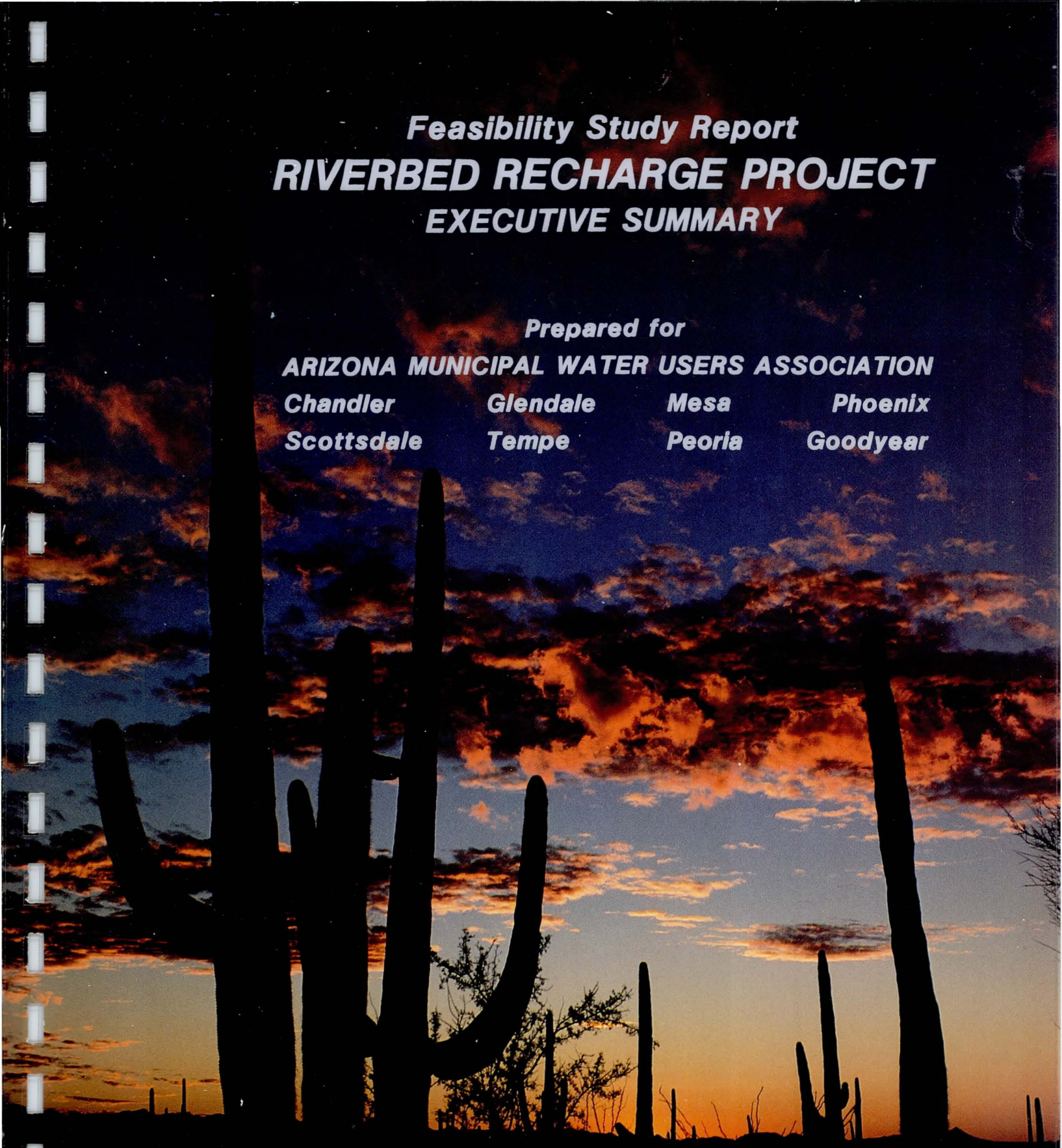


Feasibility Study Report
RIVERBED RECHARGE PROJECT
EXECUTIVE SUMMARY

Prepared for

ARIZONA MUNICIPAL WATER USERS ASSOCIATION

Chandler Glendale Mesa Phoenix

Scottsdale Tempe Peoria Goodyear

CAMP DRESSER & McKEE, INC.

AND

W.R. MILLS & ASSOCIATES

August 1986

117.007

Property of
Flood Control District of MC Library
Please Return to
2801 W. Durango
Phoenix, AZ 85009

EXECUTIVE SUMMARY

Prepared for

ARIZONA MUNICIPAL WATER USERS ASSOCIATION

Chandler	Glendale	Mesa	Phoenix
Scottsdale	Tempe	Peoria	Goodyear

Feasibility Study Report

RIVERBED RECHARGE PROJECT

Registered Professional Engineer (Sanitary)
CERTIFICATE NO. 8242
JEFFREY K. KRACHT
Date Signed 8-29-86
ARIZONA, U.S.A.

Prepared by

CAMP DRESSER & McKEE, INC.

AND

W.R. MILLS & ASSOCIATES

August 1986

CDM
environmental engineers, scientists,
planners, & management consultants

CAMP DRESSER & McKEE INC.

Cambridge Court
2701 North 16th Street
Phoenix, Arizona 85006
602 277-9966

August 8, 1986

Mr. Roger S. Manning
Executive Director
Arizona Municipal Water Users Association
505 North 2nd Street
L'Aiglon Court Suite 385
Phoenix, Arizona 85004

Subject: Executive Summary
Feasibility Study Report -
Riverbed Recharge Project

Dear Mr. Manning:

Camp Dresser & McKee Inc. has completed the report on feasibility study for recharge of Colorado River water in the Phoenix metropolitan area groundwater aquifers.

This executive summary presents a comprehensive synopsis of the formal report. Specific information is provided regarding the project's background; identification and evaluation of recharge sites; site comparison and ranking; final site selection; preliminary designs; and recommendations for implementing recharge activities, including proposed facility cost estimates.

Should there be questions or a need for additional information, please contact us.

Sincerely,

CAMP DRESSER & McKEE INC.

