AN ANALYSIS OF THE NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 AND OF ENVIRONMENTAL IMPACT MATRICES

By

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CHAPTER I

INTRODUCTION

Ever since time began, there has been pollution of some form or another. Since man and animal have been roaming the world, the severity of the pollution problems has increased through the years. Early man slowly moved away from his inherent patterns and became dependent on learned behavior patterns for survival. The small scattered population of the world had only personal needs to care for (food, clothing, shelter, and body functions). The amount of pollution and waste could have been fairly well handled by the ecological systems.

The invention of agriculture caused some change in man's relationship with his environment. This change was kept on a small scale from 8000 B.C. to the technological revolution of about 1780 A.D. These changes were held in check by earlier attitudes and beliefs, especially religious beliefs that were handed down through the years. Man generally regarded nature and mother earth as one of the gods who ruled the world and the people on it. Man looked at agriculture as mystical powers.

Another change in attitude occurred during a sixth century revolution. The concept of one god began to appear. This god, they said, had set man outside of nature and had given him power over living things, to master nature and creatures for his own use. Man began to feel master of nature. The seed was planted for modern technology and science. The Greeks likewise in this time period were undergoing a change. They were

looking at the chaos of human experience and trying to analyze it under the growing influence of two-valued logic or the conflict of opposites. The logic of Aristotle developed from this. Changes were also occurring in China, India, and Persia at this time. Man's idea of nature controlling him had changed to him controlling nature.

Gradually the dualistic philosophy became more and more prominent. Two groups, although extremes, agreed in the basic dualism (dualistic spiritual values on the right and supporters of secular materialistic practices on the left). Both saw God outside the universe; both saw man outside and opposed to nature; both agreed that nature should be plundered by man. With this agreement the West after 1500 set out to plunder the world with the sword in one hand and the cross in the other. Those who stayed behind continued to provide the material equipment and justification for those who went around the world. One idea from this was sacrifice today so can have a better tomorrow.

The 1780s saw the development of the technology to start devastating the environment. Capitalism began to develop. Firms, corporations, guilds, etc. began to exploit the environment. It led to destruction of social grouping and of personal and social responsibilities. In the 1830s, the slums of London had human excrement eight inches deep because no social group would accept responsibility to clean it. This also led to the Industrial Revolution. The application of energy from non-living sources to the productive process. The external combustion (steam) engine led to depletion of resources. People started moving more and more toward the resources.

This migration resulted in people moving to the Americas. Labor was scarce and land was plentiful and cheap in America. Overseas it was

the opposite. The American agriculture output was measured in terms of output per man-hour while Europe was output per acre of land. Also those coming to the United States were socially alienated and psychologically restless. This migration caused the people to keep moving westward as crowding, unrest and pollution increased. In 1832, explorer-painter George Catlin, while wandering through the South Dakota wilderness, wondered about the possible extinction of the buffalo and Indians. He wrote in his journal that "Many are the rudenesses and wilds in nature's work which are destined to fall before the deadly axe and desolating hand of cultivating man." In 1864, Congress gave ten acres of Yosemite Valley to the State of California for a state park. While some people recognized that nature was being destroyed and Congress was making feeble attempts to protect it, the destruction continued. Although a few areas were set aside by state and federal laws, they were mainly for preservation of an unusual area. Around 1900, the migration was slowed as land started becoming scarcer. However, the pollution and destruction continued chiefly because people ignored it. The depression and the two world wars also affected the environment as everyone became interested in the national security and their own welfare (1).

In the mid-1960s, the environment and pollution problems started to be brought to the forefront. However, some people thought it might die out after a few years. Meanwhile Congress was looking at the problem and some members were upset. To ensure that federal agencies took into account the environment, Congress studied, amended and passed Public Law 91-190, The National Environmental Policy Act of 1969. The bill was signed by the President on 1 January, 1970. One major section

of the Act was concerning environmental impact statements with which this thesis is concerned.

The NEPA has forced federal agencies to look more closely at their actions on the environment. There are five basic points the agencies must look at:

1. The environmental impact of the proposed action.

2. Any adverse environmental effects which cannot be avoided should the proposal be implemented.

3. Alternatives to the proposed action.

4. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.

5. Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

The costs and time involved have increased considerably within some agencies. One of the biggest problems has been that this is a new law and the agencies have had to interpret it and translate it into action. Several state and federal agencies have developed a matrix-type approach. This manuscript will examine these and show the good and bad points of each. An attempt is made to combine all of the good points into one new matrix.

CHAPTER II

LITERATURE SURVEY

Legislative History

Man has more or less taken his environment for granted through the ages. Congress has passed many bills about the environment, most of which were to preserve some area or to remedy pollution in some small aspect. Several of the bills instructed federal agencies to consider certain factors in the economics of the proposed project. The National Environmental Policy Act (NEPA) was the first bill which really required a complete analysis of the environment.

One of the first bills was in 1864 when Congress gave ten acres of Yosemite Valley to the State of California. This was to preserve the area, just like the Yellowstone Act of 1872 was to preserve the geysers. In 1899, Mt. Rainier National Park was established. These acts were to preserve the area and were opposed by hunters, miners, loggers and grazing interests. In 1916, the National Park Service Act was passed which resulted in combining those in existence and those to come into one agency "to conserve the scenery and the natural and historic objects and wildlife. . . ."

In 1897 some land was set aside for National Lands and National Forests to be established. More recent legislation, Public Law 86-517 of June 12, 1960, was related to good management of the National Forests.

This law was "to authorize and direct that the national forests be managed under principles of multiple use and to produce a sustained yield of products and services, and for other purposes."

No mention of water was made in the original Constitution of the United States. The first time was in 1824 when the State of New York built the Erie Canal. The Swamp Act was passed in 1849-50 which provided for the sale of flooded lands along rivers of islands by the states.

In 1902, one of the more important acts was passed; this was the Reclamation Act. The basic principle was that the United States build irrigation works from the proceeds of public land sales in the 16 arid western states (Texas was later included). It was primarily designed to encourage settlement of the public domain. The Bureau of Reclamation was established and was authorized to investigate water diversion proposals, etc., primarily on a scale larger than a city or a state could handle. Amendments were passed in 1926 to ensure that land was to be low priced and small amounts irrigated.

On June 10, 1920, the Federal Power Act was signed, giving petitioners a legal right to protect their special interests and allowing the Federal Power Commission to recapture licensed projects.

The Antiquities Act of 1906 provided the Department of Interior with protective and research powers in respect to archeological resources. Places of historic interest were first given recognition and protection by the Historic Sites Act of 1935 which established a "national policy to preserve for public use historic sites, buildings, and objects of national significance for the inspiration and benefit of the people of the United States." In 1966 the Historic Preservation Act

expanded the preservation concept to include places of state and local, as well as national significance. This Act authorized the National Register of Historic Landmarks and required federal agencies to report the effect of projects on sites listed on the National Register. The Reservoir Salvage Act of 1960 was passed providing specifically for the preservation of historic and archeological data and sites that might otherwise be lost through dam construction, highway or pipeline construction, and other similar projects.

The first Flood Control Act was passed in 1928 which authorized increased studies in flood control prevention. National flood protection efforts began in 1933 with the massive public works projects. The Flood Control Act of 1936 had two major points. First, flood control on navigable water and tributaries is a federal responsibility. Secondly, it "requires that benefits must exceed costs, 'to whomsoever they may accrue,' for projects to be authorized." This molded the development of B/C analysis and legalized economic justification. This has led the Corps of Engineers to be so involved in the public works area.

In 1930, the Soil Conservation Service Act was passed. This was the only agency that was assigned specific responsibilities; however, they could not make their own rules and regulations as the other agencies had.

Each year flood control acts are passed to authorize planning and/or construction of projects around the country. The 1944 Flood Control Act was of importance because it authorized the Secretary of the Army, who builds and controls flood control and navigation dams, to make contracts with municipalities, private concerns, or individuals for domestic and industrial uses of surplus water available at any reservoir under his

control. This established the fact that along with the courts the federal government had control over the impounded waters.

The Federal Water Quality Law of 1956 was the most significant influence in pollution enforcement. The federal government could take over enforcement if local officials did a poor job. This also allowed for 30 percent federal funding of municipal treatment plants not to exceed $250,000.

Wilderness and open spaces have been the emphasis of recent legislation. The 1964 Wilderness Act established a National Wildlife Preservation System which would include lands that were still in a wild natural state and preserve them permanently against commercial use. The Land and Water Conservation Fund Act of 1965 established federal aid to state and local interests to encourage the establishment of parks and open spaces. The Wild and Scenic Rivers Act, passed in 1968, provides that certain rivers in the country which possess "outstanding remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values," shall be preserved and in a free-flowing condition, "for the benefit and enjoyment of present and future generations."

The Water Quality Act of 1965, by amending the 1948 Federal Water Pollution Control Act, provided that the states establish water quality standards for interstate waters within the state, with a provision if they did not do this, the Secretary of the Interior would do it for them.

While the aforementioned acts are important, most water resources developments have been governed by one non-legislative and two legislative actions. The first is the "Green Book" which presents the conclusions and recommendations of a subcommittee of the Federal Interagency

River Basin Committee in 1946 (2). The committee's purpose was to formulate mutually acceptable principles and procedures to determine benefits and costs for water resources projects. The benefits should exceed the costs at a maximum. Primary and secondary costs along with justified primary and secondary benefits could be attributed to the project. A rate of interest was suggested to use in comparing benefits and costs. The time period considered was to be the economic life rather than the physical life of the project.

The non-legislative action was the Bureau of the Budget's Circular A-47 issued December 31, 1952 (3). Procedures and standards were set forth to be used by the Executive branch in reviewing water resources project reports and budget estimates. It was aimed at developing more uniform agency policies and standards. It was also hoped that priorities for projects yielding the greatest value to the nation and effective resource development at a minimum necessary cost could be established. The Circular listed what project benefits and costs could be included in the project report. The life of the project was limited to 50 years with the discount rate being the rate of interest on interest-bearing marketable securities of the United States.

Agencies failed to completely follow these two guidelines, and hence, in 1962, Senate Document 97 was implemented (4). Document 97 replaced both the "Green Book" and Circular A-47. This document attempted to get both the Legislative and Executive branches together on evaluating procedures. Planning on a national, regional, and local level must be conducted along with coordination between federal agencies. Included in the document were discussions of project scale, definitions

of benefits and costs, period of analysis, discount rates, and price levels. A supplement to the document included recreation as a major benefit to be considered.

Document 97 has not been as complete as it was hoped. As a result of this void, Congress has passed 13 acts trying to strengthen Document 97. These acts include: Appalachian Regional Development Act (1965), Federal Water Project Recreation Act (1965), Water Resources Planning Act (1965), Public Works and Economic Development Act (1965), Water Quality Act (1965), Clean Water Restoration Act (1966), Department of Transportation Act (1966), Wild and Scenic Rivers Act (1968), National Flood Insurance Act (1968), Estuary Protection Act (1968), National Environmental Policy Act (1969), Environmental Quality Improvement Act (1970), and Flood Control Act (1970). A new directive, known as the "Blue Book," has been prepared which includes these 13 acts plus Document 97, but lacks formal approval. It has three main objectives: (1) national income objective, (2) regional development objective, (3) environmental objective.

In 1970, the National Environmental Policy Act (NEPA) was signed into law (5). This had the most sweeping effect yet attempted. This act went beyond the water field and included analysis of the total environment. Three key policy statements were included:

> To encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation.

This has resulted in a switch from an engineering team to an interdisciplinary team.

Literature

The National Environmental Policy Act was the result of several years of Congressional studies and many years of federal agencies not considering all environmental factors. All federal agencies have filed a copy of their guidelines with the Council of Environmental Quality, which subsequently have been published in the Federal Register. Several public and private agencies have developed "environmental matrices" as a result of the legislation.

Depending on which side of the problem a person is, NEPA is either a blessing to help protect the environment or a tool to hinder the already slow Federal bureaucracy even more.

The environmentalists, ecologists, preservationists, conservationists--whatever they are called--feel they have a weapon in NEPA to get federal agencies to respond to the people (6, 7, 8). They believe the federal agencies should redirect themselves to other areas (9). The plans and formulations of how projects are being determined are being aired and causing some problems for some agencies (10, 11). Some individuals feel that the environmental impact studies are not at the front of the planning process so as to affect the project (10, 12, 13). Certain organizations have filed suits in Federal Courts because the intent of the law is not being carried out (6, 8, 12, 13, 14). Zeldin (14) feels that an environmental court is needed to stop some projects, and some projects have been stopped (10, 11, 14). The courts have ruled that agencies cannot pass off others' decisions and statements as their own (11, 12). Some impact statements have not been used once they have been written (10). The environmentalists feel that some of the

first impact statements are merely justifications of authorized projects (6, 10, 14, 15). Some impact statements are not scholarly (6, 10, 15). The initial statement for the Trans-Alaska Pipeline had Federal agencies arguing with each other (6).

