Volume 1 of 4 : Final Feasibility Report

Volume 2 of 4 : Final Feasibility Report Technical Appendices

Volume 3 of 4 : Final Feasibility Report Technical Appendices

Volume 4 of 4 : Final Environmental Impact Statement

Va Shly'ay Akimel
FINAL Salt River Ecosystem Restoration Study

Prepared by:

U.S. Army Corps of Engineers
South Pacific Division
Los Angeles District

In partnership with:

Salt River Pima-Maricopa Indian Community

and the

City of Mesa

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study September 2004

FINAL FEASIBILITY REPORT
TECHNICAL APPENDICES

VOLUME 2 OF 4

LIST OF TECHNICAL APPENDICES

APPENDIX A HYDRAULICS AND HYDROLOGY
APPENDIX B WATER BUDGET ANALYSIS
APPENDIX C INTERIOR DRAINAGE
APPENDIX D GROUNDWATER MODEL
APPENDIX E GEOTECHNICAL
APPENDIX F DESIGN
APPENDIX G COST

APPENDIX

A

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

HYDRAULICS AND HYDROLOGY

INTRODUCTION 1
Purpose 1
Description of Study Area 1

DISCHARGE – FREQUENCY ANALYSIS 3

RUNOFF DISCUSSION 5

GROUNDWATER DISCUSSION 7

STUDY METHODOLOGY 10
Analysis Tool 10
Hydrology and Design Discharges 10
Determination of Manning's Roughness Coefficients 10
Environmental Features 10
Structural Features 11

HYDRAULIC ANALYSES & RESULTS 18
Without Project 18
Model 1 – Existing Conditions 18
Model 2 – Future Without Project 20
With Project 21
Model 3 – With Project (Alternative E) 21
Model 4 – With Project (Alternative F) 25
Model 5 – With Project (Alternative A) 28
Model 6 – With Project (Alternative N) 30
Model 6 – With Project (Alternative O) 30

SEDIMENT ANALYSIS 37
Without Project 37
With Project 38

GEOMORPHOLOGY DISCUSSION 44

RISK AND UNCERTANITY ANALYSIS 47

OPERATION AND MAINENANCE 48
Maintenance Considerations 48
Vegetation Damage 50

PERFERRED ALTERNATIVE 51

SUMMARY 57

REFERENCES 58

INTRODUCTION

Purpose

1. The purpose of this appendix is to document the hydrologic and hydraulic analyses completed in support of the Va Shly'ay Akimel Feasibility Study. The goals of the hydraulic analysis were to develop a one-dimensional model of the Salt River study area and model the conditions associated with the Existing Condition, Future Without Project Condition and the conditions associated with selected With Project alternatives.

Description of Study Area

2. The Va Shly'ay Akimel study area is located within Maricopa County in central Arizona, the area has a general east to west orientation. The study area includes the section of the Salt River that begins at Granite Reef Diversion Dam (Granite Reef Dam) on the east side of the study area and extends downstream to the west for a distance of approximately 15 miles to the Pima Freeway (State 101), Figure A-1.

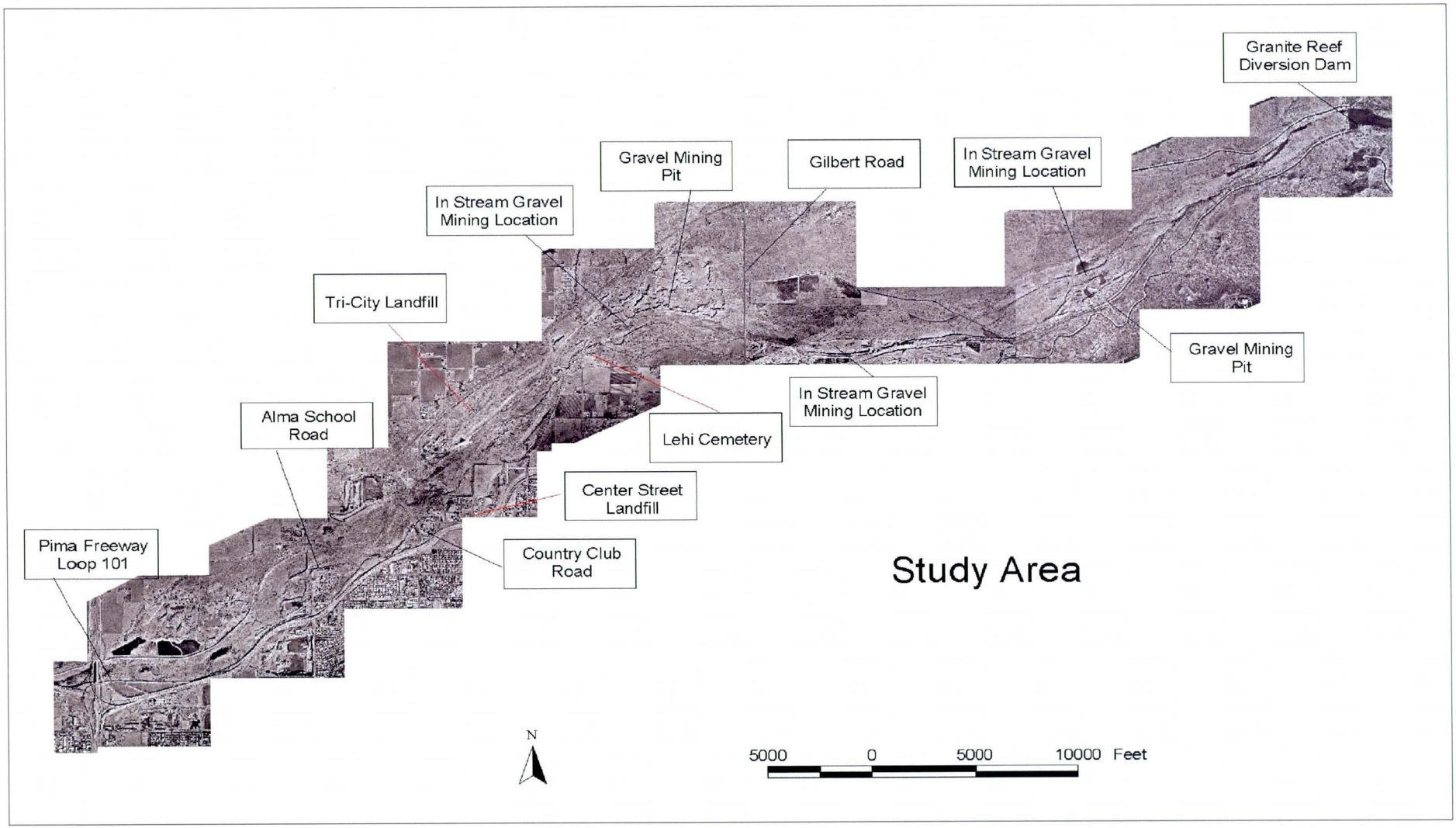
3. The majority of the study area is within the jurisdiction of the Salt River Pima-Maricopa Indian Community (SRPMIC). A portion of the project is within the jurisdiction of the City of Mesa located in the southwest part of the study area.

4. The channel of the Salt River within the study area contains several active and historic sand and gravel mining pits. There are active and inactive landfills along the north bank and there are storm drains and irrigation drains that discharge to the channel. Salt River Project (SRP) operates the Granite Reef Underground Storage Project (GRUSP) on the Salt River overbank area in the central part of the study area and the City of Mesa operates a recharge project on the west end of the study area.

5. The Salt River was a perennial stream until the construction of upstream dams, with associated reservoirs, regulated the flow. There are four dams on the Salt River and two dams on the Verde River, a tributary to the Salt River. These structures have changed the hydrologic condition of the Salt River below Granite Reef Dam into an ephemeral river. Granite Reef Dam is a diversion structure, not a water storage or flood control structure. This dam diverts the flow in the Salt River into two major irrigation canals, the Arizona Canal on the northside and the Southern Canal on the southside. Flows only occur through the study area when there are flood releases from the upstream reservoirs. The flood flows vary in duration, quantity and magnitude depending on the nature of the flood releases.

INTRODUCTION

Figure A-1. VaShly Akimel study area map (West, 2002).



DISCHARGE-FREQUENCY ANALYSIS

6. The Salt River is characterized by infrequent events, spilling over, on average, once every three years. The maximum rate of flow for each event was determined based upon a water control plan developed for the flood control pool at Modified Theodore Roosevelt Dam. The analysis is described in Corps of Engineers report prepared by the Los Angeles District, (USACE, 1996a). The following table shows the maximum discharge simulated for historic flow events from 1914 to present.

Table A-1. Summary of Simulated Salt River Flows.

Period of Flow Start Date	Period of Flow End Date	Flow Event Maximum Daily Average Flow (cfs)
2/7/1914	7/2/1914	15,800
1/29/1915	8/18/1915	18,700
1/15/1916	5/15/1916	79,100
9/8/1916	2/4/1917	21,100
4/17/1917	5/15/1917	23,400
3/7/1918	3/26/2018	28,400
11/25/1919	13/14/1919	46,200
1/4/1920	4/25/1920	87,800
12/26/1921	1/9/1922	24,100
2/8/1922	2/18/1922	10,000
3/16/1922	4/10/1922	18,000
9/18/1923	9/22/1923	24,100
12/26/1923	1/8/1924	42,800
3/31/1926	4/16/1926	28,800
2/14/1927	3/19/1927	49,800
9/12/1927	9/20/1927	16,200
4/4/1929	4/19/1929	17,200
2/12/1931	2/20/1931	22,900
2/9/1932	3/29/1932	48,700
2/6/1937	3/25/1937	36,981
2/28/1939	3/17/1939	58,739
2/5/1941	5/25/1941	32,206
12/21/1965	1/12/1966	64,000
2/20/1973	6/5/1973	22,273
2/28/1978	4/11/1978	95,800
12/16/1978	4/19/1979	110,000
1/29/1980	6/3/1980	137,725
2/2/1983	6/17/1983	30,000
9/27/1983	10/24/1983	39,878
12/24/1983	1/24/1984	11,200
12/21/1984	6/1/1985	25,604
12/22/1991	6/21/1992	12,898
8/21/1992	9/8/19992	13,615
12/28/1992	6/4/1993	99,396
1/20/1995	5/2/1995	53,316

DISCHARGE – FREQUENCY ANALYSIS

7. A flow frequency distribution was developed the Salt River Watershed under dammed, (USACE 1996a). The following table summarizes the discharges that were analyzed for the models. Change in flow is due to storage within floodplain.

Table A-2. Flow Frequency for Salt River.

Return Period	Flow at CP – 40 in ft^3/s (upstream limit at River Station 13.64)	Flow at CP – 109 in ft^3/s (River Station 7.55 just upstream of Gilbert Road)
3-Year	2,200	2,200
5 – Year	22,000	21,000
10 – Year	60,000	58,000
20 – Year	100,000	95,000
50 – Year	150,000	145,000
100 – Year	175,000	172,000
200 – Year	210,000	207,000
500 - Year	250,000	246,000

8. The average rainfall for the Phoenix area is summarized on the following table. Climate data for Phoenix is recorded at Phoenix Sky Harbor Airport located seven miles west of the downstream section of the Va Shly'ay Akimel project area. Summer thunderstorms can produce local precipitation that exceeds the monthly average and results in local flooding of streets, drainage channels and washes. The intensity and duration of the precipitation varies depending on the location of the individual storm cells. A maximum amount of rainfall at Sky Harbor from a storm may be greater or less than the amount that occurs within the project area

Table A –3. Rainfall Pattern for the Phoenix Area

Month	Rainfall in Inches
January	0.67
February	0.68
March	0.88
April	0.22
May	0.12
June	0.13
July	0.83
August	0.96
September	0.86
October	0.65
November	0.66
December	1.00
Annual Total	7.66

RUNOFF DISCUSSION

9. The winter months are typically when large regional storms or series of storms occur. These storms may include an accumulation and subsequent melt of the snow pack in the Salt River and Verde River watersheds and result in the releases of water into the Salt River system that can flow over Granite Reef Dam into the study area. While the river stages may be high for an extended period, the quantity and intensity of accompanying storm precipitation is generally reduced in the lower elevations, including the study area.

10. During the middle to late summer months the monsoon storm pattern is typical. These storms produce intense, short-duration thunderstorms with significant precipitation. During these storms the river stages are low because the storms are localized and because the upstream reservoirs usually have the capacity to store the local runoff from the watershed.

11. Interior drainage is an assessment of the storm water runoff that accumulated on the up gradient side of levees. The Va Shly'ay Akimel does not include levees and this means there are no interior drainage conditions to address. A report was completed to assess the interior drains, or side drains, that outfall into the Salt River within the study area (Knight Piésold, 2002b). These drains were evaluated to assess the potential damage that frequent inundation or high discharge velocities may cause to the restored habitat and the potential to use this water to support the restored vegetation. Canal drains and storm drains were the two types of interior drains identified that outfall into the Salt River.

12. Canal drains release water from the major SRP canals and discharge to the Salt River as an operational mechanism to control flow in the canal system. The Evergreen Drain and Hennessey Drain are canal drains and do not intercept a significant amount of storm water runoff. The peak flow rates in these canal drains are governed by the amount of water that SRP releases into the drain from the irrigation canal and not by storm events.

13. The Evergreen Drain is associated with the Evergreen Canal. The canal is operated by the SRPMIC and the drain is operated by SRP. This drain is located on the north side of the Salt River. The peak flow rate for the Evergreen Drain between 1992 and 2001 was 313 ft^3/s.

14. The Hennessey Drain is located on the southside of the Salt River. It is operated by SRP and currently is used to provide water to the GRUSP recharge project in the riverbed. The peak flow rate for the Hennessy Drain between 1992 and 2001 was 846 ft^3/s.

15. Storm drains collect runoff generated by major storm events to protect developments from occasional nuisance flooding. Storm drainage flows vary in duration, quantity and intensity depending on the rainfall event. The most significant events occur during the summer months associated with the thunderstorms of the monsoon season. These localized storms can produce intense rainfall and generate significant local runoff.

RUNOFF DISCUSSION

16. The Price Drain intercepts storm runoff from a drainage area of approximately 31.2 square miles on the southside of the Salt River. The recorded maximum daily flow rate for the brief period of record in 2001 was 236 ft^3/s. The peak flow rate for the 100-Year storm event was estimate to be approximately 10,000 ft^3/s. However, the maximum capacity of the channel is 6,800 ft^3/s, which governs the maximum flow rate possible in this channel. This flow rate would generate a discharge velocity of 8.2 ft/sec.

17. The Tempe Drain intercepts storm runoff from a drainage area of approximately 10.0 square miles on the southside of the Salt River. The peak flow in this drain is governed by storm events in conjunction with canal releases. The recorded maximum daily flow rate for the period from 1992 through 2001 was 531 ft^3/s. However, the peak flow rate for the 100-Year storm event was estimate to be approximately 4,000 ft^3/s. The maximum capacity of the channel is 4,000 ft^3/s, and this would generate a discharge velocity of 8.0 ft/sec.

18. The remaining storm drains within the study area could generate peak flow rates as great as 300 ft^3/s with a discharge velocity of 10.6 ft/sec. The peak flow rates generated by the drainage areas for these drains may be greater than 300 ft^3/s. However, detention facilities and the maximum capacity of the outlet pipes govern the maximum discharge rate to the Salt River.

19. A summary of the average annual runoff (Knight Piésold, 2002b) is presented on the following table.

Table A-4. Storm Drain Average Annual Runoff Volumes
Runoff is in acre-feet

Interior Drain	Drainage Area (SqMi)	Month												Annual
		Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	
Price Drain	31.2	195.7	201.5	257.0	64.3	35.0	38.0	242.4	280.4	251.2	189.8	192.8	292.0	2,240.0
Tempe Drain	10.0	64.6	66.6	84.9	21.2	11.6	12.5	80.1	92.6	83.0	62.7	63.7	96.5	740.0
Price Road Freeway Local Drainage	0.4	2.6	2.7	3.4	0.9	0.5	0.5	3.2	3.8	3.4	2.5	2.6	3.9	30.0
Dobson Road Storm Drain	1.8	12.2	12.6	16.1	4.0	2.2	2.4	15.1	17.5	15.7	11.9	12.0	18.3	140.0
McLellan Road Storm Drain	1.0	7.0	7.2	9.2	2.3	1.3	1.4	8.7	10.0	9.0	6.8	6.9	10.4	80.0
Country Club/McKellips Storm Drain	3.7	26.2	27.0	34.4	8.6	4.7	5.1	32.5	37.5	33.6	25.4	25.8	39.1	300.0
Red Mountain Freeway Local Drainage	Not Known	Minimal												
Natural Drainage	2.0	Minimal												
Alma School Storm Drain	Not Known	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

GROUNDWATER DISCUSSION

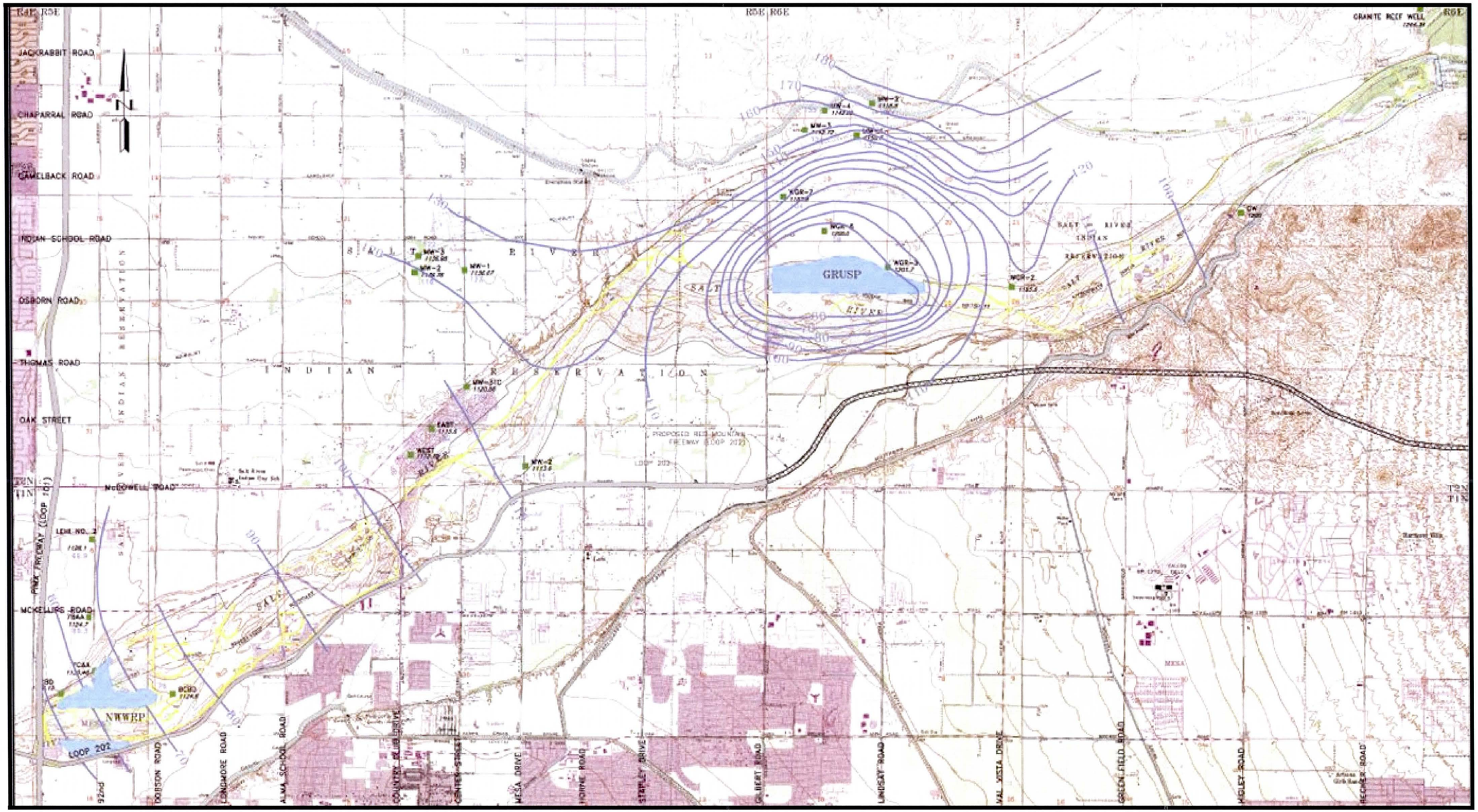
20. Depth to the groundwater table varies throughout the study area as a result of the hydrogeologic conditions and dams constructed on the Salt and Verde Rivers. Granite Reef Dam was constructed to divert the Salt River flow into the Arizona Canal and the Southern Canal. This dam marks the upstream boundary of the project area. Although not intended to be a storage reservoir, some water is retained up stream of the dam at all times. Small flood flows can be released to the Salt River through radial gates while larger flood flows are allowed to pass over the dam crest. SRP reported that water seeps through the radial gates because the gates do not form a tight seal with the granite bedrock. The result is a continuous flow of water downstream from the dam. SRP does not monitor the seepage and does not have flow records.

21. The local geology helps to maintain this seepage as a surface flow. A bedrock shelf overlain by a veneer of sedimentary materials extends downstream from Granite Reef Dam. The seepage is sufficient to saturate these alluvial sediments. This flow has been sufficient to establish and support abundant wetland vegetation. In addition, areas of open water provide riparian and aquatic habitat. This pattern continues for approximately one mile downstream.

22. The depth to the bedrock shelf rapidly increases at the basin border fault, located approximately 1.5 to 2.0 miles downstream from Granite Reef Dam. As the bedrock depth increases, the surface flow that supports wetland vegetation upstream becomes subsurface water and part of the groundwater supply. Regional groundwater pumping resulted in a general lowering of the water table throughout the area from predevelopment conditions. In addition, dams located upstream on the Verde River and Salt River prevent perennial flow in the river channel and limit natural recharge. The result is that the general groundwater depth beneath the Salt River ranges from 50 ft at the recharge sites to approximately 175 ft south of Granite Reef Dam, Figure A-2. The majority of the study area has a depth to groundwater of 100 ft (Knight Piésold, 2002c).

GROUNDWATER DISCUSSION

Figure A-2. Groundwater depth in 2001 (Knight Piésold, 2002c).



GROUNDWATER DISCUSSION

23. There are two groundwater recharge projects in the study area that impact the groundwater table. SRP recharges water into the upper alluvial aquifer through the Granite Reef Underground Storage Project (GRUSP). SRP recharges approximately 90,000 acre-feet of water per year. The recharge basins cover approximately 216 acres of the river channel. SRP's recharge permit allows a maximum of 200,000 acre-feet per year. However, this would produce a groundwater mound that could impact other facilities and SRP limits the quantity of water recharged to maintain the groundwater level at least 25 feet below the bottom of the Salt River Landfill on Gilbert Road and State Route 87. This results in a water level that is about 50 to 60 feet below the river channel in the immediate GRUSP area.

24. The second recharge project is located near the downstream end of the project area. Effluent from the Northwest Water Reclamation Plant (NWWRP), owned and operated by the City of Mesa, is discharged into a series of recharge ponds where the effluent is allowed to infiltrate into the Salt River sediments. Approximately 5,000 to 6,000 acre-feet of water is recharged annually into these ponds. The SRPMIC owns five ponds on the northside of the river totaling 75 acres; these ponds have received an average of 330 acre-feet of effluent each month. Mesa owns four ponds on the southside of the river totaling 27 acres; these ponds have received an average of 140 acre-feet of effluent. The groundwater mound produced by this recharge raises the local water table in this area to within 50 to 60 feet below the river bed.

STUDY METHODOLOGY

Analysis Tool

25. The HEC River Analysis System (HEC-RAS), Version 3.1.1, was used for the modeling (USACE, 1998a). A series of eight flow profiles were developed for each model based on the 3, 5, 10, 20, 50, 100, 200 and 500 -Year Events.

Determination of Manning's Roughness Coefficient

26. The Existing Condition Manning's roughness coefficients ("n" values) were used for the initial channel conditions in the models. The USACE calculated the "n" value of the different environmental features by the procedure where "n" may be computed by:

27. $n = (n_0 + n_1 + n_2 + n_3 + n_4)m_5$

28. Where n_0 is a basic "n" value for a straight, uniform, smooth channel in the natural riverbed materials. Then n_1 is added to correct for the effect of the surface irregularities, n_2 is added to account for variations in shape and size of the channel cross-section, n_3 is added for channel obstructions and n_4 is a value added for vegetation and flow conditions. The m_5 value is to correct for the meandering of the channel. In this study the Existing Condition Manning's "n" value varied from 0.028 to as much as 0.2 (West, 2002).

Environmental Features

29. The Va Shly'ay Akimel study area has locations where there is existing vegetation supported by precipitation, seepage, periodic flood flows, stormwater runoff and irrigation discharges. The USACE developed 15 alternatives in the Feasibility Study F4 and the goals of the alternatives were to increase the native riparian vegetation, increase the vegetation connectivity and stabilize bank sections where needed. A mixture of five environmental features are included in the With Project alternatives. These include: Cottonwood/Willow, Mesquite, Wetlands, Upper Sonoran Desert and River Bottom.

30. Cottonwood/Willow (CW). The existing CW stands are located near saturated soil conditions near river overbank areas. CW a water table within 25 feet of the land surface or supplemental irrigation will be required to support the vegetation. Initial plantings will require irrigation to achieve a high survival rate. Once established, CW areas will need drip irrigation or water from the Surface Braided Irrigation Network (SBIN) to supply water. Uneven grading of the river bottom and overbank areas to create pockets to retain water will help maintain the CW. In the model, the CW areas were assigned an "n" value of 0.098.

31. Mesquite (MS). The MS vegetation is commonly located about 5 to 20 feet above the river channel. The water table must be within 30 feet of the surface to support established MS. Irrigation will be needed to help the MS get established but then flood irrigation or

water from the SBIN will support the vegetation. In the model, MS was assigned an "n" value of 0.073.

32. Wetlands (WT). The WT areas can include open water, submerged vegetation and muddy shorelines. These features require a high water table at or near the surface or may need to be lined to retain water from other sources. The WT features will require excavation in the riverbed to construct the basins and this changes the configuration of the channel bed. Some WT features may need both inflow and outflow channels. The WT areas were assigned an "n" value of 0.048.

33. Sonoran Desert (SD). The SD includes a wide range of vegetation species and the species developed in any area will be dependent on the aggregate soil type. Once established, precipitation and periodic floods will maintain the SD. The "n" value assigned to SD was 0.058.

34. River Bottom (RB). RB will require some reshaping to fill in large depressions and to create mounds to reduce flood flow impacts to the restoration features. The RB areas may be hydro-seeded with native river bottom shrub and grass species but this vegetation should not impact the hydraulic capacity of the river. The "n" value assigned for RB was 0.035.

Structural Features

35. There are several structural features within the study area including bridges, grade control structures and sand and gravel mining operations.

36. There are three bridges in the study area at Alma School Road, Country Club Road and Gilbert Road. There is a grade control structure downstream of the Alma School Road Bridge.

37. There are active sand and gravel mining pits in the channel and on the overbank within the study area. The pits in the channel are located at River Station 6.4 about one mile downstream from the Gilbert Road Bridge, at River Station 8.0 about one mile upstream of the Gilbert Road Bridge and at River Station 10.5 about three miles upstream of the Gilbert Road Bridge. There are two sand and gravel mining operations on the overbank area; located 800 feet downstream from the Gilbert Road Bridge and about three miles upstream of the Gilbert Road Bridge.

38. Additional structural features were incorporated in the alternatives when necessary. These structural features include: low flow channel, buried guide dikes, bank stabilization, grade control structure, wetland creation, concrete spillways and surface braided irrigation network. The structural descriptions provided are only preliminary and will be developed more thoroughly, if necessary, during the Preliminary Engineering and Design Phase (PED).

Low Flow Channel

39. A low flow channel was included in the design along two segments of the Salt River, River Station 9.6 to 7.65 and 4.4 to 2.2. Purposes of the channel were to increase conveyance to offset the increased roughness caused by new vegetation proposed in the main channel and to collect excess irrigation water that could be used to irrigate wetland habitat and river bottom areas. The low flow channel was designed to convey 11,000 ft^3/s (corresponding recurrence interval is greater that the 3-Year event but less than the 5-Year). Initial channel dimension were: average bottom width of 300 feet to 400 feet, average depth of 6 feet, design slope of 0.2%, side slope of 1 vertical for 3 horizontal and a channel Manning's roughness coefficient of 0.035. A 200 foot buffer was included on both sides of the channel to allow for lateral migration. The low flow channel configuration followed the existing river thalwag. Initially the channel design was unlined to allow lateral migration. The low flow channel was included in alternatives F, I and O.

Distribution Channel

40. A distribution channel was designed to convey irrigation water from the source points to vegetated areas throughout the project area. Alternatives H, B, C, E and G include the distribution channel in their design. The channel consists of a lined, 40 feet wide, 3.5 feet deep channel with a slope of 0.01%. Segments of the channel will be damaged during river flow events.

Buried Guide Dikes

41. Buried guide dikes are used to control lateral migration of the low flow channel. Guide dikes were only recommended for Alternative I. The guide dikes are trapezoidal soil cement structures buried perpendicular to the low flow channel. The guide dikes will have a top width of 5 ft, bottom width of 20 ft, and have an average length of 700 ft. The length of the guide dikes will depend on the position of the guide dikes with respect to the second terrace. A longitudinal spacing of 1,000 ft was included in the analysis. The preliminary design for the buried guide dikes was based on a previous design, Rio Salado Restoration Project. In addition, engineering judgment, an initial analysis of the channel configuration and morphology and a conservative approach, were all taken into account when estimating the size and location of the structures.

Bank Stabilization

42. Bank Stabilization was evaluated for locations along the project area where the bank appeared unstable, prone to erosion caused by lateral migration of the channel and required protection to prevent damage to project features or existing structures (Gilbert Road Bridge). All alternatives have bank stabilization components included in the design except alternatives A, K, N and O.

43. Locations 22, 51, 52, 53 and 62 were considered for stabilization, Figure A-3.

1) Location 22, bank erosion appears to be a problem along south bank because of the existing channel configuration in this reach. Hard banking the south bank with soil cement, as shown on Figure A-3, is recommended to prevent a southerly migration of the river and damage to project features and to the 101 Freeway. Soil cement bank protection will be 3,000 feet long, 40 feet tall (height) and 6 feet in depth (thickness).

2) Location 51 may require bank stabilization because of the elevation difference between the main channel and the quarry pit invert. It is possible that without sufficient bank stabilization, the river may migrate north into the quarry pit. This could cause head cutting which would impact Gilbert Road Bridge, (West, 2002), and produce scouring downstream that could damage both a nearby landfill and several project features. The quarry needs to be reshaped, the existing north banked stabilized and a spillway should be constructed to allow water to flow into the quarry area to prevent these impacts from occurring. The surface water re-connection of the quarry would provide minimal flood mitigation, increase river bottom, increase groundwater recharge and provide more suitable conditions to establish CW, SD and MS. The soil cement bank protection will be 6,500 feet long, 30 feet tall (height) and 6 feet in depth (thickness). It is important to remember that because the mining operations continue within the river channel, sediment deposition, areas of erosion and excavation locations are continually changing.

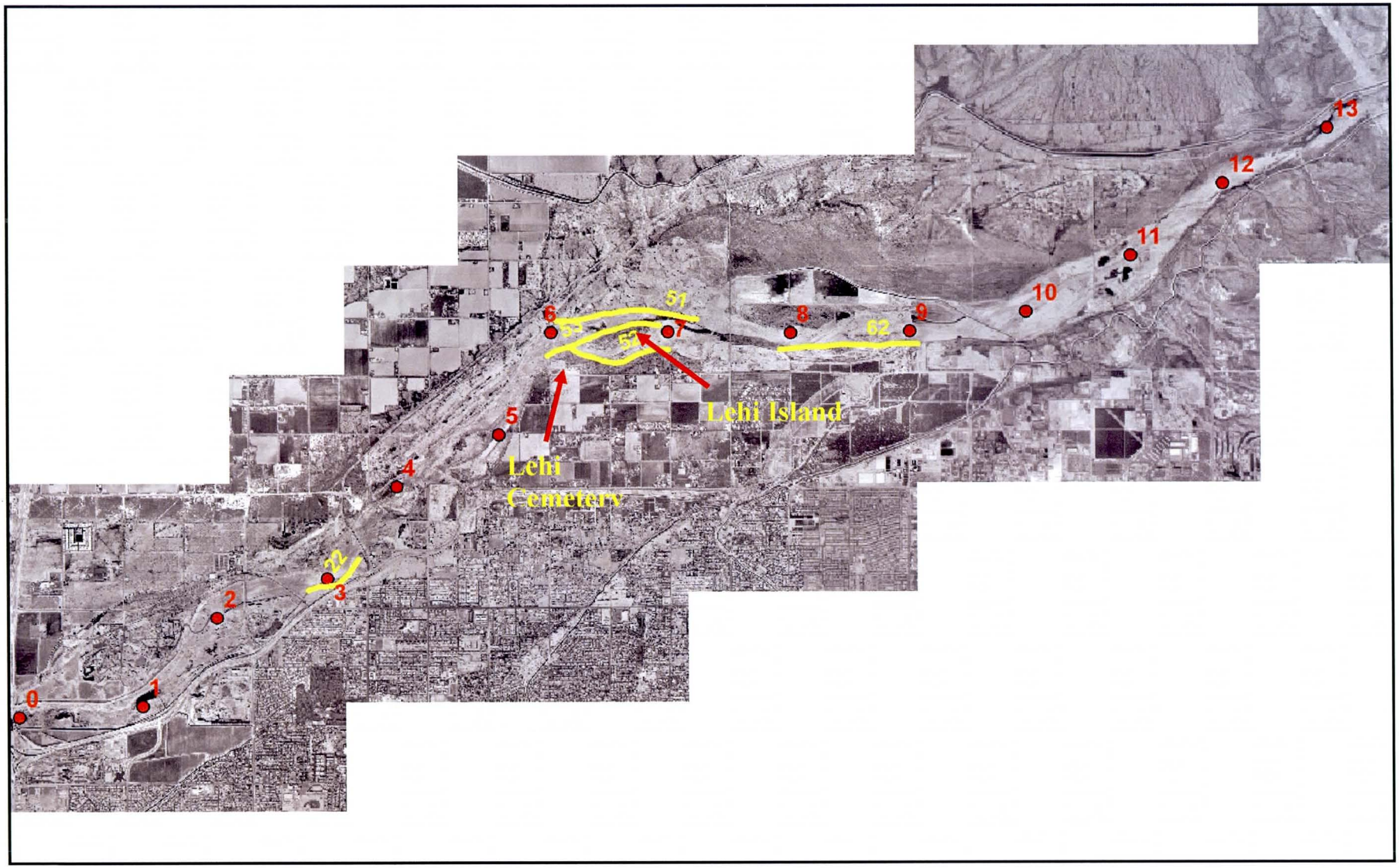
3) Location 52 lies along the south bank of Reach 5 extending from downstream of Gilbert Road to Lehi Cemetery. The Lehi Cemetery is a culturally sensitive area that is being threatened by erosion along the southern bank of the river. This is also the site proposed for several project features in some alternatives. Cottonwood and other dense riparian vegetation would reduce conveyance and shear stresses along the south bank and prevent the erosion from continuing to threaten both the cemetery and the newly established vegetation. The reduced conveyance will, however, force more flow north of the island, potentially causing erosion and requiring additional widening or deepening of the main channel. The structure would be 5,000 feet long, 30 feet tall (height) and 6 feet in depth (thickness).

