RIPARIAN HABITAT REPLACEMENT WITHIN ACTIVE FLOODPLAINS

BRUCE M. PHILLIPS, M.S., P.E.

ABSTRACT

Conventional flood control engineering techniques and approaches that have been traditionally been applied are now challenged by the public and no longer readily available as floodplain management tools. Increased awareness and concern regarding environmental degradation has resulted in protection of the riparian and river ecosystems. A variety of drainage related projects are required to provide habitat mitigation as a part of regulatory permit requirements. Natural floodplains typically provide the most appropriate location for constructing habitat replacement since this is a natural riparian ecosystem, especially in semi-arid areas. Incorporating environmental features into an active floodplain requires an understanding of the natural physical processes and stream mechanics, along with commonly encountered failure problems. General planning guidelines and a formalized design process adopt fundamental procedures to enhance the preservation of the natural floodplain characteristics. The recommendations include typical design considerations and site selection techniques addressing many primary concerns. Recent technology utilizing computer graphic visualizations facilitates the design development process and assists in the consensus building process with the community. Applying multi-disciplined planning guidelines to develop habitat mitigation within active floodplains assists in developing an implementable and successful long-term floodplain management project which addresses flood protection as well as providing environmental opportunities.

INTRODUCTION

The current challenge of flood control design solution is to incorporate multi-objective stream corridor planning which addresses both the engineering and natural resource issues, including the preservation or replacement of riparian habitat. The detrimental effect of common channel modifications and maintenance practices is well documented. Flood control channelization projects typically impact sensitive riparian ecosystems which are located in existing active floodplains. These riverine ecosystems are regulated by environmental permitting agencies and require appropriate mitigation of the impacts through avoidance or replacement of the habitat. The riparian habitat located in the existing floodplain is generally a minor component of the surrounding area, however, it provides a resource of more structurally diverse and productive plant life. In addition, existing riparian ecosystems provide food, cover, and water for wildlife, as well as migration corridors or linkages for animals. Riparian ecosystems in natural active floodplains are especially important resource in the semi-arid areas of the Southwest. These areas represent the potentially most suitable location for developing constructed habitat replacement projects.

Development of an acceptable floodplain management program through implementation of flood control improvement projects requires integrating the various goals for river systems, not only flood protection, through effective multi-objective stream corridor management focusing on preservation of the natural stream

characteristics and biological values. The engineering design must incorporate habitat enhancement areas as an integral part of the design function and operation of the riverine system. An important step in achieving this goal is through initially identifying habitat mitigation as a primary objective of the project in order to successfully integrate this element into a comprehensive and functional design. Environmental opportunities should be clearly recognized and then selection of the features which will meet the environmental objectives. The most effective design is the best combination of the environmental features which will meet the engineering/flood protection and environmental objectives. Successfully incorporating environmental features, such as habitat mitigation, into the design as part of an active floodplain relies on an understanding of (1) fluvial morphology, (2) watershed characteristics, (3) sediment transport, (4) hydrology, (5) biology, and (6) floodplain hydraulics.

INITIAL PLANNING GUIDELINES AND COMMON PROBLEMS WITH MITIGATION

The planning and design of floodplain management projects which integrate riparian habitat creation is a difficult task since streams are naturally dynamic. The flood control engineer must carefully evaluate the general issues associated with the engineering of floodplain management and environmental requirements during the initial design planning process. Understanding of geomorphic principles is an essential component of the design in order to emulate the natural characteristics of river channel in the creation of a successful riparian ecosystem. An important concept in planning relies on utilizing geomorphic engineering techniques which recognize a balance between channel form and process. Initial data collected can identify the physical characteristics of the existing riverine system, including insight into: (1) natural river adjustment, (2) accuracy of prediction methodologies, (3) development of empirical relations, (4) relative stability of the floodplain elements, and (5) consequence of changes to the system. The initial planning level assessment utilizes these tools available to determine or predict the (1) projected habitat characteristics, and then (2) evaluate the channel stability or system response.

A minimum suggested design and planning work program for integrating habitat features into a floodplain management program has been developed as guideline which has been applied on similar floodplain management projects. An important component of the planning effort is the involvement and communication with the resource agencies which allows direct input during the design development and assists in satisfying permit requirements.

