreational users of the river, and drinking water consumers. No negative benefits were estimated from drainage projects.

Services enjoyed by these beneficiaries were concentrated in economic categories like Capital Investment, Production, and Consumption. The social category Emergency Preparedness was also highly impacted. Ecosystem services impacted by drainage were food-fiber-fuel, greenspace, water quality, and water quantity in the river. Water quality was a positive owing to natural filtration associated with gravity drainage.

Drainage projects are better for ecosystem benefits than pump stations, but this might be adjusted based on pump station planning that integrated greenspace into the plan.

4.2.1.3 Levee Maintenance

Beneficiaries from maintenance and repair of levees (both local and along the river) included nearly all (19) user groups from residential, industrial, and recreational beneficiary categories.

Benefits in the industrial categories were highest, but recreational was also important based on enjoyment of the water level in the river and creation of novel habitat for fish and wildlife. Services enjoyed by these beneficiaries were dominated by economic categories like Production, Capital Investment, Consumption, and Employment. Social service categories of importance were Public Works, Emergency Preparedness, Availability of a Labor Pool, and Community Building. Ecosystem service benefits were highest for this action category and included water quantity and quality in the river, food-fiber-fuel, and availability of greenspace including river availability for recreation and aesthetics. Levee maintenance benefits people in the economic, social, and ecosystem categories which combine to provide overall well-being benefits.

4.2.1.4 Greenspace Development

Beneficiaries of near-river resilience projects like greenspace development include recreational users, but also include indirect benefits of open space to farmers and foresters, as well as people who use the river for transportation. There are also indirect benefits to people aesthetically and for hunting and gathering.

Services enjoyed by described beneficiaries are dominated by social categories like Community Building and Education, but also include economic categories associated with quality of life such as Production. Ecosystem services increased by greenspace are availability of open space for recreation, harvesting of food-fiber-fuel, and indirect contributions to water quantity in the river (e.g., drainage).

Greenspace is any publicly available open space in a community so the services provided can be a part of other projects (e.g., drainage) and so change the service delivery of those projects. This trade-off is an important component of planning for maximizing human well-being.

4.2.1.5 River Pool/Navigation Projects

Beneficiaries of maintaining the lock and dam system on the river are dominated by users of the river such as transporters, recreational boaters and swimmers, and wastewater dischargers. Flood control also is a factor benefitting farmers, foresters, property owners, and industrial facilities near the river. Finally, there is a smaller positive benefit from habitat creation to food gatherers, nature viewers, hunters, and community group development around these activities. While it can be argued that river level maintenance removes the 'naturalness' from the river, this is only in comparison to the uncontrolled past. The locks serve as a regime shift of sorts in river habitat and support wildlife and plants that favor current conditions on the river. For instance, creation of larger portions of reservoir habitat support navigation but also vastly increase habitat for lotic species and recreational access to lakes.

Services enjoyed by these beneficiaries are evenly distributed among the economic services consumption and production, the social services of public works, and the ecosystem services of water quantity in the river. There is also associated social services stemming from water quantity for community building and education. A central point here is that habitat creation is a part of navigation control. The level of focus on this benefit will vary by project but seems to be important in the Ouachita River system.

4.2.1.6 Dredging for Navigation

Beneficiaries of dredging projects are dominated by transporters of goods and transporters of people. There are slightly smaller benefits to property owners and industrial concerns near the river from a reduction in flood risk. Dredging does impact some beneficiary groups negatively because of dredging impacts on water quality and clarity—as well as a reduction in naturalness of carving out a navigation channel and moving the material into the shallow water areas of the river. These negative impacts are estimated to be relatively small as the outcome is to move material around in the river, not to add material to the river.

Services enjoyed by these beneficiaries are dominated by the social service of public works, the economic service consumption, and the ecosystem service of water quantity. Smaller positive benefits to greenspace and water quality are also ecosystem service impacts. There is an estimated net negative impact on food-fiber-fuel (habitat loss) and community building (less recreation) from dredging. However, the importance of these negative impacts can be abrogated based on dredging approach, particularly dredge spoil placement along the River.
Dredging has both positive and negative impacts on river services, but net positive with the potential to minimize negative impact through approach planning.

4.3 Well-being of Ouachita Parish

The Human Well-being Index is a comparative tool for Ouachita Parish to use as a meaningful benchmark for strategic planning. Overall well-being scores in Ouachita parish are about average. Although Connection to Nature is a Parish high score, it is lower than average for the neighboring Parishes, which may be an effect of the Monroe metro area being included in this score. Meaningful individual Connection to Nature is high compared to other domains but low for the area and about average for Louisiana, so this is a generally high category for the region. Social Cohesion is one of the lowest and ranks below average across the board, so is an area worth focusing on for improvement (Note community gave high weight to this Domain in WS1).

Ouachita Parish also scored well in Health and Work-life Balance—slightly above average both nationally and for the state (Table 3.7). The Health and Work-life Balance scores reflect community investments in availability of healthcare, as well as an emphasis on family life and recreational time. The domains for Safety and Living Standards were ranked higher in importance by residents than Health or Work-life Balance during Workshop 1.

In terms of objective HWBI scores, Ouachita Parish scored above average for Safety and below average for Living Standards compared to neighboring parishes in Louisiana. This gives the community some guidance for judging change, as we will focus on those domains with a high score and those domains rated as important by stakeholders. Changes in HWBI were projected based on changes in availability of river services providing a useful tool for examining the human impact of decisions that affect the River.

4.4 Well-being Impacts of Proposed Actions

Human well-being is separated into eight general domains that differ in relative importance to Community well-being. Differences in impacts of action categories on the domains of well-being represent investments and trade-offs that should be highlighted as some of them can be maximized through small alterations to the project approach. Below we discuss key take-away messages for the estimated impact of various action categories on well-being while emphasizing the fact that economic, social, and ecosystem services are increased by all these actions.

4.4.1 Pump Stations

Pump systems have a strong positive effect on Social Cohesion, Education, and Safety from impacts on community stability. Negative effects were predicted for Connection to Nature and Living Standards based on public land loss. For example, the cost of pumping, and the associated land loss needed for pumps, have negative impacts on some aspects of human well-being but represent a trade-off with increases in Safety and Community Strength.

4.4.2 Drainage Projects

Drainage projects have a strong positive influence on Social Cohesion with small or neutral effects on other domains except negative effect on living standard resulting from increases in capital investment and conversion of neighborhood land for drainage improvements. Drainage projects help with stability but come at a cost of non-economic public resources. This could be countered with inclusion of greenspace projects in the drainage plan, such as in West Monroe.

4.4.3 Levee

Service impacts of functioning levees are varied and broad resulting in predicted positive effects on Living Standards and Safety with smaller negative impacts on Connection to Nature and Work-life Balance from spatial impacts (barrier to river, limit connectivity of community). Generally positive impacts on well-being compared to other project types based on diverse positive service impacts. This demonstrated that levees affect most aspects of community well-being (social/environmental as well as economic) and yielded “yes/no” responses rather than “high/low” as compared to the other action categories.