   Active mining in the main channel downstream of Gilbert Road has increased the conveyance in the channel this could reduce stresses that caused the bank erosion around Lehi Cemetery. Analyses may show that lowering the main channel increases conveyance reducing shear stresses along the south bank, eliminating the need for bank stabilization along Location 52. Soil cement, although not recommended for this location, should be examined. In addition, mining may necessitate the need for protection along the north side of the Lehi Island, Figure A-3.

4) Location 53, bank stabilization may be necessary to offset erosion concerns along the north side of the island caused by mining. The soil cement bank protection for Location 53 is 5,500 ft long, 30 ft tall (height) and 6 feet in depth (thickness).

5) Location 62 lies along the south bank between River Station 8.98 and 8.1. An old quarry on the south bank, with a maximum depth below riverbed of 40 ft, is oriented such that the quarry pit could encourage the river to be redirected south into the pit, causing bank erosion along the south bank and a headcut migration upstream and down cutting downstream of the quarry (West, 2002). The headcut would adversely affect any attempts of vegetation establishment within Reach 6 and may affect the Gilbert Road Bridge. There are two measures that could be applied to prevent this from occurring. First, it is recommended that the pit be partially filled with material and second, that the south bank be reestablished north of the quarry, with the riverside hard banked.

Figure A-3. Bank stabilization locations (yellow) and river stations (red).



Grade Control Structure

44. Mining along the Salt River within the project area has created large depressions with active area of flow conveyance and sediment transport. The large depressions alter the hydraulic conditions encouraging scouring upstream and downstream of the depressions and bank instability. Quarry locations are shown in Figure A-1. Gilbert Quarry, located between River Station 7.32 to 6.4 approximately 20 to 30 ft bellow the existing channel bottom creating a steep vertical drop from the river to the quarry. Head cutting upstream is a likely scenario that would damage project features located upstream of the Gilbert Road Quarry refer to the without project sedimentation analysis (West, 2002). A grade control structure was recommended to prevent this scenario from occurring, Figure A-4. A description of this feature is discussed in Design and Cost Appendix. A grade control structure was included in Alternatives D, F, L, K, N and O.

Figure A-4 Grade Control Structure Location.

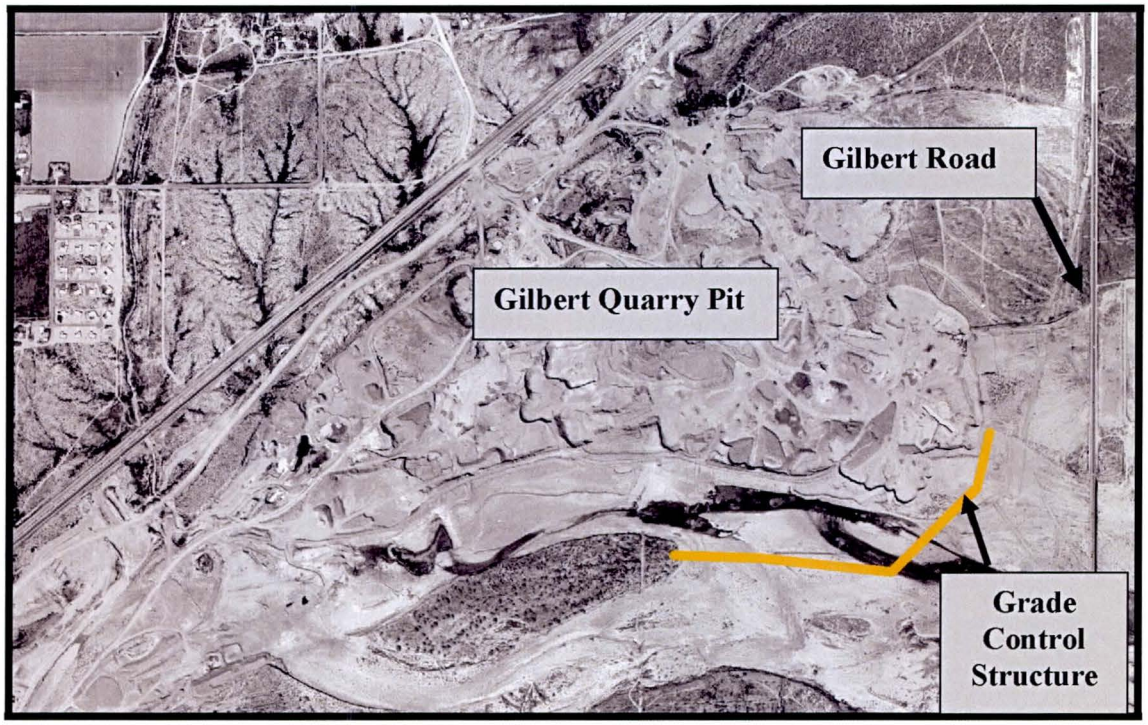
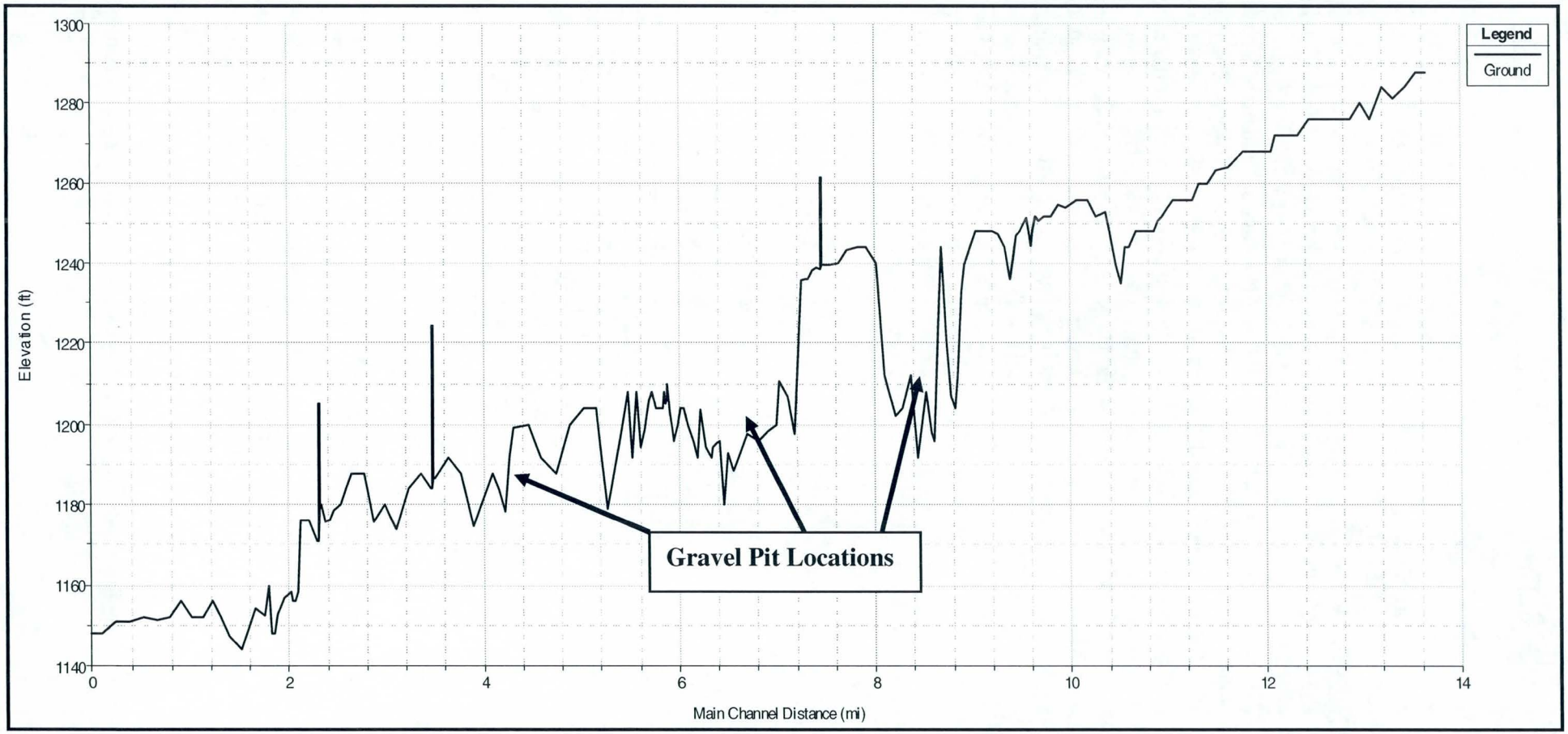


Figure A-5. Longitudinal Profile for the Salt River (West, 2002).



HYDRAULIC ANALYSIS

45. West consultants completed a hydraulic analysis of the existing and future without project conditions using HEC-RAS (West, 2002). The hydraulic analysis was based on a digital terrain model generated from aerial survey's completed in December of 2001. The results generated for the West existing model were referred to as Model 2. Since December 2001, additional mining has changed the terrain along the Salt River, specifically in the Gilbert Road Quarry area. Mining operators have also informed the USACE study team that mining will continue in the future at both Gilbert Road Quarry and at the Higgley Plant, see Figure A-1. Assuming that additional mining will continue, the hydraulic model developed by West was modified to take into account the mining. It was assumed that mining would lower the riverbed elevation from River Station 7.3 to 6.0, within the Gilbert Road Quarry area. The USACE project team and sponsors developed an initial series of 15 alternatives, identified as alternatives A through O, for the Va Shly'ay Akimel project based on the mining assumption. The 15 alternatives were evaluated using the Hydro-Geomorphic Model (HGM) to assess habitat values, from which five preferred alternatives were chosen. The baseline model was then modified to assess each of the five preferred alternatives impact on existing hydraulic conditions. These are Alternative A, Alternative E, Alternative F, Alternative N and Alternative O. In all, eight models are discussed in this report, Table A-5.

Table A-5. Hec-Ras models and description.

Hec Ras Model	Description
11	Baseline
9	Alt O
6	Alt N
5	Alt A
4	Alt F
3	Alt E
2	Future Without Project
1	West Existing

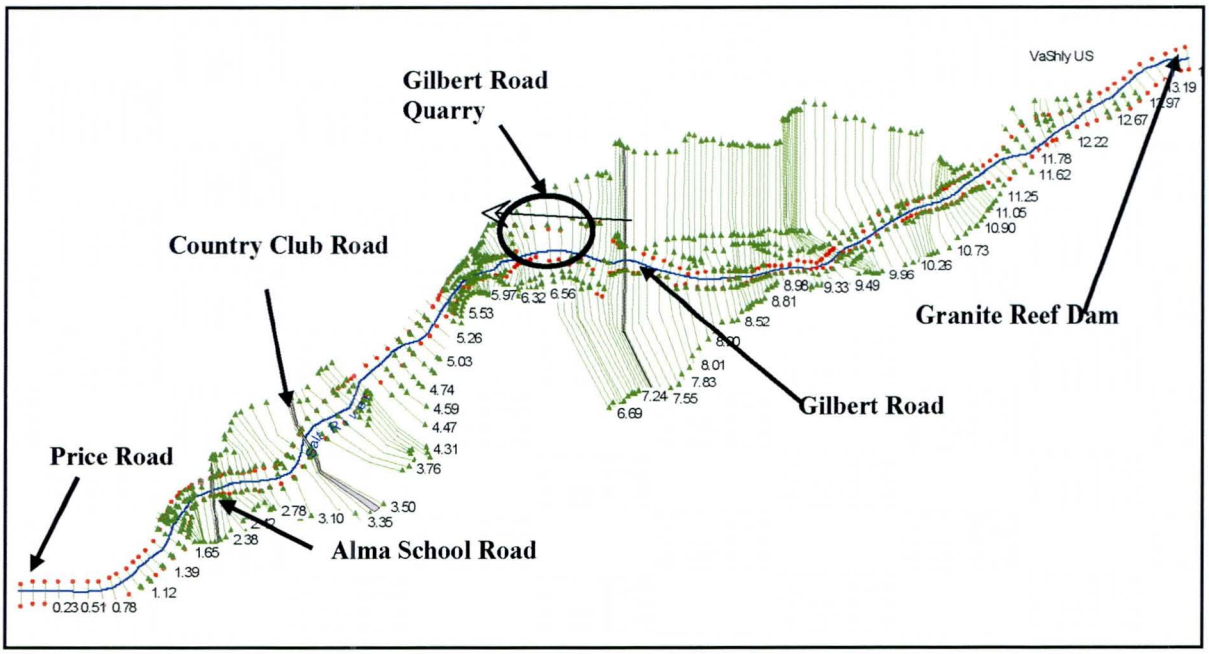
Without Project

Model 11 – Baseline Condition, With Future Mining

46. The Baseline Condition, Model 11, is the without project condition at the target year 2011, the baseline hydraulic condition along the Salt River from Granite Reef Dam to Pima Road assuming future mining. The cross-section information was based on a digital elevation model generated from a 2001 LIDAR survey. Future mining was taken into account at the Gilbert Road Quarry Area. Mining assumptions were based on SRPMIC future plans. Lay out of the Salt River Model is shown in Figure A-6. The model consists of the main Salt River channel and the overbank area (West, 2002). It was assumed that

the Gilbert Quarry Pit would be completely mined out. The mining would create a large depression in the channel. The mines are identified by drops elevation at River Stations 7.17 and 9.0. Additional mining was taken into account for mine operations occurring at River Station 7.17.

Figure A-6. VaShly HEC-RAS model.



47. It was assumed that the channel and overbank Manning's roughness coefficients were 0.035. In certain locations the model developers set the Manning's roughness coefficient to 5 to make the area ineffective. The "n" value used at the Pima Freeway (State 101) identified as River Station 0.00 was 0.035 and decreased upstream to 0.028 at Granite Reef Dam.

48. Peak discharges listed in the Discharge Frequency Analysis section were used in the Baseline Condition model simulations.

49. The calculated water surface elevation in the Baseline Condition is super critical at four locations within the study area. These are River Stations 2.12, 7.24, 8.68 and 9. The critical flow is due to abrupt changes in slope caused by sand and gravel mining at these locations.

50. Water surface elevations computed in the West model and the Baseline Condition were compared to the Flood Control District of Maricopa County (FCDMC) model. Some differences were evident between the models. The water surface dips at River Station 9.39 during high flows because there is a significant decrease in channel width. The water surface elevation at Alma School Road Bridge was 0.3 feet higher in Baseline Conditions than in the FCDMC model due to a larger bridge pier width used in the Baseline Conditions. The water surface elevation at the Country Club Road bridge was

four feet higher than the FCDMC model. The differences are due to the channel elevations at the bridge boundary. The calculations produced in the Baseline Condition are assumed to be more accurate. The flow at the Gilbert Road Bridge was were two feet higher than in the FCDMC model. The flow areas in the Baseline Condition model define a narrower width and produced the higher water surface elevation.

51. Hydraulic results for the Baseline Condition are found in the Exhibits section of the Hydraulics and Hydrology Appendix.

Model 2 – Future Without Project

52. Model 2, Future Without Project Condition, was developed using the altered cross section profiles generated from one dimensional sediment transport model, HEC-6T. The sediment model was run for a simulation period of 50 years, simulation flow record was based on estimated flow records for the Salt River. The model consists of the 2001 terrain information for the main Salt River channel and a side channel located at the Gilbert Road Quarry (West, 2002). The future mining assumption was not taken into account due to the uncertainty and the complexity of the sedimentation model. It was decided that for the F5 level of analysis the Future Without Project condition could adequately be represented by the 2001 survey information.

53. The future without project HEC-RAS model was run to simulate the 5-, 10-, 20-, 50-100-, 200-, and 500-Year events. The Pima Freeway (State 101) starting water surface elevation was computed using the water surface elevations in the HEC-6T results for the different frequencies at the end of the 50 year periods.

54. It was assumed that the channel Manning's roughness coefficient and the ineffective flow areas did not change from the Base Case Condition throughout most of the study area. The overbank "n" values were adjusted between River Stations 4.47 to 5.47, 6.09 to 7.24 and 7.71 to 10.06 to produce a consistent flow distribution in the channel and overbank sections.

55. It was assumed that the Salt River flowed through a gravel mining pit located upstream of Gilbert Road along the south bank, River Station 8.98 to 8.10.

56. The Future Without Project water surface elevations were compared to the Baseline Condition. The data showed that under the Future Without Project, the water surface elevations are lower between River Stations 0.00 to 10.95 when compared to the Existing Condition. The long-term scour of the riverbed throughout most of the study area produced lower water surface elevations.

57. Between River Stations 10.95 and 11.99, the Future Without Project simulations of the 5- through the 50-Year events produced higher water surface elevations than modeled in the Baseline Condition. The differences ranged from + 2 feet at 10.95 to 0.5 feet at 11.99. The deposition at the in-stream sand and gravel mining pit produced the rise in the water surface elevation.

58. Upstream of River Station 11.99 the water surface elevations in the Future Without Project simulations were equal to or less than the Baseline Condition.

59. Future mining will increase the amount of deposition that occurs in depositional areas and exasperate the amount of scouring that occurs upstream and downstream from depositional areas.

With Project

60. A series of five models were developed to assess the "with project" impacts on the Baseline hydraulic conditions. The five alternative modeled were: Alternative E (Model 3), Alternative F (Model 4), Alternative A (Model 5), Alternative N (Model 6) and Alternative O (Model 9). Vegetation layout figures are provided for each alternative. The 10- and 100-Year event areas of inundation are for existing without project conditions.

61. To properly simulate the with project conditions several changes had to be made to Baseline Condition model. Changes included modifications to the ineffective flow areas, Manning's roughness coefficient values and the inclusion of a secondary channel between River Station 9.04 to 8.10. The secondary channel was included to simulate split flow conditions due to a large quarry, South Quarry Pit, located between River Station 9.04 to 8.10. The quarry was assumed to be the main channel in the original existing without project hydraulic analysis. For the with project conditions a split flow computation option was used to simulate this area. The split flow method allows more flexibility in assessing the hydraulic impact due to alternatives in this area. Additional mining was taken into account for in the Gilbert Quarry Pit area.

62. In the models, the channel and overbank Manning's roughness coefficients varied from 0.035 to 0.2 based on the analysis of local conditions. The causes of the high roughness values were due to surface irregularities, n_1, channel cross section variation, n_2, and channel obstruction, n_3. In other locations the Manning's roughness coefficient was set to 5 to make the area ineffective

63. When modifying the with project conditions, the Manning's roughness coefficient n_0 = 0.028 (coarse gravel), n_1 = 0.002 to 0.02 (minor to severe surface irregularities), n_2 = 0.0 to 0.015 (gradual to frequently alternating channel cross section), n_3 = 0.005 to 0.05 (negligible to severe effect of obstructions), n_4 = 0.00 to 0.050 (no to very high vegetation) and m_1 =1.0 (minor meandering).

Model 3 – With Project (Alternative E)

64. Model 3, With Project Alternative E, represents the hydraulic model including reshaping and increased roughness due to vegetation. The Baseline Condition geometry file was modified to account for the features included in Alternative E.

65. As a part of Model 3 development several assumptions were made for conditions in the project area. It was assumed that the channel and overbank Manning's roughness coefficient was 0.035. In other locations the roughness coefficient was set to 5 to make the areas ineffective.

66. It was assumed that Manning's roughness coefficient did not change with respect to stage and was independent of vegetation maturity level. This was because both factors would require a varying roughness coefficient and for the feasibility study it was believed unnecessary. The maximum roughness coefficient was used for all vegetation types. Cottonwood/Willow has a roughness coefficient of 0.098, Mesquite has a roughness coefficient of 0.073, Upper Sonoran Desert has a roughness coefficient of 0.058, Wetland has a roughness coefficient of 0.048 and river bottom has a roughness coefficient of 0.035. The area not altered by the project has an assigned roughness coefficient of 0.035. In certain locations the Baseline Condition model was set with a roughness coefficient of 5 to make areas ineffective, this was preserved in the Alternative E model.

67. It was assumed that the Gilbert Road Quarry Pit diverted flow from the main channel for events greater than the 5-Year peak discharge, 31,000 ft^3/s; a lateral spillway was incorporated in the design and that bed material is transported downstream in the main channel.

68. Based on site observations made during site visits to the Salt River near Gilbert Quarry, it was determined that additional mining had occurred within the main channel of the Salt River after the original Future Without Project model was completed. It was decided that the additional mining would be included in Model 3, With Project (Alternative E).

69. The existing channel geometry was modified to account for new mining that has occurred after the existing survey was completed. The mining had occurred within the main channel of the Salt River between River Station 6.91 to 6.38 and it was estimated that mining lowered the channel bottom 24 to 5 ft.

70. In addition, Model 3 required a secondary channel to be included in the design. A split flow condition was included on the Salt River from station 9.04 to 8.01. This differed from the original existing HEC-RAS model.

Results

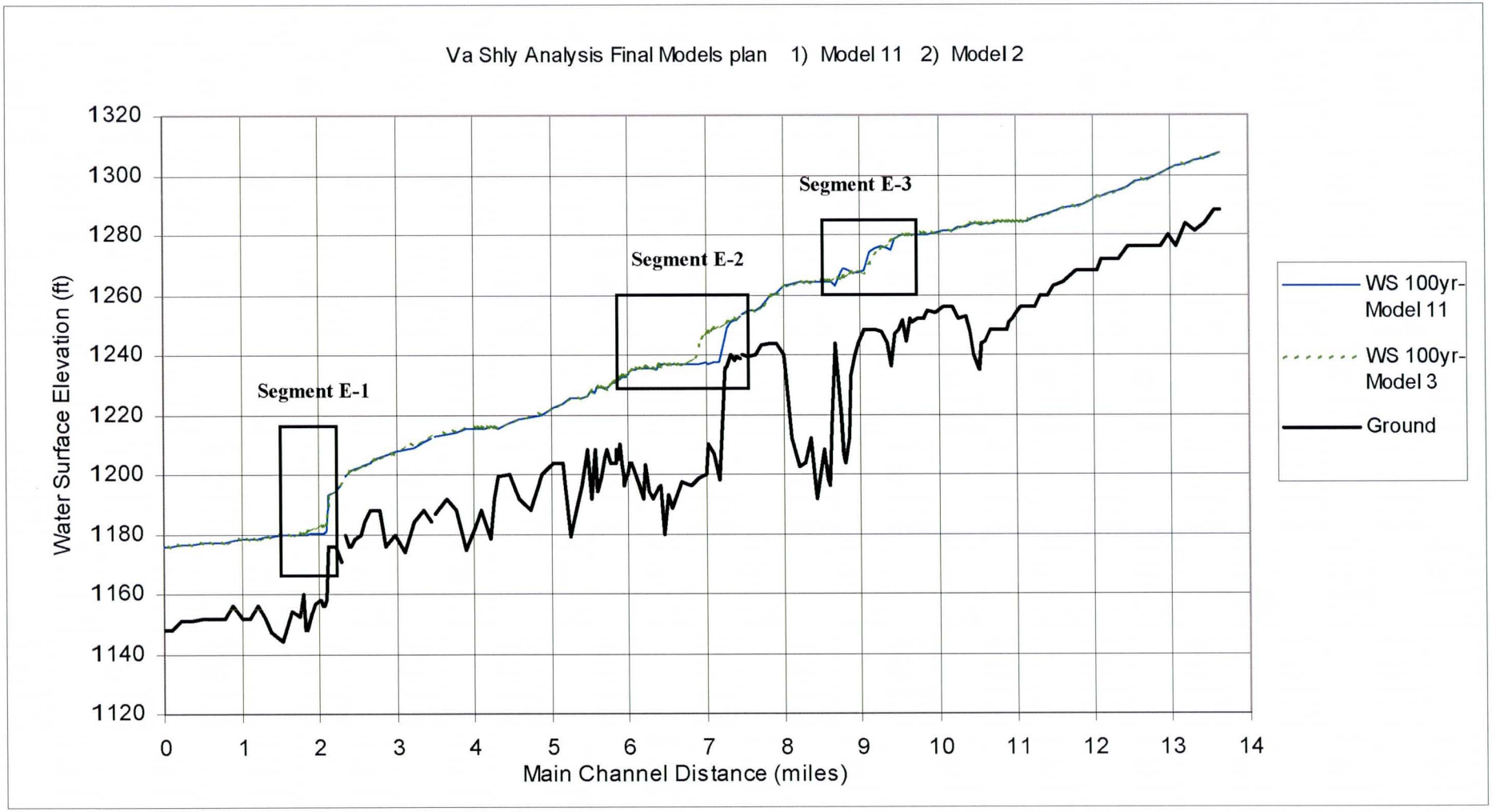
71. Alternative E included the establishment of new vegetation primarily outside the existing 10-Year area of inundation. Overflow spillways were included at River Stations 8.90 and 8.1 to control surface flows into the South Quarry Pit and to stabilize this reach of the Salt River, Figure A-7.

72. The result of hydraulic modeling showed limited change throughout much of the project area, Figure A-7. Changes that did occur were in sections from River Stations

1.76 to 2.01 (Segment E-1), 6.45 to 7.24 (Segment E-2) and 9.39 to 10.4 (Segment E-3). Areas where water surface elevations are higher than Baseline Conditions may not increase flood damages. However, if flood damages are increased, modifications will be made to the design in the F5 Phase to lower water surface elevation to existing condition levels.

73. The increase in water surface elevation observed in Segment 1 was caused by the establishment of Upper Sonoran Desert vegetation in the main channel. Water levels increased by a 1 foot in the 100-Year event, Figure A-8. Water surface levels were lowered in Segment 2 as a result of the lowering of the channel bottom due to mining. Water level dropped about 10 feet for the 100-Year event and velocities were reduced (channel slope through segment lowered). However, the drop in elevation at River Station 7.04 increased channel velocities from River Station 6.85 to 7.28 and lowered velocities from 6.0 to 6.85. In Segment 3 water level increased for the 100-Year event due to the establishment of Sonoran Desert vegetation along the main channel.

Figure A-7. Alternative E water surface profile for the 100-Year event.



Model 4 – With Project (Alternative F)

74. Model 4, With Project Alternative F, represents the hydraulic model that included reshaping, increased roughness due to vegetation and the inclusion of a drop structure. The Baseline Condition geometry file was modified to take into account the features included in Alternative F.

75. As part of the Model 4 development several assumptions were developed based on the conditions in the project area. It was assumed that Manning's roughness coefficient did not change with respect to stage and was independent of vegetation maturity level because both factors would require a varying roughness coefficient and for the feasibility study it was believed that this level of detail was unnecessary. The maximum roughness coefficient was used for all vegetation types. Cottonwood/Willow has a roughness coefficient of 0.098, Mesquite has a roughness coefficient of 0.073, Upper Sonoran Desert has a roughness coefficient of 0.058, Wetland has a roughness coefficient of 0.048 and river bottom has a roughness coefficient of 0.035. The area not altered by the project has an assumed roughness coefficient of 0.035. In other locations the Baseline Condition model was set with a roughness coefficient of 5 to make areas ineffective, this was preserved in the Alternative F model.

76. Baseline Condition cross sections were modified to account for the design of a low flow channel, channel realignment, grade control structure and quarry reshaping.

77. It was assumed that the Gilbert Road Quarry Pit diverted flow from the main channel for events greater than the 5-Year peak discharge, 31,000 ft^3/s; a lateral spillway has been incorporated in the design and that bed material is transported downstream in the main channel.

78. A drop structure was included in the design. The drop structure was necessary to prevent headcutting that could damage rehabilitated areas upstream of River Station 6.8 and at the Gilbert Road Bridge.

79. The existing channel geometry was modified to account for new mining that occurred after the Future Without Project conditions model was completed. The mining occurred within the main channel of the Salt River between River Station 6.91 to 6.38. It was assumed that mining lowered the channel bottom 24 to 5 feet.

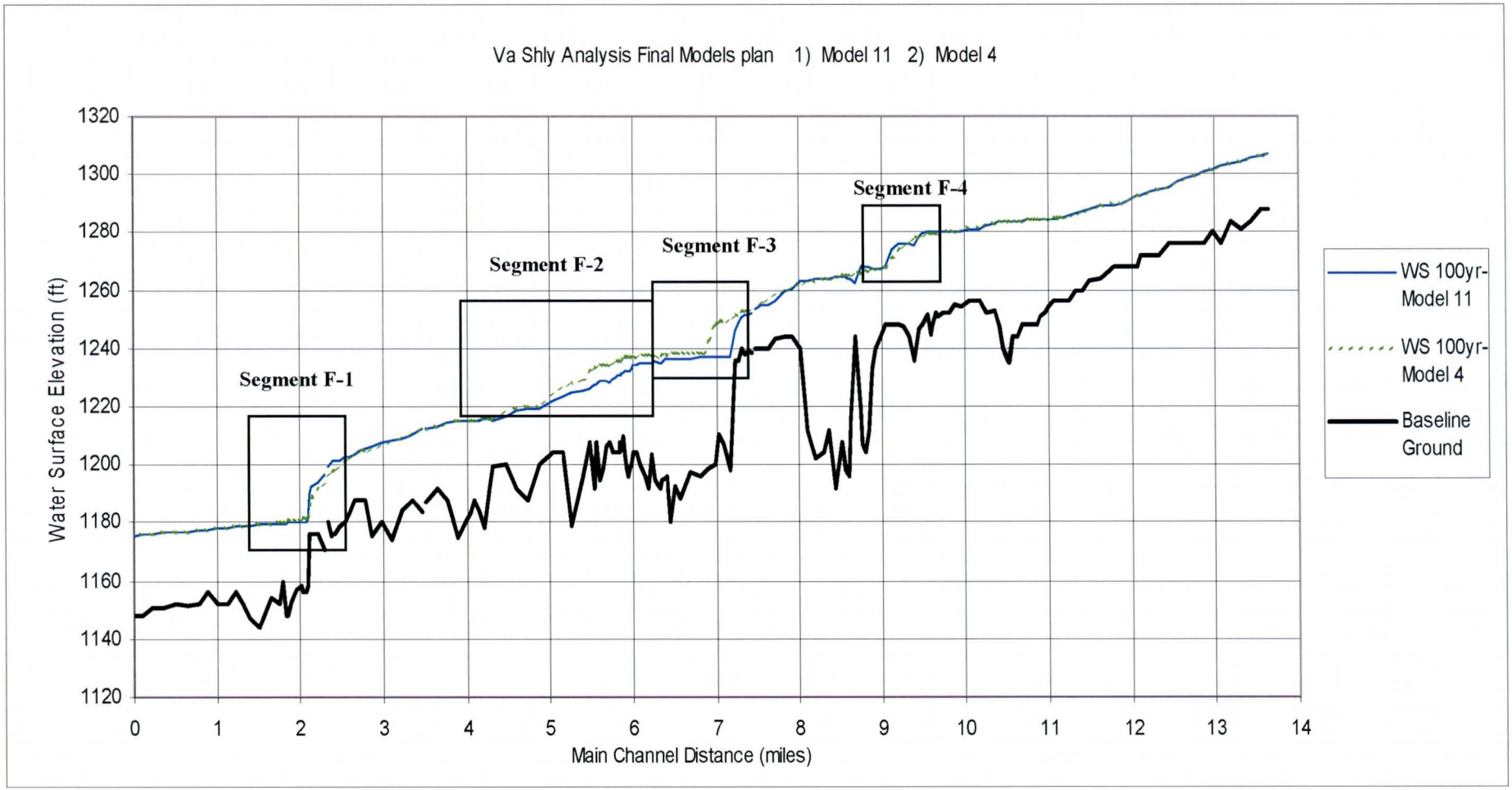
80. In addition, the Salt River from River Station 9.04 to 8.01 was modeled as a split flow condition which differed from the original existing HEC-RAS model. The With Project model required the split flow condition to allow for new alternative features to be incorporated into the model.

Results

81. Alternative F included the establishment of new vegetation throughout the project area both in the active area of conveyance,10-Year area of inundation, and along the overbanks. A low flow channel was included in the design to offset the increased roughness along reaches of the project area. Overflow spillways were also included at River Stations 7.32, 8.10 and 8.90. Areas where water surface elevations are higher than Baseline Condition may not increase flood damages. However, if flood damages are increased, modifications will be made to the design in the F5 Phase to lower water surface elevation to existing condition levels.

