APPENDIX B

Adaptive Management Plan

United States Army Corps of Engineers
Memphis District

Adaptive Management Plan for the Grand Prairie Area Demonstration Project Regarding the ivory-billed woodpecker

April 2007

Executive Summary

This adaptive management plan has been developed as a result of a cooperative effort between the United States Army Corps of Engineers, the United States Fish and Wildlife Service, the White River Irrigation District, and a partnership of state and federal agencies and non-governmental organizations including the Arkansas Game and Fish Commission, Arkansas Natural Resources Commission, Arkansas Natural Heritage Commission, Natural Resources Conservation Service, and The Nature Conservancy.

This plan consists of two monitoring plans (hydrologic and vegetative) that have been designed to allow for identification of impacts that may result from implementation of the Grand Prairie Area Demonstration Project on the preferred habitat of the endangered ivory-billed woodpecker. The triggering mechanisms in this design are sensitive enough to identify impacts early enough that they could be reversed and cause no long-term damage.

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Introduction: When the ivory-billed woodpecker (*Campephilus principalis*) was discovered living in the forests of east-central Arkansas, the United States Army Corps of Engineers (USACE), Memphis District entered into informal consultation with the United States Fish and Wildlife Service (USFWS) to assess the potential impacts of the Grand Prairie Area Demonstration Project (GPADP) on this endangered species. The Corps' May 2005 Biological Assessment (BA) concluded that the project is unlikely to adversely affect the species. The USFWS in their June 8, 2005 correspondence indicated that with the implementation of certain recommendations, which included preconstruction surveys, post construction monitoring and adaptive management, that they would concur that the project is not likely to adversely affect the IBW. The USACE agreed to these recommendations on February 1, 2006. The inter-agency team then began conducting surveys along the proposed pipeline through Wattensaw Wildlife Management Area. Subsequent to conclusion of informal consultation, the USFWS finalized the recommended IBW survey criteria; identified the potential range of the IBW; and, listed characteristics of potential IBW habitat to use for determining whether surveys for the species would be recommended.

Adaptive management is an iterative process (Figure 1.) that integrates results and analysis of long term monitoring with adjustments to project operation to inform environmental protection and operational efficiency decisions. This adaptive management plan (AMP) describes how the operation of the GPADP will be adjusted if long term monitoring finds adverse impacts from the GPADP on the native vegetation and hydrology that lies near the area where the ivory-billed woodpecker (IBW) is thought to occur. It describes the process for evaluating the results of the monitoring program, membership and responsibilities of the interagency team, "triggers" or action points that would necessitate a change in the operation of the project and potential operational changes that would be implemented to mitigate adverse impacts.

Background: Heavy agricultural demands have severely depleted the alluvial aquifer in the GPADP area of eastern Arkansas. The USACE and Natural Resources Conservation Service (NRCS), as a cooperating agency, investigated several alternative plans and selected a plan that includes a pumping station to divert flow from the White River for irrigation purposes. The pump station is approximately 15 linear miles from the location of the reported rediscovery of the IBW. The project area includes significant portions of Arkansas and Prairie counties and small portions of Monroe and Lonoke counties (Figure 1). The GPADP will provide agricultural water supply, water conservation, aquifer protection, waterfowl management, and prairie grass restoration. A general reevaluation report (GRR) and final environmental impact statement (EIS) were prepared by the U.S. Army Corps of Engineers (Corps), Memphis District, and circulated for public review in December 1999. The record of decision was signed in February 2000.