4.4.4 Dredging Projects

Dredging projects mimic the well-being impacts of levees but with slightly more magnitude of highs and lows. Dredging had a positive impact on Living Standards and Safety based on impacts in commerce and navigability of the river. The positive impact on Connection to Nature results from contributions to status quo habitat of the river system. Negative impacts of dredging on naturalness can be reduced if this is a priority of dredge planning, such as placement of spoil. Non-economic impacts of dredging include increases in greenspace and water quality/quantity in the river and the positive social impacts of a public works investment and social stability from emergency preparedness.

4.4.5 Locks/Dam Maintenance

Locks and dams, in addition to stabilizing river depth for navigation, create lake habitat along the river, which is a shift from natural condition, but is also a benefit to certain flora and fauna and represents a form of greenspace creation. Highest positive well-being impacts of locks and dams are for Safety followed by Living Standards based on stability of river pool depth. Influence is also positive for Connection to Nature based on habitat creation, and negative for Education, Health, and Cultural Fulfillment as ancillary impacts of navigation support and community building. Most non-economic impacts come from services provided by river pool depth, such as water quantity, the positive social benefits of a public works project, habitat creation near lakes as greenspace, and maintenance of water quality in the river.

4.4.6 Greenspace

Greenspace is created public space not developed for other purposes and available for outdoor leisure activities. It is not necessarily natural space, such as protected land, but more often parks or open land with no specific use. Greenspace increases well-being in Social Cohesion and Work-life Balance with smaller positives for Health, Living Standards, and Cultural Fulfillment. Greenspace can have a negative effect on Safety and Connection to Nature, as it brings people outside but attracts them to built-space rather than purely natural-space. However, as highlighted already, such trade-offs can be accounted for in planning of combinations of built infrastructure and greenspace. Further, addition of greenspace to other types of actions, such as drainage projects, yields positive effects not observed when greenspace is not included. Well-being is maximized when greenspace is combined with public safety projects in such a way as to enhance other important well-being domains.

5 Future Recommendations

5.1 What to do next?

In response to 2016 flooding impacts, the Ouachita Council of Governments (OCOG), in cooperation with state and federal flood management authorities, formed Ouachita Strong with the objective of making Ouachita Parish more resilient to future flood events. This investment prioritizes a comprehensive approach to both risk management and community planning for flood recovery. The results of this ecosystem services analysis can support Ouachita Strong priorities by providing important guidance on how:

- Resilience plans should account for community fundamental objectives regarding important ecosystem goods and services
- Those services interact with built infrastructure to support community well-being.

In addition to Safety, high priority domains of human well-being in Ouachita Parish are Social Cohesion and Living Standards. The latter two are best served by an integrated project approach that prioritizes (1) ecosystem services, such as greenspace and water quality and (2) social services, such as education and public works. Targeting community well-being and ecosystem services has several important advantages. First, it is a comprehensive approach that integrates economic, social, and environmental outcomes. Second, it is inclusive in that community values and goals can be easily combined and translated into well-being domains as demonstrated in this report. Finally, the well-being approach provides a pathway to integrating different types of projects to maximize improvements across as many domains of community well-being as possible. The stakeholder input obtained for this report and its analysis support the following recommendations:

- Use the findings of this report to integrate ecosystem service priorities and human well-being endpoints into the planning process as targets for resilience and recovery actions.
- Consider trade-offs between economic, social, and environmental services present in major action categories in developing specific actions, such as stormwater projects, to maximize the well-being improvements.
- Invest in critical infrastructure, such as levee maintenance that supports ecosystem services of the Ouachita River and highlight these services to stakeholders.
- Recognize the impact of direct service enhancements, such as creation of greenspace, as a critical element of resilience and community identity and broaden the impact of actions on well-being.
- Identify all river ecosystem services as vital community resources that require support and should be considered in measuring restoration success.

5.2 Combination with other data

These findings and recommendations should be viewed as a part of a larger discussion on the services to stakeholders from combinations of ecosystem services and built infrastructure intended to maximize human benefit from the Ouachita River. The economic value of the Ouachita River to communities in northeastern Louisiana and southeastern Arkansas has been the subject of a recent valuation study (Eisenstadt and Nelson 2017). This report complements and expands on their valuation by considering how to value social and environmental benefits and by focusing on the communities of Monroe and West Monroe, LA as a complex but approachable group of people with diverse priorities. The combination of findings will allow for a comprehensive communication of services from the Ouachita River. This will support decision making where the goal is the collective well-being of all citizens and the sustainability of all services.

6 References

Boyd, J., & Banzhaf, H. S. (2007). What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics, 63*(2-3), 616-626.

Bradley, P., Fisher, W., Dyson, B., Yee, S., Carriger, J., Gambirazzio, G., Bousquin, J., & Huertas, E. (2016). *Application of a structured decision process for informing watershed management options in Guánica Bay, Puerto Rico*. U.S. Environmental Protection Agency, Office of Research and Development, Narragansett, RI. EPA/600/R-15/248.

Eisenstadt, R. C., & Nelson, P. S. (2017). *The economic impact on Arkansas and Louisiana of the Ouachita River*. Researched and prepared for the North Louisiana Economic Partnership. Monroe, Louisiana: University of Louisiana at Monroe.

Fulford, R. S., Smith, L. M., Harwell, M., Dantin, D., Russell, M., & Harvey, J. (2015). Human well-being differs by community type: Toward reference points in a human well-being indicator useful for decision support. *Ecological Indicators,* 56: 194-204.

Fulford, R. S., Bruins, R., Canfield, T. J., Handy, J. B., Johnston, J. M., Ringold, P., Russell, M., Seeteram, N., Winters, K., & Yee, S. (2016a). *Lessons learned in applying ecosystem goods and services to community decision making, community-based decision support*. U.S. Environmental Protection Agency, Gulf Breeze, FL. EPA/600/R-16/136.

Fulford, R. S., Russell, M., Harvey, J., & Harwell, M. C. (2016b). *Sustainability at the community level: Searching for common ground as a part of a national strategy for decision support.* U.S. Environmental Protection Agency, Gulf Breeze, FL. EPA/600/R-16/178.

Gregory, R. S., & Keeney, R. L. (2002). Making smarter environmental management decisions. *Journal of the American Water Resources Association*, 38:1601-1612.

Keeney, R. L. (1992). Value-focused thinking: A path to creative decision making. Harvard University Press.

Landers, D. H., & Nahlik, A. M. (2013). *Final Ecosystem Goods and Services Classification System* (FEGS-CS). U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory. EPA/600/R-13/ORD-004914.

Louisiana State University (LSU) (2017). *Ouachita Parish hazard mitigation plan update*. Prepared by Stephenson Disaster Management Institute, LSU, for Ouachita Parish, Louisiana.