82. The hydraulic results showed changes occurred from River Station 4.24 to 6.45 (Segment F-2), River Stations 2.12 to 2.65 (Segment F-1), River Stations 6.45 to 7.24 (Segment F-3) and River Stations 7.44 to 8.01 (Segment F-4), Figure A-8. The higher water surface elevation in Segment F-2 was caused by the establishment of cottonwood/willow and wetland vegetation in the main channel. Water surface elevations decreased along Segment F-1 because of the low flow channel. Segment F-3 had a lower water surface elevation because of the additional mining. However, the drop in elevation at station 7.04 increased channel velocities from station 6.85 to 7.28 and lowered velocities from 6.0 to 6.85. Segment F-4 had an increase in water surface elevation due to the establishment of cottonwood/willow vegetation along the main channel. A low flow channel was included in the design but results show that the design conveyance was not sufficient to offset the additional vegetation based on the 100-Year event results, Figure A-8.

Figure A-8. Alternative F water surface profile for the 100-Year event.



Model 5 – With Project (Alternative A)

83. Model 5, With Project Alternative A, includes the increased roughness due to vegetation. The Existing Condition geometry file was modified to incorporate the features included in Alternative A.

84. As part of the Model 5 development several assumptions were incorporated into the database based on conditions in the project area. It was assumed that Manning's roughness coefficient did not change with respect to stage and was independent of vegetation maturity level. This was because both factors would require a varying roughness coefficient and for the feasibility study it was believed this level of detail was not necessary for the feasibility study. The maximum roughness coefficient was used for all vegetation types. Cottonwood/Willow has a roughness coefficient of 0.098, Mesquite has a roughness coefficient of 0.073, Upper Sonoran Desert has a roughness coefficient of 0.058, Wetland has a roughness coefficient of 0.048 and river bottom has a roughness coefficient of 0.035. The area not altered by the project has a roughness coefficient of 0.035. In other locations the Baseline Condition model was set with a roughness coefficient of 5 to make areas ineffective, this was preserved in the Alternative A model.

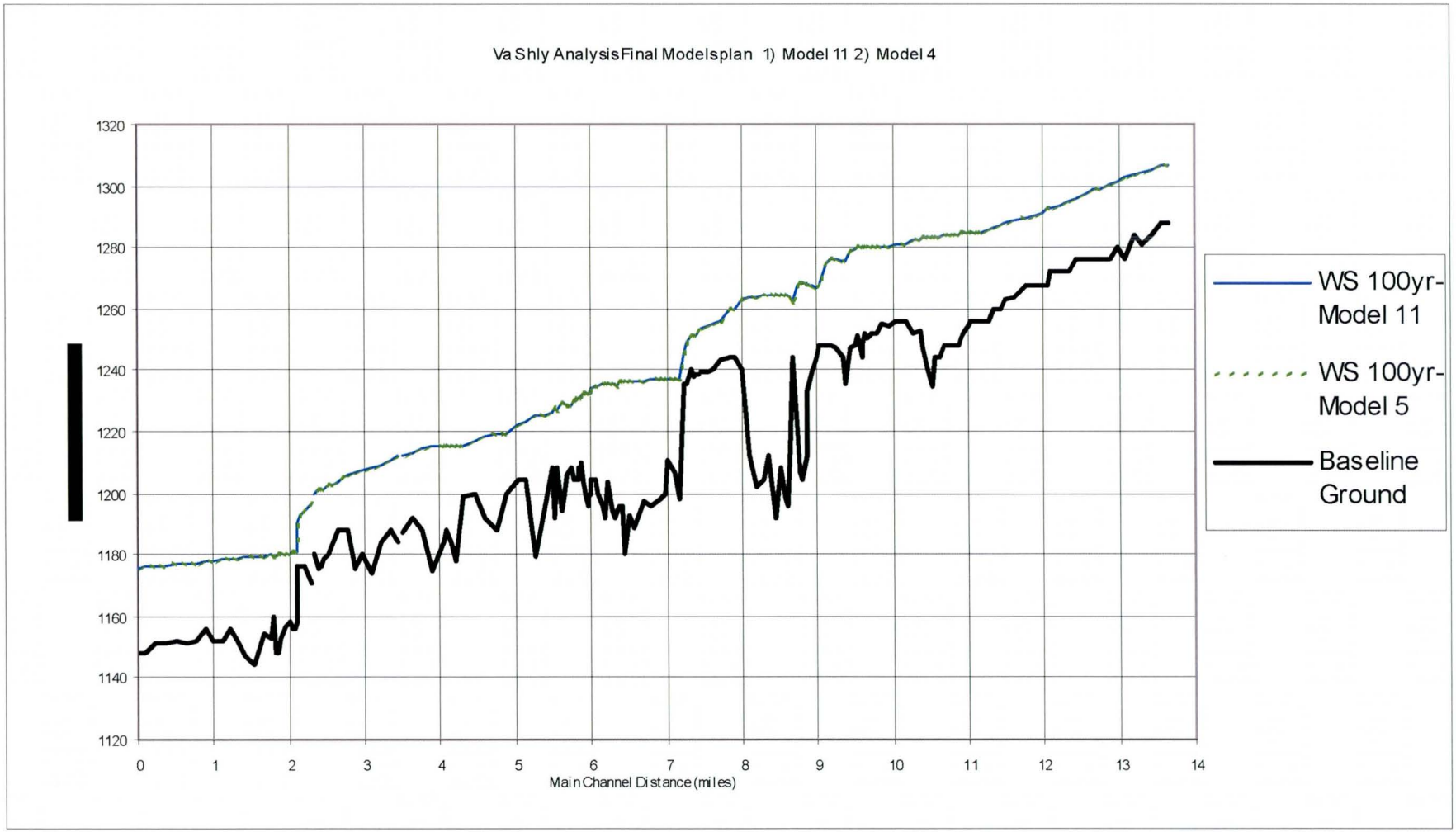
85. The existing channel geometry was modified to account for new mining that occurred after the Future Without Project condition model was completed. The mining occurred within the main channel of the Salt River between River Station 6.91 to 6.38. It was assumed that mining lowered the channel bottom 24 to 5 feet.

86. In addition, the Salt River from River Station 9.04 to 8.01 was modeled as a split flow condition. This differed from the original existing HEC-RAS model. The With Project model required the split flow condition so that new alternative features can be incorporated into the model.

Results

87. Alternative A included the establishment of new vegetation along the overbank area but was limited to outside the existing 10-Year area of inundation.
The results of hydraulic modeling showed no change to the existing conditions, Figure A-9.

Figure A-9. Alternative A water surface profile for the 100-Year event.



Model 6 – With Project (Alternative N)

88. Model 6, With Project Alternative N, represents the hydraulic model that included reshaping, increased roughness due to vegetation and the inclusion of a drop structure. The Baseline Condition geometry file was modified to take into account the features included in Alternative N.

89. As with the other models a series of assumptions were developed based on the local conditions. It was assumed that Manning's roughness coefficient did not change with respect to stage and was independent of vegetation maturity level. This was because both factors would require a varying roughness coefficient and for the feasibility study it was believed this level of detail was unnecessary. The maximum roughness coefficient was used for all vegetation types. Cottonwood/Willow has a roughness coefficient of 0.098, Mesquite has a roughness coefficient of 0.073, Upper Sonoran Desert has a roughness coefficient of 0.058, Wetland has a roughness coefficient of 0.048 and river bottom has a roughness coefficient of 0.035. The area not altered by the project has a roughness coefficient of 0.035. In other locations, the Existing Condition model was set with a roughness coefficient of 5 to make areas ineffective, this was preserved in the Alternative N model.

90. Baseline Condition cross sections were modified to account for quarry reshaping. No bank stabilization was included in this alternative.

91. It was assumed that the Gilbert Road Quarry Pit diverted flow from the main channel for events greater than the 5-Year peak discharge, 31,000 ft^3/s.

92. A drop structure was included in the design. The drop structure was necessary to prevent head cutting upstream which would damage project areas and the Gilbert Road Bridge. The grade control structure is located at River Station 7.24.

93. The existing channel geometry was modified to account for new mining that occurred after the Future Without Project condition model completed. The mining simulated in Alternative N was more extensive than that which was assumed for Alternative E, F and A. In the model for Alternative N, mining lowered the channel bed between River Station 7.17 to 6.38 24 to 10 feet. The additional mining takes into account new information provided by the mine operators.

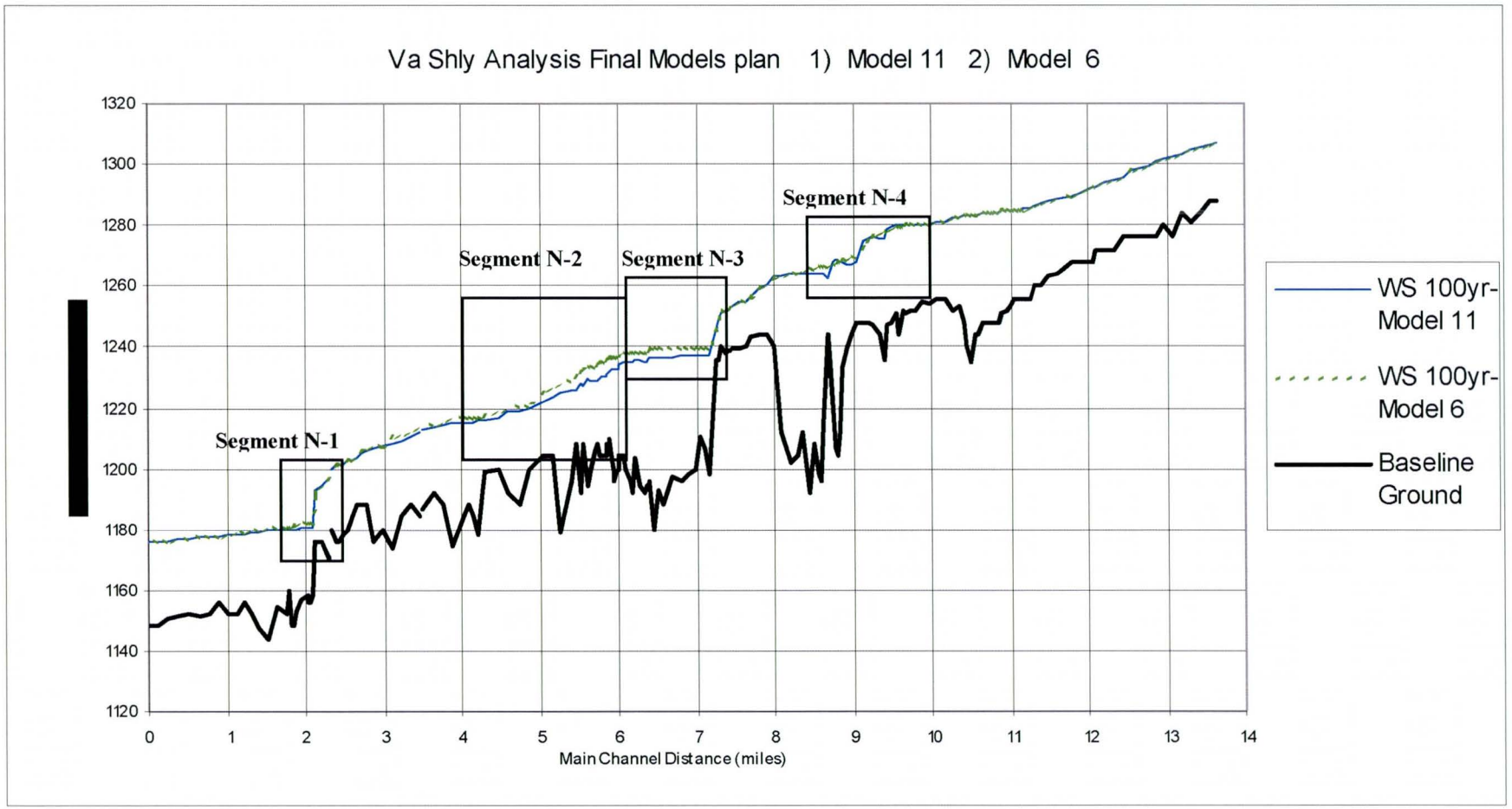
94. Alternative N model needed a split flow condition at River Station 8.10 and 8.98 to simulate a flow diversion occurring from station 9.04 to 8.01. This differed from the Future Without Project model. In addition, because of the extensive mining that occurred between River Station 7.17 and 6.38, it was assumed that the original north bank was removed.

Results

95. Alternative N included the establishment of new vegetation in the active area of conveyance, 10-Year area of inundation, and on the overbank. Areas where water surface elevation are higher than Without Project conditions may not increase flood damages. No additional changes were made to the design because Alternative N was not the preferred alternative

96. The result of hydraulic modeling showed changes occurred along River Station 2.12 to 2.65 (Segment N-1), 4.24 to 6.45 (Segment FN-2), 6.45 to 7.24 (Segment N-3) and 7.91 to 9.04 (Segment N-4), Figure A-10. The changes in Segment N-1 and N-2 were a result of the establishment of cottonwood/willow and wetland vegetation in the main channel. Segment N-3 had lower water surface elevation due to the additional mining. However, the drop in elevation at River Station 7.17 increased channel velocities from station 6.85 to 7.28 and lowered velocities from 6.0 to 6.85. Segment F-4 had an increase in water surface elevation due to the establishment of cottonwood/willow and wetlands within the main channel.

Figure A-10. Alternative N water surface profile for the 100-Year event.



Model 8 – With Project (Alternative O)

97. Model 9, With Project Alternative O, represents the hydraulic model that included reshaping, increased roughness due to vegetation and the inclusion of a drop structure. The Baseline Condition geometry file was modified to take into account the features included in Alternative N with additional vegetation in sub-areas 1 and 2. A low flow channel was included, channel extended from River Station 2.78 to 2.13.

98. As with the other models a series of assumptions were developed based on the local conditions. It was assumed that Manning's roughness coefficient did not change with respect to stage and was independent of vegetation maturity level. This was because both factors would require a varying roughness coefficient and for the feasibility study it was believed this level of detail was unnecessary. The maximum roughness coefficient was used for all vegetation types. Cottonwood/Willow has a roughness coefficient of 0.098, Mesquite has a roughness coefficient of 0.073, Upper Sonoran Desert has a roughness coefficient of 0.058, Wetland has a roughness coefficient of 0.048 and river bottom has a roughness coefficient of 0.035. The area not altered by the project has a roughness coefficient of 0.035. In other locations, the Baseline Condition model was set with a roughness coefficient of 5 to make areas ineffective, this was preserved in the Alternative N model.

99. Baseline Condition cross sections were modified to account for channel reshaping. No bank stabilization was included in this alternative.

100. A drop structure was included in the design. The drop structure was necessary to prevent head cutting upstream which would damage project features in sub-area 5.2 and 6.2 and the Gilbert Road Bridge. The grade control structure is located at River Station 7.24.

101. The existing channel geometry was modified to account for new mining that occurred after the Future Without Project condition model completed. The mining simulated in Alternative O was more extensive than that which was assumed for Alternative E, F and A. In the model for Alternative O, mining lowered the channel bed between River Station 7.17 to 6.38 24 to 10 feet. The additional mining takes into account new information provided by the mine operators.

102. Alternative O model needed a split flow condition at River Station 8.10 and 8.98 to simulate a flow diversion occurring from station 9.04 to 8.01. This differed from the Future Without Project model. In addition, because of the extensive mining that occurred between River Station 7.17 and 6.38, it was assumed that the original north bank was removed.

Results

103. Alternative O included the establishment of new vegetation in the active area of conveyance, 10-Year area of inundation, sub-area 2.2, 2.3 and 2.4, and on the overbank. The proposed low flow channel offset the addition of vegetation Figure 11. The abrupt drop in elevation found in Segment O-3 and O-4 were due to mining operations.

104. The result of hydraulic modeling showed minimal changes along River Station 1.22 to 2.12 (Segment O-1), 5.0 to 6.45 (Segment O-2), 6.45 to 7.24 (Segment O-3), and 7.91 to 9.04 (Segment O-4), Figure A-12. In Segment O-1 water surface elevation were slightly lower due to the addition of a low flow channel that offset the reduction of conveyance because of vegetation. Segment O-2 had higher water surface elevation due to additional vegetation between River Station 4.5 and 6.0. The rise in water levels does not increase the 100-Year area of inundation. The drop in elevation at River Station 7.17 was due future mining in the Gilbert Quarry area. The change in elevation increased channel velocities from station 6.85 to 7.28 and lowered velocities from 6.0 to 6.85, Figure A-12. To offset the change increase in velocity a drop structure was proposed at this location. Segment O-3 had an increase in water surface elevation due to the establishment of cottonwood/willow and wetlands within the main channel.

Figure A-11. Alternative O vegetation layout.

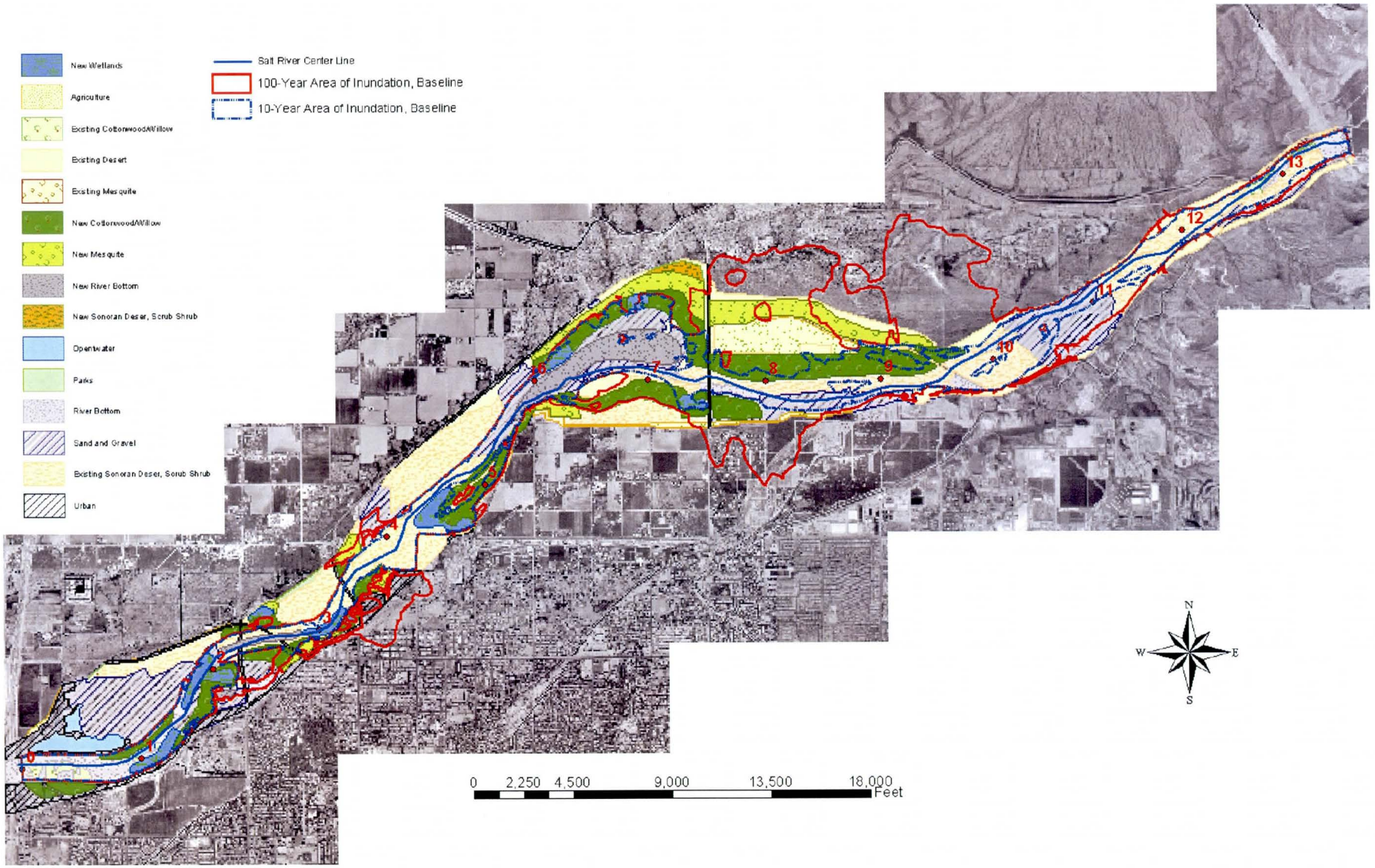
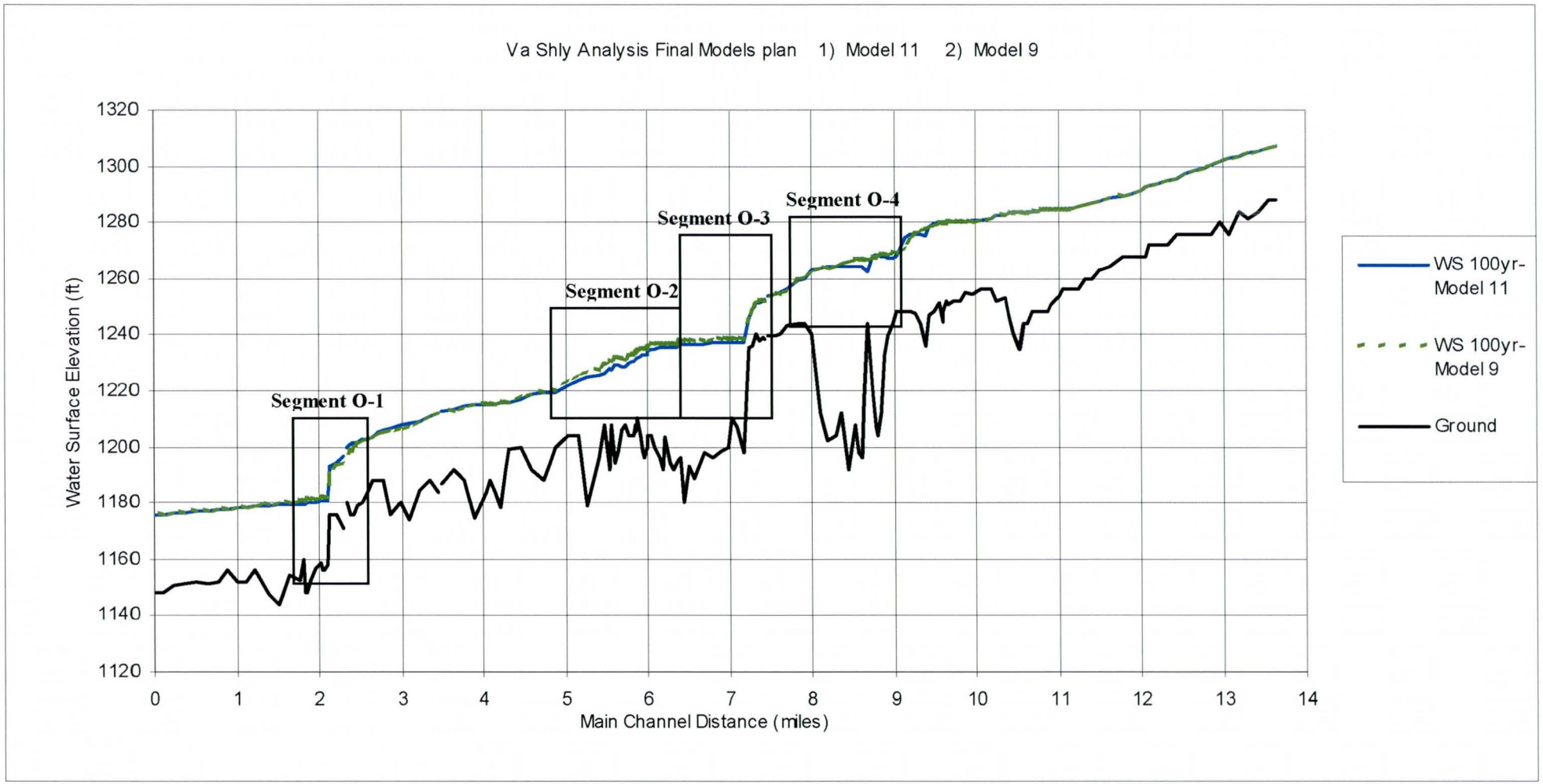


Figure 12. Alternative O water surface profile for the 100-Year event.



SEDIMENT ANALYSIS

SEDIMENTATION ANALYSIS

Without Project

105. The without project sedimentation analyses showed that the overall trend of the area appears to be degrading, Figure A-14 and Figure A-16, (West, 2002). Quarry operations had a significant impact on altering channel hydraulics to encourage deposition at quarry locations and initiate scouring upstream and downstream of these locations. The sedimentation analysis did not take into account future mining operations within the study area.

106. The HEC6T model was calibrated by comparing the water surface elevation from the HEC-6T model to the HEC-RAS model for the 5-, 10-, 20-, 50- and 100-Year peak flows. The differences in the computed water surface elevations were on average less than 0.01 feet and the channel velocity differences were within 0.5 feet per second. The sedimentation model simulates 50 years of channel hydraulic conditions to estimate the rates of scouring or deposition occurring along the Salt River from Granite Reef Dam to the 101 Hwy.

107. Bed sediment samples were collected at 16 locations within the study area. The measured bed gradation data were input into the HEC-6T model. The channel bed materials were composed of sand (30 %), gravel (50 %) and cobbles (20 %). The channel bed material is primarily sand and gravel. There is a high percentage of gravel in the bed and thus WEST used the Toffaleti, Meyer-Peter and Muller (TMPM) combination transport model in the HEC-6T sediment transport models to simulate the transportation of gravel and sand.

108. The sediment transport model could not be directly calibrated to historic conditions because detailed historic bed elevations are not available and sand and gravel mining and channelization has changed the bed elevations. An equilibrium bed material load at the upstream section of the study area was calculated for a range of discharges up to 200,000 ft^3/s and this was used as the basis for inflowing sediment load for the HEC-6T model.

109. The upstream limit of the study area is Granite Reef Dam. The USACE suggested that the equilibrium load be used as a reasonable estimate for the inflowing bed load material because the Granite Reef Dam diverts water and does not store water, therefore it does not significantly reduce the sediment load transported by the Salt River. WEST did not find evidence of deposition or scour downstream of the Granite Reef Dam and this confirms that the equilibrium load assumption is realistic. A more comprehensive discussion for estimating the equilibrium bed load is found in the WEST report (West, 2002).

110. Overall, the VaShly Project area appeared to be degrading based on the sedimentation analysis, Figure A-14, Model 11 and 2, Baseline and Future Without Project Conditions. The longitudinal profile shows an overall lowering of the channel invert. The Future Without Project conditions model does not take into account

additional mining that has or will occur after year 2001, topographical information was based on 2001 survey information. If the additional mining that was taken into account in Models 3, 4, 5, 6, 9 and 11, was incorporated in the Future Without Project model, the amount of scouring would increase predominantly in Areas C, E and G. A more comprehensive evaluation of the sedimentation analysis is provided in the West report (West, 2002) .

111. There are 7 areas that are of particular concern, Areas A, B, C, D, E, F and G, Figure A-20. Areas A and B show a 50-Year aggradation trend from 1-9 ft, while Area C shows some degradation, 4 to 9 ft. These areas appear to be directly influenced by mining operations. The more severe areas are D, E, F and G., mining has altered the channel profile causing scouring up to 22 ft, Area E and G, and aggradation up to 10 to 30 ft, Areas D and F. Areas D and F are old quarry pits that filled in during the 50-Year simulation period. Refer to the West report for a more detailed discussion of without project sedimentation analysis results (West, 2002).

With Project

112. Due to time constraints a detailed sediment transport analysis was not completed for the with project conditions phase of the study. The without project sedimentation analysis and with project hydraulic results were used to assess the with project sedimentation trends. The preferred alternative will be analyzed in the PED phase of the study using the 1-D sedimentation analysis computer program HEC-6T.

113. Mining operations are a factor impacting the sedimentation trends throughout the project area. Based on the Without Project sedimentation analysis, seven areas were identified as having depths of deposition or scouring that appeared to be greater than would be considered stable, Figure A-16. These areas, under existing conditions could damage project features or increase maintenance in and around these areas. Sub-area numbers were used to refer to specific locations in the With Project sedimentation analysis, as shown on Figure A-13. In addition, mining operations in the future will impact project features. To prevent damages from occurring, future mining operations need to be understood and taken into account in PED phases.

114. Alternative E. There are concerns for features in sub-area 2.2, because the features appear susceptible to damage due to deposition. Sub-area 6.2, along the south bank, will not be damaged due to deposition because the overflow spillway and bank stabilization will reduce the amount of material flowing into this area. There appear to be no other areas of concern. Features in sub-area 5.2 will be susceptible to damage due to aggradation of coarse material and the lateral migration of the main channel.

115. Alternative F. There are concerns for features in sub-area 4.1, appear susceptible to scouring. With the recommended modification in sub-area 6.2, the low flow channel appears to be susceptible to some scouring during extreme events. Sub-area 3.2 and 3.1 appears to be susceptible to both scouring and deposition. Because the north and south banks will be stabilized and spillways constructed in sub-area 5.2, bed load material will

be confined to the main channel. The aggradation trend for the existing without project condition will be reduced in Area D because water and bed material will be forced through the existing main channel. There may be some damages but the features can be designed in F5 to account for accumulation of material.

116. Alternative A. There are no sedimentation concerns

117. Alternative N. There are erosion concerns for features in sub-area 6.1 and 4.1. No bank stabilization or diversion structures were included in Alternative N. This was intended to allow the river to naturally aggrade and meander in Area D. To minimize damage to features, cottonwood and mesquite vegetation was placed outside the Without Project area of aggradation, Figure A-16.

118. Alternative O. There are erosion concerns for features in sub-area 2.2, 2.3 and 4.1. No bank stabilization or diversion structures were included in Alternative O. This was intended to reduce construction and maintenance costs. Under this situation, the Salt River will continue to change, the most sensitive areas are in Area D, E and F. Cottonwood and mesquite vegetation was placed outside the Without Project area of aggradation to minimize damage to features. Cottonwood and wetland features located in sub-area 2.2, 2.3 and 4.1 are susceptible to damage because they are located in the 10-Year area of inundation and assumed a high velocity zone. This makes the features susceptible to high velocities when flow events do occur. Mining in the future could threaten the project features. To better understand the impact of mining further analysis is necessary prior to construction during the PED phase. Refer to Figure A-16, Area F, for quarry location, and erosion and deposition trends.

Figure A-13. Sub-area and river station numbers for project area. Sub-area numbers are in yellow.

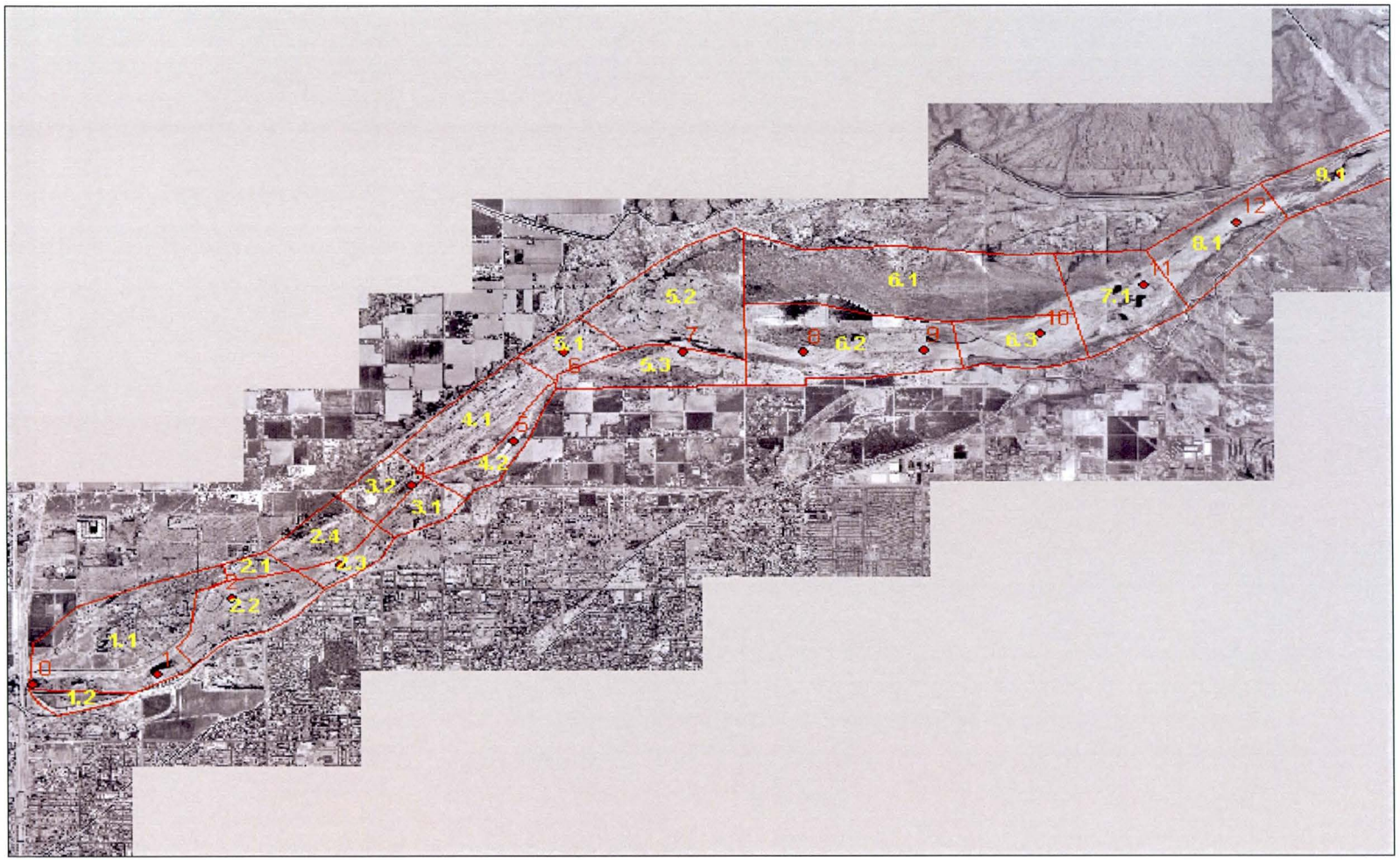


Figure A-14. Without project water surface profiles for the 100-Year Event for the Baseline, Model 11, and Future Without Project, Model 2.

