Geographic Information System Task Force

Report and Recommendations

Bonneville Power Administration

Office of Power and Resources Management

Division of Power Resources Planning

August 1985

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The findings contained in this report represent the views of the individual Task Force members and do not necessarily reflect the policies or positions of their employing agencies.

Geographic Information System Task Force
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Geographic Information System Task Force
Report and Recommendations

I. Executive Summary

The Bonneville Power Administration's (BPA) Office of Power and Resources Management and the Northwest Power Planning Council (Council) are performing generating resource studies which involve a large number of project and geographic data elements. The most prominent of these, the Pacific Northwest Rivers Study (Rivers Study), is now developing information on the significance of river resources in the four Northwest states. These data need to be stored and retrieved systematically. The Rivers Study will determine the relative significance of the region's rivers for resident fish, wildlife, natural features, recreation, cultural features, and institutional constraints. The Council's Hydro Assessment Study will collect similar information for anadromous fish and Indian cultural values. The resource information being collected in both of the above studies will be analyzed in conjunction with the region's Hydro Site Data Base being developed by the U.S. Army Corps of Engineers for the Council and BPA.

A Geographic Information System (GIS) is a computerized system designed to capture, store, process, analyze, and display spatial data. The most significant difference between a GIS and other computerized information systems is the spatial or geographic nature of the data. The data must be geo-referenced, that is, tied to locations on the surface of the earth. The primary source of data input to a GIS is maps.

GIS can be used to analyze any generating resource where the manipulation of large quantities of spatially related data is required. The hydroelectric resource is an excellent example of an application that will use many of the capabilities that a GIS offers. One typical GIS function, network analysis, is used to distinguish the direction of flow and connections in a linear system, such as river basins. This capability will be extremely useful in analyzing potential downstream and upstream effects of hydropower development, as well as the potential for cumulative effects. Many questions can be answered very quickly because of the ability of a GIS to analyze numerous scenarios efficiently. Results of these analyses are typically recorded on maps and tabular displays. This analysis capability will greatly enhance the ability to evaluate regional generating resource development.

Geographic Information System technology has been identified as a tool which would greatly facilitate geographic data management and the analysis of hydropower development opportunities. Other future applications might include BPA's cumulative effects study, the addition of other potential generating

resources to the GIS for spatial evaluation (e.g., cogeneration, geothermal, solar, and wind), and state resource inventory efforts. Many GIS hardware/software packages are in use in the Northwest at various state and Federal agencies. BPA Power Management and Council needs have been generally defined. There appear to be a number of alternatives to satisfy these general needs.

To assist BPA and the Council in determining a reasonable course of action, in May of 1985, BPA invited eight GIS experts to participate on a Task Force. The Task Force members (Appendix 2) were given a Statement of Work (Appendix 1) to guide them through their tasks. The Statement of Work proposed a three phase development: 1) problem definition, 2) testing, and 3) implementation. This approach incorporated two decision points to ensure that the application of any GIS technology within BPA's Office of Power and Resources Management for the Rivers Study proceeded in a structured manner, at a measured pace. The Task Force has evaluated BPA's analysis needs related to the Rivers Study and has recommended a plan for proceeding to the testing and implementation phases of a Rivers Study GIS. In summary, the Task Force recommends the following.

A. In the short term, that BPA:

1. acquire the Environmental Protection Agency's (EPA) hydrographic digital data base at 1:250,000 scale;

2. develop cross-reference files to link EPA river reach numbers and stream segments to individual state schemes;

3. contract out the building of digital files; and

4. use GIS capability to display and analyze Rivers Study results in 1986.

B. In the long-term, BPA should examine overall agency needs for and uses of GIS technology.

BPA has recently acquired a fully operational Geographic Information System (Environmental Analysis Branch, Division of Land Resources, Office of Engineering and Construction). This system is currently being used for environmental analysis and transmission line siting studies. Although this system was acquired for purposes other than the Rivers Study, there is the potential it could be adapted for use on the Rivers Study should this be deemed appropriate to meet overall functional and organizational needs.

