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FEDERAL AGENCY PROCEDURES FOR PROJECT DESIGN FLOOD DETERMINATION

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By

L. Douglas James
Director, Utah Water Research Laboratory
Utah State University
Logan, Utah 84322

H. James Owen
Consulting Engineer
4145 Maybell Way
Palo Alto, California 94306

Chapter I

ISSUES RELATED TO FLOOD DETERMINATION

THE SCALING ISSUE

Levees, channels, storage reservoirs and other structural flood control components may be sized to protect against inundation by floods of various magnitude. The design flood magnitude is commonly designated by a percent chance of being equalled or exceeded in any given year. Design sizes to protect against larger floods (those having a smaller chance of occurrence) achieve greater economic benefits (net reduction in average annual damages) and provide greater safety for the lives and property of the people protected. However, they do so at greater cost (expenditure of public funds) and sometimes greater environmental and social disruption. Project sizing is the process of determining the design level of protection (chance of design flood occurrence) that achieves the best balance between a project too small to achieve acceptable benefits and safety and a project so large as to be an unnecessary burden to the taxpayer and to the natural and social environments.

The criterion of economic efficiency resolves this issue by providing a basis for selection of the design flood that maximizes project net benefits or total project benefits minus total project cost. This principle of economic optimization was incorporated as the national economic development objective by the Water Resources Council in the Principles and Standards[1] for agency application.

The history of federal project design, however, shows that many selected design floods vary from this standard and that the departures

[1] U.S. Water Resources Council. Principles and Standards for Planning of Water and Land Resources.

are biased toward provision of higher levels of protection. This tendency raises several issues. Is the additional financial burden associated with the higher cost of a larger project warranted? Is the additional environmental burden of greater disruption by larger projects warranted? Do the processes used to decide which projects should be built to contain floods larger than those prescribed by economic efficiency--and how much larger those projects should be--treat all owners of flood plain property equitably, or are they more favorable to some interests than to others?

Theoretical Considerations

If there are no legitimate reasons of theory or equity for departing from economic optimality, any such departure in practice must be reckoned undesirable. However, if there are sound reasons for such departures, one must ask if the particular departures being made are soundly grounded in explicit applications of these legitimate reasons. If the answer to that enquiry were clearly yes, or so close to yes that further analysis and corrective effort could not be justified, no further enquiries would be necessary. If the answer were negative, specific departures would need to be identified and analyzed to determine the magnitude of the associated financial cost and environmental disruption. Then, the decision-making processes leading to these unsatisfactory choices would need to be analyzed to determine what factors underlied the disruptive results and what methods would be most productive for influencing the decision-making process to become more in line with the public interest.

The discipline of welfare economics, which developed the theoretical foundation for economic efficiency criteria, has long distinguished a first order or social welfare function that encompasses and adds to the second order or net benefit maximization principle by incorporating values that cannot be expressed in monetary units. The concept of multiple objective planning as developed over the last 15 years, has dealt with this problem by providing a theoretical foundation for identifying and quantifying other important objectives and integrating them with planning for economic efficiency. The Principles and Standards is the instrument most responsible for instigating working application of this planning perspective by federal water agencies. Certainly, the concept of considering objectives other than economic efficiency in selection of design flood levels must be considered legitimate; the first question of this section must be answered in the affirmative.

Since the concept of other objectives is legitimate, the theoretical soundness of departures from economic optimality in design flood selection depends on whether or not the specific objectives being used are legitimate and if optimality with respect to them varies from optimality with respect to economic efficiency. The principal other objective used in flood control project scaling is the personal safety and peace of mind of residents in protected areas. It is an objective that one cannot quarrel with theoretically and which, as presented in detail later in this report, has been required of the federal agencies by congressional mandate. Since a higher level of protection enhances this objective, the legitimacy of protecting human life can justify the selection of a design flood greater than the one that maximizes net benefits. The same rationale can be applied for environmental and other objectives. The analysis then revolves about determining whether or not the specific departures occurring in practice can be considered sound. That determination requires empirical information on how economic benefits, hazards to life, and other objectives are now being handled in project scaling within the federal water agencies. In summary, the principle of departure is theoretically sound, but individual departures can only be judged as to soundness by examining their specifics.

