FINAL REPORT

EFFICIENT AND EQUITABLE SOLUTION OF INDIAN RESERVED RIGHTS

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University of Arizona

Water Resources Research Center

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ABSTRACT

The water rights claims of many Indian reservations in the West are now under adjudication. Frequently, the parties to these adjudications acknowledge that their interests may be better served through negotiated settlements, but they lack comprehensive means for determining mutually acceptable solutions to the conflicts. The research conducted under the title of "Efficient and Equitable Solution of Indian Reserved Rights" (Project #14-08-0001-G1320) sought to 1) develop a conceptual basis for determining Indian water rights; 2) develop an analytical procedure to provide the information needed to resolve water rights conflicts; and 3) apply this analytical procedure to a test case involving the Gila River Basin in Arizona. The methodological core of the research is a set of linked models, encompassing historical, hydrologic, economic, psychological, and institutional elements of the conflict. Hydrologic, institutional, and economic analyses of conjunctive management of surface and groundwater supplies were facilitated by the use of MODSIM, a network optimization model.

Data from the model enabled the investigators to construct an impact matrix, defining the effect of each possible settlement option on the goals of the parties. The preferences of the parties were elicited through social judgement analysis. Twelve settlement options were defined on the basis of knowledge of other negotiated settlements, and a final option, representing possible outcomes should the negotiation process fail, was included in the analysis. The next step was to model the possible choices available the contending parties, utilizing an n-person cooperative game framework. This analysis indicated that a set of three settlement options dominated the adjudication option for all players. Each of these included the provision of imported water in lieu of water currently being used in the basin. It is anticipated that the results of this research will be developed as a book-length manuscript by the principal investigators and the research team.

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INTRODUCTION

Indian water rights claims are presently being adjudicated in almost every Western state. Such claims are usually very senior and are still unquantified. They create an atmosphere of uncertainty for both Indian and non-Indian water users alike. Indians look to the acquisition of senior water rights as a major way of increasing tribal resources and improving the possibilities for achieving tribal goals. Non-Indian water users fear the possibility of weakened priority, increased uncertainty of water supplies, and economic losses. Federal authorities pursue conflicting objectives, responsive as they must be to trust responsibilities to tribes, political pressures from states and organized water constituent groups, and the fiscal responsibility to control federal outlays.

Determination of the water rights of an Indian reservation depends upon an understanding of the purposes for which the reservation was established, for the tribes are held to be entitled to enough water to fulfill those purposes. Court interpretations have varied over the years, but in 1963, in <u>Arizona v. California</u>, the Supreme Court established the provisional standard of practically irrigable acreage (PIA). It now appears that the PIA standard should be reexamined, for it violates norms of equity by treating Indian tribes quite differently (some reservations have little or no PIA, while others have vast amounts) and also places the burden of achieving the goals of national Indian policy on non-Indian water users. Negotiated settlement of

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Indian water rights conflicts, a complement to litigation and legislation, is becoming increasingly important throughout the West. Many water users and Indian tribes are finding that their objectives can best be met, and conflicts over water rights resolved, through negotiated settlements. Such negotiations have not been easily initiated, conducted, or implemented, however. Affected parties have not always grasped the potential benefits of negotiation, and have not always been able negotiators. Better information about the possibilities of negotiated settlements, about the objectives of other parties, about the hydrologic and social realities which constrain both negotiation and litigation, and about available settlement options and their potential consequences is needed to facilitate the negotiation process.

Objectives

The three objectives of the research reported herein all address the need for better information to support the negotiation process. Those objectives were:

1) To develop a conceptual basis for establishing Indian water rights.

2) To develop an analytical procedure which will provide the information needed to resolve specific Indian water rights conflicts.

3) To apply the proposed analytical procedure in one test case, a portion of the Gila River Basin in Arizona.