Nahlik A. M., Kentula, M. E., Fennessy, M. S., & Landers, D. H. (2012). Where is the consensus? A proposed foundation for moving ecosystem service concepts into practice. *Ecological Economics,* 77: 27-35.

Ouachita Parish Police Jury (OPPJ) (2019). *History of Ouachita Parish*. https://www.oppj.org/residents/

Ouachita Parish School Board (OPSB) (2019). *Colleges.* https://www.opsb.net/213092_2

Restore Louisiana Task Force (RLTF) (2016). *March 2016 Flood Event, Ouachita Parish, Louisiana*. RLTF Meeting Document. http://d2se92fabdh4cm.cloudfront.net/wp-content/uploads/2016/12/Ouachita-Parish-RLTF-Meeting-Document.pdf

Smith, L. M., Case, J. L., Smith, H. M., Harwell, L. C., & Summers, J. K. (2013). Relating ecosystem services to domains of human well-being: Foundation for a U.S. index. *Ecological Indicators,* 28:79-90.

Summers, J. K., L.C. Harwell, L. C., & L.M. Smith, L. M. (2016). A model for change: An approach for forecasting well-being from service-based decisions. *Ecological Indicators,* 69:295-309.

USACE. (1993). *Water resources development of Louisiana*. U.S. Army Corps of Engineers.

USACE. (2009). *Inland waterway navigation, value to the nation*. U.S. Army Corps of Engineers, Institute for Water Resources. https://www.iwr.usace.army.mil/Portals/70/docs/VTN/VTNInlandNavBro_lores.pdf

USACE. (2018). *Levee portfolio report, a summary of risks and benefits associated with the USACE levee portfolio*. U.S. Army Corps of Engineers, Levee Safety Program.

USACE. (2019a). *RiverGages.com, water levels of rivers and lakes, station: Ouachita River at Monroe, Louisiana*. http://rivergages.mvr.usace.army.mil/WaterControl/stationinfo2.cfm?sid=D11732CA&fid=MLUL1&dt=S

USACE. (2019b). *Welcome to the Ouachita/Black River Area*. https://www.mvk.usace.army.mil/Missions/Recreation/Ouachita-Black-River/

U.S. Environmental Protection Agency. (2014). *A U.S. Human Well-being Index (HWBI) for multiple scales: Linking services provisioning to human well-being endpoints (2000-2010).* EPA/600/R-14/223. pp. 200. http://tinyurl.com/synth-1222.

7 Appendices

7.1 *Appendix A - Full description and examples of the eight domains of human well-being used to organize discussions of community fundamental objectives.*

The domains were called community 'Goals' during Workshop 1 discussions to assist stakeholder identification and prioritization of community fundamental objectives.

Goal	What does it mean?	Examples of what a community can do
Education		
Basic educational knowledge and skills	Basic knowledge and skills obtained through grade school (K-8) education in areas such as reading, math, and science	• Provide a quality K-8 education • Support children's participation in school
Positive social, emotional, and physical development of children and youth	Getting a good physical and emotional start in life and learning how to have healthy social interactions with others	• Support quality pre-school programs and daycare • Provide young reader programs in libraries • Support young parents (e.g., with parenting workshops) • Provide safe and healthy schools, free from bullying • Support public pediatric and teen clinics
More advanced knowledge and skills	More advanced knowledge and skills obtained through high school, college, adult education, and job training	• Provide a good quality high school education • Provide services to help at-risk youth stay in school • Provide strong career guidance services in high school • Offer adult literacy and GED classes • Provide job training, placement, and counseling services
Health		
Reasonable life expectancy	Living a long, productive life	• Support clinics and provide affordable transit to clinics for expectant mothers, infants, older adults, and the disabled • Support suicide prevention services
Physical and mental well-being	Good health and freedom from debilitating physical and mental illnesses like heart disease, cancer, diabetes, asthma, obesity, and depression	• Prevent pollution that causes asthma and other diseases • Educate residents on how to lower the risk of diabetes, coronary heart disease, and obesity • Provide safe streets and parks for walking, biking, and play • Help de-stigmatize depression and support treatment
Emotional well-being	Feeling good about ourselves and being satisfied with our lives	• Take actions to help reduce residents' stress (e.g., provide safe neighborhoods, affordable places to live) • Support diverse local cultural opportunities and social events
Good quality healthcare	Access to quality family doctors, hospitals, and other healthcare providers	• Support community clinics • Recruit and retain private family medical practices • Provide public transit between residences, clinics, and medical offices

Goal	What does it mean?	Examples of what a community can do
Healthy lifestyle and behavior	Making and helping others make healthy choices, like eating well and avoiding risky behaviors	• Educate teens about the risks of smoking and alcohol consumption • Provide after-school programs that promote healthy social interactions and help teens make smart choices • Support smoking cessation programs • Provide workshops on healthy eating and nutrition
Work-Life Balance		
Enough time available for basic leisure activities	Having enough time available to socialize with friends and family, enjoy group activities, and just relax	• Support good connections between affordable places to live, work, and shop to minimize time commuting and running errands • Provide safe neighborhoods for strolling • Provide neighborhood parks and other public meeting places
Enough time available for physical activity and vacation	Having enough time available for physical activity, such as running, walking, and gardening and to get away on vacation and visit out-of-town family and friends	• Support good connections between affordable places to live, work, and shop to minimize time commuting and running errands • Provide safe neighborhoods for running, walking, and gardening • Provide good transportation options to public exercise programs • Provide good access to nearby travel destinations, interstate highways, and airports
Reasonable balance between leisure time, work, and caring for others	Finding a healthy, sustainable balance between the hours that we work and that we spend providing care for older family members and the hours that we devote to ourselves	• Support affordable transportation and housing options so people do not need to work long hours or multiple jobs to survive • Provide social services to assist caregivers • Provide affordable access to elderly care facilities and providers
Living Standards		
Ability to afford basic necessities	Ability to afford housing and to feed and clothe ourselves and our families	• Support diverse economic development and job opportunities • Support affordable transportation and housing • Provide job training, placement, and counseling services • Support affordable access to day care
Reasonable income	Having enough income to go beyond the most basic needs and afford healthcare, get to work, improve job prospects, etc.	• Support diverse economic development and job opportunities • Provide public transit between housing and job centers • Support post-secondary education and job training
Reasonable wealth	Equity in a home and other assets that helps provide options to adapt to hardships, retire, and/or leave something for future generations	• Provide services to assist residents in addressing credit issues • Help residents access down payment and mortgage assistance programs • Implement development policies that support/increase home values • Provide home improvement assistance programs

