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Status of Instream Flows and Channel Maintenance Program: Agricultural Research Service

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ARS policy regarding instream flow/channel maintenance is uncertain and vague. Senate Document 59 identified channel stability and sedimentation problems as needing attention in all but four of the fifteen major physiographic regions of the country. The four regions that were considered to have no serious sedimentation or channel stability problems are the Northern Great Plains, Great Lakes Timbered Lands, Lake and Till Plains, and the Northeast. However, the resources that have been made available to develop and assess solutions to these problems have never been sufficient to make the progress needed in the eleven regions. The primary center for sedimentation and channel stability research in ARS is the National Sedimentation Laboratory at Oxford, Mississippi. Even at this facility the pressure to address other research priorities, coupled with a lack of appropriated funds for channel stability research has resulted in a steady reduction of effort. Most of the work in other regions of the country has been terminated because of shifts in national priorities and a redirection of resources to higher priority research, or because stream sediments in the experimental watersheds were not of sufficient concern to support the work. The net result is that research on stream sedimentation, gully erosion, and channel bank stabilization in the Agency has reached a historical low point.

A change in the present situation is unlikely unless there is a change in national priorities or strong expressions of concern are voiced by agencies with the responsibility for reducing the environmental and economic damages of sedimentation. The major impetus for expanding ARS research on these problems in recent years has come from the Demonstration Erosion Control Project (DEC) in the Yazoo River Basin of Mississippi. The strong support that the project has received, and the overwhelming evidence that the transported sediments are the result of channel erosion has given this work a high visibility within ARS.

Historically, there has been little research undertaken in ARS to determine the effects of different land uses and land treatments on low flows. In part, this reflects the limited attention that had been given by the agency to the recreational and wildlife aspects of water resources management. However, in recent years, ARS has become more actively involved in research on the effects of stream quality on aquatic ecology. This work is also largely centered at the National Sedimentation Laboratory, and owes its present high visibility to support from the SCS and COE in Mississippi. Some excellent research has been done at other ARS locations but generally in response to specific requests for assistance.

This frank statement is not intended to negate the importance of the subject to USDA programs and societal wishes, but rather to state that the monetary and people resources to address the problems in ARS are limited at the present time. Whereas other program areas of the workshop are receiving considerable societal impetus which results in funding initiatives and policy statements, instream flows and channel maintenance are currently languishing and receiving little emphasis (with the exception of the preciously cited DEC program).

Existing Programs

Existing programs on instream flows and channel maintenance in the ARS 1991 Strategic Plan are not specifically identified in either area 1 for RESOURCE MANAGEMENT or area 6 for SYSTEMS INTEGRATION. Rather the subject is inferred in the sub-problems such as 1.1 (Atmosphere and Climate), 1.2 (Soil), 1.3 (Water), 6.1 (Resource Management: Systems and Models) and 6.6 (Systems Integration). Furthermore, the research includes both applied and basic research that involves a mix of modeling and experimental

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methods that build on a mix of both methods evolving in time. Experimental facilities used to address the problem vary from the controlled facilities such as hydraulic flumes in laboratories such as the USDA Sedimentation Laboratory, to the heterogeneous conditions encountered with experimental watersheds, to the use of remote sensing to develop data bases, to the use of personal computers (PC's) for hypothesis building and testing in analytical models. Thus the facilities range in size from the small laboratory hydraulic flume, a computer, remote sensing instrument, to a rainfall simulator plot, to a large (approximately 100 sq. mi.) experimental watershed (Fig. 1). In general, research objectives involve understanding the physical processes involved and how and why various management systems respond to perturbations in system inputs or states. The research must also consider how the agricultural resource base will respond to climate change.

