Lewis Springs Fish Barrier

Phase 1 Investigations

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and

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12661 East Broadway Boulevard
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Table of Contents

I. Introduction

Lewis Springs consists of several perennial springs that feed into Government Draw, which is a tributary to the San Pedro River. The springs are located near the town of Sierra Vista about 2 miles north of the Highway 90 bridge over the San Pedro River in Cochise County, Arizona (see Figures 1 and 2). The area is within the Bureau of Land Management's San Pedro Riparian National Conservation Area.

The perennial portion of the stream is about 1,800 feet long, with a flow of approximately 100 gallons per minute. Surface flow ends just downstream of the railroad crossing, although water reappears just before entering the confluence with the San Pedro River, 1,000 feet downstream of the railroad crossing.

Native fish species found in Lewis Springs are longfin dace (*Agosia chrysogaster*), Sonora sucker (*Catostomus insignis)*, and desert sucker (*Pantosteus clarki*). Non-native species known to be present are green sunfish (*Lepomis cyanellus*), mosquitofish (*Gambusia affinis*), bullfrog (*Rana catesbeiana*), and crayfish (*Orconectes virilis*). Native fishes to be potentially repatriated to Lewis Springs include Gila topminnow (*Poeciliopsis occidentalis*), desert pupfish (*Cyprinodon macularius*), and possibly Gila chub (*Gila intermedia*),

U.S. Bureau of Reclamation (Reclamation), U.S. Fish and Wildlife Service (FWS), and U.S. Bureau of Land Management (BLM) have identified Lewis Springs as having potential for the placement of a fish barrier to prevent upstream movement of non-native fishes. This Phase 1 fish barrier investigation of Lewis Springs results from the provisions of the 1994 and 2001 biological opinions on transportation and delivery of Central Arizona Project water to the Gila River basin. This report summarizes site investigations, discusses engineering and construction considerations, geology, hydrology, geomorphology, conceptual design, construction costs, National Environmental Policy Act (NEPA), Endangered Species Act (ESA), Clean Water Act (CWA) compliance, right-of-way, and provides recommendations for further action.

Site investigations took place on June 9, 2003 and included representatives from Arizona Game and Fish Department, FWS, BLM, and Reclamation. The group hiked from the springs to the confluence with the San Pedro River and measured and photographed the most promising sites for a fish barrier.

II. Site Information

A. General - The springs surface at the base of a hillside that forms the south bank of Government Draw, about 900 feet upstream of the railroad crossing (Photo 1). The springs appear to be a series of seeps that produce roughly 30 gallons per minute. Surface water upstream of the railroad crossing creates a dense riparian zone.

B. Stream morphology - Upstream of the railroad crossing, the stream consists of a series of slow moving pools, up to 8 feet wide, within an approximately 130-foot wide riparian zone (Photos 2 and 3). Dense vegetation and thick grasses make the silty channel fairly stable. Channel slope is about 1.1%.

The stream banks upstream of the railroad crossing are comprised of erodible alluvial materials. However, the south bank appears relatively stable, owing to dense vegetation anchoring the soil. The north bank is shallow (6 to 8 feet) and unstable. Downstream of the railroad crossing, both banks are 6 to 8 feet in height, erodible, and unstable.

Downstream of the crossing, flows disappear underground within 100 feet, and the stream gives way to a dry, erodible, poorly defined channel. Head cutting is evident and the slope increases to about 1.3%.

C. Ground water - Lewis Springs flows year round and ground water will be encountered during excavation in the channel upstream of the railroad crossing. Downstream of the crossing, water would not be as big an issue, but would probably be encountered during excavations.

D. Hydrology - Government Draw drains 52 square miles. The elevation at the spring is about 4,040, and about 4,900 at the upper end of the drainage. The 17-mile long watershed is uncontrolled. The culverts associated with the railroad crossing have a capacity of about 7,400 cfs, which probably corresponds to the 100-year flood.

The San Pedro River is perennial at the confluence, with a base flow in the range of 10 cfs. The 100-year instantaneous frequency flood at the Charleston gage is 49,500 cfs.

E. Access - Lewis Springs is accessed from State Highway 90 by taking a one-lane road on the east side of the San Pedro River north for 2 miles. The road is adequate for construction traffic.

III. Potential Fish Barrier Locations

A. General - There are three potential sites for a fish barrier at Lewis Springs: just upstream of the railroad crossing; the railroad crossing itself; and about 300 feet downstream of the railroad crossing.

The height of the barrier drop discussed in the field was 3 feet. Although this height would not meet the 4-foot minimum criterion provided by FWS for Biological Opinion barriers, use of other funds established under the opinions is an option. Further consultation with FWS would be needed if this barrier were to be considered as part of opinion-mandated barriers. For the purposes of this report, the barrier vertical drop is considered to be 3 feet.

B. Site 1 Upstream of Railroad Crossing - This site was chosen as a possibility because it is at the lower end of the riparian reach, 50 to 100 feet upstream of the culvert railroad crossing (Photo 4). The banks at this site are about 140 feet across and are composed of alluvial materials. A 100-foot wide construction zone would affect cottonwoods, mesquite, bushes, and grasses. Bedrock is likely too deep to consider anchoring the structure.

One concern at this site is the ponding effect the barrier would have on the upstream habitat. Assuming a 3-foot vertical drop, combined with a sloping apron that adds another 6 inches above the stream thalweg, the barrier would raise water and sediment levels 3.5 feet. Factoring in a channel slope of 0.011, water would pond upstream of the barrier for 320 feet. Additionally, assuming that the slope of the sediment trapped by the barrier fills in at about ½ the original channel slope, sediment effects would extend upstream for about 640 feet. This is about a third of the perennial reach. The actual upstream effects may be more or less, but there would be significant geomorphologic and biological impacts to the area being protected.

C. Site at Railroad Crossing - This concept envisions using the corrugated metal pipe culverts (Photo 5) to house the barrier. 3-foot drop structures would be placed at the downstream end of each of the 12 culverts (Photo 6). This would effectively reduce the cross-sectional area of the culverts by 29%. The advantages of this option are that abutment work is not required, few materials are required, and construction costs would be low.

