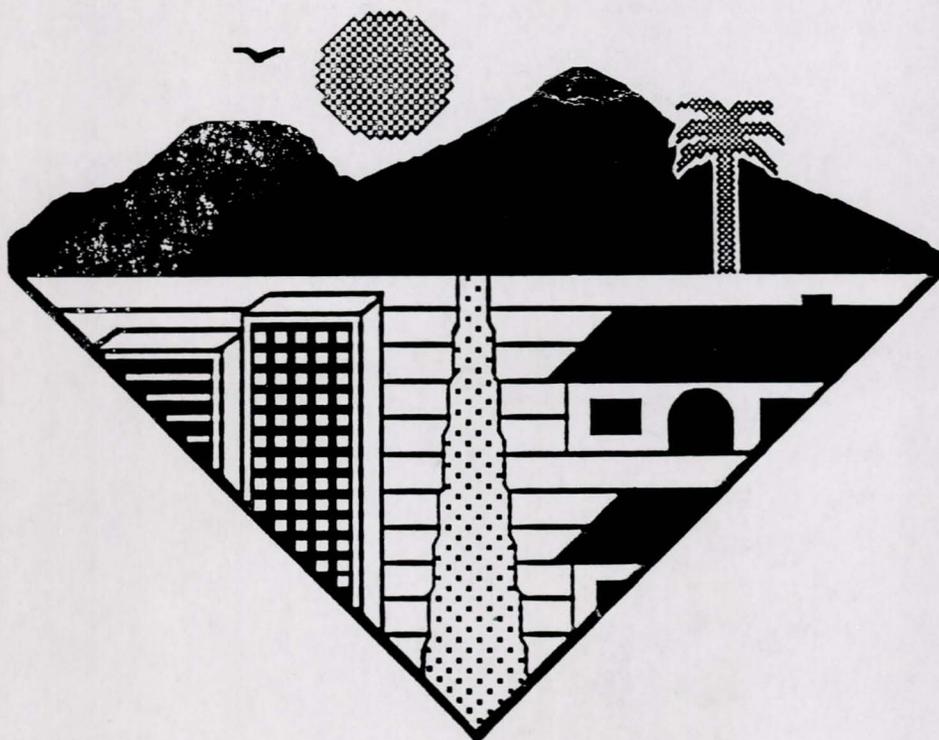


Feasibility Report

Phoenix Metropolitan Area Old Cross-Cut Canal

Phoenix, Arizona

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A103.901

April 1989

REVISED: OCTOBER 1989

PHOENIX METROPOLITAN AREA, AZ

OLD CROSS-CUT CANAL

FEASIBILITY REPORT

REVISED: OCTOBER 1989

APRIL 1989

OLD CROSS-CUT CANAL
PHOENIX, ARIZONA

SYLLABUS

This report is the concluding response to a resolution adopted 31 July 1973 by the Committee for Public Works of the United States Senate that authorized planning studies of water and related land resources of the Phoenix metropolitan area. The first report, the Phoenix Urban Study, was approved by the Board of Engineers for Rivers and Harbors in March 1983. That report recommended further detailed study of the Old Cross-Cut Canal as a flood control facility. The Flood Control District of Maricopa County, Arizona passed a resolution on 12 December 1983 authorizing their participation with the Corps in a study of the Old Cross-Cut Canal. A cost sharing agreement was approved by the Office of the Chief of Engineers in April 1985 and feasibility study funds were allocated in June 1985.

Flooding problems occur in the Old Cross-Cut area when runoff from Camelback Mountain ponds on the north side of the Arizona Canal and floods the residential area immediately to the north of that canal. When ponding depths exceed the height of the north bank, floodwaters can breach or overtop the canal and disperse throughout the totally developed residential area below the Arizona Canal.

A wide array of flood protection measures were considered, including non-structural and structural alternatives and a no-action plan. Three primary alternatives were identified, of which one, the Full Lafayette Alternative, was selected for detailed analysis. The Full Lafayette Plan called for an inlet structure above the Arizona Canal and a siphon which would direct floodwaters

under the canal and into an improved Old Cross-Cut Canal. The Full Lafayette Alternative had a 25-year level of protection, a first cost of \$20.8 million, average annual cost of \$1.9 million, and average annual benefits of \$0.5 million for a benefit cost ratio of 0.3.

During development of that plan, full consideration was given to engineering, economic, environmental, and social values. The study area is heavily developed, and the natural biotic community largely disturbed. Due to extensive urbanization, no Federal or state threatened or endangered species are known to exist in the study area.

A significant feature of this study was the close cooperative effort not only between the Corps of Engineers and the Flood Control District of Maricopa County, but also with the City of Phoenix, Salt River Project, Arizona Department of Transportation, and other Federal, state and local agencies.

The study conclusion was that no alternative analyzed could provide a Federally justified solution to flooding problems in the area. Based on the findings of this study, no Federal action should be taken at this time to implement structural improvements to the Old Cross-Cut Canal. Since the study recommendation was for no Federal action, an environmental impact statement, or assessment, was not required.

OLD CROSS-CUT CANAL
PHOENIX, ARIZONA

TABLE OF CONTENTS

SYLLABUS.....i

LIST OF FIGURES.....v

LIST OF TABLES.....vi

LIST OF PHOTOS.....vii

I. INTRODUCTION.....1

 A. STUDY AUTHORITY.....1

 B. STUDY PURPOSE.....1

 C. STUDY SCOPE AND GOALS.....2

 D. STUDY HISTORY.....2

 E. STUDY PARTICIPANTS.....6

 F. PUBLIC INVOLVEMENT.....6

 G. EXISTING WATER RESOURCE PROJECTS.....7

II. DESCRIPTION OF STUDY AREA.....8

 A. LOCATION AND BOUNDARIES.....8

 B. DEMOGRAPHICS.....8

 C. TOPOGRAPHY AND GEOLOGY.....9

 D. WATER RESOURCES.....10

 E. SURFACE WATER.....10

 F. GROUNDWATER.....15

 G. BIOLOGICAL RESOURCES.....16

 H. CULTURAL RESOURCES.....16

III. PROBLEM IDENTIFICATION AND OPPORTUNITIES.....	17
A. FLOODING.....	17
B. WATER QUALITY.....	20
C. RECREATION AND AESTHETICS.....	21
D. ENVIRONMENTAL.....	21
E. CULTURAL RESOURCES AND HISTORIC PROPERTY.....	23
F. PUBLIC CONCERNS.....	23
IV. PLAN FORMULATION.....	24
A. INTRODUCTION.....	24
B. STUDY PROCESS.....	24
C. PLANNING CONSTRAINTS.....	25
D. PLANNING OBJECTIVES.....	26
E. PLAN EVALUATION CRITERIA.....	28
F. DEVELOPMENT OF ALTERNATIVES.....	29
G. ALTERNATIVE EVALUATION.....	33
V. CONCLUSIONS.....	47
VI. RECOMMENDATION.....	49

LIST OF FIGURES

1. Location Map.....3

2. Study Area Map.....4

3. Second Iteration Alternative Screening.....39

4. Full Lafayette Alternative.....41

5. Third Iterative Alternative Screening.....43

6. Drainage Area Map.....44

LIST OF TABLES

1. Without Project Damages by Event.....20
2. Overflow Depths.....45

LIST OF PHOTOS

1. Arizona Canal.....	12
2. Old Cross-Cut Canal.....	12
3. Gates at 48th St. and Arizona Canal.....	13
4. Gates at 48th St. and Arizona Canal.....	13
5. Gates at Arizona Canal Open for Drainage.....	14
6. Old Cross-Cut Canal Carrying Excess Water.....	14
7. Flooded Yard - Arizona Canal.....	18
8. Minor Flooding - Arizona Canal.....	18
9. Ponding - Arizona Canal.....	19
10. Residential Yard Flooding - Arizona Canal.....	19
11. West Bank of Old Cross-Cut Canal.....	22
12. Old Cross-Cut Canal - Osborne Bridge.....	22

OLD CROSS-CUT CANAL
PHOENIX, ARIZONA

FEASIBILITY REPORT

APRIL 1989

CHAPTER I

INTRODUCTION

A. STUDY AUTHORITY

The Old Cross-Cut Canal Feasibility Study was initiated under a resolution adopted 31 July 1973 by the Committee on Public Works of the United States Senate for the Phoenix Urban Study. It states:

"That the Board of Engineers, created under the provisions of Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby required to review with the Chief of Engineers pertinent reports pertaining to Maricopa County, Arizona, with a view to determining whether any modifications of the recommendations contained therein are advisable at the present time, with particular reference to providing a plan for the control, development, utilization, and conservation of water and related land resources of the Phoenix metropolitan region..."

B. STUDY PURPOSE

The purpose of this study was to identify and investigate current and future problems, needs, and opportunities associated with flooding in the Old Cross-Cut Canal area. This report discusses and presents the results of the

plan formulation process and identifies specific analytical results of the plan selected for detailed analysis.