Persons in the government and outside of it know NEPA is costing a lot of time and money (7, 10, 11, 16, 17). Warren (16) states that environmental impact statements have cost the Corps of Engineers $825 million per year for 87 projects worth $5.3 billion that have been delayed. Warren also states that during the 1970s an additional $1.5 billion will be needed for power plant planning (16). Alaska highway costs have doubled (14). The preparation of impact statements is costing about $65 million a year (13).

Certain people feel that some production must continue in harmony with the environment (16, 17, 18, 19). Others feel that the nation needs to be saved from the preservationists who claim to be helping the country (18, 20). Many inexperienced people in the field are also causing problems. Some suits have stopped projects that were actually aimed at helping to clean up the environment, because they needed an environmental impact statement (7, 8, 11, 21). The federal government moved into the environmental protection field because the states have not been willing to carry their share, especially since 1965 when a growing distrust between them started (19, 21, 22).

Because environmentalists have stopped so many projects and the federal agencies are spending so much time and money, certain members of Congress have introduced new bills to change and weaken NEPA (7, 8, 14). Plans are also being formulated to exempt certain agencies and activities from NEPA (7, 8, 10, 11, 14). Some people are worried because

several states have already passed their own "NEPA's" (8). One co-author of the original legislation feels that if NEPA was on the floor today, Section 102 (which requires the environmental impact statement) would not pass (14).

CHAPTER III

REVIEW OF ENVIRONMENTAL ANALYSIS TECHNIQUES

National Environmental Policy Act of 1969

The purposes of the National Environmental Policy Act are to establish a national policy on the environment and to establish a Council on Environmental Quality (CEQ). The Act sets forth that man and nature can exist in harmony and yet fulfill the requirements for present and future generations. While the Federal government is given overall responsibility to see that it is done, each individual must also contribute to helping to preserve and enhance the environment.

Section 102 of the Act is what has been at the center of the controversy. Subsection (a) under 102.2 requires that a systematic interdisciplinary approach or method be used. In (b), procedures must be developed to include environmental as well as economic and technical considerations in the decision process. This, along with (a), has led to the development of environmental matrices. The environmental impact statements and what is to be included in them is set forth in (c). The agencies are also required to interact and consult with each other. The remainder of the section deals with describing alternatives with conflicting uses of resources, international cooperation, providing information to states and individuals, using ecological information, and assisting the CEQ.

Section 103 requires the agencies to review their authority, regulations and policies to see if there are any deficiencies or inconsistencies that would prevent full compliance. These agencies are also to report to the President any measures taken to fully comply with the intent of the Act.

The last two sections state that the Act does not affect any other acts governing the agencies.

Title ii of the Act deals with the establishment and duties of the Council on Environmental Quality. An annual report must be sent to Congress by the President on the conditions and policies related to the environment. The CEQ is to have three members which are to have expertise in the environmental field.

The duties of the Council as set forth in Section 204 are to: advise and assist the President in preparation of the report; gather information on the trend of the environment; analyze the programs of the different agencies to see if they are following the policies of this Act; recommend national policy related to the environment; conduct investigations; determine changes in the natural environment; report conditions of the environment once a year; and conduct studies as required. This is to be accomplished by coordination with other groups.

The last two sections deal with pay schedules and terms of office for the Council members and the financing to support the Council.

U. S. Geological Survey Circular 645

The USGS Circular is entitled "A Procedure for Evaluating Environmental Impact" (23). The primary purpose as stated in the publication was to show "a procedure that may assist in developing uniform

environmental impact statements." As stated by Gillette (11) in a recent article in Science, "The law's instructions for preparing an impact report apparently are not specific enough to insure that an agency will fully or even usefully examine the environmental effects of the projects it plans."

A matrix (Enclosure 1) has been developed for use as a reference checklist or a reminder of impacts to be considered. This allows evaluators to make a "quick evaluation and determine the significant impacts." This simple system is a guide until the results of studies on matrices for environmental effects being done have been completed.

This system provides for the analysis and numerical weighting of probable impacts. This analysis does not result in an overall quantitative rating, but reflects value judgments made by the evaluator. This system does allow that alternatives and their impacts be considered.

Circular 645 presents a generalized procedure for a development of an action program. If this procedure is followed, the result would be an environmental impact statement in form. The content and degree of analysis would dictate how good the environmental impact was. The outline of the procedure is:

(a) Statement of the major objective

(b) Technologic possibilities for achieving objective

(c) Proposed actions and alternatives

(d) Characterization report of existing environment prior to initiation of action

(e) Alternative engineering plans

(f) Identification of impact and analysis of magnitude and importance of impact

(g) Assessment of impact

(h) Recommendations.

The text of the assessment should be a discussion that follows the Council of Environmental Quality guidelines as published in the Federal Register (1971):

(1) A description of the proposed action including information and technical data adequate to permit careful assessment of impact.

(2) The probable impact of the proposed action on the environment.

(3) Any probable adverse environmental effects which cannot be avoided.

(4) Alternatives to the proposed action.

(5) The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.

(6) Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

(7) Where appropriate, a discussion of problems and objectives raised by other Federal, State, and local agencies and by private organizations and individuals in the review process and the disposition of the issues involved.

Circular 645 concludes the wide variety of projects does not allow for a single impact assessment to be accepted, rather for a simple way of summarizing which impacts are considered the greatest. It also recognizes that different conclusions can be drawn by different assessors, but it would be useful to know the basis for the difference. As little bias as possible should be in the numerical ranking of the boxes in the matrix. Finally realizing this matrix is just a draft, that it is subject to improvement, expansion, and change.

University of Texas at Austin

Bureau of Economic Geology

Circular 71-1

The title of this publication is "Resource Capability Units--Their Utility in Land- and Water-Use Management With Examples From the Texas Coastal Zone" (24). This circular is primarily concerned with proper land-use and resource development: "For prudent, fair land- and water-use management policies to be developed, adequate inventories must be made of these resources, their composition, properties, and natural capacity for a variety of uses." Many current environmental programs are remedial, "aimed at curing or rectifying existing problems." This is fine where serious problems exist, but environmental programs must also be preventative. "If future development and utilization of natural resources--land, water, and biota--are consistent with the natural capabilities and limits of these resources, most environmental problems can be precluded or minimized." Man needs the resources and the environment. "Prudent use is conservation, as opposed to severely limited use or non-use in the context of strict preservation." Guidelines should permit maximum but wise use of resources, with a minimum of environmental damage. To develop these guidelines "requires an adequate inventory, description and delineation of these natural units in order that their capability for varied use can be properly evaluated. This leads to the concept of natural resource capability units." This report outlines

> (1) the nature of resource capability units, (2) the basic factors and properties exhibited by the units that define the limits of their use, and (3) the application of resource capability units to environmental management. Specific examples are shown for the 20,000 square miles of the Texas Coastal Zone, where a wide variety of resource units occur in an area of diverse human activities.

Circular 71-1 defines a resource capability unit as an "environmental entity--land, water, area of active process, or biota--defined in terms of the nature, degree of activity, or use it can sustain without losing an acceptable level of environmental quality." It further states that "Units are established by recognizing elements of first-order environmental significance, whether dominantly, physical, biologic, or chemical." These include (1) physical units where physical properties are important; (2) process units where "active physical processes" dominate; (3) biologic units where biologic activity and habitation are significant; and (4) man-made units which "has resulted in important environmental modification." "Particularly important to environmental quality are those factors that limit the use of a given land or water unit for specific uses or activities."

The circular suggests, "The delineation of resource capability units requires an adequate inventory of the nature, grade, and distribution of these resources. Such an inventory can be accomplished only through appropriate mapping and description." Maps have been one of our basic information sources and decision helpers for years:

> Basic land and water resource maps provide an inventory of natural units that show the distribution of kinds and grades of resources. These basic map units can be evaluated in terms of current and potential use; the limits of their capability for various uses can be used to develop guidelines that will permit maximum use consistent with minimum environmental degradation. Resource capability maps chart the distribution of natural units; description of these units defines their capabilities.

Table I does not consider effects of human activities on resource units but only the incapacity of a given resource unit to support a particular activity without environmental damage. Where blanks appear

TABLE I

USES AND CAPABILITIES OF COASTAL ZONE RESOURCES

RESOURCE CAPABILITY UNITS \ ACTIVITIES			Liquid Waste Disposal			Solid Waste Disposal	Construction of Offshore and Bay Platforms	Coastal Construction			Inland Construction				Dredging of Canals and Channels, and Spoil Disposal ★	Excavation (includes extraction of natural materials)	Filling for Development	Draining of Wetlands	Well Development	Deregulation	Transversing with Vehicles (marsh buggies, air boats, dune buggies, motorcycles)	Use of Herbicides, Pesticides, Insecticides
			Surface Disposal of Untreated Liquid Wastes	Disposal of Untreated Liquid Wastes, Subsurface, Shallow	Maintenance of Feed Lots	Disposal of Solid Waste Materials	Construction of Jetties, Groins, Piers	Construction of Storm Barriers and/or Seawalls	Placement of Pipelines and/or Subsurface Cables ▲	Light Construction	Construction of Highways	Heavy Construction	Flooding (through dam construction)									
WATER CAPABILITY UNITS	Bays, Estuaries, and Lagoons	River Influenced Bay Areas Including Prodelta and Delta Front	X	X		X	O	O	X	O					X		X		O			
		Enclosed Bay Areas	X	X		X	O		X	O					O		O		O			
		Living Oyster Reefs and Related Areas	X	X		X	X	X	X	X					X		X		X			
		Dead Oyster and Serpulid Reefs and Related Areas	X	X		X	O	O	X	O					X		X		O			
		Grassflats	X	X		X	X	X	X	X					X		X		X			
		Mobile Bay-Margin Sand Areas	X	X		X	X	X	X	X					X		X		O			
		Tidally Influenced Open Bay Areas	X	X		X	O	O	X	O					X		X		O			
		Subaqueous Spoil Areas	X	X		X	O	O		O							O		O			
		Inlet and Tidal Delta Areas	X	X		X	X	X	X	X					X		X		O			
		Tidal Flats	X	X		X			X	X	X	X	X		O	X	X		O			
LAND CAPABILITY UNITS	Coastal Wetlands	Salt-Water Marsh	X			X	X		X	X	X	X	X	X	X	X	X	X	O	X	X	X
		Fresh-Water Marsh	X			X			X	O	X	X	X	X	X	X	X	X	O	X	X	X
		Swamps	X			X				O	X	X	X	X	O	O	X	X	O	X	O	X
	Coastal Barriers	Beach and Shoreface	X	X		X		X	O		X	X	X		X	X			X		O	
		Fore-Island Dunes and Vegetated Barrier Flats	X	X	X	X			X		+	+	+		X	X			O	X	X	X
		Washover Areas	X	X	X	X		X	X	X	X	X	X		X		X		X			
		Blowouts and Back-Island Dune Fields	X	X		X				O	X	X	X		X				X			
		Wind Tidal Flats	X	X		X					X	X	X		O		X		O			
	Man-Made	Swales	X	X		X					X	X	X		X	X	X	X		X		X
		Made Land and Spoil	X	X	X	X							O							X		
	Coastal Plains	Highly Permeable Sands	X	X	X	X									O	X			O	X		X
		Moderately Permeable Sands	X	X	X	X									O	X			O	X		X
		Impermeable Muds	O							O	O	O	O						O			O
		Broad Shallow Depressions •	O								X	O	X						O			O
		Highly Forested Upland Areas •												X					O	X		X
		Steep Lands, Locally High Relief	X			X					O		O			X				X		O
		Stabilized Dunes	X	X	X	X						O			X	X			O	X	X	X
		Unstabilized, Unvegetated Dunes	X	X		X				O	X	X	X		X				X			
		Fresh-Water Lakes, Ponds, Sloughs, Playas	X			X									X		X	X	O			X
		Mainland Beaches	X	X		X		X	X		X	X	X		X	X	X		X	O		
		Areas of Active Faulting and Subsidence	O	O		O				X	O	O	X						O			
	Major Floodplain Systems	Point-Bar Sands	X	X	X	X					O				X				O	X		X
		Overbank Muds and Silts	X	X	X	X				O	O	O	O	O								O
		Water	X			X								O	X							X

X Undesirable (will require special planning and engineering)
O Possible problem(s)
+ Barrier Flat only (no construction on dunes)
• Substrate variable
▲ Also occurs in Offshore Construction
★ Also occurs in Offshore Canals and Dredging

in the table, "either a given activity is not applicable to a given resource unit or there is no significant limit on that activity."

A maximum use of the environment with a minimum of environmental degradation can occur. Proper management of land and water resources can occur, neither strict preservation or exploitation. Circular 71-1 states that several critical areas need to be studied very soon. Areas within and adjacent to the larger metropolitan centers with high concentrations of populations and industries with high use of land and water resources. Also areas adjacent to inland water bodies where development has and will occur. All areas where large scale construction projects are anticipated should be evaluated in terms of resource capability. "Another important element in land- and water-use management is adequate inventory of the nature, degree, and distribution of man's activities throughout the State and the environmental stresses these activities create."

