An Assessment of Watershed Planning in Corps of Engineers Civil Works Projects

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OVERVIEW

The U.S. Army Corps of Engineers (Corps) recognizes the value of watershed planning and has made a commitment to integrate watershed planning into its Civil Works program (Figure 1). This commitment is evidenced by the Corps' 18 October 2000 adoption of the Unified Federal Policy (UFP) on watershed management, which provides a framework for a watershed approach to Federal land and resource management activities (Federal Register 2000).

Commitment of the Corps to a watershed planning approach is further evident in policy documents and regulations that guide day-to-day operations, such as the "Digest of Water Resources Policies & Authorities" (U.S. Army Corps of Engineers (USACE), 19 February 2002). General policies within the Digest indicate that "the watershed perspective applies to all Civil Works programs through planning, design, construction, operation, maintenance, restoration, rehabilitation, and regulatory activities."

Although the Corps has worked to implement these guidelines for several years, a consensus on what constitutes a "watershed planning approach" remains elusive. Additionally, there has been no comprehensive effort to assess the success of watershed-based practices within the Corps. Many different approaches have been utilized because the 41 Corps Districts have latitude in the specific approaches employed when implementing watershed planning efforts and because the requirements and constraints vary from project to project. An assessment of these practices is needed to evaluate the overall success of watershed planning within the Corps.

The primary objective of this assessment is to compare and contrast the management practices of a "watershed approach" with planning practices used by the Corps prior to adopting the UFP.

Figure 1. The Corps is committed to integration of watershed planning into the Civil Works program. This study assesses Corps success in recent years

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CORPS PLANNING PROCESS

To facilitate analysis of current projects undertaken by the Corps, the following information is provided as an overview of the Corps planning process. Corps projects typically originate from communities that have identified a water resource problem they cannot address alone. However, the Corps must obtain study and budget authorities from Congress before getting involved.

After authorization, the Corps enters the reconnaissance study phase. The purpose of this phase is to study the water resource problem to gain a better understanding of its elements, determine the likelihood of local sponsorship, and recommend either termination of the project or continuation into the next phase. Reconnaissance is limited to a timeline of no more than 1 year and a cost cap of $100,000 (National Research Council (NRC) 1999).

The feasibility phase begins once the Corps and local sponsor have negotiated a project study plan, arranged cost sharing, and identified study schedules, costs, and work responsibilities. At the beginning of this phase, the Corps announces the project feasibility study and conducts a public workshop. Alternative plans are formulated with the aid of the sponsor, stakeholders, and Corps headquarters. Designs are analyzed, and cost/benefit estimates are made.

Upon completion of a draft feasibility report and environmental impact statement, the Corps distributes reports for a 45-day public review. Another public meeting is held, and a revised feasibility report is drafted to incorporate additional comments. This phase ends with an agreement between the Corps and project sponsor and the signing of the Division Engineer's notice. The average time to complete the collective reconnaissance and feasibility studies is approximately 5.6 years. The preconstruction engineering and design phase takes another two years or more and includes specifications, clear identification of lands, easements, rights of way, relocations, and required disposal areas (NRC 1999).

COMPONENTS OF A WATERSHED APPROACH

A major challenge in establishing a framework for watershed planning is to assure that no two projects will be exactly alike. Variable goals, watershed conditions, stakeholders, funding, infrastructure, timelines, and other elements make each process fundamentally the same but circumstantially different.

Many documents provide guidance on conducting watershed assessments. Although the specific steps outlined in these documents vary, all include consideration of common criteria that can be regarded as central to any watershed assessment. In this document, steps and criteria for a watershed planning approach have been compiled from the following documents: *A Framework for Analyzing the Hydrologic Condition of Watersheds* (McCammon, Rector, and Gebhardt 1998), *Oregon Watershed Assessment Manual* (Watershed Professionals Network 1999), *Watershed Protection: A Project Focus* (Environmental Protection Agency, 3 January 2002), and *Stream Corridor Restoration: Principles, Processes, and Practices* (Federal Interagency Stream Restoration Working Group 1998).

Despite the commonalities of a watershed planning framework, the level of emphasis and detail necessary at each planning stage will vary among projects. Additionally, an iterative process may be required among the steps as the planning process progresses. The general steps in a watershed assessment recommended by the referenced publications are outlined in the following section.

STEP 1: Delineate the Watershed Boundaries

Watershed boundaries used in project planning may be largely dependent upon the particular project details, such as the size of the impact area, nature and extent of the water resource problem, timelines, existing administrative boundaries, funding constraints, and ecoregion boundaries. The U.S. Geological Survey has developed a national framework for delineating hydrologic units, based upon a spectrum of geographic scales, which are identified by Hydrologic Unit Codes (HUCs). These HUCs are generally used as a basis for watershed identification.

STEP 2: Characterize the Watershed

Information is gathered to establish and compare current watershed conditions with reference or historic conditions to identify changes. This information is also used in conjunction with various analytical techniques to predict future watershed conditions, such as potential demography, land use changes, and project impacts. The objective is to formulate an understanding of the form and function of the system and the cause/effect relationships among ecosystem components and human uses. Although the relative importance of watershed characteristics will vary among individual planning projects, the following information is relevant in characterizing watersheds:

Physical Criteria: e.g., climate, geology, watershed morphology, hydrology, hydraulic and sedimentation processes;
Chemical Criteria: e.g., water quality conditions, hazardous, toxic, and radioactive waste (HTRW) sites;
Biological Criteria: e.g., vegetation, aquatic habitat, aquatic organisms, terrestrial habitat, and terrestrial organisms;
Social Considerations: e.g., land use, infrastructure, proposed development, natural resources, and cultural resources;
Equilibrium Conditions: e.g., overall watershed condition, stability, and trends.