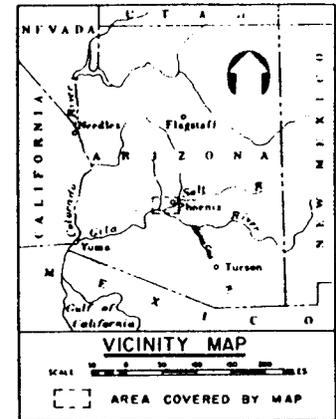
C. STUDY SCOPE AND GOAL

In early scoping sessions with the Flood Control District of Maricopa County, it was determined that a solution was needed to unresolved flooding problems which exist along and below the Arizona Canal in the vicinity of the Old Cross Canal. A generalized location map is provided in Figure 1, and the study area is more specifically identified in Figure 2.

The goal of the study was to identify and select a plan that would assist in solving water resource problems in the area. Measures were developed to solve specific problems at specific locations. These measures were then screened using a variety of criteria, including support from local interests, environmental and social acceptability, and engineering and economic feasibility. The most acceptable measures were combined into more comprehensive alternatives. These alternatives were then screened against the above criteria. The screening and evaluation process was iterative, and the process was repeated throughout the study as new measures or alternatives were developed and refined.

D. STUDY HISTORY

Preliminary investigations by the Corps of Engineers for solutions to flooding problems in the Old Cross-Cut area date at least to the 1960's. The



OLD CROSS CUT CANAL STUDY AREA

LEGEND

- AREA UNDER STUDY
- /// AUTHORIZED CHANNEL

LOCATION MAP
OLD CROSS CUT CANAL
PHOENIX, ARIZONA

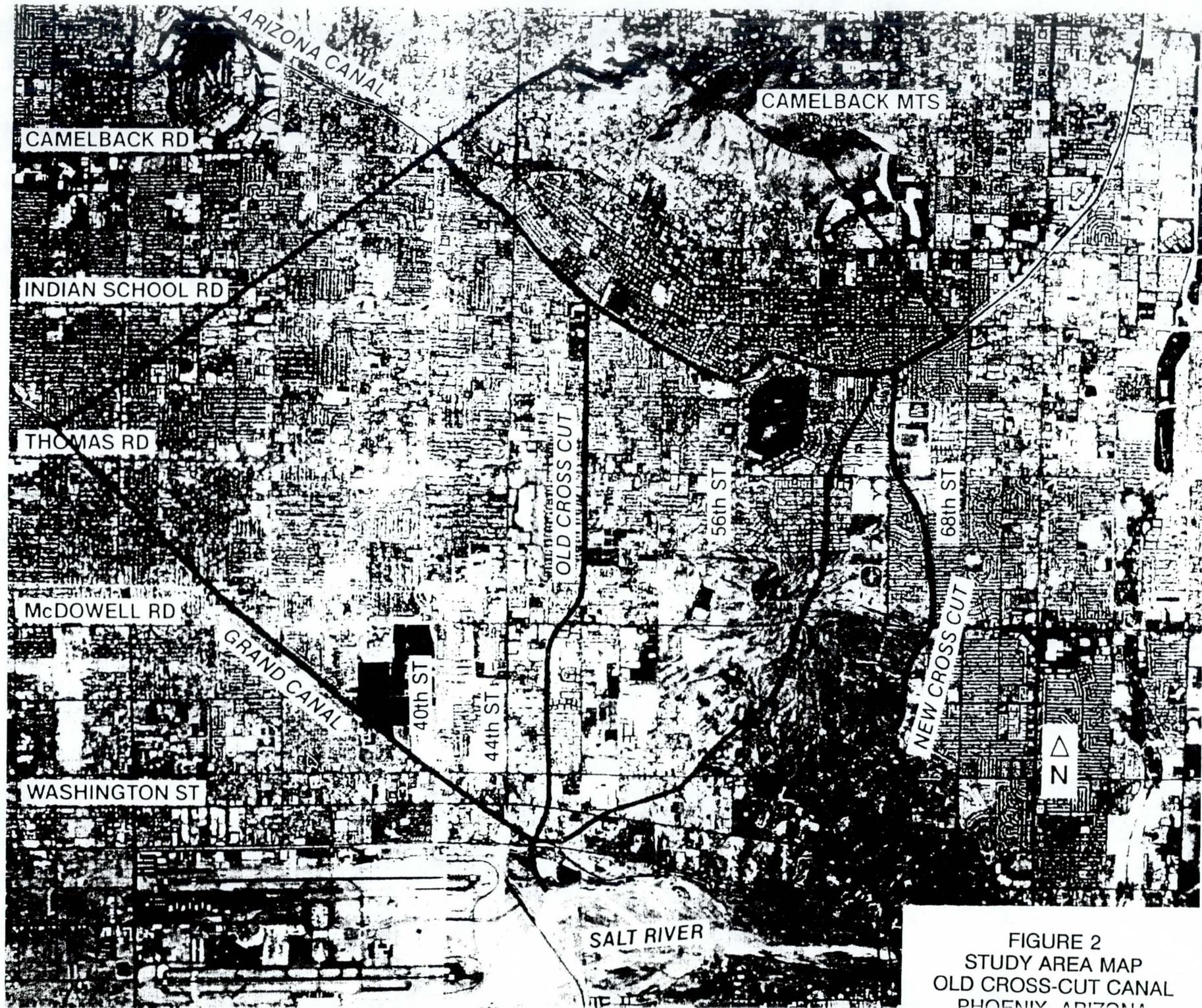


FIGURE 2
STUDY AREA MAP
OLD CROSS-CUT CANAL
PHOENIX, ARIZONA

area was first studied in some detail by the Corps during a Phoenix Urban Study in 1977 and 1978. Preliminary estimates developed during that study indicated a favorable benefit-cost ratio for a project providing a 25-year protection. Study of the canal was halted in July of 1978 when an interpretation of Corps engineering regulations indicated that the canal did not appear to conform to all criteria required for Corps participation in a flood control project. In 1982 the Board of Engineers for Rivers and Harbors questioned study termination under that interpretation and, later that same year, the Office of the Chief of Engineers determined that the regulation did not preclude further studies. The Old Cross-Cut Canal project therefore became eligible for further study and the Phoenix Urban Study final report recommendations were changed to recommend further detailed study of the canal.

During this time period, the Corps instituted a two phase planning process which called for a reconnaissance phase and a feasibility phase. It was determined that work done under the Phoenix Urban Study could be relied upon for reconnaissance level information and that a feasibility study would be initiated. Results of much of the design and cost estimates and benefit analyses from the Phoenix Urban Study became the basis for entering into the feasibility study upon which this report is developed.

On 12 September 1983, the Board of Directors of the Flood Control District of Maricopa County (FCDMC) passed a resolution authorizing the District to participate with the Corps in development of the study. With the formal initiation of cost-sharing between the Corps and local entities, a signed feasibility cost sharing agreement was obtained with the FCDMC in February 1985.

E. STUDY PARTICIPANTS

Because this was a cost shared study, an Executive Management Committee was established. Members consisted of the District Engineer and Chief of Planning Division, Los Angeles District, Corps of Engineers, and the Chairman of the Board of Directors and Chief Engineer and General Manager of the FCDMC. Due to the institutional, planning, and political setting of the study area, the City of Phoenix and Salt River Project were made exofficio members. The Executive Management Committee met on a regular basis and was responsible for study direction. A Study Management Team was also established with staff members from the same organizations. The Study Management Team developed recommendations on issues that arose and the Executive Management Team then ruled on those decisions.

F. PUBLIC INVOLVEMENT

A public involvement program was developed with the public divided into two groups: technical and general. Technical public input was used specifically during problem identification and in the formulation of preliminary alternatives. Input from both the technical and general public was used in the evaluation of alternatives and selection of a recommended solution.

Technical meetings were held in November 1985 and January 1986. Technical public participants included; FCDMC, City of Phoenix, Salt River Project, Arizona Department of Transportation, City of Scottsdale, Arizona Army National Guard, U.S. Fish and Wildlife Service, Maricopa Association of Governments,

U.S. Bureau of Reclamation, Motorola, John Carollo Engineers, and GMIS Corporation. In addition, individual briefings were held with various neighborhood interest groups. These included, the Greater East Phoenix Neighborhood Association, the Central Arcadia Conservation District, and the Hohokam Parkway Advisory Groups. General public involvement meetings were held in February 1987 and May 1988. Citizens were informed of these meetings through newsletters and newspaper articles. On each of the above dates, separate meetings were held for residents living north of, and south of the Arizona Canal. The technical public meetings were attended by approximately 100 individuals. The general public meetings were attended by over 300 citizens. Attendees at all meetings provided both verbal and written input.

G. EXISTING WATER RESOURCE PROJECTS

Corps of Engineers projects designed to provide flood control protection are located on each side of the Old Cross-Cut study area. Indian Bend Wash, completed in 1984, lies to the east in the City of Scottsdale and provides protection to the area immediately east of the study area. Another Corps project, the Arizona Canal Diversion Channel, is located west of Old Cross-Cut, and is currently under construction with a completion date of 1992.

CHAPTER II

DESCRIPTION OF STUDY AREA

A. LOCATION AND BOUNDARIES

The Old Cross-Cut Canal study area is located in the east-central portion of Phoenix in Maricopa County, Arizona. The study area includes about 17 square miles and is bounded on the north by Camelback Mountain, on the south by the Salt River, roughly by 68th Street to the east, and extending in a point to 24th Street and Thomas to the west. The upper portion of the study area is commonly referred to locally as the Arcadia District. A small segment of the northeastern corner of the study area is in the City of Scottsdale. Most of the area, including the entire Old Cross-Cut Canal, is within the City of Phoenix.