University of Georgia

Institute of Ecology

The title of this report is "Optimum Pathway Matrix Analysis Approach to the Environmental Decision-Making Process" (25), and is subtitled "Testcase: Relative Impact of Proposed Highway Alternatives." The Institute was to conduct a summary evaluation of reports prepared on alternate routes of uncompleted I 75 north of Atlanta. Their study was "designed to merge all component factors in a totality analysis with emphasis on the effect of each alternative on the 'Quality of Human Environment.'" The effects of the environment, economics, and human factors were

considered, weighed and entered into a systems analysis. The component values that went into the final data set were loosely categorized into four groups:

1. Group E - Economic and Highway Engineering considerations
2. Group L - Environmental and Land Use considerations
3. Group R - Recreation considerations
4. Group S - Social and Human considerations.

The general method developed in this study has broad applications in problems of this sort, although it is to be emphasized that the actual numerical component values would vary in terms of the land areas under consideration.

Recreation (R) was included as a major category in this study because in one form or another, Lake Allatoona and the surrounding land areas represent a major recreation resource and green belt area of increasing importance for the Atlanta metropolitan area.

The Institute felt that "the environment as it affects the future quality of human existence was given adequate weight along with cost-benefit and other purely economic considerations." They tried not to overemphasize the natural environment, but also to consider "safety and future economic development." A unique feature of this study was that both the immediate and future impact was considered, with greater emphasis applied to the future (a one to ten ratio).

The method decided upon is essentially a linear combination of component values (the amount of urban land disturbed, the relative safety of a route, the cost of a route, etc., multiplied by a weighting factor giving the relative importance of the particular component values. Values were then scaled so that a mean impact index could be calculated for each route. To calculate an index for each route, it was necessary to establish a means of scaling many different measurements in comparable units.

For example, cost of the road and number of lives saved are not comparable. However, when using several options, it would be possible to give some value to the most expensive road and scale the other routes to this standard, or similarly the safety of a highway. The process was

such to make each component value for each route a dimensionless number that was "used as an index of the relative merit of each route." Each value was weighed in terms of present or long-term effects. Values for a component were determined for each alternative. The maximum value determined was used as a scaling factor and was divided into all values for that component. Thus the best alternative for that component would have a value of one while all others would be less than one. The summation of these component values times the weighting factor would give the impact index for each route.

Conclusions reached by the Institute were

> Since an Interstate Highway proves to be one of the most irresistible developmental magnets produced by man, this study clearly indicates that major highways are best routes (1) where they do least damage to land areas that are not by nature or function compatible with the results of the structure, and (2) where they will enhance an orderly economic development by virtue of planning and facilities (incorporated towns, water and sewage treatment, land use zoning and so forth) that have already gone into pre-existing centers of urban growth. Since in the long run the quality of urban areas depends on the quality of its buffer 'life support system' (i.e., the water-air-food-fiber-recreation natural environment), it makes common sense as well as economic sense not to route highways through the life support greenbelt needed for future protection of metropolitan centers when such a highway can be routed so as to have positive value for the already developed urban areas.

The Institute also stated some recommendations, two of which are: "State, Federal and private agencies need to develop better and more quantitative means of preparing impact reports in order that data can be integrated into total network matrices" and "We recommend that procedures developed in this study be used in the selection of sites for atomic power plants, large industrial parks, major airports, and so on."

Battelle Memorial Institute

Columbus Laboratories

The system described below was designed by Battelle Memorial Institute, Columbus Laboratories, for the Bureau of Reclamation, United States Department of the Interior, under contract 14-06-D-7005. The title of this system is "Design of an Environmental Evaluation System" (26), and is to be applied to all Bureau of Reclamation projects in determining their environmental impact. The system includes the "relative importance of various types of environmental impacts expressed as 'weights' assigned to each type of environmental indicator selected." The Battelle Institute states that extensive field testing must be carried out to ensure the widespread applicability of the system.

"Our ability to evaluate environmental impacts has not kept pace with the ability to design and construct larger and more complex projects." They felt a real gap existed "between the need to perform environmental impact evaluations and our ability to do so." They further believed that

> Water resources development projects, by their very purpose, are conceived and designed to achieve major environmental changes. While most water resources projects have been successful at achieving their objectives (irrigation, hydropower, flood control, etc.), many projects have led to changes in the external environment that were not predicted at the time of project planning. At times, agencies responsible for the construction of water resource projects have had little concern for environmental changes.

With this in mind, Battelle-Columbus was to develop a procedure for evaluating the environmental impacts of water resources development projects that would become part of the Bureau's river basin and project planning studies.

The Bureau felt that three elements were essential in accomplishing the objectives which they set forth. They wanted the study to be: comprehensive, systematic, and interdisciplinary. Since the environment is such a large "intricate system of living and non-living elements," with a broad spectrum of impacts from natural resources, to living organisms, to people, the procedure had to be comprehensive to include everything. The procedure also had to be systematic so it could be "applicable to any project" and the "resultant evaluation must be replicable by different analysts." It also had to be equatible when comparing alternatives. An interdisciplinary approach was needed because the environment is such a wide field and no one person can be an expert in all of them. They stated that "at a minimum the physical, biological, and social sciences" should be included.

The Battelle-Columbus team performed the following research activities in developing the environmental evaluation system (EES):

(1) Extensive review of literature pertaining to evaluating environmental impacts.
(2) Conceptualization of an interdisciplinary framework for comprehensive, systematic environmental evaluation.
(3) Field inspection of Bureau of Reclamation projects in Colorado and Nevada.
(4) Formal and informal discussions between the research team and Bureau of Reclamation staff to bring about a frequent interchange of ideas.
(5) Development of a detailed framework for evaluating the environmental impacts of water development projects.
(6) Development of a comprehensive list of environmental parameters, in major categories and subcategories of environmental concern.
(7) Evaluation of each environmental parameter in relation to Bureau of Reclamation needs and activities to produce a set of usable environmental parameters.
(8) Screening of all parameters to achieve consistency between all major categories of environmental concern.
(9) Determination of the relative significance of each environmental category, subcategory, and parameter based on judgments of the research team.

(10) Development of a weighting or ranking scale for the EES based on relative significance.
(11) Determination of necessary conditions for application of the EES to Bureau of Reclamation needs.
(12) Determination of research needs that correspond to limitations in the EES.

Several factors influenced the structural makeup of the EES. To be useful the system had to be a simple versus a complex one, yet it also had to be comprehensive. Therefore, a "hierarchical evaluation system" was employed. It broke the "subjects of environmental concern into major categories, major subcategories (called components in the system), and then into detailed environmental parameters." The environmental parameters included were selected because of their "specific appropriateness to the Bureau of Reclamation." Battelle stated that other types of projects could be evaluated by developing a "new set of environmental parameters with new weightings." The time frame that was considered was a "with-without comparison." This is more relevant than a before-after comparison, since some changes are likely to occur even if the project is not built. Consideration also must be given to the full life of the project. The weighting system was developed with the "best judgment at this time." While Battelle realizes that weighting is subject to controversy, some sort of ranking had to be developed. They also state that as more studying is done of weighting and ranking, a less judgmental system will result. Battelle also felt that the method should be extensively field tested by a joint Bureau-Battelle team to uncover any weaknesses that might exist in the system.

The EES greatly simplifies the environment into a small number of indicators. It is structured to be "replicable from project to project and yet be flexible. . . ." The EES is a tool that "strikes a balance

between too little detail and too much detail--a tool that can be valuable in the water resources planning process if used intelligently and honestly." The EES is shown in Table II.

The weighting of the EES required considerable time and effort on the part of the Battelle-Columbus team. They developed a weighting system that

> was believed to be applicable to the Bureau's needs, yet relatively simple. The weight-system is based upon a total assignment of 1000 'Environmental Quality Units,' divided among the 4 categories, 17 components, and 66 parameters of environmental quality. The value assigned to each parameter represents a maximum value that the given parameter is worth relative to all parameters.

The weights are presented only as a starting point to be revised as more scientific evidence is collected. A more detailed description of this procedure is included in Battelle's report.

An environmental evaluation determines if there is an impact, what type, and what adjustments should be made. "However, the process of choosing between alternatives can be improved by relating all environmental impacts to a single set of units." Thus, "the net environmental impact of any project is stated as a single value." In the weighting procedure,

> judgmental weights are given to each of the parameters expressing the importance of that parameter relative to other parameters in the system. Also, included in the weighting procedure is a determination of weights for the various levels of quality described by each of the parameters. The index of environmental quality is obtained by combining the weighted parameters with their respective levels of quality.

For the weighting system to be used, the parameters must be complete, exclusive, and of importance. It should be remembered that the weightings apply only to the impact of Bureau projects. The value of the weight used also represents the range of quality for that parameter.

TABLE II

ENVIRONMENTAL EVALUATION SYSTEM

Sample Form

Project Location_____
Project Name_____
Dates of Evaluation_____
Site Evaluated_____

Evaluation Team

Prepared for Bureau of Reclamation
by Battelle - Columbus
June 30, 1971
Contract 14-06-D-7006

I. ECOLOGY

Environmental Quality Units (EQU) 0 10 20 30 40 50

			Value in EQU		
			Without Project	With Project	Net Change
A. Species and Populations (144 EQU)	(1)	Rare and endangered species (15)			
	(2)	Productive plant species (18)			
	(3)	Game animals (15)			
	(4)	Other animals (15)			
	(5)	Resident and migratory birds (18)			
	(6)	Sport fisheries (15)			
	(7)	Commercial fisheries (15)			
	(8)	Pestilent species (15)			
	(9)	Parasites (15)			
		SUBTOTAL - Species and Populations			
B. Habitats and Communities (96 EQU)	(10)	Species diversity (48)			
	(11)	Food chains (24)			
	(12)	Land use (24)			
		SUBTOTAL - Habitats and Communities			
C. Ecosystems (75 EQU)	(13)	Productivity rate (25)			
	(14)	Hydrologic budget (25)			
	(15)	Nutrient budget (25)			
		SUBTOTAL - Ecosystems			
		TOTAL - Ecology (315 EQU)			

II. ENVIRONMENTAL POLLUTION

Environmental Quality Units (EQU) 0 10 20 30 40 50

			Value in EQU		
			Without Project	With Project	Net Change
D. Water Pollution (160 EQU)	(16)	Algal blooms (5)			
	(17)	Dissolved oxygen (20)			
	(18)	Evaporation (6)			
	(19)	Fecal coliforms (5)			
	(20)	Nutrients (12)			
	(21)	Pesticides, herbicides, defoliants (8)			
	(22)	pH (8)			
	(23)	Physical river characteristics (6)			
	(24)	Sediment load (15)			
	(25)	Stream flow (20)			
	(26)	Temperature (20)			
	(27)	Total dissolved solids (20)			
	(28)	Toxic substances (5)			
	(29)	Turbidity (10)			
		SUBTOTAL - Water Pollution			
E. Air Pollution (40 EQU)	(30)	Carbon monoxide (8)			
	(31)	Hydrocarbons (8)			
	(32)	Particulate matter (8)			
	(33)	Photochemical oxidants (8)			
	(34)	Sulfur oxides (8)			
		SUBTOTAL - Air Pollution			
F. Land Pollution (93 EQU)	(35)	Land use and misuse (31)			
	(36)	Soil erosion (31)			
	(37)	Soil pollution (31)			
		SUBTOTAL - Land Pollution			
G. Noise Pollution (28 EQU)	(38)	Noise (28)			
		SUBTOTAL - Noise Pollution			
		TOTAL - Environmental Pollution (321 EQU)			

III. ESTHETICS

Environmental Quality Units (EQU) 0 10 20 30 40 50

			Value in EQU		
			Without Project	With Project	Net Change
H. Land (25 EQU)	(39)	Land forms (15)			
	(40)	Geologic surface material (10)			
		SUBTOTAL - Land			
I. Air (11 EQU)	(41)	Pleasantness of sounds (11)			
		SUBTOTAL - Air			
J. Water (39 EQU)	(42)	Surface characteristics (25)			
	(43)	Water/land interface (14)			
		SUBTOTAL - Water			
K. Biota (28 EQU)	(44)	Vegetation (18)			
	(45)	Fauna (10)			
		SUBTOTAL - Biota			
L. Man-Made Objects (21 EQU)	(46)	Visual (8)			
	(47)	Condition (5)			
	(48)	Conformance with environment (8)			
		SUBTOTAL - Man-Made Objects			
M. Composition (35 EQU)	(49)	Interactions (25)			
	(50)	Color (10)			
		SUBTOTAL - Composition			
		TOTAL - Esthetics (159 EQU)			