STEP 3: Identify Problems and Constraints

It is necessary to identify (and quantify, if possible) problems and constraints. A major component of watershed evaluation involves the social effects of a project, including benefits, negative impacts, and risks to communities and existing infrastructure. It is prudent during the identification of problems and constraints to involve stakeholders that have an interest in the outcome of a project decision.

STEP 4: Set Goals and Identify Solutions

Objectives that are specific and achievable must next be formulated for the project. Similar to identifying problems and constraints, a thorough process with the collective input of interested parties is required to identify goals that will result in ecological soundness, feasibility, cost-effectiveness, and practicality. Project objectives and solutions are often driven by social values and legal mandates, so these must be incorporated into the process of goal establishment. Once goals are established, a suite of alternative solutions should be formulated for evaluation. These alternatives should address the underlying problem(s) for the watershed, and should be achievable in light of the identified constraints (e.g., legal, political, funding).

STEP 5: Select and Implement Plan

Once potential solutions have been identified, several analyses are conducted to help identify and select the “best” alternative. The alternative selected for any project is generally that most likely to meet the established goals, objectives, and project constraints at the lowest cost. The selected alternative is then implemented in accordance with the plans.

STEP 6: Measure Success and Make Adjustments

Measuring the success of a watershed project requires monitoring and evaluating

the outcomes. Monitoring plans should be identified and developed in concert with the project design and should be specifically related to the project goals. Adaptive management practices may be necessary if goals and objectives have not initially been met.

METHODOLOGY AND CASE STUDIES

Seventeen Corps Civil Works projects were identified from a database query obtained from Corps Headquarters. This list encompasses all the Civil Works projects dated from 1999 through 2001 that involved either environmental restoration or flood damage reduction as the major project purpose and were listed on the Division Engineer's Notice list. Figure 2 shows the project locations relative to Corps organizational Divisions.

A list of the case studies evaluated in this technical note, the corresponding identification numbers, project locations, and brief project descriptions are displayed in Table 1. The main purpose of Projects 1-5 is environmental restoration. Projects 6-10 are mainly flood damage reduction projects. More detailed descriptions of the studies are presented in Hansen (2002).

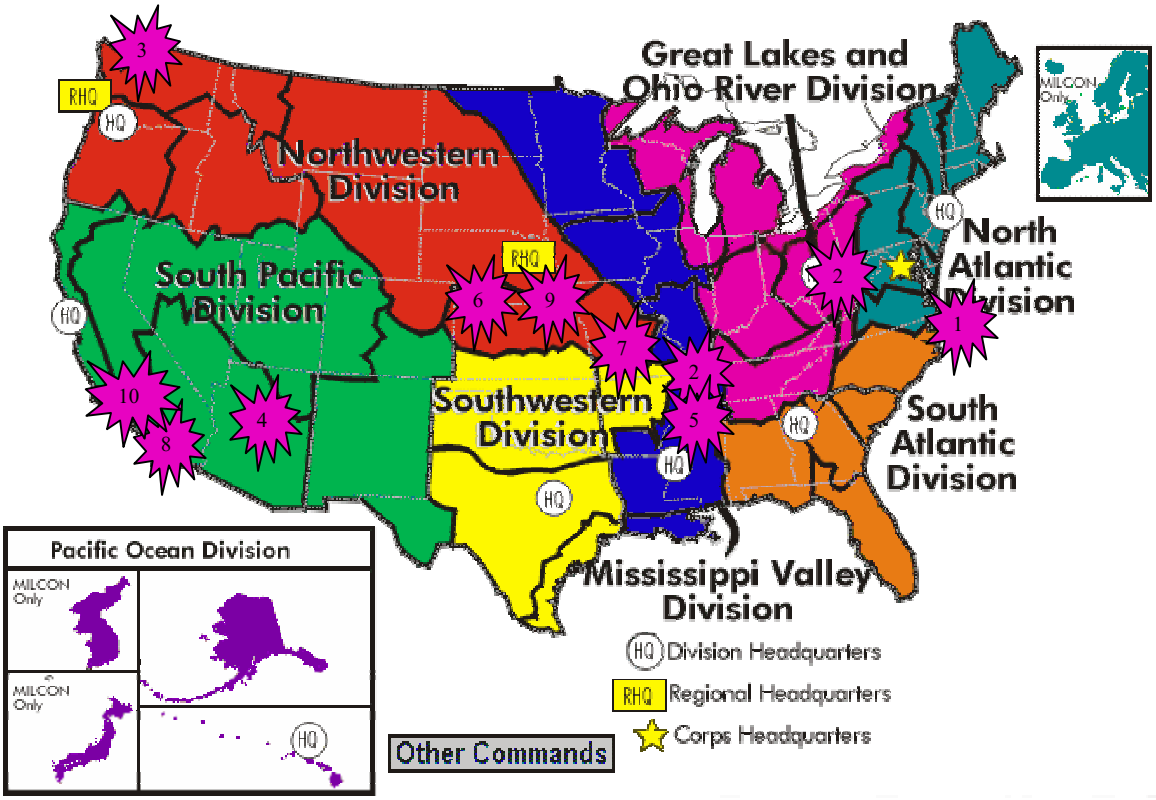

Figure 2. Project locations relative to Corps organizational divisions (USACE, 17 Jan 2002)

Table 2 is a matrix summarizing the criteria considered fundamental to a watershed analysis approach and the extent to which each of the 10 project feasibility reports and environmental reports reflected consideration of those criteria. In reality, the relative importance of each of these criteria varies according to the details of each particular project. However, for

purposes of this study, each criterion is weighted equally across all projects regardless of differing factors, such as purpose, scope, and funding.