B. DEMOGRAPHICS

Phoenix is one of the ten largest U.S. cities and has a population estimated in 1989 at nearly 1 million. The city continues to experience extremely rapid growth. Phoenix is also the state capitol, and is the commercial center for much of the southwestern United States. The study area is highly developed, and consists of residential areas interspersed with commercial development along major streets.

C. TOPOGRAPHY AND GEOLOGY

About 20 percent of the study area is mountainous. Camelback Mountain, located in the north part of the study area, is 2700 feet at its peak and is rugged and steep with a slope of about 60 percent. Papago Park Mountain, in the eastern portion of the study area is less rugged and more gently sloping. The flat valley region which dominates the area between the base of Camelback Mountain and the Salt River is densely populated with a 1 percent slope. Land in the area was originally covered by natural vegetation, but now is almost all urbanized. Camelback Mountain is too steep for intensive development, but it is experiencing limited residential building.

Three geologic units are exposed in the study area: Recent (Quaternary) Alluvium, Tertiary Red Unit, and Precambrian Igneous Complex. Recent alluvium underlies most of the project area, reaching a maximum thickness of 250 feet near the Salt River. Materials in the study area are classified and described as silty clayey sands to sandy clays with a moderate calcareous cementation of the soil in the form of caliche below 5 feet. The uncemented layer above the caliche is susceptible to erosion, and some portions of the Old Cross-Cut Canal channel slopes have eroded.

The dominant seismic feature in Central Arizona is the Verde fault system, located 55 miles northeast of the project. The study area itself is located in Seismic Zone 1 (U.S. Army Corps of Engineers, 1983), indicating that only minor seismic activity may be expected.

D. WATER RESOURCES

The climate of study area is arid with an annual precipitation of about 8 inches. Most precipitation occurs in two distinct seasons, summer (June through September) and winter (December through March), and is about equally divided between them. Monthly, seasonal, and annual precipitation amounts vary considerably from year to year. During any season there may be many successive rainless days.

E. SURFACE WATER

Most of the area is subject to flooding from two distinct types of topography: gently sloping valley areas and steep hills. Runoff tends flow downhill at somewhat equal depths across the entire valley area.

In the drainage area, runoff from Camelback Mountain concentrates in numerous small gullies rather than one major water course. Upon reaching the valley area, runoff again disperses into sheet flow. Flow paths in the valley area are controlled by slope of the land and manmade obstructions. When the path of flow is interrupted by embankments, such as those for highways and canals, ponding and diversion may occur. Drainage boundaries at several locations for this study are defined by such embankments.

A number of structures in the area affect surface runoff, including the Arizona Canal, the Old Cross-Cut Canal, and the Grand Canal. A brief

description of each follows.

The Arizona Canal is a partially entrenched water supply canal which carries water between Granite Reef dam and Skunk Creek (Photo 1). Flow in the canal varies from 700 cfs to 1100 cfs within the study area. During storms, water ponds behind the north bank causing flooding. If flows in the canal exceed capacity, the southern bank is overtopped or can break causing flooding downstream of spillways and the 48th Street gates, which allows for water disposal. The Arizona Canal also has diversion structures to provide water to customers. One such diversion is the New Cross-Cut Canal located a few miles to the east of the Old Cross-Cut Canal and outside the study area. Starting at the Arizona Canal and Invergordon Road, the New Cross-Cut Canal delivers water to the Penstock water treatment plant.

The Old Cross-Cut Canal was constructed in the late 1880's to transfer water between the Arizona Canal and the Grand Canal. The Canal is located adjacent to 48th street between the Arizona Canal and McDowell Road (Photo 2). At McDowell Road, it transitions to the west and parallels 46th street to the Grand Canal. The 3.6 mile long canal consists of a deeply incised earth channel beginning from a gated outlet at the Arizona Canal. The largely unimproved channel crosses major streets through varied shaped culverts. The channel, which receives local storm drainage from the east and west, is no longer used as a water supply transfer system between the Arizona and Grand Canals. However, it is used to discharge water from the Arizona Canal during rainstorms and floods (Photos 3-6). Under the terms of an intergovernmental agreement, the Salt River Valley Water Users' Association is allowed to discharge from the Arizona Canal into the Old Cross-Cut Canal. The City of

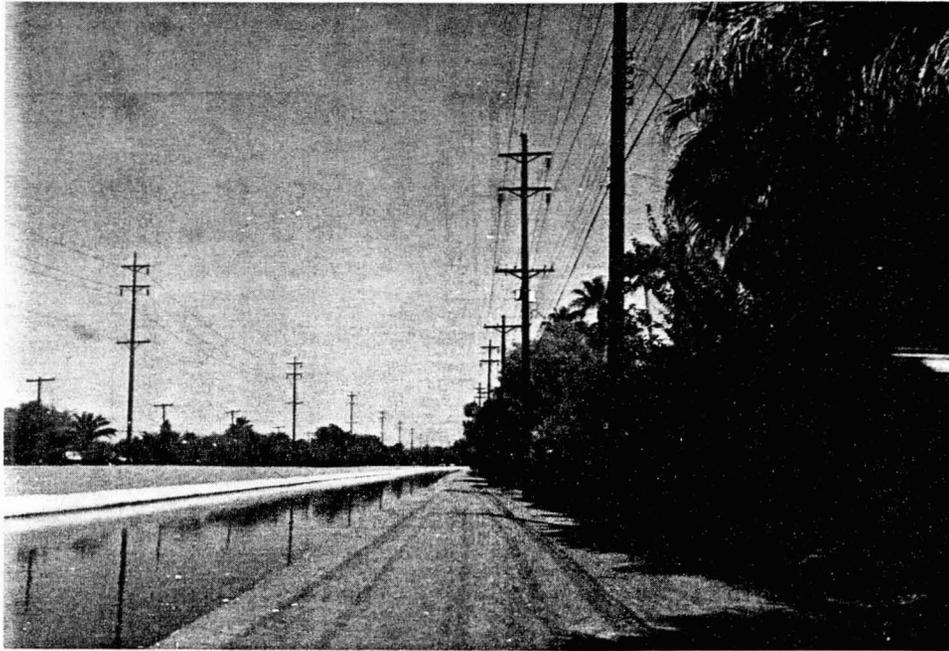


PHOTO 1
Arizona Canal. View looking east near
Old Cross-Cut Canal. (May 1988)



PHOTO 2
Old Cross-Cut Canal. View looking
south below Thomas. (May 1988)

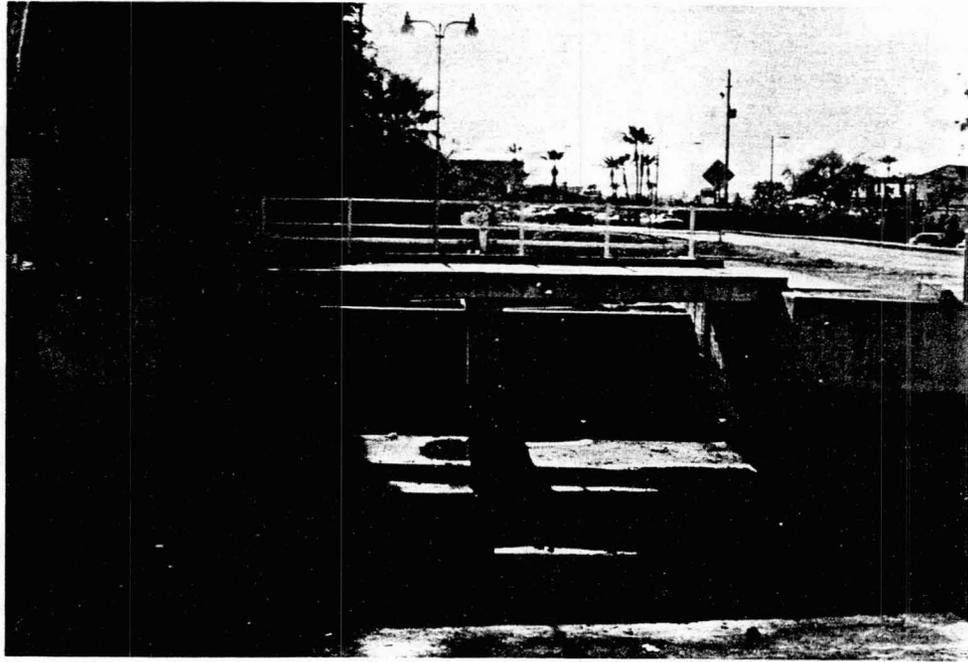


PHOTO 3
Gates at 48th Street and Arizona Canal.
View looking south across Arizona Canal
toward Old Cross-Cut Canal. (May 1988)