Table No. 1 - Typical Planning and Design Program
1. Resource Agency Pre-Design Conference 2. Site Reconnaissance 3. Establishment of Project Objectives 4. Baseline Data Compilation 5. Biological Assessment 6. Qualitative Geomorphic Analysis

7. Engineering Analysis of Baseline Floodplain Characteristics
8. Alternative Development and Selection of Design Features
9. Quantitative Engineering Evaluation of Alternatives and Riverine Response
10. Biological Evaluation of Alternatives
10. Planting Design / Irrigation
11. Implementation
12. Monitoring

The design process for habitat creation in floodplains has inherent limitations since it is not possible to accurately predict the responses in alluvial stream systems. The apparent deficiencies associated with the design process includes (1) modeling limitations, (2) limited design criteria, (3) extremely site specific design applications, (4) difficult prediction of hydraulics and stream response, (5) rely on empirical geomorphology relationships, (6) impact on ecosystem unpredictable, (7) uncertainties regarding sedimentation and erosion, and (8) alluvial stream mechanics have numerous degrees of freedom and variables.

An awareness of common problems associated with the success of riparian habitat creation in active floodplains will assist in guiding the initial planning. There have been numerous unsuccessful attempts at habitat creation in floodplains and important design concepts can be assimilated from these failures. Most of these failures are related to (1) dynamics of alluvial floodplains, (2) apparent survival rate of vegetation, (3) vegetation damage compared to replacement costs, (4) flow velocities versus vegetative damage, (5) water supply requirements, (6) debris and sediment accumulation, (7) erosion damage and streambed migration, (8) compatibility with structural flood control measures, (9) integration and compatibility with natural ecosystem, (10) reduced hydraulic efficiency, (11) vegetation irrigation during non-rainfall seasons, and (12) overall site suitability.

An accurate baseline database is a critical component to develop the foundation of the design during the initial planning effort. The accumulation of data should include information on (1) hydro periods, (2) floodplain hydraulics and delineation, (3) geomorphology, (4) historic stream characteristics, (5) stream cross sections, (6) meander geometry, (7) hydrology and historic flood values, (8) channel bed and bank stability, (9) grain size distribution, (10) biologic survey and vegetative mapping, (11) groundwater, and (12) existing habitat evaluation. Inadequate and incomplete data will lead to increased difficulties in developing predictions regarding hydraulic channel responses since proper watershed management guidance relies on an understanding of cause/effect relations. Inventory of additional floodplain morphology data should include (1) stream patterns, (2) bed profile, (3) channel geometry, (4) streambed and bank stability, and (5) depositional patterns.

TYPICAL DESIGN CONSIDERATIONS

The critical design considerations for planning the incorporation of environmental features into a floodplain management program focus on three primary areas which include: (1) biological, (2) hydraulic / hydrology, (3) geomorphic fluvial controls.

Table No. 2 - Design Considerations for Planning Habitat Features

Biological	Hydraulics / Hydrology	Geomorphic Controls
·Low wildlife value ·Adequate water supply ·Native plant community ·Habitat evaluation ·Biologic survey ·Long term survival	·Sediment continuity ·Conveyance capacity ·Flood duration ·Flood frequency ·Floodplain limits ·Hydraulic characteristics	·Geomorphic planforms ·Stable channel design ·Stream characteristics ·Meander frequency ·Equilibrium slope

DESIGN PROCESS FOR INCORPORATING HABITAT MITIGATION FEATURES

SPECIFIC DESIGN REQUIREMENTS

·Protective structural control measures: Develop hydraulic structural control measures to protect the habitat area from adverse hydraulic forces during establishment period. Control measures can be multi-purpose and function as habitat enhancement features. The design of the protective measures should consider the potential of sediment ramping.

·Flow velocity controls abundance and damage to vegetation: Floodplain modeling should be used to establish the variation of velocity within the floodplain and the potential sites for habitat placement. Two dimensional hydraulic models can assist in evaluating the velocity variation and flow patterns.

·Provisions to reduce sediment deposition / debris accumulation: Reduced channel velocities in the habitat replacement area will develop a zone within the floodplain which will have deposition tendencies. Sediment accumulation can quickly eliminate the effectiveness of the riparian replacement area and can even cause reduction of hydraulic conveyance or flood protection levels. Diverse flow patterns may change with flood frequencies and the varying flows of the storm hydrograph.

·Incorporating tiered or composite channel section: Tiered channel cross sections allow accommodation of various storm frequencies and corresponding hydroperiods for vegetation. Damage from impinging low-flows can be easily protected.