The disadvantage is that it is unlikely that Southern Pacific Railroad would agree to this scheme unless the crossing is over-designed by about 30% or more. There are no tangible benefits to the railroad, and the culverts would be more prone to clogging. Upstream effects to habitat would be similar to the previous site, although the barrier crests would be about 10 inches lower than the upstream site, resulting in water ponding for 240 feet and sediment effects for 480 feet.

One other possible option is to utilize the two headcutting "nick" points in the Government Draw channel between the railroad crossing and the San Pedro River. A narrow channel within the main channel could be excavated, effectively lowering the thalweg upstream to the railroad crossing. Eventually, this would probably happen naturally. The channel could probably be lowered 3 feet. Then at the culvert outlets, the channel could be excavated the full width of the crossing. A concrete splash pad could be constructed downstream of the culverts, and streamflows would freefall about 3 feet from the culverts to the splash pad. This would be a relatively inexpensive option, but would require the cooperation of Southern Pacific Railroad. This option would require further study of its viability.

D. Site 300 Feet Downstream of Railroad Crossing (Photos 7 and 8) - This site would minimize effects to the riparian habitat, although further studies are needed to determine if San Pedro River flooding would inundate the barrier. Additional surveys would be required to define the sedimentation effects at the railroad crossing. Southern Pacific Railroad would receive a grade control benefit from a barrier at this site that could potentially offset sediment concerns.

The distance between banks is 97 feet. The banks are easily erodible alluvial deposits 5 to 6 feet above the stream thalweg. Substantial bank stabilization work would be required to prevent erosion around the end of the structure.

A 2-foot deep headcut (Photo 9) is occurring about 90 feet downstream of the barrier site and would need to be considered by the engineer. The potential exists for another currently stable headcut drop at the San Pedro confluence to begin working its way upstream (Photo 10).

It is unlikely that bedrock would be present at a shallow enough depth to be beneficial to the design.

Construction access is good. Excavation work would encounter less water than at the upper site.

IV. Engineering and Design Considerations

A. General - The principle engineering challenge at the two stream channel sites is to prevent flood flows from eroding beneath and around the ends of the structure. The expected depth of alluvium makes tying the structure to bedrock prohibitively expensive. The structure must be engineered to withstand various types of scour, and the abutments must be strengthened to prevent a lateral shift in the stream channel. Scour prevention walls need to extend far enough down into the alluvium to prevent flood flows from undercutting and destabilizing the structure.

B. Site investigations - Two channel cross-sections and a channel longitudinal profile are included with this report (Figures 3, 4, and 5). The surveys were performed in February 2003 by Jeff Simms of BLM.

If Lewis Springs is to be further considered for emplacement of a fish barrier, additional information needs to be gathered at the site. Detailed surveys of the barrier site and the channel thalweg are required. The San Pedro River needs to be surveyed for a river hydraulics study to determine if floodwaters would reach the barrier. Test pits would be needed to classify and grade channel materials in order to evaluate scour potential. The test pits would be excavated with a backhoe. Samples would be tested in Reclamation's Phoenix lab. If there is a potential for tying the structure into bedrock, drilling should be done to determine the depth of alluvium to bedrock. A drill rig would auger down to bedrock, stopping at a maximum of 100 deep. Drilling below 100 feet requires a special aquifer protection permit, and is well beyond the depth any work would extend, even if piles are considered. The work would be done by Reclamation's drill crew from the Yuma office.

C. Engineering - The design flood used would probably be the 100-year instantaneous peak flow. After the design flood is determined, scour, sliding, and overturning forces can be evaluated.

There are three types of scour that need to be evaluated: natural bed scour associated with the depth of alluvial material that is in motion during the design flood; bridge pier type scour that occurs when the flow contacts the fish barrier structure; and downstream scour from the erosive action created by the structure. Scour will be accounted for with scour prevention walls extending below the channel surface, riprap armoring, stilling basin, piles, or a combination of these.

Sliding and overturning forces are a function of the force of the water and alluvium impacting the upstream face of the structure. Piles can be used to resist sliding. Overturning is primarily a function of the weight of the structure and is not anticipated to be a problem, but will be evaluated.

The crest of the structure would be built about 3.5 feet above the general contours of the existing channel cross-section (a 3-foot drop plus 6 additional inches from a sloping apron). It is desirable for stream bank stability to have the high points of the crest at the ends. A notch capable of passing the bankfull flow (about 1.5-year flood) will be constructed in the crest. This maintains the stream in its current location and limits deep scour to the notch area, thereby allowing vegetation to reestablish and create a more stable stream channel.

There may be considerable work required to keep the streamflow from eroding the banks and diverting flows around the barrier. The existing banks do not appear high enough to contain flood flows, especially considering that the barrier will raise the channel 3.5 feet, and the water surface a corresponding amount.

D. Conceptual fish barrier - A conceptual cross-section of a fish barrier structure is depicted in Figure 6. Dimensions shown on the drawing are only for magnitude reference, and will change during the engineering phase.

V. Construction Considerations

A. Access - The road to the site provides good access, and should not require much grading or maintenance. The road crosses the railroad tracks once, and would cross again if the lower site is selected. Construction traffic must be aware of train traffic, and crossing safety features may need to be implemented. The pullout onto Highway 90 will require signing and possibly flagmen.

Transit mixers, vehicles pulling low-boy trailers, and other construction equipment should have no difficulty accessing the site.

B. Construction Equipment - The following is a list of expected construction equipment that would be on-site at certain times during construction. The equipment actually used may vary somewhat depending on the contractor's approach to the work and equipment availability.

Front end loader	Concrete transit mixers
Dozer	Crane
Dump truck	Dewatering pumps
Excavator	Generators

C. Excavation - Materials can be excavated using common methods, like an excavator. The excavated area will need to be dewatered to maintain the excavated slopes. Excavated materials will be used for backfill around the structure.

D. Diversion and dewatering - The above-ground stream flows will need to be diverted away from construction activities. To accomplish this, the steam will be diverted as far to one side of the channel as possible, while work occurs on the other side. The flows will eventually be diverted to the other side to finish the work. A dozer would likely be used to create the diversion channels and associated berms.