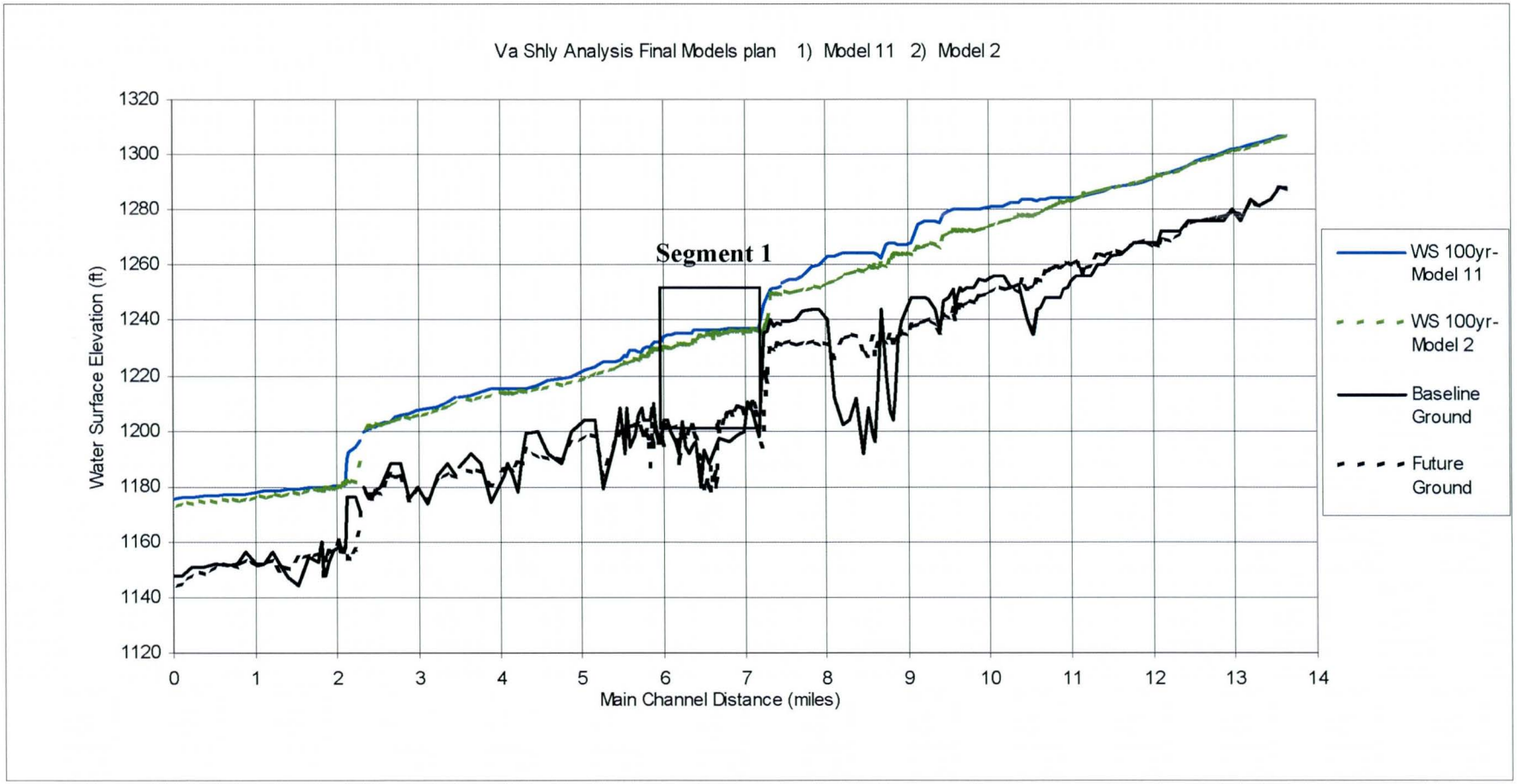


Figure A-15. Baseline, Model 11, and Future Without Project, Model 2, main channel average velocity for the 100-Year Event.

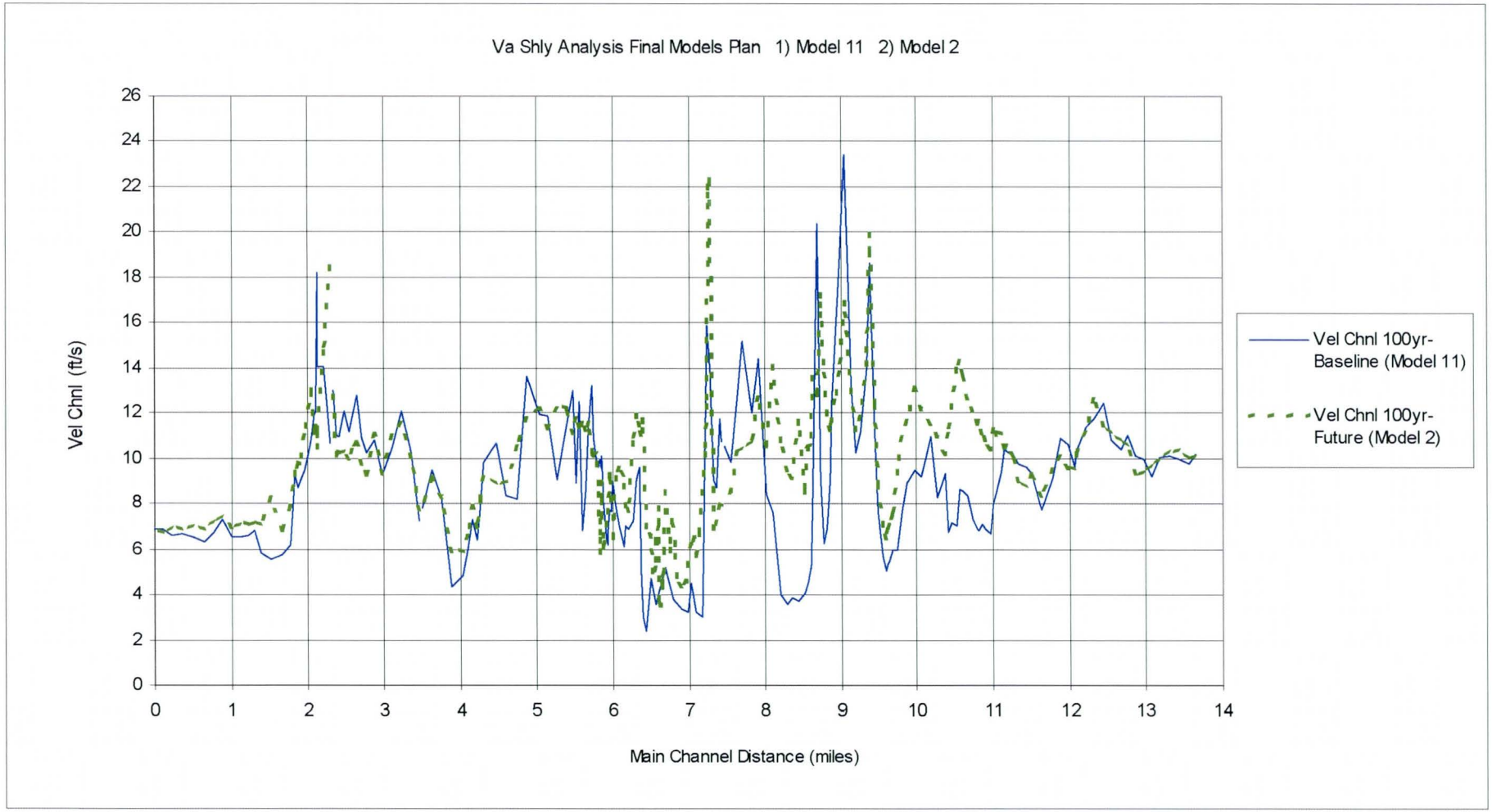
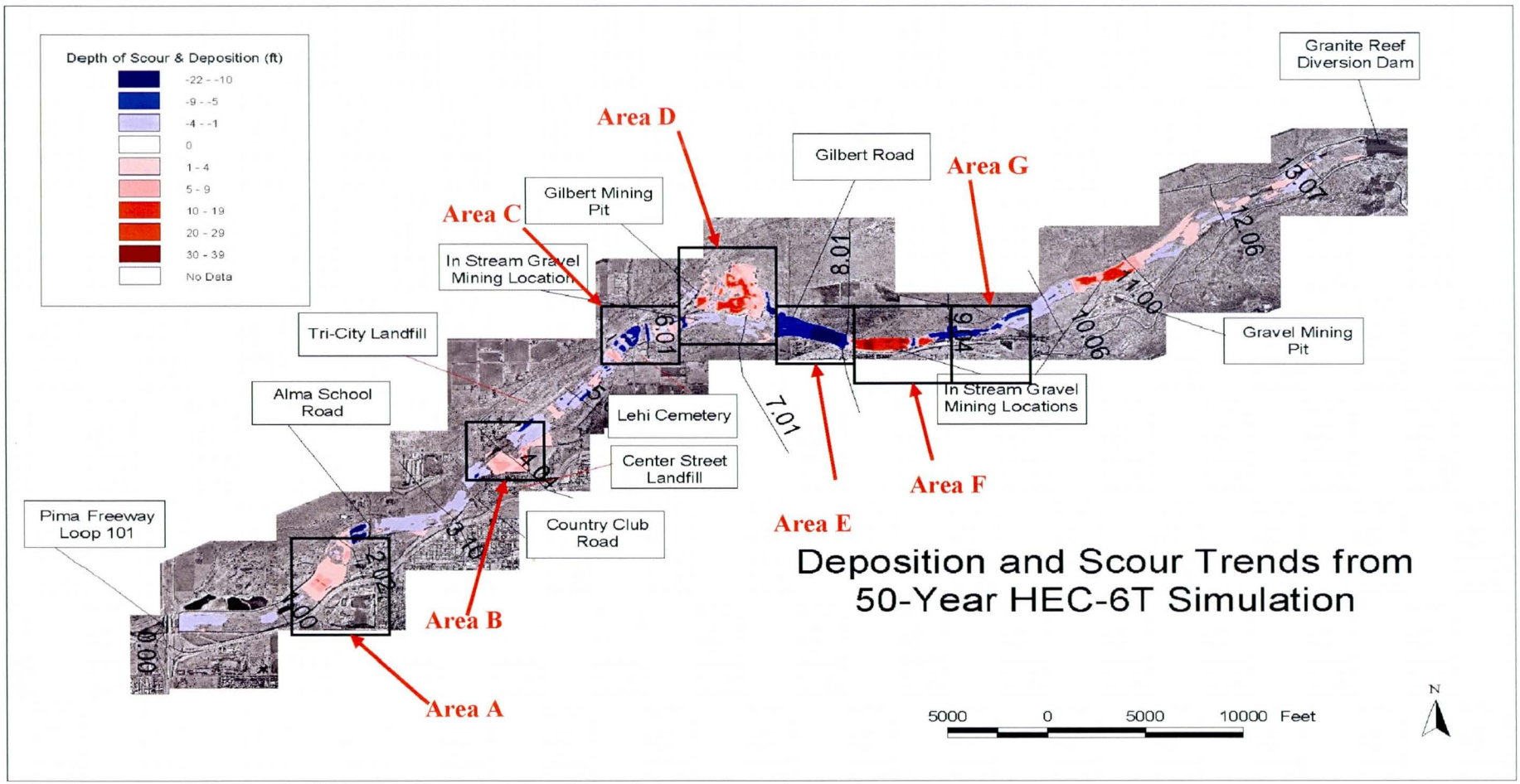


Figure A-16. Deposition and Scour Trends from 50-Year HEC-6T Simulation and sedimentation areas of concern (West, 2002).



GEOMORPHOLOGY DISCUSSION

119. Historic records indicate an increase in human influences on the Salt River exemplified by the encroachment of urban, commercial and gravel mining areas. Long-term channel responses are entirely dependent on future development in and around the channel. If there is no additional gravel mining, the channel will reach a state of equilibrium but only after all the gravel pits have reached a sediment transport balance through the natural migration of the river system or restoration activities have been conducted (West, 2002).

120. A significant concern on the stability of the river is the influence of gravel mining on the erosion and planform evolution of the channel. Gravel pits in the channel act as a reach of zero slope and serve to trap sediment. Downstream of the gravel pits, sediment supply to the channel is reduced due to the trapping of sediments within the pits. In order to meet sediment transport capacity, the downstream channel may erode its bed to reduce its slope and corresponding sediment transport capacity. According to Lane (1957), as the slope is reduced the channel would transition form a braided to intermediate planform condition.

121. The historic migration of the Salt River from Granite Reef Dam to Price Road is depicted in bank migration pattern from 1935 to 2002, Figure A-17. It clearly shows that the Salt River still actively changes channel configuration, conforming to the river flows. However, hard banking and other encroachments throughout the 100-Year Floodplain have confined the lateral migration of the river.

122. For a more detailed discussion on the Geomorphology of the Salt River within the study area refer to West report (West, 2002).

Erosion Concerns

123. Lehi Cemetery located along the south bank at River Station 6 is an area that does not appear to be in any immediate threat to erosion. Currently, the river is constricted by the Tri City Landfill on the north bank and a geological outcrop on the south bank. The south bank has been actively eroding for the past 65 years, Figure A-17. Because of the erosion that has occurred local sponsors have expressed erosion concerns over Lehi Cemetery. Using aerial photos from 1935, 1957, 1979 and 2002, the bank lines were determined and an average rate of migration calculated. From 1935 to 2002 the south bank moved south 740 ft at an average rate of 11 ft/yr. This area has shown a consistent pattern of change, that is, the channel has gradually got wider. Because bank migration rates are dependent on the number of river flow events, peak discharge and duration, in addition to changes in the channel geometry, it is difficult to determine a rate of migration. For this report it was assumed that the average rate of migration was 11 ft/yr. Assuming this rate the Lehi Cemetery will be impacted in 33 years. However, other factors such as the mining operations have substantially changed the landscape and the channel geometry. Steeper and taller channel banks may decrease bank stability which

would encourage erosion. On the other hand due to the gradual widening of the channel the boundary shear stress for a given discharge has reduced.

124. Another important point is that due to the increase in the Rio Salado Watershed storage capacity upstream of the Granite Reef Dam, because of current climate conditions and increased reservoir storage, flows in the future have a lower probable peak discharge than in the past. Thus, unless climate conditions change, i.e. more precipitation, expected river flows will be less.

125. Because of the complexity of estimating erosion and future erosion conditions it was decided that another approach would be to compare flow conditions at Lehi Cemetery to the entire study reach for the100-Year event. Baseline Conditions average channel velocity in this area ranges from 6 to 10 ft/s for the 100-Year event. This range is comparable to the other areas along the Salt River.

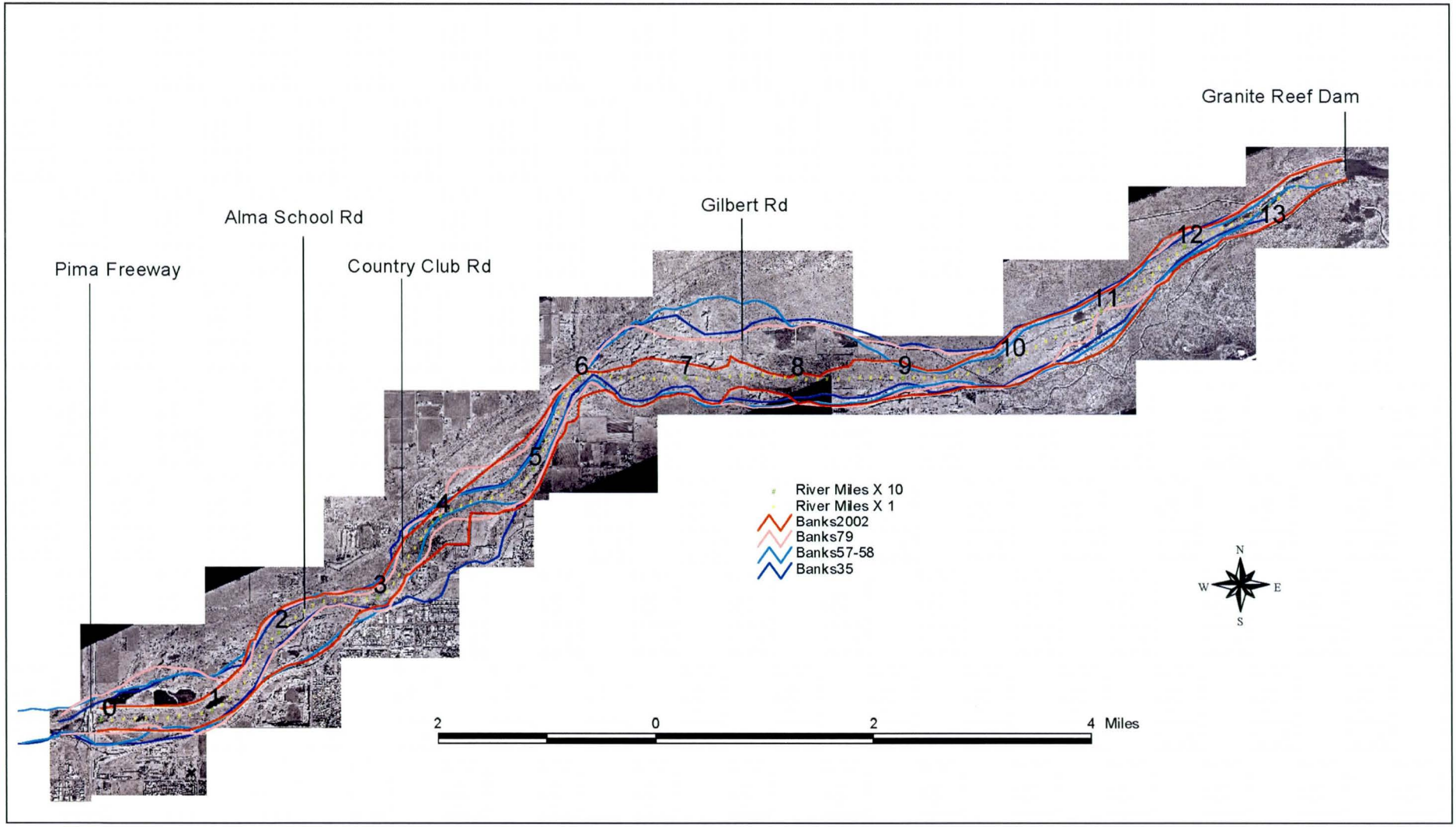
126. For the Future Without Project condition the average channel velocity remains relatively the same, Figure A-15. With project conditions shows equal or lower channel velocity conditions, model results found in appendix exhibits. Thus, for the Lehi Cemetery area bank erosion was not a concern based on the feasibility analysis and no bank stabilization was proposed for this area.

127. Another area of concern is the south bank at River Station 3. Because of the geometry of the Salt River, a 45 degree bend, aerial photos indicate the south bank has been actively eroding, Figure A-17.

128. Scouring affects the stability of the channel (changes in lateral and vertically channel geometry) and hydraulic conditions (changes in velocity and water surface elevations). These changes in the future would impact with project features by increasing the potential of damages associated to scouring. Based on the existing sedimentation model the areas most susceptible to damages for Alternative O are found between River Station 9.5 to 7.5. In addition, results show that minimal amounts of erosion occur downstream of Gilbert Quarry. Future mining was not taken into account in the model. If additional mining was taken into account, it can be assumed that erosion rates would be increased for future conditions.

GEOMORPHOLOGY DISCUSSION

Figure A-17. Historic channel bank locations superimposed on 2002 imagery (West, 2002).



RISK AND UNCERTAINTY ANALYSES

RISK AND UNCERTAINTY ANALYSIS

129. Procedures outlined in EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies" (USACE, 1996b), were followed to determine the standard deviation for computed water surface profiles at specific index locations. Specifically, Section 5-4, "Uncertainty in Stage for Ungauged Stream Reaches," and Section 5-5, "Uncertainty in Stages for Computed Water Surface Profiles," were followed. Only the 100-Year event standard deviation was calculated using these methods because the computer program HEC-FDA (HEC 1998) adjusts the standard deviation for the other stage discharge values. For discharge values greater than the 100-Year event discharge, the standard deviation is assumed equal to the standard deviation of the 100-year event discharge. For discharge values smaller than the 100-Year event discharge, the standard deviation is the standard deviation of error associated with the 100-Year event discharge multiplied by the ratio of the given discharge to the 100-Year event discharge. A summary of the uncertainty analysis for the different alternatives at the index locations is presented in Table A-6. The standard deviation for each alternative is tabulated under the column heading "Stotal."

Table A-6. Risk analysis standard deviation.

Reach and Index Cross Section Rio Salado Vashly	Frequency	Q (cfs)	Stotal (ft)	Reach and Index Cross Section Rio Salado Vashly	Frequency	Q (cfs)	Stotal (ft)
	500-YR	246000	0.7		500-YR	250000	0.7
	200-YR	207000	0.7		200-YR	210000	0.7
Reach 1	100-YR	172000	0.7	Reach 6	100-YR	175000	0.7
Cross-Section .89	50-YR	145000	0.6	Cross-Section 7.63	50-YR	150000	0.6
0 to 1.52	20-YR	95000	0.4	6.45 to 8.98	20-YR	100000	0.4
	10-YR	58000	0.2		10-YR	60000	0.2
	5-YR	21000	0.1		5-YR	22000	0.1
	3-YR	2200	0.01		3-YR	2200	0.01
	500-YR	246000	0.7		500-YR	250000	0.8
	200-YR	207000	0.7		200-YR	210000	0.8
Reach 2	100-YR	172000	0.7	Reach 7	100-YR	175000	0.8
Cross-Section 2.47	50-YR	145000	0.6	Cross-Section 9.64	50-YR	150000	0.7
1.52 to 3.23	20-YR	95000	0.4	8.98 to 10.06	20-YR	100000	0.5
	10-YR	58000	0.3		10-YR	60000	0.3
	5-YR	21000	0.1		5-YR	22000	0.1
	3-YR	2200	0.01		3-YR	2200	0.01
	500-YR	246000	0.8		500-YR	250000	0.8
	200-YR	207000	0.8		200-YR	210000	0.8
Reach 3	100-YR	172000	0.8	Reach 8	100-YR	175000	0.8
Cross-Section 3.76	50-YR	145000	0.7	Cross-Section 11.05	50-YR	150000	0.7
3.23 to 4.27	20-YR	95000	0.4	10.06 to 11.17	20-YR	100000	0.5
	10-YR	58000	0.2		10-YR	60000	0.3
	5-YR	21000	0.1		5-YR	22000	0.1
	3-YR	2200	0.01		3-YR	2200	0.01
	500-YR	246000	0.7		500-YR	250000	0.7
	200-YR	207000	0.7		200-YR	210000	0.7
Reach 4	100-YR	172000	0.7	Reach 9	100-YR	175000	0.7
Cross-Section 5.03	50-YR	145000	0.6	Cross-Section 12.1	50-YR	150000	0.7
4.27 to 5.88	20-YR	95000	0.4	11.17 to 12.33	20-YR	100000	0.5
	10-YR	58000	0.2		10-YR	60000	0.3
	5-YR	21000	0.1		5-YR	22000	0.1
	3-YR	2200	0.01		3-YR	2200	0.01
	500-YR	246000	0.8		500-YR	250000	0.7
	200-YR	207000	0.8		200-YR	210000	0.7
Reach 5	100-YR	172000	0.8	Reach 10	100-YR	175000	0.7
Cross-Section 6.05	50-YR	145000	0.7	Cross-Section 12.97	50-YR	150000	0.7
5.88 to 6.40	20-YR	95000	0.5	12.33 to 13.64	20-YR	100000	0.5
	10-YR	58000	0.3		10-YR	60000	0.3
	5-YR	21000	0.1		5-YR	22000	0.1
	3-YR	2200	0.01		3-YR	2200	0.01

OPERATION AND MAINTENANCE

130. The Baseline Condition and With Project hydraulic results and the Without Project sedimentation results were used to asses the operation and maintenance concerns for this project. During this F5 phase of the study, the With Project sediment analysis was not undertaken. Instead, results from the With Project hydraulic analysis and Without Project sediment analysis (West, 2002) were used to estimate the frequency that environmental features are damaged in each alternative. The method of analysis was to compare the Baseline Condition area of inundation for the 5 and 10-Year events to the vegetated area, Arc-View was used to perform this comparison. It was assumed that the Baseline Condition 5 and 10-Year area of inundation represented the area of highest velocities. Because the alternatives did not significantly alter the existing flow path, it was assumed that the Baseline Condition area of inundation would be sufficient to complete the With Project damage assessment. Damage due to duration of inundation was not taken into account in this analysis. Note that the frequency of vegetation replacement was not analyzed in this study.

Maintenance Considerations

131. It was assumed that all vegetated areas require an irrigation system to establish and maintain the vegetation. Two types of irrigation systems were analyzed, surface braided irrigation system and drip irrigation. An in depth maintenance assessment was not be performed as a part of this analysis. Estimating the maintenance requirements for the irrigation system required the assumption that the With Project vegetated area inundated by the Baseline Condition 10-Year events would require maintenance. The total vegetated area inundated is shown in Table A-7. The area represents Wetlands, Cottonwood/Willow, Mesquite and Upper Sonoran Desert. The area damaged for the 20 to 500-Year events corresponds to a percentage of the vegetated area inundated by the 10-Year event. For the 5-Year event it was assumed that 50% of the area inundated was damaged. For the 10-Year event, 70 % of the area inundated was damaged. For the 20-Year event, 80% of the area and 90 % for the 50 to 500-Year events. These assumptions are based on engineering judgment applicable for the F4 phase of this investigation. Alternative F and Alternative O had the greatest amount of damages, Table A-8.

Table A-7. Vegetated area inundated by the 5 and 10-Year events for the without project existing conditions.

	5-Year	10-Year
Alternative	Area (acres)	Area (acres)
A	32	95
E	268	395
F	454	754
N	337	582
O	336	537

Table A-8. Irrigation area requiring maintenance based on recurrence interval.

	5-Year	10-Year	20-Year	>50-Year
Alternative	Area (acres)	Area (acres)	Area (acres)	Area (acres)
A	16	67	76	86
E	134	277	316	356
F	227	528	603	679
N	169	407	466	524
O	168	376	430	483

132. A low flow channel was included in the design of Alternative F. It was assumed that maintenance would be required when the low flow channel average velocity exceeds the maximum permissible velocity for the bank material d_{50}. The low flow channel from River Station 9.6 to 7.65, the d_{50} for the bank material = 0.9 mm. The corresponding permissible velocity = 5 ft/s, permissible velocity for graded silt to cobble, noncolloidal, for water transporting noncolloidal material (Julien, 1998). The low flow channel from River Station 4.4 to 2.2, the d_{50} for the bank material = 19.3 mm. The corresponding permissible velocity = 6.5 ft/s, permissible velocity for small cobble and shingles, for water transporting noncolloidal material (Julien, 1998).

133. The low flow channel from River Station 9.6 to 7.6, the main channel average velocity exceeds the maximum permissible velocity for flows equal to or greater than the 5-Year event. Because the channel was designed to allow the channel to migrate laterally, it was assumed that maintenance would occur after events greater than the 10-Year event.

134. The low flow channel from River Station 4.4 to 2.2, the main channel average velocity exceeds the maximum permissible velocity for flows equal to or greater than the 10-Year event. The channel was designed to allow the channel to migrate laterally and thus it was assumed that some maintenance would occur after events greater than the 20-Year event.

135. A water distribution channel will be incorporated in the design for Alternatives H, B, C, E and G. Based on a similar analysis as performed for the low flow channel it was assumed that for velocity's greater than 5 ft/s, distribution channel will be damaged. Because most of these channels will be planned in or near the 10-Year flow event it was assumed that 40% of the channel was damaged for flow equal to the 5-Year event, 50% for flows equal to the 10-Year event, 60% for flows equal to the 20-Year event and 80% for flows greater than the 50-Year event. Percent damages were based on engineering judgment. The resulting damage to the distribution channel is shown in Table A-9. Alternative G and H have the most damages to the distribution channel.

Figure A-9. Distribution channel damages based on recurrence interval.

Alternative	Distribution Channel Length (ft)	5-Year Level of Damage (ft)	10-Year Level of Damage (ft)	20-Year Level of Damage (ft)	>50 - Year Level of Damage (ft)
G	68,500	27,400	34,250	41,100	54,800
H	68,500	27,400	34,250	41,100	54,800
C	25,000	10,000	12,500	15,000	20,000
B	3,000	1,200	1,500	1,800	2,400
E	3,000	1,200	1,500	1,800	2,400

136. Maintenance may also be necessary to minimize or control the spreading of large woody vegetation into the main channel. This is necessary to maintain an area of conveyance great enough to maintain existing conditions.

Vegetation Damage

137. The vegetation damage was evaluated using a similar method as was used for the maintenance considerations. For the 5-Year event it was assumed that 50% of the area inundated was damaged. For the 10-Year event, 70 % of the area inundated was damaged. The area damaged for the 20 to 500-Year events corresponds to a percentage of the vegetated area inundated by the 10-Year event. For the 5-Year event it was assumed that 50% of the area inundated was damaged. For the 10-Year event, 70 percent of the area inundated was damaged. For the 20-Year event, 80% of the area and 90 % for the 50 to 500-Year events. These assumptions are based on engineering judgment applicable for the F5 phase of this investigation. Alternative F and Alternative O had the most damage, Table A-10.

Table A-10. Vegetation damaged area for a given recurrence interval.

	5-Year	10-Year	20-Year	> 50-Year
Alternative	Area (acres)	Area (acres)	Area (acres)	Area (acres)
A	16	67	76	86
E	134	276	316	355
F	227	528	603	678
N	168	407	465	523
O	204	463	529	595

PREFERRED ALTERNATIVE

Preferred Alternative: Alternative O

138. It was determined that the recommended alternative was Alternative O. The following section provides additional information concerning project features, with project hydraulic conditions and impact to project features.

139. Alternative O consists of the following vegetation types: 883 acres of Cottonwood/Willow, 380 acres of Mesquite, 200 acres of wetland, and 24 acres of Sonoran Desert. A majority of the vegetation planned for lies outside the 10-Year (determined as the active area of conveyance), 336 acres of the total 1463 acres are located within the 10-Year area of inundation. By minimizing the amount of vegetation within the 10-Year area of inundation the impact to the hydraulic conditions was reduced and the damage risk to vegetation minimized.

140. The Alternative O project features are shown on Figure A-23. The most significant impediment to the river flows are the wetland features found in sub-area's 1.1, 2.2, 2.3 and 4.1. It was assumed for the F5 hydraulic analysis study that the roughness value would remain constant for all flows. This is a conservative estimate of what would actually occur but for the scope of this study it was deemed appropriate. Some of the cottonwood/willow vegetation along the river bank affects high flow conditions, but it was deemed not significant based on water surface elevation profiles for the with project condition. Where water levels were significantly impacted a low flow channel was designed to offset the reduction of conveyance in the channel, sub-area 2.1 to 2.3.

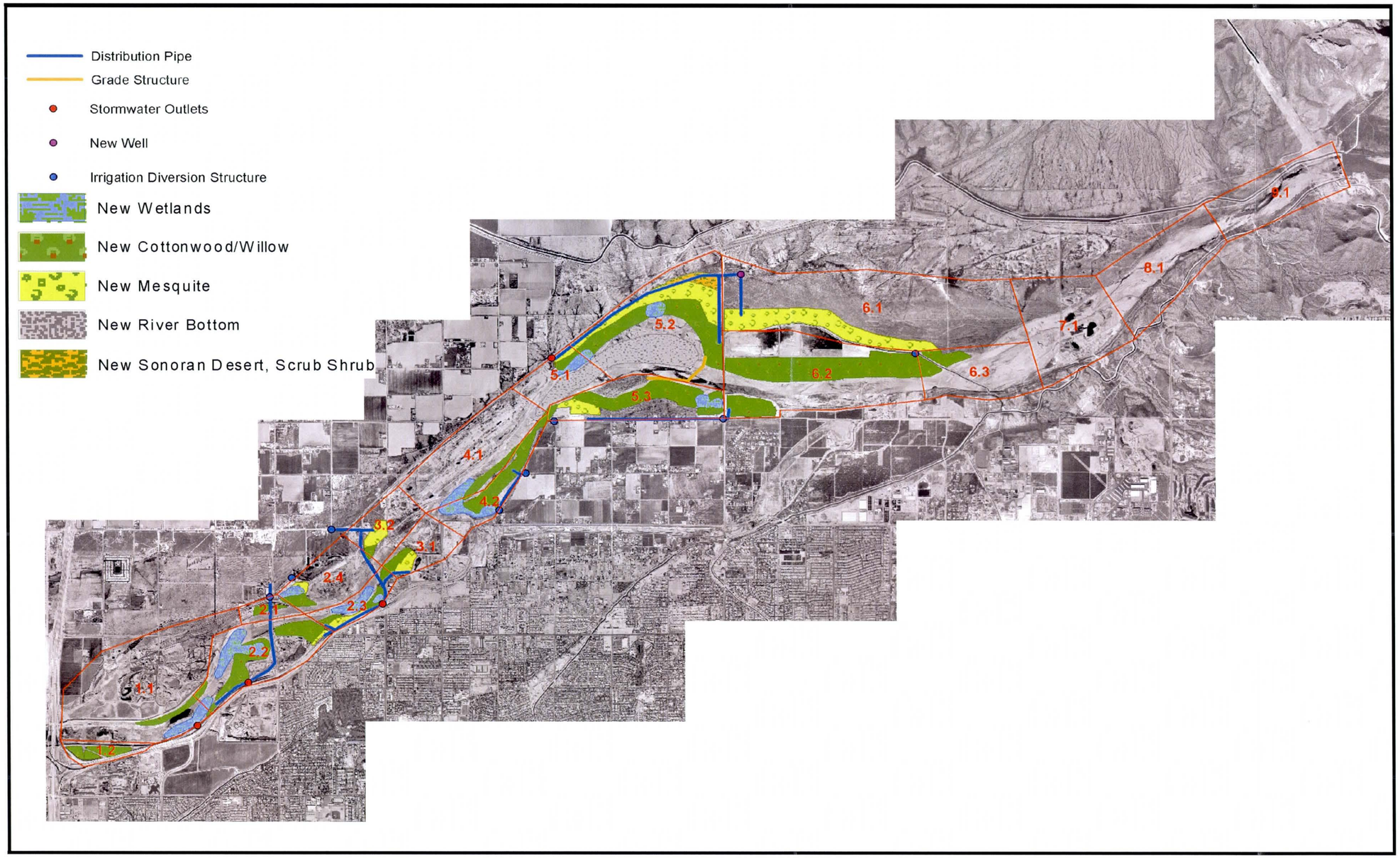
141. In addition to high flows, mining operations impact the project features. Sub-areas 5.1, 5.2, 6.2 and 6.3 are the areas with the greatest risk of damage due to mining activities that have occurred in past and have been proposed in the future. It was assumed that future mining activities would increase the pit size in sub-area 5.2 and 7.1. To minimize the risk to project features, vegetation in 6.2 was placed only on the north bank and a grade control structure was proposed in 5.2. The wetlands placed in sub-areas 1.1, 2.2, 2.3 and 4.1 have a higher associated risk but the damage can be minimized based on the wetland design and the sponsor willingness to allow for some changes to the features.

