# Maumelle River, Pulaski County, Arkansas Section 206 Aquatic Ecosystem Restoration Feasibility Study

*Appendix C-3: Habitat Modeling*

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US Army Corps
of Engineers®
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# 1.0 Table of Contents

# HABITAT MODELING APPENDIX

## 1.0 Conceptual Ecological Model (CEM)

A conceptual ecological model (CEM) is a qualitative representation of a system or sub-system that serves as a basis for the organization of processes that can be utilized to understand and communicate the function of that process and the identification of factors impairing the optimal performance of the systems. The models, as applied to ecosystems are simple and qualitative, represented by a diagram which describes general functional relationships among the essential components of an ecosystem.

A resource agency kick-off meeting was held on 1-3 August 2017 with the U.S. Army Corps of Engineers (USACE), Central Arkansas Water (CAW), U.S. Fish and Wildlife Service (USFWS), Arkansas Game and Fish Commission (AGFC), and Arkansas Natural Heritage Commission (ANHC) to develop a CEM for the study. The CEM depicts the condition of the existing environment described in Section 4 and identifies factors that have resulted in the degradation of the Maumelle River ecosystem. The resulting CEM is presented in Figure 1-1.

The CEM provides a framework enabling the team to characterize the drivers and effects of impediments to ecosystem functions, potential measures to address these impediments, and methodologies to characterize and quantify ecosystem benefits resulting from any restoration actions. The CEM format utilized here follows a top-down hierarchy of information. The Maumelle River CEM does not attempt to explain all possible relationships or include all possible factors influencing the performance measure targets within natural systems in the study area. Rather, the model attempts to simplify ecosystem function by containing only information deemed most relevant to ecosystem restoration and monitoring goals.

The CEM includes the following components:

- **Drivers:** Includes major external driving forces that have large-scale influences on natural systems. Drivers may be natural (e.g. climate change) or anthropogenic (e.g. hydrologic alteration) in nature. Anthropogenic drivers provide opportunities for finding relevant solutions to problems. Natural drivers, however, cannot be influenced directly by human interference. Some drivers are both anthropogenic and natural in nature. The Maumelle River CEM introduces three drivers: Altered Hydrology, Agriculture, and Climate Change.
- **Ecological Stressors:** Physical or chemical changes that occur within the natural system which are produced or affected by drivers and are directly responsible for significant changes in biological components, patterns, and relationships in natural systems.
- **Existing Conditions:** Biological, physical, or chemical responses within the natural system that are produced or affected by stressors. CEMs propose linkages between one or more ecological stressors and ecological effects and attributes to explain changes that have occurred in ecosystems. Construction of low-head dams, levees, and agriculture (sod farm) have led to degraded aquatic and riparian systems because of the stressors described above. The resulting ecosystem is comprised of fragmented habitats that impact hydrology, fish passage, aquatic and riparian habitats, water quality, and recreational opportunities.
- **Management Actions:** Actions that can be implemented to minimize the adverse effects of stressors and move the existing system to a more natural and stable system. Although management actions can address the effects of a single stressor, often each management action mitigates the effects of multiple stressors.

- **Endpoints:** Expected results from the implementation of the identified management actions. As most of the management actions address multiple stressors, the benefits are accordingly the result of multiple management actions.
- **Receptors**: Includes specific environmental attributes that benefit from each endpoint (or combination of endpoints) that can be evaluated to assess the health and stability of an ecosystem. As management actions are implemented and the expected endpoints are realized, receptors will respond to the improved conditions. Attributes may include populations, species, communities, and physical or chemical processes.

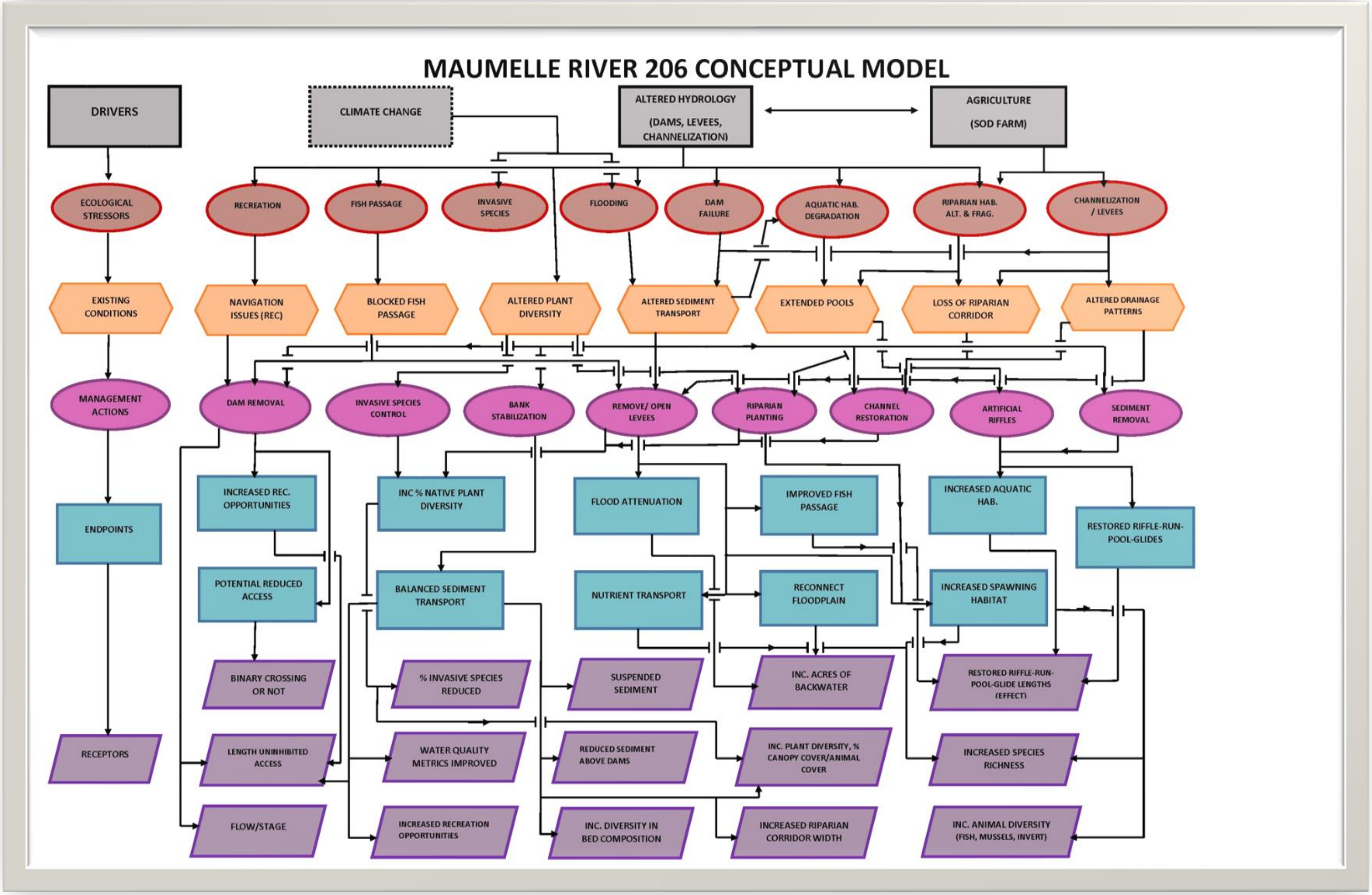


**Figure 1-1. Maumelle River Aquatic Ecosystem Restoration Conceptual Ecological Model**

# 2.0 Habitat Classification

## 2.1 Model Selection and Data Collection

Two habitat types were assessed for the Maumelle River Study: Riparian Forest and Riverine. These assessments were based on the historical conditions of the Maumelle River and riparian area, and the ecosystem restoration goals for the feasibility study.

The Barred Owl, Gray Squirrel, and Downy Woodpecker Habitat Suitability Index (HSI) were utilized to assess the ecological integrity and habitat conditions of existing and future forested habitats (USFWS, 1987a; USFWS 1987b; USFWS 1983). All three HSI models have been certified by the USACE Ecosystem Restoration Planning Center of Expertise (EcoPCX) for regional use, which includes Arkansas.

The Qualitative Habitat Evaluation Index model (QHEI 2006) was utilized to assess the ecological integrity and habitat conditions of the riverine habitats. The QHEI model has been certified by USACE EcoPCX for use. This model was chosen based on existing aquatic habitat conditions and professional judgment. Aquatic habitat assessments were conducted by USACE and CAW biologists during the week of October 5-9, 2020. Areas surveyed included: the inundated pool area above each low-water crossing; the downstream channel below each low-water crossing to include one riffle-run-pool habitat sequence; the braided side-channel on the left descending side below River Crossing 1 (RC1), both isolated side channels (one adjacent to RC1, and one between RC2 and RC3), and the pool adjacent to, and the riffle downstream of, RC3. Within each area surveyed, data collection points were selected based on aerial imagery from existing Geographic Information System (GIS) data or were added during the field survey (Figures 2-1 and 2-2).

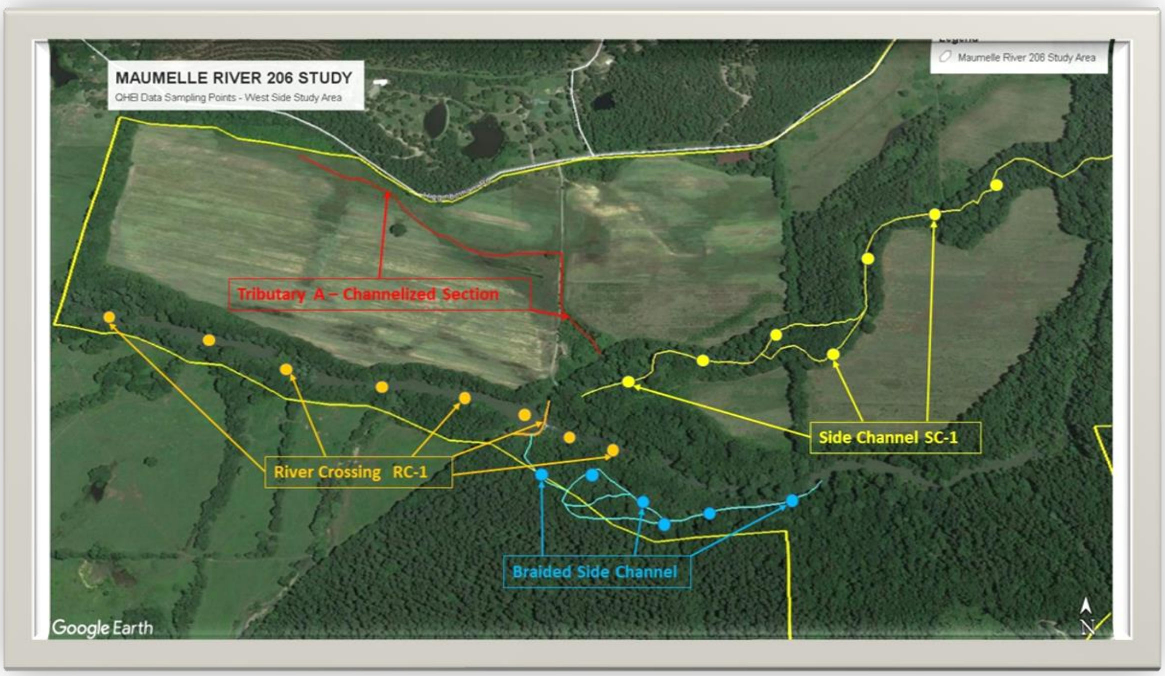


**Figure 2-1. QHEI Data Points - West Side of Study Area**

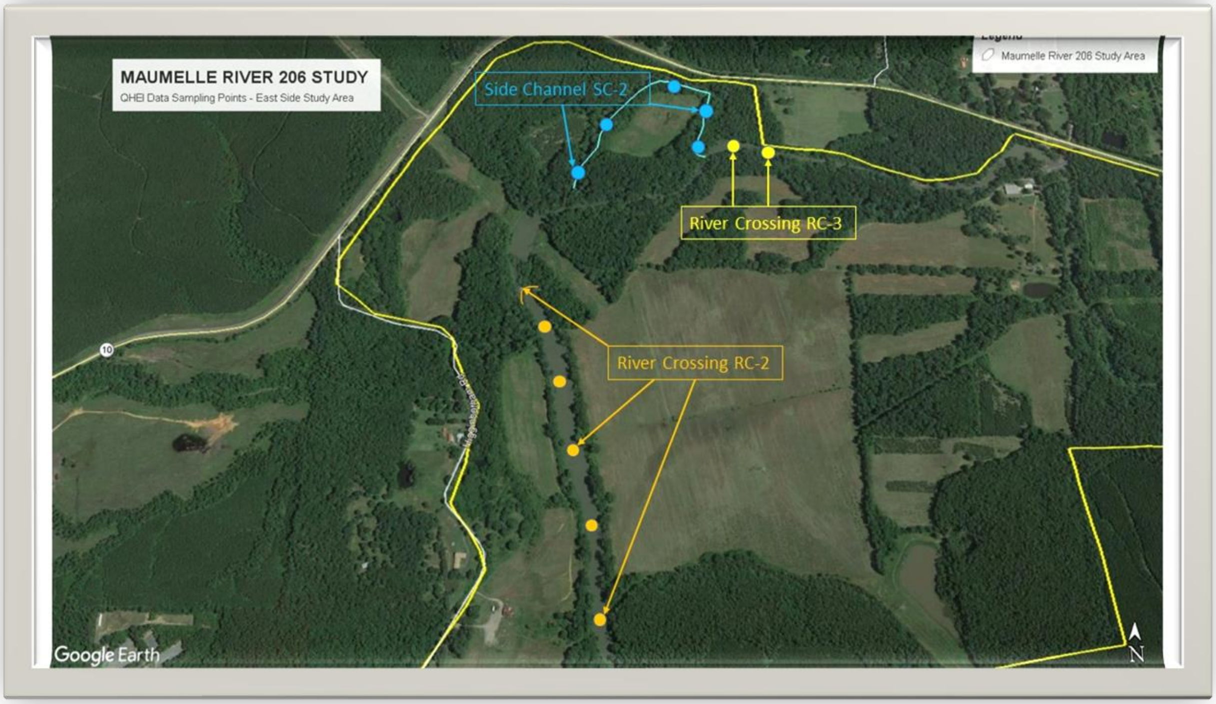


**Figure 2-2. QHEI Data Points - East Side of Study Area**

### 2.1.1 Habitat Evaluation Procedure and Habitat Suitability Index

Habitat Evaluation Procedure (HEP) models involve defining the study area, delineating habitats (i.e. cover types) within the study area, selecting HSI models and/or evaluation species, and characterizing the study area based on the results of the HEP. HEP was developed by the USFWS to quantify the impacts of habitat changes resulting from land or water development projects (USFWS 1980). HEP is based on suitability models that provide a quantitative assessment of the habitat requirements for a species or group of species.

The area to be analyzed using the HEP models consists of open fields currently used for commercial sod production (primarily zoysia grass). Since all metrics for the three HEP models used, there was no need to select survey points for the Future Without Project (FWOP) condition. CAW and USACE biologists consulted and agreed that the existing condition for all HSI metrics was zero. For the Future With Project (FWP) condition, we developed estimates for each metric based on past experiences with bottomland hardwood reforestation on adjacent CAW property and throughout the Mississippi Alluvial Valley.

Habitat quality is estimated using the habitat models selected to represent each specific habitat type(s). Each model consists of a list of variables or Suitability Indices (SIs) that are essential to satisfy the life requisites (e.g. reproduction, food, cover, etc.) of a particular species. Each SI can be expressed as a mathematical function with each habitat metric as an independent variable. Each SI ranges from 0.1 to 1.0, with 1.0 representing optimal condition for the variable in question. The SIs for each specific life requisite are then calculated using a mathematical formula to estimate the Life Requisite Suitability Index (LRSI) for each life requisite. The final HSI of the habitat type can then be calculated as a function of the LRSIs.

The HSI methodology and calculations for the barred owl, gray squirrel, and downy woodpecker habitat models are provided in Tables 2-1, 2-2, and 3-3. The barred owl HSI is calculated using the reproduction life requisite (SIR). For the gray squirrel, two LRSIs are calculated (winter food and cover/reproduction; SIWF and SICR, respectively). Because the two gray squirrel life requisites are assumed to be of equal importance, the HSI is equal to the lowest LRSI. Similarly, the downy woodpecker HSI uses two LRSIs (food and reproduction; SIF and SIR, respectively). Both life requisites are assumed to be of equal importance, thus the HSI is equal to the lowest LRSI.