Methodology

The research project, which was conducted from 1986 to 1989, was broadly interdisciplinary, reflecting the fact that the problem of negotiating settlements of Indian water rights claims

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cannot be subsumed within the subject matter of any single discipline. It has hydrologic, environmental, anthropological, economic, legal, political, and psychological aspects. Consequently, the methodology employed is multidisciplinary. It relies upon the concept of linked models. Linked models are commonly used in hydrology, where surface and groundwater models are sometimes linked, and in economics, where programming models and demand models are sometimes linked. Seldom, however, have so many models, from so broad an array of disciplines, been linked as has been attempted in this study. The linkage of these diverse models, in this case historical, legal, hydrologic, economic, psychological, and political, is the chief theoretical and methodological contribution of the study..

Three of the linked models were formal mathematical ones. A hydrologic-institutional-economic network optimization model described the workings of the system in which the conflict was embedded. A multiple regression preference elicitation model described the objectives of the contending parties in the conflict. Finally, an n-person cooperative game theory model described the conflict itself.

The research project consisted of the following eight tasks:
1)   Comprehensive Policy Review

A comprehensive review of federal Indian policy, reservation establishment and maintenance, and issues of social equity in Indian affairs, was conducted by T.R. McGuire, co-principal investigator and Assistant Research Anthropologist in the Bureau of Applied Research in Anthropology. McGuire's paper reporting on this task is being revised for publication. It provides a

recapitulation of the stated purposes of the reservation policy when it was established, of the evolution of those purposes during the implementation period of the past century, and of alternative purposes which were advanced by the executive, legislative, and judicial branches throughout this period. McGuire identified economic self-sufficiency, tribal sovereignty, and cultural pluralism as the central purposes of federal Indian policy. His work was reviewed by two legal scholars.

A critical evaluation of the PIA standard as a basis for awarding Indian water rights was conducted by Donn Stoltzfus, a graduate research assistant in water resources administration. After reviewing the Winters doctrine and the PIA standard, he concludes that the latter is an inadequate means for advancing Indian well-being, while at the same time unnecessarily penalizing non-Indian water users. The Stoltzfus paper will be expanded into an M.S. thesis, and will be summarized in a journal article by Stoltzfus and Lord.

2)   Conflict Mapping

Conflict mapping means assembling pertinent information about a particular conflict. Pertinent information refers to that information which is likely to be most useful in subsequent resolution of the conflict. It includes such obviously necessary data as the identities of the principal parties to the conflict, the factual basis of the conflict, the existing institutions (laws, rules, regulations, rights, accepted procedures) which may constrain or facilitate conflict resolution, the history of the conflict, and the goals of the parties.

Abbreviated conflict maps were constructed for each of the

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six sub-basins within the Gila River Basin. During the mapping process it became apparent that the San Pedro River Basin would be the best choice for the case study contemplated in the research plan because it was the only one of the six sub-basins for which a hydrographic survey report would be available during the study period. A hydrographic survey report (HSR) is a document compiled by the Arizona Department of Water Resources as a basic information source for the Court and the involved parties in the Gila River adjudication. It contains a listing of all claims filed with the Court and as complete a description of the hydrology of the basin as available data permit.

Two main sources of information were used for detailed mapping of the case study conflict. They were the San Pedro HSR and interviews with parties to the conflict conducted by research team members T.R. McGuire and Mary Wallace, political science research assistant with the Water Resources Research Center. They were assisted by M. Gianesello, graduate research assistant in native American studies. The interviews provided essential information not included in the HSR, such as the goals of the parties and their ideas about possible options for resolving the conflict. Personal and phone interviews were conducted with representatives of the following parties:

Table 1: FIELD INTERVIEWS

Indian Reservations:
    Gila River Indian Community
    San Carlos Indian Reservation
    Salt River Indian Reservation

Federal Agencies:
    Bureau of Indian Affairs
    Department of Interior, Office of the Field Solicitor
    Bureau of Land Management

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State Agencies:
        Arizona Department of Water Resources
        Arizona Attorney Generals office
        Arizona State Land Department
        Maricopa County Superior Court

Local Governments\Water Management Entities:
        City of Sierra Vista
        Cochise County Board of Supervisors
        San Pedro Water Resources Association

Water Users and Providers:
        Salt River Project
        San Carlos Irrigation District
        St. David Irrigation District

The conflict map of the San Pedro Sub-Basin is essentially a descriptive data base that supports subsequent analytical efforts aimed at conflict resolution. These data themselves provide little help to the conflicting parties without those subsequent analyses. Therefore, no separate publication of the results of the conflict mapping task is contemplated.