Explanation of Criteria and Parameters

The general criteria are stand-alone considerations in the matrix, meaning they either were or were not addressed in the project reports, as reflected by the corresponding symbols. A shaded dot indicates full consideration in the report for a particular criterion or parameter, whereas an open dot indicates omission in the report for that criterion or parameter. A triangle means that the report referred to the criterion or parameter but did not provide substantial information or consideration. An NA is included where the criterion or parameter is not applicable for a particular project.

The physical, chemical, biological, and social criteria are not stand-alone considerations, but are further identified by specific parameters listed in Tables 2a-2c. Percentages were assigned to the elements of the physical, biological, chemical, and social criteria in Table 2 and were based on the completeness with which the specific parameters were addressed in the project reports, as reflected in Tables 2a-2c. If any of the parameters were not applicable to a project, an NA was noted in the table and that parameter was not included in the percent determination.
For example, geology is listed as an element under physical criteria in Table 2 and would receive a 67 percent designation if two of the three geologic parameters listed in Table 2a were addressed in the report. If two of the three parameters were addressed by the project report, and the third parameter was not applicable to that project, a 100 percent designation would apply. Note that parameters marked with a triangle are weighted in percent designations as though they were not discussed in the report.

Specific parameters used in evaluating the physical and biological criteria are shown in Tables 2a and 2b. To clarify the measurement of Corps Civil Works projects in this study, physical and biological parameters are further explained in Tables 3 and 4, respectively. Chemical criteria are limited to the identification of potential HTRW sites on the landscape, as well as water quality parameters such as pH, nutrients, dissolved oxygen, heavy metals, temperature, suspended sediment, turbidity, and other contaminants (see Table 2c). Social considerations complete the list of criteria evaluated in this study. These parameters are listed in Table 2c and include project aspects that may impact society in either a positive or negative manner.

Table 1. Case Study Information

ID #	Project Name	State	Corps Districts	Project Description
1	Elizabeth River Basin	VA	Norfolk	The project proposal involves a sediment remedial action (dredging, removal, and treatment), the restoration of 18 acres of salt marsh wetlands, 3 acres of riparian habitat, and 1 acre of tidal habitat. (USACE 2001).
2	Ohio River Ecosystem Restoration	KY OH PA	Louisville Huntington Pittsburgh	Program goals are to restore and protect 25,000 acres of bottomland hardwood forests, 1,250 acres of aquatic habitat, 40 islands, 100 miles of riparian habitat, and 25,000 wetland acres at over 250 sites along a 981-mile corridor of the Ohio River. (USACE 2000a).
3	Stillaguamish River Ecosystem	WA	Seattle	The proposed project includes dike removal, channel excavation, wetland restoration, and cattle fencing at 10 sites within the basin to restore or reconnect access to 1,483 acres of critical salmon spawning, rearing, refugia, and estuarine habitats. (USACE 2000h).
4	Tres Rios	AZ	Los Angeles	The project purposes are to restore riparian and wetland habitat and provide flood control along 9.2 miles of the Salt and Gila Rivers using a regulating wetland for treatment plant discharge, riparian and marsh wetlands, and a flood control levee. (USACE 2000c).
5	Wolf River	TN	Memphis	The project proposal involves the construction of weirs in the Wolf River and tributaries, as well as earthen dams, boat ramps, and trails to stabilize the river from additional headcutting, preserve wetland and riparian habitat, prevent bridge and utility damage, and enhance recreational opportunities. (USACE 2000d).
6	Antelope Creek	NE	Omaha	The proposed project involves channel realignment, widening, and stabilization, railroad bridge modifications, and construction of a recreation trail to decrease annual flood damages by confining 100-year flows to the channel, and to enhance recreational opportunities. (USACE 2000f).
7	Chesterfield Valley	MO	St. Louis	The project would increase flood protection to a 500-year event with a system-wide levee raise, seepage control structures, road and railroad closures, raises and realignments, a gate well structure, an alternate channel alignment, four pump stations and gravity drains, and mitigation for wetland impacts. (USACE 2000e).
8	Lower Mission Creek	CA	Los Angeles	The project would provide flood protection through bridge replacement, a bypass culvert, streambed alteration, stabilization of stream banks with vertical walls and vegetated riprap, and construction of habitat zones, natural creek bottom, and wetlands. (USACE 2000b).
9	Sand Creek Watershed	NE	Omaha	The project purpose is to implement flood control measures, restore wetlands, and improve water quality with a sediment basin, a breakwater, an island, a lake/wetland complex, seven small ponds, and bottomland wetland restoration. (USACE 2000g).
10	Tule River Basin	CA	Sacramento	This project would raise the Success Dam spillway by 10 feet, to improve hydropower, irrigation, and flood protection. Mitigation would include best management practices, land acquisition, relocation of boundary fences, and improved habitat areas. (USACE 1999).