**Table 2-1. Barred Owl Habitat Suitability Index Metrics**

| **Species** | **Life Requisite Suitability Indices (LRSI)** | **HSI Formula** |
|---|---|---|
| Barred Owl | Reproduction SI (SIR) | $HSI = SIR = \sqrt{SI_1 \times SI_2} \times SI_3$ |

**Life Requisite Suitability Index Formulas & Variables**

| | |
|---|---|
| $SI_1$ | The relationship between the number of trees ≥51 cm dbh/0.4 ha and reproductive habitat quality for barred owls. |
| $SI_2$ | The relationship between mean dbh of overstory trees and reproductive habitat quality for barred owls |
| $SI_3$ | The relationship between percent canopy cover of overstory trees and reproductive habitat quality for barred owls. |

Suitability Index (SI)
Reproduction Suitability Index (SIR)
Diameter at Breast Height (dbh)

**Table 2-2. Gray Squirrel Habitat Suitability Index Metrics**

| **Species** | **Life Requisite Suitability Indices (LRSI)** | **HSI Formula** |
|---|---|---|
| Gray Squirrel | Winter Food | $SIWF = \sqrt{SI_1 \times SI_2} \times SI_3$ |
| | Cover/Reproduction | $SICR = \sqrt{SI_4 \times SI_5}$ |
| | | $HSI = \min\{SIWF, SICR\}$ |

**Life Requisite Suitability Index Formulas & Variables**

| | |
|---|---|
| $SI_1$ | Proportion of the total tree canopy cover that is hard mast producing trees ≥25 cm dbh |
| $SI_2$ | Number of hard mast tree species |
| $SI_3$, $SI_4$ | Percent canopy cover of trees |
| $SI_5$ | Mean dbh of overstory trees |

**Table 2-3. Downy Woodpecker Habitat Suitability Index Metrics**

| Species | Life Requisite Suitability Indices (LRSI) | HSI Formula |
|---|---|---|
| Downy Woodpecker | Food | $SIF = SI_1$ |
| | Reproduction | $SIR = SI_2$ |
| | | $HSI = \min\{SIF, SIR\}$ |

| Life Requisite Suitability Index Formulas & Variables | |
|---|---|
| $SI_1$ | The relationship between mean dbh of overstory trees and food habitat quality for downy woodpeckers |
| $SI_2$ | The relationship between the number of trees ≥15 cm dbh/0.4 ha and reproductive habitat quality for downy woodpeckers |

Suitability Index (SI)

Food Suitability Index (SIF)

Reproduction Suitability Index (SIR)

Diameter at Breast Height (dbh)

### 2.1.2 Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)

The QHEI model was used to evaluate the existing conditions of the riverine habitats within the study area. The QHEI is a physical habitat index designed to provide an empirical, quantified evaluation of the general lotic macrohabitat characteristics that are important to fish communities. It is composed of six principal metrics that are described below. Each of the principal metrics is composed of two or more components that are measured in the field to compare the existing, FWOP, and FWP conditions (17 total components). The maximum possible QHEI site score is 100. Each of the metrics are scored individually and then summed to provide the total QHEI site score.

**Substrate**: This metric Includes two components, substrate type and substrate quality, that are evaluated for both pools and riffles. Substrate types include such high-quality types as boulders and/or slabs, cobble, gravel sand, and bedrock. Lower quality substrate types are included on the data sheets, including hardpan, detritus, muck, silt, and artificial substrates. The origin of the substate material (parent material from which the substrate type(s) originated) is also evaluated and scored. Parent material types evaluated include limestone, tills, wetlands, hardpan, sandstone, rip/rap, lacustrine, shale, and coal fines. Finally, substrate quality is evaluated at each site and assigned a score. Substrate quality includes an evaluation of the level of siltation (heavy, moderate, normal, free) and embeddedness (extensive, moderate, normal, or none). The maximum QHEI metric score for Substrate is 20.

**Instream Cover**: Evaluates the presence of instream cover types and amount of overall instream cover. Only cover types present in an amount in sufficient quantity to support species that may commonly be associated with the habitat type are scored. Instream cover types evaluated include undercut banks, overhanging vegetation, shallows, logs or woody debris, deep pools (>70 cm), oxbows, backwaters, side channels, boulders, aquatic macrophytes, and rootwads. Extensive cover is that which is present throughout the sampling area, generally greater than about 75% of the stream reach sampled. Cover is moderate when it occurs over 25- 75% of the sampling area. Cover is sparse when it is present in less than 25% of the stream margins (sparse cover usually exists in one or more isolated patches). Cover is nearly absent when no large patch of any type of cover exists anywhere in the sampling area. The maximum QHEI metric score for Instream Cover is 20.

**Channel Morphology**: This metric emphasizes the quality of the stream channel that relates to the creation and stability of macrohabitat. It includes channel sinuosity (i.e. the degree to which the stream meanders, channel development, channelization, and channel stability. The maximum QHEI metric score for Channel Morphology is 20.

**Riparian Zone and Bank Erosion**: This metric emphasizes the quality of the riparian buffer zone and quality of the floodplain vegetation. This includes riparian zone width, floodplain quality, and extent of bank erosion. Each of the three components requires scoring the left and right banks (looking downstream). The average of the left and right banks is taken to derive the component value. The maximum score for Riparian Zone and Erosion metric is 10 points.

**Pool/Glide and Riffle-Run Quality:** This metric emphasizes the quality of the pool, glide and/or riffle-run habitats. This includes pool depth, overall diversity of current velocities (in pools and riffles), pool morphology, riffle-run depth, riffle-run substrate, and riffle-run substrate quality.

**Map Gradient:** Local or map gradient is calculated from USGS 7.5 minute topographic maps by measuring the elevation drop through the sampling area.

At each site, CAW and USACE biologists utilized the QHEI habitat metrics to independently score the existing and FWOP aquatic and riparian habitat conditions. Tributary A habitat metrics were assessed and recorded for the existing channelized reach. The remainder of the area where Trib. A is to be restored (reconstructed) received zeros for all existing and FWOP habitat metrics as the area is currently in sod production with no stream present. Many sites had habitat metrics that were easy to score, thus both evaluations resulted in the same score. Sites with different metric scores were averaged to come up with one score per metric. FWP habitat metric values were assigned independently based on professional judgement. FWP QHEI metrics were then compared and, when necessary, averaged to come up with one score per metric.

### 2.1.3 Target Years

Target Year (TY) 0 habitat conditions are represented by the existing, or baseline, habitat conditions. The field and desktop collected data were used to quantify the habitat quality of that baseline condition. Target Year 0 conditions serve as a basis of comparison for both FWOP and FWP scenarios.

Additional TYs were identified based on when implemented measures would be expected to elicit community responses represented by changes in the projected habitat variables.

TY 1 is used as a standard comparison year to identify and capture changes in habitat conditions that occur within one year after measures have been constructed. Amount of instream cover, channel development and stability, pool current and morphology, channelization, and water regimes are likely variables that may improve within this time period.

TY3 was selected to capture the increase in habitat quality associated the restoration measures that provide ecological benefits relatively quickly such as riffle/run depths and quality, and channel sinuosity.

TY5 was selected to capture the increase in habitat quality associated the restoration measures that require more time to provide ecological benefits such as natural plant establishment and plant diversity.

TY 10 is used as a point after the initial growth of vegetation and the likely increase in size and benefits plantings have sustained.

TY 15 was selected for reforestation measures only to capture the continued increase in size and benefits riparian plantings have sustained.

Similarly, TY 25 was selected to capture the growth of aquatic and riparian habitats. Riparian plant abundance and diversity are also key response variables for this target year.

TY 50 is the planning life span of the project and is used as the last projected TY for the study. Restoration measures should produce mature habitat by this target year and represent the habitat types within the study area.

### 2.1.4 Habitat Units

USACE quantifies the existing, FWOP, and FWP Ecosystem Restoration (ER) benefits using a Habitat Unit (HU) metric. HUs are calculated as the product of the HSI and the number of acres of the habitat of interest. HUs for each FWOP and FWP are then annualized over the 50-year period of analysis utilizing Equation 1 below.

**Equation 1: Annualization of Habitat Units for the FWOP and FWP Conditions**

$$\int_{0}^{T} HU\, dt = (T_2 - T_1)\left[\left(\frac{A_1H_1 + A_2H_2}{3}\right) + \left(\frac{A_2H_1 + A_1H_2}{6}\right)\right]$$

Where:

$$\int_{0}^{T} HU\, dt = Cumulative\ HUs$$

$T_1$= first target year of time interval

$T_2$ = last target year of time interval

$A_1$ = area of available habitat at beginning of time interval

$A_2$= area of available habitat as the end of time interval

$H_1$ = Index score at the beginning of time interval

$H_2$ = Index score at the end of time interval

3 and 6 = constants derived from integration of Index score x Area for the interval between any two target years

This formula was developed to estimate cumulative HUs when the HSI and/or area between two time intervals ($T_x$ to $T_{x+1}$). The sum of these time intervals over the period of analysis divided by the total number of years of that analysis (50 years for this study) provides an Average Annual Habitat Unit (AAHU). This annualization accounts for the temporal shifts in the log rhythmic rate of accumulating ecological benefits that is common when dealing with the unevenness found in nature (USFWS 1980).

As ecological systems are rarely static, The AAHUs for the FWOP may not be equal to the AAHUs of the existing condition. Therefore, the impact of a project is quantified by calculating the difference between the FWP scenarios and the FWOP. The difference in AAHUs between the FWOP and the FWP represents the net impact attributable to the project in terms of habitat quantity and quality.

Using the habitat models used to establish the existing habitat quality, an interagency team comprised of biologists from the USACE, CAW, and AGFC projected what the future habitat conditions for the FWOP and FWP conditions by consensus based on best professional judgment.

### 2.1.5 Institute for Water Resources Planning Suite II

The Institute for Water Resources (IWR) Planning Suite II is a water resources investment decision support tool originally built for the formulation and evaluation of ecosystem restoration alternatives; however, it is now more widely used by all USACE business lines for evaluation of actions involving monetary and non-monetary cost and benefits.

The purpose of the IWR Planning Suite II is to assist with the formulation and comparison of plans for Ecosystem Restoration and Mitigation Plans. It has the capability of performing the CEICA.

Ecosystem Restoration Planning Center of Expertise (ECO-PCX) annualization spreadsheets were utilized to annualize the HUs and AAHUs for each alternative's FWOP and FWP condition. All annualization calculations for AAHUs were verified by an independent review of data inputs and formulas used in the spreadsheets.

# 3.0 Array of Measures and Alternatives

## 3.1 Measures

A measure is defined as a means to an end; an act, step, or procedure designed for the accomplishment of an objective. In other words, a measure is a feature that can be implemented at a specific geographic site to address one or more planning objectives. Measures are the building blocks of plans and are categorized as structural and non-structural. Equal consideration was given to these two categories of measures during the planning process while conducting this feasibility study.

A number of management measures were considered for this study, including removal of low water crossings and culverts, notching of low water crossings, channel modification, plugging channelized ditches, planting of riparian vegetation and bottom-land hardwoods. Because there were separable areas within the study area for ecosystem restoration, these measures were combined to create alternatives. Table 3-1 lists the alternatives and management measures.

## 3.2 Alternatives

The final array of management measures were combined into alternatives that would address ecosystem restoration in the study area by restoring the structure and function of riverine and riparian forest habitats that have been heavily impacted by anthropogenic changes. Each of the alternatives shown in Table 3-1 below could be a standalone plan or be combined with other alternatives to form a single plan. To avoid double counting acres and/or AAHUs by the CECIA combining any of the individual river crossing alternatives (Alternatives A-D, since they all had the same area calculation for comparison), Alternative R was developed that included four scales of modifying or removing both RC1 and RC2 within the same alternative. Once the alternatives were finalized, the appropriate environmental model(s) was used to calculate the HUs and AAHUs for the FWOP and FWP conditions.

**Table 3-1. List and Description of Alternatives**

| Alternative Label | Alternative | Management Measures |
|---|---|---|
| A | Remove River Crossing 1 (RC1) | Remove the upper low water river crossing and dispose of concrete and off Central Arkansas Water (CAW) property |
| B | Notch RC1 | Notch the upper low water river crossing in main channel to the width of the Maumelle River above the impounded pool. All concrete to be disposed of off CAW property. |
| C | Remove River Crossing 2 (RC2) | Remove the middle low water river crossing and dispose of concrete and off CAW property |
| D | Notch RC2 | Notch the middle low water river crossing in main channel to the width of the Maumelle River above the impounded pool. All concrete to be disposed of off CAW property |
| E | Open Side Channel 1 (SC1) | Notch the existing levee adjacent to RC1 to reconnect side channel<br>Remove metal culverts in old road (road not needed)<br>Remove concrete culverts in old road (road not needed) |
| F | Open Side Channel 2 (SC2) | Notch existing levee between the Maumelle River and side channel 2. Width of opening should be approximately equal to average width of side channel 2.<br>Remove road crossing on side channel 2. |
| G | Restore Tributary A | Plant appropriate bottomland hardwood tree species (stream reforestation<br>Block channelized ditch on west end of field.<br>Excavate/Restore Tributary A. Soil can spread across fields in low level mounds (pimple mounds) and/or elongated ridges (goal is to create microtopography across field).<br>Remove culvert from road (leave gravel low water crossing for CAW access to river).<br>Block channelized ditch below (south) of #8.<br>Notch levee (to reconnect Trib. A to existing channel).<br>Plug ditch below (south) of #10 (to direct Trib. A flow into existing channel thru woods). |
| H | Sod Farm Reforestation | Plant sod fields with appropriate bottomland hardwood tree species. |
| I | Repair River Crossing 3 (RC3) | Construct rock vanes at a 20$^{o}$ angle upstream. |
| R1 | Notch RC1 and RC2 | Notch both low water river crossings and dispose of concrete off Central Arkansas Water (CAW) property |
| R2 | Notch RC1 and Remove RC2 | Notch RC1 and remove RC2 and dispose of concrete off Central Arkansas Water (CAW) property |
| R3 | Remove RC1 and Notch RC2 | Remove RC1 and notch RC2 and dispose of concrete off Central Arkansas Water (CAW) property |
| R4 | Remove RC1 and RC2 | Remove both low water river crossings and dispose of concrete off Central Arkansas Water (CAW) property |

### 3.3 Plans

Costs and environmental benefits for each of the alternatives were combined using the CEICA module in the IWR Planning Suite II to create the seven fully formed plans listed below for evaluation and comparison. The CEICA appendix presents the underlying assumptions that guided how the software generated the combinations to create fully formed plans for evaluation.

**Best Buy Plans**

1. No Action
2. Restore Tributary A
3. Restore Tributary A, Open SC1
4. Restore Tributary A, Open SC1, Sod Farm Reforestation
5. Restore Tributary A, Open SC1, Sod Farm Reforestation, Remove RC1/Remove RC2
6. Restore Tributary A, Open SC1, Sod Farm Reforestation, Remove RC1/Remove RC2, Open SC2
7. Restore Tributary A, Open SC1, Sod Farm Reforestation, Remove RC1/Remove RC2, Open SC2, Repair Bank at RC3

# 4.0 Existing, Future Without- and Future With-Project Conditions

This Section provides the inputs and results of the existing, FWOP, and FWP conditions analyses. Section 4.1 is a description of the justifications, calculations, and results of the FWOP conditions for each alternative. Section 5.0 will describe the likely future conditions in the study area over the 50-year life of each alternative (FWP conditions). Because this is an ecosystem restoration project, the FWP is assumed to provide habitat benefits regarding all alternatives. There will not be any negative impacts due to the FWP. See Attachment A for FWOP and FWP assumptions for each alternative.

Analyses involving riparian and bottomland hardwood reforestation components of each plan (if present) utilize the three HSI models to calculate the projected benefits of project implementation. The resulting HUs of the HSI models of each TY were then averaged together. The averages of those HUs were entered into the ECO-PCX annualization spreadsheets to calculate AAHUs. To clarify, HUs of the separate models were not added together, but averaged to avoid duplicating the values analyzed.

Analyses involving the riverine restoration components of each plan utilize the QHEI model to calculate the projected benefits of project implementation. The FWP scores generated by the QHEI model were entered into the ECO-PCX annualization spreadsheet to calculate AAHUs.

### 4.1 Existing and Future Without-Project Conditions

This section describes the existing conditions for various resources within the study area and the projected future condition of those resources without a project over the 50-year period planning horizon. While there would be no ecosystem restoration project, it is anticipated that natural ecological processes would continue to occur. The current degraded ecological condition in the study area (existing condition) is anticipated to continue to deteriorate over the planning horizon (FWOP condition).

### 4.1.1 Low Water Crossings RC1 and RC2

This reach of the Maumelle River (in the study area) has been adversely impacted by RC1 and RC2 since their construction in the 1980's to early 90's. Both structures have altered stream flow and sediment transport of the river. Severe pooling upstream of the crossings has also led to a disruption of substrate composition, adversely impacting the aquatic habitats remaining within the area. These impacts deter the formation of essential pool/riffle/run structures for aquatic wildlife, increase water temperatures, and lower dissolved oxygen concentrations. The cobble/gravel substrate in the pools has been adversely impacted by excessive sedimentation and embeddedness caused by the crossings preventing water flow, except during high water events. Besides the inundation of riffle-run habitats, the structures are preventing gravel bars and banks from being exposed. Prior to construction of the crossings, the gravel bars provided habitat for many riparian species like wading birds, amphibians, and herbaceous species, including several species of conservation concern.

The crossings have disrupted the natural stream connectivity that existed prior to their construction. The disruption is negatively impacting the free movement of aquatic organisms through the system. This restricted movement, coupled with the degraded benthic habitats above the crossings, has reduced the native aquatic biodiversity (including genetic diversity) that historically occurred in the river. The impacts to diversity will continue under the FWOP condition.

The braided side channel downstream of RC1 will remain partially isolated from the Maumelle River, only receiving infrequent headwater flows when the river overtops the low water crossing during flood conditions, or when the river backs into the channel from the downstream connection. Under both scenarios, flood waters will continue to deposit excessive amounts of sediment into an already heavily impacted section of stream.

In the absence of the Corps involvement, both low water crossings will remain in place and continue to alter the natural hydrology of the Maumelle River. Already degraded aquatic habitats will continue to worsen over the planning horizon.