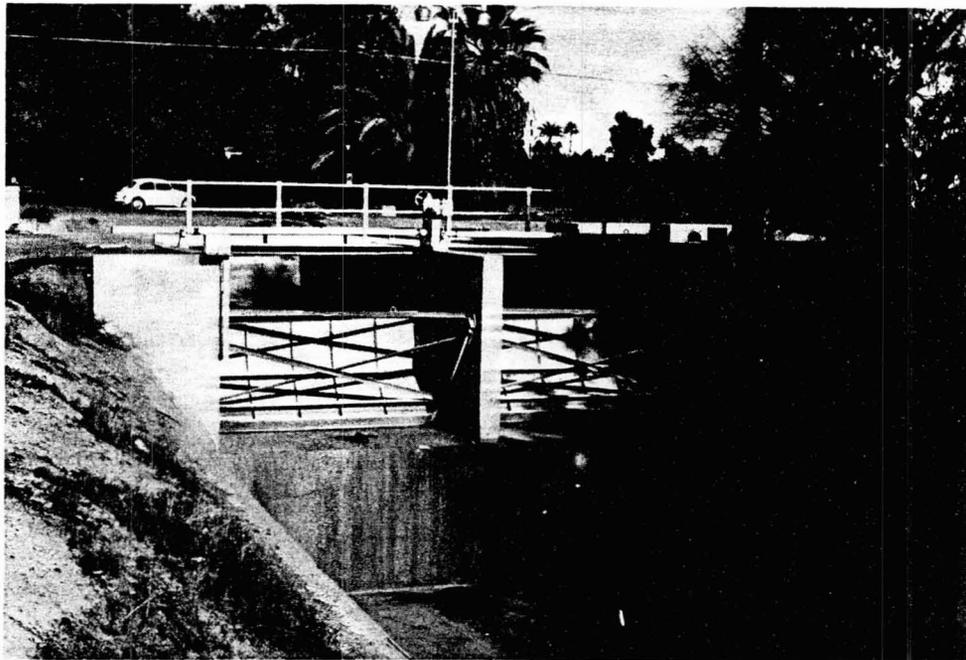


PHOTO 4
Gates at 48th Street and Arizona Canal. View looking
north along Old Cross-Cut Canal toward
Arizona Canal. (May 1988)



PHOTO 5
Gates at Arizona Canal opened for draining
into Old Cross-Cut Canal. View looking south. (Oct 1988)



PHOTO 6
Old Cross-Cut Canal carrying excess water from
Arizona Canal. View looking south, north of Osborn.
(Oct 1988)

Phoenix can discharge storm drainage into the Old Cross-Cut Canal south of the Arizona Canal. Gates in the Grand Canal, which outlet to the Salt River, discharge storm flows from the Old Cross-Cut into the river. The Flood Control District of Maricopa County is responsible for maintenance of the canal.

The Grand Canal runs parallel to and has the same function as the Arizona Canal. It receives flow from the New Cross-Cut Canal, and distributes it and outlets the excess flow into the New River. It receives flow from the Old Cross-Cut Canal during floods and either brings it westward towards the New River or passes it to the Salt River through waste gates. However, the north bank does not cause the same ponding problem because the banks are generally less than one foot and the canal is mainly entrenched.

F. GROUNDWATER

Groundwater lies at depths of less than 20 feet along the Arizona Canal west of 56th Street, and along the entire length of the Old Cross-Cut Canal. Groundwater levels drop abruptly east of 56th Street, reaching depths as great as 300 feet near the east end of the study area.

Land subsidence and associated earth fissure development have occurred in some parts of the Phoenix area due to major groundwater declines. However, a National Geodetic Survey level line along the Arizona Canal has detected no significant subsidence in the immediate study area.

G. BIOLOGICAL RESOURCES

Most of the natural biotic communities along the length of the Old Cross-Cut Canal have been disturbed as a result of urbanization of the Phoenix Area. If any natural vegetation occurs within the area, it would be in small undeveloped patches. Species that could be expected include mesquite, catclaw, acacia, paloverde, broom baccharis, creosotebush, eucalyptus, tree tobacco and russian thistle. Most of the residential areas have used nonindigenous plants for landscaping.

Dominant wildlife likely to be found includes small reptiles (lizards and snakes), small mammals, rodents, and birds (mostly passerine species). Because of the extensive urbanization within the Phoenix metropolitan area, no Federal or State threatened or endangered species are present.

H. CULTURAL RESOURCES

The Pueblo Grande Ruin, a major Hohokam village site, and Hohokam-Pima irrigation sites are located south of the project area. Both are listed on the National Register of Historical Places and are also National Historic Landmarks. Although the known sites are physically located outside the study area, the northern extent of possible archaeological materials is not known.

CHAPTER III
PROBLEM IDENTIFICATION AND OPPORTUNITIES

A. FLOODING

1. General Overview

The Old Cross-Cut drainage area is small and highly reactive to flood conditions. The steep slopes of Camelback Mountain and heavily developed area below the mountain result in minimal infiltration and rapid runoff. Storm waters pond on the north side of the Arizona Canal. A potential for damages is from overtopping or breaches in the Arizona Canal which would allow floodflows to disperse throughout the totally developed area below the canal.

2. Historical

Residences and other structures in the study area are subject to flooding in the form of flooded yards and minor property damage (Photos 7-10). Street flooding is common during heavy rains. Some residents north of the Arizona Canal have reported damage every few years from ponding. During a storm in 1972, residents were flooded south of the Arizona Canal from water crossing the Canal at the depressed intersection of 56th Street and Mitchell. Extensive ponding and \$0.6 million in damages were reported along a 12 mile reach above the canal. About one-third of this damage was in the current study area. During the same storm several breaks occurred in the Arizona Canal outside of the Old Cross-Cut Study area causing \$4.3 million in damages.



PHOTO 7
Flooded yard typical of local flooding which
frequently occurs north of the Arizona Canal.
(Oct 1988)



PHOTO 8
Another view of localized flooding
north of Arizona Canal. (Oct 1988)



PHOTO 9
Ponding behind north bank
north of Arizona Canal (Oct 1988)



PHOTO 10
Residential yard flooding
north of Arizona Canal. (Oct 1988)

3. Projected Damages

Without project Corps hydrologic and hydraulic investigations indicate that runoff from floods as frequent as a 25-year event could overtop the Arizona Canal at several locations. Table 1 illustrates estimated damages that could occur by flood event. Hydraulic and economic analysis indicated that south of the Arizona Canal there was insufficient increase in flooding depths to increase damages for the SPF event above the 100 year event.

Table 1

Without Project Damages by Event

(Oct. 1988 Prices X1000, @ 8 5/8%)

<u>Study Area</u>	<u>25 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>SPF</u>	<u>Ave Ann</u>
North of AZ. Canal	\$3,067	\$4,387	\$6,820	\$18,236	405
South of AZ. Canal	<u>\$14,680</u>	<u>\$18,080</u>	<u>\$20,077</u>	<u>\$20,077</u>	<u>\$1,228</u>
Total	\$17,747	\$22,467	\$26,887	\$38,313	\$1,633

B. WATER QUALITY

A portion of the flow of the Arizona Canal downstream from the study area is withdrawn by water treatment plants for drinking water. Any floodwaters which overtop the canal bank introduce street oils, dirt, trash, and other urban contaminants into the canal. A concern which had to be addressed by the study was any alternative which would increase urban street storm runoff into the Arizona Canal. Any increase in contaminants in the canal could impact operations and treatment procedures of the downstream water treatment plants and was of serious concern to the City of Phoenix.

C. RECREATION AND AESTHETICS

Some of the rights-of-way adjacent to the Old Cross-Cut Canal are currently utilized as bicycle and equestrian trails in the Maricopa County Trail System. There is considerable potential for additional recreational development along the Old Cross-Cut Canal. Some of the most notable shortcomings of the existing trail system could be corrected by construction of a comprehensive linear bicycle/equestrian trail system.

Comments from citizens obtained during the public involvement meetings indicated widespread feelings for improved recreational use of the canal area. Views as to the appearance of the canal ranged from many who considered the current appearance to be unsightly, to a few who felt that the present condition of the canal added a certain charm to the neighborhood (Photos 11 & 12).

D. ENVIRONMENTAL

The study area is already largely disturbed and developed. Any proposed solution to the flooding problem, however, would have to consider the impact on any of the small pockets of undisturbed natural vegetation. Opportunities for environmental enhancement are limited.

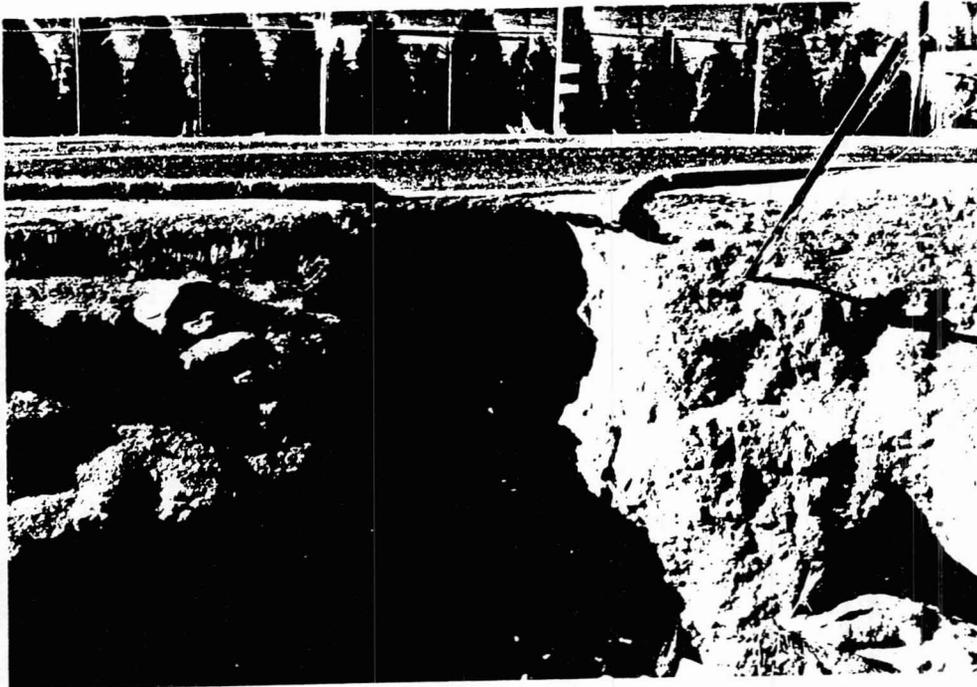


PHOTO 11
West bank of Old Cross-Cut Canal
south of Arizona Canal showing
localized erosion. (May 1988)