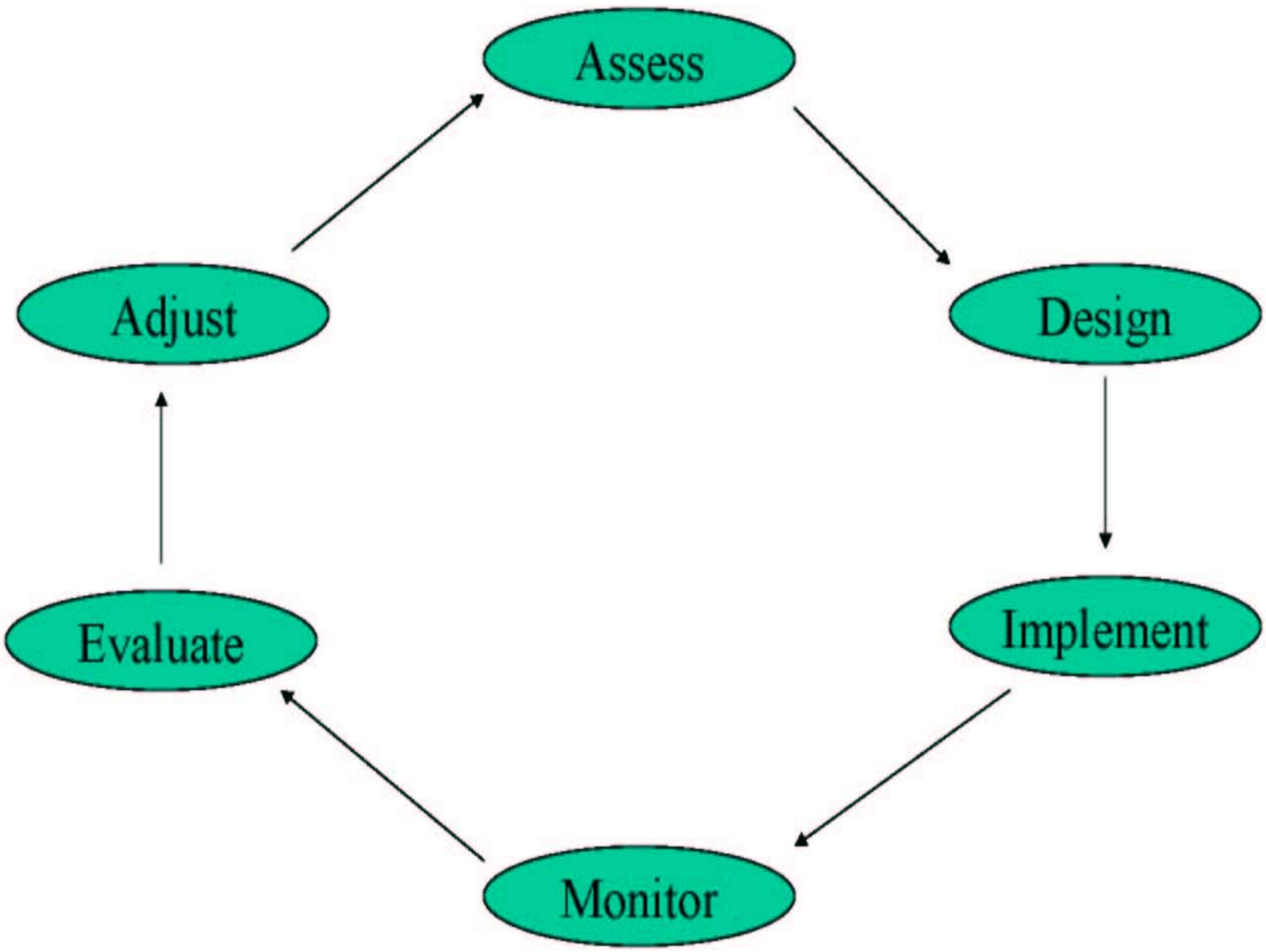

Figure 1a. Six steps of adaptive management (Nyberg 1999).

The National Wildlife Federation and the Arkansas Wildlife Federation have opposed the GPADP for several years due to concerns related to the plan to withdrawal significant amounts of water from the White River, and had previously filed lawsuits in state and federal court seeking to halt construction of the GPADP. Both lawsuits were adjudicated in favor of the Corps and construction on the pump station began in spring 2005.

In May 2005 the Department of Interior announced that the ivory-billed woodpecker had been rediscovered in the "Big Woods" of Arkansas. Shortly thereafter, these groups filed suit against the USACE and USFWS on the grounds that the project would negatively affect the IBW or its habitat. Although informal consultation had not been completed at the time, the judge hearing the case granted a temporary injunction stopping construction on the project. The judge based his decision on information generated on or before the Service's June 8, 2006 correspondence. The USACE and USFWS requested a stay in the proceedings to allow for the continuation of the consultation process and to ensure that information and agreements reached after November 2006 were included in the consultation process. Information generated after that date included detailed IBW surveys of the Wattensaw Wildlife Management Area that were focused on identifying any evidence of their presence and the development of two monitoring plans (vegetation and hydrology) that would identify indicators of potential long-term changes in these parameters before the habitat was negatively impacted. Those two monitoring plans have been incorporated into this AMP and can be found in Appendices A and B of this document.