Hydraulic Conditions

142. The with project conditions for Alternative O shows minor increases in water surface elevations. Due to the minor change in water surface elevation it was assumed that the area of inundation for flow events with a recurrence interval greater than the 50 or 20 Year events. Refer to Exhibit A-2 for additional hydraulic information

143. Hydraulic results for Alternative O are found in the Exhibits section of the Hydraulics and Hydrology Appendix.

Figure A-18 Project features for Alternative O. Sub-Area shown in Red.



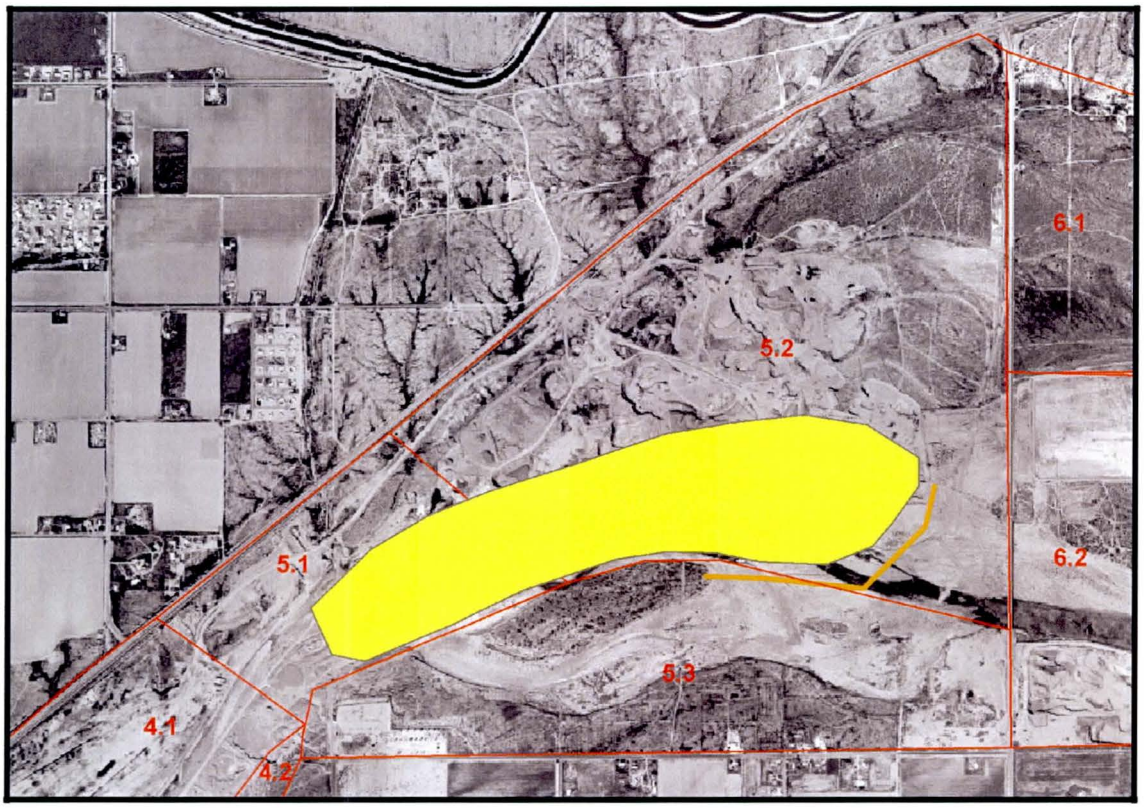
PREFERRED ALTERNATIVE

Sedimentary Conditions

144. Having minimal vegetation in active areas of conveyance reduces the damage risk due to excessive scouring and deposition. Several areas remain that may be susceptible to sedimentary conditions. Mining occurring in sub-area 7.1, Higgley Plant, can cause sediment starved flows that can cause excessive rates of erosion in sub-areas 6.2 and upstream portions of 6.3. Based on existing topographic information it was assumed that the disturbance would be focused along the southern bank of the Salt River. No vegetation was proposed in this area. Future mining in sub-area 7.1 or 6.3 will significantly impact vegetation in sub-area 6.2 and 6.3.

145. Gilbert Quarry Pit located in sub-area 5.2 has been extensively mined and will be further mined in the future. In the development of the Alternative O, as well as all the alternatives, the future mining was taken into account. It was assumed that the additional mining would remove all material within the main channel of the Salt River. Future mining is shown in yellow on Figure A-24. To prevent headcutting that would migrate upstream and damage project features in sub-areas 5.2, 5.3 and 6.2, a grade control structure was proposed in sub-area 5.2, shown in brown in Figure A-21.

Figure A-19. Assumed area of future mining (yellow). Proposed grade control structure (brown).



146. The with project sedimentation analysis for Alternative O was not completed for the F5 phase and will be completed during PED. Because the vegetation had minimal affect

on the hydraulic conditions, it can be assumed for the feasibility study that the vegetation will have minimal additional affect on the sedimentary processes. The largest human impact on the channel stability of the Salt River appears to be the mining operations. Alternative O project features over laid with scouring and deposition trends are shown on Figure A-20.

Risk Assessment

147. As discussed in the text above, the features with the highest risk are associated with those features located in the main channel area, or within the 10-Year area of inundation. However not all vegetation found in this area was or should be assumed to damages during flow events. Because of the complexity of risk assessment to vegetation due to hydraulic and sedimentary conditions, it was assumed that a percentage of vegetation within these limits would be at risk to damage, see Operation and Maintenance, Vegetation Damage Section, for more info. Based on those assumption the at risk area amounts were determined, Table A–12. Of that amount, only a portion is located along the riverbed where the highest stresses are found. The wetland features found in sub-areas 1.1, 2.2, 2.3 and 4.1 are the features most susceptible to damage. In all, 167 acres of wetlands are found in the 10-Year area of inundation. Wetlands can be engineered to resist high shear stresses such that vegetation will reestablish after larger flow events. Wetland design will be completed in the PED phase.

Table A-11. Vegetation amount within the 10-Year area of inundation

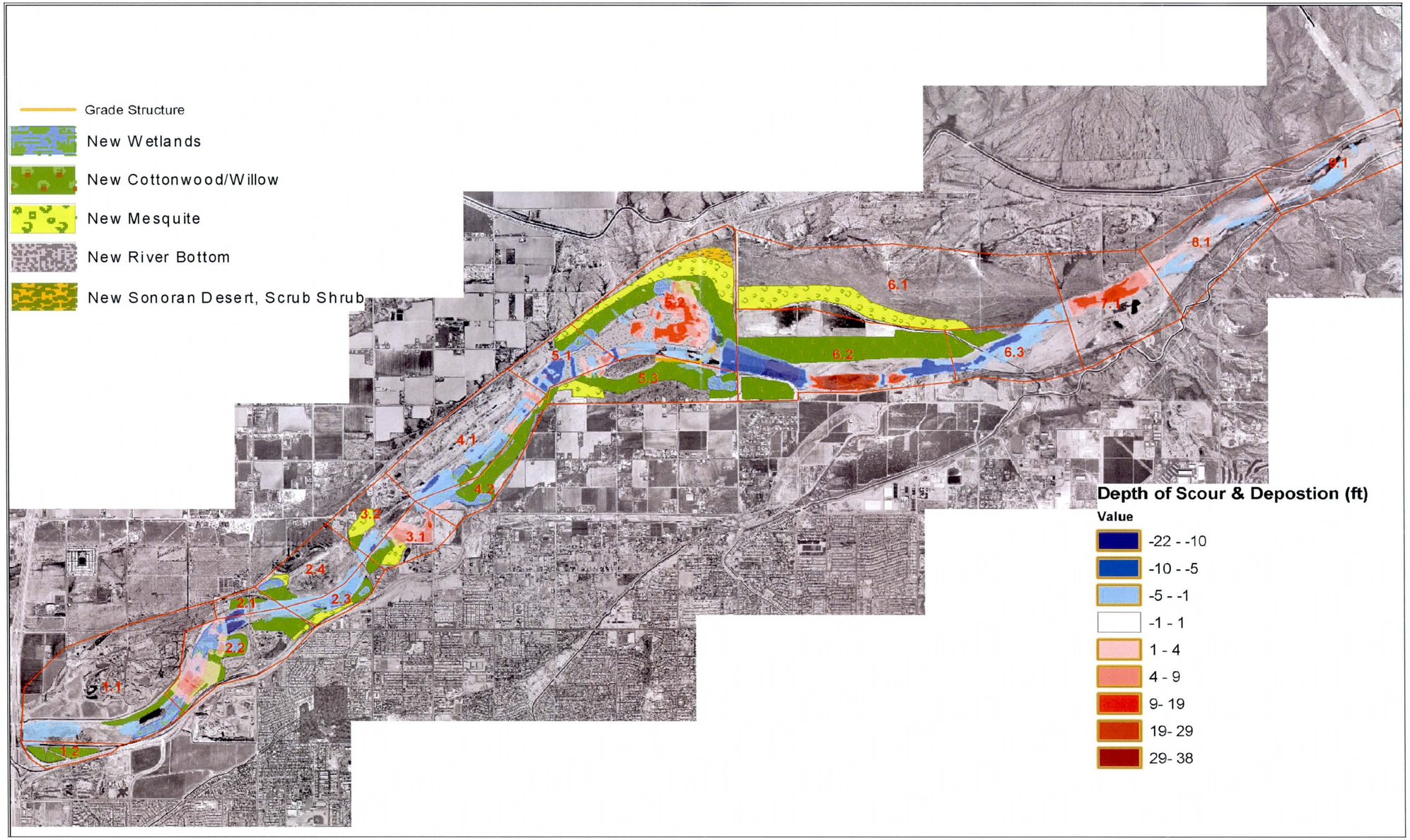
Vegetation	Area (acres)
Cottonwood	368
Mesquite	2
Wetland	167
Sonoran Desert	0

Table A-12. Vegetation damaged area for a given recurrence interval

	5-Year	10-Year	20-Year	>50-Year
Alternative	Area (acres)	Area (acres)	Area (acres)	Area (acres)
O	168	376	430	483

148. It was assumed that the main areas of concern would be associated to areas with extreme rates of scouring or deposition (i.e. extreme was assumed to be rates of scouring or deposition greater than 5 ft). Sedimentation results were based on without project conditions, the grade control structure at Gilbert Quarry Pit was not included in the model. Thus, scouring occurring upstream and downstream of Gilbert Road will be reduced by to the addition of the grade control structure. The grade control structure will also reduce the amount of deposition that occurs in sub-area 5.2. The with project sedimentation analysis will be completed in the PED phase.

Figure A-20. Scour and deposition trends with Alternative O project feature locations.



SUMMARY

Summary of Results

149. Alternative O was the preferred alternative. The alternative did not significantly raise water surface elevation, Figure A-15. To offset the addition of vegetation in areas 1 and 2 a low flow channel was proposed in sub-area 2.2 and 2.3 and a majority of the woody vegetation was placed in low or no conveyance areas. Results show minor changes in water surface elevation between the with project and Baseline conditions.

150. A more significant factor impacting the baseline hydraulic condition was the influence of mining in the project area. It was assumed that additional mining would occur in the Gilbert Quarry area. This additional mining lowered water surface elevations but also increased velocity at the upstream transition point, River Station 7.10 or 7.32 depending on alternative. A grade control structure was included in the design to prevent head cutting that could damage project features, culturally significant areas and the Gilbert Road Bridge, sub-areas 5 and 6, Figure A-20. The sedimentation analysis was not completed during the F5 phase, the sedimentation model for the final alternative will be completed during the PED phase.

151. Vegetation will be damaged during flow events greater than the 5-year event. This occurs naturally and is important in the design of this project. The SBIN or flood irrigation systems allows the most flexibility for irrigating large areas of new vegetation and the ability to modify irrigation patterns to respond to changes in the project area. It also mimics more natural conditions and the recruitment of other species. The drawback to the SBIN or flood irrigation compared to the drip irrigation is a higher water loss and potentially more reshaping after flow events for greater than the 5 to 10-Year event.

REFERENCES

Hydrologic Engineering Center, 1998, User's Manual - HEC-FDA Flood Damage Reduction Analysis, Davis, California.

Knight Piésold, 2002a, "Va Shly'ay Akimel Salt River Restoration Project Feasibility Study JAB.01E Water Budget", Consultants Report.

Knight Piésold, 2002b, "Va Shly'ay Akimel Salt River Restoration Project Feasibility Study JAB.01G Interior Drainage", Consultants Report.

Knight Piésold, 2002c, "Va Shly'ay Akimel Salt River Restoration Project Feasibility Study JAB.01J Groundwater Model", Consultants Report

Julien, Pierre Y., 1998, Erosion and Sedimentation, Cambridge Press.

US Army Corps of Engineers, 1996a, "Section 7 Study for Modified Roosevelt Dam, Arizona (Theodore Roosevelt Dam) Hydrologic Evaluation of Water Control Plans, Slat River Project to Gila River at Gillespie Dam".

US Army Corps of Engineers, 1996b, EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies, Washington, D.C.

US Army Corps of Engineers, 1998a, User's Manual – HEC-RAS River Analysis System, Hydrologic Engineering Center, Davis, CA.

US Army Corps of Engineers, 1998b, Rio Salado Feasibility Report, Technical Appendices.

West Consultants, 2002, Va Shly' Ay Akimel, Hydraulic and Sedimentation Analysis, Consultants Report.

.

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

August 2004

HYDRAULICS AND HYDROLOGY EXHIBITS

Exhibit A – Area Map

Exhibit B – HEC-RAS Model Figure, Baseline Condition (Model 11)

Exhibit C – Water Surface Profile, Baseline Condition (Model 11)

Exhibit D – Hydraulic Results, Baseline Condition (Model 11)

Exhibit E – HEC-RAS Model Figure, Alternative O (Model 9)

Exhibit F – Water Surface Profile, Alternative O (Model 9)

Exhibit G – Hydraulic Results, Alternative O (Model 9)

Exhibit H – Area of Inundation Map, Alternative O (Model 9)

EXHIBT A – AREA MAP

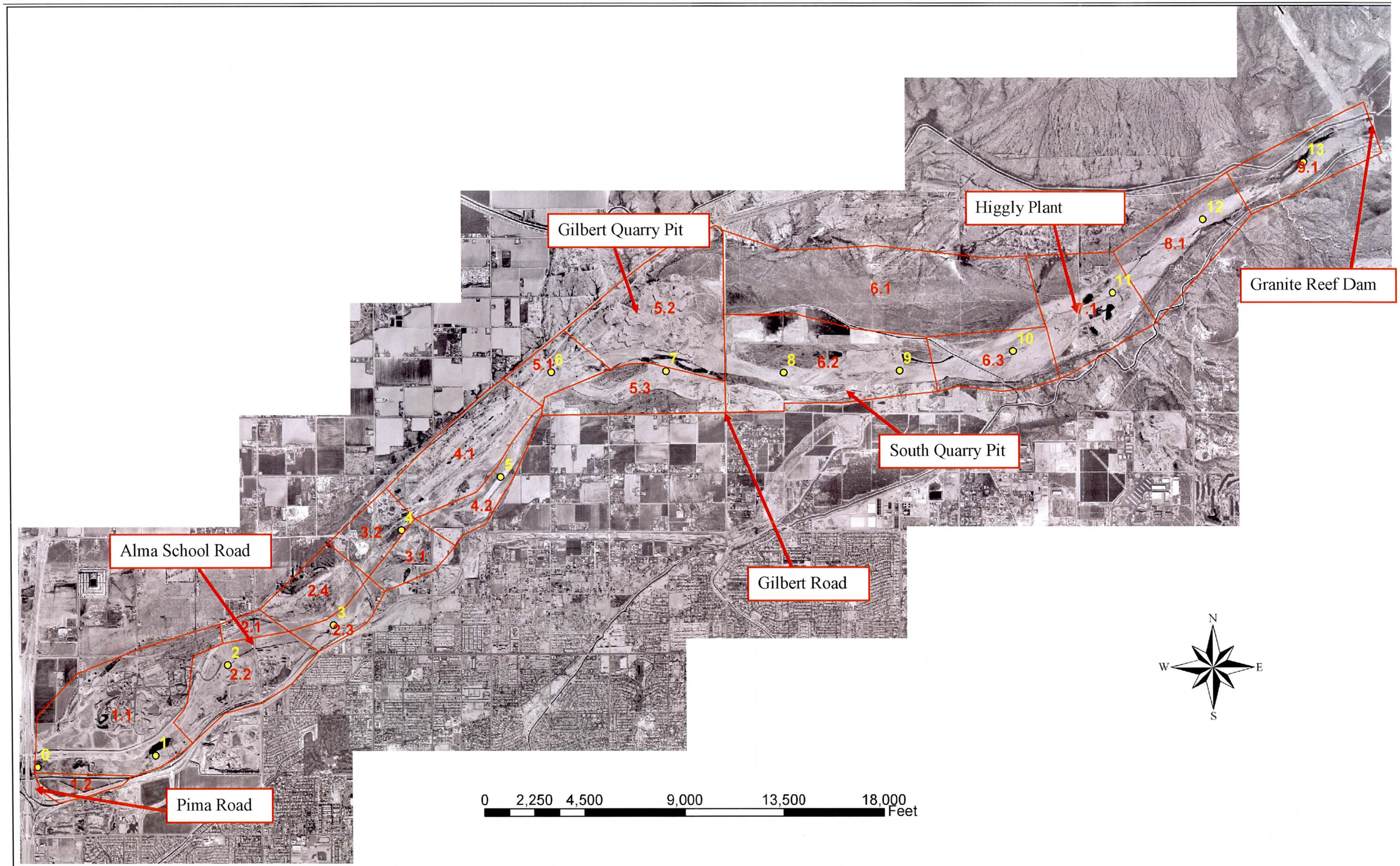


EXHIBIT B – HEC-RAS FIGURE BASELINE CONDITION

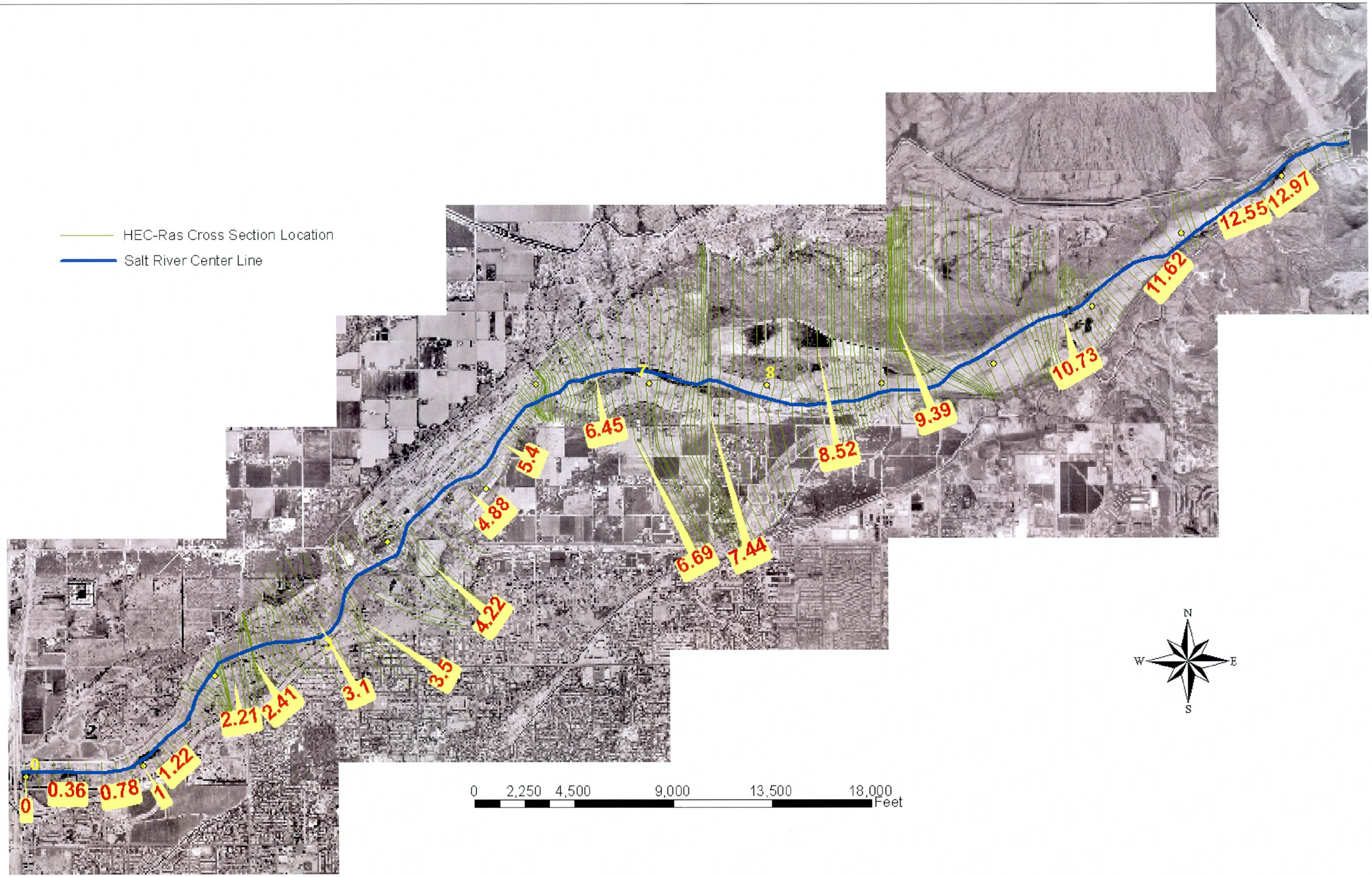


EXHIBIT C – WATER SURFACE PROFILE, BASELINE CONDITION (MODEL 11)

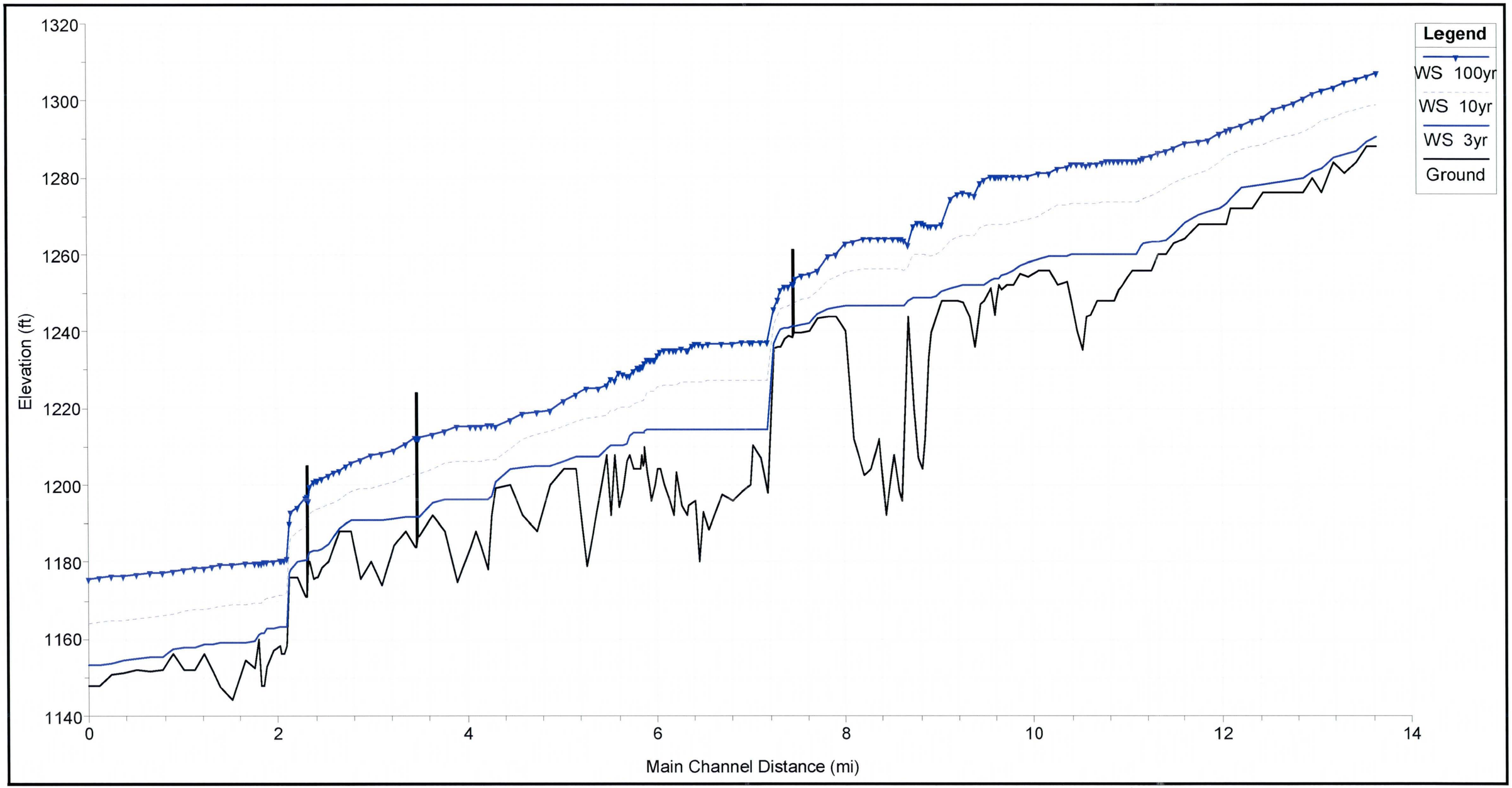


Exhibit D.1 Hydraulic Results, Baseline Condition (Model 11) for the 3-Year event.

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
13.64	2200	1288	1290.63	1290.75	0.001711	2.81	0.35
13.55	2200	1288	1289.36	1289.5	0.005398	3	0.54
13.44	2200	1284	1286.96	1287.14	0.002499	3.35	0.42
13.31	2200	1281.3	1286.05	1286.11	0.00055	1.95	0.21
13.19	2200	1284	1285.11	1285.4	0.009344	4.31	0.73
13.07	2200	1276	1282.21	1282.27	0.000397	1.9	0.18
12.97	2200	1280	1281.59	1281.88	0.00578	4.32	0.61
12.87	2200	1276	1279.95	1280.01	0.000549	2.02	0.21
12.77	2200	1276	1279.56	1279.64	0.000955	2.32	0.27
12.67	2200	1276	1279.18	1279.23	0.000602	1.92	0.21
12.55	2200	1276	1278.82	1278.88	0.000563	1.91	0.21
12.44	2200	1276	1278.32	1278.42	0.001214	2.51	0.3
12.33	2200	1272	1277.91	1277.94	0.000405	1.41	0.17
12.22	2200	1272	1277.29	1277.51	0.002722	3.8	0.45
12.1	2200	1272	1274.32	1274.94	0.008089	6.32	0.76
12.06	2200	1268	1273.28	1273.53	0.002117	4.08	0.41
11.99	2200	1268	1272.16	1272.51	0.003692	4.73	0.53
11.88	2200	1267.94	1271.07	1271.16	0.000815	2.49	0.26
11.78	2200	1268	1270.44	1270.57	0.001683	2.92	0.35
11.62	2200	1264	1268.47	1268.62	0.003616	3.17	0.47
11.49	2200	1263.04	1265.31	1265.61	0.005977	4.4	0.62
11.41	2200	1260	1263.83	1264	0.001338	3.32	0.33
11.32	2200	1260	1263.39	1263.49	0.000835	2.6	0.26
11.25	2200	1256	1263.16	1263.22	0.000463	2.03	0.2
11.17	2200	1256	1262.8	1262.92	0.001551	2.78	0.33
11.14	2200	1256	1261.95	1262.37	0.018316	5.21	0.66
11.1	2200	1256	1260.07	1260.18	0.00177	2.64	0.35
11.05	2200	1256	1259.91	1259.94	0.000168	1.28	0.12
11	2200	1254.01	1259.89	1259.9	0.000044	0.74	0.06
10.95	2200	1252	1259.89	1259.89	0.000009	0.44	0.03
10.9	2200	1250.83	1259.89	1259.89	0.000007	0.42	0.03
10.86	2200	1248	1259.88	1259.89	0.000004	0.38	0.02
10.81	2200	1248	1259.88	1259.89	0.000002	0.3	0.02
10.78	2200	1248	1259.88	1259.89	0.000002	0.3	0.02
10.73	2200	1248	1259.88	1259.88	0.000002	0.31	0.02
10.67	2200	1248	1259.88	1259.88	0.000006	0.43	0.03
10.61	2200	1244.2	1259.88	1259.88	0.000003	0.37	0.02
10.56	2200	1244	1259.88	1259.88	0.000003	0.35	0.02
10.52	2200	1234.97	1259.88	1259.88	0.000001	0.23	0.01
10.46	2200	1240	1259.88	1259.88	0.000003	0.35	0.02
10.41	2200	1247.67	1259.88	1259.88	0.000002	0.33	0.02
10.36	2200	1253	1259.77	1259.87	0.000815	2.55	0.26
10.26	2200	1252	1259.61	1259.62	0.000031	0.8	0.06
10.18	2200	1256	1259.46	1259.59	0.001077	2.79	0.29

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
10.06	2200	1256	1258.68	1258.81	0.001557	2.92	0.34
9.96	2200	1254.13	1258.07	1258.15	0.000743	2.21	0.24
9.87	2200	1254.92	1257.29	1257.54	0.005079	4.02	0.57
9.8	2200	1252	1255.71	1256.04	0.003116	4.63	0.49
9.73	2200	1252	1254.9	1255.06	0.001687	3.15	0.36
9.67	2200	1250.78	1254.42	1254.55	0.001325	2.88	0.32
9.64	2200	1252	1253.9	1254.25	0.00632	4.75	0.65
9.61	2200	1248.2	1253.66	1253.72	0.000361	1.87	0.17
9.59	2200	1244.4	1253.64	1253.67	0.00025	1.51	0.14
9.55	2200	1251.37	1253.34	1253.55	0.004141	3.69	0.52
9.49	2200	1248	1252.34	1252.46	0.002216	2.69	0.38
9.44	2200	1247.05	1252.13	1252.15	0.00015	1.35	0.12
9.39	2200	1236	1252.07	1252.12	0.000093	1.64	0.1
9.33	2200	1244	1252.04	1252.08	0.000173	1.68	0.13
9.26	2200	1247.57	1251.94	1251.99	0.000389	1.91	0.18
9.2	2200	1248	1251.78	1251.84	0.000512	1.98	0.2
9.13	2200	1248	1251.49	1251.58	0.001021	2.4	0.28
9.04	2200	1248	1250.42	1250.75	0.00495	4.59	0.59
8.98	2200	1244	1249.08	1249.38	0.003702	4.34	0.52
8.92	2200	1239.59	1248.66	1248.71	0.000196	1.79	0.14
8.88	2200	1233.08	1248.66	1248.68	0.000043	1.04	0.07
8.85	2200	1212	1248.67	1248.67	0.000002	0.4	0.02
8.81	2200	1204	1248.67	1248.67	0	0.22	0.01
8.77	2200	1206.87	1248.67	1248.67	0	0.18	0.01
8.74	2200	1220	1248.67	1248.67	0.000001	0.3	0.01
8.68	2200	1244	1248.16	1248.63	0.013099	5.51	0.88
8.63	2200	1216	1246.64	1246.64	0.000001	0.27	0.01
8.6	2200	1196	1246.64	1246.64	0	0.17	0.01
8.57	2200	1198.17	1246.64	1246.64	0	0.16	0
8.52	2200	1208	1246.64	1246.64	0	0.13	0
8.44	2200	1192	1246.64	1246.64	0	0.09	0
8.36	2200	1212	1246.64	1246.64	0	0.1	0
8.29	2200	1204	1246.64	1246.64	0	0.08	0
8.2	2200	1202.29	1246.64	1246.64	0	0.09	0
8.1	2200	1212	1246.64	1246.64	0.000001	0.23	0.01
8.01	2200	1240	1246.62	1246.64	0.000057	0.85	0.07
7.91	2200	1244	1246.44	1246.57	0.002274	2.84	0.39
7.83	2200	1244	1245.79	1245.84	0.000936	1.82	0.25
7.71	2200	1243.41	1244.58	1244.78	0.00919	3.6	0.7
7.63	2200	1240	1242.13	1242.2	0.001649	2.13	0.32
7.55	2200	1239.6	1241.72	1241.74	0.000476	1.28	0.18
7.47	2200	1239.83	1241.41	1241.46	0.001192	1.73	0.27
7.45	Bridge						
7.44	2200	1238.53	1241.24	1241.26	0.000518	1.23	0.18
7.4	2200	1239.06	1241.07	1241.11	0.000995	1.65	0.25
7.36	2200	1238.07	1240.93	1240.95	0.000511	1.24	0.18