IV. HUMAN INTEREST

Environmental Quality Units (EQU) 0 10 20 30 40 50

			Value in EQU		
			Without Project	With Project	Net Change
N. Educational - Scientific Significance (64 EQU)	(51)	Geological significance (16)			
	(52)	Ecological significance (16)			
	(53)	Archeological significance (16)			
	(54)	Unusual water phenomenon (16)			
		SUBTOTAL - Educational-Scientific Significance			
O. Historical Significance (55 EQU)	(55)	Related to persons (11)			
	(56)	Related to events (11)			
	(57)	Related to religions and cultures (11)			
	(58)	Related to architectures and styles (11)			
	(59)	Related to "western frontier" (11)			
		SUBTOTAL - Historical Significance			
P. Cultural Significance (54 EQU)	(60)	Related to indians (18)			
	(61)	Related to religious groups (18)			
	(62)	Related to ethnic groups (18)			
		SUBTOTAL - Cultural Significance			
Q. Mood Atmosphere Significance (52 EQU)	(63)	Isolation - solitude (8)			
	(64)	Awe - inspiration (8)			
	(65)	"Oneness" with nature (8)			
	(66)	Mystery (8)			
		SUBTOTAL - Mood - Atmosphere Significance			
		TOTAL - Human Interest (205 EQU)			

Total Ratings (EQU)		
Without Project	With Project	Net Change

I. Ecology
II. Environmental Pollution
III. Esthetics
IV. Human Interest
TOTAL

An example of this is parameter 17, dissolved oxygen, in the water pollution component under environmental pollution. A type of proportioning was developed. Dissolved oxygen at 4 mg/l was only valued at 25% of the maximum quality, while dissolved oxygen at 7 mg/l or up was considered 100% quality. A break-down of dissolved oxygen and the percentage of quality could be: 0 mg/l with 0% quality, 1 mg/l with 5%, 2 mg/l with 10%, 3 mg/l with 15%, 4 mg/l with 25%, 5 mg/l with 50%, 6 mg/l with 75%, 7 mg/l to 10 mg/l with 100%. With environmental quality units 20 for dissolved oxygen, the EQU value for each level from 0 mg/l to 10 mg/l would be, respectively: 0, 1, 2, 3, 5, 10, 15, 20, 20, 20, and 20. By doing this for each parameter, a better effect on the environment can be determined.

To see how good and useful this EES is to be, Battelle-Columbus recommended that field studies be conducted. How well this tool works depends on how "properly, efficiently, and consistently" the Bureau uses it. Along with the recommended field studies, Battelle-Columbus suggested some guidelines for application. The EES should be used early in the planning process so that it will affect the decision making. The location of where the EES is to be applied must be determined so as to get an accurate effect of the project. A small scale should apply to the EES, like a project of up to several hundred miles rather than an entire river basin or interbasin study. The time factor is also important, with a comparison of "with and without" better than a before and after comparison. This is due to the "with project having several time elements of construction, short-term and long-term." An interdisciplinary team of four to six persons with experience in using

the EES is strongly recommended. The EES will require more information than is now assembled to be useful.

A need for much more research was found to exist. The advanced concepts of measurement were used where applicable, but several areas are still lacking so as to provide an adequate evaluation. Battelle-Columbus stated that the fields lacking were ecology, water quality management, and land use. The EES needed to be tested in the field as opposed to the theory of the office. The value functions assigned to the parameters must be checked and revised as necessary. With the large amount of information and data that must be collected, this should be recorded and stored where a variety of users could have access to it. A greater attempt should be made to know what the public opinion is on certain parameters.

Corps of Engineers, Tulsa District

The Tulsa District of the Corps of Engineers has developed a matrix for its use in the environmental impact statements. They are also of the opinion that it may be used by the Corps nation-wide. It was developed by the head of the Environmental Resources Section. All of the matrices except the University of Texas method looked at in this study plus some others were used to develop the Corps matrix. A composite of all the good points was included. At the present time, this matrix is for official use only and the author was unable to get a copy. However, the author was able to get two impact statements that use this matrix. The two matrices are not exactly alike in that the second one has been expanded and uses a different rating system.

The Skiatook matrix (Tables III and IV) will be looked at first (27). Three primary objectives were considered: "Natural environmental considerations, social well-being, and economic considerations. All three objectives were given equal weight."

The long-term and short-term effects of each parameter were considered with the long-term effect given higher priority. Value judgments were used on several parameters; therefore the analysis is subjective. An interdisciplinary team was used in the analysis and selection of values.

A total of 26 parameters was considered with Group I having 14, Group II having 19, and Group III having 9. The groups were equated by ratios of 19:14 and 19:9. The results are shown in Table IV. Several of the parameters can be considered in each group. The raw score is the net sum of the pluses and minuses in that group under that alternative.

Birch Lake is the other impact statement (28). The matrix (Table V) is basically the same although some refinements have occurred. The three primary objectives are: "Natural environment, human life quality, and economics." Equal weight was given to all three. Again this matrix was subjective in that value judgments had to be made.

> The equivalency factor assigned to each parameter is multiplied by the raw score for that parameter to give a weighted score. The equivalency factor was calculated to insure that each division within a major planning objective has equal weight regardless of the number of subdivisions, sections, or subsections and to insure that each of the three major planning objectives have equal weight regardless of the number of divisions within each objective.

TABLE III

SKIATOOK PROJECT MATRIX ANALYSIS

Parameters	ALTERNATIVES STUDIED SINCE PASSAGE OF THE NATIONAL ENVIRONMENTAL POLICY ACT OF 1969																													
	STRUCTURAL ALTERNATIVES															NON-STRUCTURAL ALTERNATIVES													
	Skiatook Lake As Recommended			Dry Lake			Upstream MP Lakes			Levees			Levees With Upstream MP Lakes			Non-structural Flood Damage Prevention Measures			Acquire Flood Plain in Fee			Acquire Flood Plain in Easement			Develop Hominy Creek as Recreational Stream			Do Nothing		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
I Effect on Hominy Creek																														
a. Stream fishing																														
Quality (1)	0	+ + -	0	0	-	0	0	+ +	0	0	- -	0	0	+ + -	0	0	0	0	0	+	0	0	0	0	0	+	0	0	0	0
Quantity (2)	0	+ - -	0	0	0	0	0	+ +	0	0	0	0	0	+ +	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b. Total sport fishing in basin																														
Quantity (3)	0	+ + +	0	0	0	0	0	+ + +	0	0	0	0	0	+ + +	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diversity (4)	0	+ + +	0	0	0	0	0	+ + +	0	0	0	0	0	+ + +	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c. Scenic beauty (5)	0	+ + + -	0	0	- -	0	0	+ + -	0	0	-	0	0	+ + -	0	0	0	0	0	+	0	0	0	0	0	+ +	0	0	0	0
d. Access (6)	0	+ +	0	0	+ +	0	0	+ +	0	0	+	0	0	+ + +	0	0	0	0	0	+	0	0	0	0	0	+ + +	0	0	0	0
II Total Recreational Diversity																														
a. Hominy Creek Basin (7)	0	+ + +	0	0	+	0	0	+ + +	0	0	0	0	0	+ + +	0	0	0	0	0	+	0	0	0	0	0	+ +	0	0	0	0
b. Regional (8)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	0	0
III Total Recreational Visitation (9)	- - -	0	+ + +	-	0	+	- - -	0	+ + +	-	0	+	- - -	0	+ + +	0	0	0	-	0	+	0	0	0	- -	0	+ +	0	0	0
IV Water Quality Control (10)	+ + +	+ + +	+ + +	-	-	0	+ +	+ +	+	-	-	0	+ + -	+ + -	+	0	0	0	+	+	0	0	0	0	+	+	0	0	0	0
V Providing Water Supply for Projected Municipal & Industrial Needs (11)	0	+ + +	+ + +	0	0	0	0	+	+	0	0	0	0	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VI Effect on Wildlife Habitat & Hunting																														
a. Terrestrial (12)	+ - -	+ - -	0	+ -	+ + -	0	+ - -	+ - -	0	+ -	+ -	0	+ + - -	+ + - -	0	0	0	0	+ -	+ +	0	0	0	0	+ - -	+	0	0	0	0
b. Waterfowl (13)	+ +	+ +	0	0	0	0	+ + +	+ + +	0	0	0	0	+ + +	+ + +	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VII Formation of Defoliated Zone (14)	- -	0	0	- - -	0	0	- -	0	0	0	0	0	- -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VIII Effect on Total Timber Harvest (15)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IX Effect on Farming & Ranching (16)	-	+ - -	+ - -	-	+ + -	+ + -	-	+ + -	+ + -	-	+	+	- -	+ - -	+ - -	0	0	0	+ +	- -	- -	0	+	+	+	-	-	0	0	0
X Effect on Mineral Resources (17)	+	-	- - -	+	-	- -	+	-	- - -	0	0	0	+	-	- - -	0	0	0	+	-	- -	0	0	0	+	-	-	0	0	0
XI Effect on Population of Hominy Basin (18)	- - -	+ + - -	+ + +	-	+ -	+	- - -	+ + - -	+ + +	-	+ -	+	- - -	+ + - -	+ + +	0	0	0	+	+ -	-	0	0	0	0	0	0	0	0	0
XII Effect on Archeological Sites (19)	0	+ + - -	0	0	0	0	0	+ + - -	0	0	+ -	0	0	+ + - -	0	0	0	0	0	+	0	0	0	0	0	+ -	0	0	0	0
XIII Protection Against Flooding & Flood Losses in Hominy Creek Basin (20)	+ + - -	+ + +	+ + +	+ + - -	+ + +	+ + +	+ -	+ +	+ +	+ -	+	+	+ + - -	+ + +	+ + +	0	+	+	0	+	+	0	+	+	0	0	0	0	0	0
XIV Protection Against Flooding & Flood Losses Downstream of Hominy Creek (21)	+ + - -	+ + +	+ + +	+ + - -	+ + +	+ + +	+ -	+ +	+ +	0	0	0	+ -	+ +	+ +	0	+	+	0	+	+	0	+	+	0	0	0	0	0	0
XV Stimulation of Local Economy (22)	0	+ + +	+ + +	0	+ +	+ +	0	+ + +	+ + +	0	+	+	0	+ + +	+ + +	0	+	+	0	+	+	0	+	+	0	+	+	0	0	0
XVI Ecosystem Diversity and Stability **																														
a. Aquatic (23)	+ + -	0	0	+ -	0	0	+ - - -	0	0	0	0	0	+ - - -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b. Terrestrial (24)	+ + - -	0	0	+ + - -	0	0	+ - -	0	0	+ + - -	0	0	+ + - -	0	0	0	0	0	+ +	0	0	0	0	0	+	0	0	0	0	0
XVII Ecosystem Productivity ***																														
a. Aquatic (25)	+ +	0	0	-	0	0	+ + +	0	0	0	0	0	+ + +	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b. Terrestrial (26)	- - -	0	0	- -	0	0	- - -	0	0	- -	0	0	- - -	0	0	0	0	0	+ +	0	0	0	0	0	+ -	0	0	0	0	0

* Vertical columns designated by Roman Numerals I, II, and III refer to considerations of the natural environment, social well-being, and economic considerations, respectively, and are evaluated for each alternative. The evaluation of a parameter for an applicable group can range from a minus three (- - -) to a plus three (+ + +) with varying combinations possible. A zero (0) is evaluated as either not applicable, no effect, or an effect so slight that it merits a no-effect evaluation. A plus sign indicates a beneficial effect, and a minus sign indicates a detrimental effect.

** Diversity refers to the total information (number of species and their randomness and types of habitat) in the entire Hominy Creek Basin system, while stability refers to the ability of the Hominy Creek basin system to re-establish homeostasis in the original steady-state or in some new steady-state after a disturbance.

*** Productivity refers in this case to the total potential for biological productivity of the Hominy Creek Basin system.

TABLE IV

SUMMARY OF THE SKIATOOK MATRIX ANALYSIS*

Rank	Alternative	Group I Considerations of the Natural Environment (Equivalency Factor 1.36)		Group II Social Well-Being (Equivalency Factor 1.0)		Group III Economic Considerations (Equivalency Factor 2.11)		Net Impact
		Raw Score	Adjusted Score	Raw Score	Adjusted Score	Raw Score	Adjusted Score	
1	Skiatook Lake as recommended	- 5	- 6.80	+ 30	+ 30.00	+ 20	+ 42.20	+ 65.40
2	Levees with upstream lakes	- 5	- 6.80	+ 28	+ 28.00	+ 15	+ 31.65	+ 52.85
3	Upstream MP lakes	- 3	- 4.08	+ 28	+ 28.00	+ 13	+ 27.43	+ 51.35
4	Acquire flood plain in fee	+ 8	+ 10.88	+ 8	+ 8.00	- 1	- 2.11	+ 16.77
5	Dry Lake	- 9	- 12.24	+ 8	+ 8.00	+ 9	+ 18.99	+ 14.75
6	Develop Hominy Creek as recreation stream	+ 1	+ 1.36	+ 10	+ 10.00	+ 1	+ 2.11	+ 13.47
7	Acquire flood plain in easement	0	0	+ 4	+ 4.00	+ 4	+ 8.44	+ 12.44
8	Non-structural damage prevention measures	0	0	+ 3	+ 3.00	+ 3	+ 6.33	+ 9.33
9	Levees	- 6	- 8.16	0	0	+ 5	+ 10.55	+ 2.39
10	Do nothing	0	0	0	0	0	0	0

*The equivalency factors result from the fact that all three groups are considered to carry equal weight. Since Group II had the most parameters considered, Groups I and III had to have raw scores multiplied by a corresponding factor to present an equal weight.