An inter-agency team was assembled early in the coordination of the GPADP that has an advisory capacity which includes making recommendations to USACE regarding trends or potential for impacts, and reviewing various project components. The inter-agency team was fully involved in the development of the monitoring plans included in the AMP, and is also responsible for reviewing the results of the monitoring and ensuring that any impacts are adequately addressed.

Goal and Objectives:

The objective of the GPADP is to provide agricultural water supply, water conservation, aquifer protection, waterfowl management, and prairie grass restoration. The plan, as presented in the GRR and EIS would include a 1,640-cubic feet per second (cfs) pumping station to divert 487,700 acre-feet of surface water from the White River annually to 247,556 acres of irrigated cropland in the 362,662-acre project area, 8,849 acres of new on-farm irrigation reservoirs, on-farm tail water recovery systems, establishment of native prairie vegetation on approximately 3,000 acres of canal rights-of-way, and the annual flooding of 38,529 acres of harvested rice fields for waterfowl. In addition to the pumping station, the project delivery system would incorporate 102 miles of new canals, 290 miles of pipelines, and numerous other hydraulic structures (e.g., gated check structures, wasteways, culverts, siphons, turnouts) would be constructed in association with the water delivery system.

Because the GPADP would have the capability to divert enough water from the White River to have as much as a one foot reduction of stage during certain times of the year, there is concern that the alteration of hydrology in the White and lower Cache Rivers could have an adverse impact on the ecology of the floodplain ecosystem in the projected impact area. This AMP is designed to identify specific steps in the process used to assess information obtained by monitoring the health of the bottomland hardwood (BLH) forests and river and floodplain hydrology and analyzing any changes as they relate to project operation including the organizational structure of the interagency team, a timetable for evaluating monitoring results, and specific operational changes available to the project manager if negative changes in composition or health of the BLH are identified as resulting from the operation of the project.

The Goal of this plan is to ensure that the GPADP has no adverse impacts on the IBW or its preferred habitat. The objectives are to specify the organizational structure and responsibilities of the members of the interagency team as relates to implementing this AMP; identify the mechanism for evaluating the results of habitat, hydrologic, and project monitoring; identify triggering mechanisms that will alert the project principles and interagency team members of the need to take action; identify potential adaptive project management options; and, direct project adjustments into a feedback loop to inform and provide input to the decision making process.

Organizational Structure:

The USACE, Memphis District will lead the adaptive management team that will include representatives of the GPADP interagency team. This team is comprised of representatives from the Arkansas Game and Fish Commission, USFWS, White River Irrigation District, NRCS, Arkansas Natural Resources Commission, and the Arkansas Natural Heritage Commission. This team has participated in numerous aspects of the GPADP including development of environmental features of the project, environmental review of on-farm components, and development of the monitoring components of the AMP.

Roles and Responsibilities

Decision making. The USACE Memphis District Commander will be the final decision maker on issues relating to alteration of project operations.

Data collection, analysis, and storage. USACE will be responsible for collection, analysis and storage of data pertinent to this AMP. It is anticipated that USACE will hire contractors to collect and analyze this data in accordance with scientific standards which are agreed upon by the inter-agency team. The inter-agency team is responsible for reviewing data and its analyses, and making recommendations to USACE.

Review Process: The inter-agency team will meet annually to evaluate project operation and monitoring data and will determine whether triggering indicators have been reached. They will also advise UASCE on whether monitoring results warrant modification of the project operation, based on the data results from the previous period and any trends that have been observed since the beginning of data collection. Because the BLH monitoring (Heitmeyer) will collect data at five year intervals, the annual review will often be restricted to hydrologic data and project operation. As the BLH database builds over time, these two data sets will be analyzed in relation to each other, and recommendations will be made to the decision maker based on this analysis. In addition, scientists with knowledge and experience of a level that will allow for the interpretation of data resulting from the studies associated with this AMP will be employed to provide assessments to the inter-agency team. Due to the long-term nature of this monitoring, it is likely that different scientists will be used over the life of the project. Therefore, the scientists overseeing the individual studies will have qualifications and experience that is acceptable to a majority of the team members.

Cooperative agreement: Language specific to the course of action appropriate to the situation will be included in a written agreement between the action agency (USACE) and the local sponsor. This language will be discussed and coordination upon by the inter-agency team and will be binding in nature (i.e. actions will be mandatory when triggered). The local sponsor has agreed to implement the components of this adaptive management plan. Binding language will be included in the project operation and maintenance plan.