Instream flows from the standpoint of maintaining wildlife and aquatic habitat have not been addressed heretofore in the ARS research program with the exception of research at the National Sedimentation Laboratory and some research on the effect of upstream agricultural practices on the survival of salmonid embryo by the staff in Fort Collins, Colorado. Research at the National Sedimentation Laboratory on the ecology of watershed channels includes (1) the collection of baseline data on DEC watersheds before erosion control construction, (2) the evaluation of slow release devices on retention structures to provide maintenance flow in ephemeral channels, (3) adaptation and evaluation of channel structures to enhance environmental conditions, and (4) use of constructed wetlands to clean up point sources of pollution, primarily animal waste. On the other hand, flood series frequency analyses have received considerable attention both from analysis of the flood time series on experimental watersheds and from simulation using analytical computer models. It should be possible to use both of these approaches (runoff time series and analytical models) to predict low flow rates and amounts for different flow periods. To this point in time, there have been no demands of ARS engineers and scientists for such work except in the Tucannon River where the role of upstream agricultural practices were investigated for its impact on salmonid embryos.

Instream flow maintenance is of major concern to the nonagricultural industry. The hydroelectric power industry is investigating the role of

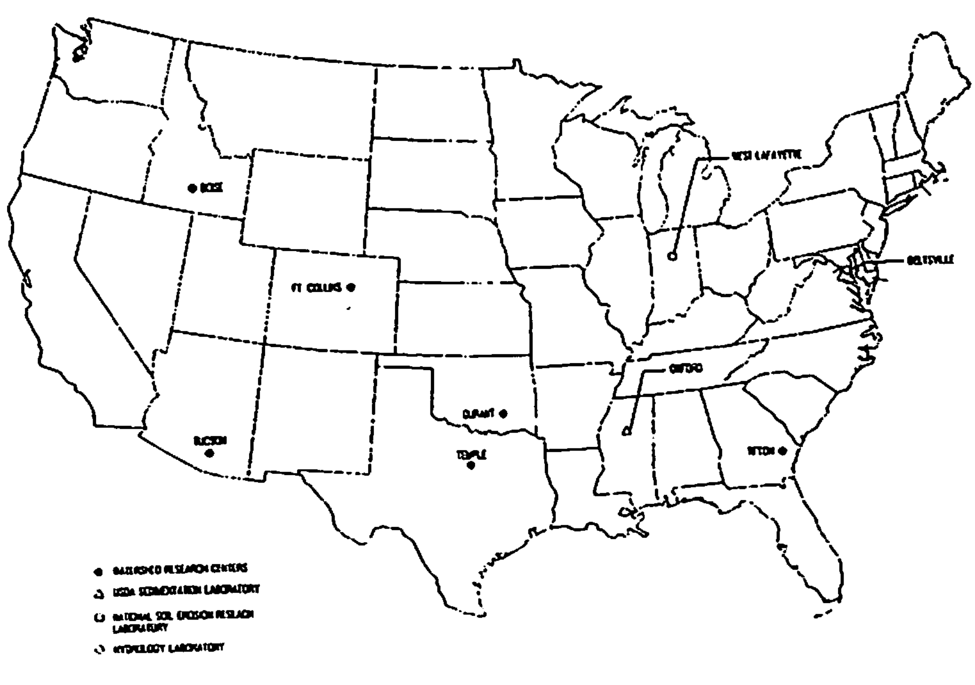

FIG. 1. ARS Locations contributing to instream flow/channel maintenance.

watershed management for its impact on water quantity. Thus, they are concerned with water yield, low flow relationships, and, of equal significance, on channel maintenance because the sediments from channels have major impact on reservoir storage capacity and generator performance. Whereas ARS has technical capabilities to research some of these problems, the resources and mandate to conduct such research have not been available.

Channel maintenance research programs in ARS suffer from the perceived concept that engineering efforts associated with bank stabilization, grade control, dredging, energy control, etc., are aesthetically unacceptable and destroy wildlife and biological habitat. Thus USDA efforts associated with engineering approaches to watershed management (and flood control and channel maintenance) are not receiving as much support as in the past. Although support for research programs has also dwindled many issues remain unsolved. Success in the DEC project in Mississippi may help attract some additional support in this area.