Goal	What does it mean?	Examples of what a community can do
Job stability and satisfaction	Stable and satisfying job situation that provides confidence in the future and allows for smart decisions about spending and saving	• Support diverse economic development and job opportunities • Work with local businesses and provide education, job training, and job retraining to meet current and future needs
Safety and Security		
Being safe	Safety from crime, accidents, and other hazards, such as natural or man-made disasters	• Invest in strong police, fire, and emergency medical services • Enforce safe building codes • Provide safe streets for pedestrians, bikes, and cars (e.g., crosswalks, traffic calming features, streetlights) • Build public infrastructure to withstand anticipated natural hazards • Cooperate with local industries to develop risk management plans
Feeling safe	The feeling of being safe that allows us to live productive lives, visit others, and enjoy our surroundings	• Provide easily observed safety measures (e.g., police patrols) • Create policies that support property upkeep and prevent blight • Maintain well-lighted and well-maintained streets • Provide community with crime statistics • Support community watch and "safe routes to schools" programs
Resilience to hazards	Ability to cope with hazards (e.g., natural disasters) when they occur and sustain yourself and your family so you can quickly get back to normal and limit the impact of the event	• Support community-wide natural disaster planning, preparedness, and response • Provide educational resources for preparedness • Support access to disaster assistance for low-income, elderly, and disabled persons
Connection to Nature		
Connectedness to nature	Sense of emotional connection with other living organisms and our natural surroundings	• Provide safe and accessible public parks, trails, etc. • Offer affordable nature centers and education programs • Support organizations that promote outdoor activity • Support outdoor recreation businesses (e.g., sport fishing)
Cultural Fulfillment		
Cultural Fulfillment	Sense of connection with the "culture" of our ancestors and our existing community, including a sense of our shared history, cuisine, social habits, music, arts, language, religion, etc.	• Support community organizations and community events that celebrate different cultures (e.g., fairs, art exhibitions, music) • Create mixed-use zones that support small shops and restaurants with different cultural affiliations • Invite churches of all denominations to participate in community events • Create and support a historical society • Create a historical district

Goal	What does it mean?	Examples of what a community can do
Social Cohesion		
Healthy family bonding	Family bonding in a way that helps us value the importance of spending time together and interacting with others in a healthy, open-minded, and respectful way	• Provide social support services for young parents (e.g., parenting workshops, play groups) • Provide local reading programs (e.g., through the library) • Provide free and affordable public places for family recreation
Supportive network of friends and family	Network of extended family and friends that we can count on to support us through tough times and helps us understand the value of having and being a trustworthy friend to others	• Provide walkable, bike-friendly neighborhoods and parks for people to meet and enjoy time with neighbors • Provide safe streets and transit between different neighborhoods • Support businesses that provide gathering places (e.g., music venues, restaurants)
Regular participation in social community activities	The sense of community that comes from participating in social community activities (e.g., as a member of an organized group, volunteer, or teammate in a local sports league)	• Provide places for community groups to meet (e.g., senior center, library facilities) • Establish fulfilling volunteer opportunities and celebrate volunteers • Support local sports leagues, clubs, scouting programs, etc. • Create safe, supportive teen recreation centers
Responsible engagement in our democracy	Engagement in public meetings, service on local boards and commissions, and participation in voting for public officials	• Conduct active outreach to encourage participation in elections, referenda, and public meetings • Provide opportunities to participate on boards and commissions • Communicate with citizens regarding government activities and results • Provide support to help working families and low income and disabled residents more fully participate in government decision-making
Satisfaction with others and the community	Sense of community belonging that comes when we feel that others care about our views and our needs and we are motivated to help others feel the same	• Support educational and cultural activities that highlight the value of diversity and encourage inclusiveness • Reach out to all segments of the community and raise awareness of free, affordable, and interesting public events and programs • Ensure that diverse community viewpoints are represented in government decision-making processes

7.2 *Appendix B - Development of concept maps for linking action categories to ecosystem services and human well-being.*

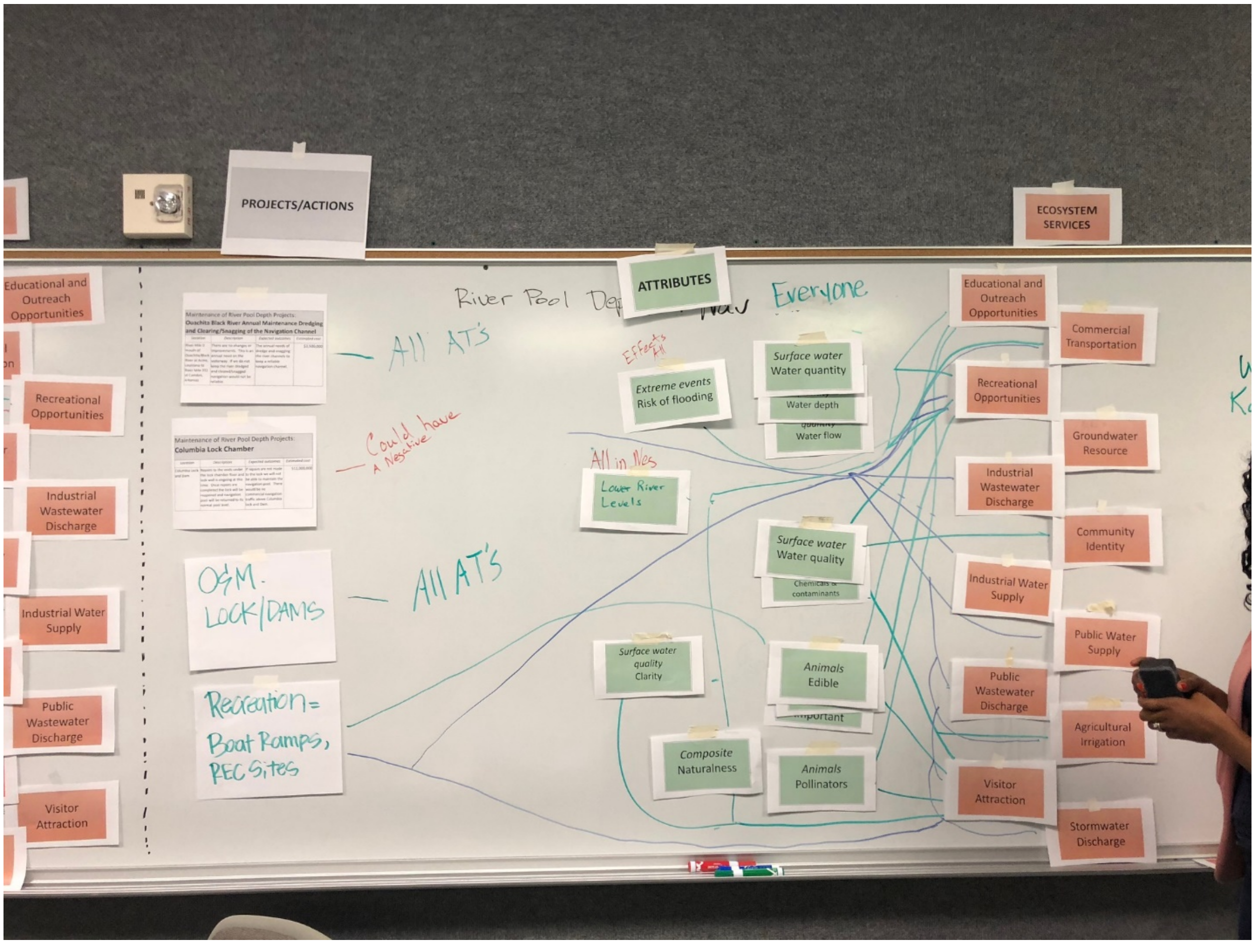


Figure 7.1 Picture of conceptual mapping exercise held during stakeholder Workshop 2 in West Monroe, LA. This concept map describes linkages between river attributes and ecosystem services impacted by river pool navigation projects such as dredging. A full concept map for the River pool/Navigation action category is shown in Figure 7.2.B.