Monitoring Plans:

Two methods will be used to assess potential impacts to BLH habitat thought to be preferred by IBW; hydrologic monitoring (to include flood pulse and flow regime variability monitoring) and BLH forest monitoring. The two components of the monitoring plan have been designed to analyze potential impacts in a systemic fashion (i.e. any correlation between project operations and changes in BLH health will be identifiable). Both of these plans have temporal and spatial components, which will help ensure potential changes in composition and function of the BLH forest ecosystem are identified. Sufficient baseline data will be collected prior to initiation of pump operations to ensure that trends not associated with pump operations can be identified and accounted for in analyses.

Pump station operations: Monitoring of project operations, including water withdrawal rates, duration, and seasonal timing will also be collected to enable analysts to compare any trends with pump operations. This will ensure no false associations between hydrologic or vegetative trends and pump operations will be made, while also ensuring appropriate monitored to enable determinations of correlation associated with project operations.

Hydrologic monitoring. This section describes hydrologic monitoring to be conducted in conjunction with the biological monitoring of White River floodplain vegetation composition and distribution. In addition to providing a hydrological context to aid in the interpretation of the biological monitoring data, the hydrological monitoring will provide a direct measurement of flooding behavior and of the inter- and intra-annual dynamics of flood cycles.

Floodplain monitoring will document floodplain inundation patterns, shallow groundwater saturation pulses on the floodplain, correlate documented inundation patterns to four hydrogeomorphic (HGM) zones and vegetation monitoring plots within the floodplain, and (4) correlate hydrogeomorphically-related inundation patterns with long-term stage and discharge records from gaging stations at Clarendon and DeValls Bluff AR.

The objectives of the flow regime variability monitoring are to (1) establish baseline metrics for the suite of 67 flow regime parameters for the White River period of record at Clarendon and DeValls Bluff; (2) define the natural range of variability (NRV) for the 67 flow regime metrics for a pre-project baseline period; and (3) evaluate future White River discharge records to identify trends and changes in metrics with respect to the established NRV.

Hydrologic variability within the lower White River basin is complex (Craig, et. al., 2001; Haase, 2005) and is influenced by a number of factors including dam operation, consumptive water withdrawals, land-use changes, natural and man-induced channel modifications and alterations, and climatic cycles. Because of this complexity, proper identification of cause and effect relationships with regard to hydrologic trends, and the relationship of such changes to ecological processes and systems will require careful, focused hydrologic monitoring. Additionally, such monitoring will provide a sufficiently detailed context for the interpretation of biological monitoring conducted to identify and evaluate potential ecosystem impacts associated with operation of the Grand Prairie Area Demonstration Project (the project).

The hydrological monitoring activities described in the following sections have been developed to provide such a context. Because of the diverse nature of BLH and riverine floodplain ecosystems, the details and scope of the activities described, will likely need to be adjusted or modified through adaptive management, to maximize the utility of the data collected. The complete hydrologic monitoring plan can be found in Attachment 1 of this document.

Bottomland Hardwood forest monitoring. The health and condition of BLH forests can be used to assess the level and extent of impacts to the overall health of the forest community caused by abnormal hydrologic conditions such as those caused by flood control and irrigation diversion projects or excessive impoundment of water in reservoirs designed for waterfowl. This concept was recently used in the adjacent Bayou Meto watershed of Arkansas to identify, validate, and propose monitoring protocols using scientifically proven ecological indicators of hydrological change on BLH stands (Heitmeyer et al. 2002, Heitmeyer et al. 2004, Heitmeyer and Ederington 2005, and references within these publications). Conversely, this type of evaluation can also assess changes in forest community composition and structure due to other hydrologic alterations including reduced flooding frequency and duration. This same approach will be used as part of this AMP, with specific information on the monitoring plan being contained in Attachment 2 of this document.

Adaptive Management Actions:

Should hydrologic and BLH monitoring show that project operations are beginning to have a deleterious impact on the BLH as identified by the triggering mechanisms described below, the Corps will initiate actions to address the situation beginning with convening a meeting of the interagency team to assess the data, determine if whether hydrologic and biological impacts can be correlated to some specific aspects of project operation and concluding with recommendations to the WRID and USACE Memphis District Commander a list of recommended corrective actions to be implemented. Actions taken will be appropriate based on the type and level of impact.