Dewatering will be required to maintain an open excavation in the alluvial material. The contractor will likely install a well point just upstream of the barrier. A downstream well point may be installed, but is probably not necessary. The pump in the well point will probably be placed about 5 feet below the lowest excavation. The pumps will need to operate 24 hours a day. Power will probably come from generators, which will need to be placed outside of the floodway, although there are powerlines to the site. Dewatering is a critical activity on this job and a thorough plan needs to be developed by the contractor.

E. Concrete availability - There are several sources of concrete in the Sierra Vista area. Some research should be done to determine the reliability of these plants, from a production and quality standpoint. Those plants meeting the necessary criteria should be listed in the construction specifications as approved sources.

VI. NEPA, ESA, and Clean Water Act

Consideration of a Lewis Springs fish barrier beyond the feasibility stage must include provisions for compliance with NEPA, ESA, and CWA. The NEPA process entails writing draft and final Environmental Assessments of the preferred project and its considered alternatives, and potentially presenting the preferred and alternative projects at public meetings. The NEPA process can take 6-12 months to complete. If Reclamation were to undertake the NEPA compliance, our costs to perform this work is estimated at approximately $40,000, depending on the proposed action selected.

ESA compliance likely will involve writing a Biological Assessment that determines effects of the project to federally-listed species and designated critical habitat for species. Although Lewis Springs appears to be unoccupied by federally-listed species, the fish barrier project may affect designated critical habitat, and thus project impacts likely must be formally consulted on with FWS. As the project is for the benefit of native fishes, consultation with FWS should proceed smoothly, as it did recently with Reclamation's Aravaipa Creek and Fossil Creek fish barrier projects. Reclamation estimates that ESA compliance activities should not take more than 3-6 months, depending on the priority it receives from FWS. Estimated costs for ESA compliance is approximately $10,000.

The acquisition process for a 404 permit under requirements of CWA includes determining the impact footprint of the barriers (flooding, sedimentation, and construction zones), receiving a jurisdictional delineation from U.S. Army Corps of Engineers, further processing of a 404 permit application, and identification of possible mitigation for certain impacts to "waters of the US." Processing time for CWA compliance will be 6-12 months. Reclamation estimates that compliance costs associated with CWA regulations would be approximately $30,000.

VII. Conclusions and Recommendations

From a construction standpoint, a fish barrier at Lewis Springs is feasible. Access is good and a structure could be constructed without difficulty. However, there are two main drawbacks to this area. First, the active stream is only 1,800 feet long, so it is difficult to justify the expense of construction of a conventional concrete barrier for protection of a stream of this length. In addition, the upstream option and the culvert option would impact about 1/3 of the valued habitat with water ponding and sediment deposition.

The other main concern is the physical characteristics of the stream channel. The banks are relatively low and do not appear to contain large flood events, especially if a 3.5-foot structure is placed within the channel. The structure would raise the water surface profile and create greater bank erosion potential. These problems would necessitate substantial bank work to ensure the floodwaters are contained within the banks, or the upper terrace cannot erode downward. These concerns can be addressed with engineering, but contribute to the costs.

The lower site has low banks, but should not greatly impact the valued habitat. If affected by San Pedro River flood flows, the lower site may not be worthwhile, depending on the recurrence interval of the flood. This needs to be determined early in the process if this project continues to move forward.

Although a site with reachable bedrock would be desirable, neither of the in-channel sites appeared to have potential for a bedrock tie. A stable structure can be designed despite the foundation, as was done at Aravaipa Creek.

Overall, Lewis Springs contains excellent habitat and appears to have great potential for native fish. However, the short reach of valued habitat combined with the expense of constructing a functional, stable structure makes this project difficult to justify at two of the evaluated barrier sites. Consequently, Reclamation does not recommend consideration of a conventional fish barrier at Lewis Springs.

The two non-conventional concepts, in-culvert barriers and lowering the Government Draw thalweg to the San Pedro River, could be investigated. The costs of these options would be much lower than a conventional barrier, but could be met with opposition from Southern Pacific Railroad.

VIII. Construction Cost Estimates

A. Site upstream of railroad crossing - Channel is 140 feet across. This cost estimate is largely based on the actual construction costs for a similar barrier concept that was built at Aravaipa Creek near Dudleyville, Arizona in 2000-2001.

1. Mobilization (5% of subtotal) = $33,299
2. Water for dust abatement = $8,000
3. Diversion of stream = $5,000
4. Dewatering = $100,000
5. Clearing and grubbing = $3,000
6. Common excavation = ($4/cy)(34 cy/ft)(140 ft) = $19,000
7. Compacted backfill = ($10/cy)(13 cy/ft)(140 ft) = $18,000
8. Backfill = ($5/cy)(16 cy/ft)(140 ft) = $11,000
9. Riprap = ($48/cy)(500 cy) = $24,000
10. Mass concrete (below ground) = ($260/cy)(3.5 cy/ft)(140 ft) = $127,000
11. Structural concrete (crest and apron) = ($230/cy)(2.7 cy/ft)(140 ft) = $87,000
12. Rebar = ($0.70/lb)(930 lb)(140 ft) = $91,000
13. Bank stabilization) = $130,000

Subtotal (without inflation) = $623,000
Inflation index from 10-00 to 10-03 = 6.9%

Subtotal with inflation =	$665,987	
Mobilization (5%) =	$ 33,299	
	$699,286	
Contingencies (15%)	$104,893	
Total =	$804,179	Use $800,000

B. Site downstream of railroad crossing - Use ratio of channel width to upstream site.

97 ft/140 ft = 0.69

($800,000)(0.69) = 552,000 Use $560,000

C. Site at railroad crossing - Two estimates are associated with the culvert crossing; barriers within the twelve 9-foot culverts, and lowering the thalweg with a splash pad at the culvert outlets. These estimates have less detail than the previous estimates due to unknowns.