### 4.1.2 Side Channels 1 and 2

The man-made levee on the north side of the river will continue to separate the river from both side channels, thereby significantly limiting floodplain connectivity in the study area. The loss of flood storage capacity caused by this floodplain isolation will continue to cause bank stabilization issues throughout the study area. Aquatic and riparian habitats in and along the Maumelle River will continue to be impacted by scouring actions created by restricted flows during flood events.

Both SC1 and SC2 have been heavily impacted by years of sedimentation and embeddedness of the natural gravel substrate that historically provided important spawning and nursery habitat for numerous aquatic organisms. Under existing conditions the average annual frequency of connection between the river and side channels is only once every 10-15 years, when flood waters reach an elevation that water backs into the side channels from partially blocked downstream ends, resulting in the deposition of additional sediments from the slower moving flood waters. Historically the connection between the river and side channels was much more frequent, often once every 18 months or less, and entailed floodwater entering at the top end of the side channels. The already degraded aquatic and riparian habitat in and along the side channels will continue to worsen over the planning horizon from nutrient and sediment inputs during extreme flood conditions and from the commercial sod farm operation adjacent to SC1.

### 4.1.3 Sod Farm Fields

Under the FWOP scenario, the fields in the western part of the study area will remain in some sort of agricultural production (crops, grazing, haying, etc. [personal communication with the nonfederal sponsor]). The degraded habitat quality in the study area resulting from the conversion of native bottomland hardwood forests and channelization of natural streams will continue to depress the level of floral and faunal diversity that historically existed in the study area. These impacts are not limited to just the open fields. The absence of riparian and bottomland hardwood forests, and subsequent loss of organic allochthonous material input, reduces the amount of energy available to the lower trophic organisms that drive and support the Maumelle River ecosystem. These impacts will continue to occur in the FWOP condition.

Three channelized ditches constructed on the sod farm area have, and will continue to funnel sediment, nutrients, and even herbicides directly into the Maumelle River and SC1. One ditch was constructed on the western boundary of the sod farm (and study area) to divert upstream flows away from the fields and directly into the Maumelle River near the upstream end of the large pool impounded by RC1. A naturally occurring intermittent stream that used to meander across the west side of the study area was channelized to divert waters draining from part of the fields directly into SC1. A third ditch built to drain the eastern part of the current sod fields also diverts drainage into SC1. All three ditches carry excess amounts of sediment from the frequently disturbed soils, as well as fertilizers and herbicides necessary for commercial sod production, directly into these streams. As a result, the benthic habitats have been severely degraded by several inches of silt and muck covering the cobble and gravel substrates (especially evident in SC1). The already degraded habitats will continue to worsen in the FWOP condition.

### 4.1.4 Low Water Crossing RC3

RC3 was constructed sometime between 1973 and 1983. The structure was destroyed by flood waters in the early 2000’s, which resulted in severe lateral erosion of the left river bank (descending). CAW subsequently funded a project to restore the bank using natural channel design techniques to reduce excessive sediment loads to the river (estimated at 1,350 tons of sediment and 650 pounds of phosphorus, annually).

- The repair of bank erosion at RC3 (site of a former low water dam) will significantly reduce or eliminate active erosion occurring at the site.
- The bank restoration will reduce the amount of fine sediments entering the Maumelle River, thus improving benthic habitat diversity downstream.
- Reduces loss of water supply storage in Lake Maumelle due to sedimentation.

### 4.1.5 Evaluation of Existing and FWOP Riverine Restoration Alternatives and River Segments – QHEI Model

As discussed in Section 2.1.2, 17 habitat components from the QHEI model were measured at each sample site to assess each alternative that addressed instream modifications (e.g., low water crossing notching, removal, etc.). Additionally, QHEI values were calculated for four river segments above, below, and between RC1 and RC2 as part of both the FWOP and FWP analysis so that AAHU measurements could be included during plan formulation to account for the increase in fish passage as a result of modifying or removing each river crossing.

As seen in Table 4-1, the majority of alternative QHEI scores ranged from 0.51 – 0.57, indicative of significantly reduced habitat quality compared to a pristine condition QHEI = 1.0). Alternatives scoring in this range all involve restoration of the main river channel (RC1 and RC2) and side channels (SC1 and SC2). All of these areas exhibited significant sedimentation and embeddedness of gravel and cobble substrates. As expected, QHEI metrics measuring substrate, pool, and riffle quality all received correspondingly low scores.

The alternative “RC3 Bank Repair” had the highest FWOP QHEI index of 0.65. While benthic habitats downstream of the eroding stream bank did show evidence of excessive embeddedness, habitat metrics such as channel morphology and pool quality (upstream and adjacent to RC3) received average to high scores.

As expected, the QHEI score for the Alternative “Restore Tributary A” was extremely low (0.18). This was due to the only riverine habitat available to score was a channelized section of the historic stream and channelized ditches. With only a narrow herbaceous riparian area present, if any, sediments and nutrients from the adjacent sod farm easily enters the channelized sections and is funneled to Side Channel 1, where benthic habitats have been severely impacted.

Since alternatives A – D contain the same footprint for FWOP and FWP comparisons, allowing CEICA to combine any of these individual measures would result in double-counting acres and AAHUs. To avoid this issue, a “river combination” alternative with for separate scales was included in the analysis (R1, R2, R3, and R4). To calculate HUs and resultant AAHUs for the four alternative scales, the river footprint in the project area was broken into separate sections. In addition to the two artificially impounded pools above each river crossing, the area for four segments (above and below RC1 and RC2, side channel below RC1, and river segment between RC1 and RC2) were calculated and a QHEI value was estimated for each section through on-site sampling and professional expertise. HUs and AAHUs were then calculated for each segment to allow for the summation of those segments and avoid double-counting benefits. FWOP QHEI values for the four river segments ranged from 0.61 to 0.88. All FWOP habitat conditions for the four riverine segments between the two river crossing are projected to remain the same in the 50-year planning horizon. The side channel below RC1 and river segment between RC1 and RC2 are projected to change in the FWP condition, depending on what action is taken for each river crossing (notching or removal). These changes will be discussed in Section 5.0.

**Table 4-1. Maumelle River Future Without-Project Quality Habitat Index for Each Target Year and the Average Annual Habitat Units for Instream Modifications of each Alternative and Associated River Segments Used for Final Plan AAHU Calculations**

| Alternatives | Model | Acres | 0 | | 1 | | 3 | | 5 | | 10 | | 25 | | 50 | | AAHU |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | QHEI | HU | QHEI | HU | QHEI | HU | QHEI | HU | QHEI | HU | QHEI | HU | QHEI | HU | |
| **[1]RC 1 ([2]Removal)** | QHEI | 9 | 0.54 | 4.86 | 0.54 | 4.86 | 0.54 | 4.86 | 0.54 | 4.86 | 0.54 | 4.86 | 0.54 | 4.86 | 0.54 | 4.86 | 5.03 |
| **RC 1 ([3]Modification)** | QHEI | 9 | 0.54 | 4.86 | 0.54 | 4.86 | 0.54 | 4.86 | 0.54 | 4.86 | 0.54 | 4.86 | 0.54 | 4.86 | 0.54 | 4.86 | 5.03 |
| **RC 2 (Removal)** | QHEI | 24 | 0.57 | 13.68 | 0.57 | 13.68 | 0.57 | 13.68 | 0.57 | 13.68 | 0.57 | 13.68 | 0.57 | 13.68 | 0.57 | 13.68 | 13.82 |
| **RC 2 ([3]Modification)** | QHEI | 24 | 0.57 | 13.68 | 0.57 | 13.68 | 0.57 | 13.68 | 0.57 | 13.68 | 0.57 | 13.68 | 0.57 | 13.68 | 0.57 | 13.68 | 13.82 |
| **Open [4]SC1** | QHEI | 40 | 0.53 | 21.2 | 0.53 | 21.2 | 0.53 | 21.2 | 0.53 | 21.2 | 0.53 | 21.2 | 0.53 | 21.2 | 0.53 | 21.2 | 20.08 |
| **Open SC2** | QHEI | 20 | 0.51 | 9.69 | 0.51 | 9.69 | 0.51 | 9.69 | 0.51 | 9.69 | 0.51 | 9.69 | 0.51 | 9.69 | 0.51 | 9.69 | 9.69 |
| **Restore Tributary A** | QHEI | 66 | 0.18 | 3.4 | 0.18 | 3.4 | 0.18 | 3.4 | 0.18 | 3.4 | 0.18 | 3.4 | 0.18 | 3.4 | 0.18 | 3.4 | 3.46 |
| **RC 3 Bank Repair** | QHEI | 11 | 0.68 | 7.48 | 0.68 | 7.48 | 0.68 | 7.48 | 0.68 | 7.48 | 0.68 | 7.48 | 0.68 | 7.48 | 0.68 | 7 | 7.21 |
| **[5]River Above RC1** | QHEI | 94 | 0.85 | 79.9 | 0.85 | 79.9 | 0.85 | 79.9 | 0.85 | 79.9 | 0.85 | 79.9 | 0.85 | 79.9 | 0.85 | 79.9 | 80.17 |
| **[5]Side Channel Below RC1** | QHEI | 22 | 0.61 | 13.42 | 0.61 | 13.42 | 0.61 | 13.42 | 0.61 | 13.42 | 0.61 | 13.42 | 0.61 | 13.42 | 0.61 | 13.42 | 13.40 |
| **[5]River Between RC1 and RC2** | QHEI | 45 | 0.78 | 35.1 | 0.78 | 35.1 | 0.78 | 35.1 | 0.78 | 35.1 | 0.78 | 35.1 | 0.78 | 35.1 | 0.78 | 35.1 | 34.86 |
| **[5]River Below RC2** | QHEI | 96 | 0.88 | 84.48 | 0.88 | 84.48 | 0.88 | 84.48 | 0.88 | 84.48 | 0.88 | 84.48 | 0.88 | 84.48 | 0.88 | 84.48 | 84.48 |

Target Year columns: 0, 1, 3, 5, 10, 25, 50.

[1]RC: River Crossing
[2]Removal: QHEI and HUs in regard to the complete removal of low water crossings within the study area.
[3]Modification: QHEI and HUs in regard to the notching of the low water crossings within the study area.
[4]SC: Side Channel
[5]NOT AN ALTERNATIVE – river segment used for FWOP and FWP AAHU calculations for all alternatives

### 4.1.6 Evaluation of FWOP Reforestation Alternatives – HEP Models

The three HEP models discussed in Section 2.1.1 were used two evaluate two alternatives that include the restoration of bottomland hardwood forests; the riparian forest restoration as part of Alternative G - Restore Tributary A, and Alternative H - Sod Farm Reforestation. While the QHEI model used for "Restore Tributary A" has a metric for riparian zone quality, that measurement focuses on the benefits that the aquatic habitat derives from the riparian zone. To adequately assess the value of the restored riparian area to terrestrial wildlife (e.g., forage and nesting quality), HEP models were employed. To capture the full benefits gained with Alternative G - Restore Tributary A, the results of the QHEI and HEP models were added together.

As discussed in Section 2.1.1, the existing habitat for both reforestation alternatives is open fields currently in commercial sod production. Because there is no suitable vegetation for any of the three species evaluated, the calculated HSIs were 0.0, resulting in an AAHU of 0 for the area (Table 4-2).

The conditions affecting the terrestrial FWOP AAHUs are expected to remain the same over the 50-year planning period.

**Table 4-2. Maumelle River Partially Formed Plans Future Without-Project Habitat Suitability Index for Barred Owl, Gray Squirrel, and Downy Woodpecker Habitat Units for Each Target Year, Average Habitat Units for Each Target Year between the Models, and the Average Annual Habitat Units for Reforestation Restoration**

| Alternative | Model | Acres | Target Year | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 5 | | 10 | | 15 | | 25 | | 50 | |
| | | | HSI | HU | HSI | HU | HSI | HU | HSI | HU | HSI | HU | HSI | HU | HSI | HU |
| Restore Trib. A | Barred Owl | 66 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| | Gray Squirrel | | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| | Downy Woodpecker | | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| Sod Farm Reforestation | Barred Owl | 74 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| | Gray Squirrel | | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| | Downy Woodpecker | | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| **AAHU = 1** | **[4]Average HU** | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | |

# 5.0 Future With-Project Conditions

The FWP conditions will evaluate the ecosystem benefits each partially formed plan will have on various resources within the study area and the projected future condition of those resources over the 50-year period planning horizon. As was done when calculating the FWOP conditions, ecosystem benefits were assessed and projected with the habitat models by USACE and CAW biologists using professional judgment and existing data for each target year. The actions described below are the assumed benefits of project implementation.

As was done when calculating the FWOP conditions, USACE and CAW biologists utilized terrestrial and riverine habitat models to project future ecosystem benefits. To accurately assess the benefits of project implementation, the FWP conditions were compared to the Existing and FWOP conditions using the same model metric values and area of analysis (with the exception of removing the two low water crossings). To capture the benefits gained in stream connectivity by removal of the crossings, the FWP area included the stream section above or below the FWOP area that would be open to fish passage with the removal each crossing.

## 5.1 Evaluation of FWP Riverine Restoration Alternatives – QHEI Model

As discussed in Section 2.1.2, 17 habitat components from the QHEI model were measured at each sample site to assess each alternative that addressed instream modifications (e.g., low water crossing notching, removal, etc.). FWP QHEI values were also calculated for four river segments above, below, and between RC1 and RC2, so that AAHU measurements could be included during plan formulation to account for the increase in fish passage as a result of modifying or removing each river crossing.

As seen in Table 5-1, the FWP QHEI scores for the four river crossing options show significant increases over their FWOP scores (0.19 – 0.29). As discussed in Sections 5.2.2 – 5.2.5 below, the majority of increase is the result of restored riffle-pool habitats. The alternatives for notching the crossings scored lower due to impacts from the remaining crossing material being left in the stream channel.

Opening the side channels SC1 and SC2 results in a QHEI value increase of 0.31 for both alternatives (Table 3-3) as the result of the restored benthic habitat. Sections 5.2.6 and 5.2.7 below describe the forecasted benefits for the side channels.

Alternative I - RC3 Bank Repair shows only a 0.11 increase in QHEI value, which is the least habitat gain of any of the alternatives. The reason for the slight increase, as discussed in Section 5.2.8, is that the FWOP habitat condition was already in good shape (Table 5-1).

As expected, the QHEI score for Alternative G - Restore Tributary A is significantly larger than that FWOP score (0.74 vs. 0.18) due to the entire 66 acres being forecast as a riparian forest. Section 5.2.9 discusses this increase in detail.

FWP QHEI values for the four river segments discussed in Section 4.1.5 ranged from 0.85 to 0.94. As was the case for the FWOP condition, the river segment above RC1 and below RC2, the FWP QHEI values are projected to remain the same (0.85 and 0.88, respectively). The side channel below RC1 and river segment between RC1 and RC2 are projected to change in the FWP condition, depending on what action is taken for each river crossing (notching or removal). For the individual removal or notching of RC1 or RC2 (Alternatives A - D), the FWOP and FWP AAHUs for the river segment between the two crossings is projected to remain the same. While there may be some limited benefit by the modification/removal of one crossing, the remaining crossing will continue to limit the ability for the river to repair itself. The removal of RC1 (Alternative A) would restore headwater flows through the braided side channel below the crossing, thus the FWP condition for Alternative A includes increased AAHUs for the side channel and the restored riffle-run-pool habitat sequences above the crossing location. Notching RC1 would not reconnect the side channel to the main river.

For the four scales of Alternative R (which involve a management action on both crossings), their removal and/or notching will benefit the river segment between the crossings by restoring the natural hydrologic flows that historically existed. With the removal of RC1 in Alternative R (scales R3 and R4), the braided side channel below RC1 will be reconnected to the main river channel, allowing headwater flows to flush the excess sediments out of the side channel during high flow events. These headwater flows will reduce the sedimentation and embeddedness that currently exist in the channel, thus exposing and cleansing the gravel substrate and improving habitat conditions for numerous native aquatic species. This channel restoration (via headwater flows) will not occur with the notching of RC1 (Alternatives R1 and R2), as the side channel will remain separated from the main river by remaining dam material.