Triggering Mechanisms

- **BLH Triggers (potential) –**
    1. Changes in forest composition, distribution, and size that result from an alteration in hydrologic regime
    2. Direct tree mortality associated with changes in hydrologic regime
    3. Leading indicators of flooding stress including basal swelling, tip die-back, and leaf chlorosis
    4. Changes herbaceous and shrub density, type, and coverage that are different than would be expected with natural processes
    5. Alteration of vegetative regeneration with changes in hydrologic regime
    6. Changes in densities of standing snags and down stems
    7. Changes in soil characteristics that are associated with changes in hydrologic regime

- **Hydrologic Triggers (potential)**
    1. Changes in flood timing, magnitude, and duration
    2. Flow regimes outside the Natural Range of Variation
    3. Long-term changes in flow regimes at gaging stations

Potential Project Operation Alterations

- Reduce duration of pumping (daily duration, weekly, monthly, or seasonal duration);
- Reduce rate of pumping (Reduce from full capacity to ¾ capacity; ½ capacity, etc.);
- Vary rate of pumping (e.g., full capacity for three hours, ½ capacity for three hours, etc.);
- Alter timing of pumping (e.g., time pumping to the degree feasible to high flows during the specific season (This would be determined by the IHA analysis of historic and baseline conditions).

Because of the design of the monitoring program, negative impacts would be detectable in early stress indicators such as leaf chlorosis, which can be reversed with no long-term damage to the trees. If this type of impact is correlated to project operations, the appropriate alterations in project operations would be implemented, and continued monitoring would ensure that these changes have the desired effect. Conversely, and more importantly for the GPADP, changes in forest composition toward conditions significantly drier than would be expected for floodplain habitats in the lower White River basin, and outside the known BLH forest conditions thought to be used by the IBW would be detected and corrected before wholesale changes would occur.

Literature Cited

Craig, M. A., W. R. Wise, and W. M. Kitchens, 2001. Analysis of hydrologic data from the White River Basin. Unpublished report submitted to U. S. Environmental Protection Agency, Region VI, Dallas, TX.

Haase, C. S., 2005. Analysis of natural flow regime alteration within the lower White River Basin of Arkansas: results and implications for Ecologically Sustainable Water Management. Abstracts with Program for 2005 Regional Wetlands Technical Conference, Corpus Christi TX, May 17-19, 2005.

Heitmeyer, M.E., L.H. Fredrickson, B. Ederington and S.L. King. 2002. An evaluation of ecosystem restoration options for the Bayou Meto Basin of Arkansas. Gaylord Memorial Laboratory Special Publication No. 5. Prepared for U. S. Army Corps of Engineers, Memphis District. University of Missouri-Columbia, Puxico, MO.

Heitmeyer, M.E., B. Ederington and L.H. Fredrickson. 2004. Bayou Meto Wildlife Management Area Wetland Management Plan. Gaylord Memorial Laboratory Special Publication No. 7. Prepared for U.S. Army Corps of Engineers, Memphis District. University of Missouri-Columbia, Puxico, MO.

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Nyberg, B. 1999. Implementing Adaptive Management of British Columbia's Forests - Where Have We Gone Wrong and Right? In: McDonald, G.B., J. Fraser and P. Gray (Eds.). Adaptive Management Forum: Linking Management and Science to Achieve Ecological Sustainability. OMNR, Peterborough, ON, Canada. pp. 17-20.

ATTACHMENT 1

HYDROLOGIC MONITORING

Flood Pulse Monitoring

The dynamics of flood pulses and shallow groundwater saturation events within the shallow saturated zone of the White River floodplain will be monitored. Continuous recording pressure transducers will be placed at selected localities representative of various hydrogeomorphic (HGM) zones within the White River floodplain. Data recorded will document the magnitude and duration of flood pulses and saturation events in the shallow groundwater table. Flood pulse and saturation monitoring will be conducted for a minimum of three to five years to establish floodplain inundation relationships between vegetation monitoring locations and the Clarendon and DeValls Bluff gaging stations.

Objective

The objectives of floodplain monitoring are (1) document floodplain inundation patterns: (2) document shallow groundwater saturation pulses on the floodplain; (3) correlate documented inundation patterns to four HGM zones and vegetation monitoring plots within the floodplain; and (4) correlate hydrogeomorphically-related inundation patterns with long-term stage and discharge records from gaging stations at Clarendon and DeValls Bluff AR.