II. Introduction

The principal objective of the Task Force was to assist BPA and the Council to define the most effective means of analyzing the information being generated by BPA's Rivers Study and the Council's anadromous fish and Indian cultural assessments. This application was the focus of the Task Force activities because of the Rivers Study's near-term needs. Although the Task Force was asked to concentrate on this near-term need, they were requested to do so while considering other resource analysis needs of BPA and the Council, such as generating resource supply forecasting.

The group was also asked to identify existing regional systems with a capability to meet near-term needs. The Task Force considered the following:

- data analysis needs;
- data storage requirements;
- data interfacing needs (data transfer among systems);
- data input requirements;
- data output requirements; and
- existing systems which may be used.

After preliminary discussions, the Task Force decided to focus on two activities: (1) the definition of data analysis needs (Statement of Work, Task 1), and (2) the recommendation of best data collection techniques (Statement of Work, Task 7b). The Task Force concluded that GIS technology is sufficiently advanced that problems of data interfacing, storage, input, and output are minor compared to the need to adequately define data analysis needs and to design a process and specific techniques that will satisfy those needs. In light of the above, the Task Force felt it most appropriate to concentrate on the steps necessary to ensure that Rivers Study data can be spatially analyzed and results produced in early 1986. This effort was conducted in the context of overall planning needs. It was felt that focusing on the Rivers Study application would be the best use of the Task Force expertise and an appropriate first step in developing a foundation on which to examine other GIS applications.

The Task Force also suggested long-term objectives for both BPA and the Council to facilitate the exchange of digital geographic information throughout the Northwest, thus aiding BPA, Council, state, Indian tribal, and Federal planning processes.

This report documents the group's findings and recommendations.

III. Pacific Northwest Rivers Study (Rivers Study)

The Rivers Study began in September 1984, when BPA contracted with the states of Idaho, Montana, Oregon, and Washington, the U.S.D.A. Forest Service, the Bureau of Land Management, the U.S. Fish and Wildlife Service, and the National Park Service to undertake an assessment of the natural, cultural, and recreational resource values of the region's rivers. Many of the region's Indian tribes subsequently became involved in the study.

The objective of the Rivers Study is to provide information to BPA and the Council to assist in estimating the remaining supply of developable hydropower in the region. The Rivers Study will not result in rivers being ranked in numerical order. It will, however, result in stream reaches being clustered into groups according to the relative significance of their resources.

This information will form a consistent and verifiable river resource data base which will be able to identify resource considerations which might have a bearing on hydropower development. Study results will be used by BPA and the Council to forecast the amount of developable hydropower. The Council will also use the results to determine protected areas (those streams where future hydro development should be prohibited based on their substantial resource values) and assist in ranking stream reaches based on their developability from the environmental perspective.

A. Statement of Problem

The Rivers Study is collecting large quantities of river resource information which will need to be analyzed in conjunction with other Council generated anadromous fish, Indian cultural, and hydro site information. Prior to analysis, study results will need to be summarized and presented for participant and public review. The data collected will consist of geographically related sets of point, line, and polygon (area) attributes. Data from the Rivers Study will be compiled by resource experts in the four Northwest states on 1:100,000-scale maps and associated data forms. Draft maps and data forms are expected to be available for all resource categories in all states by November 30, 1985. The assessment method separates each resource into a different study, and many category results should be available prior to November.

The Task Force recognizes the usefulness of a GIS to handle the data storage and analysis requirements presented above. The value of the river resource data collected will be greatly enhanced by the analytical capability of a GIS. It also recognizes that the objective of facilitating all resource analysis needs through the exchange of digital information requires that both short-term and long-term needs be considered.

Therefore, GIS data base development is envisioned as a process of discrete steps towards the long-term goal. The initial steps of that process are:

1. Produce 1:500,000-scale summary maps for public review by February 1986.
2. Develop data analysis procedures by May 1986.
3. Compile a 1:100,000-scale digital regional resource data base kept current and available to all for planning purposes by 1990.
4. Enhance the data base to 1:24,000 scale in the future.

B. Product Requirements

Both Rivers Study participants and the general public will want to review study results. Study products will include sets of 1:100,000-scale maps and supporting tabular data forms for each of six river resource values in each of the four Northwest states. This will produce about 1,650 maps. The same geographic area can be covered on twenty-four (4 states, 6 values each) 1:500,000-scale maps for review and comment. These 1:500,000 summary maps and associated tabular data are expected by February 1986.