Table 2. Project Summaries

Project Considerations	Project Identification Number									
	1	2	3	4	5	6	7	8	9	10
General Criteria										
Scale of Hydrologic Unit	W	B	W	I	SB	SW	I	SW	W	W
Historic/Reference Conditions	●	●	●	●	●	▼	▼	●	●	▼
Current Conditions	●	●	●	●	●	●	●	●	●	●
Future Conditions	●	●	●	●	●	●	●	●	●	●
Equilibrium Conditions	●	●	●	○	●	○	○	○	●	●
Project Life (years)	50	15	50	50	50	50	50	50	50	50
Economic Considerations	●	●	●	●	●	●	●	●	●	●
Stakeholder Involvement	●	●	●	●	●	●	●	●	●	●
Problem Identification	●	●	●	●	●	●	●	●	●	●
Other Watershed Issues	●	●	●	●	●	●	●	●	●	●
Goals	●	●	●	●	●	●	●	●	●	●
Alternative Solutions	●	●	●	●	●	●	●	●	●	●
Monitoring Plan	○	●	●	●	●	○	●	●	●	●
Adaptive Management Plan	○	▼	●	●	●	○	○	▼	▼	○
Physical Criteria (%)										
Climate	100	0	100	100	100	100	100	100	100	100
Geology	67	34	67	67	100	100	67	67	100	100
Watershed Morphology	78	30	100	100	90	70	70	90	67	30
Hydrology/Hydraulics	0	38	75	100	75	50	75	100	100	75
Sediment Processes	0	0	100	100	100	0	0	100	100	34
Biological Criteria (%)										
Vegetation	50	38	75	100	100	13	50	88	88	100
Aquatic Habitat	75	50	100	88	75	29	25	88	86	88
Aquatic Organisms	100	20	100	80	80	20	80	100	80	100
Terrestrial Habitat	50	63	88	75	63	0	13	100	100	88
Terrestrial Organisms	50	20	100	100	80	20	40	100	100	60
Chemical Criteria (%)										
Water Quality	60	80	100	75	100	22	89	90	100	80
HTRW Sites	100	100	0	100	100	100	100	100	100	100
Social Criteria (%)										
Social Effects	92	31	23	82	100	82	92	77	92	85
Social Benefits	100	100	100	100	100	100	100	100	100	100

R = Region S = Sub-Region B = Basin SB = Sub-Basin W = Watershed SW = Sub-Watershed
I = Individual project ● = Addressed in feasibility report or FEIS ○ = Not addressed in report or FEIS
▼ = No substantive comments in report or FEIS (not included in %) NA = Not Applicable to project (not included in %)

Table 2a. Physical Criteria and Parameters

Criteria & Parameters	Project Identification Number									
	1	2	3	4	5	6	7	8	9	10
Climate Parameters										
Precipitation	●	▼	●	●	●	●	●	●	●	●
Air Temperature	●	▼	●	●	●	●	●	●	●	●
Evaporation/Wind	●	▼	NA	●	NA	●	NA	●	●	●
Geology Parameters										
Parent Material	●	●	●	●	●	●	●	●	●	●
Soil Composition	●	▼	▼	●	●	●	●	●	●	●
Erosive Resistance/Sensitivity	○	▼	●	○	●	●	▼	○	●	●
Watershed Morphology Parameters										
Elevation	●	▼	●	NA	●	●	▼	●	▼	●
Watershed Size	●	●	●	●	●	●	●	●	●	●
Watershed Aspect	NA	▼	●	●	●	●	●	●	NA	●
Drainage Density/Pattern	●	○	●	NA	●	●	●	●	●	○
Channel Type	●	●	●	●	○	○	●	●	●	○
Channel Dimensions	●	▼	●	●	●	●	▼	●	●	○
Channel Substrate Composition	●	▼	●	●	●	●	●	●	▼	○
Sediment Sources and Erosion Processes	○	▼	●	●	●	▼	▼	●	●	○
Watershed Cover/Imperviousness	●	▼	●	●	●	●	●	●	●	○
Floodplain Connectivity	▼	●	●	●	●	▼	●	▼	▼	○
Hydrology/Hydraulic Parameters										
Average Annual Discharge	NA	▼	▼	●	●	○	○	●	●	●
Monthly Discharge	NA	▼	●	●	○	○	●	●	●	●
Peak Flows	NA	▼	●	●	●	●	●	●	●	●
Minimum Flows	NA	▼	●	●	○	●	○	●	●	●
Flow Frequency and Duration	NA	●	●	●	●	●	●	●	●	●
Surface and Groundwater Sources	▼	●	●	●	●	●	●	●	●	●
Infiltration/Runoff Processes	▼	▼	●	●	●	▼	●	●	●	○
Channel Velocities/Shear Forces	▼	●	▼	●	●	▼	●	●	●	○
Sedimentation Parameters										
Transport/Deposition	○	▼	●	●	●	○	▼	●	●	○
Erosion Rates	○	▼	●	●	●	▼	▼	●	●	○
Sediment Yield	○	▼	●	●	●	○	▼	●	●	●

● = Addressed in feasibility report or FEIS ○ = Not addressed in report or FEIS ▼ = No substantive comments in report or FEIS (not included in %) NA = Not Applicable to project (not included in %)