Barriers within the culverts:

1. Concrete - Area = (18.3 sq ft)(12 culverts) = 220 sq ft
   Volume = (220 sq ft)(2 ft thick) = 440 cu ft = 17 cy

   (17 cy)($500/cy) = $8,500

2. Erosion protection riprap - (140 ft w)(20 ft l)(5 ft d)/27 = 520 cy

   (520 cy)($50/cy) = $26,000

3. Subtotal = $34,500
   Contingencies 20% = $6,900
   Total = $41,400 Use $42,000

Lower thalweg with splash pad at culvert outlets

1. Excavate thalweg for 850 feet - Excavator (5/8 cy bucket) and operator for 2 days

   Excavator - ($470/day)(2 days) = $940
   Operator - ($420/day)(2 days) = $840
   Hourly operating cost = ($18/hr)(16 hrs) = $288
   Subtotal = $2,068

2. Concrete splash pad
   slab[(140 ft w)(1 ft th)(10 ft l) + key(140 ft w)(7 ft d)(1 ft th)](1/27) = 88 cy

   (88 cy)($350/cy) = $30,800

3. Subtotal = $32,868
   Contingencies 20% = $6,574
   Total = $39,442 Use $40,000

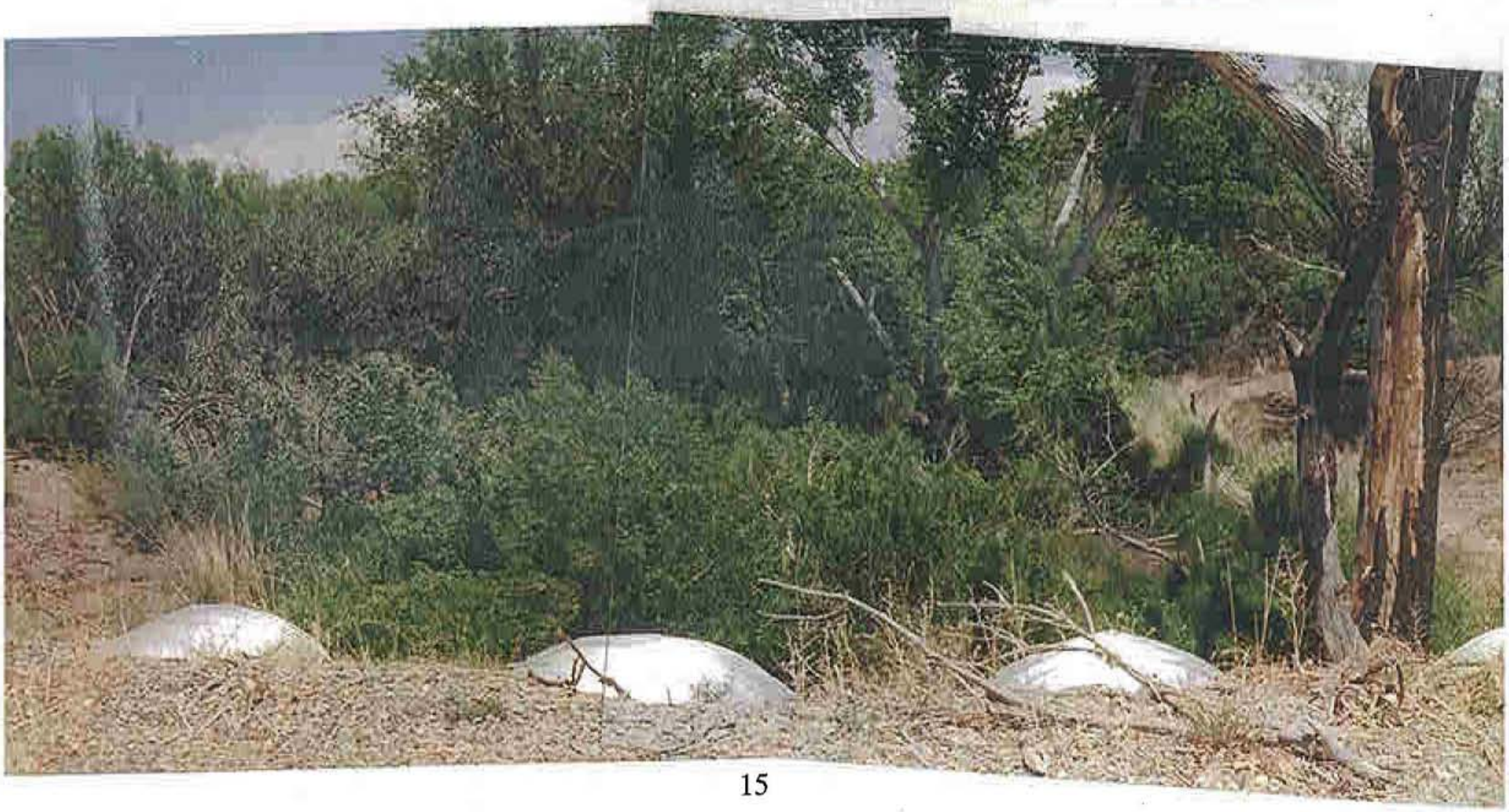
IX. Photos

Photo 1 - Near headwaters of Lewis Spring in Government Draw.

Photo 2 - Typical pond downstream of Lewis Spring.

Photo 3 - Example of riffle and pools downstream of Lewis Springs.

Photo 4 - Looking upstream at the barrier site upstream of the railroad crossing.