Jeffrey K. Kracht, P.E.
Vice President

JKK:sml

EXECUTIVE SUMMARY
Feasibility Study Report -- AMWUA Riverbed Recharge Project

TABLE OF CONTENTS

	Page
INTRODUCTION	1
BACKGROUND	1
Figure 1: Location of AMWUA Riverbed Recharge Project	3
RECHARGE SITE IDENTIFICATION AND EVALUATION	2
Agua Fria River	4
Table 1: Summary of Physical Characteristics for Potential Recharge Areas	5
New River	6
Skunk Creek	6
Cave Creek	7
Indian Bend Wash	8
Salt River	8
Queen Creek	9
LAND COSTS	9
SITE COMPARISONS AND RANKING	10
FINAL SITE SELECTION	10
Table 2: Recharge Site Ranking	11
Table 3: Annualized Capital and Operations and Maintenance Costs for Conceptual Designs	12
PRELIMINARY DESIGNS	13
General Design Considerations	13
Agua Fria River	14
Salt River	14
Monitoring Program	15
Recoverable Water	15
RECOMMENDATIONS FOR IMPLEMENTING RECHARGE ACTIVITIES	16
Permits	16
Figure 2: Conceptual Recharge Facility-Agua Fria	17
Figure 3: Conceptual Recharge Facility-Salt River	18
Data Deficiencies	19
Schedule for Project Implementation	19
Table 4: Schedule for Project Implementation	20
COST ESTIMATES	21
Capital Cost of Recharge Facilities	21
Table 5: Preliminary Design Recharge Facility Construction Costs	21
Total Project Costs	22
Table 6: Summary of Costs Agua Fria Recharge Facility	22
Table 7: Summary of Costa Salt River Recharge Facility	23

EXECUTIVE SUMMARY

INTRODUCTION

Artificial recharge involves releasing water over the ground surface and allowing it to infiltrate into the ground and percolate to the subsurface aquifers. Spreading methods include flooding, ditch and furrow, irrigation, natural channel, shallow spreading basins, and deep basin or pit techniques. In addition, artificial recharge may also be accomplished by using injection wells or shallow basins augmented by shafts or recharge wells. Currently, the most commonly used methods for artificial recharge are shallow spreading basins and deep basins or pits.

The purpose of this feasibility study report was to determine possible sites to be developed for artificial recharge activities of Central Arizona Project Water (CAP) into the Salt River Basin regional aquifer. The review identified a total of thirteen riverbed areas in which CAP water could potentially be recharged. The thirteen potential sites were screened to ten sites which were evaluated in depth during the investigation. Preliminary designs were then developed for two sites.

BACKGROUND

Beginning in 1986, Colorado River water will be transported via the Central Arizona Project (CAP) to CAP subcontractors in Maricopa County. At the present time, the CAP delivery capacity exceeds the water demands which may be placed on the system by CAP water users, particularly in the early years of CAP operation. Because surplus water is available, early delivery and storage of water will enhance future conjunctive management of present and future water supplies. In the Phoenix Active Management Area (AMA), significant amounts of water can be stored for later use by recharging the alluvial groundwater basins that underlie the greater Phoenix Metropolitan area.

Siting constraints established for the riverbed recharge study narrowed potential sites to river channel areas within the 100-year floodplain. In addition, recharge methods are required which will quickly transmit and store large quantities of water in the underground. The specific areas considered included the river channel areas downstream of the CAP Granite Reef/Salt-Gila Aqueducts consisting of the: 1) Agua Fria River to Grand Avenue, 2) New River to the Agua Fria River, 3) Skunk Creek to the New River, 4) Cave Creek to the Arizona Canal, 5) Indian Bend Wash to the Salt River, 6) Salt River from the Granite Reef Dam to Tempe Buttes, and 7) Queen Creek to the Roosevelt Canal. The location of each river system in the study area is shown on Figure 1. The objective of the AMWUA Riverbed Recharge Study was to identify and evaluate the recharge and storage capabilities for each of the river segments which are adjacent to, and downstream of, the Granite Reef or Salt-Gila Aqueducts.

RECHARGE SITE IDENTIFICATION AND EVALUATION

Recent aerial photographs (1985) of drainage courses were reviewed to locate undeveloped lands within the study areas and near the Central Arizona Project or other major water conveyance facilities which are connected to the CAP, such as the Arizona Canal. The review identified a total of thirteen riverbed areas in which CAP water could potentially be recharged. The thirteen potential sites were later screened to the ten sites which were evaluated in-depth during the investigation.

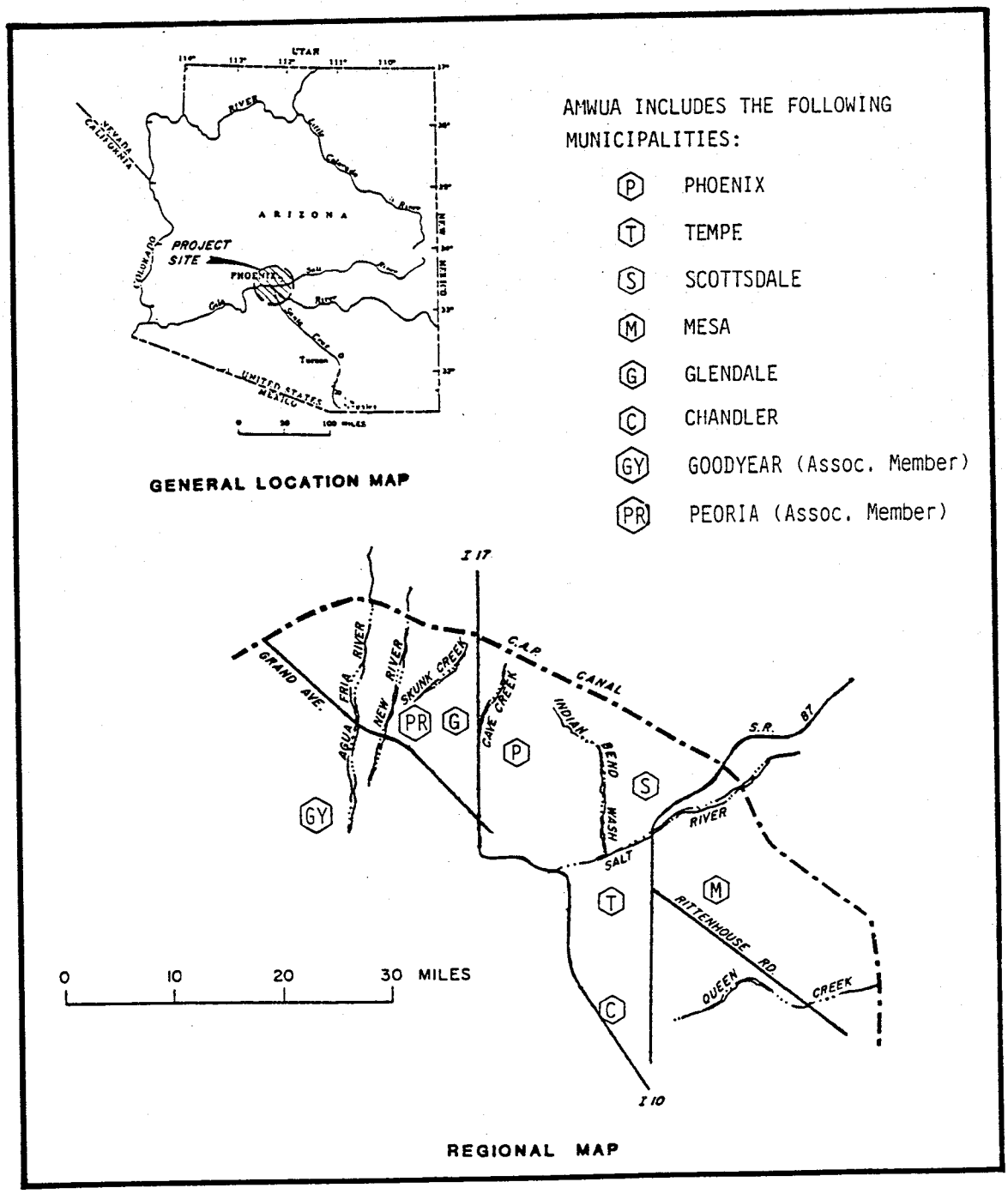
Each of the ten potential recharge sites were evaluated with regard to the following criteria, based upon existing data:

- Infiltration rates
- Mounding potential
- Available storage capacity
- Groundwater quality
- Perched water table conditions
- Proximity to residential neighborhoods
- Proximity to landfills and waste disposal sites
- Environmental factors
- Land Ownership

FIGURE 1

LOCATION OF AMWUA RIVERBED RECHARGE PROJECT

Feasibility Study Report -- AMWUA Riverbed Recharge Project



CAMP DRESSER & McKEE INC.