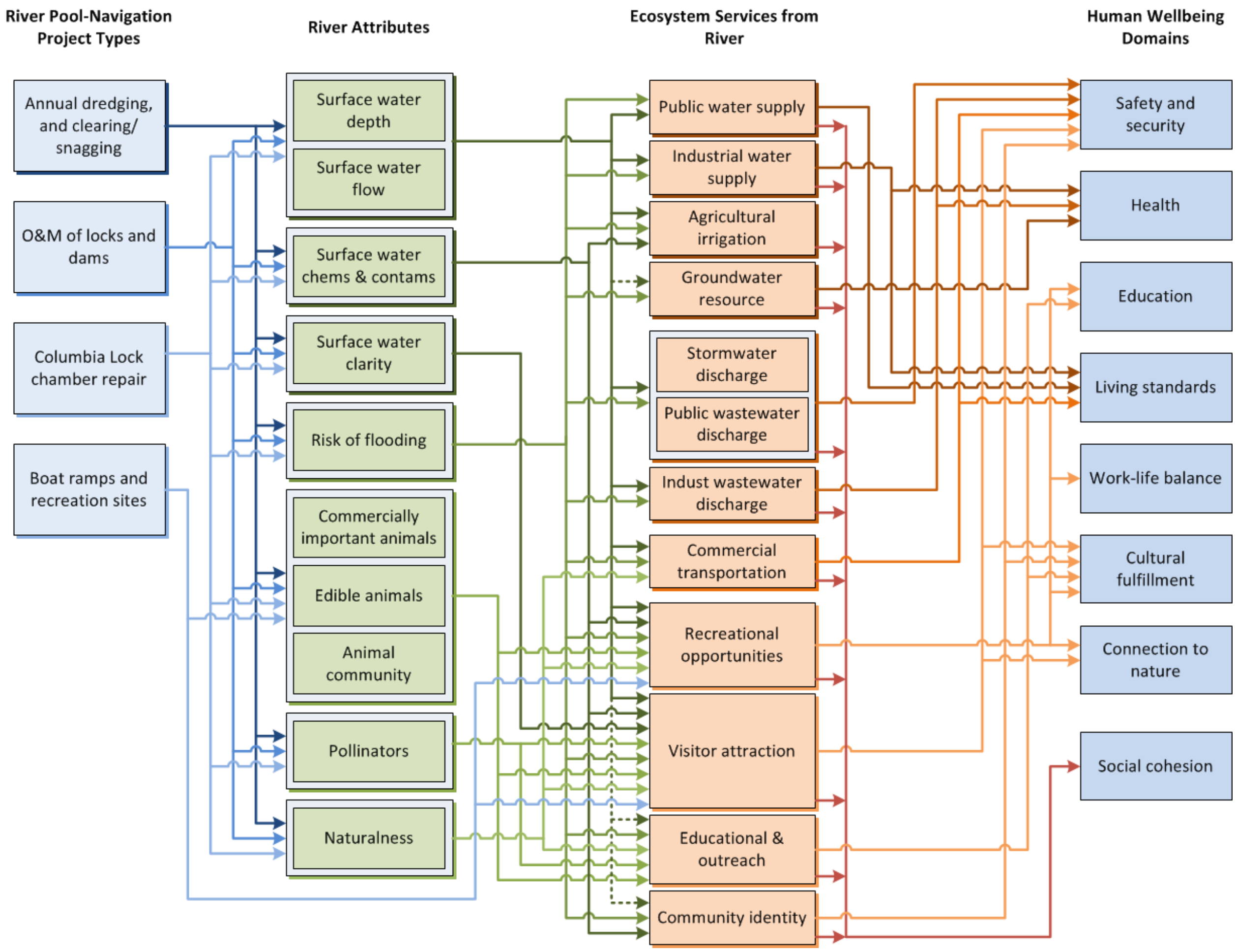


Figure 7.2 Concept map describing links between river attributes, ecosystem services, and domains of human well-being impacted by river pool navigation projects on the Ouachita River. This concept map is the result of information collected during stakeholder Workshop 2 held in West Monroe, LA. An example is given in Figure 7.2.A.

7.3 *Appendix C - Summary of River Attribute-Beneficiary-River Service impact scores used in the calculation of Service impacts on stakeholders in Monroe/West Monroe, LA.*

These scores are the result of the Beneficiary analysis described in Section 2.4. Each action category is a different table. The tables are organized alphabetically by beneficiary group and color coded by importance score (1, 2, 3).

Stormwater – Pump Station Maintenance			
River attributes	Beneficiaries	Services	Importance to beneficiary (max 3)
Surface water flow	Anglers	Navigable waterways	1
Surface water clarity	Anglers	Catchable fish	1
Surface water chemicals and contaminants	Anglers	Recreational opportunities	2
Surface water pathogens and parasites	Anglers	Recreational opportunities	3
Surface water flow	Boaters	Recreational opportunities	1
Surface water chemicals and contaminants	Boaters	Visitor attraction	1
Surface water pathogens and parasites	Boaters	Visitor attraction	1
Surface water depth	Boaters	Recreational opportunities	2
Surface water clarity	Drinking water consumers	Public water supply	2
Surface water chemicals and contaminants	Drinking water consumers	Public water supply	3
Surface water pathogens and parasites	Drinking water consumers	Public water supply	3
Surface water flow	Farmers	Agricultural irrigation	2
Surface water chemicals and contaminants	Farmers	Crop growth	2
Surface water pathogens and parasites	Farmers	Crop growth	2
Risk of flooding	Farmers	Crop damage/loss	2
Surface water flow	Foresters	Tree growth	1
Surface water chemicals and contaminants	Foresters	Groundwater resource	2
Surface water chemicals and contaminants	Industrial dischargers	Industrial wastewater discharge	1
Risk of flooding	Industrial dischargers	Property damage/loss	2
Surface water flow	Industrial dischargers	Industrial wastewater discharge	3