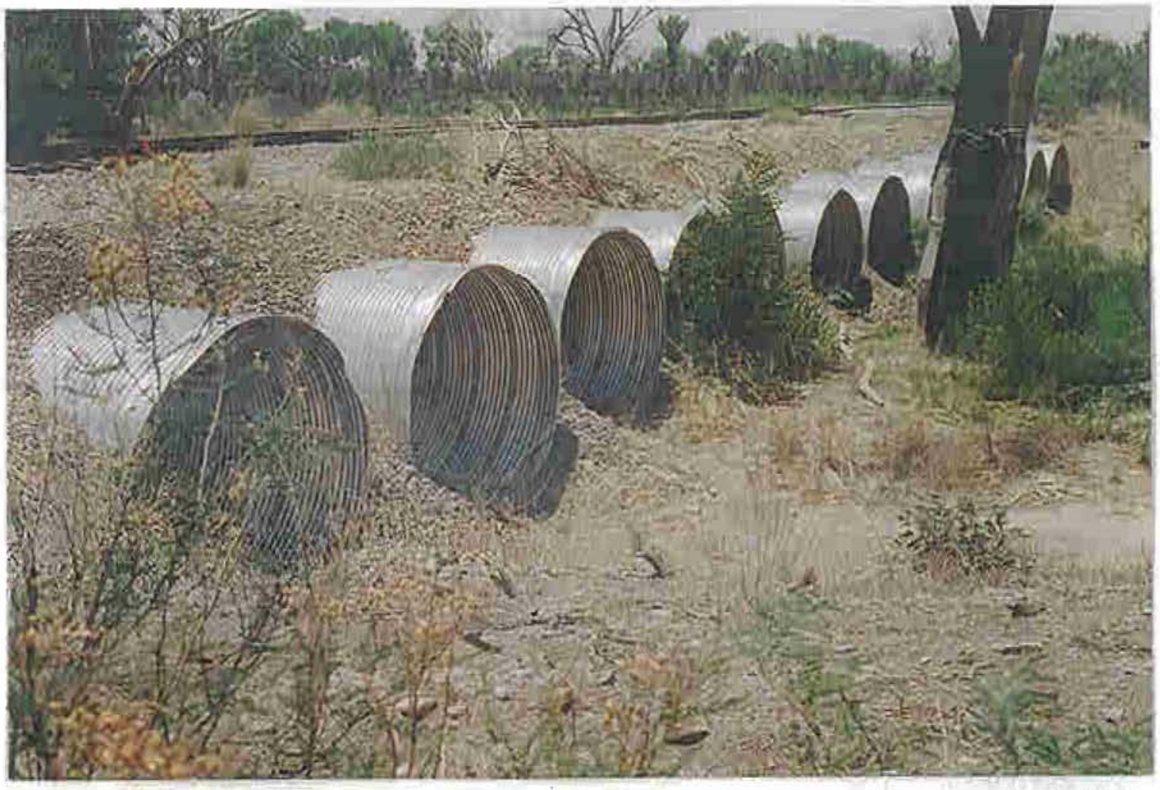


Photo 5 - Upstream side of the railroad crossing. Twelve 9-foot CMP's.

Photo 6 - Downstream end of railroad crossing culverts.

Photo 7 - Site 300 feet downstream of railroad crossing. Looking north along alignment at right abutment.

Photo 8 - Site 300 feet downstream of railroad crossing. Looking south along alignment at left abutment.

Photo 9 - Headcutting notch 30 feet downstream of downstream barrier site.

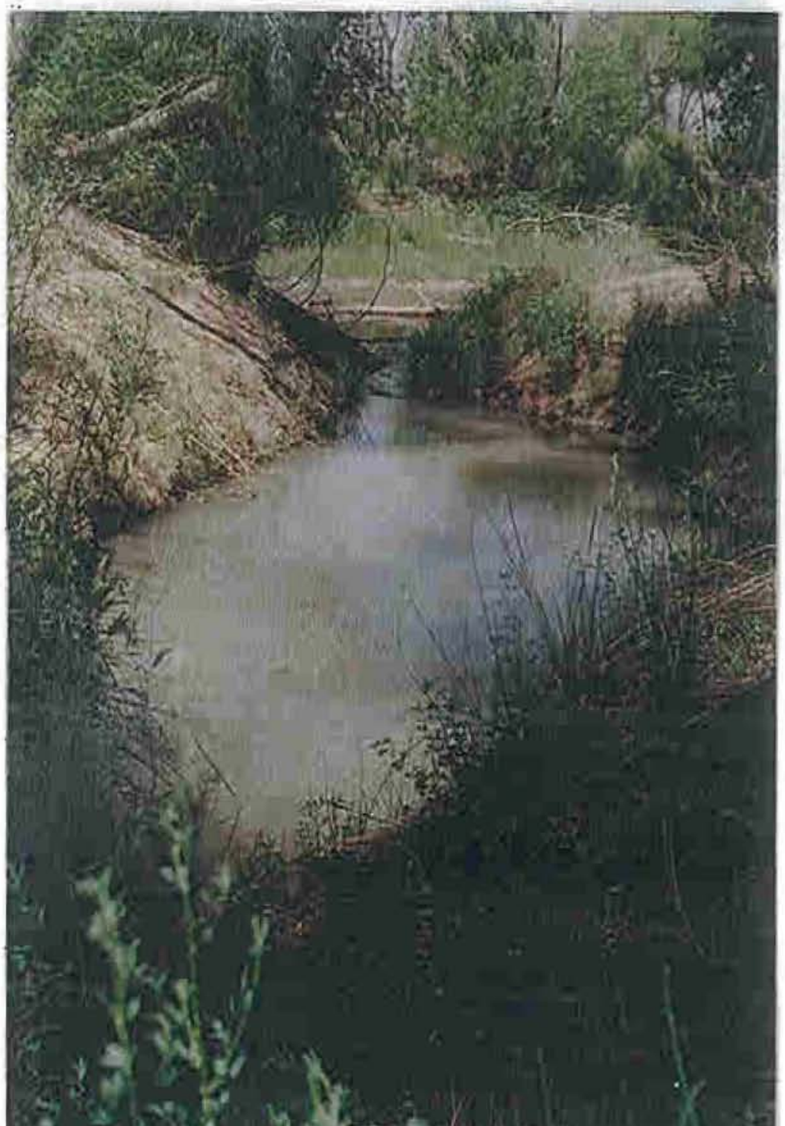
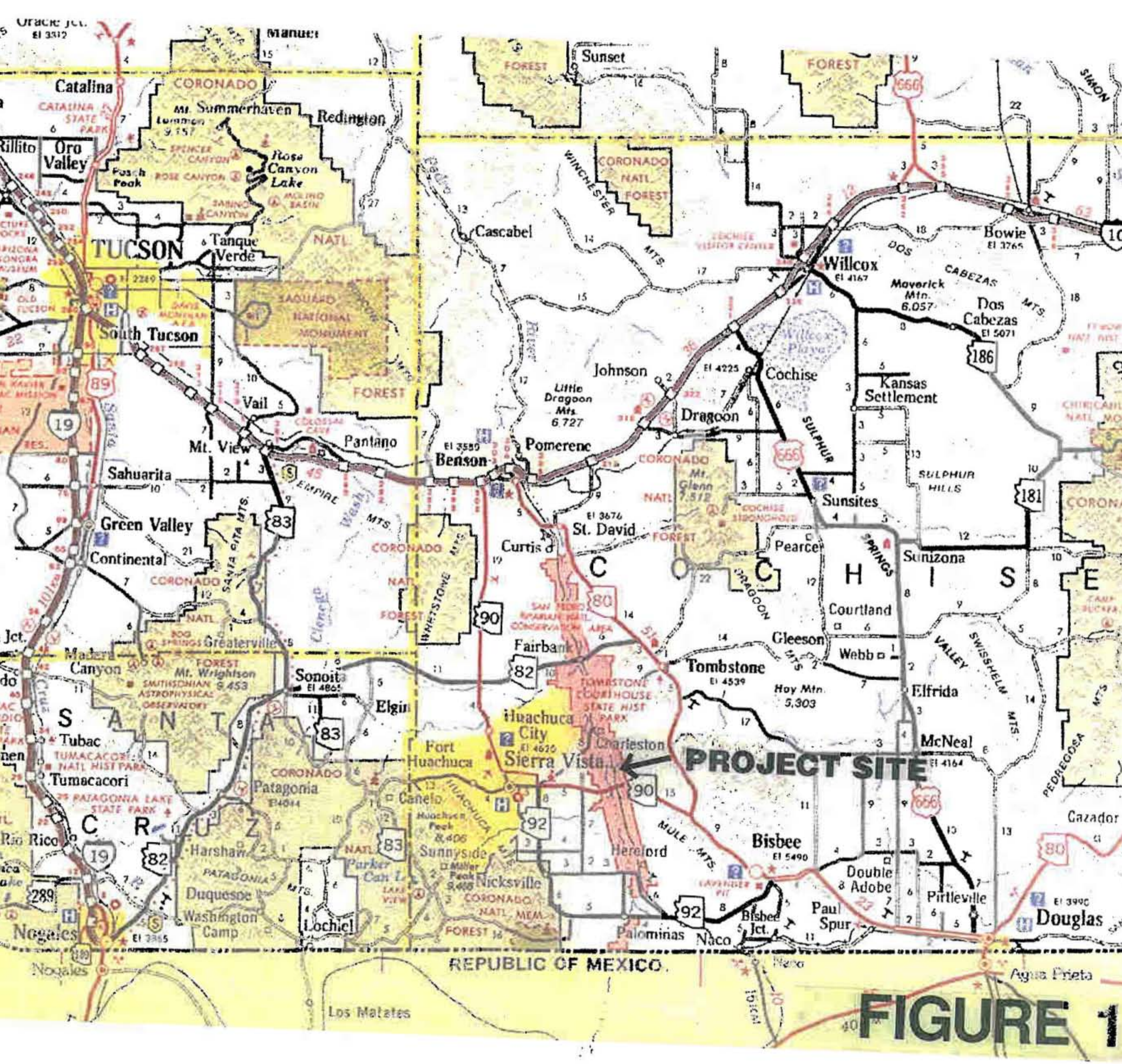