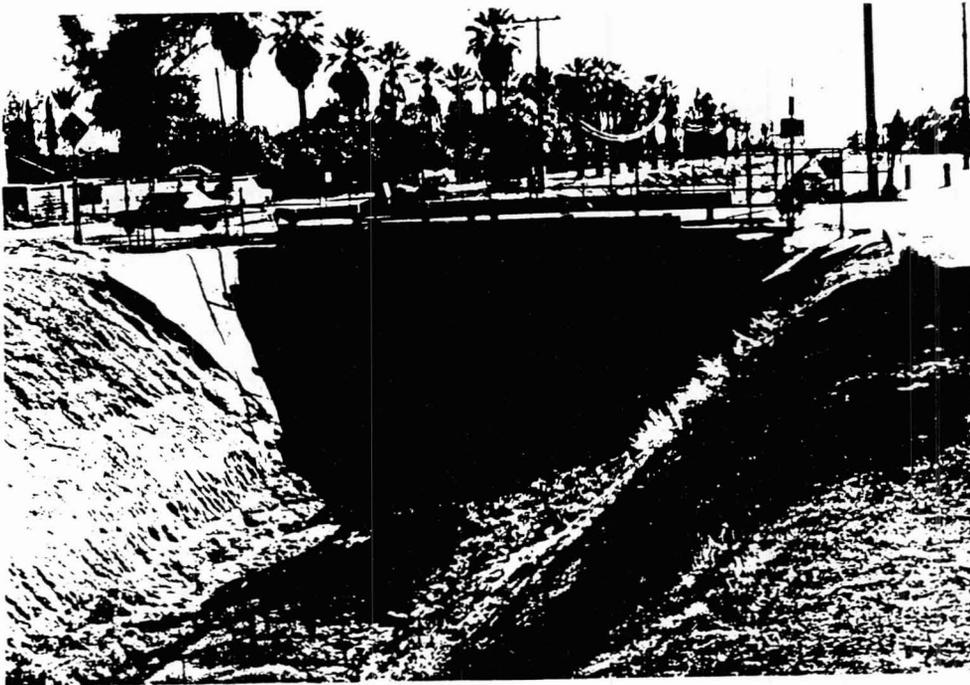


PHOTO 12
Old Cross-Cut Canal. View to south
at Osborn Road Crossing. (May 1988)

E. CULTURAL RESOURCES AND HISTORIC PROPERTY

The northern extent of archeological materials associated with known Hohokam Indian sites located to the south of the study area is unknown. Any proposed construction, therefore, would require a program for identification and evaluation of archaeologically significant sites.

F. PUBLIC CONCERNS

Concerns about flooding in the area were widely expressed during public meetings held for this study. Most flooding experienced by residents of the area has been in the form of flooded yards, street flooding, and minor property damage. Most residents north of the Arizona Canal were well aware of flooding problems, while the majority of residents south of the canal did not appear to be aware of the possibility of a break or overtopping of the Arizona Canal and resulting flooding in their area.

Despite a few comments to the contrary, the appearance and safety hazard presented by the Old Cross-Cut Canal is a concern to most people in the neighborhood. Local residents also expressed strong concerns over the potentially disruptive impact of any project, during construction, as well as the cost of the project itself.

IV. PLAN FORMULATION

A. INTRODUCTION

Plan formulation had to address three flooding problems: (1) storm water runoff and resulting ponding north of the Arizona Canal, (2) overtopping and possible breaks or breaches in the Arizona Canal during major flood events, and (3) subsequent flooding below the canal as a result of (2). Plan formulation had to deal with each problem separately and in combination.

The institutional and political setting of the area required plan formulation in close cooperation with a number of local entities. The City of Phoenix, Salt River Project, and Arizona Department of Transportation, in addition to the Flood Control District of Maricopa County, all had specific responsibilities and interests which impacted plan formulation. These responsibilities and interests had to be addressed in addition to economic, engineering and environmental criteria.

B. STUDY PROCESS

The planning process consists of six steps to identify or respond to problems and opportunities associated with the Federal objective and specific local concerns, and is designated to culminate in plan selection. The process involves an orderly and systematic approach to making determinations and decisions at each step. This approach ensures that the interested public and decision-makers in the planning organization are fully aware of the basic assumptions employed, data and information analyzed, areas of risk and

uncertainty, reasons and rationales used, and significant implications of each alternative. The following identifies those steps:

Step 1: Specification of the Problems and Opportunities Associated with the Federal Objective and Specific State and Local Concerns.

Step 2: Inventory and Forecast Water and Related Land Resource Conditions.

Step 3: Formulation of Alternative Plans.

Step 4: Evaluation of Effects.

Step 5: Comparison of Alternative Plans

Step 6: Plan Selection

C. PLANNING CONSTRAINTS

Plans were formulated within existing laws, policies, regulations, and the authorizing resolution. Other constraints include limits presented by area topography, shortage of land resources, protection of environmental and cultural resources, and need to minimize relocation in the highly developed residential area.

D. PLANNING OBJECTIVES

1. The Federal Objective

The Federal objective of water and related land resources planning is to contribute to the national economic development consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable Executive Orders, and other Federal planning requirements. Corps planning objectives are:

a. National Economic Development (NED)

Contributions to national economic development (NED) are increases in the net value of the national output of goods and services (benefits from the project). The plan that reasonably maximizes net benefits (the NED plan) is selected unless there is overwhelming justification for another plan. The NED plan is also the most economically efficient plan. For these studies, therefore, the NED objective was to develop plans that would:

- 1) provide the maximum reduction in potential flood losses in the Old Cross-Cut area.
- 2) maximize associated NED benefits realized at the national scale.

b. Compliance with National Environmental Statutes

In addition to meeting the criterion of economic efficiency, any Federal project must comply with the National Environmental Policies Act of 1969 (NEPA). A partial requirement of NEPA is the completion of an Environmental Assessment (EA) which provides documentation of a Finding of No Significant Impact (FONSI), or an Environmental Impact Statement (EIS) if impacts to the environment are significant or potentially significant.

c. Compliance with Applicable Executive Orders

In addition to executive orders which relate directly to environmental quality, Executive Order 11593 instructs Federal agencies to institute procedures to assure that Federal plans contribute to the preservation and enhancement of non-Federally owned sites, structures and objects of historical, architectural, and archeological significance. The National Historic Preservation Act of 1966, as amended, embodies many of the provisions of the Executive Order. Thus, consideration of historic preservation was a planning objective.

d. Compliance with other Federal Planning Requirements

In addition to the NED objective, alternative plans must be evaluated for effectiveness, completeness, and acceptability. A project must effectively perform design task. A recommended plan must also contain all elements which are necessary for it to function effectively. A recommended plan must also be acceptable to the community, the local sponsor, and other Federal and State

agencies.

e. Consideration of Nonstructural Measures

Section 905(a) of Public Law 99-662 requires that consideration be given to nonstructural measures in the planning formulation of all flood damage reduction plans.

E. PLAN EVALUATION CRITERIA

Criteria used in the plan formulation process adhered to current Corps guidelines as follows:

1. Technical Criteria

Discharge-Frequency relationships for urbanized areas were adopted from earlier Corps hydrological studies in the Phoenix area. Hydraulic designs were based on approved design practice and on theoretical analyses using applicable criteria set forth in Corps of Engineers' Engineering Manuals.

2. Economic Criteria

An amortization period of 100 years was used. An interest rate of 8-5/8 percent was used during screening and for the selected plans. Costs incurred during construction were increased by adding compound interest computed at the project discount rate. Methodology was in accordance with Principles and

Guidelines.

3. Environmental Criteria

Impacts on fish and wildlife resources and/or habitat were to be quantified to the extent possible. Impacts which could not be quantified were to be identified. Mitigation plans were to be developed if necessary.

4. Social Criteria

Adverse impacts identified in Section 122 of Public Law 91-611 were to be assessed and considered in development of measures and alternative plans.

In addition to these criteria, the desires of local interests and the needs associated with local governmental concerns were used to weigh alternatives. A public involvement effort was made to elicit the concerns of area residents and to give all local interests a voice in the plan formulation process.