Watershed planning procedures in U.S. action agencies such as SCS and FS of USDA, the USCOE in the Defense Department, and USDI agencies like BR, BLM, and BIA must include water management as a major factor. Any treatment of channel erosion/maintenance must be based on consideration of the temporal and spatial complexity within the entire watershed, a very complex problem at best.

Most watershed planning and evaluation methods require the use of some type of computer model, a technology for which ARS has considerable expertise and many ongoing efforts. These models, designed for specific and general application deal with watersheds as landscape pieces (grid pieces and/or subwatersheds) or by processes such as upland areas of runoff and erosion, and channel processes composed of runoff routing and erosion and sediment transport.

Unfortunately, the models currently available emphasize upland processes or channel hydraulic processes and such a model providing equal treatment of both is not readily available. As larger watersheds are being evaluated, the upland part of the watershed becomes less significant. For example, measurements on Goodwin Creek, MS, revealed that over 60% of the silt and clay size fraction sediment came from channel erosion whereas practically all sand came from gullies and channels. It is important to note that channel erosion tends to increase with low sediment loads from decreased upland erosion and decrease with increased upland erosion. Thus, erosion control in farm fields and upland areas, such as might result from conservation tillage and/or grassed waterways, may result in excessive channel instability if runoff is not also controlled. Channel erosion damages include instability resulting from steepened banks, over-bank storm flow in reaches where sand and gravel accumulates leading to poor flood plain drainage, runoff pollution and offsite damages. Fortunately, upland programs might be expected to reduce runoff rates and amounts but such may be accomplished at the expense of reduced downstream water supplies.

Upland watershed flood detention structures have been used by USDA in watershed protection programs for a long time. In many states, the water detained behind such structures must be released within a specified time to satisfy downstream water rights. ARS was involved in the evaluation of such a program on the Washita River in Oklahoma. The research was designed to evaluate the impact of flood peak discharge reductions on downstream channel dynamics as well as the net water yield and water quality. Although the research has been redirected to other topics, the results of the work are most significant. For example, although there was an overall decrease of 5% in the water yield, the results were highly variable. Furthermore, the average sediment yield was reduced by over 30% and was also highly variable temporally and spatially.

Man-induced actions associated with dredging and timber removal increased the water yield about as much as the structures reduced it. Flow duration curves at various locations in the Washita River indicated that the downstream locations had lower flows than upstream which probably resulted from a large irrigation withdrawal.

In the same project, channel changes were also observed. In some reaches, a massive erosional change took place with the channel doubling in width, and a channel meander realignment occurring. Some reaches shortened by 40% resulting from some large flood flows in the 1940's and 1950's. The percentage of sand delivered to a channel system appears to increase with the runoff event size, the amount of cultivated land, and the amount of gullying. Channelization also appeared to effect channel stability. Large flows about doubled the channel cross section with deposition downstream eventually scoured out in a 10-year period. The final summary was that the effect of floodwater-retarding structures on the Washita River channel was unclear.

Channel instabilities are a significant problem in many areas of the country. They vary from situations of channel filling by sediment deposits to entrenchment and bank failures associated with erosion within channels. The problems are especially severe along the bluff line of the Mississippi/Yazoo River flood plain where steep gradients promote channel erosion and the low gradients of channels on the flood plain cause the sediment to be deposited. Flood control reservoirs also include deposition within upstream channels.

Technologies for rectification are available including vegetation, riprap and various other structural materials for bank stabilization; grade control structures for bed stabilization; and snagging and debris removal, channel realignment, and river-training structures for increasing sediment and water conveyance. Upland treatments may increase retention time for runoff and thus reduce the flood peaks and associated erosive capacity within channels and limit the delivery of sediment to channels subject to deposition. The Demonstration Erosion Control Project in the Yazoo Basin of Mississippi is designed to demonstrate the effectiveness of existing technology to the solution of channel problems. It provides an excellent opportunity to evaluate a number of rectification technologies over a wide area and possibly to develop new, more effective technologies for specific problems. It also affords an opportunity to determine the effect of channel restoration methods on the environment. In support of this program and to develop more general methods for the prediction and control of erosion, transport, and deposition of sediment by flows within the stream channels, the National Sedimentation Laboratory has several specific research projects:

1. Evaluation of rectifications installed by action agencies (SCS and USCOE) in the Yazoo Basin for channel erosion control and maintenance of environmental quality.
2. Evaluation of various combinations of vegetation and structural methods for stabilizing stream banks.
3. Developing improved predictors for the equilibrium or capacity transport rates of bed material (gravel and sand) by flows within stream channels and thereby to ascertain the potential for sediment control through channel design and flow control.
4. Determining the effects of bank stabilization and grade control structures on the delivery of sediment from stream channels and on ecological parameters.
5. Evaluation of upland treatment to reduce the sediment delivery to streams; to reduce peak flow rates to lessen stream flow erosivity; and to increase the time length of low flow to enhance channel ecology.

Public concern requires our consideration of water quality and other environmental factors in all natural resource research. All rectification technologies must pass the test of maintaining environmental quality and new technologies are needed to improve water quality and ecological parameters in watersheds (see the companion paper on ARS Wetland/Riparian Status Report by Shields and Cooper).

The amount of effort being applied to the above projects is limited and certainly not commensurate with the research needs of the action agencies charged with the rectification of channel erosion problems. An increased effort by ARS to develop of more effective and economical rectification/ maintenance strategy for stream channels is a continuing need.

Channel maintenance research requires channel profile and cross section data that is both expensive and difficult to obtain. ARS personnel at the Hydrology Laboratory in Beltsville, Maryland, have been using some new equipment that holds great promise.

Landscape features related to erosion and hydrology are being measured using an airborne laser profiler. The airborne laser profiler makes 4,000 measurements per second with a vertical accuracy of 5 cm on a single measurement. Digital data from the laser are recorded and analyzed with a personal computer (PC). These airborne laser profiles provide information on surface features of the landscape. Topography, canopy heights, cover, and distribution of natural vegetation were determined in studies in south Texas. Laser measurements of shrub cover along 6.5 km transects were highly correlated (r^2 = 0.98) with ground measurements made with line intercept methods. Stream channel cross sections on Goodwin Creek in Mississippi were measured quickly and accurately with airborne laser equipment. Airborne laser profile data were used to locate small gullies in a fallow level field and in a field with mature soybean. While conventional ground based techniques can be used to make these measurements, airborne laser profiler techniques allow data to be collected faster, with a greater density, and in areas that are essentially inaccessible for ground surveys. Airborne laser profiler data can quantify landscape features related to erosion and runoff and is a useful tool for providing data for studying and managing our natural resources.

Research Resources

Personnel: ARS research personnel with expertise in water resources, while being involved with site specific objectives, have demonstrated the ability to direct their expertise and resources in multilocation and multidiscipline efforts. Past successful efforts that are most notable are the CREAMS modeling work in support of PL 92-500, EPIC in support of the USDA RCA program (PL 95-192), the SPUR modeling effort in support of range resources, and recent efforts such as RUSLE and WEPP to support the 1985 Food Security Act and its successor.

The expertise in these modeling efforts require nearly all fields of engineering, biology, geomorphology, climatology, hydrology, soil science, range science, crop science, and mathematics. These disciplines are available in ARS current programs but their assignment to other priority research does not imply they could work on this program thrust. In addition, experimentalists proficient in field data collection programs are available, but these too are involved in other priority research.

Facilities: The companion ARS report by D. DeCoursey on "Water Quantity and Water Quality" presents an excellent summary of the experimentalwatershedscurrentlybeingmonitored by ARS as well as a synopsis of the watershed sizes, data base length, and land use. Unfortunately, those of the watersheds with continuous or even intermittent sediment data are restricted and in most instances, the sediment data record length is less. Table 1 summarizes those experimental watersheds which have some sediment data. Unfortunately, the sediment data inventory does not list the duration of such sediment records, whether the samples are time based (i.e., whether storm total, instantaneous suspended sample, whether the sample is discharge weighted, etc.)