·Utilization of ineffective flow areas: Identifying areas within the floodplain which have characteristic low-velocities as potential candidate sites have the advantage in not removing significant hydraulic conveyance and limit potential vegetation damage.

·Emulate or preservation of natural morphological characteristics: Maintaining the natural stream characteristics will assist in predicting the physical response of the stream and reduce potential damaging consequences from stream adjustments.

·Separate flood control and habitat uses: Maintaining a distinction between the habitat and flood control uses within the floodplain will assist in assuring the long term objectives are achieved. Adequate hydraulic flood control conveyance must be guaranteed to provide the necessary level of flood protection.

·Maintain sediment transport conveyance: Providing sediment conveyance continuity within the floodplain will reduce the potential of degradation or agradation.
·Continuous water supply or circulation: Long term water supply must be furnished to ensure the vegetation survival, preferably by natural means, and allowed to continuously circulate through the riparian habitat without stagnation to reduce vector problems.
·Separate flood conveyance section: Providing a separate dedicated flood control conveyance section will allow standard maintenance and clearing operations to ensure the hydraulic conveyance without disturbing the habitat zone.

APPROPRIATE SITE SELECTION TECHNIQUES

Identification of the appropriate site to incorporate habitat creation within the floodplain is one of the critical elements to ensure the long term success of the vegetation. Site selection techniques require evaluation of the biological, hydrologic/hydraulic, fluvial geomorphic constraints and requirements. Some of the issues in site selection optimization include:

- Utilization of ineffective flow areas
- Emulate the natural floodplain geometry
- Long-term geomorphic response
- Incorporate tiered or multi-staged cross sections
- Appropriate hydrology and water supply
- Soil requirements
- Component of wildlife corridor
- Allow separation of flood conveyance and habitat zones
- Existing habitat survival and concentrations

UTILIZATION OF COMPUTER VISUALIZATION IN DESIGN PROCESS

A useful technique to assist in the design process incorporates current computer technology to develop computer visualizations of the proposed floodplain modifications. The visualizations provide a simple and cost effective method to evaluate and communicate the anticipated design program. The visualizations utilize design of the proposed improvements developed in CAD and ground photographs from a reference point. The reference point can be translated into a perspective view of the proposed improvements utilizing the CAD software. Developing the visualization is a four step process which involves (1) background photograph, (2) solid model of improvement in perspective view, (3) solid model composite, and (4) final visualization incorporating the appropriate visual textures to simulate improvements or vegetation.

PROJECT APPLICATION: CALLEGUAS CREEK (VENTURA, CA)

Calleguas Creek is a dynamic alluvial channel located in Ventura County, California, that has historically experienced significant change due to erosion. A single property owner controls the majority of undeveloped land adjacent to approximately two miles of the creek between Mission Oaks Road Boulevard and Upland Road. This portion of

Calleguas Creek within the City of Camarillo is mainly natural floodplain and drains a tributary watershed area of 168.6 square miles, with a estimated 100-year peak flow rate of 27,600 cfs. Consolidated land ownership has provided a unique opportunity to ensure the development of a comprehensive regional flood control improvement program which incorporated habitat mitigation within the floodplain as an integral element of the design to satisfy environmental considerations.

The specific biotic feature of this project included a 32.5-acre riparian replacement site located within the existing active floodplain, along the outside of a large meander scar which maintained a large effective flow width. A unique feature developed to assist the long term survival of the habitat is a low-height soil-cement berm which divides the floodplain in this area into a (1) primary flood control conveyance zone and (2) habitat replacement overbank area. The riparian habitat area have been developed as "off-channel" or depressed vegetated overbank, in order not to be in the primary hydraulic conveyance path or modified active floodplain. The low-height berm does not completely enclose the habitat replacement area, but is left open perpendicular to the direction of the flow, in order to provide adequate flushing during larger flood events and minimize sedimentation. The low-height berm was elevated above the annual flood depth which will assist in (1) preventing low-flow meander damage, (2) preventing the majority of the bedload sediment transport from depositing in the habitat area, (3) allows for flood control maintenance of the of the hydraulic flowpath, (4) reduces hydraulic flow velocities in the overbank area, and (5) provides a serviceable in-channel maintenance path around the perimeter of the habitat enhancement area. Additional unique features which were included in the design to facilitate community awareness and operational success of the program.