3)   Analysis of Alternative Water Allocations.

A model of the hydrologic and economic system of water allocation within the San Pedro basin was needed to facilitate exploration of conflict resolution alternatives. MODSIM, a network optimization model employing the out-of-kilter algorithm and specified for a conjunctive surface and groundwater management system by John Labadie and his colleagues at Colorado State University was chosen for this purpose. MODSIM not only models the typical dendritic hydrologic system efficiently but also permits water allocation to be responsive to a set of generalized criteria which may be specified to simulate the prior appropriation doctrine, water markets, or other institutional options. Water may be introduced to the system and withdrawn from it at

San Pedro River Watershed
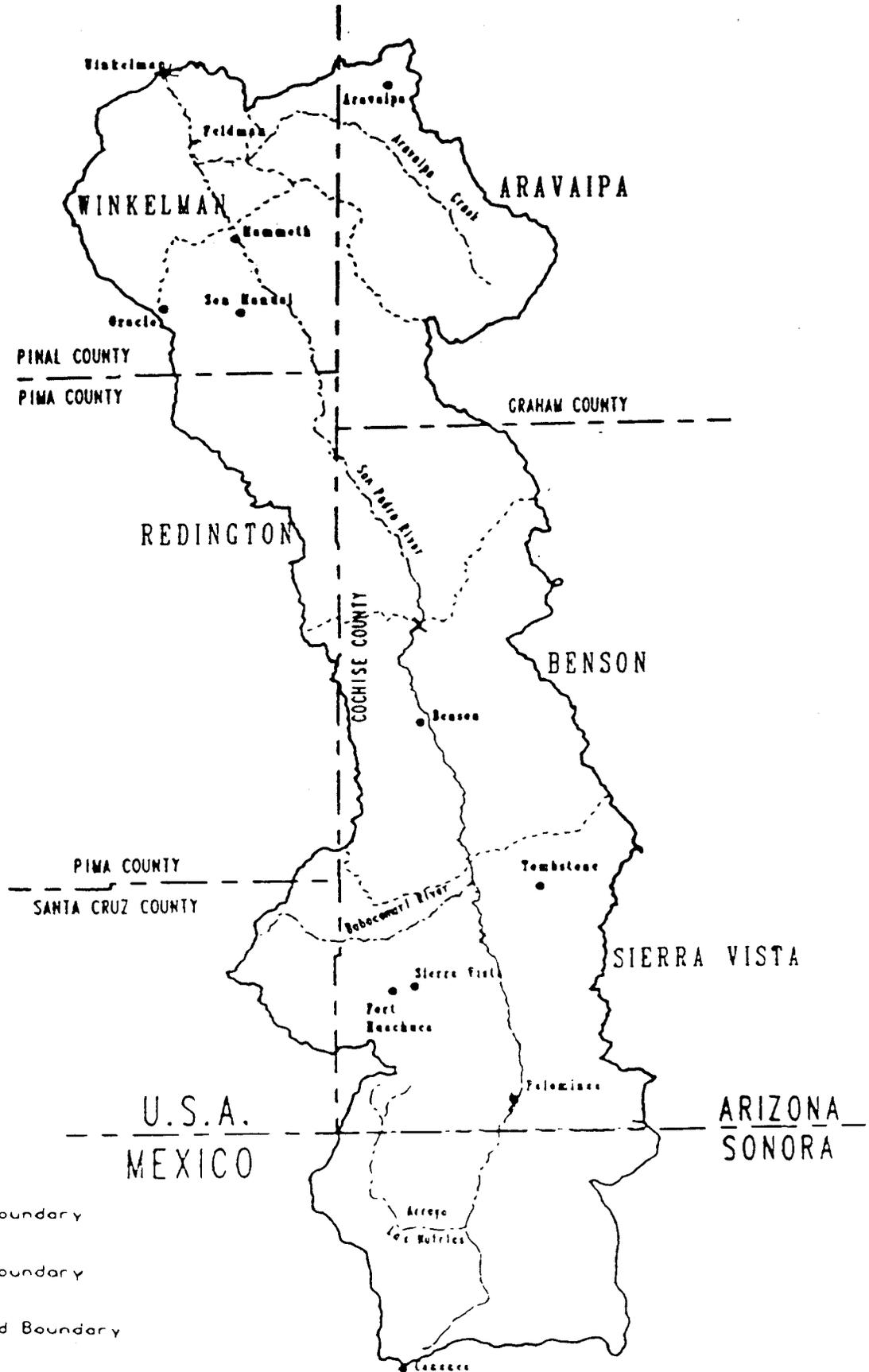
Legend:
- Political Boundary
- Watershed Boundary
- Subwatershed Boundary