We suspect that data from the 193 watershed locations listed by DeCoursey as discontinued contained only minimal sediment data.

This data base should be most valuable for instream flow analysis. Unfortunately its utility for channel stability and sedimentation analysis is problematic. For example, cross sections and channel profile data along with particle size distributions for the bed and bank material will undoubtedly be needed but not available for the historic data.

Table 1. ARS watersheds with runoff and sediment data.

Size (acres)	Number with runoff	Number with sediment
<10	58	55
10-100	28	25
100-1,000	20	20
1,000-10,000	19	13
>10,000	15	10

Additional facilities such as the hydraulic laboratories at the National Sedimentation Laboratory in Oxford, Mississippi, and the National Soil Erosion Laboratory in West Lafayette, Indiana, will provide the facilities needed to address channel hydraulic problems.

Funding: Funds available at ARS locations for the instream flow-channel maintenance issue are difficult to assess because of the intimate relationship of this research with other water related programs. For example, the instream flows work is not specifically identified in current funding but could be considered a part of the existing $7.1 million program on the water supply and more specifically the 0.2 million for streamflow. Thus the funds available for such analyses are extremely limited.

For the channel maintenance (erosion, sedimentation, channel stability), there is $5.2 million earmarked for control of soil losses and $14.8 million for watershed management/water quality with a reasonable estimate being about $5 million for channel maintenance. Thus an estimate might be that about 0.8% of the ARS budget and 6.5% of the Natural Resources and Environment budgets are directed toward instream flows/channel maintenance research in FY-91.

Accomplishments in the Last Five Years

This report does not permit a complete detailed summary of recent progress. Rather, a few specific examples are presented which may be of greatest interest to the workshop participants.

Demonstration Erosion Control (DEC) Project on Yazoo River Basin — Research in association with the three agency DEC project in the Yazoo Basin in Mississippi has numerous interesting applications for channel maintenance. For example, in one experiment combinations of vegetative and structural materials were installed on selected reaches on Johnson and Goodwin Creeks near Batesville, Mississippi. Twenty-nine treatment areas were established from 1979 through 1981 on 5,000 linear feet of formed channel banks. Field evaluations are nearing completion and the data collected should be most valuable for testing analytical models of the various treatments.

Runoff from a watershed carries sediment that must be conveyed by flows in downstream channels. Stream channel research has been one of the major efforts of ARS, and measurement of flow and sediment transport rates have been routine parts of research watershed measurement programs. Although the intent of channel measurement has been to determine the quantities of sediment eroded from the watersheds, the associations between the sediment load and channel stability have been identified. Defining the mechanics of sediment transport became a part of the National Sediment Laboratory mission, and the need for rectification of stream channel problems led to the interagency effort known as the DEC (Demonstration and Erosion Control) Project. Recent concern with the environment has greatly increased research on water quality and ecology in the DEC watersheds.

The two major problems in stream channels are erosion of the channel boundary and deposition of sediment within the channels. These are closely related to bed material transport (sand and gravel) and the meander tendency of alluvial streams with low gradients. Bank failures and headcuts are the most obvious feature of local instability. The propagation of bank erosion has been shown to be very sporadic and influenced by the temporal variability of extreme flow events and the spatial variability of bed and bank materials.

Stage frequency functions were developed for four consecutive water years for Goodwin Creek near Batesville, Mississippi. These were used along with the average rating for the transport of sands to obtain estimates of the expected annual delivery of sands by the observed flows. Also, a shift factor to correct the rating for deviations of each ETR sample therefrom was used to obtain the best estimate of the "measured" sand delivery. The measured sand deliveries differ significantly from that expected for individual years. The differences in the average sand deliveries for the four years are primarily due to differences in the amount of rainfall.