F. DEVELOPMENT OF ALTERNATIVES

1. Management Measures

Within the framework of plan formulation criteria, a wide range of measures were identified. Measures provided the basis for formulating alternatives. The following is a list of various measures identified and considered:

a. Flood Control Measures

1) Structural Measures

a) Collector system above Arizona Canal

b) Alternative means to divert water from above Arizona Canal into the Arizona Canal and/or Old Cross-Cut Canal

c) Improved Old Cross-Cut Canal with possible increased capacity

2) Non-structural Measures

a) Flood warning system

b) Floodwalls/floodproofing

c) Floodplain management

d) Flood emergency action plan

e) Temporary or permanent relocation

b. Recreation Measures

- 1) Bike and pedestrian paths along Old Cross-Cut Canal
- 2) Picnic and play areas along canal

c. Fish and Wildlife Measures

- 1) Protection of any existing resources
- 2) Mitigation of construction impacts

d. Cultural Resource Measures

- 1) Preconstruction survey to identify undiscovered resources
- 2) Caution to not destroy any resources discovered during construction

e. No Action Measure

2. Plans by Others

During preparation of this Feasibility Report, coordination was maintained with a number of agencies responsible for implementing plans which either addressed or impacted the planning objectives of this study. The following local planning efforts are currently under consideration:

City of Phoenix

The City of Phoenix has responsibility for local storm drains in the study area. City storm drains are normally sized for two year events. The City regularly develops and updates local drainage plans which include the Old Cross-Cut area. Only limited drainage construction is planned in the study area over the next five years. Drains associated with impending street work along Camelback and McDowell roads will only have limited impact on floodflows addressed by the Federal project. The city does strongly believe an improved storm drainage system is desirable in order to provide flood relief in the affected area. In addition, the city is considering a parkway from McDowell Road to Indian School as an extension of ADOT plans for freeway development from the Salt River to McDowell. The ADOT freeway and city parkway would parallel the Old Cross-Cut Canal.

Arizona Department of Transportation (ADOT)

ADOT is considering a number of highway development plans in or near the study area. The plans would include storm drain facilities. One such plan includes the Hohokam Extension from the Salt River to McDowell.

Flood Control District of Maricopa County (FCDMC)

The FCDMC is responsible for providing flood control for all of Maricopa County, which includes the study area. The FCDMC was the local sponsor for the study, provided coordination and liaison with other local entities, and cooperated with the Corps in all aspects of plan formulation and evaluation.

G. ALTERNATIVE EVALUATION

a. Pre-feasibility Studies

The earliest Corps planning for the Old Cross-Cut area consisted of preliminary efforts discussed in the Phoenix, Arizona and Vicinity Interim Survey Report, January 1964. Additional preliminary evaluation was prepared for the Phoenix Urban Study in 1977-1978. Pre-feasibility studies focused on gate modifications and construction of a collector system north of the Arizona Canal which would convey flood flows to an improved Old Cross-Cut Canal. Documentation from these early studies indicated that a 25 year level of protection was selected as a basis of design because of right of way constraints upstream of the Arizona Canal and along the Old Cross-Cut Canal. These constraints made higher levels of protection costly, primarily due to potential relocations.

b. Feasibility Phase

During the feasibility phase a three stage iterative process was used to screen alternatives. The process consisted of an initial iteration where a large number of measures were discussed and evaluated. The second iteration was an intermediate stage when general concepts and designs were evaluated. The third, and final, iteration consisted of a small number of alternatives where specific designs were prepared and benefit cost techniques applied.

1. First Iteration

The first iteration consisted of an evaluation of a number of measures, including the flood control measures listed earlier (Section F1). Certain structural solutions, such as detention basins, levees, and major channelization, were not considered reasonable due to such factors as local unacceptability, high construction costs, social impacts, and/or environmental impact.

Non-structural solutions such as temporary or permanent relocation were not considered satisfactory due to expense and social impact. Other non-structural measures, including flood proofing and floodwalls, might serve to protect some structures, but would not provide a comprehensive solution to the overall flooding problem in the area. In addition, such actions would restrict the area that flood waters could occupy. Runoff would then concentrate in unprotected areas, pond to greater depths, and add to the possible overtopping or breaching of the Arizona Canal. Flood proofing and floodwalls also would be of high cost to homeowners and was considered to contain adverse social and esthetic impacts.

Flood plain management was also considered as a non-structural solution. The main value of flood plain management would be to control future developments. Except for a few small locations the area is essentially urbanized and flood plain management would have minimal positive impacts.

Flood warning and evacuation was not considered to be the solution to the flooding problem. Heavy rainfall advisories more than 8 hours in advance of

storms are usually beyond the capabilities of the weather services. Even with sufficient advance warning time, evacuation is a difficult, socially upsetting, and costly procedure. Some possible reduction of damage to contents could be realized, but other damages would continue unabated.

While the above measures were rejected during the first iteration, there were a number of operational and structural solutions which were discussed and qualitatively evaluated and which provided the basis for development of a reduced number of alternatives for the second iteration stage.

A no action alternative was also included for comparison purposes throughout the evaluation process. Without resolution of the problem, frequent flooding will continue to occur. As urbanization increases, the flood problem would become magnified because of greater population density and increased runoff from developed areas.

2. Second Iteration

As a result of meetings with local interests, the Technical Advisory Committee, and Corps technical staff, a preliminary array of seven alternatives was developed for a second iterative evaluation as listed below:

a. OPERATIONAL MODIFICATIONS. Currently there are two existing radial gates across the Arizona Canal, one at Scottsdale Road and the other at 56th Street. During periods of flooding, both gates would be closed so that portion of the Arizona Canal would be drained. All flows east of Scottsdale Road would

be put into the Indian Bend Wash system. Flows between Scottsdale Road and 56th Street would drain down the New Cross-Cut Canal (located at 64th Street) and flows west of 56th Street would drain into the Old Cross-Cut and also continue down the Arizona Canal. As the Arizona Canal was drained, flood flows could enter the Arizona Canal by lowering the north bank.

b. INCREASE NUMBER OF OLD CROSS-CUT CANAL GATES. This alternative included the components of Alternative #1 and provided for an increased number of gates on the Old Cross-Cut Canal. Increasing the gates would allow for more flood waters to be drained, thereby increasing the level of protection that could be provided. The design of this alternative would consist of lowering the north bank of the Arizona Canal, increasing the gates of the Old Cross-Cut Canal increasing the capacity of the canal, and constructing larger bridges over the Old Cross-Cut Canal. Preliminary investigations indicated that the Old Cross-Cut Canal itself has the capacity to carry additional flows, but bridges are the constrictions. Depending on velocities, some type of lining might be needed.

c. ADDITIONAL PLAN COMPONENTS. The third alternative consisted of adding additional plan components to the alternatives outlined above to increase the level of protection. These components would include adding two new radial gates across the Arizona Canal (one just west of the New Cross-Cut Canal and one just west of the Old Cross-Cut Canal) and adding an additional outlet at the golf course located at 56th Street. These new components would allow more flood flows to be drained at a faster rate than in Alternatives 1-3. In addition to design items listed in Alternative #2, this alternative would include the design and cost of two new radial gates and, if needed, the design

and cost of increasing the capacity of a small lake at an existing golf course in the proposed project area to temporarily store runoff.

d. DUAL CHANNEL SYSTEM. This alternative addressed the concern of water quality as well as the flooding. A wall would be constructed down the center of the existing Arizona Canal thereby creating a dual channel system. During minor flood flows, one side of the canal would be used to capture the flood flows while the other side would still continue regular water deliveries. During larger flood events, both sides of the canal would be used for flood control. This alternative protects the quality water by not allowing the mixing of the two during minor flood events. Design of this alternative would consist of lowering the north bank of the Arizona Canal so that flood flows could flow into the canal, construction of a flood wall down the center of the Arizona Canal, providing a way for the flood waters to get from the Arizona Canal flood channel to the Old Cross-Cut Canal, and increasing the capacity of bridges crossing the Old Cross-Cut Canal.

e. INCREASE SLOPE OF ARIZONA CANAL. This alternative would increase the efficiency of the existing system by increasing the slope of the Arizona Canal. Potential locations include increasing the slope between 64th and 56th Street or between 56th and 48th Street. The design of this alternative would involve lowering the north bank of the Arizona Canal so the flood flows could flow into the canal, reconstructing the Arizona Canal, and modifying to the Old Cross-Cut Canal.

f. COLLECTOR SYSTEM NORTH OF THE ARIZONA CANAL. This alternative was originally considered during the Phoenix Urban Study. Design would consist of a collector system just north of the Arizona Canal, a siphon to get the water under the Arizona Canal and into the Old Cross-Cut Canal, and major improvements to the Old Cross-Cut Canal.

g. COLLECTOR SYSTEM ALONG MAJOR STREETS. This alternative would collect and transport flood flows to the Old Cross-Cut Canal before they pond against the Arizona Canal. Underground pipes running along both Lafayette and Camelback Roads would collect and transport sheet flow to the Old Cross-Cut Canal. Design of this alternative would consist of construction of underground pipes along two streets above the Arizona Canal, a siphon to get the flows into the Old Cross-Cut Canal, and major improvements to the Old Cross-Cut Canal.

An evaluation of the above alternatives, including discussions with local interests, determined that Alternatives #1, #2 and #3 required complex operational procedures that would not be practical or acceptable to them under actual flooding conditions. In addition, these same three alternatives would release floodflows into the Arizona Canal and create water quality problems. Alternative 4 was rejected because of excessive cost. Alternative 5 also was rejected because of its high construction cost, as well as water quality concerns. A decision was made at the end of the first iterative evaluation to only carry variations of Alternatives 6 and 7 into the second iterative process. Figure 3 displays a summary of the second iterative alternative results.