any point (node), subject to availability and cost.

A variety of data were collected in order to specify the MODSIM model for the San Pedro Basin. Hydrologic and water rights data were obtained from the HSR. A ten year period of record was chosen, encompassing both wet and dry periods. Water demand projections were constructed from current use data and municipal growth projections for urban areas. Economic estimates of the marginal value of water in alternative uses, including irrigation on the Gila Indian Reservation, were formulated from farm budget data and from opportunity cost data for urban and industrial water supply sources.

Several team members worked on the specification of the MODSIM model to represent the San Pedro Basin. Donn Stoltzfus and P. Schwartzman, M. S. candidate in hydrology, developed the hydrologic and water rights information. An economic analysis of water use in the basin and final specification of the MODSIM model were accomplished by W. Bazlen, whose M.S. thesis in water resources administration summarizes this study and was completed in early 1989.

4) Definition of Options

The conflict mapping exercise yielded one set of suggested alternatives for resolving the Indian water rights conflict in the San Pedro Sub-Basin, namely that set suggested by the participants themselves. However, another method was employed to enrich the range of alternative settlement options to be evaluated. Mary Wallace collected information about the characteristics of seven pending or finalized Indian water rights settlements. An explicit analytical framework was designed and employed to

reveal the strategically important aspects of those settlements. From this, the research team was able to identify common elements, as well as differences, and deduce those features which seemed to be necessary for conflict resolution. They were awards of water rights to tribes, no uncompensated diminution of water rights of non-Indian water users, and federal financial responsibility for all or most of the costs incurred, with the federal contribution on the order of fifty million dollars per settlement. Another common feature was federal water supply augmentation in those instances where appropriable water resources were insufficient to support the award of rights to tribes. A separate paper is in preparation reporting the results of this examination and analysis of prior settlements. Elements of these settlements are summarized in the following table:

Table 2: SUMMARY OF INDIAN WATER RIGHTS SETTLEMENTS

Settlement	Amount of water	Total costs ($)	Federal costs ($)	State costs ($)	Indian costs ($)	Local costs ($)
Ak-Chin	75,000af	66.70M	65.70M	1.00M	-	-
SAWRSA	76,000af	32.25M	26.75M	2.50M	UK	3.00M
San Luis	45,200af	8.85M	3.00M	-	2.15M	3.70M
Salt River	122,400af	165.30M	60.10M	-	22.00M	83.20M
Ute Tribes (two tribes/states)	126,400af	592.60M	501.10M	91.50M	-	-
Ute Compact	258,943af	UK	UK	UK	UK	UK
Fort Peck	950,000af	NA	NA	NA	NA	NA