Empirical Context

The ideal context for appraising actual decision-making processes would be the examination of many similar projects planned according to similar criteria within a fairly short period of time. The study could then determine relatively easily whether different planning units and agencies in different sections of the country are making consistent and therefore equitable decisions.

The actual context in which the agencies' decision-making takes place is quite different. Each potential project has unique physical factors and implications for local values which prevent strict analogies with others. The duration of project planning is longer than the life of some design criteria, and rule changes sometimes require shifts in project design midway through the planning process. The long duration of the planning process also requires sometimes that planning agencies simultaneously consider projects planned under different rules. National goals, technological possibilities, planning concepts and directives, and local preferences can all fluctuate greatly over the period required to plan a project. If it were determined that past projects were planned inadequately, the agencies' response could well be that planning is now done differently.

Three major trends in planning for flood damage reduction have affected the decision-making in recent years, namely: (1) an increasing specificity of official intra and interagency guidance on how to plan; (2) a movement toward the quantification and more explicit consideration of non-economic objectives; and (3) a movement from the almost exclusive reliance on structural flood control measures towards the consideration and use of nonstructural measures. These changes have not proceeded at an equal rate with respect to all agencies, all planning offices of a given agency or all personnel at a particular planning office. The institutionalization of agency and interagency guidance has been more effective in some areas than in others. In summary, planning practice is dynamic. Past practices will not necessarily be repeated and empirical observation of what has happened is only a general guide to what is happening now. Past deficiencies therefore cannot be treated as a sure guide to needed change.

The major implication of the dynamic context for this study is that one cannot expect to reach valid conclusions by theoretical derivation or carefully structured empirical experimentation. It is more productive to discuss the issues with practicing engineers and planners to determine their perceptions of public needs and policy requirements, their conceptions of the issues, and the planning principles they intend to apply. This type of information is far more likely than officially documented past planning results to explain present planning decisions on project scaling and suggest what future practices will be. The projected future decision-making practices in selecting levels of protection can then be compared with normative practice to determine whether additional or revised planning guidance would be useful.

Issues in Definition of the Design Flood

A frequent oversight when discussing economic analysis of flood control measures is the failure to recognize the number of design decisions involving scaling issues. The simplistic approach is definition of the design flood in terms of incipient flooding, development of a single curve of net benefits versus design frequency of incipient flooding, and selection of the frequency associated with the maximum point on the curve for use in project design.

However, it is common for a single project to have a variety of design floods. In addition to reducing the frequency of incipient flooding, the designer needs to reduce the damages larger floods would cause. For example, the design flood for a storage reservoir is the flood that can be contained in dedicated flood storage operated in accord with some standard procedure. Other larger design floods are those used to determine the crest stage for the emergency spillway and the flood to be contained without the dam being overtopped. The design flood usually referenced for a channel (a conveyance that keeps the surface of the design flood near or below ground level) or for a levee (design water surface above ground level) is the largest flood that will be entirely contained. Other design floods pertinent to these measures are those used to: (1) size riprap, bridge openings and other appurtenances to channels so that flows exceeding channel capacity do not cause their failure and/or worsen flood problems; and (2) design levees so that any overtopping that does occur will take place at locations minimizing total damage and hazard to life. Still other design floods are used for nonstructural measures in areas partially protected by structural flood control.

Separate economic optimizations to maximize benefits net of costs could be performed to select a frequency for each of these design floods, but any effort to do so is greatly complicated by the facts that: (1) the estimates of flows associated with a hydrologic probability for those rarer events used to design against structural failure are much less precise than those for more ordinary floods; and (2) the social and environmental intangibles become relatively more important than economic factors among the consequences of those rarer floods. For these reasons, It was elected for this study to investigate project scaling only with respect to design floods as defined by the frequency of incipient damages.

A second but related issue is that a design flood defined at a point of incipient damages gives little information on the severity range of larger floods[2]. In one case, a channel designed to carry the 100-year flow may be overtopped by several feet during the 200-year

[2] Davis and Ulm, "Degree of Protection; What are the Major Issues?" Corps of Engineers, Hydrologic Engineering Center, Davis, California, November 29, 1977.

flood, whereas in another case, the overtopping may be only a few inches. Certainly, these two situations have quite different effects when measured with respect to economic objectives and consequently quite different implications with respect to the advisability of going to a larger design flood.