Photo 10 - Confluence of Government Draw and the San Pedro River. Approximate 3-foot headcut at bottom of photo.

X. Maps and Figures



Catalina
Oro Valley
Summerhaven
Redington
Rose Canyon Lake
TUCSON
Tanque Verde
South Tucson
Cascabel
Sunset
Bowie
Willcox
Dos Cabezas
Cochise
Johnson
Kansas Settlement
Dragoon
Vail
Mt. View
Pantano
Benson
Pomerene
Sahuarita
Green Valley
Continental
St. David
Curtis
Pearce
Sunsites
Sunizona
Courtland
Gleeson
Webb
Tombstone
Fairbank
Sonoita
Elgin
Greaterville
Tubac
Tumacacori
Patagonia
Fort Huachuca
Huachuca City
Sierra Vista
Charleston
PROJECT SITE
Elfrida
McNeal
Bisbee
Hereford
Canelo
Sunnyside
Nicksville
Harshaw
Duquesne
Washington Camp
Lochiel
Nogales
Rio Rico
Palominas
Naco
Bisbee Jct.
Paul Spur
Double Adobe
Pirtleville
Douglas
Cazador
Agua Prieta
REPUBLIC OF MEXICO
Los Matales
CORONADO NATL FOREST
SAGUARO NATIONAL MONUMENT
SANTA CRUZ
COCHISE