The sand-load frequency tends to increase rapidly with increasing stage at low stages and to approach a constant value at higher stages. This suggests that the extreme, but frequent, flow events constitute significant contributions to the sand load. Research at the National Sedimentation Laboratory has resulted in new knowledge of turbulence near channel boundaries, and sand and gravel transport in ephemeral channels.

Effects of Upstream Agricultural Practices on Survival of Salmonid Embryos — A general study to evaluate the potential offsite economic benefits of soil and water conservation measures were conducted for the Tucannon River Basin, Washington, was conducted by the Fort Collins, CO, group with the support and cooperation of the Soil Conservation Service. The offsite economic benefits were based upon a projected increase in the commercial and recreational harvest of salmonid in the Pacific Northwest. The Tucannon River is representative of the overall decline in salmonid rearing habitat which has occurred in the Columbia River Basin as a result of increased agricultural activity over the last century. A physical-process based computer program was developed to quantify the cause and effect relationship between the survival of salmonid embryo and upstream agricultural practices. The alternatives on the spawning and incubation environment of salmonids was emphasized. The quality of this environment affects both the embryo development and the fry emergence from the gravel substrate. The four major program components, and the system design of the computer program, which simulated the percent fry emergence, and the cause and effect relationships between the percent fry emergence, and the upstream soil and water conservation measures were developed.

The sediment intrusion and dissolved-oxygen (SIDO) model developed by ARS for the Tucannon River is currently being adapted to conditions prevalent in the South Fork of the Salmon River in central Idaho under a cooperative agreement with the U.S. Forest Service Intermountain Research Laboratory at Boise.

Streambank Erosion Due to Bed Degradation — Erosion of channel banks causes severe damage to land and adjoining property. This is a common occurrence along many miles of streams throughout the United States. In many sections of the country, this problem has reached acute stages. Channel erosion is very costly; removing sediment from choked streams and reservoirs in the United States is estimated to exceed $250 million a year. In addition, the loss of prime agricultural land and adjacent property is valued at millions of dollars annually.

Processes of fluvial erosion which operate on the banks of alluvial streams were examined by considering mechanisms of bed and bank erosion and mass failure of drained, homogeneous cohesive banks. These concepts were used to formulate a mathematical model to evaluate bed degradation for the case in which bed lowering causes bank instability. Application of a model to a laboratory experiment verified the behavior of the bed degradation submodel. Analysis of a more complex scenario demonstrated the importance of considering streambank erosion in streambed degradation analyses.

Grazing Riparian Areas — On grazing lands in the Western U.S., cattle access to streams often leads to accelerated bank erosion and channel instability. Although this was the topic of another presentation at the workshop, it is presented here because of the impact on channel maintenance. A recent survey of ranchers and environment groups has shown that grazing riparian areas is considered to be a most important issue of the 1990's. A relatively new component of ARS research in Reno, Nevada, provides a unique blend of biological and physical studies of riparian areas and grazing interactions. Preliminary results provide key answers for the restoration of riparian areas and the interaction and impact of grazing animals in these areas and the watersheds above them. Earlier research on the Reynolds Creek Experimental Watershed near Boise, Idaho, showed dramatic increases in coliform concentrations in streams where the cattle had access to the stream. ARS also has these types of studies in the DEC project at Oxford, Mississippi.

Analytical Models to Simulate Water Resources and Land Management Impacts — Much progress has been made by ARS scientists and engineers in the past few years involving the development of analytical simulation models. Although such models do a fairly good job on the water balance and on runoff simulation, none adequately treat the channel stability in sufficient detail to reflect watershed protection methods, such as channel straightening, spur dikes, and other mechanical methods of alignment, stabilization, and maintenance dredging. Channel erosion control includes bank shaping and mechanical or vegetative stabilization for localized erosion problems and grade control structures to reduce grade and transport capacity of channel flows are also not adequately addressed.

Future Direction

Research efforts involving instream flow maintenance, although nonexistent in current ARS programs, could be initiated with some new funds or an expression of interest from other USDA agencies. Such research might be closely allied to the water quantity and global change thrusts or from cooperative endeavors with agencies outside USDA. The research might involve special analyses of existing runoff data from the ARS experimental watersheds. More realistically, it might involve using simulation models which might then be used to reflect the impact of land use changes, management practices, and global change on water yield/low flow discharge.