A qualitative rating system, using the above criteria, was used to select suitable alternative recharge sites. To complete the ranking process, conceptual designs were developed for each of the ten sites so that site development costs could be factored into the rankings. The conceptual designs were prepared with considerations for public land availability, recharge water availability, and the recharge characteristics of each site. The location and relative technical merits of each site area are summarized in the following paragraphs. A summary of physical characteristics for the potential recharge sites is presented in Table 1.

Agua Fria River

Of the river systems investigated, the Agua Fria River area is one of the most suitable areas for artificial recharge from a technical standpoint. The floodplain is wide with substantial amounts of publicly-owned, undeveloped land. CAP water can be supplied to the recharge areas either directly from the Granite Reef Aqueduct or through the Beardsley Canal. The best section of the Agua Fria River area for recharge lies between Jomax Road and Grand Avenue. However, because the recharge potential in this reach of the river is so much greater than the amount of CAP water potentially available (estimated to range from 50,000 to 400,000 acre-feet per year [ac-ft/yr] in the near term), it will fully percolate by the time it gets to Deer Valley Road, located about three miles south of Jomax Road. Up to 400,000 ac-ft/yr could be available through 1992, with half of this amount being available for the West Salt River Valley and half for the East Salt River Valley.

Based on the selection criteria, groundwater mounding may be a problem. Groundwater mounding occurs when the groundwater table beneath the recharge operation rises to the ground surface, thus reducing the recharge rate. The potential for mounding can be verified with exploratory drilling in the area under consideration. However, mounding can be controlled operationally by rotating recharge operations from one area of the facility to another, thus allowing the groundwater mound time to dissipate.

The conceptual design for the Agua Fria River recharge facilities consists

TABLE 1

SUMMARY OF PHYSICAL CHARACTERISTICS FOR POTENTIAL RECHARGE AREAS IN THE AMWUA RIVERBED RECHARGE STUDY

Feasibility Study Report - AMWUA Riverbed Recharge Project

LOCATION	DEPTH TO WATER (a) (feet)		INFILTRATION RATE (ft/day)		TRANSMISSIVITY (kgpd/ft)		SPECIFIC YIELD		STORAGE CAPACITY (af/ac) (b)	AREA FOR POTENTIAL RECHARGE (ac)	PRESENCE OF PERCHING ZONE	WATER QUALITY PROBLEMS
	RANGE / MEAN (c)		RANGE / MEAN (c)		RANGE / MEAN (c)		RANGE / MEAN (c)					
Agua Fria	100-350	280	2.1-3.8	3.2	5-80	35	.05-.10	.09	25.2	2,150	2 mi. south-west & down-gradient	F elevated 4 mi. SW TCE 3 mi. S
New River	250-500	450	1.2-3.2	2.5	25-200	60	.07-.12	.09	40.0	495	possible	DBCF in southern portion
Skunk Creek	480-530	500	0.2-0.3	0.3	10-75	64	.10-.15	.10	50.0	520	possible	High NO3 1 mi. upgradient
Upper Cave Creek	270-300	275	0.1-2.1	1.8	10-30	14	.07-.10	.10	27.5	240	possible	Data deficiences
Lower Cave Creek	400	400	1.8-3.0	2.3	10	10	.05-.10	.07	28.0	400	possible	TCE .5-1.0 mi. S.
Upper Indian Bend Wash	300-440	430	0.3	0.3	5-15	11	.05-.10	.09	38.7	1,430	possible	Elevated Cr does not exceed standards
Lower Indian Bend Wash	340-400	340	.25	.25	20-100	40	.03-.05	.05	17.0	90	yes	High Cr 1 mi. east
Upper Salt River	310	310	1.9	1.9	70-110	81	.07-.10	.08	24.8	810	possible	TCE, DBCP, F & Cl .5-1.0 mi. downgradient
Lower Salt River	180-320	315	1.9-2.5	2.5	20-100	56	.05-.10	.09	28.4	2,550	yes	TCE, DBCP, high Cl downgradient
Queen Creek	430-480	460	2.1-3.2	2.7	60-150	111	.03-.12	.10	46.0	755	possible	Elevated NO3, Cl

a Based on 50% wet-dry application cycle.
b Groundwater stored above the water table.
c Area weighted; considered representative for recharge site.

CAMP DRESSER & McKEE INC.

of about 610 acres of in-channel "T" levee basins and about 515 acres of off-channel shallow basins. CAP water would be delivered at the Granite Reef Aqueduct turnout into the Beardsley Canal, and then released into spreading facilities near Jomax Road from the Beardsley Canal. This system would have a recharge capacity of about 415,000 ac-ft/yr. The Beardsley Canal is owned and operated by the Maricopa Water District, and it would be necessary to negotiate an agreement to use the canal for a recharge project.

New River

The area under investigation along the New River is located about 1.5 miles south of the Granite Reef Aqueduct, just below the Upper New River Dam. To avoid percolating water into a small, hydraulically isolated groundwater basin located adjacent to the aqueduct, water diverted from the CAP would have to be transported in a lined canal to the recharge area.

Using the selection criteria, several items were identified which are potential drawbacks to establishing a recharge facility on the New River. These include the need to build an expensive conveyance system between the aqueduct and the recharge basins; the existence of poor quality groundwater beneath, and downstream of, the site; the proximity of residential development; and, the presence of privately-owned, undeveloped land which would have to be purchased or leased to build the recharge facilities.

The conceptual design for the New River recharge facilities consists of about 515 acres of in-channel "T" levees which derive their water from the Granite Reef Aqueduct via a new trapezoidal, concrete-lined channel. This facility would have a recharge capacity of about 225,000 ac-ft/yr.

Skunk Creek

The area best suited for recharge facilities along Skunk Creek is behind Skunk Creek Dam, located near Deer Valley Road and 35th Avenue, approximately 3.5 miles south of the Granite Reef Aqueduct. Because the facility

would be located behind a flood control structure, the 520 acres of recharge basins would be subject to periodic inundation by flood waters.