**Table 5-1. The Instream Modification Future With-Project Habitat Quality Index for Habitat Units for Each Target Year, and the Average Annual Habitat Units for Riverine Restoration Alternatives.**

| Alternative | Model | Acres | Target Year 0 | | 1 | | 3 | | 5 | | 10 | | 25 | | 50 | | AAHU |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | QHEI | HU | QHEI | HU | QHEI | HU | QHEI | HU | QHEI | HU | QHEI | HU | QHEI | HU | |
| **[1]RC 1 ([2]Removal)** | QHEI | 9 | 0.62 | 5.58 | 0.69 | 6.21 | 0.83 | 7.47 | 0.83 | 7.47 | 0.86 | 7.74 | 0.86 | 7.74 | 0.86 | 7.74 | 7.87 |
| **RC 1 ([3]Modification)** | QHEI | 9 | 0.61 | 5.49 | 0.63 | 5.67 | 0.73 | 6.57 | 0.73 | 6.57 | 0.74 | 6.66 | 0.74 | 6.66 | 0.74 | 6.66 | 6.84 |
| **RC 2 (Removal)** | QHEI | 24 | 0.63 | 15.12 | 0.70 | 16.80 | 0.84 | 20.16 | 0.84 | 20.16 | 0.88 | 21.12 | 0.88 | 21.12 | 0.88 | 21.12 | 21.04 |
| **RC 2 ([3]Modification)** | QHEI | 24 | 0.62 | 14.88 | 0.64 | 15.36 | 0.74 | 17.76 | 0.74 | 17.76 | 0.76 | 18.24 | 0.76 | 18.24 | 0.76 | 18.24 | 18.25 |
| **OPEN [4]SC1** | QHEI | 40 | 0.54 | 21.6 | 0.58 | 23.2 | 0.62 | 24.8 | 0.85 | 34.0 | 0.85 | 34.0 | 0.85 | 34.0 | 0.85 | 34.0 | 32.99 |
| **OPEN SC2** | QHEI | 20 | 0.52 | 10.4 | 0.56 | 11.2 | 0.60 | 12.0 | 0.83 | 16.6 | 0.83 | 16.6 | 0.83 | 16.6 | 0.83 | 16.6 | 15.94 |
| **Restore Tributary A** | QHEI | 66 | 0.18 | 11.9 | 0.28 | 18.5 | 0.35 | 23.1 | 0.45 | 29.7 | 0.63 | 41.6 | 0.74 | 48.8 | 0.74 | 48.8 | 43.86 |
| **RC 3 Bank Repair** | QHEI | 11 | 0.68 | 7.48 | 0.74 | 8.14 | 0.74 | 8.14 | 0.74 | 8.14 | 0.74 | 8.14 | 0.74 | 8.14 | 0.74 | 8.14 | 7.21 |
| **[5]River Above RC1** | QHEI | 94 | 0.85 | 79.9 | 0.85 | 79.9 | 0.85 | 79.9 | 0.85 | 79.9 | 0.85 | 79.9 | 0.85 | 79.9 | 0.85 | 79.9 | 80.17 |
| **[5]Side Channel Below RC1** | QHEI | 22 | 0.68 | 14.96 | 0.76 | 16.72 | 0.94 | 20.68 | 0.94 | 20.68 | 0.94 | 20.68 | 0.94 | 20.68 | 0.94 | 20.68 | 18.46 |
| **[5]River Between RC1 and RC2** | QHEI | 45 | 0.78 | 35.1 | 0.81 | 36.45 | 0.85 | 38.25 | 0.90 | 40.5 | 0.90 | 40.5 | 0.90 | 40.5 | 0.90 | 40.5 | 39.96 |
| **[5]River Below RC2** | QHEI | 96 | 0.88 | 84.48 | 0.88 | 84.48 | 0.88 | 84.48 | 0.88 | 84.48 | 0.88 | 84.48 | 0.88 | 84.48 | 0.88 | 84.48 | 84.48 |

[1]RC: River Crossing
[2]Removal: QHEI and HUs in regard to the complete removal of low water crossings within the study area.
[3]Modification: QHEI and HUs in regard to the notching of the low water crossings within the study area.
[4]SC: Side Channel
[5]NOT AN ALTERNATIVE – river segment used for FWOP and FWP AAHU calculations for all alternatives

### 5.1.1 Alternative A - Remove Low Water Crossing 1 (RC1)

The FWP analysis area for the removal of RC1 includes the pool area impounded above the structure, the braided side channel below RC1, the river section between the RC1 and RC2, the pool area above RC2, and the river segments above RC1 (to the next partial blockage) and below RC2 to Lake Maumelle (290 acres). Figure 5-1 provides a visual depiction of the FWOP and FWP analysis areas (red numbers represent FWP QHEI values).

The removal of RC1 will provide an increased QHEI value over a 50-year planning horizon from 0.54 to 0.86 (Table 5-1), resulting in an increase of 8 AAHUs (232 FWOP AAHUs vs. 240 FWP AAHUs). The removal of RC1 partially restores the natural hydrology in the study area and moves sediment and energy transport towards a natural condition. The removal will also normalize water temperature regimes above the crossing and improve dissolved oxygen concentrations downstream.

While the AAHU increase is relatively minor for the entire FWOP and FWP area, it is only measuring the increase in habitat value for the conversion of the impounded pool above RC1 to riffle-pool-run habitat that historically existed. With the removal, the water surface elevation will return to normal stages (estimated 6+ foot elevation drop [~ height of RC1]). Thalweg survey data collected by the U.S. Geological Survey (USGS) indicates that restoring normal water surface elevations will expose an estimated three or more riffle-pool habitat sequences. The restored flow conditions will increase substrate stability and quality by flushing excess sediments covering the cobble/gravel substrate and reduce embeddedness. Additionally, channel morphology will be restored to historic conditions (improved channel development and increased sinuosity).

The increased AAHU value does not account for the value of stream connectivity afforded by the removal of RC1. With the removal, aquatic organisms (e.g. native darters, minnows, mussels, etc.) above RC1, between RC1 and RC2, and in the side channel below RC1, will have a significantly larger in-stream area for migration and increased access to more and better quality habitat for foraging and reproduction. This increased access to aquatic habitats, as well as a larger genetic pool, will help to restore the biological diversity that historically existed in the Maumelle River.

The removal of RC1 will restore the connection between the river and the braided side channel downstream. The restored headwater flows will flush excess sediments out of the channel and reduce embeddedness of the gravel substrate. The restored aquatic habitat will benefit many native species that will utilize the side channel for spawning and nursery areas, as well as provide refugia to aquatic organisms during flood events. Many riparian-dependent species will also benefit from the restored aquatic habitat.

The reduced water surface elevation above the RC1 location will also expose gravel banks and bars that will provide habitat for many riparian species such as wading birds, amphibians, and many plant species, including several state-sensitive plant species of conservation concern.

The riparian zone width and quality will also be restored to historic conditions with the reforestation of the adjacent sod farm.

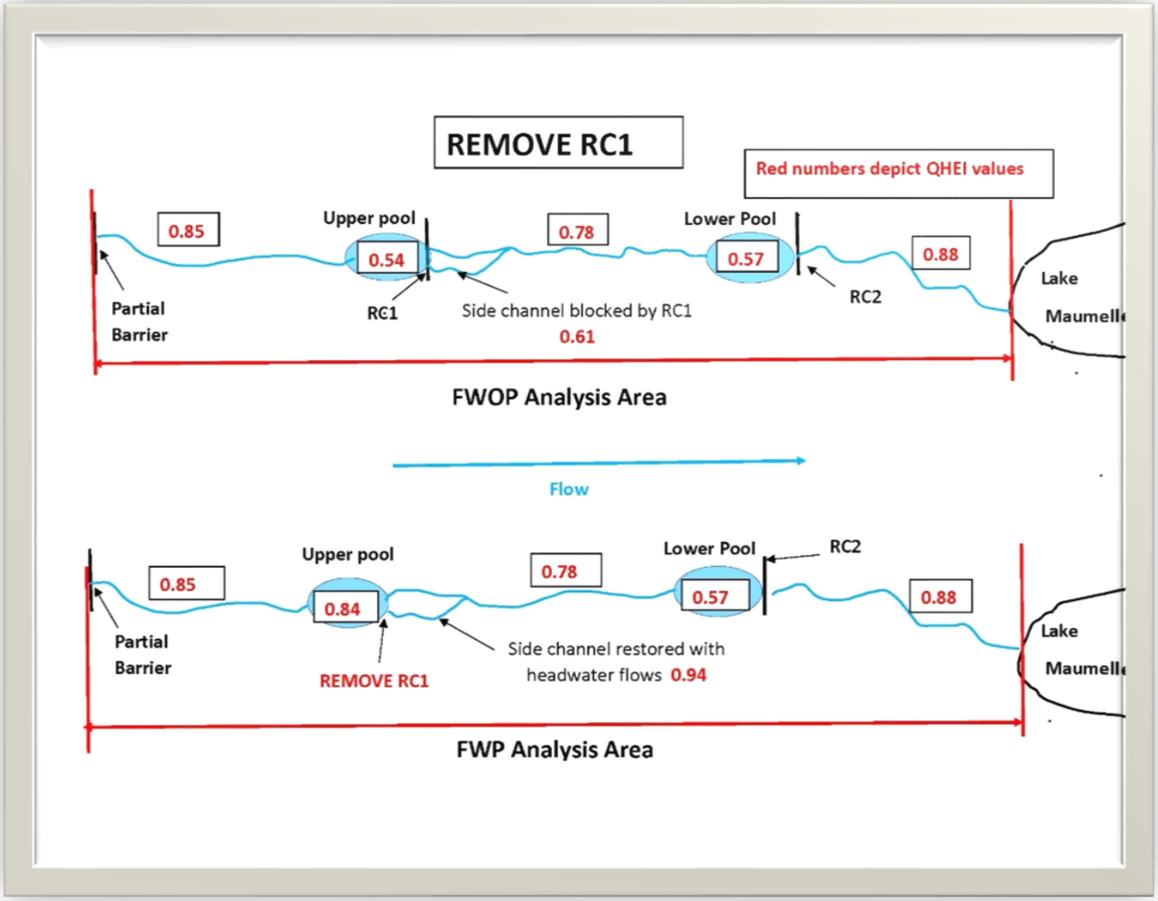


**Figure 5-1. Alternative A - Remove RC1 - FWOP and FWP Analysis Area**

### 5.1.2 Alternative B - Notch Low Water Crossing 1 (RC1)

Alternative B - Notch RC1 entails removing a central section of the low water crossing to restore stream connectivity. The estimated width of the notch would be 60 feet, which is the approximate width of the Maumelle River above the impounded pool. The FWP area of analysis for Alternative B is the same as that for the removal of RC1. Some of the FWP QHEI projections for the removal of RC1 were reduced based on the projected effects the remaining low water crossing material left in the river would have on habitat conditions.

The notching of RC1 will provide an increase of QHEI value over a 50-year period from 0.54 to 0.74 (Table 5-1), resulting in an increase of 2 AAHUs (232 FWOP AAHUs vs. 234 FWP AAHUs).

Habitat benefits derived from notching RC1 are similar to many listed in Section 5.1.1. The restoration of the riffle-pool habitats will occur with this alternative, however there will be a reduction in the duration that they will be exposed due to the water level being held at a higher elevation. While substrate stability and quality will improve, the remaining low water crossing sections in the river channel will continue to impede natural flow conditions during high water events that will likely result in some increased sedimentation continuing to occur upstream. Channel development and sinuosity will improve, but the higher water level elevation will limit the benefits.

One significant difference from the "Remove RC1" alternative is that the braided side channel below RC1 would remain separated by the remaining low water crossing sections, thus the FWP habitat value is the same as the FWOP value and the primary reason the FWP AAHUs for notching being less than that for the "Remove RC1" Alternative (6 or the 8 AAHUs in Alternative A are due to side channel benefits. (Figure 5.2).

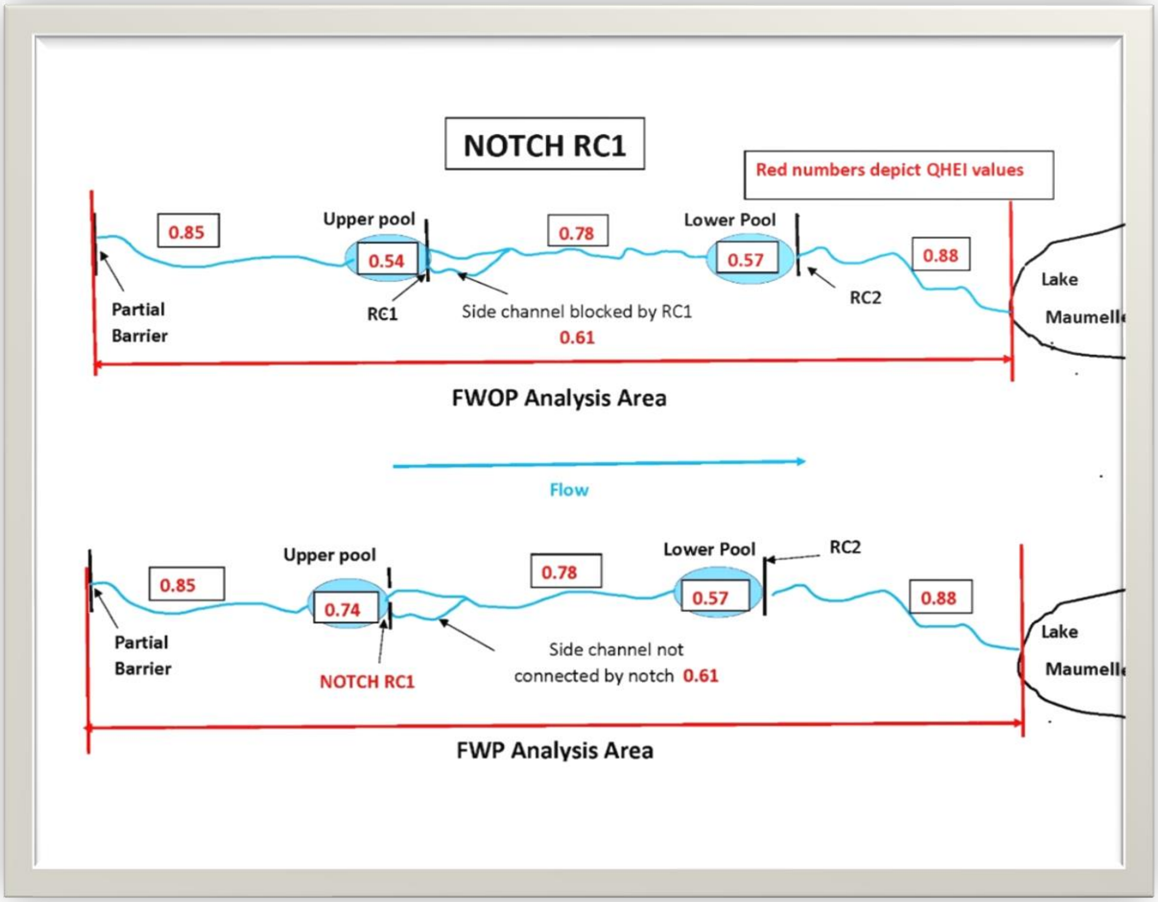


**Figure 5-2. Alternative B - Notch RC1 - FWOP and FWP Analysis Area**

### 5.1.3 Alternative C - Remove Low Water Crossing 2 (RC2)

The FWP analysis area for the removal of RC2 is the same as the FWOP area (290 acres). Figure 5-3 provides a visual depiction of the FWOP and FWP analysis areas (red numbers represent FWP QHEI values). The removal of RC1 will provide an increased QHEI value over a 50-year planning horizon from 0.57 to 0.88 (Table 5-1), resulting in an increase of 7 AAHUs (232 FWOP AAHUs vs. 239 FWP AAHUs).

The removal of RC2 partially restores the natural hydrology in the study area and moves sediment and energy transport towards a natural condition. The removal will also normalize water temperature regimes above the crossing and improve dissolved oxygen concentrations downstream.

While the AAHU increase is relatively minor for the entire FWOP and FWP area, it is only measuring the increase in habitat value for the conversion of the impounded pool above RC2 to riffle-pool-run habitat that historically existed. With the removal, the water surface elevation will return to normal stages (estimated 6+ foot elevation drop [~ height of RC2]). Thalweg survey data collected by the U.S. Geological Survey (USGS) indicates that restoring normal water surface elevations will expose an estimated three or more riffle-pool habitat sequences. The restored flow conditions will increase substrate stability and quality by flushing excess sediments covering the cobble/gravel substrate and reduce embeddedness. Additionally, channel morphology will be restored to historic conditions (improved channel development and increased sinuosity). The reduced water surface elevation will also expose gravel banks and bars that will provide habitat for many riparian species such as wading birds, amphibians, and many plant species, including several state-sensitive plant species of conservation concern.

The increased AAHU value does not account for the value of stream connectivity afforded by the removal of RC2. With the removal, aquatic organisms (e.g. native darters, minnows, mussels, etc.) below RC2 and between RC1 and RC2 will have a significantly larger in-stream area for migration and increased access to more and better quality habitat for foraging and reproduction. This increased access to aquatic habitats, as well as a larger genetic pool, will help to restore the biological diversity that historically existed in the Maumelle River.

The reduced water surface elevation above the RC2 location will also expose gravel banks and bars that will provide habitat for many riparian species such as wading birds, amphibians, and many plant species, including several state-sensitive plant species of conservation concern.

Unlike the removal of RC1, the braided side channel below RC1 will remain isolated from the main river channel and only receiving backwater flow during high water events. This continued isolation from the main river channel results in the side channel continuing to degrade over the 50 year planning horizon.

Removing RC2 will have no effect on the connection between the river and the braided side channel below RC1, thus the FWOP and FWP conditions for the side channel will remain the same.