Channel maintenance involving sediment transport, channel stability, channel erosion, and agronomic and engineering treatments to enhance channel dynamics and environmental control will continue. The research will be dictated by current research efforts in response to existing technical questions. Specific technical problems include:

1. Sediment transport is still poorly defined. Deviations of actual measurements of transport rates of sand from average trends are large with long time periods. Consequently, estimates of the sand load for unmeasured streams or for single events in even our most intensively observed channels can not be reliably made. Measurements of gravel fractions of bed material load are few, and evidence suggests the gravel accumulation in alternate bars may deflect the flow and cause erosion of the opposite banks. Consequently, control design remains largely an art with almost no basis to define a failure probability. Rectification methods vary in cost, so means are needed to design rectifications to balance construction and maintenance costs with potential losses from failures. Development of new, more economical rectification methods may be feasible. Research is needed to define the relative effectiveness of various protective measure combinations not only in protecting local channel reaches but also in altering the sediment load delivered downstream. Development of a system approach to

channel rectification is needed.

2. The distribution of shear between bed and bank materials and between particles of different sizes is poorly understood. Fundamental studies are needed to clarify these uncertainties.
3. Evaluation of downstream impacts has been restricted mostly to the effects of sediment on stability of channels and filling of reservoirs in relatively small watersheds. Most of this effort has been concentrated in traditionally agricultural areas in the South and Midwest. In addition to climatic variability and hydrologic differences, some areas of the country have influent rather than effluent streambeds which may change the results.
4. The channel dynamic conditions must be incorporated into water resource analytic models in sufficient detail to permit assessing the role of engineering structures and channel heterogeneity in a meaningful way.

Opportunities of Inter-department Cooperation -

1. Aquatic resources include sport and commercial fisheries. The U.S. Fish and Wildlife Service reported that $17.3 billion was spent in 1980 on sport fishing along. The U.S. Forest Service reported that $434 million worth of fish per year were commercially harvested in the Pacific Northwest during the mid-1970's. The number of fish making spawning runs today are less than a third of those observed in the 1970's. Naturally, these and other agencies are highly interested in accurate analyses of cause and effect between manmade sources of water pollutants and the status of the Nation's fisheries.

   Timber harvest and road construction coupled with major storm events and wildfire have all contributed to excessive inflows of sediments into the South Fork of the Salmon River in central Idaho. The Forest Service is currently embarked on a comprehensive research program to quantify the effect of forest land use on sediment yield and the resulting impact in fish resources. This effort could greatly benefit from the assistance of ARS scientists in the development of comprehensive models of sediment yield from large forested watersheds.

   A similar problem currently confronts Alaska in the Tongass National Forest. An undergoing investigation to identify the effects of fine sediment intrusion on salmon habitat has been turned over to private outfits in the absence of federal interest and participation.

   Both the U.S. Fish and Wildlife and the Corps of Engineers are continuously interested in better instream flow analysis techniques to develop flushing flow recommendations for maintaining the quantity and quality of salmonid spawning gravels, particularly in rivers where gravels are in finite supply.
2. The U.S. Federal Highway Administration has initiated a comprehensive revision of the Finite Element Surface-Water Modeling System: 2-Dimensional Flow in a Horizontal Plane (FESWMS-2DH) used by the agency for engineering design and evaluation of highway river crossings. The main objectives of this massive effort are to enhance the capability of the model to handle larger and more complicated flow problems, add the capability to simulate sediment transport and scour around river crossings, and conduct experimental verifications.