Table 2b. Biological Criteria and Parameters

Criteria & Parameters	Project Identification Number									
	1	2	3	4	5	6	7	8	9	10
Vegetation Parameters										
Historic Species	▼	▼	●	●	●	○	▼	●	●	●
Current Species	●	●	●	●	●	▼	●	●	●	●
Native/Non-Native/Invasive	○	▼	▼	●	●	○	▼	●	○	●
Community Type	▼	●	●	●	●	○	●	●	●	●
Distribution	●	●	●	●	●	○	●	●	●	●
Surface/Canopy Cover	●	▼	●	●	●	○	▼	●	●	●
Dynamics/Succession	NA	▼	●	●	●	○	▼	●	●	●
Threatened/Endangered	NA	▼	○	●	NA	●	●	○	●	●
Aquatic Habitat Parameters										
Historic Habitat Types	●	●	●	●	●	○	▼	●	●	●
Current Habitat Types	●	●	●	●	●	●	▼	●	●	●
Location and Distribution	●	▼	●	●	●	●	▼	●	●	●
Diversity	●	▼	●	●	●	▼	●	▼	●	●
Cover	○	▼	●	●	●	▼	○	●	○	●
Critical Habitat	●	▼	●	○	○	NA	○	●	NA	●
Connectivity	▼	●	●	●	○	○	●	●	●	○
Trends	●	●	●	●	●	○	○	●	●	●
Aquatic Organism Parameters										
Historic Species Assemblage	●	▼	●	●	●	○	●	●	●	●
Current Species Assemblage	●	▼	●	●	●	▼	●	●	●	●
Distribution/Range	●	▼	●	▼	▼	○	○	●	○	●
Population Trends	●	●	●	●	●	○	●	●	●	●
Threatened/Endangered	●	▼	●	●	●	●	●	●	●	●
Terrestrial Habitat Parameters										
Historic Habitat Type	▼	●	●	●	●	○	▼	●	●	●
Current Habitat Type	●	●	●	●	●	▼	●	●	●	●
Location and Distribution	NA	●	●	●	▼	○	○	●	●	●
Diversity	NA	▼	●	●	●	○	○	●	●	●
Cover	NA	▼	●	▼	●	○	○	●	●	●
Critical Habitat	NA	▼	○	○	○	NA	○	●	NA	●
Connectivity	NA	●	●	●	○	○	○	●	●	○
Trends	NA	●	●	●	●	○	○	●	●	●
Terrestrial Organism Parameters										
Historic Species Assemblage	○	●	●	●	●	○	▼	●	●	○
Current Species Assemblage	●	▼	●	●	●	○	●	●	●	●
Distribution/Range	NA	▼	●	●	▼	○	▼	●	●	●
Population Trends	○	▼	●	●	●	○	▼	●	●	○
Threatened/Endangered	●	▼	●	●	●	●	●	●	●	●

● = Addressed in feasibility report or FEIS ○ = Not addressed in report or FEIS ▼ = No substantive comments in report or FEIS (not included in %) NA = Not Applicable to project (not included in %)

Table 2c. Chemical and Social Criteria and Parameters

Criteria & Parameters	Project Identification Number									
	1	2	3	4	5	6	7	8	9	10
Chemical Criteria										
HTRW Sites/Concerns	●	●	○	●	●	●	●	●	●	●
Water Quality Parameters										
pH	○	●	●	○	●	○	○	○	●	○
Microorganisms	○	●	●	NA	NA	○	●	●	●	●
Nutrients	●	●	●	●	●	○	●	●	●	●
Dissolved Oxygen	●	●	●	●	●	○	●	●	●	●
Heavy Metals	●	●	●	●	●	○	●	●	●	●
Temperature	○	●	●	○	●	○	●	●	●	●
Pesticides/Herbicides	○	○	●	●	●	○	●	●	●	●
Suspended Sediment	●	●	●	●	●	●	●	●	●	●
Turbidity	●	●	●	●	●	●	●	●	●	○
Other Contaminants	●	○	NA	NA	NA	NA	NA	●	NA	●
Social Criteria										
Social Effects Parameters										
Air Quality	●	●	○	●	●	●	●	●	●	●
Noise	●	●	○	●	●	●	●	●	●	●
Aesthetics	●	●	●	●	●	●	●	●	●	●
Displacement of People/Bus/Farm	NA	▼	●	NA	NA	●	●	●	●	●
Community Cohesion	●	▼	○	●	●	●	●	○	●	○
Local Government Finance	●	▼	▼	●	●	●	●	●	●	●
Tax Revenues	●	▼	○	○	●	○	○	○	●	○
Property Values	●	▼	○	○	●	○	●	●	●	●
Irretrievable Resources	○	▼	○	●	●	NA	●	●	○	●
Public Services/Facilities	●	▼	○	●	●	●	●	▼	●	●
Community/Regional Growth	●	▼	▼	NA	●	●	●	●	●	●
Employment	●	▼	○	●	●	NA	●	●	●	●
Cultural Resources	●	●	●	●	●	●	●	●	●	●
Social Benefits Parameters										
Flood Protection	NA	NA	NA	●	●	●	●	●	●	●
Water Supply	NA	NA	NA	NA	NA	NA	NA	NA	NA	●
Hydropower Generation	NA	NA	NA	NA	NA	NA	NA	NA	NA	●
Navigation	●	NA	NA	NA	NA	NA	NA	NA	NA	NA
Recreation	●	●	●	●	●	●	NA	●	●	●

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Table 3. Explanation of Physical Parameters