UK - unknown, NA - not applicable

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Thirteen different settlement options were identified on the basis of the research described above. They differed in several respects. First, the amount of San Pedro water awarded to the Gila River Indian Reservation could range from no new awards to the undepleted virgin flow of the river at the upstream boundary of the reservation. Second, imported water could be awarded to the Indians in place of San Pedro water, up to the same virgin flow constraint. The imported water in this case would consist of Central Arizona Project water, which can be delivered to the reservation. Third, the costs of making this water available to the Indians could be borne in various ways. The entire burden might be borne by the junior appropriators on the San Pedro, through loss of water rights, the burden could be spread more generally among all of the San Pedro water users, or the burden could be borne by the federal taxpayer. Combinations are also possible. Fourth, the Indians could be awarded monetary payments or subsidies to permit them to develop new water. Again, the burden of doing so could be spread in various ways. Fifth, the Indians could be awarded monetary payments in lieu of new water, and be permitted to use these funds for economic development purposes on the reservation. This burden could also be assigned in various ways. Sixth, water marketing could be permitted in order to allow limited water supplies to flow to their highest uses, and thus to minimize the social costs of any award to the Indians.

In addition, the research team projected three possible outcomes of a failure to reach a negotiated settlement. Failure to negotiate successfully in this case meant that the Gila River

Adjudication would proceed to its conclusion unassisted and that the court would then face the more limited options of awarding available San Pedro water to the claimants without the flexibility to consider imported water, to compensate the Indians monetarily, or to specify cost-sharing arrangements. Since no one can foresee how much San Pedro water the court might award to the Indians we defined three different possibilities and assigned probabilities to them. This probability assignment was highly arbitrary, so that provision was made for changing it easily in subsequent analytical efforts. Failure to reach a negotiated settlement was taken to imply that a probability-weighted combination of the three possible adjudication outcomes would have to be considered by the parties. The settlement and adjudication alternatives are listed in the following table.

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Table 3: ALTERNATIVES FOR NEGOTIATED SETTLEMENTS

1. Award to Indians in San Pedro water - full hydrologic
        entitlement - 9000 af
    Federal government pays development costs and purchases lower
        basin agricultural rights

2. Award to Indians in San Pedro water - full hydrologic
        entitlement - 9000 af
    Federal government pays development costs
    Mines, municipalities, and upper basin agricultural users
        purchase lower basin agricultural rights

3. Award to Indians in San Pedro water - full hydrologic
        entitlement - 9000 af
    Federal government pays the development costs
    San Pedro users provide the water with no water marketing
        allowed

4. Award to Indians in San Pedro water - full hydrologic
        entitlement - 9000 af
   Federal government does not pay development costs or
        compensate San Pedro users
   Mines, municipalities, and upper basin agricultural users
        purchase lower basin agricultural rights

5. Award to Indians in San Pedro water - full hydrologic
        entitlement - 9000 af
   Federal government does not pay development costs or
        compensate San Pedro users
   San Pedro water users provide water, no water marketing

6. Award to Indians in CAP water
   Federal government pays development costs and CAP costs

7. Award to Indians in CAP water
   Federal government pays the development costs
   San Pedro water users pay the CAP costs

8. Award to Indians in CAP water
   Federal government does not pay development costs but does
   pay CAP costs

9. Award to Indians in CAP water
   Federal government does not pay development costs
   San Pedro water users pay CAP costs

10. Award to Indians in money
    Federal government pays all costs

11. Award to Indians in money
    San Pedro water users pay all costs

12. Award to Indians in money
    Federal government pays 50% of the costs
    San Pedro water users pay 50% of the costs

13. Adjudication alternative - Indians win water, pay court
         costs
    Federal government pays court costs
    San Pedro water users lose water and pay court costs
    Probability = .6

14. Adjudication alternative - Indians do not receive water
        and pay court costs
    Federal government pays court costs
    San Pedro water users do not lose water and do pay court
        costs
    Probability = .2

15. Adjudication alternative - Indians win water and pay court
        costs
    Marketing is allowed
    Federal government pays court costs
    San Pedro pays court costs
    Mines, municipalities and upper basin agricultural users
        purchase lower basin agricultural rights
    Probability = .2

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5) Determination of Preferences

    Consideration of a possible settlement option by a poten-

tially affected party depends not only upon the objective charac-

teristics of that option (its potential impacts upon water dis-

tribution and use, monetary exchanges between the parties, etc.)

but also upon how the affected party assesses the importance or

value of any impacts to it. In order to model the negotiation,

then, it is necessary to model the preferences or values of the

negotiators.