The selected site has several drawbacks related to its development as a recharge facility. Because of its distance from the aqueduct and the presence of a landfill upstream of the proposed facility, a lined conveyance channel would have to be constructed to deliver CAP water to the recharge basins. Over half of the site area is privately owned and residential development is located within one-half mile of the site. Also, environmentally sensitive areas exist near the site. Finally, quality of groundwater beneath the site may be a problem because of the extensive agricultural activity that historically surrounded the site area. However, one of the major advantages of the site is the fact that it is located in an area of considerable historic groundwater overdraft, therefore, recharging this particular area would have very positive water management implications.

The conceptual design for the Skunk Creek recharge facilities calls for 30 to 40 permanent, off-stream shallow basins, each approximately one acre in size. Water would be delivered to the basins via a 19,000-foot concrete-lined trapezoidal channel. The system would have a recharge capacity of about 40,000 ac-ft/yr.

Cave Creek

Two sites close to one another are located along Cave Creek. The first is located between Deer Valley Road and Union Hills Drive, while the second site is located between Bell Road and Greenway. These sites are located about 1.5 miles south of the Granite Reef Aqueduct.

The sites have some fundamental problems as recharge sites. First, a conveyance facility will be needed to carry water around a landfill located between the aqueduct and the recharge basins. Groundwater quality may be a problem downstream of the basins because of elevated concentrations of nitrates and volatile organic chemicals. Finally, residential zoning and other privately owned land is present.

The conceptual design for the Cave Creek recharge facilities consists of a combination of in-channel and off-channel basins, covering an area of 140 and 495 acres, respectively. Water would be delivered from the aqueduct by way of a 10,000-foot concrete-lined, trapezoidal channel. The recharge capacity of the combined facilities would be about 250,000 ac-ft/yr.

Indian Bend Wash

Most of the lands along Indian Bend Wash are already developed. However, two areas were identified for evaluation. The first site is located adjacent to the Granite Reef Aqueduct. The second potential site is located in the stream channel between Indian Bend Road and McDonald Drive, just south of the Arizona Canal. At the upper (or northern) site, CAP water would be diverted directly into the recharge basins. At the lower (or southern) site, CAP water would have to be delivered via the Arizona Canal.

The upper site is not well-suited for development of recharge facilities. Drawbacks include low infiltration rates, privately owned land and residential zoning, and possible groundwater quality problems. The lower site is not particularly suited to large-scale recharge activities. It is relatively small, underlying groundwater quality in the area is poor, and the site is very close to residential development.

The conceptual design for the upper site calls for about 40 shallow basins, each having an area of 30 to 40 acres. This facility could recharge about 105,000 ac-ft/yr.

The conceptual design for the lower site, Indian Bend Wash, calls for an in-stream "T" levee system covering an area of about 90 acres. CAP water would be diverted into the Arizona Canal at the Granite Reef Dam and conveyed to the site. The facility could recharge about 5,000 ac-ft/yr.

Salt River

The Salt River area appears to have excellent potential as a major recharge site for CAP water. Two major areas were identified along the Salt River

for investigation. These two areas are adjacent to each other, and would be developed in a similar manner. For this reason, the two sites were combined to make one large site. CAP water would be delivered to the site from a turnout at the Granite Reef Dam, or out of the Southern Canal, west of Granite Reef Dam. Like the Agua Fria River recharge facilities, more land is available on the Salt River than is needed to recharge the estimated available 200,000 ac-ft/yr of recharge water, therefore, facilities can be expanded to accept additional available recharge water.

Overall, the Salt River is highly feasible for recharging CAP water. The site is near the CAP, it is a very large area, required land is publicly owned, and recharge characteristics are good. The only potential drawback for this area is the presence of poor quality groundwater downgradient of the facilities.

The conceptual design for the Salt River recharge facilities calls for both in-stream and off-stream basins, covering an area of about 1,170 acres. These basins would have a total recharge capacity of about 430,000 ac-ft/yr.

Queen Creek

The Queen Creek recharge facilities would be located immediately west of the Salt-Gila Aqueduct, covering an area of about 755 acres. The site appears to be excellent because it covers a large area with high recharge potential, is free from residential and environmental problems, and is near the CAP. Two significant problems with the site are that the land is almost entirely privately owned, and there is a potential for perched water conditions beneath the site.

The conceptual design for the Queen Creek facility consists of in-stream "T" levees. The recharge capacity of the facility would be about 385,000 ac-ft/yr.

LAND COSTS

AMWUA has investigated the cost to purchase privately owned, undeveloped

land for use as recharge sites. The estimated land costs for the river systems ranged between $1,000 per acre along Queen Creek and $30,000 per acre along Indian Bend Wash. Because surface spreading operations are land-intensive, use of privately owned land purchased at these prices would constitute a major capital expense. For example, land for the Upper Indian Bend Wash facility, which covers about 1,430 acres would cost over $40 million, which is over ten times the estimated cost of actual recharge facilities.

SITE COMPARISONS AND RANKING

The physical characteristics for each of the ten potential recharge sites is summarized in Table 1. The physical characteristics for each site was evalauted relative to the other sites. From the evaluation, the sites were ranked on a technical basis relative to one another. Table 2 presents the relative technical ranking of the sites and indicates that the Agua Fria River, Salt River, and Queen Creek sites are most feasible, based on technical merit.

Table 3 summarizes the adjusted recharge rate used for the conceptual design, as well as the annualized capital and operation and maintenance (O&M) costs for each site. O&M costs are assumed to be constant, based on the O&M costs incurred by similar facilities in southern California. The total annualized costs shown in the last column of Table 3 provides a unit cost comparison of the recharge sites. From a unit cost standpoint, the Agua Fria River, Salt River, and Queen Creek sites are the most feasible, with annualized capital costs of less than 30 cents per acre-foot of recharge capacity for in-stream facilities.

FINAL SITE SELECTION

All ten sites evaluated during the screening process can be used to recharge CAP water. None of the sites appeared to have a technical "fatal flaw." With the exception of the Skunk Creek facilities, the difference in

cost for constructing, operating, and maintaining any site was insufficient justification to eliminate that site. At the Skunk Creek site, low infiltration rates (thus the cost per acre-foot of water recharged) make the development of recharge facilities relatively expensive.