Surface water chemicals and contaminants	Industrial processors	Industrial water supply	2
Surface water pathogens and parasites	Industrial processors	Industrial water supply	2
Risk of flooding	Industrial processors	Property damage/loss	2
Surface water flow	Industrial processors	Industrial water supply	3
Surface water chemicals and contaminants	Municipal waste dischargers	Public wastewater discharge	1
Surface water flow	Municipal waste dischargers	Public wastewater discharge	3
Surface water flow	Residential property owners	Stormwater discharge	2
Risk of flooding	Residential property owners	Property damage/loss	3
Surface water flow	Transporters of goods	Navigable waterways	3
Surface water depth	Transporters of goods	Navigable waterways	3
Surface water flow	Transporters of people	Navigable waterways	3
Surface water depth	Transporters of people	Navigable waterways	3
Surface water flow	Waders, swimmers, divers, skiers	Recreational opportunities	1
Surface water depth	Waders, swimmers, divers, skiers	Recreational opportunities	2
Surface water clarity	Waders, swimmers, divers, skiers	Visitor attraction	2
Surface water chemicals and contaminants	Waders, swimmers, divers, skiers	Visitor attraction	3
Surface water pathogens and parasites	Waders, swimmers, divers, skiers	Visitor attraction	3

Stormwater – Drainage Projects			
River attributes	Beneficiaries	Services	Importance to beneficiary (max 3)
Surface water flow	Anglers	Navigable waterways	1
Surface water clarity	Anglers	Catchable fish	1
Surface water chemicals and contaminants	Anglers	Recreational opportunities	2
Surface water pathogens and parasites	Anglers	Recreational opportunities	3
Surface water flow	Boaters	Recreational opportunities	1
Surface water chemicals and contaminants	Boaters	Visitor attraction	1
Surface water pathogens and parasites	Boaters	Visitor attraction	1
Surface water depth	Boaters	Recreational opportunities	2
Surface water clarity	Drinking water consumers	Public water supply	2
Surface water chemicals and contaminants	Drinking water consumers	Public water supply	3
Surface water pathogens and parasites	Drinking water consumers	Public water supply	3
Surface water flow	Farmers	Agricultural irrigation	2
Surface water chemicals and contaminants	Farmers	Crop growth	2
Surface water pathogens and parasites	Farmers	Crop growth	2
Risk of flooding	Farmers	Crop damage/loss	2
Surface water flow	Foresters	Tree growth	1
Surface water chemicals and contaminants	Foresters	Groundwater resource	2
Surface water chemicals and contaminants	Industrial dischargers	Industrial wastewater discharge	1
Risk of flooding	Industrial dischargers	Property damage/loss	2
Surface water flow	Industrial dischargers	Industrial wastewater discharge	3
Surface water chemicals and contaminants	Industrial processors	Industrial water supply	2
Surface water pathogens and parasites	Industrial processors	Industrial water supply	2
Risk of flooding	Industrial processors	Property damage/loss	2
Surface water flow	Industrial processors	Industrial water supply	3
Surface water chemicals and contaminants	Municipal waste dischargers	Public wastewater discharge	1

Surface water flow	Municipal waste dischargers	Public wastewater discharge	3
Surface water flow	Residential property owners	Stormwater discharge	2
Risk of flooding	Residential property owners	Property damage/loss	3
Surface water flow	Transporters of goods	Navigable waterways	3
Surface water depth	Transporters of goods	Navigable waterways	3
Surface water flow	Transporters of people	Navigable waterways	3
Surface water depth	Transporters of people	Navigable waterways	3
Surface water flow	Waders, swimmers, divers, skiers	Recreational opportunities	1
Surface water depth	Waders, swimmers, divers, skiers	Recreational opportunities	2
Surface water clarity	Waders, swimmers, divers, skiers	Visitor attraction	2
Surface water chemicals and contaminants	Waders, swimmers, divers, skiers	Visitor attraction	3
Surface water pathogens and parasites	Waders, swimmers, divers, skiers	Visitor attraction	3

Levee Maintenance			
River attributes	**Beneficiaries**	**Services**	**Importance to beneficiary (max 3)**
Naturalness	Anglers	Visitor attraction	1
Surface water flow	Anglers	Navigable waterways	1
Environmental aesthetics	Anglers	Visitor attraction	2
Open space	Anglers	Recreational opportunities	2
Edible fauna	Anglers	Catchable fish	3
Naturalness	Artists	Visitor attraction	2
Environmental aesthetics	Artists	Visitor attraction	3
Naturalness	Boaters	Recreational opportunities	1
Surface water flow	Boaters	Recreational opportunities	1
Environmental aesthetics	Boaters	Visitor attraction	2
Open space	Boaters	Recreational opportunities	2
Surface water depth	Boaters	Recreational opportunities	2
Naturalness	Ceremonial participants	Community identity	2
Environmental aesthetics	Ceremonial participants	Community identity	3
Open space	Ceremonial participants	Community identity	3
Ground water level	Drinking water consumers	Public water supply	1
Ground water storage	Drinking water consumers	Public water supply	2
Ground water quality	Drinking water consumers	Public water supply	3
Naturalness	Educators/students/researchers	Community identity	2
Open space	Educators/students/researchers	Education and outreach	2
Naturalness	Experiencers/viewers	Community identity	2
Environmental aesthetics	Experiencers/viewers	Visitor attraction	3
Open space	Experiencers/viewers	Recreational opportunities	3
Ground water level	Farmers	Agricultural irrigation	1
Ground water quality	Farmers	Agricultural irrigation	2
Ground water storage	Farmers	Agricultural irrigation	2
Pollinators	Farmers	Crop growth	2
Surface water flow	Farmers	Agricultural irrigation	2
Risk of flooding	Farmers	Crop damage/loss	2
Open space	Farmers	Crop growth	3
Naturalness	Food pickers/gatherers	Recreational opportunities	1

Open space	Food pickers/gatherers	Recreational opportunities	1
Environmental aesthetics	Food pickers/gatherers	Recreational opportunities	2
Edible plants/fungi	Food pickers/gatherers	Harvestable food	3
Ground water quality	Foresters	Groundwater resource	1
Surface water flow	Foresters	Tree growth	1
Open space	Foresters	Tree growth	2
Naturalness	Hunters	Recreational opportunities	1
Environmental aesthetics	Hunters	Recreational opportunities	1
Open space	Hunters	Recreational opportunities	2
Edible fauna	Hunters	Harvestable animals	3
Risk of flooding	Industrial dischargers	Property damage/loss	2
Surface water flow	Industrial dischargers	Industrial wastewater discharge	3
Ground water level	Industrial processors	Industrial water supply	1
Ground water storage	Industrial processors	Industrial water supply	1
Ground water quality	Industrial processors	Industrial water supply	2
Risk of flooding	Industrial processors	Property damage/loss	2
Surface water flow	Industrial processors	Industrial water supply	3
Ground water storage	Municipal waste dischargers	Public wastewater discharge	1
Surface water flow	Municipal waste dischargers	Public wastewater discharge	3
Environmental aesthetics	People who care	Visitor attraction	2
Open space	People who care	Community identity	3
Naturalness	Residential property owners	Property value	1
Ground water level	Residential property owners	Public water supply	1
Open space	Residential property owners	Property value	1
Surface water flow	Residential property owners	Stormwater discharge	2
Ground water quality	Residential property owners	Public water supply	3
Environmental aesthetics	Residential property owners	Property value	3
Risk of flooding	Residential property owners	Property damage/loss	3
Open space	Transporters of goods	0	0
Surface water depth	Transporters of goods	Navigable waterways	3
Surface water flow	Transporters of goods	Navigable waterways	3
Naturalness	Transporters of people	Commercial transportation	1
Environmental aesthetics	Transporters of people	Commercial transportation	1