TABLE V

BIRCH PROJECT MATRIX ANALYSIS

	Parameters	Weighting Factors	Equivalency Factors	A Birch Lake		B Upstream WS & WQ Lake Plus Dry Lake		C Upstream MP Birch Lake		D Avant Lake		E Flood Plain Zoning, Flood Insurance, Early Warning, & Flood Proofing		F Develop Birch Creek as a Recreational Stream		G No Action (1)	
				Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
NATURAL ENVIRONMENT	I Endangered Species																
	A. Fauna	9	9	0		0		0		0		0		0		0	0
	B. Flora	1	1	0		0		0		0		0		0		0	0
	II Plant and Animal Habitat																
	A. Aquatic	0.4															
	1. Lotic (flowing)	0.9															
	a. Quality	7	2.52	+5	+12.60	+5	+12.60	+5	+12.60	+5	+12.60	+1	+ 2.52	+1	+ 2.52	0	0
	b. Quantity	3	1.08	-2	- 2.16	-1	- 1.08	-1	- 1.08	-5	- 5.40	0	0	0	0	0	0
	2. Lentic (standing)	0.1															
	a. Quality	7	0.28	+4	+ 1.12	+5	+ 1.40	+4	+ 1.12	+3	+ 0.84	0	0	0	0	0	0
	b. Quantity	3	0.12	+3	+ 0.36	+2	+ 0.24	+2	+ 0.24	+5	+ 0.60	0	0	0	0	0	0
	B. Terrestrial	0.6															
	1. Grassland, pasture, cropland	0.2															
	a. Quality	7	0.84	+3	+ 2.52	+3	+ 2.52	+4	+ 3.36	+2	+ 1.68	+1	+ 0.84	-2	- 1.68	0	0
	b. Quantity	3	0.36	-2	- 0.72	-3	- 1.08	-2	- 0.72	-5	- 1.80	0	0	-1	- 0.36	0	0
	2. Forest and woodland	0.8															
	a. Quality	7	3.36	-1	- 3.36	-1	- 3.36	-1	- 3.36	-1	- 3.36	0	0	+2	+ 6.72	0	0
	b. Quantity	3	1.44	-2	- 2.88	-3	- 4.32	-2	- 2.88	-5	- 7.20	0	0	+2	+ 2.88	0	0
	III Ecosystem Diversity and Stability																
	A. Aquatic	4	4	+4	+16.00	+5	+20.00	+5	+20.00	+3	+12.00	0	0	+1	+ 4.00	0	0
	B. Terrestrial	6	6	-2	-12.00	-3	-18.00	-2	-12.00	-5	-30.00	-1	- 6.00	+1	+ 6.00	0	0
	IV Ecosystem Productivity																
	A. Aquatic	4	4	+3	+12.00	+3	+12.00	+3	+12.00	+5	+20.00	0	0	0	0	0	0
	B. Terrestrial	6	6	-2	-12.00	-2	-12.00	-2	-12.00	-5	-30.00	-1	- 6.00	0	0	0	0
	NET IMPACT				+ 11.48		+ 8.92		+ 17.28		- 30.04		- 8.64		+ 20.08		0
HUMAN LIFE QUALITY	I Recreational Opportunities																
	A. Water Oriented	0.4															
	1. Sport Fishing	0.18															
	a. Stream-oriented	7	0.67	+1	+ 0.67	+2	+ 1.34	+2	+ 1.34	-1	- 0.67	0	0	0	0	0	0
	b. Total (including lakes)	3	0.29	+3	+ 0.87	+4	+ 1.16	+4	+ 1.16	+5	+ 1.45	0	0	0	0	0	0
	2. Waterfowl - Hunting	.02	0.11	+1	+ 0.11	+1	+ 0.11	+1	+ 0.11	+2	+ 0.22	0	0	0	0	0	0
	3. Other water-oriented recreation	.8															
	a. Stream-oriented	7	2.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	b. Total (including lakes)	3	1.28	+5	+ 6.40	+5	+ 6.40	+5	+ 6.40	+5	+ 6.40	0	0	0	0	0	0
	B. Land Oriented	0.6															
	1. Terrestrial Hunting	.6	0.48	-1	- 0.48	-1	- 0.48	-1	- 0.48	-2	- 0.96	0	0	+1	+ 0.48	0	0
	2. Other land-oriented recreation	9.4	7.52	+5	+37.60	+5	+37.60	+5	+37.60	+5	+37.60	0	0	+1	+ 7.52	0	0
	II Anxiety Factors																
	A. Congestion and Noise	1	1.33	-5	- 6.65	-4	- 5.32	-3	- 3.99	-5	- 6.65	0	0	-2	- 2.66	0	0
	B. Nuisance and Vandalism	1	1.33	-5	- 6.65	-4	- 5.32	-3	- 3.99	-5	- 6.65	0	0	-2	- 2.66	0	0
	C. Flooding	3.5	4.67	+5	+23.35	+5	+23.35	+4	+18.68	+5	+23.35	+1	+ 4.67	0	0	0	0
	D. Stream Water Quality	1	1.33	+5	+ 6.65	+4	+ 5.32	+ 4	+ 5.32	+ 5	+ 6.65	0	0	0	0	0	0
	E. Water Supply	3.5	4.67	+5	+23.35	+4	+18.68	+4	+18.68	+5	+23.35	0	0	0	0	0	0
	III Other Human Life Quality Considerations																
	A. Aesthetics	3	4.0	+2	+ 8.00	0	0	+2	+ 8.00	+1	+ 4.00	0	0	+2	+ 8.00	0	0
	B. Unique Historical & Scientific Areas	4	5.33	+3	+15.99	+1	+5.33	-2	-10.66	-5	-26.65	0	0	+3	+15.99	0	0
	C. Life Style & Cultural Opportunities	3	4.0	+4	+16.00	+4	+16.00	+2	+ 8.00	+5	+20.00	0	0	+2	+ 8.00	0	0
	NET IMPACT				+ 125.21		+ 93.51		+ 86.17		+ 81.44		+ 4.67		+ 34.67		0
ECONOMICS	I Project Efficiency	10	20	+5	+100.00	+2	+40.00	+3	+60.00	-5	-100.00	0	0	+1	+20.00	0	0
	II Gross Economic Output																
	A. Income																
	1. Wage and Salary	7	4.67	+4	+18.68	+4	+18.68	+2	+ 9.34	+5	+23.35	0	0	+1	+ 4.67	0	0
	2. Other Components (Welfare, Rental, etc)	2	1.33	+4	+ 5.32	+4	+ 5.32	+2	+ 2.66	+5	+ 6.65	0	0	+1	+ 1.33	0	0
	3. Sales Tax Revenue	1	0.67	+4	+ 2.68	+4	+ 2.68	+2	+ 1.34	+5	+ 3.35	0	0	+1	+ 0.67	0	0
	B. Employment																
	1. Primary (Revenue producing)	8	5.33	+3	+15.99	+3	+15.99	+1	+ 5.33	+4	+21.32	0	0	+1	+ 5.33	0	0
	2. Secondary (Revenue circulating)	2	1.33	+4	+ 5.32	+4	+ 5.32	+2	+ 2.66	+5	+ 6.65	0	0	+1	+ 1.33	0	0
	C. Value of Farm Products																
	1. Crops	4	2.67	+4	+10.68	+4	+ 10.68	+3	+ 8.01	+5	+13.35	0	0	0	0	0	0
	2. Livestock	6	4.00	+4	+16.00	+4	+16.00	+3	+12.00	+5	+20.00	0	0	0	0	0	0
	NET IMPACT				+ 174.67		+ 114.67		+ 101.34		- 5.33		0		33.33		0
	TOTAL NET IMPACT				311.36		217.10		204.79		46.07		- 3.97		88.08		0
	RANKING				First		Second		Third		Fifth		Seventh		Fourth		Sixth

(1) The no action alternative is a base point evaluated on what exists presently and on what is expected with current trends. Everything else is judged as being either positive or negative with respect to the no action alternative. Hence, the no action alternative has a zero impact.

Iowa State University

Skunk River, Iowa

Ames Reservoir

The Corps of Engineers, Rock Island District, contracted with the Iowa State Water Resources Research Institute (both Iowa State University and Iowa University) to do a study of the proposed Ames Reservoir near Ames, Iowa (29). An interdisciplinary team was set up because NEPA requires a broader look at a project than by an engineering design team. The stream is used as a natural resource area by ISU as an outdoor teaching laboratory. Therefore, the universities already had some data related to the basin. The environmental review study was used to determine both the merits of the project and the alternatives. The alternatives were considered with and without the project and the present and future time span. A total of 17 disciplines was involved, with many faculty members, graduate and undergraduate students involved. Five functional categories were set up that had much interlocking involved. The categories were: (1) Reservoir site and stream system as resource entities; (2) Social and economic impact of the reservoir; (3) Recreation and related open-space uses and needs; (4) Physical relationship with the agricultural sector of the environment; and (5) Physical relationship with the urban sector of the environment. A landscape overview model was used in the study. Certain members of the Corps were assigned to each category for help and discussion. At four-month intervals were "checkpoint" meetings to check on how progress was coming along. Monthly progress reports were also required by the contract. All governmental agencies were asked to assign a technical liaison person to help coordinate between the agency and the study group. Some categories met

every week while others met less frequently. The research study had two coordinators which they found to be inadequate because other activities vied for their time. They suggested one principal coordinator with no other activity distracting him. At present the study is not complete.

CHAPTER IV

DEVELOPMENT OF A WATER RESOURCES ENVIRONMENTAL IMPACT MATRIX

This author was involved in an interdisciplinary writing of an environmental impact statement during his graduate study. Several disciplines were involved (civil engineering, geology, agricultural economics, geography, economics, and zoology) with team efforts being divided along departmental lines. These teams consisted of faculty members, graduate and undergraduate students. An overall coordination was assigned. This author was involved in the engineering and hydrologic studies for the project.

In November, 1972, Oklahoma State University entered into a contract with the Corps of Engineers, Tulsa District, to write an environmental impact statement for the Arcadia Project on the Deep Fork River. The 1970 survey report (30) proposed a multi-purpose reservoir located just upstream of Arcadia, Oklahoma, on the Deep Fork River located in Oklahoma County (Figure 1). The structure as proposed was to be an earth-filled embankment with a valley ogee spillway, with four tainter gates. The purposes of the project are recreation, flood control, water supply and water quality. The need to study the environment was critical as the project is located within 10 miles of Oklahoma City and Edmond. The 105 square miles of drainage area above the project are already 30