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
7.32	2200	1240	1240.65	1240.75	0.007151	2.52	0.58
7.28	2200	1236	1239.19	1239.49	0.006186	4.38	0.63
7.24	2200	1235.58	1236.78	1237.14	0.019729	4.8	1
7.17	2200	1197.93	1214.63	1214.63	0.000008	0.36	0.03
7.1	2200	1206.84	1214.63	1214.63	0.000013	0.34	0.03
7.03	2200	1210.44	1214.62	1214.62	0.000056	0.61	0.07
6.99	2200	1200	1214.61	1214.61	0	0.12	0.01
6.91	2200	1198.45	1214.61	1214.61	0.000001	0.18	0.01
6.8	2200	1196	1214.61	1214.61	0.000001	0.17	0.01
6.69	2200	1197.62	1214.61	1214.61	0.000019	0.46	0.04
6.56	2200	1188.55	1214.6	1214.6	0.000001	0.15	0.01
6.5	2200	1192.83	1214.6	1214.6	0.000001	0.22	0.01
6.45	2200	1180	1214.6	1214.6	0	0.08	0
6.4	2200	1196	1214.6	1214.6	0	0.1	0
6.38	2200	1195.4	1214.6	1214.6	0.000001	0.21	0.01
6.35	2200	1194.53	1214.6	1214.6	0.000003	0.39	0.02
6.32	2200	1192	1214.6	1214.6	0.000002	0.35	0.02
6.27	2200	1194.49	1214.6	1214.6	0.000002	0.34	0.02
6.22	2200	1203.46	1214.58	1214.6	0.000041	1.11	0.07
6.18	2200	1192	1214.57	1214.59	0.000034	1.02	0.06
6.14	2200	1196	1214.58	1214.58	0.000002	0.31	0.01
6.09	2200	1200	1214.58	1214.58	0.000006	0.45	0.03
6.05	2200	1204	1214.57	1214.58	0.000015	0.59	0.04
6.01	2200	1204	1214.57	1214.57	0.000518	0.67	0.04
5.99	2200	1200	1214.54	1214.55	0.000012	0.49	0.03
5.97	2200	1198.59	1214.54	1214.54	0.000006	0.38	0.02
5.95	2200	1196	1214.54	1214.54	0.000003	0.31	0.02
5.93	2200	1198.79	1214.54	1214.54	0.000003	0.31	0.02
5.91	2200	1203.31	1214.54	1214.54	0.000026	0.59	0.04
5.88	2200	1209.96	1214.24	1214.51	0.024652	4.14	0.47
5.87	2200	1206.22	1213.79	1213.85	0.002417	1.83	0.17
5.86	2200	1205.11	1213.75	1213.78	0.00013	1.36	0.11
5.85	2200	1208	1213.74	1213.77	0.000046	1.46	0.12
5.84	2200	1204	1213.69	1213.76	0.000379	2.16	0.18
5.82	2200	1204	1213.66	1213.72	0.000367	2.04	0.18
5.8	2200	1204	1213.66	1213.68	0.00012	1.34	0.11
5.76	2200	1204	1213.6	1213.65	0.000375	1.77	0.18
5.73	2200	1208	1212.95	1213.46	0.017365	5.7	0.99
5.69	2200	1206.01	1210.55	1210.61	0.000412	1.89	0.18
5.65	2200	1198.67	1210.55	1210.55	0.000007	0.51	0.03
5.6	2200	1194.35	1210.55	1210.55	0.000002	0.34	0.02
5.56	2200	1208	1210.39	1210.53	0.002365	3.01	0.4
5.53	2200	1192	1210.27	1210.27	0.000004	0.46	0.02
5.47	2200	1208	1209.71	1210.22	0.012738	5.71	0.88
5.4	2200	1196	1207.54	1207.56	0.000033	1.05	0.06
5.26	2200	1179.01	1207.54	1207.54	0.000005	0.43	0.02

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
5.15	2200	1204	1207.42	1207.52	0.001649	2.58	0.34
5.03	2200	1204	1206.01	1206.15	0.002983	3.01	0.44
4.88	2200	1200	1204.84	1204.88	0.000208	1.5	0.13
4.74	2200	1188	1204.77	1204.78	0.000048	0.34	0.02
4.59	2200	1192	1204.71	1204.71	0.000236	0.54	0.05
4.47	2200	1200	1204.34	1204.42	0.002281	2.19	0.36
4.31	2200	1199.24	1200.65	1201	0.020282	4.77	1
4.27	2200	1192	1197.26	1197.62	0.008383	4.79	0.72
4.22	2200	1178.19	1196.35	1196.35	0.00001	0.66	0.04
4.15	2200	1184	1196.33	1196.35	0.000084	1.11	0.09
4.09	2200	1188	1196.29	1196.31	0.000137	1.09	0.11
4.04	2200	1184	1196.28	1196.28	0.00002	0.51	0.04
3.89	2200	1174.66	1196.27	1196.28	0.000001	0.3	0.01
3.76	2200	1188	1196.24	1196.27	0.000293	1.31	0.15
3.64	2200	1192	1195.3	1195.86	0.009471	6	0.8
3.5	2200	1186.84	1191.82	1191.88	0.000475	1.9	0.2
3.48	Bridge						
3.46	2200	1184	1191.77	1191.79	0.000094	1.07	0.09
3.35	2200	1188	1191.54	1191.66	0.001249	2.74	0.31
3.23	2200	1184.27	1191.15	1191.18	0.000223	1.5	0.14
3.1	2200	1174.02	1191.09	1191.09	0.00001	0.54	0.03
2.98	2200	1180	1191.08	1191.08	0.000016	0.63	0.04
2.87	2200	1175.62	1191.07	1191.07	0.000012	0.65	0.04
2.78	2200	1188	1190.93	1191.05	0.002909	2.83	0.43
2.71	2200	1188	1190.18	1190.28	0.001853	2.54	0.35
2.65	2200	1187.99	1188.85	1189.1	0.012588	4.02	0.8
2.59	2200	1184	1186.69	1186.86	0.002433	3.31	0.41
2.53	2200	1180	1184.7	1185.53	0.008812	7.32	0.82
2.47	2200	1178.61	1183.39	1183.67	0.001973	4.24	0.41
2.42	2200	1176	1183.19	1183.29	0.000482	2.6	0.21
2.41	2200	1176	1183.19	1183.27	0.000353	2.34	0.18
2.4	2200	1176	1183.18	1183.26	0.000286	2.27	0.17
2.38	2200	1175.59	1183.15	1183.21	0.000255	1.91	0.15
2.33	2200	1180	1182.8	1183.05	0.002782	4.02	0.46
2.31	Bridge						
2.29	2200	1170.86	1180.46	1180.47	0.00003	0.78	0.06
2.21	2200	1176	1180.04	1180.35	0.003393	4.45	0.5
2.13	2200	1176	1178.27	1178.6	0.005598	4.65	0.62
2.12	2200	1176	1177.37	1177.97	0.017088	6.25	1.01
2.1	2200	1158.27	1163.19	1163.43	0.002249	3.91	0.42
2.07	2200	1156	1163.08	1163.18	0.000539	2.44	0.22
2.04	2200	1156.31	1163.06	1163.09	0.00024	1.42	0.14
2.02	2200	1158.36	1163.05	1163.07	0.000124	1.12	0.1
1.95	2200	1157.05	1162.96	1163	0.000373	1.61	0.17
1.89	2200	1152.71	1162.56	1162.74	0.014518	3.44	0.44
1.86	2200	1148	1161.65	1161.66	0.000027	0.81	0.05

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
1.83	2200	1148	1161.6	1161.65	0.000265	1.65	0.15
1.8	2200	1160	1161.05	1161.52	0.017688	5.49	0.99
1.76	2200	1152.5	1159.28	1159.32	0.000247	1.56	0.15
1.65	2200	1154.51	1159.07	1159.12	0.000611	1.83	0.21
1.52	2200	1144	1158.89	1158.89	0.000001	0.24	0.01
1.39	2200	1147.32	1158.88	1158.89	0.000013	0.45	0.03
1.3	2200	1152	1158.8	1158.87	0.00046	2.09	0.2
1.22	2200	1156	1158.44	1158.55	0.002427	2.67	0.39
1.12	2200	1152	1157.82	1157.83	0.000056	0.92	0.07
1	2200	1152	1157.77	1157.79	0.000104	1	0.09
0.89	2200	1156	1157.43	1157.65	0.005829	3.78	0.59
0.78	2200	1152	1155.49	1155.56	0.000928	2.18	0.26
0.65	2200	1151.5	1155.16	1155.18	0.000175	1.05	0.12
0.51	2200	1152	1154.92	1154.97	0.00062	1.79	0.21
0.36	2200	1151.05	1154.35	1154.41	0.000839	1.95	0.24
0.23	2200	1150.96	1153.68	1153.74	0.001233	2.01	0.28
0.11	2200	1148	1153.21	1153.24	0.000305	1.44	0.15
0	2200	1148	1153.09	1153.1	0.000124	0.97	0.1

Exhibit D.2 Hydraulic Results, Baseline Condition (Model 11) for the 10-Year event.

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
13.64	60000	1288	1299.07	1299.87	0.001845	7.15	0.45
13.55	60000	1288	1298.47	1299.09	0.001161	6.34	0.37
13.44	60000	1284	1297.75	1298.39	0.001181	6.42	0.37
13.31	60000	1281.3	1296.9	1297.58	0.001289	6.62	0.39
13.19	60000	1284	1295.58	1296.49	0.002178	7.67	0.49
13.07	60000	1276	1294.62	1295.32	0.001352	6.74	0.4
12.97	60000	1280	1293.09	1294.33	0.003102	8.91	0.58
12.87	60000	1276	1291.83	1292.98	0.001552	8.6	0.44
12.77	60000	1276	1290.92	1292.08	0.001886	8.64	0.48
12.67	60000	1276	1290.43	1291.14	0.001234	6.76	0.38
12.55	60000	1276	1289.7	1290.42	0.001113	6.8	0.37
12.44	60000	1276	1288.55	1289.54	0.002044	8	0.48
12.33	60000	1272	1287.95	1288.61	0.000914	6.48	0.34
12.22	60000	1272	1287.23	1287.95	0.001427	6.8	0.4
12.1	60000	1272	1286.13	1286.9	0.002032	7.05	0.47
12.06	60000	1268	1285.59	1286.38	0.002035	7.11	0.47
11.99	60000	1268	1284.02	1285.29	0.00435	9.03	0.66
11.88	60000	1267.94	1282.01	1283.1	0.003204	8.4	0.58
11.78	60000	1268	1281	1281.69	0.001652	6.67	0.43
11.62	60000	1264	1280.01	1280.49	0.00101	5.57	0.34
11.49	60000	1263.04	1278.82	1279.64	0.001589	7.24	0.43
11.41	60000	1260	1277.47	1278.72	0.002823	8.95	0.56
11.32	60000	1260	1276.08	1277.41	0.002989	9.24	0.58
11.25	60000	1256	1275.34	1276.34	0.001921	8	0.47
11.17	60000	1256	1274.63	1275.57	0.001694	7.77	0.45
11.14	60000	1256	1274.09	1275.1	0.005206	8.07	0.46
11.1	60000	1256	1273.75	1274.35	0.000778	6.21	0.31
11.05	60000	1256	1273.74	1274.16	0.000427	5.18	0.24
11	60000	1254.01	1273.71	1274.02	0.000257	4.5	0.19
10.95	60000	1252	1273.73	1273.94	0.000154	3.69	0.15
10.9	60000	1250.83	1273.69	1273.91	0.000153	3.75	0.15
10.86	60000	1248	1273.65	1273.87	0.000147	3.78	0.15
10.81	60000	1248	1273.64	1273.83	0.000104	3.47	0.13
10.78	60000	1248	1273.62	1273.81	0.000105	3.51	0.13
10.73	60000	1248	1273.57	1273.78	0.000115	3.67	0.13
10.67	60000	1248	1273.43	1273.73	0.000192	4.36	0.17
10.61	60000	1244.2	1273.38	1273.66	0.000168	4.32	0.16
10.56	60000	1244	1273.34	1273.62	0.000157	4.27	0.16
10.52	60000	1234.97	1273.39	1273.57	0.000079	3.4	0.11
10.46	60000	1240	1273.29	1273.53	0.000145	3.97	0.15
10.41	60000	1247.67	1273.29	1273.48	0.000106	3.49	0.13
10.36	60000	1253	1272.76	1273.39	0.000855	6.35	0.33
10.26	60000	1252	1272.63	1273	0.000369	4.84	0.22
10.18	60000	1256	1271.58	1272.64	0.002169	8.29	0.5

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
10.06	60000	1256	1270.09	1271.33	0.002115	8.95	0.5
9.96	60000	1254.13	1269.17	1270.22	0.001603	8.41	0.45
9.87	60000	1254.92	1268.64	1269.48	0.001402	7.6	0.41
9.8	60000	1252	1268.26	1269	0.001146	7.33	0.38
9.73	60000	1252	1268	1268.56	0.001005	6.45	0.35
9.67	60000	1250.78	1267.89	1268.27	0.000532	5.53	0.27
9.64	60000	1252	1267.87	1268.19	0.000471	5.03	0.25
9.61	60000	1248.2	1267.86	1268.12	0.000316	4.53	0.21
9.59	60000	1244.4	1267.86	1268.07	0.000243	4.15	0.18
9.55	60000	1251.37	1267.75	1268.01	0.000306	4.38	0.2
9.49	60000	1248	1267.46	1267.86	0.000398	5.25	0.23
9.44	60000	1247.05	1266.98	1267.72	0.00062	7.12	0.3
9.39	60000	1236	1265.02	1267.28	0.002419	12.54	0.57
9.33	60000	1244	1265.12	1266.45	0.001492	9.51	0.44
9.26	60000	1247.57	1264.98	1265.86	0.001028	7.75	0.37
9.2	60000	1248	1264.76	1265.51	0.000854	7.13	0.34
9.13	60000	1248	1263.88	1265.07	0.001338	9	0.42
9.04	60000	1248	1260.71	1263.85	0.004819	14.66	0.77
8.98	60000	1244	1260.1	1262.24	0.003565	12.1	0.66
8.92	60000	1239.59	1259.78	1261.14	0.002061	9.62	0.51
8.88	60000	1233.08	1259.78	1260.71	0.001319	7.94	0.41
8.85	60000	1212	1260.02	1260.4	0.000331	5.09	0.22
8.81	60000	1204	1260.12	1260.3	0.000094	3.47	0.12
8.77	60000	1206.87	1260.14	1260.27	0.000054	3.03	0.1
8.74	60000	1220	1259.93	1260.24	0.000079	4.57	0.16
8.68	60000	1244	1256.52	1259.89	0.010266	15.16	1.03
8.63	60000	1216	1256.07	1256.36	0.000243	4.49	0.18
8.6	60000	1196	1256.2	1256.28	0.00003	2.52	0.07
8.57	60000	1198.17	1256.21	1256.27	0.000019	2.09	0.06
8.52	60000	1208	1256.21	1256.26	0.000014	1.89	0.05
8.44	60000	1192	1256.21	1256.26	0.000013	1.71	0.05
8.36	60000	1212	1256.2	1256.25	0.000017	1.83	0.05
8.29	60000	1204	1256.2	1256.24	0.000011	1.62	0.04
8.2	60000	1202.29	1256.19	1256.23	0.000013	1.8	0.05
8.1	60000	1212	1255.99	1256.2	0.000115	3.83	0.13
8.01	60000	1240	1255.65	1256.1	0.000728	5.48	0.3
7.91	60000	1244	1254.07	1255.39	0.003086	9.38	0.59
7.83	60000	1244	1253.17	1254.12	0.002193	7.86	0.49
7.71	60000	1243.41	1250.32	1252.08	0.005694	10.65	0.76
7.63	60000	1240	1248.88	1249.92	0.002605	8.2	0.53
7.55	58000	1239.6	1248.41	1248.97	0.001278	6	0.38
7.47	58000	1239.83	1247.67	1248.34	0.001768	6.56	0.44
7.45	Bridge						
7.44	58000	1238.53	1247.14	1247.75	0.001569	6.29	0.41
7.4	58000	1239.06	1246.66	1247.35	0.002203	6.83	0.48
7.36	58000	1238.07	1246.34	1246.88	0.001757	5.94	0.42
7.32	58000	1240	1245.88	1246.48	0.002259	6.23	0.47

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
7.28	58000	1236	1244.42	1245.77	0.006977	9.33	0.8
7.24	58000	1235.58	1241.71	1243.61	0.010667	11.05	1
7.17	58000	1197.93	1227.34	1227.39	0.000058	1.81	0.09
7.1	58000	1206.84	1227.32	1227.37	0.000049	1.82	0.08
7.03	58000	1210.44	1227.23	1227.34	0.000112	2.63	0.12
6.99	58000	1200	1227.27	1227.3	0.00002	1.56	0.06
6.91	58000	1198.45	1227.24	1227.29	0.000043	1.82	0.08
6.8	58000	1196	1227.21	1227.27	0.000034	1.89	0.07
6.69	58000	1197.62	1227.11	1227.23	0.000111	2.82	0.12
6.56	58000	1188.55	1227.11	1227.16	0.000028	1.76	0.07
6.5	58000	1192.83	1227.05	1227.14	0.000057	2.38	0.09
6.45	58000	1180	1227.09	1227.11	0.000009	1.1	0.04
6.4	58000	1196	1227.08	1227.11	0.000014	1.39	0.05
6.38	58000	1195.4	1227	1227.1	0.000064	2.37	0.1
6.35	58000	1194.53	1226.71	1227.06	0.000242	4.75	0.19
6.32	58000	1192	1226.71	1227.02	0.000198	4.44	0.17
6.27	58000	1194.49	1226.71	1226.93	0.000185	3.77	0.16
6.22	58000	1203.46	1226	1226.79	0.001193	7.17	0.38
6.18	58000	1192	1226.1	1226.51	0.000556	5.15	0.26
6.14	58000	1196	1226.19	1226.36	0.000133	3.23	0.14
6.09	58000	1200	1226.08	1226.31	0.000222	3.85	0.17
6.05	58000	1204	1225.8	1226.21	0.000465	5.15	0.25
6.01	58000	1204	1225.46	1226.03	0.022449	6.04	0.3
5.99	58000	1200	1224.42	1224.82	0.000688	5.09	0.24
5.97	58000	1198.59	1224.4	1224.75	0.000596	4.74	0.22
5.95	58000	1196	1224.39	1224.66	0.000317	4.17	0.18
5.93	58000	1198.79	1224.37	1224.62	0.000408	4.04	0.18
5.91	58000	1203.31	1224.15	1224.55	0.000789	5.04	0.27
5.88	58000	1209.96	1222.39	1224.16	0.014327	10.69	0.82
5.87	58000	1206.22	1222.18	1223.65	0.004639	9.75	0.69
5.86	58000	1205.11	1222.03	1223.18	0.02146	8.59	0.54
5.85	58000	1208	1221.74	1222.35	0.001035	6.29	0.35
5.84	58000	1204	1221.64	1222.28	0.001043	6.44	0.35
5.82	58000	1204	1221.6	1222.16	0.000861	6.02	0.32
5.8	58000	1204	1221.52	1222.08	0.000816	6	0.32
5.76	58000	1204	1221.11	1221.88	0.00131	7.01	0.39
5.73	58000	1208	1220.21	1221.47	0.002689	9.01	0.55
5.69	58000	1206.01	1220.24	1221	0.001144	6.96	0.37
5.65	58000	1198.67	1220.35	1220.72	0.000365	4.92	0.22
5.6	58000	1194.35	1220.42	1220.59	0.000122	3.35	0.13
5.56	58000	1208	1219.33	1220.45	0.002219	8.49	0.5
5.53	58000	1192	1219.59	1219.99	0.00044	5.01	0.24
5.47	58000	1208	1218.16	1219.65	0.004243	9.82	0.67
5.4	58000	1196	1217.69	1218.39	0.000952	6.73	0.34
5.26	58000	1179.01	1217.44	1217.81	0.000376	4.87	0.22
5.15	58000	1204	1216.53	1217.4	0.001718	7.52	0.44
5.03	58000	1204	1215.49	1216.33	0.001587	7.34	0.43

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
4.88	58000	1200	1213.9	1214.99	0.001784	8.36	0.46
4.74	58000	1188	1213.32	1213.58	0.001377	4.09	0.18
4.59	58000	1192	1212	1212.36	0.001661	4.86	0.27
4.47	58000	1200	1209.71	1210.78	0.003588	8.33	0.6
4.31	58000	1199.24	1206.78	1207.88	0.003422	7.91	0.58
4.27	58000	1192	1206.75	1207.21	0.000923	5.43	0.33
4.22	58000	1178.19	1206.71	1206.97	0.000383	3.95	0.22
4.15	58000	1184	1206.4	1206.79	0.000753	5	0.29
4.09	58000	1188	1206.26	1206.54	0.000594	4.19	0.26
4.04	58000	1184	1206.23	1206.39	0.000213	3.2	0.16
3.89	58000	1174.66	1206.18	1206.26	0.00006	2.28	0.09
3.76	58000	1188	1205.64	1206.14	0.000812	5.66	0.31
3.64	58000	1192	1204.17	1205.28	0.002748	8.48	0.55
3.5	58000	1186.84	1202.99	1203.6	0.001062	6.24	0.36
3.48	Bridge						
3.46	58000	1184	1202.78	1203.27	0.000669	5.6	0.29
3.35	58000	1188	1202.04	1202.71	0.001136	6.6	0.37
3.23	58000	1184.27	1200.65	1201.78	0.001922	8.54	0.48
3.1	58000	1174.02	1200.08	1200.71	0.0007	6.38	0.3
2.98	58000	1180	1199.36	1200.22	0.000894	7.42	0.34
2.87	58000	1175.62	1198.99	1199.6	0.000912	6.25	0.33
2.78	58000	1188	1198.16	1198.95	0.00198	7.18	0.46
2.71	58000	1188	1197.4	1198.28	0.002157	7.54	0.49
2.65	58000	1187.99	1196.24	1197.39	0.002759	8.58	0.55
2.59	58000	1184	1195.64	1196.6	0.002179	7.85	0.49
2.53	58000	1180	1194.94	1195.85	0.002246	7.67	0.5
2.47	58000	1178.61	1194.06	1195.1	0.002472	8.17	0.52
2.42	58000	1176	1193.76	1194.5	0.001429	6.91	0.41
2.41	58000	1176	1193.72	1194.44	0.001358	6.82	0.4
2.4	58000	1176	1193.65	1194.38	0.001383	6.86	0.4
2.38	58000	1175.59	1193.38	1194.17	0.001584	7.13	0.43
2.33	58000	1180	1192.42	1193.6	0.002954	8.71	0.57
2.31	Bridge						
2.29	58000	1170.86	1189.41	1190.01	0.000915	6.19	0.33
2.21	58000	1176	1187.8	1189.15	0.00375	9.32	0.63
2.13	58000	1176	1186.41	1187.69	0.003231	9.1	0.59
2.12	58000	1176	1184.65	1187.21	0.010359	12.85	1
2.1	58000	1158.27	1172.15	1173.78	0.005572	10.23	0.75
2.07	58000	1156	1171.61	1173.01	0.003825	9.47	0.64
2.04	58000	1156.31	1171.5	1172.38	0.001714	7.53	0.45
2.02	58000	1158.36	1171.5	1172.16	0.000989	6.49	0.35
1.95	58000	1157.05	1171.15	1171.77	0.001095	6.31	0.36
1.89	58000	1152.71	1170.57	1171.31	0.00173	6.89	0.44
1.86	58000	1148	1170.36	1171.05	0.001678	6.69	0.43
1.83	58000	1148	1169.48	1170.62	0.003487	8.57	0.6
1.8	58000	1160	1169.24	1170.03	0.00227	7.14	0.49
1.76	58000	1152.5	1169.31	1169.6	0.000486	4.36	0.24

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
1.65	58000	1154.51	1168.97	1169.29	0.000664	4.49	0.27
1.52	58000	1144	1168.81	1168.96	0.000138	3.14	0.14
1.39	58000	1147.32	1168.63	1168.83	0.000256	3.63	0.18
1.3	58000	1152	1168.19	1168.62	0.000914	5.26	0.32
1.22	58000	1156	1167.89	1168.27	0.00073	4.94	0.29
1.12	58000	1152	1167.55	1167.89	0.000592	4.69	0.27
1	58000	1152	1167.22	1167.55	0.000538	4.61	0.25
0.89	58000	1156	1166.55	1167.1	0.001249	5.95	0.37
0.78	58000	1152	1166.07	1166.46	0.0007	5.06	0.29
0.65	58000	1151.5	1165.78	1166.06	0.000384	4.25	0.22
0.51	58000	1152	1165.41	1165.74	0.000485	4.57	0.24
0.36	58000	1151.05	1165	1165.34	0.000521	4.7	0.25
0.23	58000	1150.96	1164.68	1165	0.000473	4.57	0.24
0.11	58000	1148	1164.29	1164.67	0.000569	4.9	0.26
0	58000	1148	1164.04	1164.36	0.000401	4.54	0.23

Exhibit D.3 Hydraulic Results, Baseline Condition (Model 11) for the 100-Year event.

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
13.64	175000	1288	1306.99	1308.6	0.001536	10.17	0.46
13.55	175000	1288	1306.41	1307.88	0.001284	9.76	0.43
13.44	175000	1284	1305.53	1307.09	0.001344	10.01	0.44
13.31	175000	1281.3	1304.54	1306.14	0.001566	10.15	0.46
13.19	175000	1284	1303.47	1305.04	0.001771	10.07	0.48
13.07	175000	1276	1302.66	1303.98	0.001361	9.21	0.43
12.97	175000	1280	1301.64	1303.2	0.001722	10	0.48
12.87	175000	1276	1300.58	1302.17	0.001857	10.12	0.49
12.77	175000	1276	1299.28	1301.17	0.001846	11.03	0.5
12.67	175000	1276	1298.58	1300.26	0.001436	10.41	0.45
12.55	175000	1276	1297.49	1299.31	0.001632	10.83	0.48
12.44	175000	1276	1295.68	1298.09	0.002469	12.47	0.58
12.33	175000	1272	1294.69	1296.82	0.001747	11.72	0.5
12.22	175000	1272	1293.7	1295.7	0.001973	11.35	0.52
12.1	175000	1272	1292.71	1294.37	0.001966	10.34	0.51
12.06	175000	1268	1292.39	1293.83	0.001736	9.65	0.48
11.99	175000	1268	1291.29	1293.05	0.002375	10.64	0.55
11.88	175000	1267.94	1289.94	1291.78	0.002079	10.89	0.52
11.78	175000	1268	1289.45	1290.75	0.001178	9.14	0.41
11.62	175000	1264	1288.86	1289.79	0.000821	7.75	0.34
11.49	175000	1263.04	1287.72	1289.08	0.001288	9.36	0.42
11.41	175000	1260	1287.01	1288.45	0.001614	9.63	0.46
11.32	175000	1260	1286.36	1287.77	0.00134	9.79	0.43
11.25	175000	1256	1285.72	1287.26	0.001162	10.14	0.41
11.17	175000	1256	1285.14	1286.77	0.001151	10.31	0.41
11.14	175000	1256	1284.75	1286.44	0.003492	10.48	0.42
11.1	175000	1256	1284.52	1285.9	0.000814	9.45	0.35
11.05	175000	1256	1284.54	1285.67	0.000583	8.51	0.31
11	175000	1254.01	1284.48	1285.47	0.000448	7.99	0.27
10.95	175000	1252	1284.59	1285.29	0.000298	6.7	0.22
10.9	175000	1250.83	1284.48	1285.22	0.000311	6.89	0.23
10.86	175000	1248	1284.35	1285.14	0.000314	7.11	0.23
10.81	175000	1248	1284.33	1285.05	0.000261	6.82	0.21
10.78	175000	1248	1284.25	1284.99	0.000279	6.92	0.22
10.73	175000	1248	1284.1	1284.92	0.000293	7.28	0.23
10.67	175000	1248	1283.7	1284.78	0.000435	8.34	0.27
10.61	175000	1244.2	1283.5	1284.63	0.000425	8.54	0.27
10.56	175000	1244	1283.38	1284.53	0.000421	8.61	0.27
10.52	175000	1234.97	1283.58	1284.33	0.000237	7.03	0.21
10.46	175000	1240	1283.5	1284.24	0.000298	7.16	0.23
10.41	175000	1247.67	1283.47	1284.16	0.000251	6.75	0.21
10.36	175000	1253	1282.68	1283.99	0.000839	9.37	0.36
10.26	175000	1252	1282.5	1283.56	0.000567	8.29	0.3
10.18	175000	1256	1281.26	1283.11	0.001536	10.93	0.47

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
10.06	175000	1256	1281.03	1282.17	0.000851	9.18	0.36
9.96	175000	1254.13	1280.47	1281.69	0.000823	9.51	0.36
9.87	175000	1254.92	1280.2	1281.31	0.000712	8.89	0.33
9.8	175000	1252	1280.23	1280.98	0.000485	7.63	0.28
9.73	175000	1252	1280.31	1280.74	0.000306	5.97	0.22
9.67	175000	1250.78	1280.24	1280.65	0.000259	5.95	0.21
9.64	175000	1252	1280.25	1280.6	0.000227	5.48	0.19
9.61	175000	1248.2	1280.24	1280.57	0.000196	5.35	0.18
9.59	175000	1244.4	1280.24	1280.53	0.000169	5.08	0.17
9.55	175000	1251.37	1280.09	1280.48	0.000224	5.66	0.19
9.49	175000	1248	1279.58	1280.34	0.000397	7.64	0.26
9.44	175000	1247.05	1278.5	1280.14	0.000834	11.17	0.37
9.39	175000	1236	1275.23	1279.52	0.002914	18.65	0.67
9.33	175000	1244	1275.83	1278.37	0.001565	13.97	0.5
9.26	175000	1247.57	1276	1277.64	0.00099	11.17	0.4
9.2	175000	1248	1275.87	1277.26	0.000854	10.26	0.37
9.13	175000	1248	1274.43	1276.75	0.001442	13.29	0.48
9.04	175000	1248	1267.84	1275.11	0.006714	23.41	0.98
8.98	175000	1244	1267.26	1271.89	0.004426	18.75	0.79
8.92	175000	1239.59	1267.32	1270.3	0.002619	15.04	0.62
8.88	175000	1233.08	1267.58	1269.63	0.001712	12.46	0.5
8.85	175000	1212	1268.05	1269.14	0.000656	9.1	0.32
8.81	175000	1204	1268.28	1268.91	0.000261	6.87	0.21
8.77	175000	1206.87	1268.31	1268.83	0.000181	6.23	0.18
8.74	175000	1220	1267.6	1268.72	0.000478	9.21	0.28
8.68	175000	1244	1262.56	1268.01	0.008526	20.36	1.04
8.63	175000	1216	1263.83	1264.71	0.000535	8.17	0.29
8.6	175000	1196	1264.17	1264.5	0.000108	5.27	0.14
8.57	175000	1198.17	1264.21	1264.46	0.000069	4.53	0.11
8.52	175000	1208	1264.22	1264.43	0.000055	4.11	0.1
8.44	175000	1192	1264.22	1264.4	0.000049	3.7	0.1
8.36	175000	1212	1264.17	1264.37	0.000059	3.9	0.11
8.29	175000	1204	1264.17	1264.34	0.00004	3.56	0.09
8.2	175000	1202.29	1264.11	1264.32	0.000049	3.98	0.1
8.1	175000	1212	1263.48	1264.22	0.00032	7.58	0.23
8.01	175000	1240	1263.05	1264	0.000848	8.4	0.35
7.91	175000	1244	1260.18	1263.1	0.00342	14.39	0.68
7.83	175000	1244	1259.5	1261.58	0.002331	12	0.56
7.71	175000	1243.41	1256.06	1259.5	0.004908	15.21	0.79
7.63	175000	1240	1254.89	1257.36	0.002947	12.73	0.62
7.55	172000	1239.6	1254.61	1256.12	0.001644	9.87	0.47
7.47	172000	1239.83	1253.59	1255.32	0.002057	10.53	0.52
7.45	Bridge						
7.44	172000	1238.53	1252.44	1254.22	0.002239	10.72	0.54
7.4	172000	1239.06	1251.6	1253.62	0.003015	11.71	0.61
7.36	172000	1238.07	1251.58	1252.7	0.001677	8.7	0.46
7.32	172000	1240	1251.08	1252.33	0.001961	9.09	0.49