Open space	Transporters of people	Commercial transportation	1
Surface water depth	Transporters of people	Navigable waterways	3
Surface water flow	Transporters of people	Navigable waterways	3
Naturalness	Waders, swimmers, divers, skiers	Recreational opportunities	1
Open space	Waders, swimmers, divers, skiers	Recreational opportunities	1
Surface water flow	Waders, swimmers, divers, skiers	Recreational opportunities	1
Environmental aesthetics	Waders, swimmers, divers, skiers	Visitor attraction	2
Surface water depth	Waders, swimmers, divers, skiers	Recreational opportunities	2

River Pool/Navigation – Dredging			
River attributes	**Beneficiaries**	**Services**	**Importance to beneficiary (max 3)**
Naturalness	Anglers	Visitor attraction	1
Surface water clarity	Anglers	Catchable fish	1
Surface water flow	Anglers	Navigable waterways	1
Commercially important fauna	Anglers	Catchable fish	2
Surface water chemicals and contaminants	Anglers	Recreational opportunities	2
Faunal community	Anglers	Catchable fish	3
Faunal community	Artists	Visitor attraction	2
Naturalness	Artists	Visitor attraction	2
Naturalness	Boaters	Recreational opportunities	1
Surface water chemicals and contaminants	Boaters	Visitor attraction	1
Surface water flow	Boaters	Recreational opportunities	1
Surface water depth	Boaters	Recreational opportunities	2
Faunal community	Ceremonial participants	Community identity	2
Naturalness	Ceremonial participants	Community identity	2
Surface water chemicals and contaminants	Drinking water consumers	Public water supply	1
Surface water clarity	Drinking water consumers	Public water supply	1
Naturalness	Educators/students/researchers	Community identity	2
Faunal community	Educators/students/researchers	Community identity	3
Faunal community	Experiencers/viewers	Visitor attraction	2
Naturalness	Experiencers/viewers	Community identity	2
Pollinators	Farmers	Crop growth	2
Pest predators	Farmers	Crop growth	2
Surface water chemicals and contaminants	Farmers	Crop growth	2
Risk of flooding	Farmers	Crop damage/loss	2
Surface water flow	Farmers	Agricultural irrigation	2
Naturalness	Food pickers/gatherers	Recreational opportunities	1
Pest predators	Food pickers/gatherers	Harvestable food	1
Surface water flow	Foresters	Tree growth	1
Surface water chemicals and contaminants	Foresters	Groundwater resource	2

Naturalness	Hunters	Recreational opportunities	1
Commercially important fauna	Hunters	Harvestable animals	2
Faunal community	Hunters	Harvestable animals	3
Surface water chemicals and contaminants	Industrial dischargers	Industrial wastewater discharge	1
Risk of flooding	Industrial dischargers	Property damage/loss	2
Surface water flow	Industrial dischargers	Industrial wastewater discharge	3
Surface water chemicals and contaminants	Industrial processors	Industrial water supply	2
Risk of flooding	Industrial processors	Property damage/loss	2
Surface water flow	Industrial processors	Industrial water supply	3
Surface water chemicals and contaminants	Municipal waste dischargers	Public wastewater discharge	1
Surface water flow	Municipal waste dischargers	Public wastewater discharge	3
Naturalness	Residential property owners	Property value	1
Surface water flow	Residential property owners	Stormwater discharge	2
Risk of flooding	Residential property owners	Property damage/loss	3
Surface water depth	Transporters of goods	Navigable waterways	3
Surface water flow	Transporters of goods	Navigable waterways	3
Naturalness	Transporters of people	Commercial transportation	1
Surface water depth	Transporters of people	Navigable waterways	3
Surface water flow	Transporters of people	Navigable waterways	3
Naturalness	Waders, swimmers, divers, skiers	Recreational opportunities	1
Surface water flow	Waders, swimmers, divers, skiers	Recreational opportunities	1
Surface water clarity	Waders, swimmers, divers, skiers	Visitor attraction	2
Surface water depth	Waders, swimmers, divers, skiers	Recreational opportunities	2
Surface water chemicals and contaminants	Waders, swimmers, divers, skiers	Visitor attraction	3

River Pool/Navigation – Lock/Dam Maintenance			
River attributes	**Beneficiaries**	**Services**	**Importance to beneficiary (max 3)**
Surface water clarity	Anglers	Catchable fish	1
Naturalness	Anglers	Visitor attraction	1
Surface water flow	Anglers	Navigable waterways	1
Surface water chemicals and contaminants	Anglers	Recreational opportunities	2
Commercially important fauna	Anglers	Catchable fish	2
Faunal community	Anglers	Catchable fish	3
Faunal community	Artists	Visitor attraction	2
Naturalness	Artists	Visitor attraction	2
Surface water chemicals and contaminants	Boaters	Visitor attraction	1
Naturalness	Boaters	Recreational opportunities	1
Surface water flow	Boaters	Recreational opportunities	1
Surface water depth	Boaters	Recreational opportunities	2
Faunal community	Ceremonial participants	Community identity	2
Naturalness	Ceremonial participants	Community identity	2
Surface water clarity	Drinking water consumers	Public water supply	2
Surface water chemicals and contaminants	Drinking water consumers	Public water supply	3
Naturalness	Educators/students/researchers	Community identity	2
Faunal community	Educators/students/researchers	Community identity	3
Faunal community	Experiencers/viewers	Visitor attraction	2
Naturalness	Experiencers/viewers	Community identity	2
Pollinators	Farmers	Crop growth	2
Surface water chemicals and contaminants	Farmers	Crop growth	2
Pest predators	Farmers	Crop growth	2
Surface water flow	Farmers	Agricultural irrigation	2
Risk of flooding	Farmers	Crop damage/loss	2
Pest predators	Food pickers/gatherers	Harvestable food	1
Naturalness	Food pickers/gatherers	Recreational opportunities	1
Surface water flow	Foresters	Tree growth	1
Surface water chemicals and contaminants	Foresters	Groundwater resource	2