STUDY OBJECTIVES

The first step in determining whether the Corps of Engineers, Soil Conservation Service, Tennessee Valley Authority, and Bureau of Reclamation practices are soundly grounded and equitably executed is to determine what those practices are. This step corresponds to the purpose for this project stated by the Water Resources Council, namely to analyze and describe the procedure for agencies' determination of project design floods.

A second step, determining the basis for existing practices, is needed for determination of whether the reasons are valid and of what might be effective in changing practices that are not. Consequently, the objectives of the analysis of the described Agency procedures were fourfold, namely to:

1. Identify the criteria which are now used to choose a project design flood level other than that which maximizes net economic benefits and explain why each criterion is significant. These criteria are to be arranged to the extent practicable in an order from most significant to least significant in terms of their importance to the agency decisions regarding choice of project design flood protection levels. The judgments of significance are to be based on the collective information from the various agency respondents.

2. Specify, as possible from the available information, ways of expressing the value (monetary or nonmonetary) of the additional benefits attributable to these criteria for recommending a project design flood level other than that level which maximizes net economic benefits.

3. Identify the encountered differences in project characteristics (type of project) and associated costs between the recommended project and the project which maximizes net economic benefits. This enables differences in the type of project (example reservoir vs. enlarged channel) and the incremental cost to be made explicit.

4. Identify policy options which may be implemented to address any problems or inconsistencies arising from identified lack of uniform, acceptable procedures for selection of project design flood level of protection.

STUDY METHODOLOGY

The changing dynamics of the planning process mean that future planning procedures are best predicted by understanding how planners perceive problems and why they choose one alternative over another for dealing with them. The study methodology therefore identified key planners and engineers and sought information from them on what level of protection they have been choosing to provide, what factors have led them to make those choices, and their general philosophy on the issues related to project scaling. Approximately 45 planners and engineers in the Corps of Engineers, 10 in the Soil Conservation Service, 3 in the Tennessee Valley Authority, and 6 in the Bureau of Reclamation were interviewed by telephone in November and December of 1978. The individuals interviewed were selected by the respective agencies at their chief of planning or national level and were chosen to cover planning decision-making at the district, regional, and national levels.

The examination of the policies and procedures in each agency began with review of the agency's legislated objectives because of the influence official missions have on operational policy. At the next step, the specific agency guidance on design flood selection was obtained and reviewed. With this information at hand, district and regional field personnel were contacted and asked five basic questions:[3]

1. Does your planning process routinely determine the level of protection in project design that maximizes net benefits? If this is done in some but not all cases, what factors govern the decision to perform or not perform the analysis?

2. Does your planning unit have a policy dictating a minimum acceptable level of protection for structural flood control? How does that policy vary with measure type (levees, channels, and reservoir storage) and land use (rural vs. urban and residential vs. industrial)?

3. Has your planning unit selected or accepted projects that provide less than the economically optimal level of protection? What factors were used to justify this decision? What example project reports illustrate these points?

[3] The questions were asked orally and their number and precise wording varied as study objectives and methodology became more sharply in focus during the course of the investigation; the substance rather than the exact content of these questions is stated here.

4. Has your planning unit selected or accepted projects that provide greater than the economically optimal and minimum acceptable level of protection? What factors were used to justify this decision? What example project reports illustrate these points?

5. Has your planning unit used or do you have any ideas for quantifying any factors, other than the benefits and costs customarily used in economic analysis, for determining the optimal level of protection from a multiple objective viewpoint?

Answers to the interview questions were then discussed with planners and engineers at the national level. Referenced reports that could be obtained within the available time frame were reviewed. Information obtained in these several ways was then synthesized to establish reasons why decisions and viewpoints vary the way they do, and whether actual planning practice is causing problems of over scaling or inequitable treatment of beneficiaries. The end product was a set of recommendations on what the Water Resources Council might do to define these important issues more precisely and to use the information obtained to improve the planning process.