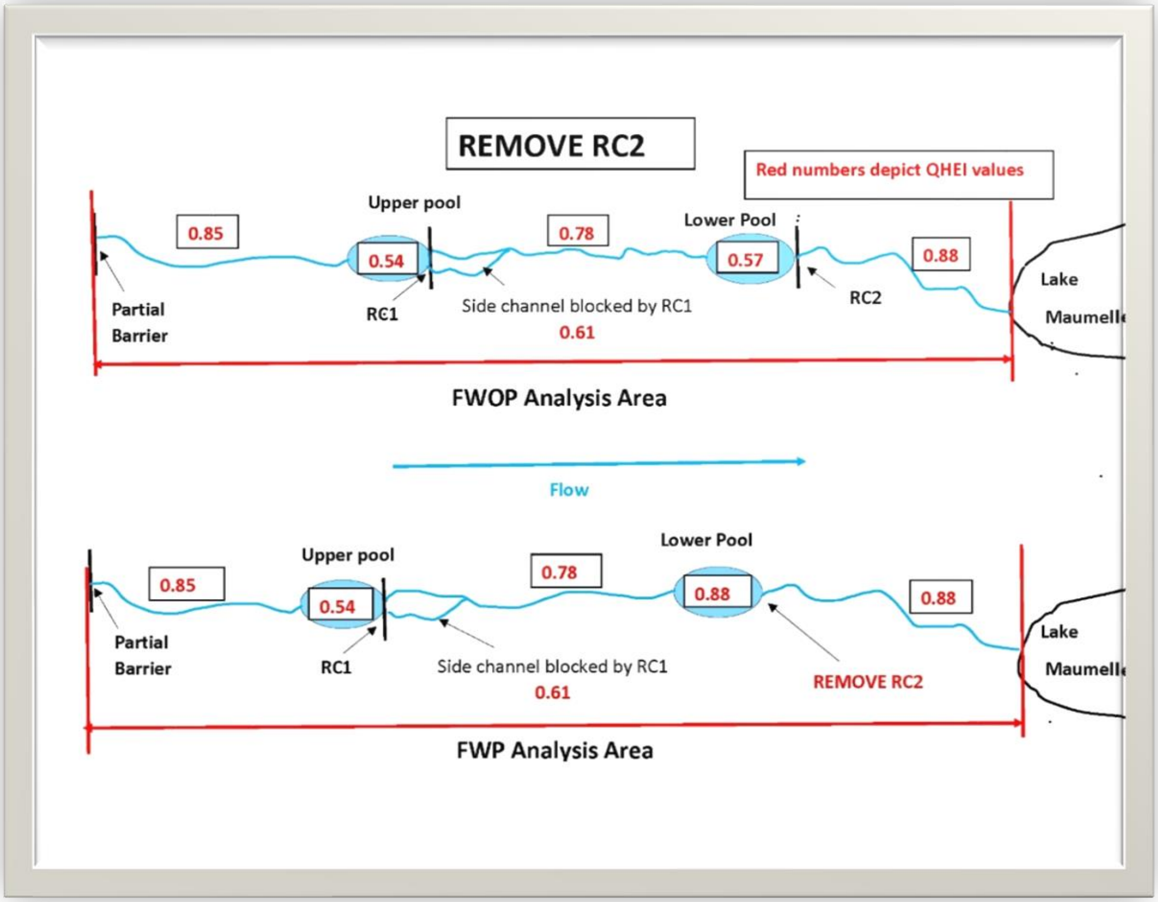


**Figure 5-3. Alternative C - Remove RC2 - FWOP and FWP Analysis Area**

### 5.1.4 Alternative D - Notch Low Water Crossing 2 (RC2)

Similar to notching RC1, Alternative D – Notch RC2 entails removing a central section of the low water crossing to restore stream connectivity. The estimated width of the notch would be 60 feet, which is the approximate width of the Maumelle River above the impounded pool. The FWP area of analysis for Alternative D is the same as that for the removal of RC2 (Section 5.1.3).

As shown in Figure 5-4, notching RC2 will provide an increase of QHEI value over a 50-year period from 0.57 to 0.76 (Table 5-1), resulting in an increase of 4 AAHUs (232 FWOP AAHUs vs. 236 FWP AAHUs).

Habitat benefits derived from notching RC2 are similar to those for the removal, with similar exceptions noted in the discussion of notching RC1 (Section 5.1.2). The restoration of the riffle-pool habitats above the RC2 crossing will occur with this alternative as well, however there will be a reduction in the duration that they will be exposed due to the water level being held at a higher elevation. Channel development and sinuosity will improve, but the higher water level elevation will limit the benefits. Substrate stability and quality will also improve, but the remaining low water crossing sections in the river channel will continue to impede natural flow conditions during high water events that will likely result in some increased sedimentation continuing to occur upstream. A significant amount of bank armoring will be required downstream of the crossing, as the notch will force high flows into the descending left bank.

Notching RC2 will have no effect on the connection between the river and the braided side channel below RC1, thus the FWOP and FWP conditions for the side channel will remain the same.

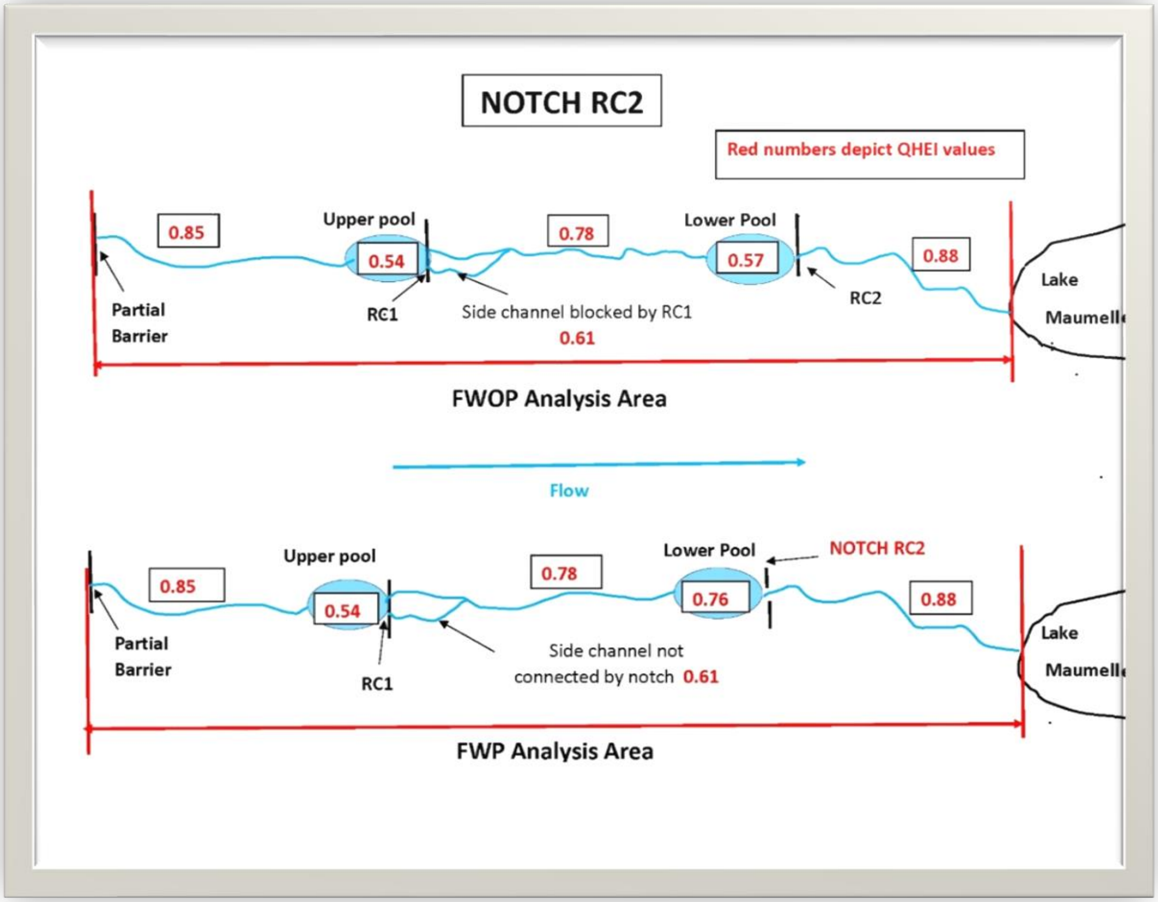


**Figure 5-4. Alternative D - Notch RC2 - FWOP and FWP Analysis Area**

### 5.1.5 Alternative E – Open Side Channel 1 (SC1)

To assess the benefits of opening SC1, the FWP conditions were compared to the Existing and FWOP conditions using the same model metric values and area of analysis (40 acres).

Opening SC1 will provide an increase of QHEI value over a 50-year period from 0.53 to 0.85, resulting in an increase of 13 AAHUs (20 FWOP AAHUs vs. 33 FWP AAHUs).

To reconnect the Maumelle River to SC1, a section of the man-made levee adjacent to RC1 will be removed. Hydrologic and Hydrology modeling indicates that restoring this connection at the elevation of the bottom of the side channel would reestablish flow through this Freshwater Forested Wetland approximately once every eighteen months for the period of record (currently once in 10-15 years). This reconnection partially restores the natural hydrology in the study area and moves sediment and energy transport towards a natural condition. Opening SC1 will increase the flood storage capacity, normalize water temperature regimes, improve dissolved oxygen concentrations, and restore organic allochthonous material input to the aquatic system and provide the energy to the lower trophic organisms that drive and support the Maumelle River ecosystem.

The majority of habitat benefits comes from restoration of riffle-pool habitat complexes that once existed in the channel. Removal of four collapsed culverts in the side channel will lower the water surface elevation and expose the riffle-pool habitats. The restored flow conditions will increase substrate stability and quality by flushing excess sediments covering the cobble/gravel substrate and reduce embeddedness. The restored benthic habitat will significantly benefit many aquatic species that require it for foraging, spawning, and nursery areas (increased biodiversity). The majority of FWP QHEI metric value increases come from improved substrate quality and type (0.15), and pool and riffle quality (0.11) over the FWOP condition. Other improvements include channel morphology and riparian zone width.

### 5.1.6 Alternative F – Open Side Channel 2 (SC2)

To assess the benefits of opening SC2, the FWP conditions were compared to the Existing and FWOP conditions using the same model metric values and area of analysis (20 acres).

Opening SC2 will provide an increase of QHEI value over a 50-year period from 0.51 to 0.83, resulting in an increase of 6 AAHUs (10 FWOP AAHUs vs. 16 FWP AAHUs).

Similar to SC1, reconnecting SC2 involves the removal of a section of man-made levee. The current issues plaguing this isolated side channel, and the habitat benefits gained by the reconnection, are similar to those discussed for reconnecting SC1 (Section 5.1.5).

The majority of FWP QHEI metric value increases come from improved substrate quality and type (0.14), and pool and riffle quality (0.11) over the FWOP condition. Other improvements include channel morphology and riparian zone width.

### 5.1.7 Alternative I – River Crossing 3 Bank Repair

Alternative “RC3 Bank Repair” shows only a 0.06 increase in QHEI value, which is the least habitat gain of any of the alternatives. The reason for the slight increase is that the FWOP habitat condition was already in good shape (Table 5-1). The substrate quality is forecast to have the largest improvement, with a QHEI metric increase of 0.04. Improvements in channel stability and decreased bank erosion made up the remainder of the QHEI gain.

### 5.1.8 Alternative R1 – Notch RC1 and RC2

As discussed in Section 3.2, Alternative R was included in the final array to avoid the double counting of acres and benefits that would occur with CEICA combining Alternatives A or B with Alternatives C or D. Four scales of Alternative R were included in the analysis that have different combinations of proposed actions on both river crossings.

Alternative R1 entails removing a central section of both low water crossings to restore stream connectivity. The estimated width of the notches would be 60 feet, which is the approximate width of the Maumelle River above the impounded pools. Sections 5.1.2 and 5.1.4 discuss the increase in QHEI values of each pool with a notching alternative as well as a description of those benefits.

In addition to the habitat value lift calculated for the pools, the QHEI value of the river between RC1 and RC2 would increase from 0.78 to 0.90 due to the free flow condition of the river with both openings. As previously discussed, the FWOP and FWP habitat conditions, thus QHEI values, do not change for the river sections above RC1 and below RC2. With the notching of RC1, the braided side channel below the crossing would remain isolated by sections of the crossing that are left in the river (Figure 5-5).

The FWP condition of Alternative R1 results in an AAHU lift of 11 (232 FWOP AAHUs vs. 243 FWP AAHUs).

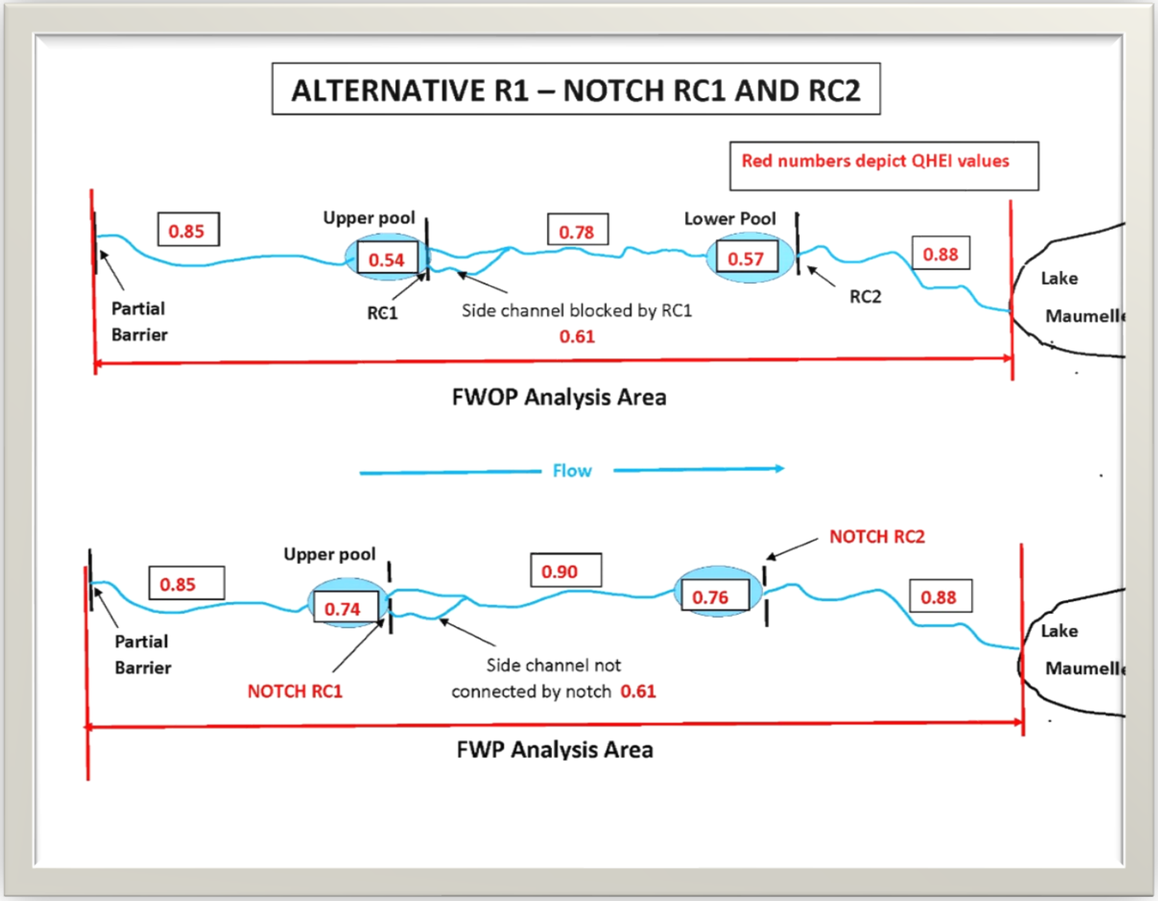


**Figure 5-5. Alternative R1 - Notch RC1 and RC2 FWOP and FWP Analysis Area**

### 5.1.9 Alternative R2 – Notch RC1 and Remove RC2

Alternative R2 entails removing a central section of RC1 (notching) and the complete removal of RC2 to restore stream connectivity. Sections 5.1.2 and 5.1.3 discuss the increase in QHEI values of each pool, as well as a description of those benefits.

Similar to Alternative R1, the QHEI value of the river between RC1 and RC2 would increase from 0.78 to 0.90 due to the free flow condition of the river with both openings. As previously discussed, the FWOP and FWP habitat conditions, thus QHEI values, do not change for the river sections above RC1 and below RC2. With the notching of RC1, the braided side channel below the crossing would remain isolated by sections of the crossing that are left in the river (Figure 5-6).

The FWP condition of Alternative R2 results in an AAHU lift of 14 (232 FWOP AAHUs vs. 246 FWP AAHUs).