Approach

Initially, 15 monitoring localities within the White River floodplain between Clarendon and DeValls Bluff and adjacent areas will be selected. Monitoring sites will be distributed among the four HGM landforms identified in the study area (point-bar complexes, backswamps, natural levees, and abandoned channels). Approximately three monitoring locations will be identified for each landform, and three monitoring locations will be distributed between the two reference sites associated with BLH vegetation monitoring. Proximity to BLH monitoring plots will be considered in identification of flood pulse monitoring localities.

At each locality a shallow (~4 to 5-ft-deep) monitoring well will be hand-augured and a 2-in-diameter, slotted PVC casing installed. The casing will be capped on the bottom and will extend approximately 12 in above ground surface. The top will be fitted with a locking cap that will also serve to suspend a pressure transducer within the casing. Continuously recording pressure transducers (Solinst LevelLogger, or equivalent) will be suspended within the PVC well casing so that the measuring port of the transducer is as close to the bottom of the casing as practicable. The transducer will be set to record the depth of water above the measuring port on an hourly basis (24 measurements per day). At such a collection rate the transducer can record data for approximately two years. For this project, however, data will be retrieved from the transducers on a semi-annual or annual basis throughout the monitoring period.

One or more interim benchmarks will be established in the vicinity of each monitoring well and the elevation of the transducer measuring port with respect to the interim benchmark(s) will be established. At a subsequent time, the absolute elevations of the interim benchmarks will be established with respect to USACE or USGS benchmarks in the vicinity of the monitored area.

An additional locality in the immediate vicinity of the monitored area will be identified for deployment of a pressure transducer (Solinst BaroLogger, or equivalent) to record atmospheric pressure throughout the monitoring period. Data from this pressure transducer are needed to correct the data collected from the in-well pressure transducers for the variability of atmospheric pressure during the monitoring period. The additional transducer can be mounted in any readily accessible, secure, above-ground locality that is not subject to flooding.

Anticipated Results
Data obtained from the flood pulse monitoring will include: (1) annual number of shallow water table near-surface saturation events; (2) annual number of flood pulses; (3) duration and timing of near-surface saturation events and flood pulses; (4) water depth histories for flood pulses; (5) rates of change (increase and decrease) for near-surface saturation events and flood pulses; and (5) lag-time relationships between flood pulses and near-surface saturation events.

The data on flood pulses and near-surface saturation events will be used to provide a detailed hydrologic context for the vegetation monitoring results obtained concurrently with the hydrologic monitoring. At a minimum, metrics such as flood timing, magnitude, and duration can be related to the HGM zones within the floodplain, to observed vegetation communities, and to changes within such communities. Development of such a relationship is essential to interpretation of patterns and long-term changes that may be observed for the vegetative communities.

When absolute elevations for the monitoring localities are established, the metrics for flood pulses and near-surface saturation events can be related to the long-term stage and discharge records for the Clarendon and DeValls Bluff gaging stations. Such a relationship can then be used to hypothesize historic trends in floodplain inundation patterns within the monitored area, and to identify and monitor potential future inter- and intra-annual changes within such patterns as subsequent data become available.

At the conclusion of the initial three- to five-year monitoring period, the cumulative data record from the 15 monitoring locations will be evaluated by the cognizant agencies to determine the adequacy of monitoring results. At that time a decision will be made to (1) continue monitoring at the initial localities for an additional time period; (2) identify up to 15 new localities within the monitored area for data collection over an additional three- to five-year time period; or (3) reduce the number of monitored localities to a number to be determined based on the initial results for long-term monitoring to verify the accuracy of correlation(s) established between observed flood behavior and stage data from the Clarendon and DeValls Bluff gaging stations.

Reporting
Data from the flood pulse monitoring will be summarized and reported by letter report on an annual basis. Interpretation of the data will be included with data from the vegetation monitoring on the reporting cycle of that monitoring activity. All monitoring data will be published annually as an appendix to each letter report.

Flow Regime Variability Monitoring

Long-term data records for White River discharge obtained at USACE/USGS gaging stations at Clarendon and DeValls Bluff will be analyzed to determine the Natural Range of Variation (NRV) for a suite of ecologically-relevant hydrologic metrics for a baseline period that consists of the flow-regulated portion of the period of record. A suite of 67 flow regime metrics that evaluate the timing, duration, magnitude, frequency, and rates of change of high- and low-flow events, and for monthly median flows have been identified by Richter et. al. (1996, 1997). Such flow regime metrics have been incorporated into the Indicators of Hydrologic Alteration (IHA) software package that statistically characterizes flow regime metrics in an inter- and intra-annual basis. The IHA software can also be used to identify temporal trends and changes in long-term flow records (Richter et. al., 1996). As monitoring proceeds, the IHA software will be used to analyze river discharge data from subsequent years, and the results of such analyses will be compared to results for the baseline period in order to identify long-term trends and quantify the characteristics of any trends noted.