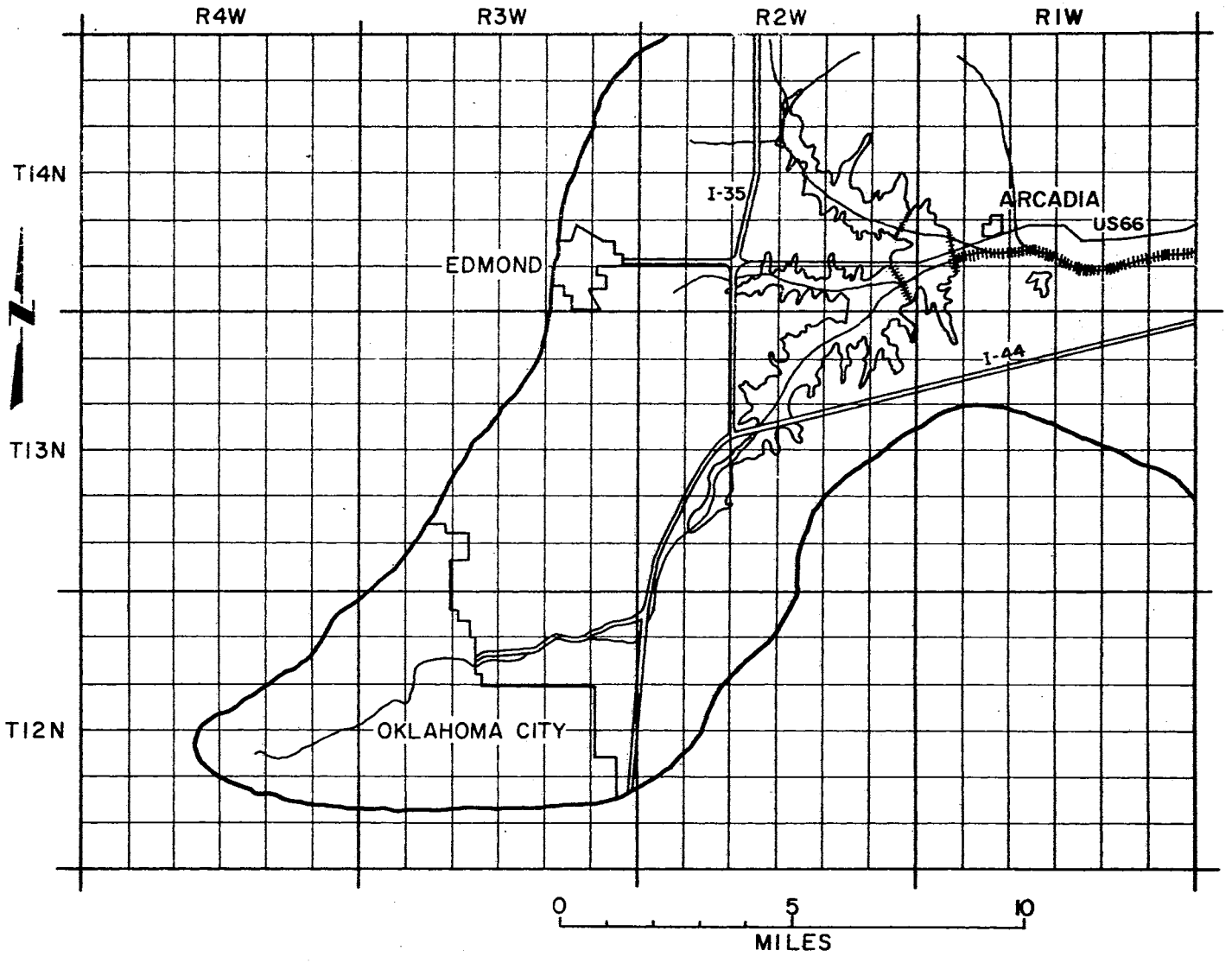


Figure 1. Arcadia Site

percent urbanized. Currently two sewage treatment plants discharge over 24 million gallons daily into the river above the project.

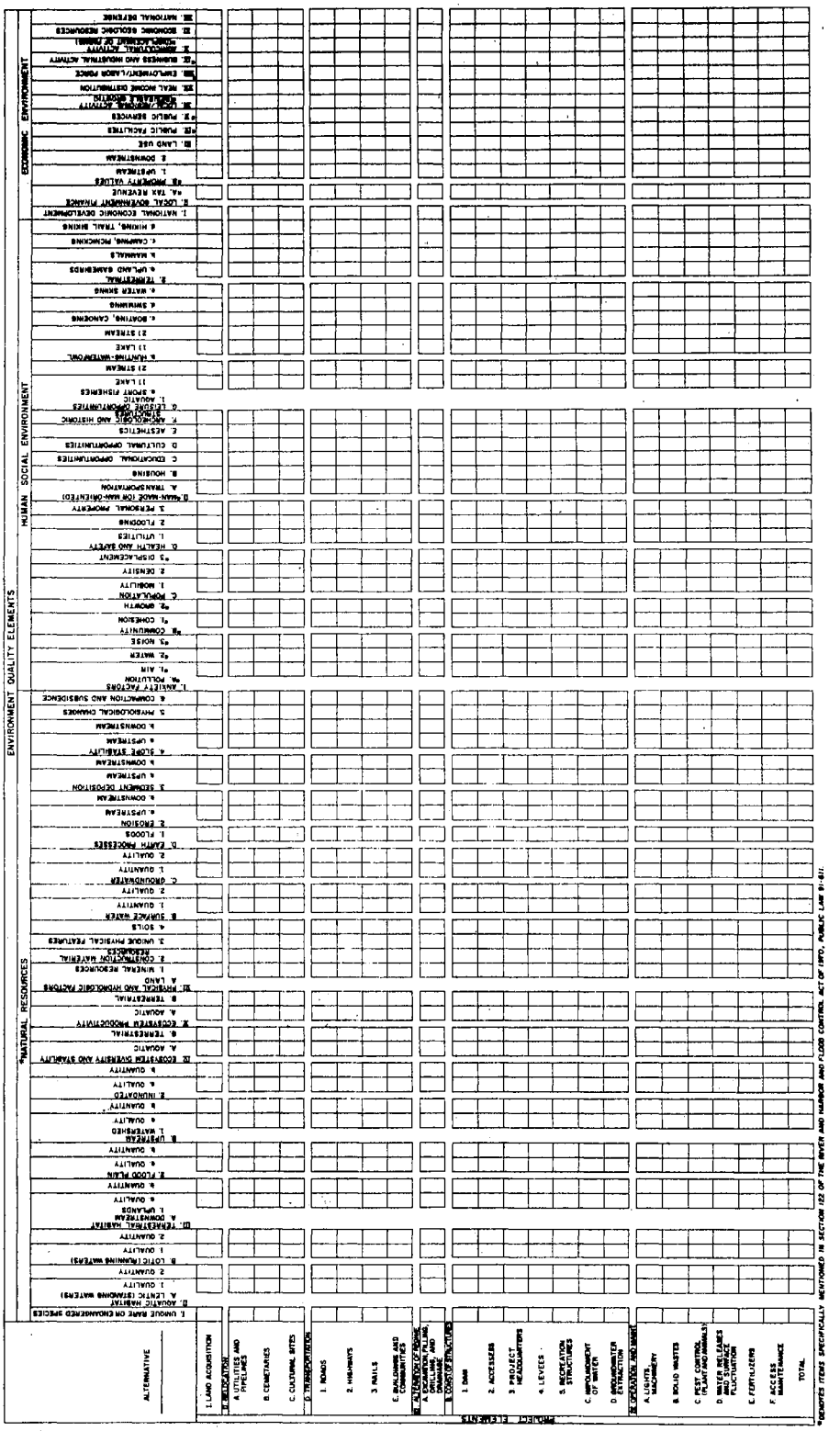
Due to the urban nature of the project, an initial list of approximately 65 alternatives was compiled. Research was begun to narrow the list to the 10 best alternatives. Weekly meetings were held to discuss progress and problems of the teams. The engineering team maintained weekly contact with a representative of the Corps. The other teams met with Corps' representatives as needed. The majority of the coordination with State and local agencies was done by the Corps with information passed on to the specific research team. After considerable study, the list was narrowed to 10 alternatives.

The alternatives consisted of a wide range of action. The first alternative was a structure at the proposed initial site. A second alternative was a smaller structure located on a tributary, Coffee Creek. A larger structure on the Deep Fork River just upstream of the confluence of Coffee Creek was another course of action. A system of small lakes in the area was considered. An alternative was a dry dam (small permanent pool) located at the initial site. Downstream courses of action were: flooding easements, floodplain management, and a system of levees. A water supply from groundwater was considered. This was also analyzed in combination with the downstream alternatives. The final alternative was no action at all. One alternative should always be no action.

A tentative matrix was developed early in the study based on information from the interdisciplinary teams and initial studies on the project. After many revisions, a Water Resources Matrix (see Table VI)

TABLE VI

WATER RESOURCES MATRIX



was developed satisfactory to members of the study. The interdisciplinary team believes that each alternative should be analyzed separately and then compared to each other.

The vertical axis of the matrix was entitled "Project Elements." This axis contains actions that could affect the environment. It was primarily designed by the engineering team, with some help from the geology and zoology teams. The four main classifications are: land acquisition, relocation, alteration of regime, and operation and maintenance. One of the important aspects of this axis is that both short- and long-term effects of the project are considered. On the horizontal axis are the "Environmental Quality Elements." These are areas that could be affected by the project. This axis was designed by the other research teams in the study. There are 20 classifications grouped into three broad categories: natural resources, human social environment, and economic environment. Both quantity and quality must be considered on this axis. A difference between upstream and downstream should be noted because of project effects in these areas.

The matrix is evaluated in terms of what effects the project has on the environment. In determining values of the interactions, they should be based on facts and measurable units as much as possible. The range of values used was a +2 for a significant beneficial effect to a -2 for a significant detrimental effect. A small beneficial effect was a +1, while a small detrimental effect was a -1. Zero was used to denote no effect. After a value has been determined for each interaction, the summation for each environmental quality element is obtained and placed in the "total" boxes on the project element axis. These can then be summed. This is done for each alternative. The net value of

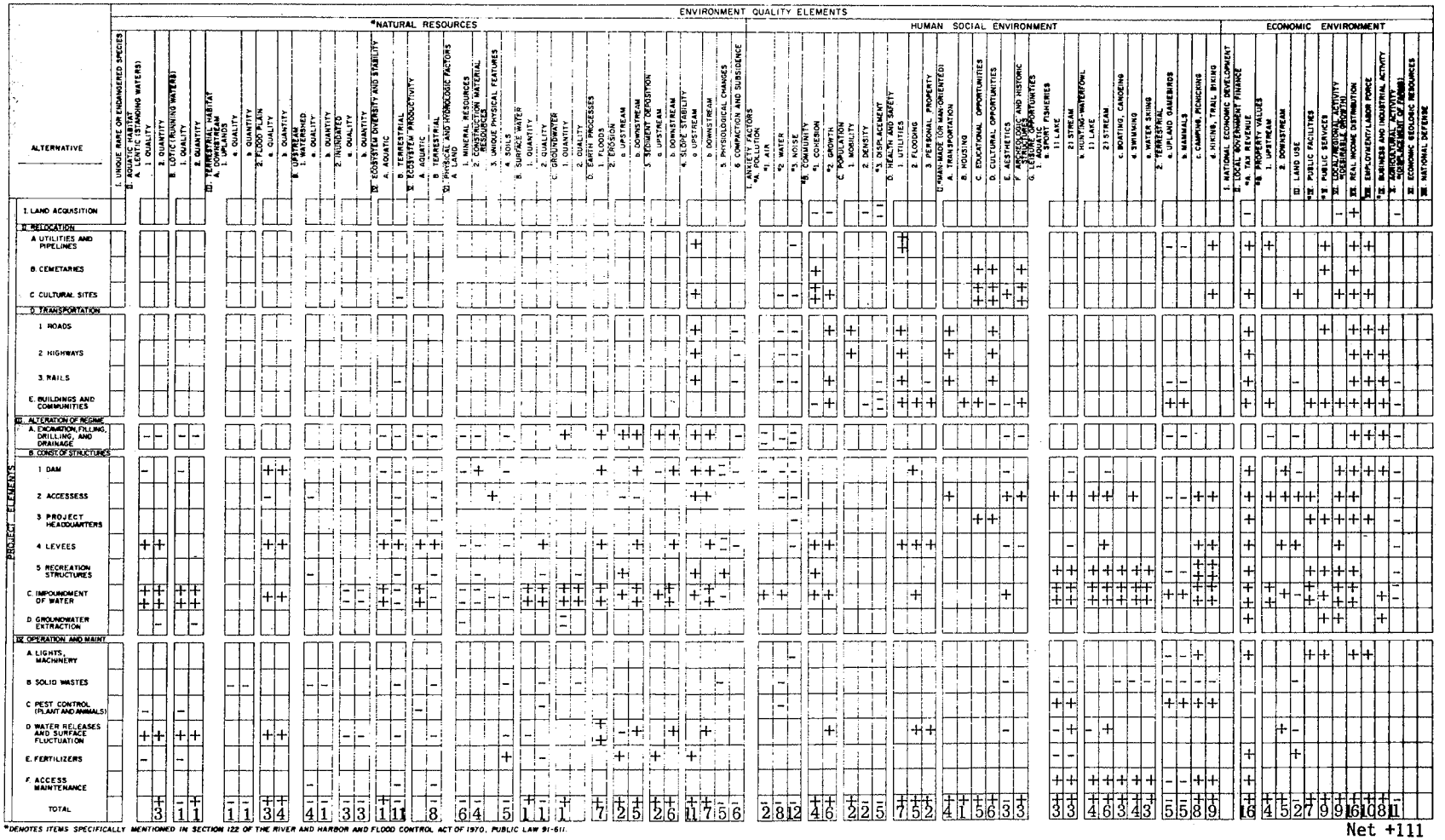
each alternative is then compared to each other to see which one has the least detrimental effect (maximum positive value). These values are then combined with economic considerations on a 60 percent to 40 percent ratio to determine the best project.

An example of a completed matrix is shown in Table VII for Alternative One, the proposed site. A look at a specific interaction will help illustrate the value system. The effect of the impoundment of water upon the lake fishing was rated a +2. If the impoundment helps create a favorable habitat for sport fishing, it is rated a +2. It is rated a +1 if some sport fishing will take place above what now occurs. A zero is for no effect or no change. A -1 value is for occasional fish kills and imbalance in the habitat. A -2 is used if the impoundment destroys the habitat so that no fish can survive.

This matrix is the result of an interdisciplinary team effort. A systematic approach was followed in evaluating the environment. This matrix is being used to determine the environmental inventory of the Arcadia project. At the present time, this matrix is the best available to evaluate a water resources project.