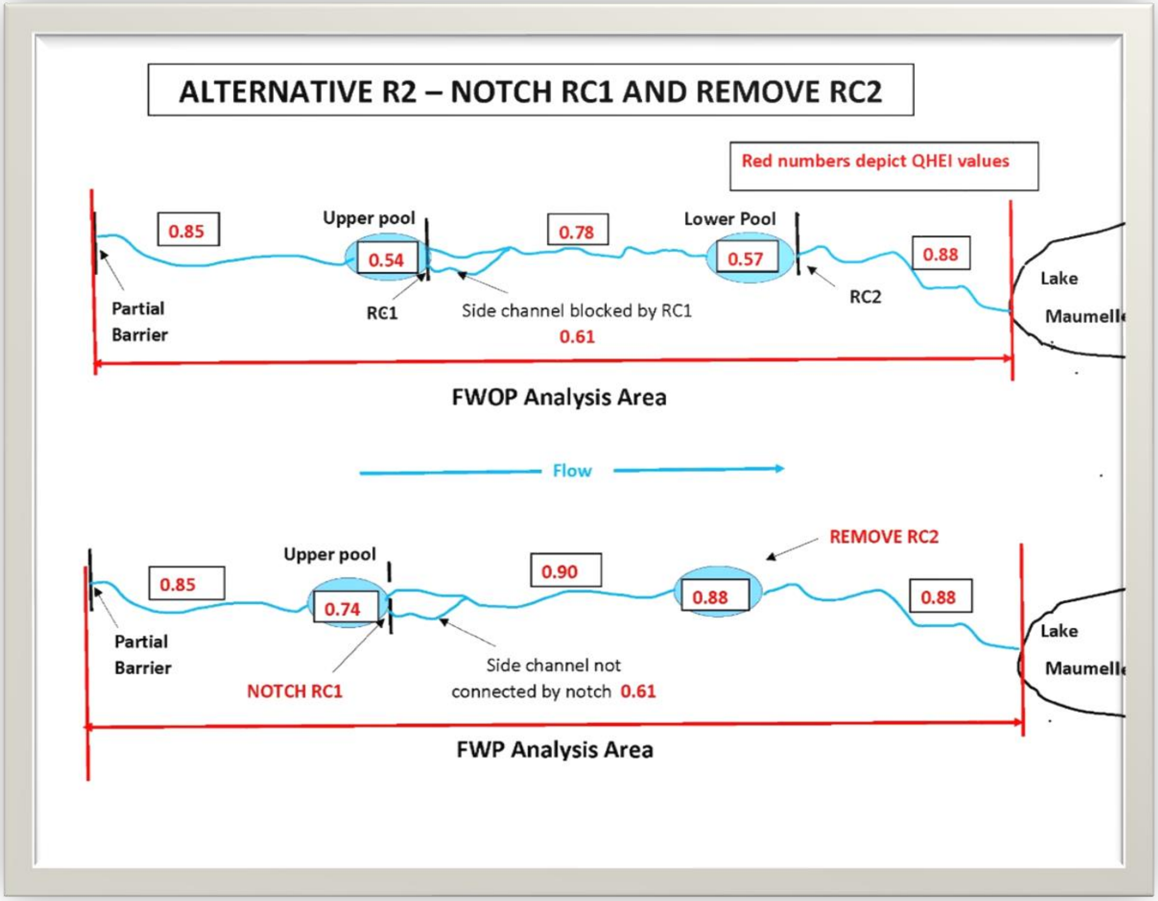


**Figure 5-6. Alternative R2 - Notch RC1 and Remove RC2 FWOP and FWP Analysis Area**

### 5.1.10 Alternative R3 – Remove RC1 and Notch RC2

Alternative R3 entails removing RC1 and notching RC2 to restore stream connectivity. Sections 5.1.1 and 5.1.4 discuss the increase in QHEI values of each pool, as well as a description of those benefits.

The QHEI value of the river between RC1 and RC2 would increase from 0.78 to 0.90 due to the free flow condition of the river with both openings. As previously discussed, the FWOP and FWP habitat conditions, thus QHEI values, do not change for the river sections above RC1 and below RC2. With the removal of RC1, the braided side channel below the crossing would be reconnected to the main river channel, which significantly increases the QHEI value for that section (Figure 5-7).

The FWP condition of Alternative R3 results in an AAHU lift of 17 (232 FWOP AAHUs vs. 249 FWP AAHUs).

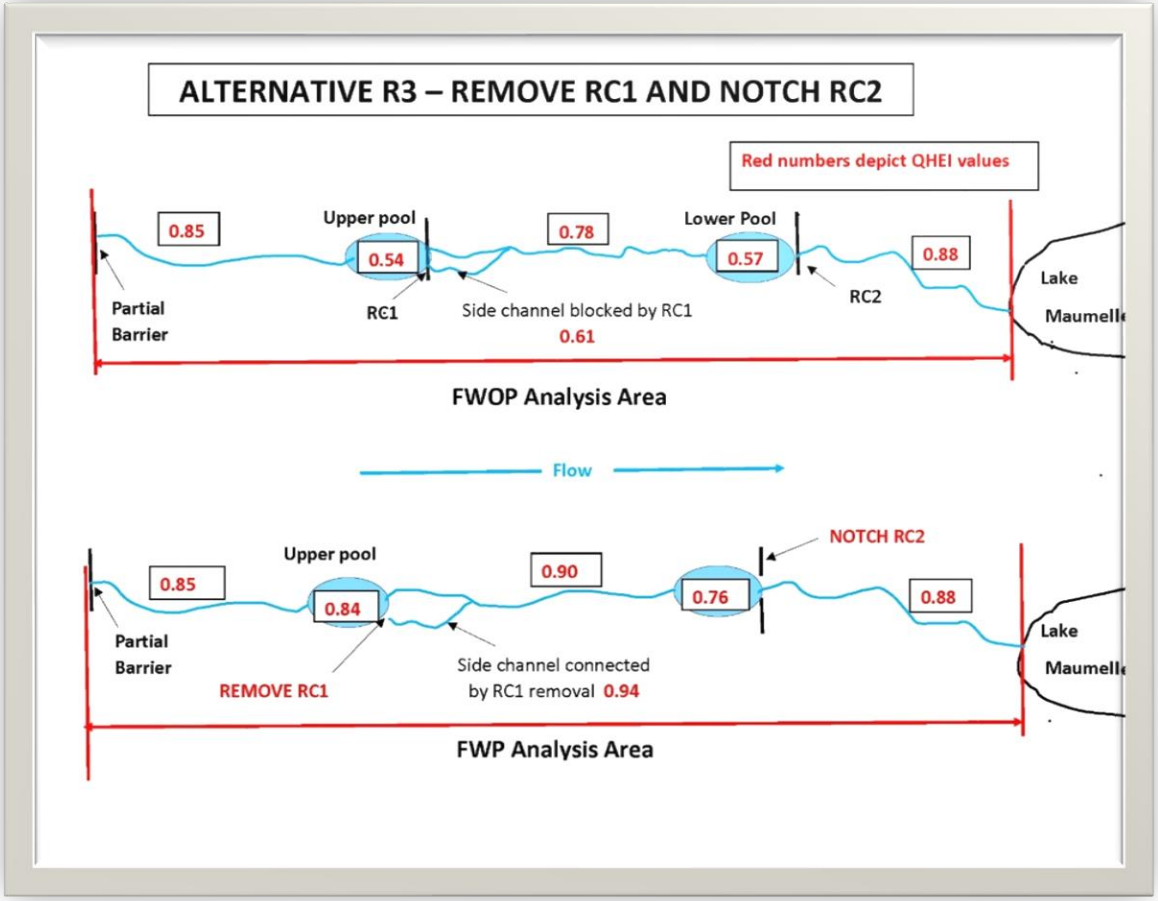


**Figure 5-7. Alternative R3 – Remove RC1 and Notch RC2 FWOP and FWP Analysis Area**

### 5.1.11 Alternative R4 – Remove RC1 and RC2

Alternative R4 entails the removal of both RC1 and RC2 to restore stream connectivity. Sections 5.1.1 and 5.1.3 discuss the increase in QHEI values of each pool, as well as a description of those benefits.

The QHEI value of the river between RC1 and RC2 would increase from 0.78 to 0.90 due to the free flow condition of the river with both openings. As previously discussed, the FWOP and FWP habitat conditions, thus QHEI values, do not change for the river sections above RC1 and below RC2. With the removal of RC1, the braided side channel below the crossing would be reconnected to the main river channel, which significantly increases the QHEI value for that section (Figure 5-7).

The FWP condition of Alternative R4 results in an AAHU lift of 20 (232 FWOP AAHUs vs. 252 FWP AAHUs).

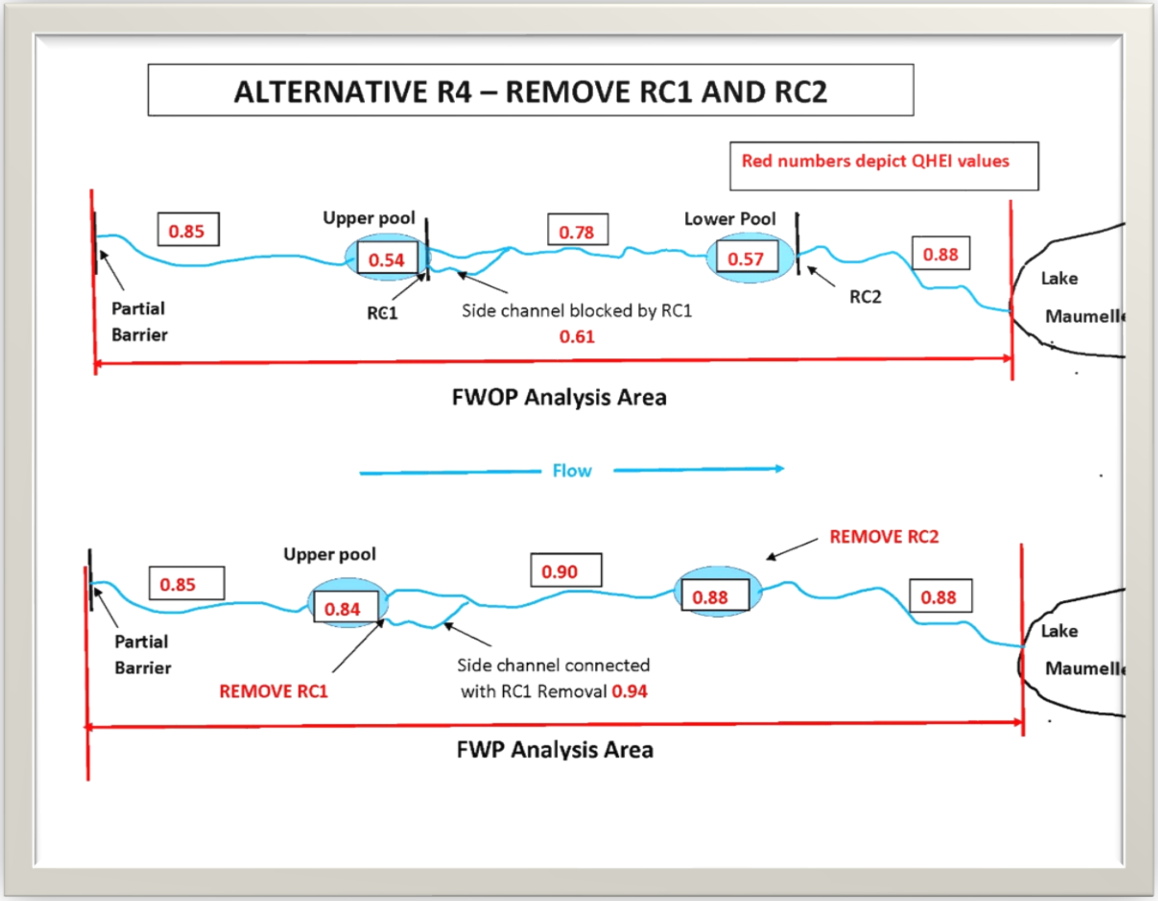


**Figure 5-7. Alternative R4 – Remove RC1 and RC2 FWOP and FWP Analysis Area**

### 5.1.12 Alternative G – Restore Tributary A (Sod Farm)

To assess the benefits of restoring tributary A, the FWOP analysis area included 19 acres that are in the channelized ditches that replaced the historic channel. HUs were calculated for these acres. The remaining 47 acres included in the FWP condition (66 acres total) are currently in commercial sod production, thus no riverine habitat exists. Since no habitat is present, a HU of 0 was assessed for these acres. The sum of the two HUs were used to calculate AAHUs so the 47 acres of no habitat would not artificially inflate the AAHUs.

As discussed in Section 2.1, the QHEI model was used to assess the ecological integrity and habitat conditions of the riverine habitats, while the three HEP models were utilized to assess the ecological integrity and habitat conditions of existing and future forested habitats. As this alternative includes the restoration of a riparian corridor on either side of Tributary A, all four models were used to calculate the FWOP and FWP conditions. The riparian zone metric in the QHEI model assesses the benefit that a riparian area provides to the aquatic environment. To fully calculate the environmental benefits of the restored corridor, we included the three HEPs to calculate the terrestrial benefits of the corridor (Table 5-2). The outputs from the three HEP models were averaged to generate one terrestrial value. The QHEI and averaged HEP values were added together to capture the full FWOP and FWP condition.

Restoring Tributary A will provide an increase of QHEI value over a 50-year period from 0.18 to 0.74., resulting in an increase of 40 AAHUs (4 FWOP AAHUs vs. 44 FWP AAHUs).

Restoring Tributary A will provide an increase of HSI value over a 50-year period from 0.00 to 0.96, resulting in an increase of 39 AAHUs (0.00 FWOP AAHUs vs. 39 FWP AAHUs).

The sum of the two AAHUs results in a total environmental lift of 79 AAHUs.

This alternative provides significant aquatic habitat benefits by restoring the natural hydrology that existed prior to the conversion of native forests to agricultural fields. The restoration of Tributary A will significantly reduce or eliminate the conduit of sediment and nutrients currently flowing into the Maumelle River and SC1 through channelized ditches, which will translate into improved habitat conditions in those streams. This benefit will extend to Lake Maumelle by reducing the loss of water supply storage due to sedimentation. Planting appropriate native vegetation (native bottomland hardwood species) in the riparian corridor will further improve water quality in the study area by filtering out sediments. The restored stream channel will also increase the flood storage capacity of the floodplain.

The restoration of this historic channel reestablishes important spawning and nursery habitat for native fish species that require small, shallow, intermittent streams for spawning and nursery habitat. The restored riparian corridor will normalize the temperature regimes in Tributary A and provide organic allochthonous material to the aquatic system and provide the energy to the lower trophic organisms that drive and support the Maumelle River ecosystem.

One of the measures of this alternative entails the planting of native hardwood species in the riparian corridor. This reforestation partially restores the bottomland and riparian hardwood habitat that historically existed in the study area. As the riparian forest matures over the 50-year planning period, numerous habitat benefits will emerge such as the stratification of vertical structure, increase in terrestrial shading, and development of hard and soft mast diversity. This increasing diversity of habitat will be utilized by numerous riparian-dependent wildlife species, including species of conservation concern (forest interior birds, reptiles and amphibians, bats, etc.), as well as relatively stable native wildlife species.

An important by-product of restoring the historic forested habitat condition on the sod farm is a likely decrease the incidence of invasive species encroachment as native woody and herbaceous species become established.

Another by-product of the restored stream channel is that the material excavated for the restored stream channel can be utilized to recreate microtopography across the now-levelized sod fields. A discussion of this benefit is included in Section 5.1.13.

### 5.1.13 Alternative H – Reforest Sod Farm

To assess the benefits of restoring the remaining acres of fields not restored with the Tributary A alternative, the FWP conditions were compared to the Existing and FWOP conditions using the same model metric values and area of analysis (74 acres). The three HEP models discussed in Section 2.1 were used to assess the ecological integrity and habitat conditions of existing and future forested habitats. By projecting future forest growth (basal area) and percent canopy cover, HEP scores were calculated for a period of 50 years, with indexes estimated for 1, 5, 10, 15, and 25 years after the initial planting. A period of 50 years was selected to allow the maturing of the woody vegetation to fulfill the life requisites for the gray squirrel, downy woodpecker, and barred owl. Because the sod farm will be completely lacking vegetation upon project implementation, there is an enormous habitat unit lift from Year 0 to Year 50 for every metric. Mean dbh, percent canopy cover of trees for food and cover/reproduction will significantly increase at TY 25 (Table 5-2).

Restoring the historic forested wetland will provide an increase of HSI value over a 50-year period from 0.00 to 0.96, resulting in an increase of 44 AAHUs (0.00 FWOP AAHUs vs. 44 FWP AAHUs).

The reforestation benefits discussed in Section 5.1.12 will be maximized with the reforestation of the remaining sod fields. As the riparian forest matures over the 50-year planning period, numerous habitat benefits will emerge such as the stratification of vertical structure, increase in terrestrial shading, and development of hard and soft mast diversity. This increasing diversity of habitat will be utilized by numerous riparian-dependent wildlife species, including species of conservation concern (forest interior birds, reptiles and amphibians, bats, etc.), as well as relatively stable native wildlife species.

An important by-product of restoring the historic forested habitat condition on the sod farm is a likely decrease the incidence of invasive species encroachment as native woody and herbaceous species become established.

As mentioned in the previous section, the material excavated to restore Tributary A can be used to re-create microtopography on the presently leveled fields. Reference sites in the project area exhibit small ridges, swales, small mounds, and alluvial depressions that were destroyed when the historic forested wetland was converted to agriculture fields. Recreating these features will provide microhabitats that are important to many forest-dependent species that utilize such habitats for foraging, reproduction, and as refugia during drought conditions.