    There are several ways to do this. One way is to let the

parties themselves choose between options. In a real negotia-

tion, as opposed to a research project, this would be the best

way. It was not a possibility for us because we did not wish to

intervene in or influence the San Pedro case in any way. A

second way is to model the preference functions of the parties

using available information. We chose this method in the sole

instance of the federal government because the government is a

very complex entity with many interests at stake in the situa-

tion, including its trust responsibility to the Indians, its proprietary responsibility as manager of land within the basin, its political responsibility to constituent groups at interest, and its fiscal responsibility to all federal taxpayers. It would have been impossible to find an individual to represent or to role play for the government, and in any case, we judged the Reagan Administration's Indian policy, particularly as it was manifest in Indian water rights matters, to be sufficiently different from both previous administrations and those likely to follow that we sought a broader view. As previously discussed, Tom McGuire conducted a review of federal Indian policy, from which three trust responsibility objectives were isolated. The research team then worked out operational definitions of these policy objectives so that degree of attainment could be measured with available data.

A third way of defining the preference functions of parties to the negotiation is to role play. We chose this method for all parties save the federal government. Research team members interviewed representatives of the parties and achieved a sense of what was important to them. As a result, team members were able to play the roles of the negotiating parties with some degree of knowledge and empathy. Intensive discussions among the research team members were used to identify the variables which were strategically important to the negotiators' preference functions (their underlying values). These values then became the pertinent impact categories for evaluating conflict resolution options.

Next, instead of attempting to represent the underlying

preference functions directly we asked each role playing team member to evaluate a series of profiles which were characterized by randomly chosen levels of attainment of the relevant impact categories. Although randomly chosen, the values of these variables fell within what we estimated to be the relevant range of impacts of the real solution options. Multiple regression analyses were performed on the resulting data sets, thus yielding linear representations of the preference functions, together with estimates of the internal consistency of the respondents' judgments (this technique is known as social judgment analysis, and has been applied also in the Bureau of Reclamation's MATS approach for water planning and conflict resolution).

Also included in the social judgment analysis was a stochastic variable, the response to which permitted us to estimate the respondent's risk preference. Quantification of risk preference was necessary because the three potential adjudication outcomes, each of which was characterized by a stated probability of occurrence, had to be combined into a single weighted outcome which represented the potential consequence of unsuccessful negotiations. W. Lord led the social judgment analysis study, assisted by M. Osborne, research assistant in the Water Resources Research Center. McGuire has proposed to extend this work in the context of a proposal for further study of the San Pedro Basin, addressing federal environmental objectives for the recently acquired BLM San Pedro riparian natural area.

6)   Modeling of Options and Strategies

The twelve potential settlement options identified in (3) above, and the thirteenth option arising out of failure to nego-

tiate successfully, constituted the only theoretically possible outcomes, in the sense that they incorporated the hydrologic and economic reality constraints which any settlement would have to accommodate. They did not reflect or imply anything about the negotiation process, and it was not clear whether any or all of them were possible of attainment within the context of that process. The next step, then, was to model the possible choices available to each of the contending parties. Choices of this kind are often called alternatives or options. We shall call them alternatives, since we have used the term option to refer to a possible result of negotiations rather than a possible choice within the process.

Indians, for example, could demand all of the San Pedro water to which they could conceivably be entitled (the reconstructed virgin flow) and refuse to settle for less. Alternatively, they could agree to accept a lesser award. They could demand monetary compensation, either in lieu of water or in addition to it. They could agree to accept imported (CAP) water in lieu of San Pedro water. The possible alternatives available to each player were studied and systematically recorded by the research team. There were five or six such alternatives for each.