Although development of each of the sites evaluated is feasible, some sites were better than others. Considering that one of the primary objectives of the program is to recharge large quantities of water, in a short period of time, in the near future, in-channel facilities would be best for rapid development, provided that the sites are located on public

TABLE 2

RECHARGE SITE RANKING

Feasibility Study Report -- AMWUA Riverbed Recharge Project

	ADVANTAGES				DISADVANTAGES					
	Large Facility	Near Supply Source	Public Lands Available	Receiving Water Quality Good	Private Lands Required	Conveyance Facility Needed	Known Perched Water Conditions	Small Facility	Receiving Water Quality Problems	Comments
MOST FEASIBLE										
1. Agua Fria (Middle)	●	●	●	●						
2. Salt River (Upper)	●	●	●						●	DBCP
3. Salt River (Lower)	●	●	●				◐		●	DBCP
4. Queen Creek	●	●		◐	●				◐	NO_3
FEASIBLE WITH MAJOR DRAWBACKS										
5. Skunk Creek	●				◐	●			◐	NO_3 and landfill
6. New River (Lower)	●				●	●			●	DBCP
7. Cave Creek (Upper)	●				●	●			●	VOC
8. Cave Creek (Lower)	●				●	●			◐	landfill
LEAST FEASIBLE										
9. Upper Indian Bend	●	●			●				●	Cr^{+6}
10. Lower Indian Bend		●			●		●	●		

CAMP DRESSER & McKEE INC.

LEGEND

● Applies

◐ Partially Applies

land and that conveyance facilities are not required. The Agua Fria and Salt River sites best meet this criterion. Together, the in-stream recharge facilities on the Agua Fria and Salt Rivers have a maximum potential recharge capacity of 54,000 ac-tf/yr. Based on the evaluation and final screening presented, preliminary designs were prepared for in-channel facilities on the Aqua Fria and Salt River sites.

TABLE 3

ANNUALIZED CAPITAL AND O&M COSTS FOR CONCEPTUAL DESIGNS

Feasibility Study Report -- AMWUA Riverbed Recharge Project

RECHARGE SITE	RECHARGE RATE (kaf/yr)	CAPITAL COST ($ x 1000)		ANNUAL COST ($/AF)		
		TOTAL	ANNUALIZED	CAPITAL	O & M	TOTAL
AGUA FRIA RIVER						
In-Stream Facilities	225	561	53	0.23	4.00	4.23
Off-Stream Facilities	190	1,795	168	0.89	4.00	4.89
NEW RIVER						
In-Stream Facilities	225	4,921	461	2.05	4.00	6.05
SKUNK CREEK						
Off-Stream Facilities	40	6,781	635	15.88	4.00	19.88
UPPER CAVE CREEK						
In-Stream Facilities	15	758	71	4.73	4.00	8.73
Off-Stream Facilities	60	2,588	242	4.04	4.00	8.04
LOWER CAVE CREEK						
In-Stream Facilities	40	888	83	2.08	4.00	6.08
Off-Stream Facilities	135	2,950	276	2.05	4.00	6.05
UPPER INDIAN BEND WASH						
Off-Stream Facilities	105	2,999	281	2.68	4.00	6.68
LOWER INDIAN BEND WASH						
In-Stream Facilities	5	118	11	2.21	4.00	6.21
UPPER SALT RIVER						
In-Stream Facilities	110	343	32	0.29	4.00	4.29
LOWER SALT RIVER						
In-Stream Facilities	205	461	43	0.21	4.00	4.21
Off-Stream Facilities	115	1,008	94	0.82	4.00	4.82
QUEEN CREEK						
In-Stream Facilities	385	906	85	0.22	4.00	4.22

CAMP DRESSER & McKEE INC.

NOTES:
1. Capital costs are exclusive of land acquisition costs.
2. Capital costs amortized at 8% over 25 years.
3. The O&M costs are exclusive of the purchase of CAP water.

PRELIMINARY DESIGNS

General Design Considerations

As the recharge site evaluation progressed from the conceptual to preliminary design phase, the focus of the study changed from a general overview, to a more detailed consideration of the selected sites. The conceptual designs for ten recharge systems were formulated as described earlier. The sites were configured to make reasonable use of available vacant lands within each study area, without regard to land ownership. The recharge area for each system was, in general, limited to vacant lands within the floodplain. However, once the Agua Fria and Salt River areas were screened, and selected as the most feasible sites, a more in-depth investigation was undertaken to develop preliminary designs.

Prior to initiating the preliminary design process, the project team and AMWUA staff considered and decided on several issues that greatly affected the preliminary designs, as follows. Based on preliminary data on the availability of surplus CAP water for artificial recharge, the recharge area for preliminary designs should be sufficient to recharge about 200,000 ac-ft/yr at each site. Because the estimated sustained infiltration rate at both sites had been previously estimated at one foot per day, the corresponding area needed to recharge 200,000 ac-ft/yr is about 550 acres. Although actual infiltration rates have not been verified in either the Agua Fria or Salt River areas, sufficient area is available at both sites to allow for expansion or contraction of facilities to accommodate actual recharge rates and available water.

The Salt River recharge facility was located convenient to a future turnout location on the Southern Canal, and a proposed CAP/SRP Inter-Connection Facility downstream of Granite Reef Dam. Potential turnout locations were investigated in the field. For the Southern Canal turnout, the most favorable location, an existing drainage channel to the Salt River was identified. The 550-acre Salt River recharge facility was then laid out downstream of the tributary drainage channel.

The use of public lands was considered as an important factor for implementation of a recharge project. Recharge facilities could be constructed more cheaply by avoiding the cost of purchase and/or lease of privately owned lands. The amount of publicly owned lands appeared sufficient at both sites, therefore preliminary designs exclude privately owned lands. Preliminary designs were prepared only for in-channel "T" levee spreading facilities which can be easily constructed at a relatively low cost, and provide the desired recharge capability. Specific details for the proposed Agua Fria and Salt River recharge facilities are outlined in the following paragraphs.