**Table 5-2. Maumelle River Future With-Project Habitat Suitability Index for Barred Owl, Gray Squirrel, and Downy Woodpecker Habitat Units for Each Target Year, Average Habitat Units for Each Target Year between the Models, and the Average Annual Habitat Units for Reforestation Restoration Alternatives**

| Alternative | Model | Acres | Target Year 0 | | 1 | | 5 | | 10 | | 15 | | 25 | | 50 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | HSI | HU | HSI | HU | HSI | HU | HSI | HU | HSI | HU | HSI | HU | HSI | HU |
| Restore Trib. A | Barred Owl | 66 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.09 | 5.72 | 1.0 | 66 | 1.0 | 66 |
| | Gray Squirrel | | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.28 | 18.5 | 0.8 | 52.8 | 0.88 | 58.1 |
| | Downy Woodpecker | | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.2 | 13.2 | 0.4 | 26.4 | 0.8 | 52.8 | 1.0 | 66 |
| Sod Farm Reforestation | Barred Owl | 74 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.07 | 5.2 | 1.0 | 74 | 1.0 | 74 |
| | Gray Squirrel | | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.28 | 20.8 | 1.0 | 74 | 1.0 | 74 |
| | Downy Woodpecker | | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.2 | 14.8 | 0.4 | 29.6 | 0.8 | 59.2 | 1.0 | 74 |
| **AAHU = 1** | **[4]Average HU** | | 0 | | 0 | | 0 | | 4.93 | | 18.53 | | 64.13 | | 71.05 | |

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# 7.0 List of Preparers

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# ATTACHMENT A

## FWOP AND FWP ASSUMPTIONS FOR QHEI AND HEP MODELS

MAUMELLE RIVER 206 STUDY

ASSUMPTIONS FOR RESTORATION CALCULATORS

**Removal of RC1**

Area assumptions for annualization calculator: use an average width for benefit (using 150' – cross section measurement from top of artificial levee to edge of pasture in narrow part of impounded pool). We'll use this figure multiplied times the measured stream length to generate the area.

Pool Area impacted by RC1: 165 X 1,230' (pool length) = 202,950 sq.ft. ~ 4.7 acres

Stream Area above impounded pool to first possible barrier:

~2.5 miles (12,450') from top of impounded pool to first possible barrier; Using the same width as the pool for standardization.

12,450' X 165' = 2,054,250 sq.ft. ~ 47.2 acres

Braided stream below RC1 that would be reconnected with **removal ONLY**

~2,900 ft (braided stream length X 165 (width) = 478,500 sq.ft. ~ 11 acres

**QHEI model results show a lift of 30 points, from 54 to 84.**

Substrate quality ( 4-point lift)

- Existing condition is heavy siltation and extensive embeddedness (resulting from significant erosion in Patterson Branch);
- Assumption is that it will take several flushing flows after dam removal to reduce sediment/embeddedness **(3 years).**

Instream Cover (1-point lift)

- Existing Condition: the pool above RC1 contains undercut banks, overhanging vegetation, pool >70cm, boulders, and aquatic macrophytes.
- Assumption – removal of RC1 will drop the water level to a point that "Shallows" can be added to the habitat presence **(0 year).**

Channel sinuosity (3-point lift)

- Existing condition is large, straight pool due to impoundment from dam RC1.
- Assumption – removal of RC1 will result in high sinuosity. The river will be able to reconnect to secondary channels during high flows, providing increased habitat. It may take several flows to establish historic sinuosity due to heavy siltation and embeddedness **(3 years).**

Channel development (6-point lift)

- Existing condition is poor channel development due to the artificial pool created by RC1. There are no riffle-run habitat complexes due to this impounded pool.
- Assumption – removal of RC1 will lower the surface water level ~4-6 feet, exposing 3-5 riffle-run habitat complexes, based on USGS survey data. Riffle-run habitat will be exposed immediately upon dam removal **(1 year).**

Channel Stability (1-point lift)

- Existing condition is moderate stability. There is some active bank erosion on-going, possibly from the water level being held at an artificially high level, which keeps the banks saturated.
- Assumption – lowering the water surface level 4-6 feet will expose several areas of riffle-run habitat with cobble/gravel banks. Lower water levels in the pools will allow currently saturated banks to dry out which may reduce erosion potential **(1 year).**

Floodplain Quality (2-point lift)

- Existing condition: the immediate riparian vegetation is bottomland hardwood forest (70 – 200+ft in width). Beyond that, the floodplain north of the river is currently in sod production. The floodplain south of the river is primarily pasture.
- Assumption – The lease on the sod farm will expire in 2022 and will not be renewed. Hopefully the sod fields will be restored as part of this ecosystem restoration, however at minimum the sod fields will be allowed to revert to old fields **(10 years).**

Pool Current (5-point lift)

- Existing condition: During low to normal water levels (absent flushing rains), there is no flow in the pool above RC1, therefore would receive a value of zero (value not in QHEI matrix).
- Assumption: With the removal of RC1, flows will return to pre-dam condition. Flows will range from slow to very fast **(0 year).**

Pool Morphology (1-point lift)

- Existing condition: The impacted area above RC1 is entirely pool habitat, thus scored as riffle=pool (1 point).
- Assumption – with the water level drop, riffle-run-pool habitat will be exposed. Pool widths are expected to be wider than riffle widths **(0 year).**

Riffle-Run Depth (3-point lift)

- Existing condition: No riffle-run habitat exists in the impacted area due to artificial impoundment from RC1.
- Assumption: with the water level drop, riffle-run-pool habitat will be exposed. Based on sampling from nearby riffle-run habitat, riffle depth is expected to be

>10cm, and run depths <50cm; it may take several flushing flows to reach maximum depths **(3 years)**.

Riffle/Run Substrate Quality (2-point lift)

- Existing condition: inundated riffle areas (from RC1 impoundment) are likely silt covered.
- Assumption: It will take several flushing flows to remove the sediment in the riffle/run areas **(3 years).**

Riffle/Run Embeddedness (2-point lift)

- Existing condition: inundated riffle/run areas have moderate embeddedness due to lack of consistent flows.
- Assumption: It will take several flushing flows to reduce the embeddedness in the riffle/run areas **(3 years).**

**<u>RC1 – Breach Only</u>**

Same area calculation results as RC1 Removal above, except NO connection with downstream braided channel.

**QHEI model results show a lift of 20 points, from 54 to 74.**

<u>Substrate quality (2-point lift)</u>

- Existing condition is heavy siltation and extensive embeddedness (resulting from significant erosion in Patterson Branch);
- Assumption is that it will take several flushing flows after a dam breach to reduce sediment/embeddedness. Because of flow constriction during high water events, it is expected that sediment will continue to be deposited along the stream edge and behind the remaining dam material **(3 years).**

<u>Instream Cover (1-point lift)</u>

- Existing Condition: the pool above RC1 contains undercut banks, overhanging vegetation, pool >70cm, boulders, and aquatic macrophytes.
- Assumption – breaching RC1 will drop the water level to a point that "Shallows" can be added to the habitat presence **(0 year).**

<u>Channel sinuosity (2-point lift)</u>

- Existing condition is large, straight pool due to impoundment from dam RC1.
- Assumption – breaching RC1 will result in low sinuosity in the same stretch. Leaving the remaining dam material on either side of the main channel will prevent the river from reconnecting to secondary channels during high flow events. It may take several flows to establish sinuosity due to heavy siltation and embeddedness **(3 years).**

<u>Channel development (4-point lift)</u>

- Existing condition is poor channel development due to the artificial pool created by RC1. There are no riffle-run habitat complexes due to this impounded pool.
- Assumption – breaching RC1 will lower the surface water level ~4-6 feet, exposing 3-5 riffle-run habitat complexes based on USGS survey data. Channel development is expected to improve to fair. Riffle-run habitat will be exposed immediately upon dam removal. **(1 year).**

<u>Pool Current (3-point lift)</u>

- Existing condition: During low to normal water levels (absent flushing rains), there is no flow in the pool above RC1, therefore would receive a value of zero (value not in QHEI matrix).
- Assumption: With the breach of RC1, flows will largely return to pre-dam condition. Flows will range from slow to fast. The remaining dam material will constrict flow during high water events, thereby preventing very fast flow conditions upstream **(0 year).**

Pool Morphology (1-point lift)

- Existing condition: The impacted area above RC1 is entirely pool habitat, thus scored as riffle=pool (1 point).
- Assumption – with the water level drop, riffle-run-pool habitat will be exposed. Pool widths are expected to be wider than riffle widths **(0 year).**

Riffle-Run Depth (3-point lift)

- Existing condition: No riffle-run habitat exists in the impacted area due to artificial impoundment from RC1.
- Assumption: with the water level drop, riffle-run-pool habitat will be exposed. Based on sampling from nearby riffle-run habitat, riffle depth is expected to be >10cm, and run depths <50cm; it may take several flushing flows to reach maximum depths **(3 years)**.

Riffle/Run Substrate Quality (2-point lift)

- Existing condition: inundated riffle areas (from RC1 impoundment) are likely silt covered.
- Assumption: It will take several flushing flows to remove the sediment in the riffle/run areas **(3 years).**

Riffle/Run Embeddedness (2-point lift)

- Existing condition: inundated riffle/run areas have moderate embeddedness due to lack of consistent flows.
- Assumption: It will take several flushing flows to reduce the embeddedness in the riffle/run areas **(3 years).**

**Braided Side Channel below RC1**

Braided channel length = 2,900 ft.

Area: 2,900 ft X 330 ft (riparian width)/43,560 $ft^2$ = 21.97 acres

**QHEI model results show a lift of 3 points, from 61 to 94.**

Substrate Quality (4-point lift)

- Existing condition is heavy siltation and extensive embeddedness.
- Assumption is that it will take several flushing flows after RC1 removal to remove the sediment/embeddedness. **(5 years).**

Instream Cover - Type (3-point lift)

- Existing Condition: several different cover types exist in the side channel, but some have been impacted by sediment, thus do not provide benefits.
- Assumption: Restored headwater flows will flush excess sediments that are impacting instream cover. (**5 years**).

Channel development (6-point lift)

- There are no riffle-run habitat complexes due to lack of steam flow.
- Assumption – restoring flow thru the side channel by removal of RC1will significantly improve channel development. **(3 years).**

Channel Stability (1-point lift)

- Existing condition is moderate stability.
- Assumption – Lower water levels in the pools will allow currently saturated banks to dry out which will reduce erosion potential **(1 year).**

Pool Quality – Depth (5-point lift)

- Existing condition: Pools in the side channel are heavily embedded.
- Assumption: The removal of RC1 will restore headwater flows through the side channel, flushing excessive sediments out of the channel and reducing embeddedness **(1 year).**

Pool Quality – Current (7-point lift)

- Existing condition: No headwater flows, except during flood conditions, due to presence of RC1.
- Assumption: With the removal of RC1, headwater flows will be restored, and will range from slow to very fast **(1 year).**

Pool Quality - Morphology (1-point lift)

- Existing condition: due to lack of headwater flows, there is no riffle-run habitat; thus, scored as riffle=pool (1 point).
- Assumption – with restored headwater flows, riffle-run-pool habitat will be exposed. Pool widths are expected to be wider than riffle widths **(0 year).**

Riffle-Run Depth (3-point lift)

- Existing condition: No riffle-run habitat exists due to lack of flow.
- Assumption: with the restoration of headwater flows, riffle-run-pool habitat will be exposed. Based on sampling from nearby riffle-run habitat, riffle depth is expected to be >10cm, and run depths <50cm; it may take several flushing flows to reach maximum depths **(5 years)**.

Riffle/Run Embeddedness (3-point lift)

- Existing condition: inundated riffle/run areas are heavily embedded due to lack of flushing flows.
- Assumption: It will take several flushing flows to reduce the embeddedness in the riffle/run areas **(5 years).**

**River between RC1 and RC2**

Braided channel length = 2,900 ft.

Area: 5,900 ft X 330 ft (riparian width)/43,560 $ft^2$ = 44.7 acres

**QHEI model results show a lift of 12 points, from 78 to 90.**

Substrate Quality (4-point lift)

- Existing condition is moderate siltation and embeddedness, likely from the slow to nonexistent water flow, except in flood conditions.
- Assumption is that it will take several flushing flows after RC1 removal to remove the sediment/embeddedness. **(3 years).**

Instream Cover – Type (1-point lift)

- Existing Condition: several different habitat types exist in the river section, although some types are impacted by excessive sediment.
- Assumption: flushing flows as the result of crossing removals will improve habitat conditions and increase availability. (**5 years**).

Riparian Zone – Bank Erosion (1-point lift)

- Existing condition: both river crossings are causing minor to moderate bank erosion.
- Assumption: Removal of both crossings will alleviate the sheer stress on downstream banks. **(5 years).**

Pool Quality – Current (3-point lift)

- Existing condition: The presence of RC1 and RC2 limits water current to only minor flows, expect in flood conditions.
- Assumption: With the removal of the crossings, flow will be restored to natural conditions (e.g. slow, moderate, fast, very fast). (**1 year).**

Riffle Quality – Depth (1-point lift)

- Existing condition: water depth average in run areas is currently <50cm.
- Assumption: the restoration of water flow through this river section will increase water depth in run habitats. (**1 year**).

Riffle/Run Embeddedness (2-point lift)

- Existing condition: riffle habitat exhibits excessive embeddedness due to bank erosion and lack of flushing flows.
- Assumption: It will take several flushing flows to reduce the embeddedness in the riffle/run areas **(5 years).**

**Removal of RC2**

Area assumptions for annualization calculator: use an average width for benefit (using 200' – cross section measurement from riparian edge to riparian edge. We'll use this figure multiplied times the measured stream length to generate the area.

Pool Area impacted by RC2: 165 X 3,200' (pool length) = 528,000 sq.ft. ~12.1 acres

Stream Area above impounded pool to first possible barrier:

~1.1 miles (5,900) from top of impounded pool to base of RC1; Using the same width as the pool for comparison.

5,900 X 165' = 973,500 sq.ft. ~ 22.4 acres

**QHEI model results show a lift of 31 points, from 57 to 88.**

Substrate quality (6-point lift)

- Existing condition is moderate siltation and extensive embeddedness.
- Assumption is that it will take several flushing flows after dam removal to reduce sediment/embeddedness **(3 years).**

Instream Cover (1-point lift)

- Existing Condition: the pool above RC2 contains undercut banks, overhanging vegetation, pool >70cm, boulders, and aquatic macrophytes.
- Assumption – removal of RC2 will drop the water level to a point that "Shallows" can be added to the habitat presence **(0 year).**

Channel sinuosity (3-point lift)

- Existing condition is large, straight pool due to impoundment from dam RC2.
- Assumption – removal of RC1 will result in high sinuosity. The river will be able to reconnect to secondary channels during high flows, providing increased habitat. It may take several flows to establish historic sinuosity due to heavy siltation and embeddedness **(3 years).**

Channel development (6-point lift)

- Existing condition is poor channel development due to the artificial pool created by RC2. There are no riffle-run habitat complexes due to this impounded pool.
- Assumption – removal of RC2 will lower the surface water level ~4-6 feet, exposing 3-5 riffle-run habitat complexes, based on USGS survey data. Riffle-run habitat will be exposed immediately upon dam removal **(1 year).**

Channel Stability (1-point lift)

- Existing condition is moderate stability. There is some active bank erosion on-going, possibly from the water level being held at an artificially high level, which keeps the banks saturated.
- Assumption – lowering the water surface level 4-6 feet will expose several areas of riffle-run habitat with cobble/gravel banks. Lower water levels in the pools will allow currently saturated banks to dry out which may reduce erosion potential **(1 year).**

<u>Floodplain Quality (1-point lift)</u>

- Existing condition: the immediate riparian vegetation is bottomland hardwood forest (70 – 200+ft in width). Beyond that, the floodplain on both sides of the river are old fields (recently planted to BLH).
- Assumption – Planted BLH trees will continue to establish themselves, converting the old fields into forest **(10 years).**

<u>Pool Current (5-point lift)</u>

- Existing condition: During low to normal water levels (absent flushing rains), there is no flow in the pool above RC2, therefore would receive a value of zero (value not in QHEI matrix).
- Assumption: With the removal of RC2, flows will return to pre-dam condition. Flows will range from slow to very fast **(0 year).**

<u>Pool Morphology (1-point lift)</u>

- Existing condition: The impacted area above RC2 is entirely pool habitat, thus scored as riffle=pool (1 point).
- Assumption – with the water level drop, riffle-run-pool habitat will be exposed. Pool widths are expected to be wider than riffle widths **(0 year).**

<u>Riffle-Run Depth (3-point lift)</u>

- Existing condition: No riffle-run habitat exists in the impacted area due to artificial impoundment from RC2.
- Assumption: with the water level drop, riffle-run-pool habitat will be exposed. Based on sampling from nearby riffle-run habitat, riffle depth is expected to be >10cm, and run depths <50cm; it may take several flushing flows to reach maximum depths **(3 years)**.

<u>Riffle/Run Substrate Quality (2-point lift)</u>

- Existing condition: inundated riffle areas (from RC2 impoundment) are likely silt covered.
- Assumption: It will take several flushing flows to remove the sediment in the riffle/run areas **(3 years).**

Riffle/Run Embeddedness (2-point lift)

- Existing condition: inundated riffle/run areas have moderate embeddedness due to lack of consistent flows.
- Assumption: It will take several flushing flows to reduce the embeddedness in the riffle/run areas **(3 years).**

**RC2 – Breach Only**

QHEI model results show a lift of 19 points, from 57 to 76.