Objective
The objectives of the flow regime variability monitoring are to (1) establish baseline metrics for the suite of 67 flow regime parameters for the White River period of record at Clarendon and DeValls Bluff; (2) define NRV for the 67 flow regime metrics for a pre-project baseline period; and (3) evaluate future White River discharge records to identify trends and changes in metrics with respect to the established NRV.

Approach
Period-of-record discharge data from the USACE/USGS monitoring stations on the White River at Clarendon and DeValls Bluff will be analyzed with the IHA software program to calculate statistic parameters (minimum, median, maximum, 10^{th}-, 25^{th}-, 75^{th}-, and 90^{th}-percentiles) for a suite of 67 flow regime metrics. Metrics to be evaluated include the 1-, 3-, 7-, 30-, and 90-day annual minimum and maximum flows; monthly median flows; timing, frequency and duration of non-flood high flow pulses and extreme low-flow pulses; average annual rate of hydrograph increase and decrease; and average number of annual hydrograph reversals. The analysis will be completed for the baseline period that corresponds to the regulated period of record for the White River within the monitored area. For the White River reach in question, flow regulation begins in 1961 with the closure of Greer's Ferry Dam (the last dam to be constructed that impacts flows on the lower White River). Previous work (Craig et. al., 2001; Haase, 2005) has already documented alteration of the flow regime largely due to construction and operation of flood control and hydropower dams upstream of the monitoring area.

The statistical parameters calculated by the IHA software will be used to define a Natural Range of Variability (NRV) for each of the 67 flow regime metrics. Initially the NRV will be defined as the range of values falling between the 25th and the 75th percentiles. Such a range has proven to be a reasonable first approximation in river systems lacking specific data linking ecological processes to hydrologic variability (Richter et. al., 1996). As monitoring proceeds, the NRV definitions will be revised to incorporate new research results and data regarding the ecological responses to flow variability.

Annually, the flow data from each year will be analyzed to calculate the 67 flow regime metrics for the year. Each year's metrics will be evaluated against the NRV's determined for the initial baseline period. On a five year basis, IHA results for the previous five-year period will be summarized. Trends and distribution patterns for metrics will be analyzed and summarized to provide a comprehensive comparison of the five-year data set with the baseline values.

Anticipated Results
Anticipated results of the flow regime trend monitoring include (1) a baseline set of NRV values for each of the 67 flow regime metrics considered by the IHA software; (2) calculation of the 67 flow regime metrics for each year beyond the baseline period; (3) comparison of the new metrics to baseline NRV values and the expected frequencies of occurrence of values within the baseline NRV for each metric; and (4) identification and description of long-term trends and changes in the White River flow regime at the Clarendon and DeValls Bluff gaging stations.

Reporting
Results of the initial calculation of NRV values for the baseline period will be reported in a letter report. Results of analysis of subsequent data will be report on a five-year interval, or on an interval coinciding with the reporting of results from the vegetation and flood-pulse monitoring.

ATTACHMENT 2

BOTTOMLAND HARDWOOD FOREST MONITORING

Bottomland hardwood forest monitoring. Monitoring programs for "landscape-level" effects, such as the GPADP must be carefully designed to determine changes in ecosystem structure and function. If done properly, these monitoring programs become the cornerstone of adaptive management (Noss and Cooperrider 1994). Monitoring programs to address the above needs in the IBW "zone" of the White River (and immediate tributaries) floodplain need to be "baseline monitoring" that is directed at some element or process that is not expected to change (Noss and Cooperrider 1994:303). This type of monitoring will achieve USFWS requirements of "Determination of baseline conditions; including hydrology, forest composition, and forest health; and long term ecosystem monitoring is necessary for measuring project impacts and ensuring viability of the floodplain forest and habitat for the IBW. Monitoring will allow detection of unforeseen impacts to the floodplain forest and direct application of adaptive management if these impacts occur." (excerpted from 8 June 2005 letter from Allan Mueller to David Reece).