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
7.28	172000	1236	1248.59	1251.59	0.0063	13.89	0.85
7.24	172000	1235.58	1245.75	1249.65	0.008952	15.85	1
7.17	172000	1197.93	1237.34	1237.48	0.00008	3.03	0.11
7.1	172000	1206.84	1237.29	1237.45	0.000084	3.23	0.12
7.03	172000	1210.44	1237.08	1237.39	0.00019	4.51	0.17
6.99	172000	1200	1237.16	1237.32	0.000058	3.21	0.1
6.91	172000	1198.45	1237.11	1237.29	0.000083	3.36	0.12
6.8	172000	1196	1237.02	1237.24	0.000085	3.78	0.12
6.69	172000	1197.62	1236.73	1237.15	0.000212	5.18	0.18
6.56	172000	1188.55	1236.78	1236.98	0.000075	3.61	0.11
6.5	172000	1192.83	1236.59	1236.94	0.000148	4.74	0.16
6.45	172000	1180	1236.75	1236.84	0.000027	2.4	0.07
6.4	172000	1196	1236.68	1236.82	0.000044	3.01	0.09
6.38	172000	1195.4	1236.38	1236.79	0.000166	4.89	0.16
6.35	172000	1194.53	1235.22	1236.64	0.000662	9.61	0.33
6.32	172000	1192	1235.25	1236.52	0.000562	9.09	0.31
6.27	172000	1194.49	1235.43	1236.24	0.000413	7.26	0.26
6.22	172000	1203.46	1235.37	1236.1	0.000459	6.91	0.26
6.18	172000	1192	1235.27	1236.01	0.000466	7	0.27
6.14	172000	1196	1235.31	1235.87	0.000276	6.09	0.21
6.09	172000	1200	1235.03	1235.77	0.000404	7.01	0.25
6.05	172000	1204	1234.67	1235.63	0.000625	7.84	0.31
6.01	172000	1204	1234.11	1235.37	0.031706	8.99	0.38
5.99	172000	1200	1232.7	1233.62	0.001225	7.69	0.33
5.97	172000	1198.59	1232.58	1233.5	0.001172	7.74	0.32
5.95	172000	1196	1232.59	1233.31	0.000672	6.79	0.27
5.93	172000	1198.79	1232.63	1233.22	0.000647	6.2	0.24
5.91	172000	1203.31	1232.49	1233.13	0.000792	6.47	0.27
5.88	172000	1209.96	1231.94	1232.95	0.001083	8.19	0.38
5.87	172000	1206.22	1231.68	1232.87	0.001201	8.76	0.4
5.86	172000	1205.11	1231.13	1232.72	0.011654	10.12	0.44
5.85	172000	1208	1230.87	1232.29	0.001107	9.56	0.4
5.84	172000	1204	1230.67	1232.21	0.001193	9.95	0.41
5.82	172000	1204	1230.62	1232.07	0.001032	9.66	0.39
5.8	172000	1204	1230.48	1231.96	0.001032	9.78	0.39
5.76	172000	1204	1229.87	1231.71	0.001427	10.88	0.45
5.73	172000	1208	1228.53	1231.25	0.002438	13.24	0.58
5.69	172000	1206.01	1228.67	1230.73	0.001516	11.5	0.47
5.65	172000	1198.67	1229.07	1230.22	0.000725	8.6	0.33
5.6	172000	1194.35	1229.22	1229.94	0.000319	6.8	0.23
5.56	172000	1208	1227.22	1229.65	0.002438	12.51	0.58
5.53	172000	1192	1227.75	1228.99	0.000873	8.93	0.36
5.47	172000	1208	1225.87	1228.48	0.002876	13	0.62
5.4	172000	1196	1225.43	1227.4	0.001625	11.43	0.48
5.26	172000	1179.01	1225.08	1226.3	0.000776	9.07	0.34
5.15	172000	1204	1223.48	1225.57	0.002035	11.85	0.53
5.03	172000	1204	1222.13	1224.24	0.002089	11.92	0.54

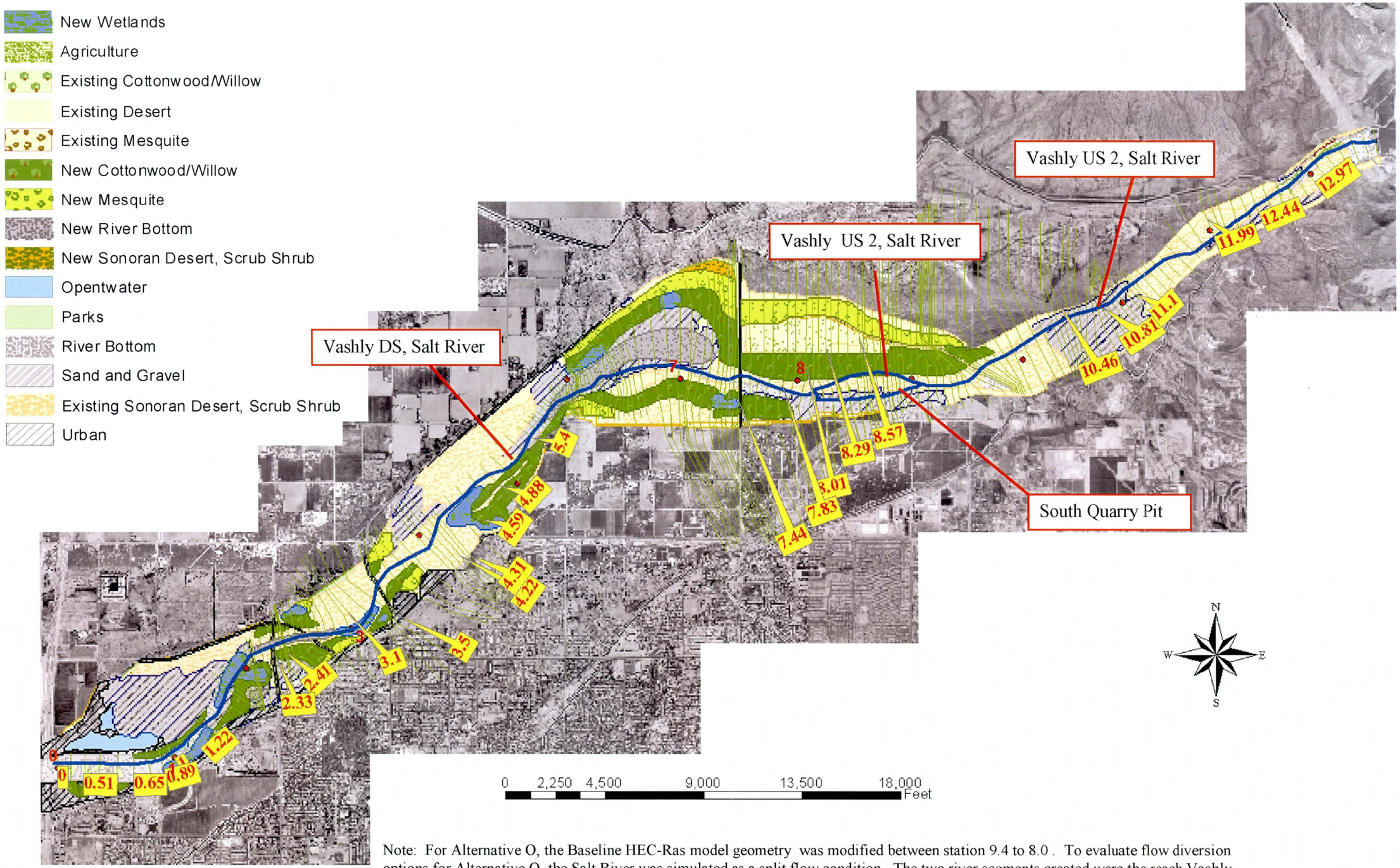
EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
4.88	172000	1200	1219.45	1222.22	0.00313	13.65	0.72
4.74	172000	1188	1219.23	1220.23	0.000817	8.23	0.34
4.59	172000	1192	1218.48	1219.53	0.000941	8.39	0.36
4.47	172000	1200	1216.91	1218.6	0.00207	10.67	0.52
4.31	172000	1199.24	1215.5	1217.04	0.001573	9.85	0.46
4.27	172000	1192	1215.66	1216.61	0.000775	7.88	0.33
4.22	172000	1178.19	1215.69	1216.35	0.000453	6.41	0.26
4.15	172000	1184	1215.32	1216.16	0.000657	7.34	0.31
4.09	172000	1188	1215.33	1215.9	0.000453	5.98	0.26
4.04	172000	1184	1215.36	1215.74	0.000268	4.86	0.2
3.89	172000	1174.66	1215.26	1215.55	0.000139	4.37	0.15
3.76	172000	1188	1214.26	1215.31	0.000894	8.23	0.36
3.64	172000	1192	1213.14	1214.54	0.001648	9.51	0.46
3.5	172000	1186.84	1212.46	1213.4	0.000775	7.77	0.33
3.48	Bridge						
3.46	172000	1184	1212.26	1213.07	0.000606	7.23	0.3
3.35	172000	1188	1210.69	1212.33	0.001317	10.28	0.44
3.23	172000	1184.27	1209	1211.27	0.002074	12.09	0.54
3.1	172000	1174.02	1208.16	1209.87	0.001412	10.5	0.45
2.98	172000	1180	1207.72	1209.05	0.000943	9.28	0.37
2.87	172000	1175.62	1206.51	1208.32	0.001429	10.79	0.45
2.78	172000	1188	1205.87	1207.51	0.001621	10.28	0.47
2.71	172000	1188	1205.08	1206.93	0.001831	10.92	0.5
2.65	172000	1187.99	1203.55	1206.09	0.002605	12.78	0.59
2.59	172000	1184	1203.11	1205.28	0.002134	11.82	0.54
2.53	172000	1180	1202.61	1204.54	0.001889	11.17	0.51
2.47	172000	1178.61	1201.6	1203.86	0.002259	12.06	0.55
2.42	172000	1176	1201.35	1203.24	0.00167	11.02	0.48
2.41	172000	1176	1201.3	1203.17	0.001627	10.96	0.48
2.4	172000	1176	1201.23	1203.1	0.001642	10.97	0.48
2.38	172000	1175.59	1200.93	1202.85	0.001828	11.11	0.5
2.33	172000	1180	1199.53	1202.15	0.002793	12.98	0.61
2.31	Bridge						
2.29	172000	1170.86	1196.83	1198.6	0.001424	10.68	0.45
2.21	172000	1176	1194.29	1197.34	0.003603	14.03	0.69
2.13	172000	1176	1192.78	1195.85	0.003607	14.06	0.69
2.12	172000	1176	1190.15	1195.29	0.008219	18.19	1
2.1	172000	1158.27	1180.87	1183.13	0.002325	12.06	0.56
2.07	172000	1156	1180.58	1182.78	0.00207	11.91	0.54
2.04	172000	1156.31	1180.55	1182.37	0.001475	10.8	0.46
2.02	172000	1158.36	1180.48	1182.18	0.001175	10.47	0.42
1.95	172000	1157.05	1180.28	1181.69	0.001045	9.5	0.39
1.89	172000	1152.71	1180.05	1181.28	0.001056	8.89	0.39
1.86	172000	1148	1179.95	1181.12	0.001	8.68	0.38
1.83	172000	1148	1179.57	1180.9	0.001327	9.28	0.42
1.8	172000	1160	1179.6	1180.62	0.000899	8.11	0.36
1.76	172000	1152.5	1179.77	1180.36	0.00041	6.19	0.25

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
1.65	172000	1154.51	1179.61	1180.12	0.000377	5.73	0.24
1.52	172000	1144	1179.42	1179.89	0.000237	5.52	0.19
1.39	172000	1147.32	1179.18	1179.7	0.000297	5.82	0.22
1.3	172000	1152	1178.78	1179.5	0.000532	6.84	0.28
1.22	172000	1156	1178.6	1179.28	0.000474	6.63	0.27
1.12	172000	1152	1178.36	1179.03	0.000436	6.54	0.26
1	172000	1152	1178.1	1178.76	0.000429	6.55	0.25
0.89	172000	1156	1177.63	1178.46	0.000608	7.31	0.3
0.78	172000	1152	1177.39	1178.1	0.000471	6.78	0.27
0.65	172000	1151.5	1177.18	1177.8	0.000352	6.32	0.23
0.51	172000	1152	1176.85	1177.51	0.000395	6.55	0.25
0.36	172000	1151.05	1176.51	1177.2	0.000411	6.67	0.25
0.23	172000	1150.96	1176.24	1176.92	0.000394	6.61	0.25
0.11	172000	1148	1175.9	1176.65	0.000442	6.92	0.26
0	172000	1148	1175.65	1176.39	0.000403	6.92	0.25

EXHIBIT E – HEC-RAS FIGUREL, ALTERNATIVE O (MODEL 9)



Note: For Alternative O, the Baseline HEC-Ras model geometry was modified between station 9.4 to 8.0 . To evaluate flow diversion options for Alternative O, the Salt River was simulated as a split flow condition. The two river segments created were the reach Vashly US 2, Salt River, and the South Quarry Pit segment.

EXHIBIT F – WATER SURFACE PROFILE, ALTERNATIVE O (MODEL 9)

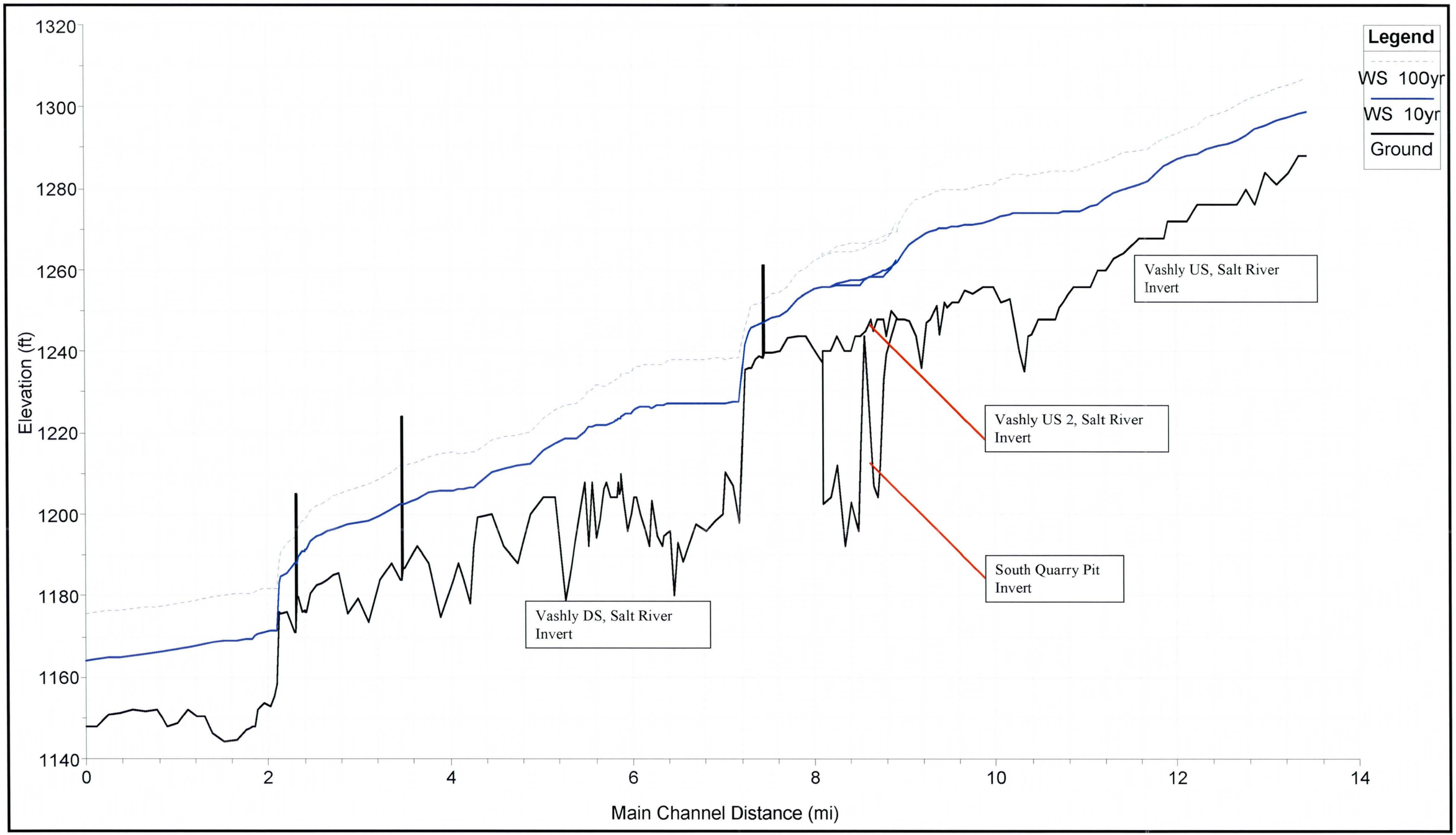


Exhibit G.1 Hydraulic Results, Alternative O (Model 9) for the 3-Year event.

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
South Quarry Pit		0.83	2172.87	1248	1252.09	1252.17	0.005025	2.3	0.23
South Quarry Pit		0.77	2172.87	1244	1250.22	1250.35	0.006842	2.82	0.27
South Quarry Pit		0.71	2172.87	1239.17	1249.11	1249.15	0.000803	1.61	0.1
South Quarry Pit		0.68	2172.87	1233.05	1249.04	1249.05	0.000209	1.01	0.05
South Quarry Pit		0.64	2172.87	1230.33	1249.03	1249.03	0.00004	0.55	0.03
South Quarry Pit		0.6	2172.87	1230	1249.02	1249.02	0.000015	0.36	0.02
South Quarry Pit		0.57	2172.87	1225.78	1249.02	1249.02	0.00001	0.3	0.01
South Quarry Pit		0.53	2172.87	1230.95	1249.02	1249.02	0.000017	0.36	0.02
South Quarry Pit		0.47	2172.87	1244	1248.84	1248.99	0.015998	3.11	0.37
South Quarry Pit		0.42	2172.87	1224.75	1246.66	1246.66	0.000024	0.42	0.02
South Quarry Pit		0.4	2172.87	1220.72	1246.66	1246.66	0.000011	0.28	0.01
South Quarry Pit		0.37	2172.87	1230.18	1246.66	1246.66	0.000007	0.23	0.01
South Quarry Pit		0.31	2172.87	1221.68	1246.66	1246.66	0.000005	0.2	0.01
South Quarry Pit		0.24	2172.87	1221.31	1246.65	1246.65	0.000003	0.17	0.01
South Quarry Pit		0.15	2172.87	1229.55	1246.65	1246.65	0.000004	0.19	0.01
South Quarry Pit		0.08	2172.87	1221.16	1246.65	1246.65	0.000005	0.19	0.01
South Quarry Pit		0	2172.87	1229.85	1246.65	1246.65	0.000005	0.21	0.01
Salt River	VaShly US	13.64	2200	1288	1290.63	1290.75	0.001711	2.81	0.35
Salt River	VaShly US	13.55	2200	1288	1289.36	1289.5	0.005398	3	0.54
Salt River	VaShly US	13.44	2200	1284	1286.96	1287.14	0.002499	3.35	0.42
Salt River	VaShly US	13.31	2200	1281.3	1286.05	1286.11	0.00055	1.95	0.21
Salt River	VaShly US	13.19	2200	1284	1285.11	1285.4	0.009344	4.31	0.73
Salt River	VaShly US	13.07	2200	1276	1282.21	1282.27	0.000397	1.9	0.18
Salt River	VaShly US	12.97	2200	1280	1281.59	1281.88	0.00578	4.32	0.61
Salt River	VaShly US	12.87	2200	1276	1279.95	1280.01	0.000549	2.02	0.21
Salt River	VaShly US	12.77	2200	1276	1279.56	1279.64	0.000955	2.32	0.27
Salt River	VaShly US	12.67	2200	1276	1279.18	1279.23	0.000602	1.92	0.21
Salt River	VaShly US	12.55	2200	1276	1278.82	1278.88	0.000563	1.91	0.21
Salt River	VaShly US	12.44	2200	1276	1278.32	1278.42	0.001214	2.51	0.3
Salt River	VaShly US	12.33	2200	1272	1277.91	1277.94	0.000405	1.41	0.17
Salt River	VaShly US	12.22	2200	1272	1277.29	1277.51	0.002722	3.8	0.45
Salt River	VaShly US	12.1	2200	1272	1274.32	1274.94	0.008089	6.32	0.76
Salt River	VaShly US	12.06	2200	1268	1273.28	1273.53	0.002117	4.08	0.41
Salt River	VaShly US	11.99	2200	1268	1272.16	1272.51	0.003691	4.73	0.53
Salt River	VaShly US	11.88	2200	1267.94	1271.07	1271.16	0.000815	2.5	0.26
Salt River	VaShly US	11.78	2200	1268	1270.44	1270.57	0.001683	2.92	0.35
Salt River	VaShly US	11.62	2200	1264	1268.47	1268.62	0.003617	3.17	0.47
Salt River	VaShly US	11.49	2200	1263.04	1265.31	1265.61	0.005975	4.4	0.62
Salt River	VaShly US	11.41	2200	1260	1263.83	1264	0.001337	3.32	0.33
Salt River	VaShly US	11.32	2200	1260	1263.39	1263.49	0.000834	2.6	0.26
Salt River	VaShly US	11.25	2200	1256	1263.16	1263.22	0.000463	2.02	0.2
Salt River	VaShly US	11.17	2200	1256	1262.8	1262.92	0.001548	2.78	0.33

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly US	11.14	2200	1256	1261.95	1262.37	0.018196	5.19	0.66
Salt River	VaShly US	11.1	2200	1256	1260.1	1260.2	0.001685	2.6	0.34
Salt River	VaShly US	11.05	2200	1256	1259.95	1259.97	0.000162	1.27	0.12
Salt River	VaShly US	11	2200	1254.01	1259.93	1259.93	0.000043	0.73	0.06
Salt River	VaShly US	10.95	2200	1252	1259.92	1259.93	0.000008	0.44	0.03
Salt River	VaShly US	10.9	2200	1250.83	1259.92	1259.93	0.000007	0.42	0.03
Salt River	VaShly US	10.86	2200	1248	1259.92	1259.92	0.000004	0.38	0.02
Salt River	VaShly US	10.81	2200	1248	1259.92	1259.92	0.000002	0.3	0.02
Salt River	VaShly US	10.78	2200	1248	1259.92	1259.92	0.000002	0.3	0.02
Salt River	VaShly US	10.73	2200	1248	1259.92	1259.92	0.000002	0.31	0.02
Salt River	VaShly US	10.67	2200	1248	1259.92	1259.92	0.000006	0.43	0.03
Salt River	VaShly US	10.61	2200	1244.2	1259.92	1259.92	0.000003	0.37	0.02
Salt River	VaShly US	10.56	2200	1244	1259.92	1259.92	0.000003	0.35	0.02
Salt River	VaShly US	10.52	2200	1234.97	1259.92	1259.92	0.000001	0.23	0.01
Salt River	VaShly US	10.46	2200	1240	1259.91	1259.92	0.000003	0.35	0.02
Salt River	VaShly US	10.41	2200	1247.67	1259.91	1259.92	0.000002	0.33	0.02
Salt River	VaShly US	10.36	2200	1253	1259.81	1259.91	0.000785	2.52	0.25
Salt River	VaShly US	10.26	2200	1252	1259.66	1259.67	0.00003	0.8	0.06
Salt River	VaShly US	10.18	2200	1256	1259.52	1259.63	0.001022	2.74	0.29
Salt River	VaShly US	10.06	2200	1256	1258.82	1258.94	0.001304	2.75	0.31
Salt River	VaShly US	9.96	2200	1254.13	1258.33	1258.39	0.00056	2.01	0.21
Salt River	VaShly US	9.87	2200	1254.92	1257.83	1257.97	0.002516	2.95	0.37
Salt River	VaShly US	9.8	2200	1252	1256.99	1257.09	0.00225	2.54	0.29
Salt River	VaShly US	9.73	2200	1252	1256.18	1256.24	0.002074	2.02	0.19
Salt River	VaShly US	9.67	2200	1250.78	1255.51	1255.58	0.001943	1.99	0.19
Salt River	VaShly US	9.64	2200	1252	1255.1	1255.21	0.005247	2.69	0.3
Salt River	VaShly US	9.61	2200	1248.2	1254.75	1254.78	0.0008	1.39	0.12
Salt River	VaShly US	9.59	2200	1244.4	1254.67	1254.69	0.000495	1.14	0.1
Salt River	VaShly US	9.55	2200	1251.37	1254.44	1254.51	0.00343	2.14	0.24
Salt River	VaShly US	9.49	2200	1248	1253.6	1253.64	0.001611	1.65	0.17
Salt River	VaShly US	9.44	2200	1247.05	1253.4	1253.41	0.000289	1.03	0.08
Salt River	VaShly US	9.39	2200	1236	1253.29	1253.33	0.000285	1.42	0.08
Salt River	VaShly US	9.33	2200	1244	1253.2	1253.23	0.000429	1.37	0.1
Salt River	VaShly US	9.26	2200	1247.57	1252.99	1253.02	0.000788	1.44	0.12
Salt River	VaShly US	9.2	2200	1248	1252.69	1252.72	0.001048	1.5	0.14
Salt River	VaShly US	9.13	2200	1248	1252.12	1252.18	0.002291	1.87	0.2
Salt River	VaShly US 2	9.04	27.13	1248	1252.17	1252.18	0.002578	0.39	0.17
Salt River	VaShly US 2	8.98	27.13	1250.19	1250.8	1250.83	0.013193	1.29	0.41
Salt River	VaShly US 2	8.92	27.13	1244	1248.81	1248.81	0.000003	0.05	0.01
Salt River	VaShly US 2	8.88	27.13	1248	1248.81	1248.81	0.00057	0.42	0.1
Salt River	VaShly US 2	8.85	27.13	1248	1248.68	1248.69	0.000963	0.58	0.13
Salt River	VaShly US 2	8.81	27.13	1248	1248.45	1248.45	0.001275	0.49	0.13
Salt River	VaShly US 2	8.77	27.13	1245.26	1248.32	1248.32	0.000012	0.11	0.02
Salt River	VaShly US 2	8.74	27.13	1248	1248.3	1248.32	0.011151	1.04	0.37

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly US 2	8.68	27.13	1245.3	1246.66	1246.66	0.00006	0.3	0.06
Salt River	VaShly US 2	8.63	27.13	1244	1246.65	1246.65	0.000013	0.15	0.02
Salt River	VaShly US 2	8.6	27.13	1244	1246.65	1246.65	0.000003	0.09	0.01
Salt River	VaShly US 2	8.57	27.13	1244	1246.65	1246.65	0.000001	0.06	0.01
Salt River	VaShly US 2	8.52	27.13	1240	1246.65	1246.65	0	0.01	0
Salt River	VaShly US 2	8.44	27.13	1240	1246.65	1246.65	0	0.02	0
Salt River	VaShly US 2	8.36	27.13	1244	1246.65	1246.65	0	0.05	0.01
Salt River	VaShly US 2	8.29	27.13	1240	1246.65	1246.65	0	0.02	0
Salt River	VaShly US 2	8.2	27.13	1240	1246.65	1246.65	0	0.02	0
Salt River	VaShly DS	8.1	2200	1237.27	1246.65	1246.65	0.000004	0.34	0.02
Salt River	VaShly DS	8.01	2200	1240	1246.63	1246.64	0.000057	0.85	0.07
Salt River	VaShly DS	7.91	2200	1244	1246.45	1246.58	0.002235	2.82	0.38
Salt River	VaShly DS	7.83	2200	1244	1245.8	1245.85	0.000955	1.81	0.25
Salt River	VaShly DS	7.71	2200	1243.41	1244.58	1244.78	0.009177	3.6	0.7
Salt River	VaShly DS	7.63	2200	1240	1242.12	1242.19	0.001674	2.14	0.32
Salt River	VaShly DS	7.55	2200	1239.6	1241.7	1241.73	0.00049	1.3	0.18
Salt River	VaShly DS	7.47	2200	1239.83	1241.39	1241.44	0.00126	1.76	0.28
Salt River	VaShly DS	7.45	Bridge						
Salt River	VaShly DS	7.44	2200	1238.53	1241.21	1241.24	0.000555	1.25	0.19
Salt River	VaShly DS	7.4	2200	1239.06	1241.06	1241.09	0.000883	1.51	0.23
Salt River	VaShly DS	7.36	2200	1238.07	1240.93	1240.95	0.000511	1.24	0.18
Salt River	VaShly DS	7.32	2200	1240	1240.65	1240.75	0.007151	2.52	0.58
Salt River	VaShly DS	7.28	2200	1236	1239.19	1239.49	0.006186	4.38	0.63
Salt River	VaShly DS	7.24	2200	1235.58	1236.78	1237.14	0.019729	4.8	1
Salt River	VaShly DS	7.17	2200	1197.93	1214.45	1214.45	0.000009	0.37	0.03
Salt River	VaShly DS	7.1	2200	1206.84	1214.45	1214.45	0.000015	0.36	0.04
Salt River	VaShly DS	7.03	2200	1210.44	1214.43	1214.44	0.000071	0.65	0.07
Salt River	VaShly DS	6.99	2200	1200	1214.43	1214.43	0	0.12	0.01
Salt River	VaShly DS	6.91	2200	1198.45	1214.43	1214.43	0.000001	0.19	0.01
Salt River	VaShly DS	6.8	2200	1196	1214.43	1214.43	0.000001	0.17	0.01
Salt River	VaShly DS	6.69	2200	1197.62	1214.42	1214.43	0.000022	0.48	0.04
Salt River	VaShly DS	6.56	2200	1188.55	1214.42	1214.42	0.000001	0.15	0.01
Salt River	VaShly DS	6.5	2200	1192.83	1214.42	1214.42	0.000001	0.22	0.01
Salt River	VaShly DS	6.45	2200	1180	1214.42	1214.42	0	0.08	0
Salt River	VaShly DS	6.4	2200	1196	1214.42	1214.42	0	0.1	0
Salt River	VaShly DS	6.38	2200	1195.4	1214.42	1214.42	0.000001	0.21	0.01
Salt River	VaShly DS	6.35	2200	1194.53	1214.41	1214.42	0.000003	0.4	0.02
Salt River	VaShly DS	6.32	2200	1192	1214.41	1214.42	0.000002	0.35	0.02
Salt River	VaShly DS	6.27	2200	1194.49	1214.41	1214.42	0.000002	0.35	0.02
Salt River	VaShly DS	6.22	2200	1203.46	1214.39	1214.41	0.000044	1.14	0.07
Salt River	VaShly DS	6.18	2200	1192	1214.39	1214.4	0.000033	1.04	0.06
Salt River	VaShly DS	6.14	2200	1196	1214.39	1214.4	0.000002	0.32	0.02
Salt River	VaShly DS	6.09	2200	1200	1214.39	1214.4	0.000006	0.46	0.03
Salt River	VaShly DS	6.05	2200	1204	1214.39	1214.39	0.000017	0.61	0.04

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly DS	6.01	2200	1204	1214.38	1214.39	0.000558	0.69	0.04
Salt River	VaShly DS	5.99	2200	1200	1214.35	1214.36	0.000013	0.5	0.03
Salt River	VaShly DS	5.97	2200	1198.59	1214.35	1214.36	0.000006	0.39	0.02
Salt River	VaShly DS	5.95	2200	1196	1214.35	1214.35	0.000004	0.32	0.02
Salt River	VaShly DS	5.93	2200	1198.79	1214.35	1214.35	0.000004	0.31	0.02
Salt River	VaShly DS	5.91	2200	1203.31	1214.35	1214.35	0.000046	0.6	0.04
Salt River	VaShly DS	5.88	2200	1209.96	1213.97	1214.3	0.011879	4.67	0.56
Salt River	VaShly DS	5.87	2200	1206.22	1213.89	1213.94	0.0009	1.79	0.17
Salt River	VaShly DS	5.86	2200	1205.11	1213.87	1213.9	0.000317	1.33	0.11
Salt River	VaShly DS	5.85	2200	1208	1213.85	1213.88	0.000354	1.43	0.11
Salt River	VaShly DS	5.84	2200	1204	1213.77	1213.84	0.000951	2.12	0.18
Salt River	VaShly DS	5.82	2200	1204	1213.7	1213.76	0.000669	2.02	0.18
Salt River	VaShly DS	5.8	2200	1204	1213.67	1213.7	0.000221	1.33	0.11
Salt River	VaShly DS	5.76	2200	1204	1213.6	1213.65	0.000375	1.77	0.18
Salt River	VaShly DS	5.73	2200	1208	1212.95	1213.46	0.017365	5.7	0.99
Salt River	VaShly DS	5.69	2200	1206.01	1210.58	1210.63	0.000403	1.88	0.18
Salt River	VaShly DS	5.65	2200	1198.67	1210.57	1210.57	0.000007	0.51	0.03
Salt River	VaShly DS	5.6	2200	1194.35	1210.57	1210.57	0.000002	0.34	0.02
Salt River	VaShly DS	5.56	2200	1208	1210.42	1210.55	0.002267	2.96	0.39
Salt River	VaShly DS	5.53	2200	1192	1210.3	1210.3	0.000005	0.46	0.02
Salt River	VaShly DS	5.47	2200	1208	1209.84	1210.26	0.009722	5.19	0.78
Salt River	VaShly DS	5.4	2200	1196	1208.18	1208.2	0.000076	0.96	0.08
Salt River	VaShly DS	5.26	2200	1179.01	1208.16	1208.16	0.000008	0.4	0.02
Salt River	VaShly DS	5.15	2200	1204	1208.09	1208.15	0.001899	1.86	0.23
Salt River	VaShly DS	5.03	2200	1204	1206.31	1206.4	0.004695	2.5	0.34
Salt River	VaShly DS	4.88	2200	1200	1204.39	1204.43	0.000301	1.7	0.16
Salt River	VaShly DS	4.74	2200	1188	1204.3	1204.3	0.000007	0.37	0.02
Salt River	VaShly DS	4.59	2200	1192	1204.29	1204.29	0.000031	0.6	0.05
Salt River	VaShly DS	4.47	2200	1200	1204.13	1204.24	0.002081	2.68	0.49
Salt River	VaShly DS	4.31	2200	1199.24	1200.87	1201.07	0.023119	3.64	0.67
Salt River	VaShly DS	4.27	2200	1192	1197.25	1197.61	0.008405	4.83	0.73
Salt River	VaShly DS	4.22	2200	1178.19	1196.33	1196.34	0.00001	0.67	0.04
Salt River	VaShly DS	4.15	2200	1184	1196.31	1196.33	0.000084	1.11	0.09
Salt River	VaShly DS	4.09	2200	1188	1196.28	1196.3	0.000138	1.09	0.11
Salt River	VaShly DS	4.04	2200	1184	1196.27	1196.27	0.00002	0.51	0.04
Salt River	VaShly DS	3.89	2200	1174.66	1196.26	1196.26	0.000001	0.24	0.01
Salt River	VaShly DS	3.76	2200	1188	1196.23	1196.26	0.000298	1.32	0.15
Salt River	VaShly DS	3.64	2200	1192	1195.21	1195.83	0.010864	6.31	0.85
Salt River	VaShly DS	3.5	2200	1186.84	1191.14	1191.23	0.000972	2.44	0.27
Salt River	VaShly DS	3.48	Bridge						
Salt River	VaShly DS	3.46	2200	1184	1191.06	1191.09	0.000148	1.28	0.11
Salt River	VaShly DS	3.35	2200	1188	1190.62	1190.89	0.007405	4.16	0.52
Salt River	VaShly DS	3.23	2200	1183.78	1188.15	1188.22	0.001044	2.16	0.21
Salt River	VaShly DS	3.1	2200	1173.54	1187.81	1187.82	0.000048	0.85	0.05