Physical Parameters	Explanation
Precipitation	Precipitation within the watershed (in./yr or mo)
Air Temperature	Monthly and annual averages, as well as extremes
Evaporation/Wind	Important factors in water budgets and effects on physical, chemical, and biological processes
Parent Material	Bedrock composition
Soils	Composition, distribution, horizon characteristics, moisture, and compaction
Erosive Resistance/Sensitivity	Resistance of soils to impacts
Elevation	Range of the watershed height in feet above sea level
Watershed Size	In acres, square miles, etc.
Watershed Aspect	The general directional orientation of the watershed (e.g., south-facing)
Drainage Density/Pattern	Channel lengths per watershed area and patterns (e.g., dendritic, trellis)
Channel Type	Identified using classifications such as those developed by Rosgen, Schumm, Montgomery and Buffington
Channel Dimensions	E.g., width, depth, slope, length
Channel Substrate Composition	E.g., predominant size, shape, and type of particles, grain size distributions, variability, armoring
Sediment Sources and Erosion Processes	Sediment source (e.g., slope wash, soil creep, mass wasting), erosion transport, deposition, consolidation
Watershed Cover/Imperviousness	General cover characteristics and area vegetated versus impervious surface
Floodplain Connectivity	Is the floodplain area continuous, or are there encroachments such as roads and buildings?
Average Annual Discharge	An average of the annual channel discharges, usually expressed in m^3/sec or ft^3/sec
Monthly Discharge	An average of the monthly channel discharges, usually expressed in m^3/sec or ft^3/sec
Peak Flow	The highest channel discharge for a given year
Minimum Flow	The lowest channel discharge for a given year
Flow Frequency and Duration	Frequency and duration of a particular discharge
Surface and Groundwater Sources	Location of various water sources such as streams, aquifers, and wells
Infiltration/Runoff Processes	Overland flow, saturation overland flow, sub-surface storm flow
Channel Velocities/Shear Forces	Speed of water in a channel and the relative shear forces acting on the channel bed and banks
Sediment Transport/Deposition	Transport processes (dissolved load, wash load, bed-material load) and depositional areas
Erosion Rates	Rate of material eroded; geologically normal vs. accelerated
Sediment Yield	Sediment yield = sediment yield/total material eroded

Table 4. Explanation of Biological Parameters

Biological Parameters	Explanation
Historic Species	Identification of the types of flora and fauna historically found in the watershed
Current Species	Identification of the types of flora and fauna currently found in the watershed
Native vs. Non-Native or Invasive	Identification of species native and non-native to the watershed, as well as any invasive species that tend to spread rapidly and harmfully
Community Type	Description of the vegetative community (e.g., bottomland hardwoods, short grass prairie)
Distribution/Range	Identification of species distributions throughout the watershed
Vegetation Surface/Canopy Cover	Description of the spatial vegetative cover within the watershed, either at the canopy or surface level
Dynamics/Succession	Identification of any changes within the vegetative community
Habitat Type	Description of the various habitats within the watershed
Location and Distribution	Identification of habitat locations and distributions throughout the watershed
Diversity	The relative variety of flora and fauna in the watershed
Habitat Cover	Abundance and importance of the spatial cover available for prey
Critical Habitat	Identification of habitat vital to the survival of certain species
Connectivity	Identification of the spatial connectivity of habitat, or its fragmentation across the watershed
Trends	Identification of habitat changes over time
Population Trends	Identification and causes of population increases or decreases of terrestrial and aquatic organisms within the watershed
Threatened/Endangered	Identification of threatened or endangered species within the watershed

RESULTS AND DISCUSSION

Despite the differences in main project purposes, there were no apparent patterns among the projects shown in Table 2. For example, one might have inferred that environmental restoration projects are more complete in the evaluation of biological criteria than are flood damage protection projects. This assumption is dispelled by the results shown in Table 2. Overall, the planning processes of eight of the 10 projects were performed at the sub-watershed, or larger, scale, whereas only Project Numbers (PN) 4 and 7 were limited in scale to individual project areas.

An additional project that warrants separation is the Ohio River Ecosystem Restoration Program (PN 2). This project is fundamentally different from the others, as it seeks to identify and authorize a basin-wide restoration "program" rather than specific, detailed project elements. Even though it is a notable example of the watershed approach, the outcome is poorly reflected by Table 2.

General Criteria

All 10 studies did a respectable job of addressing the general criteria. More than 88 percent of the total general criteria were adequately addressed; only 7.7 percent were not addressed, and 3.8 percent were mentioned but not substantively addressed. Notable shortcomings included the establishment of equilibrium conditions and the incorporation of an adaptive management plan.

Only 60 percent of the studies established equilibrium conditions, and only 30 percent incorporated an adaptive management plan. Only seven project reports discussed historic or reference conditions within the study area in sufficient detail to give the reader adequate understanding of the area prior to development. Current and future conditions were fully discussed in all documents. All of the projects used an open process to identify problems, watershed issues, goals, and potential solutions. This process involved stakeholders through public meetings, public workshops, public notices, and/or surveys. Lastly, monitoring plans were identified in eight of the projects.

Physical Criteria

Results for the physical criteria were more variable. The average score for all parameters and all projects was 72.3 percent. Six of the 10 projects adequately addressed at least 67 percent of the factors. All projects except PN 2 fully addressed climate. Geology was consistently addressed with an average score of approximately 77 percent for all studies. Erosive resistance/sensitivity, the parameter most consistently lacking, was fully addressed in only five studies. Watershed morphology parameters were addressed to a level of 72.5 percent for all factors and all studies. On PN 2 and PN 10, results for this criterion were significantly different[3] as they collectively covered only 30 percent of the parameters. However, emphasis was not placed on watershed morphology parameters for these projects. The study for PN 2 was intended to identify a possible restoration program rather than a comprehensive implementation study, and PN 10 is a flood protection project involving vertical expansion of an existing spillway. The remaining eight projects had a collective mean of 82.9 percent.