After public review, Rivers Study data must be combined with Council anadromous fish and Indian cultural data and hydro site information. This analysis of tabular and spatial data will occur in May of 1986. Digital spatial analysis is a desire of both BPA and the Council.

Although it is hoped that the Rivers Study data base will be useful for other purposes in the coming years, it must be remembered that the information submitted by resource experts will be a comparative assessment of the significance of individual resources. Future users of the data should be made aware of the sources and decide whether it meets their needs. The actual methods being used in the Rivers Study and the names of principal contacts are contained in the Pacific Northwest Rivers Study Assessment Guidelines available for each of the states involved in the study from BPA or the individual states.

Finally, a long-term goal (5 to 10 years) of all study participants is a consistent digital data base of regional resource information at 1:100,000 scale or larger. This source data file would encourage GIS assisted planning and the sharing of resource data for a number of purposes.

IV. Options for Rivers Study Data Presentation and Analysis

The Task Force considered three options in terms of time, estimated cost, and long-term benefits. The options considered were:

A. manual process of drafting 1:500,000-scale summary maps;
B. manual/automatic hybrid (GIS assisted) using existing U.S. Environmental Protection Agency (EPA) 1:250,000-scale digitized hydrographic files and manually building cross-reference files between EPA river reach numbers and individual state numbering schemes; or
C. use full GIS capabilities to build the cross-reference files (EPA to state) automatically before linking the Rivers Study attributes to the system, using the EPA river reach data as the primary data source.

This chapter will detail each of the three options. Chapter V then critiques each option. Each of the options outlined above include some common elements:

- gather field data (data forms and 1:100,000-scale maps);
- define public involvement requirements;
- determine final report and graphic requirements;
- create report and graphics;
- arrange for publication.

A. Manual Processing - This option produces manually prepared summary maps for public review and comment. Products would be twenty-four 1:500,000 map sheets (one sheet per resource category per state) with a report. This option would require 1,065 person days of effort.

1. By November 30, 1985, collect draft Rivers Study results and 1:500,000-scale mylar separates for each state (6 copies of each).

2. Manually draft source data (1:100,000) onto 1:500,000-scale maps (requires cartographers). 275 sheets in region times 6 categories = 1,650 sheets, @ 4 hours per sheet = 825 days.

3. Office edit field tabular data - about 25,000 reaches regionwide at 250 records per day = 100 days.

4. Resolve data problems = 60 days.

5. Keypunch data into a data base management system (DBMS) and edit check (optional for enhanced review). At 500 records per day = 50 days.

6. Generate reports = 30 days.

B. GIS Assisted - This option includes using existing EPA digitized hydrography files and manually preparing cross-reference tables linking EPA river reach numbers to individual state numbering systems. Products would include computer-generated maps and supporting tabular information. This option would require up to 625 person days of effort.

Prior to November 30:

1. Examine existing EPA digital hydrographic files at 1:250,000 scale. Test of 2-3 sheets = 5 days.

2. Test ability to make 1:500,000 overlays = 5 - 30 days.

3. Identify reach network structure = 10 days.

4. Automate all 1:250,000 sheets (67) for region. Run check plots. 105 days (less time if starting from cleaner maps).

Concurrently with numbers 1-4 above:

5. Assemble state river coding data and maps by state = 20 days.

6. Manually build equivalence tables linking state numbering systems to EPA river reach at the level of detail of EPA's system (5,000 to 20,000 EPA reaches in region).
   a. Regional coordination to build logic = 20 days.
   b. By state, build tabular lists using rigid set of rules. Assuming one coding system per state = 25 - 100 days.
   c. Keypunch and verify = 10 - 40 days.
   d. Link spatial files to newly created tabular files. Edit check = 15 days.

After November 30:

7. Office edit field tabular data = 100 days.

8. Resolve data problems = 60 days.

9. Keypunch data and edit check = 50 days.

10. Link attribute files to spatial files and edit check = 30 days.

11. Kick out extra and bad data. At 1% error rate = 250 errors. Public will help error check through review of mapped output.