At this point it was necessary to select an analytical technique for identifying which of the possible combinations of alternatives might result in settlement options which would be desirable to all of the conflicting parties. A. Rakshit, doctoral candidate in systems and industrial engineering, W. Lord, and L. Duckstein constructed a set of hypothetical but broadly situa-

tion-based alternatives and options, together with data approximating those which were anticipated to characterize the San Pedro Basin conflict. A variety of n-person cooperative game theory solution concepts were estimated for this data set. The investigators found that all of the solution concepts yielded almost identical results on this data set. This finding was the basis for a paper by Rakshit, Lord, and Duckstein which was presented at the 1988 annual meeting of the Operations Research Society of America. Further investigations along these lines, employing the expanded and empirically better based data set which finally emerged from the research project are still to be completed, although this is not a part of the original research plan.

The next step was to construct a matrix which would reveal which of the thirteen possible options would result from each possible combination of player alternatives. This matrix, which would contain many thousands of elements, would be very difficult to construct element by element. However, the great majority of those elements would consist of the thirteenth option, since the alternatives selected by the players would be mutually inconsistent, with the result that negotiations would fail and the adjudication would proceed unassisted.

Consequently, it was possible to follow a much simpler procedure which identified those elements which consisted of some option other than the thirteenth. This meant that subsequent analytical steps could be based solely upon the thirteen settlement options, not on the very much larger alternatives matrix. It is important to note that this simplification was possible only because the players' alternatives were defined to be inde-

pendent of each other and because the negotiating process was taken to be a game with only a single move. To so define it takes much of the meaning out of the phrase "negotiating process" and eliminates the notion of a strategy altogether. However, the objective of the research project was not to study the negotiating process per se but to provide information useful to it. We believe that this simplification does exactly that, and relieves us of the burden of providing information which would be competitively useful to any of the parties, confining our information to that which is cooperatively useful to them.

The final analytical step was to assess the prospective consequences, or outcomes, of the several settlement options (and, by implication, the players' alternative choices which led to their realization) to determine which were valid conflict resolution possibilities. A valid conflict resolution possibility is an option the outcomes or impacts of which are superior to the outcomes or impacts of failing to negotiate from every player's perspective. In other words, all the parties will continue to negotiate rather than drop out and rely on the adjudication. If there are no such possibilities then negotiations are doomed from the start. If there is only one such possibility then negotiations are theoretically unnecessary since all will agree immediately upon it. In the more usual case that multiple possibilities are found one would expect negotiations to occur between the players to find a single solution, and that those negotiations could proceed with the assurance that a successful outcome was likely.

Each settlement option was characterized by its potential impacts upon the preference functions of the several contending parties. These preference functions had been defined operationally in terms which were consistent with the outputs of the MODSIM model of the San Pedro Basin. It remained only to run the MODSIM model under sets of alternative assumptions regarding water demands and priorities which were consistent with the terms of the settlement options. The result was an impact matrix showing how each party would be affected, in terms of the variables important to it, by each of the settlement options.

Next, the impact matrix was transformed into a utility matrix by multiplying it by the vector of regression coefficients produced by the preference elicitation exercise conducted in (5) above. The elements of the utility matrix are real numbers ranging roughly from -10 to +10. They provide an ordering of the settlement options for each player. The higher the utility index, the more desirable that option to the player. The utility indices have absolutely no meaning for interplayer comparisons.

Finally, the utility indices for each settlement option were compared to the utility indices of the thirteenth (adjudication) option. Any option for which each player's utility index was higher than the index of the adjudication option for that player can be said to dominate the adjudication option (it is preferred to it by all players), and is therefore a settlement possibility. Three of the twelve settlement options were found to be settlement possibilities. Each was characterized by provision of imported water to the Indians in lieu of San Pedro water. The final matrix is represented in the following table.