Overall, sediment sources/erosion processes and floodplain connectivity need more attention, as they were adequately addressed in only 50 percent of the studies. Hydrology/hydraulic criteria were not addressed in PN 1 and were only 38 percent addressed by PN 2. A likely reason for the inadequate job in PN 1 is that the project involved sediment dredging and wetland creation in an estuarine area, where the proposed work would not have a major influence on these parameters. The report for PN 2 was a general program study rather than a detailed project-specific report. The hydrology/hydraulic average of the remaining eight projects was 69.3 percent, with infiltration/runoff processes and channel velocities/shear forces being the weakest points in these documents. Only five studies addressed average annual discharge, whereas nine studies addressed peak flows. Finally, sedimentation processes were fully addressed in five reports, partially addressed in one report, and not addressed in the remaining four reports.

Biological Criteria

Except for PN 6, which was lacking in all the biological parameters, the project reports do a reasonable job of identifying historic and current vegetation, habitat, and fish and wildlife species. The score for all projects and all parameters was slightly more than 69 percent. In general, vegetation and aquatic resources were addressed more thoroughly than terrestrial fauna and habitat. Three deficiencies were noted for vegetation parameters: Identification of historic species (60 percent), native and non-native/invasive species (40 percent), and threatened and endangered species (50 percent). The most overlooked aquatic habitat parameters were cover, critical habitat, and connectivity (scoring 40, 40, and 60 percent, respectively). Aquatic organisms were well-addressed, although the distribution/range of the species was often overlooked (40 percent). More than 50 percent of terrestrial habitat and organism parameters were not adequately addressed, with only PN 8 and PN 9 fully addressing the terrestrial ecosystem.

For all of the biological criteria, two pronounced studies did a much poorer job of addressing the parameters and were significantly different from the other eight studies. For vegetation, the average of PN 2 and PN 6 was 25.0 percent, whereas the average of the other eight studies

[3] Statistical methods: derived large-sample confidence interval for two treatment proportions to see if there were statistically significant differences between the two proportions

was 82.0 percent. For aquatic habitat, the average of PN 6 and PN 7 was 26.7 percent, while the average for the other eight projects was 81.0 percent. For aquatic organisms, the average of PN 2 and PN 6 was 20.0 percent; the average of the other eight was 90.0 percent. For terrestrial habitat, the average of PN 6 and PN 7 was 6.7 percent, and the average of the other eight was 80.7 percent. Lastly, the average coverage of terrestrial organisms by PN 2 and PN 6 was 20.0 percent, while the average coverage of the remaining eight projects was 79.5 percent.

Chemical Criteria

All except one report identified and addressed potential concerns regarding HTRW sites. Water quality analyses were largely thorough in eight of the projects (average coverage of 85.5 percent), with pH and microorganisms being the common factors not considered. PN 1 and PN 6 failed to address four and seven of the parameters, respectively, and collectively averaged 22.2 percent. The overall score for the projects was approximately 85 percent.

Social Criteria

Overall, the social effects and benefits were discussed in great detail, with an average of almost 88 percent of the parameters being fully addressed for all projects. This is not surprising, given the Corps' responsibility to demonstrate the effects of a project on the public, particularly in the form of cost-benefit ratios. However, PN 3 was limited in its discussion of the social effects shown in Table 2c, and PN 2 only generally discussed the social effects parameters. Community cohesion and tax revenues were omitted from several of the other reports.

CONCLUSIONS AND RECOMMENDATIONS

Changes in societal values over the last 40 years, accompanied by political and funding constraints, have shifted the emphasis of the Corps from large water resource development projects to environmental conservation, water quality, and recreation efforts (Reuss and Hendricks, 10 January 2002). Establishing methods, techniques, and approaches for sustainable development is essential to this task.

Since the late 1990s the Corps has made policy commitments for implementing a watershed planning approach. The main focus of this study was to introduce a watershed approach framework and gauge the extent of Corps implementation of a watershed planning approach over the past few years. Based upon the evaluation of feasibility reports and environmental impact statements for 10 recent Civil Works projects, the Corps appears to be practicing a watershed planning approach, with project scales most commonly at the sub-watershed size but ranging from basin scale down to individual project sites. It should be noted that these results might not be reflective of smaller-scaled Corps Civil Works projects.

However, analysis of Table 2 indicates that although the Corps is largely following a watershed planning approach, there are gains to be made in watershed planning efforts. If the Corps is to truly attain environmentally sustainable solutions to environmental challenges, more complete analyses of watershed conditions are necessary. Additionally, there needs to be consistency across Districts, as there is some disparity in the detail provided among projects of similar nature and scale (e.g., PN 6 and PN 8).

Table 5 summarizes assessment of the 10 projects. The table presents each consideration evaluated in this technical note and the percent to which it was addressed. The considerations are statistically separated by the upper and lower quartiles of the data. Different degrees of shading identify those areas in which the Corps studies fully addressed the concern (top), adequately addressed the concern but where some improvement is needed (middle), and failed to adequately address the issue (bottom).