12. Generate map separates and publish = 10 - 30 days.

13. Generate report = 5 - 10 days.

C. Functional GIS - This option includes using existing EPA digitized hydrography files and assigning end-points of state reaches and reach numbers as new attributes using GIS technology. Products include generic map and tabular data files. This option would require up to 550 person days of effort.

1. Build EPA files (# 1 - 4 of part B above). At 2 per day = 100 - 150 days.

Concurrently with # 1 above:

2. Assemble river reach number files and maps by state. Draft state reaches and reach numbers onto EPA 1:250,000-scale mylars = 20 days.

Then:

3. Encode and build spatial link file using GIS technology = 25 - 100 days.

4. Office edit field tabular data = 100 days.

5. Resolve data problems = 60 days.

6. Keypunch data and edit check = 50 days.

7. Link attribute files to spatial files and edit check = 30 days.

8. Generate map separates and publish = 10 - 30 days.

9. Generate report = 5 - 10 days.

V. Comparison of Options

	Alternative	Days of Effort
A.	Manual Processing	1065
B.	GIS Assisted	470 - 625
C.	Functional GIS	400 - 550

Following is a listing of the advantages and disadvantages of each option.

A. Manual Processing

Advantages:

- no spatial analysis technology required
- very little computer analyst time required
- do not have to build cross-reference tables of reach numbers

Disadvantages:

- may not be possible given Rivers Study schedule
- delays start until November 30, when data is available
- difficult to correlate tabular and spatial data for quality control
- no cross-reference tables developed
- potentially large error in time estimates
- fast start-up required
- lower long-term product value
- ignores long-term GIS implications
- manpower intensive
- high overhead costs for supervision
- data available only at 1:500,000 scale
- limited data transfer capability

B. GIS Assisted

Advantages:

- build cross-reference tables
- states can do larger share of work
- data available for others
- reduced time due to use of GIS and automated processing
- addresses long-term objectives
- provides stable GIS data base - tabular and graphic
- may be lowest cost option: lower computer cost than Option C, lower labor cost than Option A
- full range of GIS analytical capabilities available
- provides broad access to data: hard copy, computer tabular and graphic files

- can begin work today
- manual process still a fall-back option
- objective is attainable assuming resources available
- tabular data can be compiled on personal computers
- tasks can be completed concurrently

Disadvantages:

- more steps in process than Option C - more chance for errors
- may have problems with graphic registration
- will be generalizing state data; i.e., cross-reference tables will be accurate only to nearest EPA reach
- could be computer intensive

C. Functional GIS

Advantages:

- lowest total person days required
- most accurate graphics
- fewest steps in process
- build cross-reference tables
- reduced time due to use of GIS and automated processing
- provides stable GIS data base - tabular and graphic
- manual process still a fall-back option
- supports long-term objectives "best" of all options
- data available for others
- prepares correct, clean state river reach maps at 1:250,000 (not generalized as in Option B)
- can start today
- objective is attainable assuming resources available
- could be accomplished under one contract
- can use other data bases tied to EPA river reach or state river reach systems
- tasks can be completed concurrently
- full range of GIS analytical capabilities available
- most progressive approach

Disadvantages:

- most computer intensive option - cost and availability
- may have problems with graphic registration

VI. Task Force Findings and Recommendations

The Task Force has come to the following conclusions.

1. GIS capability (Option C) is needed because of the mixture of point, linear, and polygon data that will exist among data sets.

2. Short Term:

   - Data should be collected at 1:100,000 scale to ensure accuracy and future usability.

   - The EPA digital data base at 1:250,000 scale should be used for presentation and policy review.

   - Cross-reference files are needed to link EPA river reach numbers and individual state numbering schemes.

   - Considering the presentation needs of the Rivers Study, manually prepared maps should be anticipated as a fall-back position only.

   - Tabular data and maps should be tied by a specific number reference. This number can be the river reach number or as simple as a sequential series for each map. This will save reconstructing relationships later, minimize the transition effort to GIS, aid in initial presentations, and minimize errors.

3. Long Term:

   - Tabular data/map reference will aid in the eventual installation on a GIS.

   - Data structure and output requirements drive the system selection.

   - BPA should focus on its specific definable needs.