Substrate quality (2-point lift)

- Existing condition is heavy siltation and extensive embeddedness (resulting from significant erosion in Patterson Branch);
- Assumption is that it will take several flushing flows after a dam breach to reduce sediment/embeddedness. Because of flow constriction during high water events, it is expected that sediment will continue to be deposited along the stream edge and behind the remaining dam material **(3 years).**

Instream Cover (1-point lift)

- Existing Condition: the pool above RC2 contains undercut banks, overhanging vegetation, pool >70cm, boulders, and aquatic macrophytes.
- Assumption – breaching RC2 will drop the water level to a point that "Shallows" can be added to the habitat presence **(0 year).**

Channel sinuosity (1-point lift)

- Existing condition is large, straight pool due to impoundment from dam RC2.
- Assumption – breaching RC2 will result in low sinuosity in the same stretch. Leaving the remaining dam material on either side of the main channel will prevent the river from reconnecting to secondary channels during high flow events. It may take several flows to establish sinuosity due to heavy siltation and embeddedness **(3 years).**

Channel development (2-point lift)

- Existing condition is poor channel development due to the artificial pool created by RC2. There are no riffle-run habitat complexes due to this impounded pool.
- Assumption – breaching RC2 will lower the surface water level ~4-6 feet, exposing 3-5 riffle-run habitat complexes based on USGS survey data. Channel development is expected to improve to fair. Riffle-run habitat will be exposed immediately upon dam removal. **(1 year).**

Floodplain Quality (1-point lift)

- Existing condition: the immediate riparian vegetation is bottomland hardwood forest (70 – 200+ft in width). Beyond that, the floodplain north of the river is currently in sod production. The floodplain south of the river is primarily pasture.
- Assumption – Planted BLH trees will continue to establish themselves, converting the old fields into forest **(10 years).**

Pool Current (4-point lift)

- Existing condition: During low to normal water levels (absent flushing rains), there is no flow in the pool above RC2, therefore would receive a value of zero (value not in QHEI matrix).
- Assumption: With the breach of RC2, flows will largely return to pre-dam condition. Flows will range from slow to fast. The remaining dam material will constrict flow during high water events, thereby preventing very fast flow conditions upstream **(0 year).**

Pool Morphology (1-point lift)

- Existing condition: The impacted area above RC2 is entirely pool habitat, thus scored as riffle=pool (1 point).
- Assumption – with the water level drop, riffle-run-pool habitat will be exposed. Pool widths are expected to be wider than riffle widths **(0 year).**

Riffle-Run Depth (3-point lift)

- Existing condition: No riffle-run habitat exists in the impacted area due to artificial impoundment from RC2.
- Assumption: with the water level drop, riffle-run-pool habitat will be exposed. Based on sampling from nearby riffle-run habitat, riffle depth is expected to be >10cm, and run depths <50cm; it may take several flushing flows to reach maximum depths **(3 years)**.

Riffle/Run Substrate Quality (2-point lift)

- Existing condition: inundated riffle areas (from RC2 impoundment) are likely silt covered.
- Assumption: It will take several flushing flows to remove the sediment in the riffle/run areas **(3 years).**

Riffle/Run Embeddedness (2-point lift)

- Existing condition: inundated riffle/run areas have moderate embeddedness due to lack of consistent flows.
- Assumption: It will take several flushing flows to reduce the embeddedness in the riffle/run areas **(3 years).**

**<u>Restore Floodplain Connectivity – SC-1 Oxbow Connection</u>**

Stream length from river to the first culverts = 1,852'

Stream width ~40'

Riparian width 330' (165' each side).

Area: 1,852 X 370' = 685,240 sqft = 15.7

SC1 stream length between upper and lower culverts = 1,900'

Stream width ~ 100'

Area: 1,900 X 165 = 190,000 sq.ft. ~ 7.2 acres

SC1 stream length from lower culverts to river = 1,500'

Area: 1,500 X 165 = 247,500 sq.ft. ~ 5.7 acres

**QHEI model results show a lift of 32 points, from 53 to 85.**

<u>Substrate Type (11-point lift)</u>

- Existing substrate type is a heavy layer of detritus and muck that has washed in from the adjacent sod farm fields via channelized ditches. SC1 is isolated from any frequent flows due to a large levee separating it from the Maumelle River, coupled with several failed culverts in SC1. Current connectivity to the Maumelle River is once every 5-10 years (based on H&H modeling).
- Notching of the levee separating SC1 and the river, together with removal of culverts in SC1, will result in frequent flushing flows thru SC1 that will remove the muck and detritus – exposing a cobble/gravel dominated substrate (documented during field visit). **(5 years).**

<u>Substrate Quality (4-point lift)</u>

- Existing condition is heavy siltation and extensive embeddedness (resulting from significant erosion from channelized ditching from sod farm);
- Assumption is that it will take several flushing flows after removing levee and culverts (old road crossings) to remove the sediment/embeddedness. **(5 years).**

<u>Channel development (4-point lift)</u>

- There are no riffle-run habitat complexes due to impounded pools above culverts, and a layer of muck and detritus covering them.
- Assumption – restoring flow thru the side channel by levee breach above RC1, coupled with removal of culverts, will drastically improve channel development. **(3 years).**

Channel Stability (1-point lift)

- Existing condition is moderate stability.
- Assumption – Lower water levels in the pools will allow currently saturated banks to dry out which will reduce erosion potential **(1 year).**

Riparian Zone Quality (1-point lift)

- Existing condition: the immediate riparian vegetation is bottomland hardwood forest on the left bank (>50 meters). The right descending riparian vegetation is an old field.
- Assumption – CAW will plant old field to BLH forest in 2021 **(10 years).**

Pool Current (3-point lift)

- Existing condition: The river connects to SC1 once every 5-10 years. Absent that, flow in the pools are very slow to none.
- Assumption: With the reconnection of SC1 to the river, connectivity will occur at <2-year intervals, and flows will range from slow to very fast **(1 year).**

Pool Morphology (1-point lift)

- Existing condition: due to the impounded pools in SC1, there is no riffle-run habitat; thus, scored as riffle=pool (1 point).
- Assumption – with the water level drop, riffle-run-pool habitat will be exposed. Pool widths are expected to be wider than riffle widths **(0 year).**

Riffle-Run Depth (3-point lift)

- Existing condition: No riffle-run habitat exists in the impacted area due to impounded pools from collapsed culverts and lack of connection to the river.
- Assumption: with the water level drop and flushing flows, riffle-run-pool habitat will be exposed. Based on sampling from nearby riffle-run habitat, riffle depth is expected to be >10cm, and run depths <50cm; it may take several flushing flows to reach maximum depths **(5 years)**.

Riffle/Run Substrate Quality (2-point lift)

- Existing condition: inundated riffle areas are covered in a heavy layer of detritus and muck.
- Assumption: It will take several flushing flows to remove the muck in the riffle/run areas **(5 years).**

Riffle/Run Embeddedness (2-point lift)

- Existing condition: inundated riffle/run areas are heavily embedded due to lack of flushing flows (only occurs once in 5-10 years).
- Assumption: It will take several flushing flows to reduce the embeddedness in the riffle/run areas **(5 years).**

**<u>Restore Floodplain Connectivity – SC-2 Side Channel Connection</u>**

Stream length from levee to river = 2,600'

Stream length breached levee = 2,700'

Stream width ~65' (stream width of Maumelle River near side channel)

Riparian buffer = 165' (50 meters)

FWOP Area – 2,600' X 165 = 429,000 sq. ft. ~ 9.9 acres

Area: 2,700 X 165 = 445,500 sq. ft. ~ 10.2 acres

**QHEI model results show a lift of 33 points, from 51 to 83.**

<u>Substrate Type (12-point lift)</u>

- Existing substrate type is a heavy layer of detritus and muck due to lack of flushing flows. SC2 is isolated from any frequent flows due to a large levee separating it from the Maumelle River. Current connectivity to the Maumelle River is once every 5-10 years (based on H&H modeling).
- Notching of the levee separating SC2 and the river and the removal of the road crossing will result in frequent flushing flows thru SC2 that will remove the muck and detritus – exposing a cobble/gravel dominated substrate (documented during field visit). **(5 years).**

<u>Substrate Quality (4-point lift)</u>

- Existing condition is heavy siltation and extensive embeddedness.
- Assumption is that it will take several flushing flows after removing levee and road crossing to reduce sediment/embeddedness. **(5 years).**

<u>Channel development (4-point lift)</u>

- There are no riffle-run habitat complexes due to isolation from the river and the road crossing impounding a large pool.
- Assumption – restoring flow by levee breach, coupled with removal of the road crossing will drastically improve channel development. **(3 years).**

<u>Floodplain Quality (1-point lift)</u>

- Existing condition: the immediate riparian vegetation is bottomland hardwood forest on left bank (>50 meters). The right bank vegetation is an old field that has been recently planted to BLH (scored as an old field).
- Assumption – Planted BLH trees will continue to establish themselves, converting the old field into forest **(25 years).**

<u>Pool Current (3-point lift)</u>

- Existing condition: The river connects to SC2 once every 10-15 years. Absent that, flow in the pools are very slow to none.

- Assumption: With the reconnection of SC2 to the river, connectivity will occur at <2-year intervals, and flows will range from slow to very fast **(1 year).**

Pool Morphology (1-point lift)

- Existing condition: due to the impounded pools in SC2, there is no riffle-run habitat; thus, scored as riffle=pool (1 point).
- Assumption – with the water level drop, riffle-run-pool habitat will be exposed. Pool widths are expected to be wider than riffle widths **(0 year).**

Riffle-Run Depth (3-point lift)

- Existing condition: No riffle-run habitat exists in the impacted area due to impounded pools from a road crossing and lack of connection to the river.
- Assumption: with the water level drop and flushing flows, riffle-run-pool habitat will be exposed. Based on sampling from nearby riffle-run habitat, riffle depth is expected to be >10cm, and run depths <50cm; it may take several flushing flows to reach maximum depths **(5 years)**.

Riffle/Run Substrate Quality (2-point lift)

- Existing condition: inundated riffle areas are covered in a heavy layer of detritus and muck.
- Assumption: It will take several flushing flows to remove the muck in the riffle/run areas **(5 years).**

Riffle/Run Embeddedness (2-point lift)

- Existing condition: inundated riffle/run areas are heavily embedded due to lack of flushing flows (only occurs once in 5-10 years).
- Assumption: It will take several flushing flows to reduce the embeddedness in the riffle/run areas **(5 years).**

**Tributary A Restoration**

**QHEI model results show a lift of 56 points, from 18 to 74.**

Channelized stream length = 3,900’

Restored stream length (based on Ouachita Regional breached levee = 8,737’ (The length of stream on the spreadsheet entered is based on the same meander belt width and valley length measured based on lidar for reference reach #2 giving a sinuosity of 0.472 (1,755 valley length/3,720 stream length). I took the distance from where Trib A would taken out of the ditch (on the west) and measured straight line path (i.e. valley length) to where it would reconnect to the side channel (on the east). This distance was 4,124 ft in a straight line. To determine the distance with the meanders you need to divide the straight line 4,124 by the sinuosity 0.472 to get 8,737 feet.)

Bankfull width ~16.4’ (Ouachita Regional Curve Calculator)

Riparian buffer = 165’ (50 meters)

FWOP Area – 3,200’ X 165 = 528,000 sq. ft. ~ 12 acres

FWP Area: 8,737 X 165 = 1,441,605 sq. ft. ~ 33 acres

Substrate Type (9-point lift)

- Existing substrate type in the channelized ditches is a heavy layer of muck and silt due to runoff from adjacent sod farm.
- Blocking the channelized ditch on the west side of the sod field will divert flow through the restored stream channel across the sod fields. Parent substrate material above the channelized ditches is gravel and sand. Given time, this material will move downstream and deposit in the restored channel **(10 years).**

Substrate Quality (4-point lift)

- Existing condition is heavy siltation and extensive embeddedness in the channelized ditches.
- Assumption – The restored stream channel will allow frequent flows (during rain events) that will provide flushing flows. Reforestation of the riparian area to bottomland hardwood forest will provide ground cover and prevent sediment from entering the stream (riparian area will initially have native grasses that will reduce sediment potential in the stream. **(5 years).**

Instream Cover (7-point lift)

- Existing condition in the channelized ditches is shallow water and aquatic macrophytes.
- FWP – Removal of the sod farm and restoration of Tributary A will allow for the development of numerous instream cover composed initially of shallow water and aquatic macrophytes. As the surrounding riparian area grows, additional cover such as overhanging vegetation, rootmats, and woody debris will add to the complexity of the instream cover. **(25 years)**

Instream Cover Amount (4-point lift)

- Existing condition is limited to shallow water and scattered aquatic macrophytes in the channelized ditches.
- FWP – as additional instream cover types become available, the amount of instream cover will significantly increase. **(25 years)**

<u>Channel Sinuosity (3-point lift)</u>

- Existing condition is channelized ditches with no sinuosity.
- FWP – Excavation of Tributary A will include numerous meanders to approximate reference stream sinuosity. As Trib. A and riparian area become established, we may see additional meanders, or even lateral streams or oxbows, as the stream moves within the floodplain. **(1 point in first year; 1 point at year 5, and 1 point at year 10)**

<u>Channel development (4-point lift)</u>

- Existing Condition - There are no riffle-run habitat complexes in the channelized ditches.
- FWP – Tributary A will develop a series of riffle-run-pools as it becomes established in the floodplain and upstream sand and gravel progresses downstream into the restored channel. **(10 years)**

<u>Channelization (3-point lift)</u>

- Existing Condition – the current drainage is limited to channelized ditches.
- FWP – the channelized ditches will be plugged, diverting the water into the restored Trib. A. **(1 year)**

<u>Channel Stability (1-point lift)</u>

- Existing condition is moderate stability.
- Assumption – lowering the water surface level 4-6 feet will expose several areas of riffle-run habitat with cobble/gravel banks. Lower water levels in the pools will allow currently saturated banks to dry out which may reduce erosion potential **(1 year)**

<u>Riparian Zone Width (2-point lift)</u>

- Existing Condition – portions of the channelized ditches has a narrow strip (5-10 meters) of herbaceous vegetation growing on either side. In other parts, there is little to no vegetation.
- FWP – The restoration of Tributary A includes planting a riparian area (50 meters on both sides of stream) with bottomland hardwood species. **(2 points in year 3 as herbaceous vegetation becomes established)**

<u>Riparian Zone Quality (3-point lift)</u>

- Existing condition - the immediate riparian vegetation is a very narrow strip of herbaceous vegetation along portions of the channelized ditches (5 – 10 meters). Beyond that is an established sod fields.
- FWP – The reforested riparian zone will become established in herbaceous vegetation within 3 years. Riparian forest habitat will begin to emerge around year 10 and mature throughout the planning period. **(Year 3)**

Pool Quality – Max. Depth (6-point lift)

- Existing condition – very few pools exist in the channelized ditches, as water is diverted to an adjacent oxbow/side channel (SC1). Those that are present are extremely shallow, and largely exist only because of thick aquatic macrophytes in places.
- FWP – Restoration of Trib. A will result in numerous pools throughout its' length, many of which will exceed one meter in depth. **(2 points in year 3; 4 points by year 10 as restored stream becomes stable).**

Pool Current (3-point lift)

- Existing condition: flow through the channelized ditches is limited to moderate to heavy rainfall events. The presence of aquatic macrophytes in some locations (thick mats) prevents any fast flow (except in extreme conditions).
- FWP – restoration of Trib. A will allow water to flow through the system, creating fast, moderate and low flows, depending on rainfall. **(Year 1)**

Pool Morphology (1-point lift)

- Existing condition: no riffle-run habitat exists in channelized ditches, thus scored as riffle=pool (1 point).
- FWP – riffle-run-pool habitat will become established over time, as flows create different water levels, and gravel/sand moves downstream. Pool widths are expected to be wider than riffle widths **( Year 5).**

Riffle Quality - Depth (2-point lift)

- Existing condition: No riffle-run habitat exists in the channelized ditches.
- FWP – riffle-run habitat will develop over time as the stream becomes established in its' floodplain and source material (sand, gravel) moves downstream thru the system. Based on sampling from nearby riffle-run habitat, riffle depth is expected to be 5-10cm, and run depths <50cm; it will take several high flows to reach maximum depths **(5 years)**

Riffle Quality – Substrate Stability (2-point lift)

- Existing condition – channelized ditches have no riffle-run habitat.
- FWP – newly created riffle-run habitats will become stable as Trib. A becomes established in its' floodplain **(5 years)**

Riffle Quality - Substrate Embeddedness (2-point lift)

- Existing condition – channelized ditches have no riffle-run habitat.
- FWP – frequent flows through the restored stream channel will prevent embeddedness from occurring. **(Year 1).**

**<u>Riparian Forest Restoration</u>**

**<u>HEP model</u> results show a lift of  points, from**

FWOP Area – 75 acres - 2.2 acres [existing channelized ditch length (3,200') x average herbaceous vegetation width of 30'] = **72.7 acres**

FWP Area – **42 acres** (less acres here because more riparian area will be reforested in Trib. A measure due to longer stream length).

**<u>9.  RC3 Bank Stabilization</u>**

Area of consideration for modeling is tail of the upstream riffle (above erosion area) to the head of the downstream riffle. ~ 1,400'

Riparian buffer = 165' (50 meters)

FWOP and FWP Area – 1,400 X 165 = 231,000 sq. ft. ~ 5.3 acres

**QHEI model results show a lift of 6 points, from 68 to 74.**

<u>Substrate Quality (4-point lift)</u>

- Existing condition is heavy siltation and extensive embeddedness from eroding left descending bank.
- FWP Condition - it will take several flushing flows after bank stabilization to reduce sediment/embeddedness. **(5 years).**

<u>Channel Morphology - Stability (1-point lift)</u>

- Existing condition is low stability due to the severely eroding bank and resultant high bedload of sediment.
- FWP – stabilization of the eroding bank and reduction in bedload material will greatly improve channel stability in this area. **(3 years).**

<u>Riparian Zone – Bank Erosion (2=1-point lift)</u>

- Existing condition of this area includes a heavily eroding left descending bank.
- FWP – the addition of rock vanes will greatly reduce or eliminate the erosion in this area. **(1 year).**