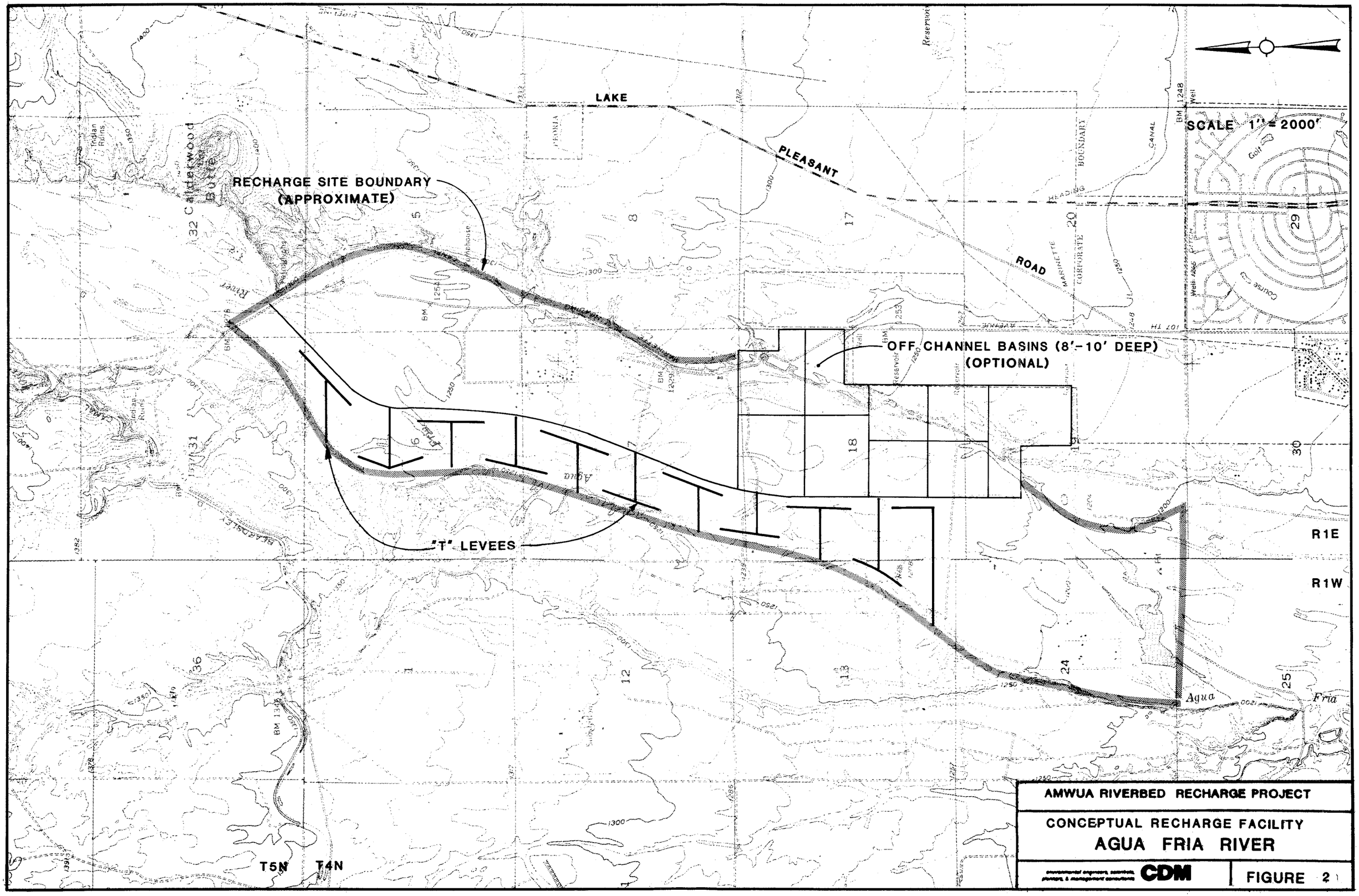
Agua Fria River

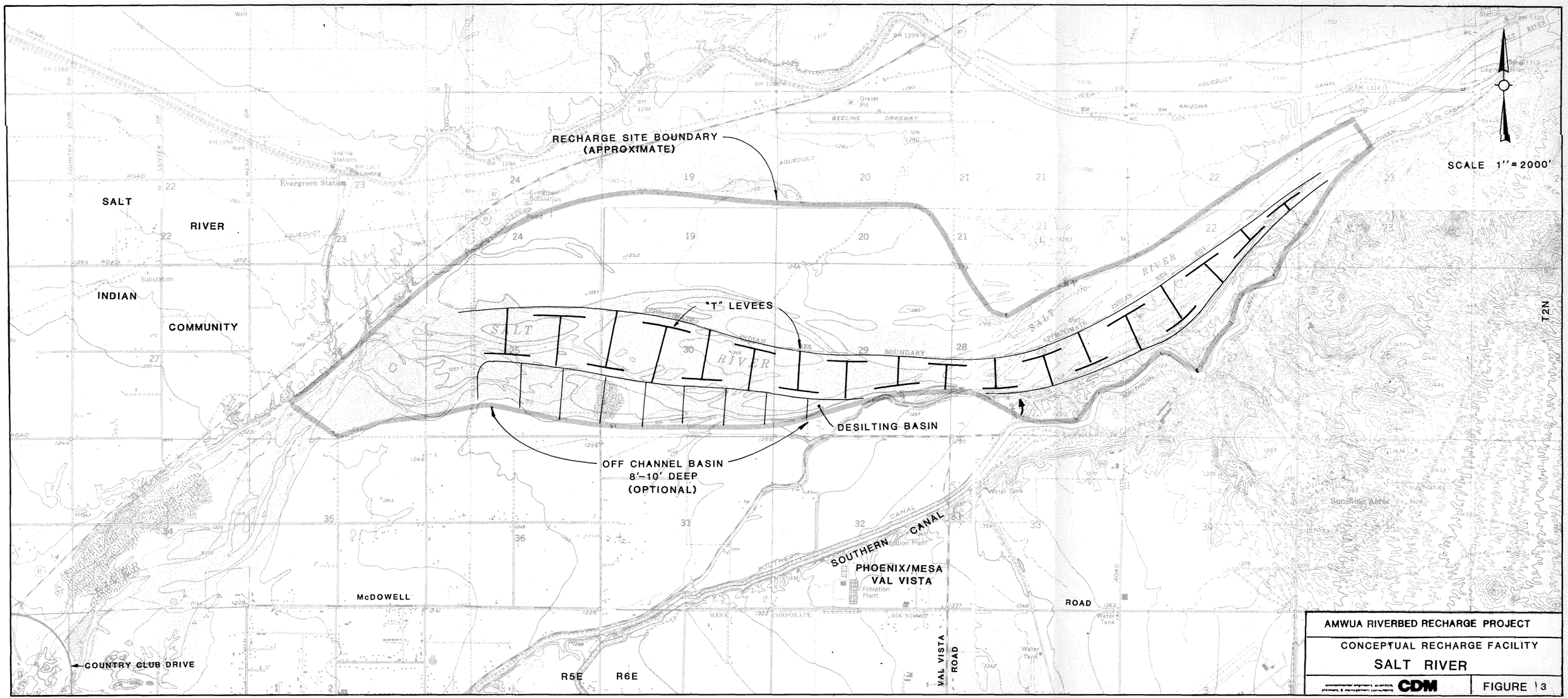
It is proposed that CAP water for the Agua Fria River recharge facility be discharged into the Beardsley Canal via the Maricopa Water District (MWD) CAP turnout. The CAP water would be conveyed approximately three miles in the Beardsley Canal to a proposed turnout at a dry wash immediately tributary to the Agua Fria River. Based on discussions with MWD, the Beardsley Canal could be utilized to convey about 180,000 ac-ft/yr to the recharge site, and canal capacity could be increased by raising and strengthening several levee segments. The in-channel average length of "T" basins is 1,300 feet. The total length of the Agua Fria recharge facility was configured at about 16,000 feet (refer to Figure 2).

Salt River

CAP water can be conveyed to the Salt River recharge facility either by discharging it directly into the river from a proposed CAP/SRP Inter-Connection Facility at Granite Reef Dam or via the SRP's Southern Canal to a proposed turnout structure to be constructed closer to the recharge facilities.

The actual vacant capacity available in the Southern Canal is presently under review by SRP. However, because the capacity of the Southern Canal is much greater in comparison to the proposed recharge flow rate of 400 cfs, adequate delivery capacity was assumed to exist within the Southern Canal to convey recharge water.