Table 4:   MATRIX OF SETTLEMENT OPTIONS

STRATEGY	CHOICE PER PLAYER						UTILITY PER PLAYER						ACCEPTABLE STRATEGY?		ACTIVITY SUMMARY				
	I	II	III	IV	V		I	II	III	IV	V				I	II	III	IV	V
1.	5	4	0	0	7		7.51	5.76	10.02	8.19	-16.05		0		1	0	1	1	0
2.	5	4	4	4	7		7.51	10.46	7.84	8.06	-16.12		0		1	1	1	1	0
3.	5	4	3	3	3		7.51	10.46	-9.14	-16.62	-.13		0		1	1	0	0	1
4.	1	0	4	4	7		7.21	11.97	7.84	8.06	-16.12		0		1	1	1	1	0
5.	1	0	3	3	3		7.21	11.97	-9.14	-16.62	-.13		0		1	1	0	0	1
6.	5	8	0	0	0		7.51	5.24	10.02	8.19	9.95		0		1	0	1	1	1
7.	5	9	4	4	4		7.51	10.46	7.60	8.05	9.88		1		1	1	1	1	1
8.	1	3	0	0	0		7.21	6.75	10.02	8.19	9.95		1		1	1	1	1	1
9.	1	7	4	4	4		7.21	11.97	7.60	8.05	9.88		1		1	1	1	1	1
10.	2	4	0	0	0		1.65	5.63	10.02	8.19	9.95		0		0	0	1	1	1
11.	2	0	4	4	4		1.65	8.23	8.82	8.12	9.91		0		0	1	1	1	1
12.	2	4	4	4	4		1.65	6.93	9.42	8.15	9.93		0		0	1	1	1	1
13.	6	4	8	8	8		7.24	11.30	-10.00	-16.62	-.13								
14.	4	4	4	4	4		-9.84	-13.33	9.16	8.19	9.95						p(13) =		.6
15.	6	4	4	4	7		7.91	11.30	6.98	8.06	-16.32		1 = yes 0 = no				p(14) =		.2
																	p(15) =		.2
13-15 adj	Expected utility						4.27	6.38	-2.82	-6.59	-1.33								

CALCULATIONS AND EXPLANATIONS

Expected utility = (player risk pref.) SUM [p(13)u(13) + p(14)u(14) + p(15)u(15)]
        where p(13) is the probability assigned to 13, and
        u(13) is the utility of 13.

Player risk preference

Player I (Indians) =	1.078	risk taker
Player II (Fed. gov.) =	1	neutral
Player III (Mines) =	1.016	risk taker
Player IV (Upper aq.) =	.9803	risk averter
Player V (Lower aq.) =	.9803	risk averter

R. Shillito, M. S. candidate in water resources administration, conducted the final game theoretic analyses described above as preliminary investigations for her thesis research. She has linked all of the mathematical models through a computer spreadsheet in a way which now permits her to explore the consequences of changing hydrologic, economic, institutional, psychological, and other data collected for the San Pedro Basin. This explora-

tion was not a part of the original research plan (the original objectives were accomplished when it was determined that three previously unidentified options were potential conflict resolution possibilities). In many ways, however, it is the most exciting aspect of the research thus far, for it permits easy and efficient exploration of the nature of the conflict resolution process itself. Shillito, along with Lord, McGuire, and Wallace, will continue to develop this line of investigation in the months ahead, perhaps in the context of a program in environmental conflict resolution in the University of Arizona's Udall Center for Public Policy Studies.

Dissemination of Research Results

Journal articles are now in preparation, and two additional M. S. theses are being completed, based upon the research project. Additionally, Lord, McGuire, Duckstein, and Wallace are considering the preparation and submission of a book-length manuscript to the University of Arizona Press reporting on the entire project, and thus capturing the comprehensive interdisciplinary approach to the conflict resolution process which cannot be conveyed in individual articles reporting on specific aspects of the research. Furthermore, McGuire plans to prepare an issue paper in the Arizona Water Resources Research Center series which will convey the pertinent applied findings to parties in the San Pedro Basin and elsewhere in Arizona who now face the possibility of negotiating Indian water rights settlements in connection with the Gila River Basin Adjudication. Finally, it is important to add that this project has provided the stimulus to the American

Water Resources Association's 1989 Symposium on Indian Water

Rights and Water Resources Management, to be held in Missoula,

Montana in late June. Lord is Chairman of the Symposium, and

McGuire and Wallace are key participants.