FIGURE 1

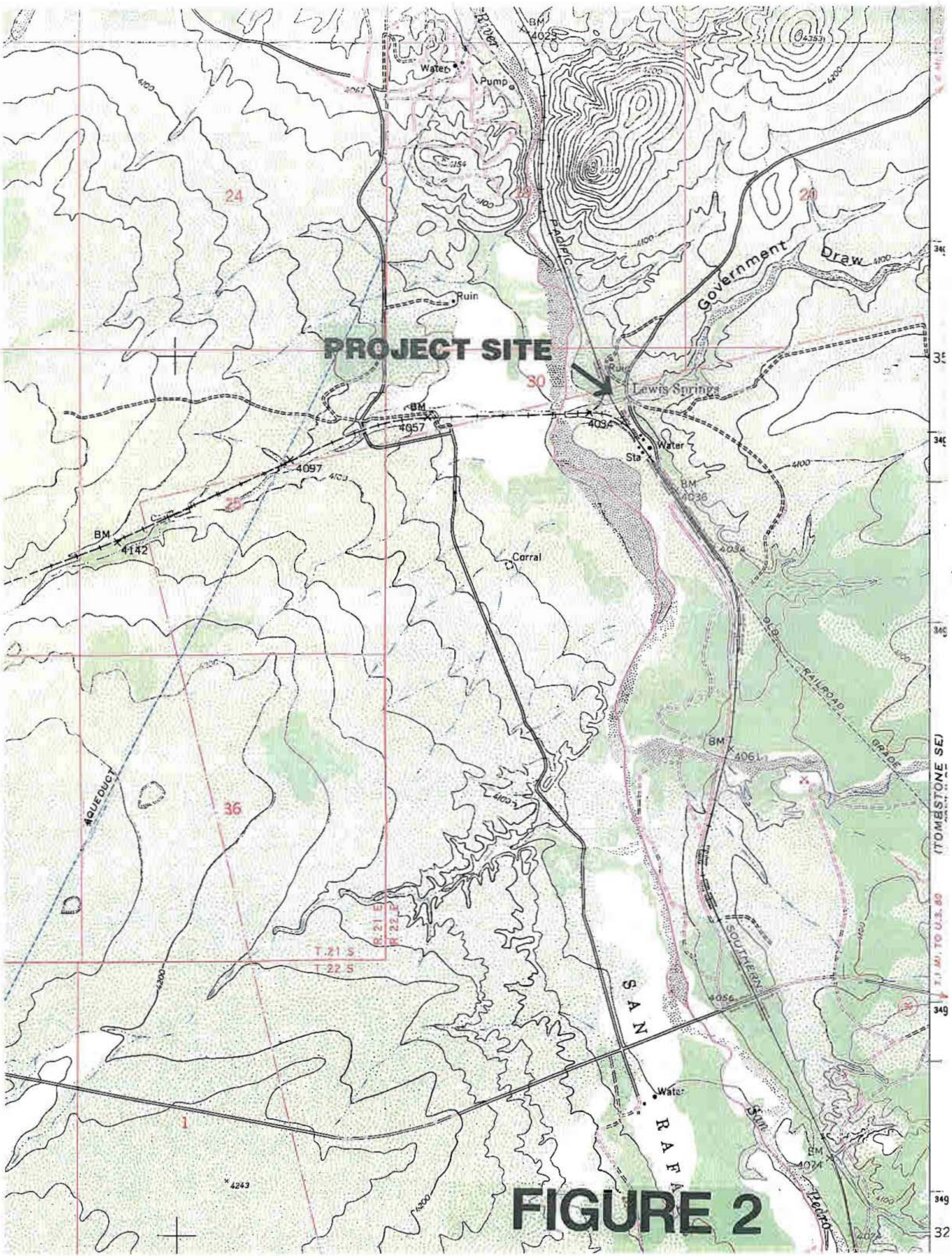
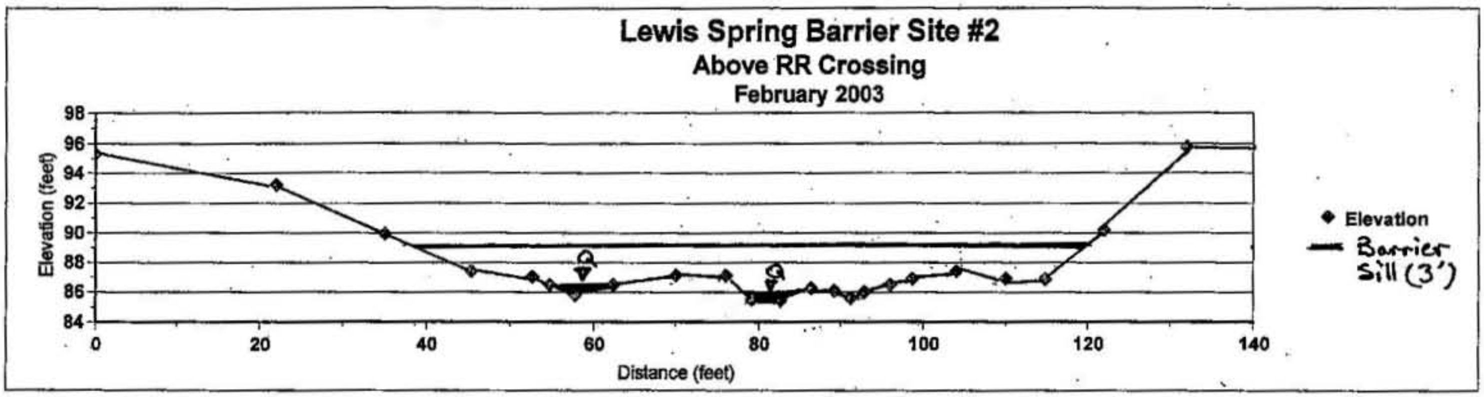

PROJECT SITE
Lewis Springs
Government Draw
PACIFIC
River
Water
Pump
Ruin
BM 4057
4097
BM 4142
4034
Sta
BM 4036
Corral
OLD RAILROAD GRADE
BM 4061
AQUEDUCT
R.21 E
R.22 E
T.21 S
T.22 S
SAN RAFA
SOUTHERN
San Pedro
BM 4074
(TOMBSTONE SE)
24
19
20
30
25
36
1

FIGURE 2



Lewis Spring Barrier Site #2
Above RR Crossing
February 2003
Elevation (feet)
98
96
94
92
90
88
86
84
0
20
40
60
80
100
120
140
Distance (feet)
Elevation
Barrier Sill (3')