Naturalness	Hunters	Recreational opportunities	1
Commercially important fauna	Hunters	Harvestable animals	2
Faunal community	Hunters	Harvestable animals	3
Surface water chemicals and contaminants	Industrial dischargers	Industrial wastewater discharge	1
Risk of flooding	Industrial dischargers	Property damage/loss	2
Surface water flow	Industrial dischargers	Industrial wastewater discharge	3
Surface water chemicals and contaminants	Industrial processors	Industrial water supply	2
Risk of flooding	Industrial processors	Property damage/loss	2
Surface water flow	Industrial processors	Industrial water supply	3
Surface water chemicals and contaminants	Municipal waste dischargers	Public wastewater discharge	1
Surface water flow	Municipal waste dischargers	Public wastewater discharge	3
Naturalness	Residential property owners	Property value	1
Surface water flow	Residential property owners	Stormwater discharge	2
Risk of flooding	Residential property owners	Property damage/loss	3
Surface water depth	Transporters of goods	Navigable waterways	3
Surface water flow	Transporters of goods	Navigable waterways	3
Naturalness	Transporters of people	Commercial transportation	1
Surface water depth	Transporters of people	Navigable waterways	3
Surface water flow	Transporters of people	Navigable waterways	3
Naturalness	Waders, swimmers, divers, skiers	Recreational opportunities	1
Surface water flow	Waders, swimmers, divers, skiers	Recreational opportunities	1
Surface water clarity	Waders, swimmers, divers, skiers	Visitor attraction	2
Surface water depth	Waders, swimmers, divers, skiers	Recreational opportunities	2
Surface water chemicals and contaminants	Waders, swimmers, divers, skiers	Visitor attraction	3

Greenspace Projects			
River attributes	Beneficiaries	Services	Importance to beneficiary (max 3)
Open space	Anglers	Recreational opportunities	2
Flora/fungi community	Artists	Visitor attraction	2
Open space	Boaters	Recreational opportunities	2
Flora/fungi community	Ceremonial participants	Community identity	2
Open space	Ceremonial participants	Community identity	3
Open space	Educators/students/researchers	Education and outreach	2
Flora/fungi community	Educators/students/researchers	Community identity	3
Flora/fungi community	Experiencers/viewers	Visitor attraction	2
Open space	Experiencers/viewers	Recreational opportunities	3
Open space	Farmers	Crop growth	3
Open space	Food pickers/gatherers	Recreational opportunities	1
Open space	Foresters	Tree growth	2
Open space	Hunters	Recreational opportunities	2
Open space	People who care	Community identity	3
Open space	Residential property owners	Property value	1
Open space	Transporters of people	Commercial transportation	1
Open space	Waders, swimmers, divers, skiers	Recreational opportunities	1

7.4 Appendix D - List of local, parish, state, and federal partners who assisted with the collection of information and the completion of this research project.

<u>**Local – Ouachita Parish**</u>	<u>**State of Louisiana**</u>	<u>**Federal Agencies**</u> *Environmental Protection Agency (EPA)* *Federal Emergency Management Agency (FEMA)* *Department of the Interior (DOI)* *Housing and Urban Development (HUD)*
Neal Brown Ouachita Parish Homeland Security and Emergency Preparedness, Director, Parish Co-Lead for RESES Project (Ouachita Parish)	**Sandra Gunner** Governor's Office of Community Development Lead Support for Project (Baton Rouge, LA)	**Mark Berry** EPA R6 Environmental Engineer (Dallas, TX)
Kevin Crosby Parish Engineer Lead for Long-term Recovery Strategy and Advisor to RESES Project (Ouachita Parish)	**Genea Lathers** Governor's Office of Homeland Security & Emergency Preparedness Emergency Management Preparedness Section Planning Branch Manager (Baton Rouge, LA)	**Richard Fulford, Ph.D.** EPA Office of Research and Development (ORD) Research Lead (Gulf Breeze, Florida)
Karen Culprit Treasurer, Police Parish Juror Lead Organizer for Long-term Recovery Team Meetings Support for RESES Project Updates (Ouachita Parish)	**Tomeka Prioleau** Louisiana Department of Environmental Quality EPA POC for Sustainability Projects (Baton Rouge, LA)	**Jim Harvey,** EPA Office of Research and Development (ORD) Research Contract Lead (Gulf Breeze, Florida)
Dr. Robert Eisenstadt University of Louisiana at Monroe (ULM), College of Business and Social Sciences Center for Business and Economic Research Support for RESES Project (Monroe)	**Joe Stewart** Governor's Office of Homeland Security and Emergency Preparedness Region 8 Coordinator (West Monroe, LA)	**Laurie King** EPA Region 6 Supervisor (Dallas, TX)
Robert "Robbie" George Lead Engineer for the City of West Monroe (City of West Monroe)		**Lawrence Martin, Ph.D.** EPA Office of Research and Development (ORD) Office of Science Advisor Policy & Engagement (Washington, DC)

Tracy Hilburn Ouachita Parish Homeland Security and Emergency Preparedness, Deputy Director, Parish Lead for RESES Project (Former Tensas Basin Levee District Operations Superintendent) (Ouachita Parish)		**Michael G, Morton, Ph.D.** EPA Region 6 Science Advisor (Dallas, TX)
Mary Lopez Ouachita Parish Homeland Security and Emergency Preparedness Grant Specialist (Ouachita Parish)		**Anisa Pjetrovic** EPA Region 6, Environmental Scientist Former Sustainability Support Assistant to EPA-FEMA Sustainability Advisors (Dallas, TX)
Tom Malmay Ouachita Parish Disaster Recovery Manager, Lead facilitator (Ouachita Parish)		**Marc J Russell, Ph.D.** EPA Office of Research and Development (ORD) Research Ecologist (Gulf Breeze, Florida)
Mayor James Mayo Mayor of City of Monroe (Monroe)		**Leah Sharpe, Ph.D.** EPA Office of Research and Development (ORD) Researcher (Gulf Breeze, Florida)
Mayor Staci A. Mitchell Mayor of City of West Monroe (West Monroe)		**Lisa Smith** EPA Office of Research and Development (ORD) Supervising Lead (Gulf Breeze, Florida)
Mayor Dave Norris Former Mayor of City of West Monroe (West Monroe)		**Joyce Stubblefield** EPA Region 6 Environmental Scientist Former EPA-FEMA Sustainability Advisor (Dallas, TX)
Scotty Robinson Ouachita Parish Police Juror, Community Leader for Project (Ouachita Parish)		**Deanne Bingham** FEMA Disaster Recovery Officer Team North (Ouachita Parish/Baton Rouge, LA)
Rayford Wilbanks Executive Director, Ouachita River Valley Authority Support for RESES Project Proposal (Regional)		**Keith McCarron** FEMA Mitigation Advisor (Baton Rouge, LA)

		Emily Meyers FEMA Disaster Recovery Officer Team North (Ouachita Parish/Baton Rouge, LA)
		Tonia Pence FEMA Federal Disaster Recovery Coordination Community Planning and Capacity Building Supervisor (Baton Rouge, LA)
		Antonio Martinez-Revell FEMA Disaster Recovery Officer Team North (Ouachita Parish/Baton Rouge, LA)
		Willis Gainer DOI - FEMA Natural & Cultural Resources Advisor (Baton Rouge, LA)
		Crystal Jones-Taylor HUD – FEMA Housing Advisor (Baton Rouge, LA)