Baseline monitoring requires careful selection of "indicators." Criteria for these indicators (Noss and Cooperrider 1994) include:

1. An indicator must be a good measure of or surrogate for the element concerned with.

2. An indicator should detect a problem before it is too late to solve it.

3. An indicator must match the temporal and spatial "scale-of-effect."

4. Wherever possible indicators should be selected for which experiment controls are available.

5. Other things being equal, a "flagship species" can be used as an indicator.

6. An indicator should be cost-effective to measure, collect, and assay and should be repeatable over specified time periods.

Below is a possible monitoring scheme that meets all of the above conditions and criteria and is recommended to meet USFWS requirements.

A Long-term Monitoring Plan for the White River Floodplain in the IBW Zone

The area identified for monitoring in the White River floodplain (see above excerpt from Mueller letter (Attached as Appendix No. ?)) is bottomland hardwood forest BLH in a major alluvial floodplain geomorphic setting (Saucier 1994). Previous studies of BLH health and condition related to potential impacts of flood control and irrigation diversion projects in the adjacent Bayou Meto watershed of Arkansas identified, validated, and implemented monitoring protocols using scientifically proven ecological indicators of hydrological change on BLH stands (Heitmeyer et al. 2002, Heitmeyer et al. 2004, Heitmeyer and Ederington 2005, and references within these publications). These indicators include measures of: 1) forest composition, distribution, and size related to varying geomorphic surfaces, soils, topography, and hydrology; 2) direct tree mortality; 3) leading indicators of flooding stress including basal swelling, tip die-back, and leaf chlorosis; 4) herbaceous and shrub density, type, and coverage; 5) regeneration; 6) standing snags and down stems, and 7) soil characteristics. These indicators are all consistent with measurements used in hydrogeomorphic (HGM) assessments by the Arkansas Multi-Agency Wetland Planning Team to provide "relative condition" of BLH in varying floodplain settings throughout the Mississippi Alluvial Valley of Arkansas. An additional ecological indicator of both past and future BLH response to changes in floodplain hydrology is analyses of annual tree growth indicated by sampling incremental cores of Nuttall oak in floodplain areas and analyzing tree-ring growth (both annual and interval). This analysis has proven to be effective in Arkansas floodplains and currently is being used in monitoring programs in the Black River floodplain of northeast Arkansas (Heitmeyer unpublished data).

Sampling of BLH in the Bayou Meto floodplain used stratified random samples of 1/8 or 1/10-acre plots distributed proportionately to area of varying geomorphic, soils, flood frequency, and topography settings. These data sets are statistically robust, cost-effective to obtain, provide consistent and repeatable measures over long time periods, and perhaps most importantly indicate changes in hydrology and tree responses before mortality or community "shifts" occur, thus allow adaptive decisions and management changes to occur without further damage to communities.

Monitoring BLH condition (and thus habitat for IBW) in the White River floodplain (DeValls Bluff to Clarendon) and lower Cache and Bayou DeView floodplains (to Highway 70 along the Cache and Highway 38 along Bayou DeView) will use a sampling and monitoring scheme similar to that used in Bayou Meto (and including increment bore samples similar to that used on the Black River floodplain) to meet all USFWS requirements. This IBW "zone" potentially affected by the GPADP includes about 25,000 acres and 3-4 distinct geomorphic/flood frequency areas. About 200 randomly selected, and permanently marked, 1/10-acre plots will be established and sampled in spring and summer (April - July) 2006 prior to any withdrawals of White River water by the GPADP. Location of plots will be stratified by geomorphic/flood frequency zone with a minimum of 30 plots each in natural levee, backswamp, and point bar depositional environments within the 2-year flood frequency zone. These plots would require 3-4 months to permanently establish and collect the initial baseline data on all leading indicators. Location of all plots would be identified with GPS coordinates and magnetic, permanent, below ground markers.

Baseline data of sampled plots will be analyzed to determine current condition and relative condition to nearby reference or “control” sites with similar geomorphic/flood frequency locations. Two reference areas will be randomly sampled and include BLH in the George Tract of the Cache River National Wildlife Refuge in the Cache River floodplain immediately north of I-40 and the Henry Gray Hurricane Lake Wildlife Management Area located about 20 miles north of I-40 in the White River floodplain (see attached map). Approximately 25 plots will be established in each of these reference areas. Permanent plots in both the reference and affected areas can be revisited at whatever intervals are desired, but at least once every 5 years.

Literature Cited

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