FIGURE 3

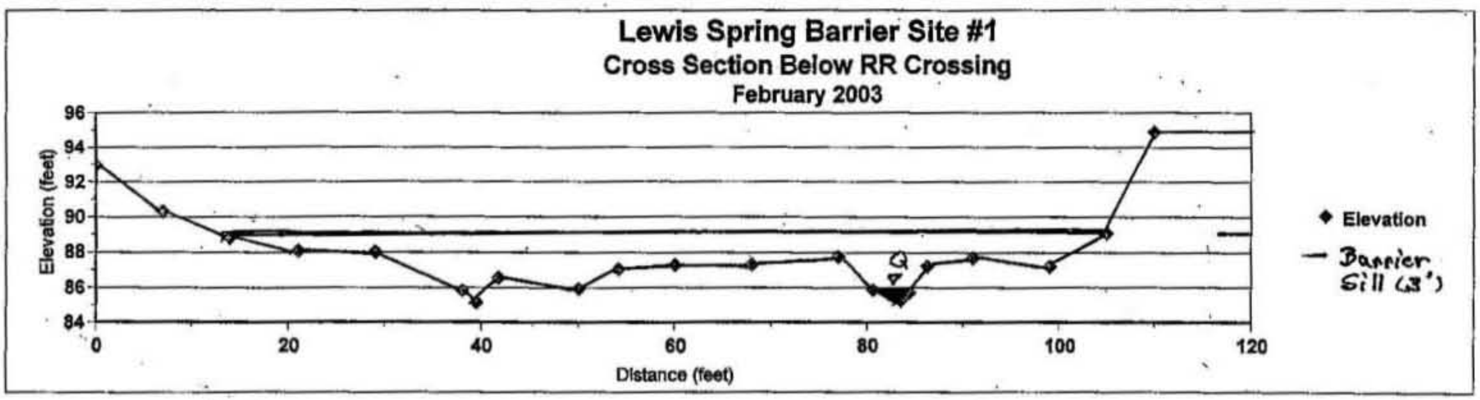

Lewis Spring Barrier Site #1
Cross Section Below RR Crossing
February 2003
Elevation (feet)
Distance (feet)
96
94
92
90
88
86
84
0
20
40
60
80
100
120
Elevation
Barrier Sill (3')

FIGURE 4

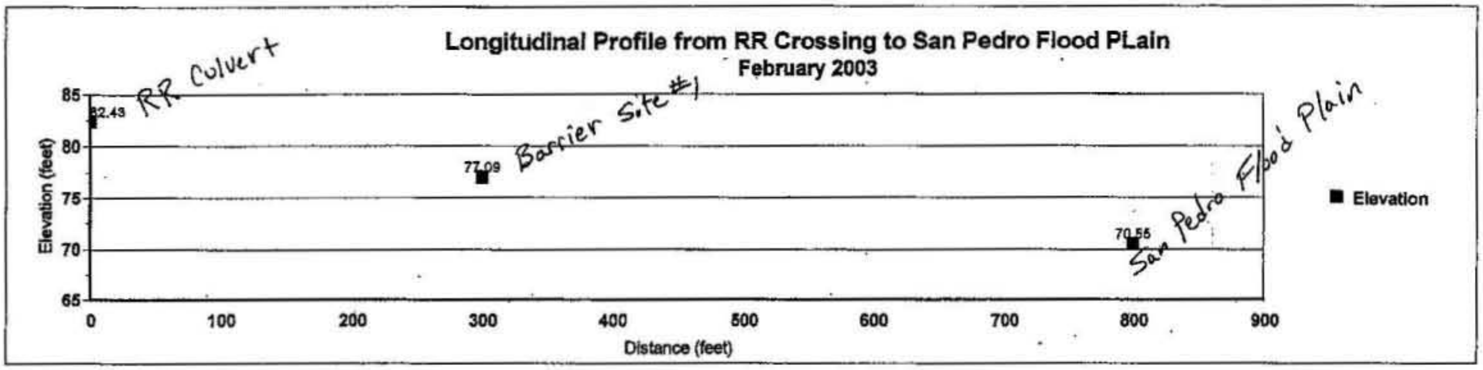
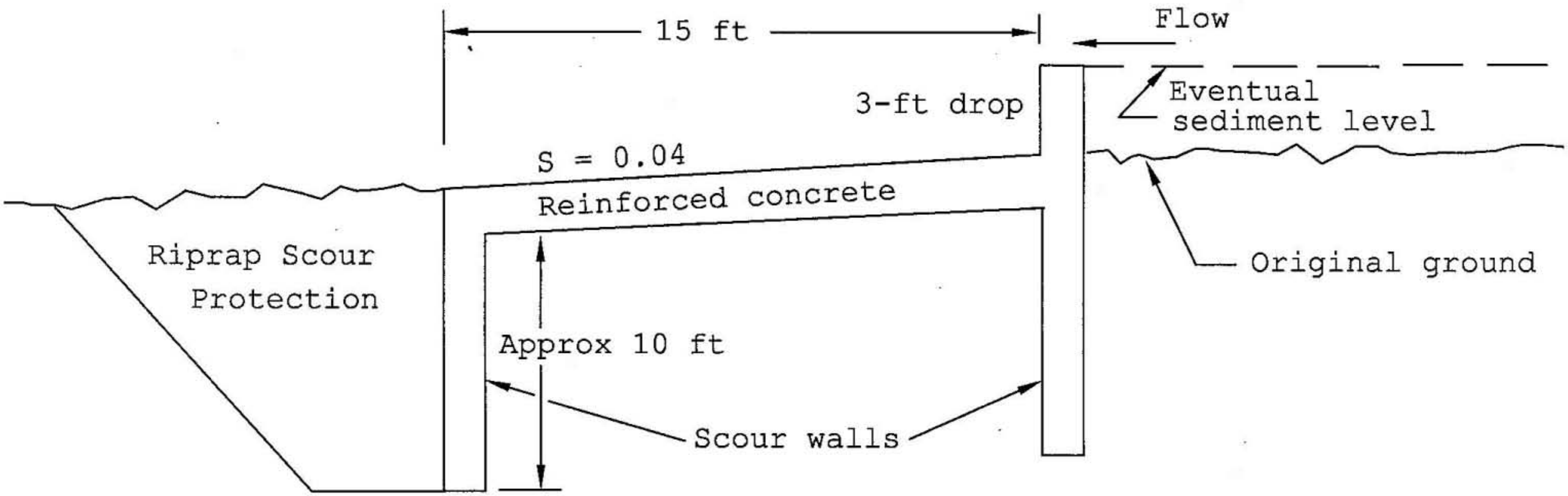

Longitudinal Profile from RR Crossing to San Pedro Flood PLain
February 2003
RR Culvert
Barrier Site #1
San Pedro Flood Plain
82.43
77.09
70.55
Elevation (feet)
Distance (feet)
Elevation
85
80
75
70
65
0
100
200
300
400
500
600
700
800
900

FIGURE 5



Conceptual Lewis Springs Fish Barrier

Cross Section

FIGURE 6