   - Compatibility cannot be assured between all hardware systems in a field that is evolving as quickly as GIS. Compatibility is enhanced by structuring files in a common format that can be converted by potential users.

   - BPA should examine its total agency GIS needs comprehensively.

A. Selected Option for Rivers Study

The Task Force recommends Option C above, Functional GIS, as the best option to pursue. The method chosen to compile the digital data can be determined by a contractor responding to specific guidelines of a Request for Proposals (RFP). There does not appear to be enough GIS capacity established within the states or Federal agencies to attempt cooperative digitizing. If the EPA data

turns out to be unusable, the base maps could be digitized from scratch or a manual approach adopted in December 1985, although either of these options would extend project completion.

The Task Force supports the functional GIS alternative for its accuracy, simplicity of design, and minimum use of manpower. More important may well be its benefits in terms of both review and presentation of Rivers Study results in the short-term (February 1986), its use in analyzing data from the Rivers Study and the Council's Hydro Assessment Study (May 1986), and its eventual benefit in the 5 to 10 year development of consistent, accessible digital data bases for geographically-related information. This final point will lead to the identification of other interested parties to share in the cost of developing the above system.

The Task Force would like to continue critiquing the public review product, as well as preparations for the analysis phase of the project in 1986.

B. Work Plan Outline (for Option C)

a. Begin framing RFP for contract digitizing, including list of prospective vendors.

b. Examine EPA digital files and procure all files.

c. Obtain maps and tabular lists of each state's river reach coding system. Review for completeness and ease of transfer to EPA 1:250,000 series.

d. Identify resources, preferably within each state, to code state reaches onto EPA 1:250,000-scale mylar overlays.

e. Ensure that all states are coding forms and 1:100,000-scale maps with river reach numbers and that there is a single numbering scheme within each state for the study. Develop codes for and map any aberrant reaches.

f. Generate and obtain hard copy of both state numbered overlays and EPA 1:250,000-scale maps.

g. Begin drafting contract specifications: generic products (i.e., standard format); integrated coverage; original EPA coordinates and data sets registered to 1:500,000 scales; enhancement of digital data (boundaries, cities, etc).

h. Develop detailed work plan, including timelines, effort, budget, potential cost-sharing parties.

i. Determine who will review responses to RFP.

Following steps b and d:

j. Get hard copy maps (EPA and state coded versions) to staff who will mark EPA 1:250,000-scale mylars with state river reach end-points and code numbers.

Following steps b, c, d, e, g, and h:

k. Complete RFP.

l. Distribute RFP.

m. Review responses to RFP.

n. Award contract.

To meet the schedule laid out above, final graphics (digitized 1:250,000 base maps) should be scheduled for November 30, 1985. The contractor's report (including specifications, methods used, users manual, etc.) with completed graphics linked to cross-referenced tabular attribute files containing Rivers Study data should be requested one month prior to the first public review.

C. Long-Term Considerations

The use of geographic data is common to many divisions throughout BPA. The agency now has the opportunity to establish an efficient procedure and organization to coordinate use of this information. From a base of many years of combined GIS experience, the Task Force offers the following suggestions so that BPA might avoid some of the common problems faced while developing GIS capability.

1. Form an inter-office GIS coordination group within BPA. This group would not be a GIS service group for completing projects; rather, it would provide GIS applications coordination among GIS users within BPA, the Council, and elsewhere.

2. The GIS group should consist of a representative from each BPA office, the Council, and a chairperson whose job description includes overall BPA GIS coordination. At least one member of the group should be a GIS technical expert and/or consultant. This group should be supported in concept, funding, and manpower.

3. The major responsibility of the GIS group should be GIS applications coordination, not hardware procurement and maintenance. The GIS group would assist the divisions in the development of specific applications.

4. The first task of the group should be a review of BPA, Council, and related agency needs. This would form the basis for further recommendations to management.

By following these suggestions, the Task Force feels that BPA will be ready for the challenges in geographic information management that are becoming increasingly central to agency decision-making. As more applications develop, there will be an increasing need for coordination of geographic information and technology. The GIS applicatons coordination group will meet this need, and minimize the duplication of effort involved with GIS development.