TABLE VII

ENVIRONMENTAL INVENTORY FOR ARCADIA, ALTERNATIVE ONE



Net +111

CHAPTER V

DISCUSSION

NEPA states that the environment is to be considered along with engineering technology and economics. Several of the matrices consider only the environment. NEPA requires an interdisciplinary team and a systematic approach. It does not state what methods should be used in these studies or what alternatives are to be considered. This has resulted in matrices being developed by agencies as the best approach. The Act states that federal officials are responsible for the environmental impact statements. To insure that the statements are adequate, federal officials have had their own agencies prepare the statements. There is no provision in the law that can stop a project. There is also no mention of where the environmental inventory is to be conducted in the planning process or that it has to be used once completed.

Circular 645 was one of the first matrices developed. It covers a wide range of actions or considerations due to its general nature. Some of the categories are difficult to analyze because they are so broad. The matrix can look at only one alternative at a time. The interactions that could occur are rated both by magnitude and importance. This allows for two judgmental values for which personal bias can affect the selection. The judgment can also be affected by the discipline of the evaluator. Some actions and areas are difficult to place a value on due to their lack of quantitative measurements. Since this is one of

the earliest matrices, it is much more subjective in nature. This matrix also considered only the environment, with no relationship with engineering and economics analyzed.

Circular 71-1 does not deal directly with the impact statements. This is primarily a system where the environment is observed and analyzed in terms of what can and cannot be built. A matrix was used as a simple way of comparison. A complete inventory of an area could be made by using geologic and soils information. This basic information could be included in the impact statements as part of the environment as is. Optimum planning for a whole region would be possible. This approach does not consider the economics of a project, nor does the matrix analyze the magnitude or importance. Either the project affects it or it does not. This approach is not subjective in nature. This initial study would present information at a minimal expense to determine if a project should be planned. If an in-depth study is to be conducted, then magnitude of the action can be determined. The information gathered in a regional study could be stored in a national data bank that would allow all agencies to use the information.

The Institute of Ecology's "Optimum Pathway" is more of a scaling or ranking approach rather than a matrix one. The determination of the component values could have some personal bias in it, although the Institute felt they kept it to a minimum. Many of the 56 components were quantifiable in comparison to the other systems. The system did include engineering and economics in the consideration of the impact index. However, it was small in nature due to the fact that only 15 components of the 56 were directly related to engineering or economics. The ranking of each alternative as compared to each other was good. Each alternative was best for some of the components. The best

alternative's component was scaled to one and the other alternatives' values were scaled down by the same factor to give values less than one. The statistical summing and comparing of the alternatives would give the best alternative. The values used in this study are limited to use in northern Georgia only. New component values would have to be determined if used elsewhere.

The Battelle Environmental Evaluation system is one of the better methods available. Written by an interdisciplinary team, it is more comprehensive in its development. The EES is good for an evaluation of the environment; however, it does not consider the engineering and economics of a project. The parameters are divided into areas of interest rather than specific actions. This is due to the concept that the environment should be looked at with and without the project. The assigning of EQU values to each parameter based upon its importance in that component is good. The scaling of the parameters' measurements to the EQU value of that parameter is an excellent idea. These remove some of the judgmental considerations that occur. Battelle recognized that there were some shortcomings of the system. This system applies only to Bureau projects. As more studies are conducted, the determination and measurement of parameters will improve.

The matrices developed by the Corps were looked at primarily based on content and other methods, as the rationale behind the system is not completely known. Both matrices are basically the same, except the later Birch matrix is more expanded. Hence this discussion will center on the Birch matrix. This matrix is the only one of the federal agencies to consider the economic as well as the environmental aspects. However, this author feels that equal weight should not be applied to

each section. Each parameter is not of equal importance. The parameter list is short. Some trade-offs could occur or an impact missed due to the lack of parameters. Judgmental factors would enter into the selection of values. The no-action alternative was the basis for other values to be determined. The comparison of the alternatives to each other was a good procedure.

The study in which this author was involved presented many of the problems involved in an environment impact study. The interdisciplinary approach is good, but the team members have trouble relating and understanding one another. A common understanding of terms had to be accomplished. Some persons felt that long-term effects should be looked at, while others felt short-term effects should be considered. Certain members, including this author, felt that long-term and short-term effects both should be considered. One very real problem throughout the study was that the engineering team was not given enough lead time, resulting in some work being delayed or redone. A major coordinator is needed to keep things running properly. There was also some justification to break the study teams into areas of interest or concern rather than departmental lines. The time and work involved indicate that a rather long time is needed to prepare impact statements. Lack of measurable parameters also caused problems in fully evaluating some actions.

The water resources matrix is at present the best available to evaluate water resources projects. Some judgmental values will enter into the evaluation. This matrix is the first to consider operation and maintenance as a project element. It is also one of the first to consider items mentioned in the 1970 Rivers and Harbors Control Act. The

environment is considered along with economics but not on an equal basis. For use in other areas, the matrix may need to be expanded.

CHAPTER VI

CONCLUSIONS

Based upon the results of this study, the following conclusions have been made:

1. The water resources matrix developed is the best one now available.

2. As time passes, matrices will get better and less subjective in value determinations.

3. An initial environmental inventory as done in the University of Texas' Circular 71-1 should be done for the entire United States.

4. The short- and long-term effects should both be analyzed.

5. The difference between the environment with and without the project should be considered.

6. Methods of analysis developed in the future should consider the environment and economics.

7. Basic data for parameters in the fields of ecology, social well-being, aesthetics, and human interests need to be determined.

8. The porportioning of the Environmental Quality Units to the parameters in the Battelle system is good.

9. The ranking of alternatives as in the University of Georgia method is good.

CHAPTER VII

SUGGESTIONS FOR FUTURE WORK

The following are suggestions for future work related to the study presented herein:

1. Is the legislative intent of Congress for NEPA being followed?

2. Does there need to be an environmental board or court that can stop any project, and what would be its makeup?

3. Would it be feasible to have a national data bank on the environment?

4. How to get the environmental inventory and analysis into the front of the planning process.

5. Determine the basic data for parameters in the fields of ecology, social well-being, aesthetics, and human interests.

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APPENDIX

THE NATIONAL ENVIRONMENTAL POLICY ACT OF 1969

Public Law 91-190 (42 U.S.C. 4321-4347)

An Act to establish a national policy for the environment, to provide for the establishment of a Council on Environmental Quality, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "National Environmental Policy Act of 1969."

Purpose

Sec. 2. The purposes of this Act are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality.

Title i

Declaration of National Environmental Policy

Sec. 101. (1) The Congress, recognizing the profound impact of man's activity on the interrelations of all components of the natural

environment, particularly the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding technological advances and recognizing further the critical importance of restoring and maintaining environmental quality to the overall welfare and development of man, declares that it is the continuing policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans.

(2) In order to carry out the policy set forth in this Act, it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may--

(a) Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;

(b) Assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings;

(c) Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;

(d) Preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible,

an environment which supports diversity, and variety of individual choice;

(e) Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and

(f) Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

(3) The Congress recognizes that each person should enjoy a healthful environment and that each person has a responsibility to contribute to the preservation and enhancement of the environment.

Sec. 102. The Congress authorizes and directs that, to the fullest extent possible: (1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in this Act, and (2) all agencies of the Federal Government shall--

(a) Utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision-making which may have an impact on man's environment;

(b) Identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by title ii of this Act, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision-making along with economic and technical considerations;

(c) Include in every recommendation or report on proposals for legislation and other major Federal actions significantly

affecting the quality of the human environment, a detailed statement by the responsible official on--

(i) The environmental impact of the proposed action,

(ii) Any adverse environmental effect which cannot be avoided should the proposal be implemented,

(iii) Alternatives to the proposed action,

(iv) The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Prior to making any detailed statement, the responsible Federal official shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Copies of such statement and the comments and views of the appropriate Federal, State, and local agencies, which are authorized to develop and enforce environmental standards, shall be made available to the President, the Council on Environmental Quality and to the public as provided by section 552 of title v, United States Code, and shall accompany the proposal through the existing agency review processes;

(d) Study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources;

(e) Recognize the worldwide and long-range character of environmental problems and, where consistent with the foreign policy

of the United States, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment;

(f) Make available to States, counties, municipalities, institutions, and individuals, advice and information useful in restoring, maintaining, and enhancing the quality of the environment;

(g) Initiate and utilize ecological information in the planning and development of resource-oriented projects; and

(h) Assist the Council on Environmental Quality established by title ii of this Act.

Sec. 103. All agencies of the Federal Government shall review their present statutory authority, administrative regulations, and current policies and procedures for the purpose of determining whether there are any deficiencies or inconsistencies therein which prohibit full compliance with the purposes and provisions of this Act and shall propose to the President not later than July 1, 1971, such measures as may be necessary to bring their authority and policies into conformity with the intent, purposes, and procedures set forth in this Act.

Sec. 104. Nothing in section 102 or 103 shall in any way affect the specific statutory obligations of any Federal agency (1) to comply with criteria or standards of environmental quality, (2) to coordinate or consult with any other Federal or State agency, or (3) to act, or refrain from acting contingent upon the recommendations or certification of any other Federal or State agency.

Sec. 105. The policies and goals set forth in this Act are supplementary to those set forth in existing authorizations of Federal agencies.

Title ii

Council on Environmental Quality

Sec. 201. The President shall transmit to the Congress annually beginning July 1, 1970, an Environmental Quality Report (hereinafter referred to as the "report") which shall set forth (1) the status and condition of the major natural, manmade, or altered environmental classes of the Nation, including, but not limited to, the air, the aquatic, including marine, estuarine, and fresh water, and the terrestrial environment, including, but not limited to, the forest, dryland, wetland, range, urban, suburban and rural environment; (2) current and foreseeable trends in the quality, management and utilization of such environments and the effects of those trends on the social, economic, and other requirements of the Nation; (3) the adequacy of available natural resources for fulfilling human and economic requirements of the Nation in the light of expected population pressures; (4) a review of the programs and activities (including regulatory activities) of the Federal Government, the State and local governments, and nongovernmental entities or individuals with particular reference to their effect on the environment and on the conservation, development and utilization of natural resources; and (5) a program for remedying the deficiencies of existing programs and activities, together with recommendations for legislation.

Sec. 202. There is created in the Executive Office of the President a Council on Environmental Quality (hereinafter referred to as the

"Council"). The Council shall be composed of three members who shall be appointed by the President to serve at his pleasure, by and with the advice and consent of the Senate. The President shall designate one of the members of the Council to serve as Chairman. Each member shall be a person who, as a result of his training, experience, and attainments, is exceptionally well qualified to analyze and interpret environmental trends and information of all kinds; to appraise programs and activities of the Federal Government in the light of the policy set forth in title i of this Act; to be conscious of and responsive to the scientific, economic, social, esthetic, and cultural needs and interests of the Nation; and to formulate and recommend national policies to promote the improvement of the quality of the environment.

Sec. 203. The Council may employ such officers and employees as may be necessary to carry out its functions under this Act. In addition, the Council may employ and fix the compensation of such experts and consultants as may be necessary for the carrying out of its functions under this Act, in accordance with section 3109 of title v, United States Code (but without regard to the last sentence thereof).

Sec. 204. It shall be the duty and function of the Council--

(1) To assist and advise the President in the preparation of the Environmental Quality Report required by section 201;

(2) To gather timely and authoritative information concerning the conditions and trends in the quality of the environment both current and prospective, to analyze and interpret such information for the purpose of determining whether such conditions and trends are interfering, or are likely to interfere, with the achievement of the policy set forth

in title i of this Act, and to compile and submit to the President studies relating to such conditions and trends;

(3) To review and appraise the various programs and activities of the Federal Government in the light of the policy set forth in title i of this Act for the purpose of determining the extent to which such programs and activities are contributing to the achievement of such policy, and to make recommendations to the President with respect thereto;

(4) To develop and recommend to the President national policies to foster and promote the improvement of environmental quality to meet the conservation, social, economic, health, and other requirements and goals of the Nation;

(5) To conduct investigations, studies, surveys, research, and analyses relating to ecological systems and environmental quality;

(6) To document and define changes in the natural environment, including the plant and animal systems, and to accumulate necessary data and other information for a continuing analysis of these changes or trends and an interpretation of their underlying causes;

(7) To report at least once each year to the President on the state and condition of the environment; and

(8) To make and furnish such studies, reports thereon, and recommendations with respect to matters of policy and legislation as the President may request.

Sec. 205. In exercising its powers, functions, and duties under this Act, the Council shall--

(1) Consult with the Citizens' Advisory Committee on Environmental Quality established by Executive Order No. 11472, dated May 29, 1969, and with such representatives of science, industry, agriculture, labor,

conservation organizations, State and local governments and other groups, as it deems advisable; and

(2) Utilize, to the fullest extent possible, the services, facilities and information (including statistical information) of public and private agencies and organizations, and individuals, in order that duplication of effort and expense may be avoided, thus assuring that the Council's activities will not unnecessarily overlap or conflict with similar activities authorized by law and performed by established agencies.