FIGURE 3
 OLD CROSS-CUT CANAL
 PHOENIX, ARIZONA
 SECOND ITERATION ALTERNATIVE SCREENING

<u>ALTERNATIVE</u>	<u>ECONOMIC FEASIBILITY</u>	<u>ENGINEERING FEASIBILITY</u>	<u>SOCIAL IMPACTS</u>	<u>ENVIRONMENTAL ACCEPTABILITY</u>	<u>SUPPORT FROM LOCAL INTERESTS</u>
1. OPERATION MODIFICATIONS	NOT ANALYZED IN DETAIL	FEASIBLE	POTENTIAL WATER QUALITY CONCERNS	POTENTIAL PUBLIC HEALTH CONCERNS	CONCERN OVER MAJOR OPERATIONAL REQUIREMENTS AND WATER QUALITY
2. INCREASE OLD CROSS-CUT GATES	SAME AS #1	FEASIBLE	SAME AS #1	SAME AS #1	SAME AS #1
3. ADDITIONAL PLAN COMPONENTS	SAME AS #1	FEASIBLE	SAME AS #1 & 2	SAME AS #1 & 2	SAME AS #1 & 2
4. DUAL CHANNEL SYSTEM	VERY HIGH CONSTRUCTION COST	FEASIBLE	WATER QUALITY A PROBLEM ONLY IN EVENTS OVER 10-YR	SOLVES PUBLIC FOR EVENTS UNDER 10-YR	CONCERN OVER REDUCED AZ CANAL CAPACITY
5. INCREASE SLOPE OF ARIZONA CANAL	HIGH CONSTRUCTION COST	FEASIBLE	SAME AS #1, 2, & 3	SAME AS #1, 2, & 3	FEWER OPERATIONAL REQUIREMENTS THAN #1, 2, & 3
6. COLLECTOR SYSTEM NORTH	DEPENDENT ON DESIGN	FEASIBLE	SOLVES WATER QUALITY PROBLEM, POSSIBLE RESIDENTIAL RELOCATION DEPENDING ON DESIGN	SOLVES WATER QUALITY PROBLEM	ACCEPTABLE UNLESS RELOCATION OF RESIDENTS NECESSARY
7. COLLECTOR SYSTEM ALONG MAJOR STREETS	DEPENDENT ON DESIGN	FEASIBLE	SOLVES WATER QUALITY PROBLEM. NO RELOCATIONS	SAME AS #6	ACCEPTABLE
8. NO ACTION	N/A	N/A	THREAT TO LIFE AND PROPERTY	N/A	NOT ACCEPTABLE SOLUTIONS TO FLOODING PROBLEM

3. Third Iteration

The following alternatives were prepared for further analysis:

a. ALLEY. This alternative consisted of inlet pipes along Lafayette Blvd and in adjacent alleys to carry flood waters to the Arizona Canal. A portion of the north bank of the canal would be lowered to relieve ponding. New gates in the Arizona Canal and at the Old Cross-Cut Canal would require manual operation.

b. PARTIAL LAFAYETTE. This alternative included inlet pipes above the Arizona Canal. An east inlet pipe would carry water to the Arizona Canal and a west inlet pipe would carry water directly to the Old Cross-Cut Canal. A portion of the north bank of the Arizona Canal would be lowered to relieve ponding. Gates at the Old Cross-Cut Canal would require manual operation.

c. FULL LAFAYETTE. This alternative would drain floodwaters from the east and west along Lafayette Blvd and then directly into the Old Cross-Cut Canal by means of a siphon (Figure 4). Inlet grates at major intersections would catch runoff. No manual operation of the gates would be required.

An additional alternative consisting of an open channel collector system placed just north of the Arizona Canal was also briefly considered. That system would run from 68th Street to 40th Street and collect all flows in the watershed and transport them to the Old Cross-Cut Canal. A siphon would be used to transport the flows from the collector system to the Old Cross-Cut

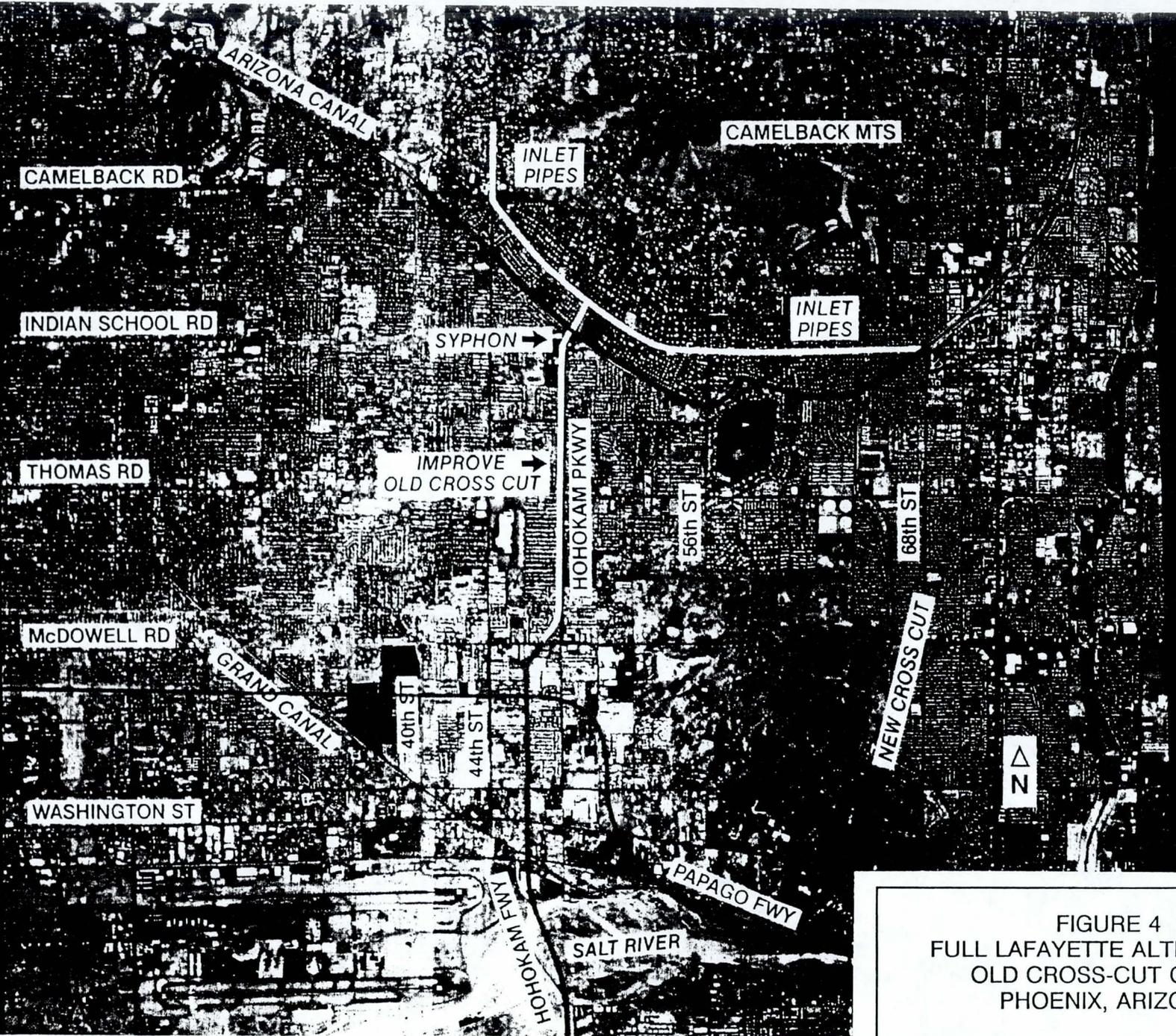


FIGURE 4
FULL LAFAYETTE ALTERNATIVE
OLD CROSS-CUT CANAL
PHOENIX, ARIZONA

Canal. No manual gate operation would be necessary. The Open Channel Alternative was considered impractical due to construction cost considerations and social impacts. The social impact resulted from the fact that numerous houses would have to be removed to obtain sufficient rights-of-way.

The Alley Alternative appeared to be the most promising from an economic standpoint, however, serious water quality, operational, and perceived public health concerns resulted in rejection of that alternative as well. The City of Phoenix presented its decision not to support the Alley Alternative in the form of a letter and City Council Report that stated they would not support any alternative that introduced storm runoff into the Arizona Canal.