   River crossings can be affected by both scour and bed-degradation processes. In contrast to scour, which refers to local and often temporary lowering of bed levels over a short distance, degradation implies an extensive and often progressive lowering of the river bed over a fairly long distance. Whereas scour problems can often be dealt with by local protective measures, progressive degradation may be more difficult to deal with if not detected in time. Consequences may include loss of land, exposure of foundations, streambank failure, loss of embankments and other river works. On the other hand, scour around local structures such as spur dikes, jetties, and bridge abutments can proceed quite independently from the more general degradation process.

   The flow pattern in the immediate vicinity of bridge structures is usually three-dimensional and the result of complex vortex stretching, vortex shedding, and flow separation. This flow region influences the flow field in the river only within a certain distance around and downstream from the structure. This so-called "near-field" turbulence stems partly from generation at the stream boundaries but also from the interaction of three-dimensional shear layers. The turbulent flow in the near-field region can give rise to a very complex sediment transport process which in many instances can only be rigorously analyzed with three-dimensional models. For practical reasons, the dimensions of the problem can be reduced by analyzing local scour processes along the same two-dimensional, depth-averaging lines currently used in FESWMS. Second, a series of 'ad-hoc' near-field solutions can be developed to simulate those local-scour situations envisioned as most usually present in highway crossings. These 'ad-hoc' solutions would necessarily incorporate reductional flow-field approximations appropriate to each situation but, at the same time, would allow maintaining high horizontal resolution and computational efficiency.

The vertically averaged approximation is usually associated with the notion of a well mixed flow which is not appropriate in situations when suspended and bedload materials move along nonaligned paths. This sedimentary behavior could be adequately treated by averaging separately, the sediment transport equations over the suspended and bedload zones and accurately characterizing the flow pattern within each zone. This approach, however, will require further research on transport of graded sediments under non-uniform, equilibrium conditions.

Outside the near-field regions, the turbulence is governed entirely by the generation at the river bed, and a predominant near-horizontal flow pattern prevails. This region is the so-called "far-field" and it encompasses the river crossing at large where bed degradation and aggradation becomes the controlling factor and computational resolution is not too critical. In this region sediment movement could be simulated by building upon the flow algorithms presently incorporated into FESWMS. In areas farther upstream and downstream, the river morphology becomes dominated by a unidirectional pattern. In these situations it will suffice to route both flow and sediment as one-dimensional processes using standard numerical schemes. The above methodology will obviously entail replacing the present modeling approach by a chain of nested models of increasing complexity.

The Federal Highway Administration is in the process of farming out part of this work to the private or academic sector for a very large sum of money. It is unfortunate that ARS scientists are not encouraged to compete for projects like this. They could not only benefit from the financial rewards but could contribute to a project of national interest, technical expertise and experimental facilities which are not currently available in the private sector.

3. Plans for long-range participation of ARS in the Demonstration Erosion Control (DEC) Project were made at a joint meeting of the Vicksburg District, COE, the Mississippi SCS and ARS in July 1991, at the National Sedimentation Laboratory (NSL). NSL plans of continued research for DEC include: (1) operation of Goodwin Creek Watershed to accumulate rainfall, runoff, sediment yield, and land-use data base; (2) operation of field-size watershed to evaluate conservation systems plot results; (3) final evaluation of vegetation-structural combinations for stabilizing stream banks were accepted. Also accepted were NSL plans to increase research and evaluation of (1) channel stability and construction measures, and (2) water quality and ecology of DEC channels. All of the planned research is cooperative with SCS, COE, Waterways Experiment Station, and USGS.

Base funds in NSL cover the continuing research in DEC. Part of the proposed research will be funded in FY-92 with soft money from COE and SCS. FY-93 funding from ARS has not been decided.

Summary

Research on instream flows in ARS is essentially nonexistent although an outstanding data base is available from the ARS experimental watersheds to perform some analyses. Research on stream sedimentation, gully erosion and channel bank stabilization in ARS has reached a historical low point. The multiagency (ARS, SCS, USCOE) Demonstrations Erosion Control project on the Yazoo River in Mississippi is a comprehensive research and demonstration project which provides some visibility for the severity of channel maintenance research. Existing research programs, past accomplishments are summarized and future directions for the research are suggested.