Overall, the studies did a very good job of characterizing existing conditions, formulating the problem, identifying solutions, and relating these to social impacts and needs. This is not surprising, since these considerations have

Table 5. Summary of Assessment

Consideration	Percent Addressed
Current Conditions	100
Economic Considerations	100
Future Conditions	100
Alternative Solutions	100
Goals	100
Other Watershed Issues	100
Problem Identification	100
Social Benefits	100
Stakeholder Involvement	100
Climate	90
HTRW Sites	90
Monitoring Plan	80
Water Quality	79.6
Geology	76.9
Aquatic Organisms	76
Social Effects	75.6
Watershed Morphology	72.5
Aquatic Habitat	70.4
Vegetation	70.2
Historic/Reference Conditions	70
Hydrology/Hydraulics	68.8
Terrestrial Organisms	67
Terrestrial Habitat	64
Equilibrium Conditions	60
Sediment Processes	53.4
Adaptive Management Plan	30

been the foundation of Corps planning studies for decades.

The studies did an adequate job of addressing the vegetation, aquatic resources, general site characteristics, chemical criteria, and social effects. These were also standard components of Corps planning studies prior to initiatives to adopt watershed-based perspectives, so it is reasonable to expect good performance. Improvement is most needed in the identification of sediment sources and characterization of erosion sensitivity, assessment of floodplain connectivity, classification of vegetation (i.e., native, non-native, invasive, threatened or endangered), identification of critical aquatic habitat and refugia, and broadening of the spectrum of social impacts. There were no apparently consistent reasons to explain these lower scores.

Overall, the studies were inadequate in addressing hydraulics and hydrology, terrestrial habitat and organisms, equilibrium conditions, and sedimentation processes. They also failed to incorporate adequate adaptive management plans. These are key components of watershed-based assessments, which are focused on the interactions in the ecosystem that often transcend the immediate project site and look beyond direct impacts. Perhaps the hydraulics and hydrology inadequacies result partly because the Corps is typically studying one particular hydrologic discharge for a given design rather than an array of discharges and responses. Hydrologic and hydraulic analyses should seek to more thoroughly evaluate the overall hydrodynamic character of the watershed and to characterize local scale and reach scale energy conditions.

Terrestrial habitat and organisms were probably not adequately discussed in the reports because the Corps is usually involved in water resource projects that have little direct effect on terrestrial areas. However, lateral movement of water, sediment, nutrients, and organisms is an important consideration that should be analyzed in more detail in future planning efforts. There was no apparent pattern to explain why equilibrium conditions and sedimentation processes were addressed in some reports and not in others. Given the current process of the Corps constructing a project and then turning it over to a local sponsor, adaptive management plans will likely continue to be omitted from Civil Works projects, at least until this practice changes.

A stronger focus on cause and effect relationships, particularly among the physical and biological components of the ecosystem, would strengthen these studies. In particular, a stronger focus on riparian and terrestrial ecosystems and their interaction with the aquatic resources and watershed hydrology is needed.

Challenges and Applications

Perhaps the most fundamental challenge facing the Corps in watershed planning lies in the constraints of the planning process. Local sponsors often approach the Corps with a water resource need specific to their community. When a project moves forward, the local sponsor is obligated to pay a considerable portion of the costs; therefore, the sponsor may be resistant to studies that encompass areas larger than the immediate community. To alleviate this problem, the Corps is currently working to develop differential cost-sharing methods that promote watershed-based planning efforts without local sponsors having to pay more than their share of the costs.

Because the Corps is an agency serving public needs, stakeholder involvement is of paramount importance. Given the diverse needs (and polar views) of the public, it is difficult to make a balanced decision. The key to overcoming this challenge is an unbiased, open process to project planning.

Existing infrastructure is another limitation that inevitably drives project decisions. The Corps analyzes the practicality of nonstructural flood control alternative solutions, such as permanent evacuation and relocation, floodplain zoning, flood proofing, flood insurance, and flood warning/emergency evacuation systems. These alternatives are being incorporated into many projects; however, their exclusive use in highly developed areas is often socially unacceptable or not cost-effective. To prevent a more costly and compounded problem in the future, construction must be avoided in flood-prone areas. This could be accomplished through local zoning ordinances, accompanied by strategic placement of open areas, bike paths, and natural areas. These features often generate an additional community tax base associated with higher property values within the surrounding areas.

Time, planning resources, and budget constraints can be limiting factors in the quality of planning approaches and decisions. Time and resources ultimately cost money, and budget constraints are inevitable. There is no way to avoid these problems, regardless of who conducts the planning. A positive aspect of watershed planning approaches is the ultimate savings in time and money, based on the concept of economies of scale.

When individual projects are viewed collectively over a specific watershed, planning resources, as well as agency resources and knowledge, are combined so that all available resources are utilized without duplicating efforts. The outcome may result in more quality data with less time, cost, and effort, and ultimately, a better planning decision. As more watershed studies are completed over time, the process will become more efficient as much of the work will already be done.

The appropriate time scales used in watershed planning remains contentious. Most Civil Works projects are evaluated with a life of 50 years, but there is debate on whether that is an adequate time scale to measure impacts such as cumulative effects. Moreover, many important processes (e.g., life cycles of some organisms) occur on much smaller time scales. Therefore, it may be necessary for effective watershed-based approaches to consider a wide range of spatial and temporal scales when evaluating proposed projects. This topic merits additional study in the future.

Economic considerations also remain contentious and deserving of additional attention. There is concern that ecological costs and benefits are poorly reflected in cost-benefit ratios associated with Civil Works projects. Economic considerations should continue to be explored for remedies to this problem.

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