Sec. 206. Members of the Council shall serve full time and the Chairman of the Council shall be compensated at the rate provided for Level II of the Executive Schedule Pay Rates (5 U.S.C. 5313). The other members of the Council shall be compensated at the rate provided for Level IV of the Executive Schedule Pay Rates (5 U.S.C. 5313).

Sec. 207. There are authorized to be appropriated to carry out the provisions of this Act not to exceed $300,000 for fiscal year 1970, $700,000 for fiscal year 1971, and $1 million for each fiscal year thereafter.

Approved January 1, 1970.

VITA

Roger William Grebing

Candidate for the Degree of

Master of Science

Thesis: AN ANALYSIS OF THE NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 AND OF ENVIRONMENTAL IMPACT MATRICES

Major Field: Bioenvironmental Engineering

Biographical:

Personal Data: Born March 19, 1949, in Tulsa, Oklahoma, the son of Mr. and Mrs. Walter W. Grebing.

Education: Graduated from Will Rogers High School, Tulsa, Oklahoma, in May, 1967; received the degree of Bachelor of Science in Civil Engineering from Oklahoma State University, Stillwater, Oklahoma, in January, 1972; completed requirements for the Master of Science degree at Oklahoma State University, Stillwater, Oklahoma, in May, 1973.

Professional Experience: Engineer trainee for the United States Army Corps of Engineers, Tulsa District, during the summers of 1968 through 1971; bioenvironmental engineering trainee, January, 1972 through December, 1972; graduate research assistant and teaching assistant, January, 1973 through May, 1973.

FIGURE 2

GEOLOGIC MAP

OF

WESTERN PAYNE COUNTY, OKLAHOMA

BY

ARTHUR JOHN GARDEN

1973

SCALE 1/63,360

0 1 MILE

STRUCTURAL CONTOURS ON TOP OF FORT RILEY LIMESTONE

NTERVAL 40 FEET

N

R 2 E

R 1 W

NOBLE COUNTY

R 1 E

LOGAN COUNTY

LINCOLN COUNTY

LAKE CARL BLACKWELL

STILLWATER

T 20 N

T 19 N

T 18 N

T 17 N

RAILROAD

SAND PIT

ROCK QUARRY

STRATIGRAPHIC CONTACTS
Dashed where infered

Castile, 1929, Sun Oil Co.

Chandler, P. P., 1960

Ellison, C. W., 1951

Hudson, H. K., 1925, Cities Service Oil Co.

Peabody, H. W., 1923-1925, Sun Oil Co.

Rixleben, 1930, Skelly Oil Co.

Schmurr, C., 1952, Sun Oil Co.

INTERSTATE HIGHWAY

U.S. HIGHWAY

STATE HIGHWAY

PAVED ROAD

IMPROVED ROAD

EXPLANATION

QUATERNARY

Qal

ALLUVIUM

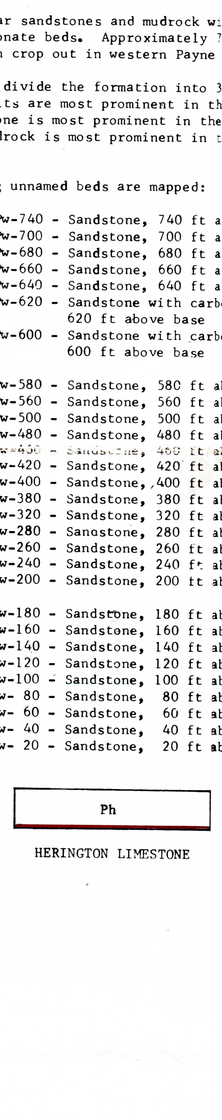
Sand, silt, and clay of present streams.

Qt

TERRACE DEPOSITS

Sand, silt, and clay with associated eolian deposits.

NORTH — SOUTH



WELLINGTON FORMATION

Red lenticular sandstones and mudrock with thin nodular carbonate beds. Approximately 780 ft of the formation crop out in western Payne County.

Two key beds divide the formation into 3 units. Carbonate units are most prominent in the upper unit; sandstone is most prominent in the middle unit; and mudrock is most prominent in the lower unit.

The following unnamed beds are mapped:

Upper Key Bed

- Pw-740 - Sandstone, 740 ft above base
- Pw-700 - Sandstone, 700 ft above base
- Pw-680 - Sandstone, 680 ft above base
- Pw-660 - Sandstone, 660 ft above base
- Pw-640 - Sandstone, 640 ft above base
- Pw-620 - Sandstone with carbonate, 620 ft above base
- Pw-600 - Sandstone with carbonate, 600 ft above base

- Pw-580 - Sandstone, 580 ft above base
- Pw-560 - Sandstone, 560 ft above base
- Pw-500 - Sandstone, 500 ft above base
- Pw-480 - Sandstone, 480 ft above base
- Pw-460 - Sandstone, 460 ft above base
- Pw-420 - Sandstone, 420 ft above base
- Pw-400 - Sandstone, 400 ft above base
- Pw-380 - Sandstone, 380 ft above base
- Pw-320 - Sandstone, 320 ft above base
- Pw-280 - Sandstone, 280 ft above base
- Pw-260 - Sandstone, 260 ft above base
- Pw-240 - Sandstone, 240 ft above base
- Pw-200 - Sandstone, 200 ft above base

Lower Key Bed

- Pw-180 - Sandstone, 180 ft above base
- Pw-160 - Sandstone, 160 ft above base
- Pw-140 - Sandstone, 140 ft above base
- Pw-120 - Sandstone, 120 ft above base
- Pw-100 - Sandstone, 100 ft above base
- Pw- 80 - Sandstone, 80 ft above base
- Pw- 60 - Sandstone, 60 ft above base
- Pw- 40 - Sandstone, 40 ft above base
- Pw- 20 - Sandstone, 20 ft above base

PERMIAN SYSTEM

LEONARDIAN SERIES

WOLFCAMPIAN SERIES

Ph

HERINGTON LIMESTONE

II PROPOSED ACTIONS WHICH MAY CAUSE ENVIRONMENTAL IMPACT

INSTRUCTIONS

1- Identify all actions (located across the top of the matrix) that are part of the proposed project.

2- Under each of the proposed actions, place a slash at the intersection with each item on the side of the matrix if an impact is possible.

3- Having completed the matrix, in the upper left-hand corner of each box with a slash, place a number from 1 to 10 which indicates the MAGNITUDE of the possible impact; 10 represents the greatest magnitude of impact and 1, the least, (no zeroes). Before each number place + if the impact would be beneficial. In the lower right-hand corner of the box place a number from 1 to 10 which indicates the IMPORTANCE of the possible impact (e. g. regional vs. local); 10 represents the greatest importance and 1, the least (no zeroes).

4- The text which accompanies the matrix should be a discussion of the significant impacts, those columns and rows with large numbers of boxes marked and individual boxes with the larger numbers.

SAMPLE MATRIX

	a	b	c	d	e
a		2/1			8/5
b		7/2	8/8	3/1	9/7

PROPOSED ACTIONS	A. MODIFICATION OF REGIME	B. LAND TRANSFORMATION AND CONSTRUCTION	C. RESOURCE EXTRACTION	D. PROCESSING	E. LAND ALTERATION	F. RESOURCE RENEWAL	G. CHANGES IN TRAFFIC	H. WASTE EMPLACEMENT AND TREATMENT	I. CHEMICAL TREATMENT	J. ACCIDENTS	OTHERS
	a. Exotic flora or fauna introduction	a. Urbanization	a. Blasting and drilling	a. Farming	a. Erosion control and terracing	a. Reforestation	a. Railway	a. Ocean dumping	a. Fertilization	a. Explosions	a.
	b. Biological controls	b. Industrial sites and buildings	b. Surface excavation	b. Ranching and grazing	b. Mine sealing and waste control	b. Wildlife stocking and management	b. Automobile	b. Landfill	b. Chemical deicing of highways, etc.	b. Spills and leaks	b.
	c. Modification of habitat	c. Airports	c. Subsurface excavation and retorting	c. Feed lots	c. Strip mining rehabilitation	c. Ground water recharge	c. Trucking	c. Emplacement of tailings, spoil and overburden	c. Chemical stabilization of soil	c. Operational failure	
	d. Alteration of ground cover	d. Highways and bridges	d. Well drilling and fluid removal	d. Dairying	d. Landscaping	d. Fertilization application	d. Shipping	d. Underground storage	d. Weed control		
	e. Alteration of ground water hydrology	e. Roads and trails	e. Dredging	e. Energy generation	e. Harbor dredging	e. Waste recycling	e. Aircraft	e. Junk disposal	e. Insect control (pesticides)		
	f. Alteration of drainage	f. Railroads	f. Clear cutting and other lumbering	f. Mineral processing	f. Marsh fill and drainage		f. River and canal traffic	f. Oil well flooding			
	g. River control and flow modification	g. Cables and lifts	g. Commercial fishing and hunting	g. Metallurgical industry			g. Pleasure boating	g. Deep well emplacement			
	h. Canalization	h. Transmission lines, pipelines and corridors		h. Chemical industry			h. Trails	h. Cooling water discharge			
	i. Irrigation	i. Barriers including fencing		i. Textile industry			i. Cables and lifts	i. Municipal waste discharge including spray irrigation			
	j. Weather modification	j. Channel dredging and straightening		j. Automobile and aircraft			j. Communication	j. Liquid effluent discharge			
	k. Burning	k. Channel revetments		k. Oil refining			k. Pipeline	k. Stabilization and oxidation ponds			
	l. Surface or paving	l. Canals		l. Food				l. Septic tanks, commercial and domestic			
	m. Noise and vibration	m. Dams and impoundments		m. Lumbering				m. Stack and exhaust emission			
		n. Piers, seawalls, marinas, and sea terminals		n. Pulp and paper				n. Spent lubricants			
		o. Offshore structures		o. Product storage							
		p. Recreational structures									
		q. Blasting and drilling									
		r. Cut and fill									
		s. Tunnels and underground structures									

I EXISTING CHARACTERISTICS AND CONDITIONS OF THE ENVIRONMENT

A. PHYSICAL AND CHEMICAL CHARACTERISTICS

1. EARTH
- a. Mineral resources
- b. Construction material
- c. Soils
- d. Land form
- e. Force fields and background radiation
- f. Unique physical features

2. WATER
- a. Surface
- b. Ocean
- c. Underground
- d. Quality
- e. Temperature
- f. Recharge
- g. Snow, ice, and permafrost

3. ATMOSPHERE
- a. Quality (gases, particulates)
- b. Climate (micro, macro)
- c. Temperature

4. PROCESSES
- a. Floods
- b. Erosion
- c. Deposition (sedimentation, precipitation)
- d. Solution
- e. Sorption (ion exchange, complexing)
- f. Compaction and settling
- g. Stability (slides, slumps)
- h. Stress-strain (earthquake)
- i. Air movements

B. BIOLOGICAL CONDITIONS

1. FLORA
- a. Trees
- b. Shrubs
- c. Grass
- d. Crops
- e. Microflora
- f. Aquatic plants
- g. Endangered species
- h. Barriers
- i. Corridors

2. FAUNA
- a. Birds
- b. Land animals including reptiles
- c. Fish and shellfish
- d. Benthic organisms
- e. Insects
- f. Microfauna
- g. Endangered species
- h. Barriers
- i. Corridors

C. CULTURAL FACTORS

1. LAND USE
- a. Wilderness and open spaces
- b. Wetlands
- c. Forestry
- d. Grazing
- e. Agriculture
- f. Residential
- g. Commercial
- h. Industrial
- i. Mining and quarrying

2. RECREATION
- a. Hunting
- b. Fishing
- c. Boating
- d. Swimming
- e. Camping and hiking
- f. Picnicking
- g. Resorts

3. AESTHETICS AND HUMAN INTEREST
- a. Scenic views and vistas
- b. Wilderness qualities
- c. Open space qualities
- d. Landscape design
- e. Unique physical features
- f. Parks and reserves
- g. Monuments
- h. Rare and unique species or ecosystems
- i. Historical or archaeological sites and objects
- j. Presence of misfits

4. CULTURAL STATUS
- a. Cultural patterns (life style)
- b. Health and safety
- c. Employment
- d. Population density

5. MAN-MADE FACILITIES AND ACTIVITIES
- a. Structures
- b. Transportation network (movement, access)
- c. Utility networks
- d. Waste disposal
- e. Barriers
- f. Corridors

D. ECOLOGICAL RELATIONSHIPS SUCH AS:
- a. Salinization of water resources
- b. Eutrophication
- c. Disease-insect vectors
- d. Food chains
- e. Salinization of surficial material
- f. Brush encroachment
- g. Other

OTHERS
- a.
- b.

COMPUTATIONS

COMPUTATIONS

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1971

Small quantities of this chart are available upon request from Distribution Section, U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202

INFORMATION MATRIX FOR ENVIRONMENTAL IMPACT ASSESSMENT