SCALE 1" = 2000'
LAKE
PLEASANT
ROAD
RECHARGE SITE BOUNDARY
(APPROXIMATE)
OFF CHANNEL BASINS (8'-10' DEEP)
(OPTIONAL)
"T" LEVEES
R1E
R1W
T5N
T4N
Agua
Fria
AMWUA RIVERBED RECHARGE PROJECT
CONCEPTUAL RECHARGE FACILITY
AGUA FRIA RIVER
CDM
FIGURE 2


RECHARGE SITE BOUNDARY
(APPROXIMATE)
SCALE 1" = 2000'
SALT
RIVER
INDIAN
COMMUNITY
"T" LEVEES
DESILTING BASIN
OFF CHANNEL BASIN
8'-10' DEEP
(OPTIONAL)
SOUTHERN CANAL
PHOENIX/MESA
VAL VISTA
McDOWELL
ROAD
VAL VISTA ROAD
COUNTRY CLUB DRIVE
R5E
R6E
T2N
AMWUA RIVERBED RECHARGE PROJECT
CONCEPTUAL RECHARGE FACILITY
SALT RIVER
CDM
FIGURE 13

The Salt River recharge facility was configured at about 16,000 feet in length with an average "T" basin spacing of 1,500 feet (Figure 3). The proposed recharge facility abuts the southern boundary of the Salt River Indian Community (SRIC) as indicated in Figure 3. Final design efforts related to implementation of the recharge project would require precise location of the SRIC boundary, as current mapping delineates the boundary as "approximate."

Monitoring Program

An integral part of a groundwater recharge project is a groundwater monitoring system. This system should be capable of detecting changes in water quality that may be directly or indirectly attributable to the recharge operation. Consequently, a monitoring network should be installed prior to the initiation of recharge. The monitoring system should also provide information necessary to more conclusively establish rates and movement direction of the recharged water on a short and long term basis.

A preliminary groundwater monitoring network was developed for both the Agua Fria and Salt River recharge facilities as a part of this study. Twelve monitoring wells formed the Agua Fria well network, while the Salt River groundwater monitoring network consisted of fourteen wells.

Recoverable Water

Non-recoverable losses of recharge water occur through free surface evaporation in the recharge basins, evapotranspiration and, satisfaction of soil moisture deficit in the unsaturated zone. Estimates of water loss for the Agua Fria and Salt River recharge facilities were formulated based on the preliminary design recharge areas and estimated sustained infiltration rates.

Free surface evaporation occurs as the water is standing in the recharge basins. This evaporation was estimated using lake evaporation data, and assumes that the entire recharge area (550 acres at each site) would be wetted continuously. Free surface evaporation would amount to less than

8,000 ac-ft/yr, which is only about two percent of the 400,000 ac-ft/yr of water recharged.

Evapotranspiration is the loss of water caused by plant respiration. It is assumed to be zero because significant areas of plant growth will not occur in the recharge areas.

The soil moisture deficiency and evapotranspiration losses were small and could be neglected. Thus, the only significant loss, over the long period, is from surface evaporation. Consequently, about 98 percent of the recharge water is subject to recovery.

RECOMMENDATIONS FOR IMPLEMENTING RECHARGE ACTIVITIES

Permits

Implementation of CAP recharge programs at the Agua Fria and Salt River sites will require obtaining the necessary permits from the appropriate local, state and federal agencies. Permits will require that certain hydrogeologic data deficiencies be satisfied, including the implementation of a monitoring program to develop baseline information. The hydrogeologic data will also be required to develop the final designs for each site.

Approximately six permits will be necessary from local, state and federal agencies to commence recharge activities. A 404 permit from the U.S. Army Corps of Engineers is necessary, which would require a general environmental assessment and take at least 60 days to obtain, after submittal of an application. As a result of the passage of Arizona House Bill 2209, a groundwater recharge permit must be obtained from the Arizona Department of Water Resources (ADWR). An Arizona Department of Health Services (ADHS) groundwater quality discharge permit is necessary for any surface impoundment discharging to groundwater. Generally, a formalized ADHS permit is granted six to eight months after permit application. A National Pollutant Discharge Elimination System (NPDES) permit may be necessary from ADHS and EPA, and will probably take about 180 days to obtain. Finally, local permits may be required if the zoning of areas within the recharge sites is currently incompatible with groundwater recharge use.

Data Deficiencies

Both the Agua Fria and Salt River recharge sites have numerous data deficiencies must be addressed prior to commencement of recharge activities. The major area of data deficiencies is the lack of detailed hydrogeologic information. The additional information required would be used to: 1) finalize recharge site designs; 2) establish baseline hydrogeologic conditions (including water quality); and 3) procure the required permits from the appropriate regulatory agencies. Much of this information can be obtained from the construction of twelve to fourteen new exploratory wells for each recharge site as part of the monitoring program.

Field infiltration rates should be determined, particularly for the Agua Fria River since no field measurements have been made at this time. Also, neutron logging in shallow piezometers prior to, and after, recharge should yield information on soil moisture deficiency and moisture content beneath the two sites, which would be used to more precisely determine accurate storage capacity and the amount of recoverable water. Finally, land ownership and detailed topographic surveys must be conducted for the preparation of final designs and construction.

Schedule for Project Implementation

An important objective of the AMWUA Riverbed Recharge Project is to initiate recharge activities as soon as possible. To get to the point that CAP water is actually being recharged, several intermediate steps need to be completed, including: 1) conducting a detailed hydrogeologic investigation at each site to support preparation of final designs and to meet all permit requirements; 2) preparing final designs, plans, and specifications for construction of recharge facilities; 3) preparing and submitting all permit applications; and 4) delineating boundaries.