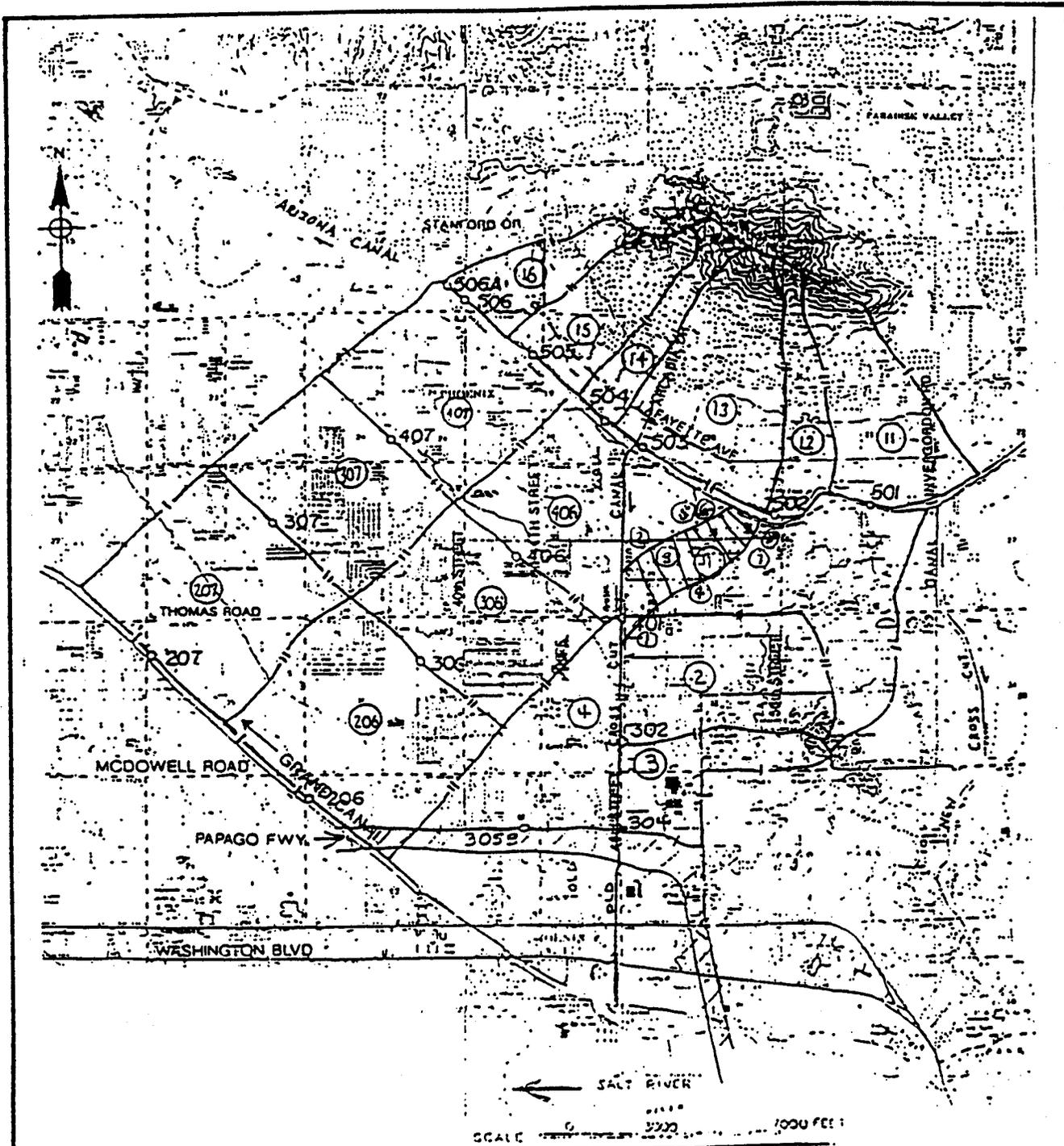
Rejection of the Alley Alternative focused attention on the Partial and Full Lafayette Alternatives. The Partial Lafayette Alternative was rejected as it contained operational concerns and appeared to have less economic justification than the Full Lafayette. Study attention was then focused on the Full Lafayette Alternative as the most promising alternative for a Federal project. Figure 5 displays a summary of the third iterative alternative results.

Associated with detailed analysis of the Full Lafayette alternative, with project overflows were updated and demonstrated that localized rainfall, not runoff, accounted for a significant portion of the flooding depths, most notably in the southern portions of the study area (Figure 6, Table 2). At the same time, a refined drainage plan was received for the proposed Papago Freeway and was included in the revised without project conditions.

Economic analysis of the Full Lafayette Alternative included an extensive

FIGURE 5
 OLD CROSS-CUT CANAL
 PHOENIX, ARIZONA
 THIRD ITERATION ALTERNATIVE SCREENING

<u>ALTERNATIVE</u>	<u>DEGREE OF PROTECTION</u>	<u>ECONOMIC FEASIBILITY</u>	<u>ENGINEERING FEASIBILITY</u>	<u>SOCIAL IMPACTS</u>	<u>ENVIRONMENTAL ACCEPTABILITY</u>	<u>SUPPORT FROM LOCAL INTERESTS</u>
1. ALLEY	25-YR	NOT FEASIBLE (PRELIMINARY B/C UNDER 1.0)	FEASIBLE	WATER QUALITY PROBLEMS	POTENTIAL PUBLIC HEALTH CONCERNS	NOT ACCEPTABLE DUE TO WATER QUALITY AND OPERATIONAL CONCERNS
2. PARTIAL LAFAYETTE	40-YR	NOT FEASIBLE (PRELIMINARY B/C UNDER 1.0)	FEASIBLE	SAME AS #1	SAME AS #1	NOT ACCEPTABLE SAME AS #1
3. FULL LAFAYETTE	25-YR	NOT FEASIBLE (1ST COST \$20.8 MILLION AVG ANNUAL COST \$1.9 MILLION AVG ANNUAL BENEFIT \$0.5 MILLION B/C=0.3	FEASIBLE	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
4. NO ACTION	N/A	N/A	NOT ACCEPTABLE	NOT ACCEPTABLE	NOT ACCEPTABLE	NOT ACCEPTABLE



- STORM DRAIN
- CONCENTRATION POINT
- ① SUBAREA NUMBER

OLD CROSS CUT STUDY

FIGURE 6
DRAINAGE AREA MAP

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

TABLE 2
 OLD CROSS-CUT CANAL
 OVER FLOW DEPTHS
 FULL LAFAYETTE ALTERNATIVE

CONCENTRATION POINT	25-YR	
	W/O PROJECT	W/ PROJECT
506A	.8	.2
506	.4	.2
505	.9	*
504	*	*
503	*	*
502	.7	*
407	.4	.2
406	.2	.2
401	.3	**
307	.4	.3
306	.3	.2
305B	.4	.2
304	.2	.2
302	.2	**
207	.4	.3
206	.4	.4
SEC1	1.6	1.6
2	1.8	1.8
3	1.8	1.8
4	1.2	1.2
5	.5	***
6	1.0	***
7	.4	***
8	1.5	***

* Arizona Canal not breached at this level of flooding

** Old Cross-Cut Canal not breached at this level of flooding

*** No flooding due to breaches in the Arizona Canal at this level of flooding

field survey of structures in the area. Results of this analysis showed that residual damages claimed in preliminary studies could not be supported; because of significant contribution of localized rainfall to flooding, residual flooding would remain significant even with the Full Lafayette Plan in place. Average annual benefits were estimated at \$515,000 (residual flood damages would be \$1,170,000) and average annual costs at \$1,894,000, for a benefit cost ratio of 0.3. Subsequent use of revised FEMA depth-damage curves and a reevaluation and confirmation effort did not substantially change the benefit cost ratio. The decision was then made to terminate the study as it became apparent that there was no potential for an economically feasible plan. The local sponsor and other interested local entities were contacted. Additional meetings were held to discuss the results and determine if some combination of Federal and local projects could be developed that would result in a positive Federal recommendation. No such combination was developed, and feasibility study analysis was terminated in February 1989.

V. CONCLUSIONS

As District Engineer, Los Angeles District, U.S. Army Corps of Engineers, I have reviewed and evaluated, in light of overall public interest, the data, information, and alternatives for water resource development pertaining to the Old Cross-Cut Canal, Phoenix, Arizona. Principle elements considered in my review included engineering feasibility, environmental impacts and effects, economic factors of regional and national economic development, and social well-being. Data and information reviewed include investigations and studies prepared by my staff, documents and information furnished by local interests, and the stated views of these interests and agencies relative to the various possible alternatives for achieving the stated objectives of providing flood control features. The Old Cross-Cut Feasibility Study Report constitutes compliance with the overall Phoenix Urban Study authority and completes studies under that authority. The study identifies historic and recent flooding problem as well as estimating future flood damages. The study has identified flood inundation as a water resource problem in the study area.

Alternative plans for solving flood problems within the study area were formulated and evaluated to determine the relative consequence of each. The study effort and alternatives considered in this report were coordinated with interested agencies at the Federal, state and local levels. Public meetings and informational meetings with local officials were held by the local sponsor to solicit public input and preferences used in formulating and evaluating alternative plans.

I find that the results of the Old Cross-Cut Canal Study, as developed in this report, are based upon a through analysis and evaluation of various

practical alternatives for achieving the stated objectives. I find that there currently appears to be no potential for a Federally implementable plan to provide flood control protection in the Old Cross-Cut area for the following reasons:

1. The cost of flood control facilities is substantially greater than the flood control benefits which would result from such facilities.
2. Flooding depths expected in the study area do not produce sufficient damages to economically justify construction.

While there are local flood control problems in the Old Cross-Cut area, no alternative was found to justify Federal participation at this time.

CHAPTER VI

RECOMMENDATION

I recommend that no Federal action be taken at this time in implementing flood control plans for the Old Cross-Cut Canal, Phoenix, Arizona.



Tadahiko Ono
Colonel, Corps of Engineers
District Engineer