Appendix 1

Statement Of Work

The Bonneville Power Administration's (BPA) Office of Power and Resources Management and the Northwest Power Planning Council (Council) are engaged in a number of generating resource studies which involve a large number of project and geographic data elements. The most prominent of these, the Pacific Northwest Rivers Study, is now developing resource information that needs to be stored and retrieved in a systematic way. The Rivers Study will determine the relative significance of the region's rivers for resident fish, wildlife, natural features, recreation, cultural resources, and institutional constraints. The Council's Hydro Assessment Study will collect similar information for anadromous fish and Indian cultural values. The resource information being collected in both of the above studies will need to be analyzed in conjunction with the Region's Hydro Site Data Base being developed by the U.S. Army Corps of Engineers for the Council and BPA.

Geographic Information System (GIS) software has been identified as a tool which would greatly facilitate data management and analysis of hydro development opportunities. Other future applications might include the Council's cumulative effects study, the addition of other potential generating resources to the GIS (e.g., cogeneration, geothermal, solar, and wind), and state resource inventory efforts. A large number of GIS hardware/software packages are in use in the Northwest at various state and Federal agencies. BPA Power Management/Council needs have only been generally defined. There appear to be a number of alternatives to satisfy these general needs. Because of these multiple alternatives and because the needs have not been specifically defined, it is not clear what alternative has the best chance for success.

Proposed Solution

Fund a 30-60 day multi-agency/state task force ($10-$15K) to determine: (1) BPA Power Management/Council analysis needs related to BPA's Rivers Study and the Council's anadromous fish and Indian cultural assessments, and (2) identify existing regional systems and capability to meet those needs. The results of this group's efforts will form the basis for a decision on how to best approach satisfying BPA Power Management/Council, GIS needs. Work would be performed in three phases: 1) problem definition, 2) testing, and 3) implementation. BPA will conduct Phase 2 to be completed by November 1985. Phase 3 will be completed during 1986.

The proposed task force would consist of a total of 5-8 individuals from BPA (E&C, PM), USGS, one (or more) states, the BIA, and the Council. Detailed Statements of Work consistent with the following tasks would be executed with selected agency experts.

Task Force Duties

1. Define data analysis needs
    a. what should the system do for us (analysis)?
    b. is spatial analysis (GIS) needed?
    c. will analysis requirements dictate storage technique?

2. Define data storage requirements
    a. disk, tape space needed (rough estimates)
    b. data storage techniques
        1. river list methods(s) to adopt
        2. other special software implications
        3. relate to analysis

3. Define data interfacing needs
    a. input
        1. need to accept computer-compatible data from other sources?
        2. base data from USGS? other options?
        3. assignment of attributes to USGS digital data
            - time
            - money
            - advantages/disadvantages
        4. variable input scales
        5. regional hydro site data base
    b. output
        1. need to talk with other systems? which one(s)?
        2. data transfer via tape? formats?

4. Define data input requirements
    a. types of data (digitizer, keyboard, tape)
    b. volume of data (% of each type)
    c. relate "a" and "b" to time, money, project schedule, budget
    d. personnel requirements
    e. scale of data

5. Define output requirements
    a. media types
        1. tape (data)
        2. printer (reports)
        3. plotter (maps)
        4. CRT hardcopy (maps, reports)
    b. scale - variable, limits
    c. format - variable
    d. volume of output
        1. time, schedule
        2. money

6. Identify existing system(s) which may be used (should it be within region or not?)

    a. identify system(s) which may meet the needs defined in tasks 1-6
    b. determine system(s) availability
        1. period of time needed (amount of time the system could be dedicated to this application)
        2. costs of use (computer time, if appropriate, etc.)
        3. operator support
        4. software support
        5. institutional accessibility

7. Report results to BPA in a consolidated draft report due July 26, 1985.

    a. recommend "best" system(s) for Phase II (testing)
    b. recommend "best" techniques
    c. prepare a short report on systems analyzed and reasons for inclusion/exclusion

Note: System(s) recommended in task 7 must not lack any basic needs as defined in tasks 1-6 or must be able to overcome any deficiencies within reason. It is highly likely that the system ultimately used for the project will be one recommended for testing in task 7. Therefore, foreseeable problems with recommended system(s) should be identified early on.

Appendix 2

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