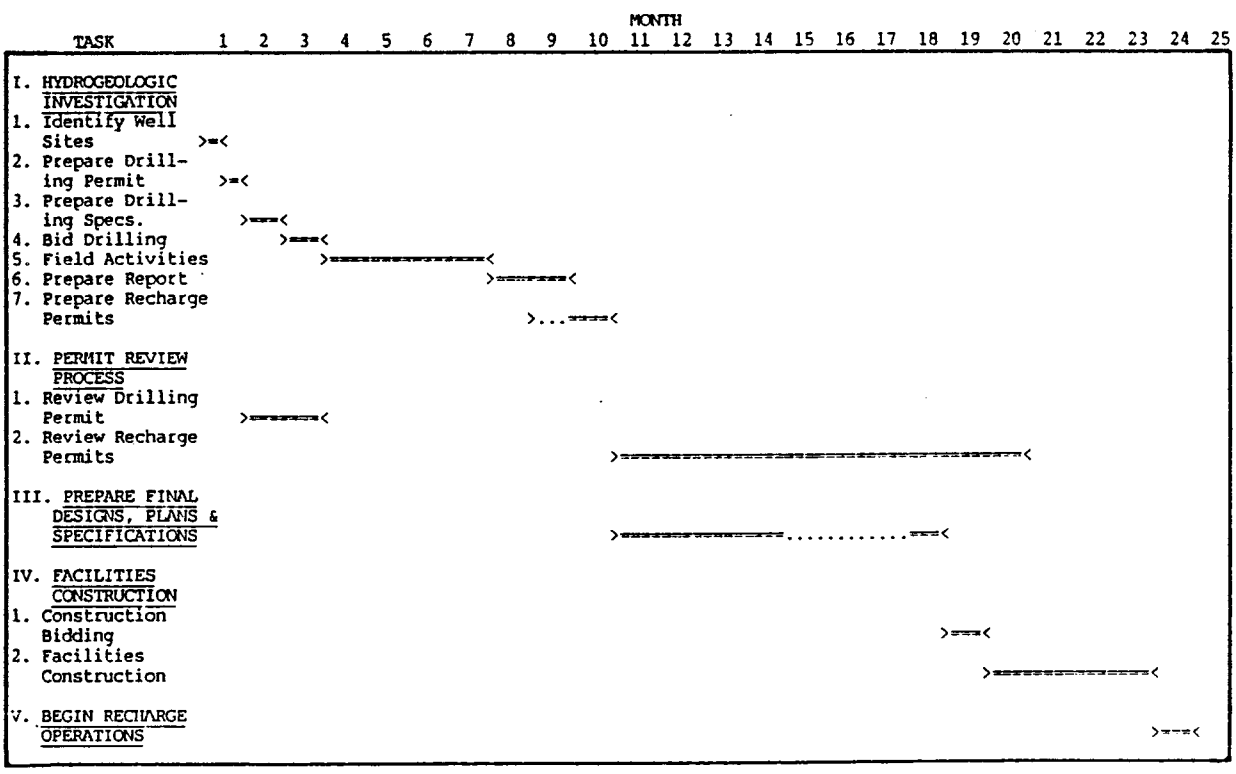
A proposed schedule for project implementation is summarized in Table 4. The hydrogeologic investigation will consist of: 1) construction, testing, and sampling of monitoring wells in, and around, each recharge site; 2) conducting infiltration tests at each site; 3) preparing a long-term

monitoring program for each site using existing wells and new monitoring wells; and 4) preparing detailed topographic and boundary maps of the site areas. As indicated on Table 4, the hydrogeologic investigations will require up to ten months to complete. Drilling activities require the greatest amount of time to complete. The duration of the field activities can be shortened if more drill rigs can be mobilized to the sites and the bidding process can be fast-tracked.

Preparation of the final designs, plans, and specifications could be completed concurrently with the preparation and review of permit applications. Final design activities will require about four months to complete. The permit review process could take as much as nine months to complete, unless the reviewing agencies can conduct their reviews on a fast-track basis. Full-time liaison activities are suggested with permitting agencies.

TABLE 4

SCHEDULE FOR PROJECT IMPLEMENTATION
Feasibility Study Report -- AMWUA Riverbed Recharge Project



CAMP DRESSER & McKEE INC.

COST ESTIMATES

Capital Cost of Recharge Facilities

Material quantities were computed from information derived from the preliminary design drawings. Unit cost information, based on current price levels (ENR 4300) were determined and used to compute total costs. Estimated construction costs for the Agua Fria and Salt River recharge facilities and monitoring systems are as shown in Table 5.

The topographic information available for the preliminary design is rather poor. Since the earthwork construction constitutes the majority of each recharge project's cost, considerable variation from earthwork computations done during this phase of work may occur when more precise topographic data become available.

TABLE 5

PRELIMINARY DESIGN RECHARGE FACILITY CONSTRUCTION COSTS

Feasibility Study Report -- AMWUA Riverbed Recharge Project

Item	Quantity	Unit	Unit Cost	Total Cost
Agua Fria River Recharge Facility				
Earthwork	300,000	CY	$ 1.80	$ 540,000
Beardsley Canal Improvements	1	EA	90,000	90,000
Turnout Structure	1	EA	40,000	40,000
Parshall Flume	1	EA	15,000	15,000
Monitoring Wells	12	EA	25,000	300,000
Contingency, Legal, Engineering and Administration (35%)				345,000
Total				$1,330,000
Salt River Recharge Facility				
Earthwork	420,000	CY	$ 1.80	$ 750,000
Turnout Structure	1	EA	40,000	40,000
Parshall Flume	1	EA	15,000	15,000
Monitoring Wells	14	EA	25,000	350,000
Contingency, Legal, Engineering and Administration (35%)				405,000
Total				$1,560,000

Total Project Costs -- Capital/O&M/Water Purchase

The estimated costs to construct, operate, and maintain the recharge facilities on the Agua Fria and Salt Rivers are summarized in Tables 6 and 7.

The total annual cost to recharge 200,000 acre feet of water at each facility, including purchase of Colorado River water, is $7,930,000 on the Agua Fria River, and $7,950,000 on the Salt River. The associated unit cost for both facilities, including the cost of water, is $40 per acre foot of water recharged.

TABLE 6

SUMMARY OF COSTS -- 200,000 AC-FT/YR AGUA FRIA RECHARGE FACILITY

Feasibility Study Report -- AMWUA Riverbed Recharge Project

Item	Construction Cost (x1000)	Annual Cost (x1000)	Annual Unit Cost ($/AF)
RECHARGE FACILITY			
Earthwork	540		
Beardsley Canal	90		
Turn Out Structure	40		
Parshall Flume	15		
Monitoring Wells	300		
Contingency, etc.	345		
Subtotal	1,330		
DATA DEFICIENCIES & PERMITTING	95		
Total	1,425	130(b)	1(c)
OPERATION & MAINTENANCE (a)	---	800	4
WATER PURCHASE (a)	---	7,000	35(d)
Total	1,425	7,930	40

CAMP DRESSER & McKEE INC

(a) Based on purchase of 200,000 AF/YR.
(b) Annualization based on 8% interest over a period of 25 years.
(c) Rounded.
(d) Estimated at $35/ac-ft.

TABLE 7

SUMMARY OF COSTS -- 200,000 AC-FT/YR SALT RIVER RECHARGE FACILITY

Feasibility Study Report -- AMWUA Riverbed Recharge Project

Item	Construction Cost (x1000)	Annual Cost (x1000)	Annual Unit Cost ($/AF)
RECHARGE FACILITY			
Earthwork	750		
Turn Out Structure	40		
Parshall Flume	15		
Monitoring Wells	350		
Contingency, etc.	405		
Subtotal	1,560		
DATA DEFICIENCIES & PERMITTING	90		
Total	1,650	150(b)	1(c)
OPERATION & MAINTENANCE (a)	---	800	4
WATER PURCHASE (a)	---	7,000	35(d)
Total	1,650	7,950	40

CAMP DRESSER & McKEE INC

(a) Based on purchase of 200,000 AF/YR.
(b) Annualization based on 8% interest over a period of 25 years.
(c) Rounded.
(d) Estimated at $35/ac-ft.