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly DS	2.98	2200	1179.21	1187.79	1187.79	0.00003	0.66	0.04
Salt River	VaShly DS	2.87	2200	1175.62	1187.77	1187.78	0.000015	0.68	0.04
Salt River	VaShly DS	2.78	2200	1185.67	1187.63	1187.75	0.002222	2.81	0.38
Salt River	VaShly DS	2.71	2200	1185.2	1186.85	1186.97	0.002665	2.76	0.41
Salt River	VaShly DS	2.65	2200	1184.02	1185.99	1186.1	0.002148	2.75	0.38
Salt River	VaShly DS	2.59	2200	1183.07	1185.41	1185.53	0.001711	2.86	0.35
Salt River	VaShly DS	2.53	2200	1182.76	1184.6	1184.78	0.003249	3.44	0.47
Salt River	VaShly DS	2.47	2200	1180.75	1183.13	1183.22	0.009582	2.48	0.3
Salt River	VaShly DS	2.42	2200	1175.84	1181.93	1181.94	0.000026	0.71	0.05
Salt River	VaShly DS	2.41	2200	1175.97	1181.93	1181.94	0.000043	0.85	0.06
Salt River	VaShly DS	2.4	2200	1176.34	1181.92	1181.94	0.000062	0.98	0.08
Salt River	VaShly DS	2.38	2200	1176.14	1181.92	1181.93	0.000043	0.84	0.06
Salt River	VaShly DS	2.33	2200	1179.92	1181.76	1181.9	0.002681	2.94	0.42
Salt River	VaShly DS	2.31	Bridge						
Salt River	VaShly DS	2.29	2200	1170.86	1178.65	1178.66	0.00007	1.02	0.08
Salt River	VaShly DS	2.21	2200	1176	1178.54	1178.6	0.000773	2.03	0.24
Salt River	VaShly DS	2.13	2200	1175.43	1177.82	1178.06	0.003773	3.93	0.51
Salt River	VaShly DS	2.12	2200	1175.83	1177.11	1177.59	0.017858	5.54	0.99
Salt River	VaShly DS	2.1	2200	1158.27	1161.79	1162.52	0.02594	7.11	0.97
Salt River	VaShly DS	2.07	2200	1155.35	1157.6	1157.88	0.004316	4.22	0.54
Salt River	VaShly DS	2.04	2200	1153.78	1157.14	1157.26	0.00245	2.78	0.31
Salt River	VaShly DS	2.02	2200	1152.83	1157	1157.05	0.000731	1.91	0.18
Salt River	VaShly DS	1.95	2200	1153.57	1156.49	1156.62	0.002774	2.94	0.33
Salt River	VaShly DS	1.89	2200	1152.14	1155.93	1156	0.000826	2.1	0.19
Salt River	VaShly DS	1.86	2200	1148	1155.91	1155.92	0.000077	0.96	0.07
Salt River	VaShly DS	1.83	2200	1148	1155.87	1155.9	0.000256	1.43	0.11
Salt River	VaShly DS	1.8	2200	1147.44	1155.86	1155.87	0.000051	0.82	0.05
Salt River	VaShly DS	1.76	2200	1146.98	1155.85	1155.86	0.000026	0.82	0.05
Salt River	VaShly DS	1.65	2200	1144.47	1155.84	1155.85	0.000012	0.48	0.03
Salt River	VaShly DS	1.52	2200	1144	1155.84	1155.84	0.000005	0.3	0.02
Salt River	VaShly DS	1.39	2200	1146.14	1155.83	1155.83	0.00006	0.61	0.05
Salt River	VaShly DS	1.3	2200	1150.23	1155.78	1155.79	0.000102	0.96	0.08
Salt River	VaShly DS	1.22	2200	1150.27	1155.73	1155.75	0.00012	1.03	0.09
Salt River	VaShly DS	1.12	2200	1152	1155.65	1155.67	0.000168	1.14	0.11
Salt River	VaShly DS	1	2200	1148.57	1155.6	1155.61	0.000021	0.61	0.04
Salt River	VaShly DS	0.89	2200	1148	1155.59	1155.6	0.000023	0.7	0.05
Salt River	VaShly DS	0.78	2200	1152	1155.49	1155.56	0.000928	2.18	0.26
Salt River	VaShly DS	0.65	2200	1151.5	1155.16	1155.18	0.000175	1.05	0.12
Salt River	VaShly DS	0.51	2200	1152	1154.92	1154.97	0.00062	1.79	0.21
Salt River	VaShly DS	0.36	2200	1151.05	1154.35	1154.41	0.000839	1.95	0.24
Salt River	VaShly DS	0.23	2200	1150.96	1153.68	1153.74	0.001233	2.01	0.28
Salt River	VaShly DS	0.11	2200	1148	1153.21	1153.24	0.000305	1.44	0.15
Salt River	VaShly DS	0	2200	1148	1153.09	1153.1	0.000124	0.97	0.1

Exhibit G.2 Hydraulic Results, Alternative O (Model 9) for the 10-Year event.

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Ch
South Quarry Pit		0.83	24591.44	1248	1262.48	1263.04	0.005108	6.05	0.29
South Quarry Pit		0.77	24591.44	1244	1260.45	1261.18	0.006856	7.03	0.33
South Quarry Pit		0.71	24591.44	1239.17	1258.97	1259.47	0.003786	6.09	0.26
South Quarry Pit		0.68	24591.44	1233.05	1258.53	1258.89	0.002455	4.96	0.21
South Quarry Pit		0.64	24591.44	1230.33	1258.37	1258.55	0.00086	3.5	0.13
South Quarry Pit		0.6	24591.44	1230	1258.3	1258.39	0.000373	2.41	0.09
South Quarry Pit		0.57	24591.44	1225.78	1258.25	1258.32	0.000277	2.1	0.07
South Quarry Pit		0.53	24591.44	1230.95	1258.16	1258.25	0.000448	2.46	0.09
South Quarry Pit		0.47	24591.44	1244	1257.47	1257.96	0.00961	5.63	0.36
South Quarry Pit		0.42	24591.44	1224.75	1256.26	1256.38	0.000712	2.72	0.11
South Quarry Pit		0.4	24591.44	1220.72	1256.25	1256.3	0.000275	1.82	0.07
South Quarry Pit		0.37	24591.44	1230.18	1256.22	1256.26	0.000174	1.58	0.06
South Quarry Pit		0.31	24591.44	1221.68	1256.18	1256.21	0.000129	1.4	0.05
South Quarry Pit		0.24	24591.44	1221.31	1256.14	1256.16	0.000096	1.24	0.04
South Quarry Pit		0.15	24591.44	1229.55	1256.09	1256.12	0.00011	1.3	0.05
South Quarry Pit		0.08	24591.44	1221.16	1256.05	1256.08	0.00012	1.35	0.05
South Quarry Pit		0	24591.44	1229.85	1255.98	1256.02	0.000144	1.55	0.05
Salt River	VaShly US	13.64	60000	1288	1299.07	1299.87	0.001845	7.15	0.45
Salt River	VaShly US	13.55	60000	1288	1298.47	1299.09	0.001161	6.34	0.37
Salt River	VaShly US	13.44	60000	1284	1297.75	1298.39	0.001181	6.42	0.37
Salt River	VaShly US	13.31	60000	1281.3	1296.9	1297.58	0.001289	6.62	0.39
Salt River	VaShly US	13.19	60000	1284	1295.58	1296.49	0.002178	7.67	0.49
Salt River	VaShly US	13.07	60000	1276	1294.62	1295.32	0.001352	6.74	0.4
Salt River	VaShly US	12.97	60000	1280	1293.09	1294.33	0.003101	8.91	0.58
Salt River	VaShly US	12.87	60000	1276	1291.83	1292.98	0.001552	8.6	0.44
Salt River	VaShly US	12.77	60000	1276	1290.92	1292.08	0.001886	8.64	0.48
Salt River	VaShly US	12.67	60000	1276	1290.43	1291.14	0.001234	6.76	0.38
Salt River	VaShly US	12.55	60000	1276	1289.7	1290.42	0.001113	6.8	0.37
Salt River	VaShly US	12.44	60000	1276	1288.55	1289.54	0.002044	8	0.48
Salt River	VaShly US	12.33	60000	1272	1287.95	1288.61	0.000913	6.48	0.34
Salt River	VaShly US	12.22	60000	1272	1287.23	1287.95	0.001426	6.8	0.4
Salt River	VaShly US	12.1	60000	1272	1286.13	1286.9	0.002031	7.05	0.47
Salt River	VaShly US	12.06	60000	1268	1285.6	1286.38	0.002034	7.11	0.47
Salt River	VaShly US	11.99	60000	1268	1284.03	1285.29	0.004339	9.02	0.66
Salt River	VaShly US	11.88	60000	1267.94	1282.02	1283.11	0.003173	8.38	0.58
Salt River	VaShly US	11.78	60000	1268	1281.03	1281.72	0.001629	6.64	0.42
Salt River	VaShly US	11.62	60000	1264	1280.06	1280.54	0.00099	5.53	0.34
Salt River	VaShly US	11.49	60000	1263.04	1278.9	1279.7	0.001555	7.18	0.42
Salt River	VaShly US	11.41	60000	1260	1277.6	1278.81	0.002722	8.81	0.55
Salt River	VaShly US	11.32	60000	1260	1276.34	1277.58	0.002741	8.95	0.55
Salt River	VaShly US	11.25	60000	1256	1275.68	1276.6	0.001716	7.72	0.45
Salt River	VaShly US	11.17	60000	1256	1275.06	1275.92	0.001467	7.42	0.42

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly US	11.14	60000	1256	1274.6	1275.51	0.004454	7.66	0.43
Salt River	VaShly US	11.1	60000	1256	1274.32	1274.87	0.00067	5.93	0.29
Salt River	VaShly US	11.05	60000	1256	1274.32	1274.7	0.000377	4.98	0.23
Salt River	VaShly US	11	60000	1254.01	1274.29	1274.58	0.000231	4.35	0.18
Salt River	VaShly US	10.95	60000	1252	1274.31	1274.51	0.00014	3.58	0.14
Salt River	VaShly US	10.9	60000	1250.83	1274.27	1274.48	0.000139	3.64	0.14
Salt River	VaShly US	10.86	60000	1248	1274.23	1274.44	0.000134	3.67	0.14
Salt River	VaShly US	10.81	60000	1248	1274.23	1274.41	0.000096	3.38	0.12
Salt River	VaShly US	10.78	60000	1248	1274.2	1274.39	0.000097	3.42	0.12
Salt River	VaShly US	10.73	60000	1248	1274.16	1274.36	0.000106	3.58	0.13
Salt River	VaShly US	10.67	60000	1248	1274.03	1274.31	0.000175	4.23	0.16
Salt River	VaShly US	10.61	60000	1244.2	1273.98	1274.25	0.000154	4.21	0.16
Salt River	VaShly US	10.56	60000	1244	1273.95	1274.22	0.000145	4.16	0.15
Salt River	VaShly US	10.52	60000	1234.97	1273.99	1274.16	0.000073	3.33	0.11
Salt River	VaShly US	10.46	60000	1240	1273.9	1274.13	0.000132	3.84	0.14
Salt River	VaShly US	10.41	60000	1247.67	1273.91	1274.08	0.000097	3.39	0.12
Salt River	VaShly US	10.36	60000	1253	1273.45	1274	0.000704	5.97	0.3
Salt River	VaShly US	10.26	60000	1252	1273.34	1273.67	0.000317	4.61	0.21
Salt River	VaShly US	10.18	60000	1256	1272.52	1273.39	0.001603	7.45	0.43
Salt River	VaShly US	10.06	60000	1256	1271.79	1272.53	0.001098	7.12	0.37
Salt River	VaShly US	9.96	60000	1254.13	1271.29	1271.96	0.000854	6.78	0.33
Salt River	VaShly US	9.87	60000	1254.92	1271.02	1271.52	0.000842	5.91	0.29
Salt River	VaShly US	9.8	60000	1252	1270.76	1271.17	0.001028	5.51	0.26
Salt River	VaShly US	9.73	60000	1252	1270.64	1270.77	0.000837	3.19	0.15
Salt River	VaShly US	9.67	60000	1250.78	1270.47	1270.57	0.000521	2.87	0.13
Salt River	VaShly US	9.64	60000	1252	1270.3	1270.48	0.001007	3.86	0.17
Salt River	VaShly US	9.61	60000	1248.2	1270.22	1270.36	0.000673	3.4	0.14
Salt River	VaShly US	9.59	60000	1244.4	1270.17	1270.27	0.000464	2.93	0.12
Salt River	VaShly US	9.55	60000	1251.37	1270.01	1270.15	0.000752	3.03	0.15
Salt River	VaShly US	9.49	60000	1248	1269.66	1269.84	0.001011	3.43	0.17
Salt River	VaShly US	9.44	60000	1247.05	1269.28	1269.55	0.001426	4.19	0.2
Salt River	VaShly US	9.39	60000	1236	1268.4	1268.92	0.003474	5.76	0.3
Salt River	VaShly US	9.33	60000	1244	1267.41	1267.93	0.003502	5.8	0.31
Salt River	VaShly US	9.26	60000	1247.57	1266.06	1266.61	0.003674	5.95	0.31
Salt River	VaShly US	9.2	60000	1248	1264.54	1265.22	0.004754	6.59	0.36
Salt River	VaShly US	9.13	60000	1248	1262.22	1263.16	0.006087	8.29	0.41
Salt River	VaShly US 2	9.04	33408.56	1248	1262.03	1263.03	0.005012	8.04	0.45
Salt River	VaShly US 2	8.98	33408.56	1250.19	1260.78	1261.36	0.004798	6.11	0.43
Salt River	VaShly US 2	8.92	33408.56	1244	1260.2	1260.37	0.000901	3.27	0.18
Salt River	VaShly US 2	8.88	33408.56	1248	1259.96	1260.17	0.001319	3.72	0.23
Salt River	VaShly US 2	8.85	33408.56	1248	1259.65	1259.89	0.002122	3.95	0.27
Salt River	VaShly US 2	8.81	33408.56	1248	1259.11	1259.42	0.002277	4.45	0.29
Salt River	VaShly US 2	8.77	33408.56	1245.26	1258.71	1258.98	0.001921	4.15	0.27
Salt River	VaShly US 2	8.74	33408.56	1248	1258.26	1258.55	0.002787	4.34	0.31

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Ch
Salt River	VaShly US 2	8.68	33408.56	1245.3	1257.81	1258.05	0.000518	3.89	0.24
Salt River	VaShly US 2	8.63	33408.56	1244	1257.58	1257.87	0.000779	4.32	0.28
Salt River	VaShly US 2	8.6	33408.56	1244	1257.5	1257.76	0.000726	4.13	0.26
Salt River	VaShly US 2	8.57	33408.56	1244	1257.42	1257.65	0.000547	3.9	0.25
Salt River	VaShly US 2	8.52	33408.56	1240	1257.41	1257.5	0.000178	2.36	0.13
Salt River	VaShly US 2	8.44	33408.56	1240	1257.21	1257.4	0.000342	3.47	0.2
Salt River	VaShly US 2	8.36	33408.56	1244	1256.65	1257.1	0.002868	5.37	0.36
Salt River	VaShly US 2	8.29	33408.56	1240	1255.95	1256.39	0.00084	5.31	0.31
Salt River	VaShly US 2	8.2	33408.56	1240	1255.73	1256.03	0.000606	4.37	0.25
Salt River	VaShly DS	8.1	58000	1237.27	1255.8	1256	0.0002	3.57	0.17
Salt River	VaShly DS	8.01	58000	1240	1255.35	1255.83	0.000872	5.56	0.32
Salt River	VaShly DS	7.91	58000	1244	1254.16	1255.12	0.002369	8.06	0.5
Salt River	VaShly DS	7.83	58000	1244	1253.15	1254.07	0.002377	7.7	0.48
Salt River	VaShly DS	7.71	58000	1243.41	1250.22	1251.92	0.005624	10.47	0.76
Salt River	VaShly DS	7.63	58000	1240	1248.81	1249.8	0.002511	8	0.52
Salt River	VaShly DS	7.55	58000	1239.6	1248.3	1248.88	0.001356	6.09	0.39
Salt River	VaShly DS	7.47	58000	1239.83	1247.51	1248.21	0.001968	6.71	0.45
Salt River	VaShly DS	7.45	Bridge						
Salt River	VaShly DS	7.44	58000	1238.53	1247.07	1247.69	0.001757	6.35	0.42
Salt River	VaShly DS	7.4	58000	1239.06	1246.64	1247.3	0.002041	6.52	0.46
Salt River	VaShly DS	7.36	58000	1238.07	1246.35	1246.89	0.001685	5.94	0.42
Salt River	VaShly DS	7.32	58000	1240	1245.91	1246.5	0.002222	6.2	0.47
Salt River	VaShly DS	7.28	58000	1236	1244.51	1245.8	0.006911	9.13	0.77
Salt River	VaShly DS	7.24	58000	1235.58	1241.71	1243.61	0.011253	11.05	1
Salt River	VaShly DS	7.17	58000	1197.93	1227.55	1227.6	0.000055	1.78	0.09
Salt River	VaShly DS	7.1	58000	1206.84	1227.53	1227.58	0.000047	1.8	0.08
Salt River	VaShly DS	7.03	58000	1210.44	1227.44	1227.55	0.000107	2.59	0.12
Salt River	VaShly DS	6.99	58000	1200	1227.48	1227.52	0.00002	1.55	0.06
Salt River	VaShly DS	6.91	58000	1198.45	1227.45	1227.5	0.000042	1.8	0.08
Salt River	VaShly DS	6.8	58000	1196	1227.43	1227.48	0.000033	1.87	0.07
Salt River	VaShly DS	6.69	58000	1197.62	1227.33	1227.45	0.000106	2.78	0.12
Salt River	VaShly DS	6.56	58000	1188.55	1227.33	1227.38	0.000027	1.74	0.06
Salt River	VaShly DS	6.5	58000	1192.83	1227.28	1227.36	0.000056	2.36	0.09
Salt River	VaShly DS	6.45	58000	1180	1227.31	1227.33	0.000008	1.1	0.04
Salt River	VaShly DS	6.4	58000	1196	1227.3	1227.33	0.000013	1.37	0.05
Salt River	VaShly DS	6.38	58000	1195.4	1227.22	1227.32	0.000062	2.35	0.09
Salt River	VaShly DS	6.35	58000	1194.53	1226.93	1227.28	0.000234	4.69	0.19
Salt River	VaShly DS	6.32	58000	1192	1226.94	1227.24	0.000192	4.39	0.17
Salt River	VaShly DS	6.27	58000	1194.49	1226.94	1227.16	0.000177	3.72	0.16
Salt River	VaShly DS	6.22	58000	1203.46	1226.26	1227.03	0.001117	7	0.37
Salt River	VaShly DS	6.18	58000	1192	1226.36	1226.76	0.000517	5.04	0.26
Salt River	VaShly DS	6.14	58000	1196	1226.46	1226.61	0.000127	3.19	0.13
Salt River	VaShly DS	6.09	58000	1200	1226.35	1226.57	0.00021	3.8	0.17
Salt River	VaShly DS	6.05	58000	1204	1226.08	1226.48	0.000435	5.05	0.24

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly DS	6.01	58000	1204	1225.77	1226.31	0.020786	5.9	0.29
Salt River	VaShly DS	5.99	58000	1200	1224.81	1225.19	0.000634	4.96	0.23
Salt River	VaShly DS	5.97	58000	1198.59	1224.79	1225.12	0.00041	4.62	0.21
Salt River	VaShly DS	5.95	58000	1196	1224.79	1225.05	0.000296	4.07	0.18
Salt River	VaShly DS	5.93	58000	1198.79	1224.78	1225.02	0.000374	3.94	0.18
Salt River	VaShly DS	5.91	58000	1203.31	1224.57	1224.94	0.001229	4.85	0.25
Salt River	VaShly DS	5.88	58000	1209.96	1223.87	1224.58	0.005431	6.76	0.48
Salt River	VaShly DS	5.87	58000	1206.22	1223.73	1224.34	0.00391	6.25	0.4
Salt River	VaShly DS	5.86	58000	1205.11	1223.51	1224.12	0.00487	6.27	0.36
Salt River	VaShly DS	5.85	58000	1208	1223.41	1223.86	0.002561	5.39	0.28
Salt River	VaShly DS	5.84	58000	1204	1223.19	1223.68	0.002797	5.61	0.29
Salt River	VaShly DS	5.82	58000	1204	1223	1223.44	0.001603	5.32	0.27
Salt River	VaShly DS	5.8	58000	1204	1222.83	1223.28	0.001643	5.36	0.27
Salt River	VaShly DS	5.76	58000	1204	1222.45	1223.04	0.000865	6.17	0.33
Salt River	VaShly DS	5.73	58000	1208	1221.92	1222.79	0.001455	7.46	0.42
Salt River	VaShly DS	5.69	58000	1206.01	1221.96	1222.52	0.000708	6.01	0.3
Salt River	VaShly DS	5.65	58000	1198.67	1222.03	1222.34	0.000258	4.43	0.19
Salt River	VaShly DS	5.6	58000	1194.35	1222.09	1222.24	0.000132	3.08	0.12
Salt River	VaShly DS	5.56	58000	1208	1221.41	1222.13	0.001986	6.79	0.38
Salt River	VaShly DS	5.53	58000	1192	1221.44	1221.74	0.000879	4.39	0.2
Salt River	VaShly DS	5.47	58000	1208	1220.43	1221.24	0.008791	7.26	0.44
Salt River	VaShly DS	5.4	58000	1196	1218.7	1219.29	0.000727	6.19	0.3
Salt River	VaShly DS	5.26	58000	1179.01	1218.43	1218.73	0.000576	4.47	0.2
Salt River	VaShly DS	5.15	58000	1204	1217.51	1218.16	0.002534	6.57	0.37
Salt River	VaShly DS	5.03	58000	1204	1215.53	1216.3	0.003309	7.13	0.42
Salt River	VaShly DS	4.88	58000	1200	1212.3	1213.77	0.003005	9.78	0.59
Salt River	VaShly DS	4.74	58000	1188	1211.85	1212.17	0.000411	4.51	0.21
Salt River	VaShly DS	4.59	58000	1192	1211.31	1211.72	0.000828	5.13	0.29
Salt River	VaShly DS	4.47	58000	1200	1210.47	1210.92	0.002007	5.88	0.4
Salt River	VaShly DS	4.31	58000	1199.24	1207.27	1208.19	0.008414	7.95	0.56
Salt River	VaShly DS	4.27	58000	1192	1206.55	1207.03	0.000991	5.56	0.34
Salt River	VaShly DS	4.22	58000	1178.19	1206.51	1206.78	0.000408	4.02	0.22
Salt River	VaShly DS	4.15	58000	1184	1206.17	1206.58	0.000818	5.13	0.31
Salt River	VaShly DS	4.09	58000	1188	1206.01	1206.31	0.000654	4.31	0.27
Salt River	VaShly DS	4.04	58000	1184	1205.98	1206.15	0.000227	3.28	0.17
Salt River	VaShly DS	3.89	58000	1174.66	1205.93	1206.01	0.00006	2.31	0.1
Salt River	VaShly DS	3.76	58000	1188	1205.36	1205.89	0.000889	5.82	0.33
Salt River	VaShly DS	3.64	58000	1192	1203.68	1204.94	0.002998	9.04	0.57
Salt River	VaShly DS	3.5	58000	1186.84	1202.49	1203.17	0.001257	6.62	0.38
Salt River	VaShly DS	3.48	Bridge						
Salt River	VaShly DS	3.46	58000	1184	1202.34	1202.83	0.000801	5.62	0.32
Salt River	VaShly DS	3.35	58000	1188	1201.41	1202.16	0.001754	6.92	0.39
Salt River	VaShly DS	3.23	58000	1183.78	1199.62	1200.78	0.002796	8.64	0.48
Salt River	VaShly DS	3.1	58000	1173.54	1198.46	1199.24	0.00126	7.09	0.34

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Ch
Salt River	VaShly DS	2.98	58000	1179.21	1197.83	1198.55	0.00099	6.79	0.3
Salt River	VaShly DS	2.87	58000	1175.62	1197.39	1198.01	0.000703	6.34	0.34
Salt River	VaShly DS	2.78	58000	1185.67	1196.87	1197.52	0.001528	6.48	0.4
Salt River	VaShly DS	2.71	58000	1185.2	1196.46	1197.05	0.001295	6.16	0.36
Salt River	VaShly DS	2.65	58000	1184.02	1195.73	1196.51	0.001672	7.08	0.41
Salt River	VaShly DS	2.59	58000	1183.07	1195	1195.94	0.002095	7.79	0.48
Salt River	VaShly DS	2.53	58000	1182.76	1194.43	1195.25	0.001859	7.25	0.46
Salt River	VaShly DS	2.47	58000	1180.75	1193.28	1194.19	0.015537	7.66	0.47
Salt River	VaShly DS	2.42	58000	1175.84	1191.41	1191.95	0.000814	5.89	0.32
Salt River	VaShly DS	2.41	58000	1175.97	1191.27	1191.9	0.001053	6.39	0.36
Salt River	VaShly DS	2.4	58000	1176.34	1191.08	1191.84	0.001418	7	0.41
Salt River	VaShly DS	2.38	58000	1176.14	1190.91	1191.64	0.001292	6.83	0.39
Salt River	VaShly DS	2.33	58000	1179.92	1189.83	1191.16	0.003502	9.27	0.61
Salt River	VaShly DS	2.31	Bridge						
Salt River	VaShly DS	2.29	58000	1170.86	1188.04	1188.79	0.0013	6.91	0.39
Salt River	VaShly DS	2.21	58000	1176	1185.7	1187.8	0.004356	11.62	0.7
Salt River	VaShly DS	2.13	58000	1175.43	1184.59	1185.98	0.003421	9.46	0.61
Salt River	VaShly DS	2.12	58000	1175.83	1183.01	1185.3	0.006805	12.15	0.85
Salt River	VaShly DS	2.1	58000	1158.27	1171.52	1173.14	0.008015	10.52	0.81
Salt River	VaShly DS	2.07	58000	1155.35	1171.35	1172.21	0.001932	7.59	0.47
Salt River	VaShly DS	2.04	58000	1153.78	1171.33	1171.86	0.001132	5.91	0.32
Salt River	VaShly DS	2.02	58000	1152.83	1171.29	1171.72	0.000795	5.31	0.26
Salt River	VaShly DS	1.95	58000	1153.57	1171	1171.42	0.000848	5.15	0.27
Salt River	VaShly DS	1.89	58000	1152.14	1170.57	1171	0.002245	5.28	0.29
Salt River	VaShly DS	1.86	58000	1148	1170.19	1170.64	0.002775	5.41	0.31
Salt River	VaShly DS	1.83	58000	1148	1169.48	1170.12	0.003036	6.44	0.39
Salt River	VaShly DS	1.8	58000	1147.44	1169.33	1169.65	0.001447	4.55	0.25
Salt River	VaShly DS	1.76	58000	1146.98	1169.2	1169.41	0.000636	3.64	0.18
Salt River	VaShly DS	1.65	58000	1144.47	1168.99	1169.14	0.000255	3.18	0.16
Salt River	VaShly DS	1.52	58000	1144	1168.83	1168.97	0.000226	3.03	0.13
Salt River	VaShly DS	1.39	58000	1146.14	1168.59	1168.75	0.000538	3.23	0.15
Salt River	VaShly DS	1.3	58000	1150.23	1168.23	1168.45	0.000699	3.84	0.2
Salt River	VaShly DS	1.22	58000	1150.27	1167.93	1168.15	0.000761	3.82	0.2
Salt River	VaShly DS	1.12	58000	1152	1167.38	1167.67	0.000998	4.31	0.23
Salt River	VaShly DS	1	58000	1148.57	1166.91	1167.14	0.000695	3.87	0.2
Salt River	VaShly DS	0.89	58000	1148	1166.51	1166.81	0.000462	4.41	0.24
Salt River	VaShly DS	0.78	58000	1152	1166.07	1166.46	0.0007	5.06	0.29
Salt River	VaShly DS	0.65	58000	1151.5	1165.78	1166.06	0.000384	4.25	0.22
Salt River	VaShly DS	0.51	58000	1152	1165.41	1165.74	0.000485	4.57	0.24
Salt River	VaShly DS	0.36	58000	1151.05	1165	1165.34	0.000521	4.7	0.25
Salt River	VaShly DS	0.23	58000	1150.96	1164.68	1165	0.000473	4.57	0.24
Salt River	VaShly DS	0.11	58000	1148	1164.29	1164.67	0.000569	4.9	0.26
Salt River	VaShly DS	0	58000	1148	1164.04	1164.36	0.000401	4.54	0.23

Exhibit G.3 Hydraulic Results, Alternative O (Model 9) for the 100-Year event.

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
South Quarry Pit		0.83	60810.77	1248	1271.65	1272.83	0.005442	8.8	0.33
South Quarry Pit		0.77	60810.77	1244	1269.18	1270.78	0.00764	10.31	0.38
South Quarry Pit		0.71	60810.77	1239.17	1267.58	1268.71	0.004918	9.07	0.31
South Quarry Pit		0.68	60810.77	1233.05	1267.01	1267.9	0.003673	7.83	0.27
South Quarry Pit		0.64	60810.77	1230.33	1266.8	1267.32	0.001708	6.04	0.19
South Quarry Pit		0.6	60810.77	1230	1266.72	1266.98	0.000781	4.24	0.13
South Quarry Pit		0.57	60810.77	1225.78	1266.61	1266.83	0.000637	3.84	0.12
South Quarry Pit		0.53	60810.77	1230.95	1266.37	1266.67	0.000969	4.43	0.14
South Quarry Pit		0.47	60810.77	1244	1265.46	1266.16	0.005339	6.72	0.3
South Quarry Pit		0.42	60810.77	1224.75	1264.78	1265.1	0.001273	4.56	0.16
South Quarry Pit		0.4	60810.77	1220.72	1264.78	1264.94	0.000548	3.21	0.1
South Quarry Pit		0.37	60810.77	1230.18	1264.73	1264.85	0.000377	2.86	0.09
South Quarry Pit		0.31	60810.77	1221.68	1264.65	1264.75	0.000294	2.56	0.08
South Quarry Pit		0.24	60810.77	1221.31	1264.56	1264.64	0.000228	2.3	0.07
South Quarry Pit		0.15	60810.77	1229.55	1264.45	1264.54	0.000251	2.38	0.07
South Quarry Pit		0.08	60810.77	1221.16	1264.34	1264.44	0.000279	2.5	0.08
South Quarry Pit		0	60810.77	1229.85	1264.17	1264.3	0.000352	2.91	0.09
Salt River	VaShly US	13.64	175000	1288	1306.99	1308.6	0.001536	10.17	0.46
Salt River	VaShly US	13.55	175000	1288	1306.41	1307.88	0.001284	9.76	0.43
Salt River	VaShly US	13.44	175000	1284	1305.53	1307.09	0.001344	10.01	0.44
Salt River	VaShly US	13.31	175000	1281.3	1304.54	1306.14	0.001566	10.15	0.46
Salt River	VaShly US	13.19	175000	1284	1303.47	1305.04	0.001771	10.07	0.48
Salt River	VaShly US	13.07	175000	1276	1302.66	1303.98	0.001361	9.21	0.43
Salt River	VaShly US	12.97	175000	1280	1301.64	1303.2	0.001722	10	0.48
Salt River	VaShly US	12.87	175000	1276	1300.58	1302.17	0.001857	10.12	0.49
Salt River	VaShly US	12.77	175000	1276	1299.28	1301.17	0.001846	11.03	0.5
Salt River	VaShly US	12.67	175000	1276	1298.57	1300.26	0.001437	10.41	0.45
Salt River	VaShly US	12.55	175000	1276	1297.48	1299.31	0.001632	10.83	0.48
Salt River	VaShly US	12.44	175000	1276	1295.68	1298.09	0.00247	12.48	0.58
Salt River	VaShly US	12.33	175000	1272	1294.69	1296.82	0.001748	11.72	0.5
Salt River	VaShly US	12.22	175000	1272	1293.69	1295.69	0.001975	11.35	0.52
Salt River	VaShly US	12.1	175000	1272	1292.7	1294.36	0.001969	10.34	0.51
Salt River	VaShly US	12.06	175000	1268	1292.38	1293.83	0.001738	9.65	0.48
Salt River	VaShly US	11.99	175000	1268	1291.28	1293.04	0.002381	10.65	0.55
Salt River	VaShly US	11.88	175000	1267.94	1289.92	1291.77	0.002087	10.9	0.52
Salt River	VaShly US	11.78	175000	1268	1289.44	1290.73	0.001182	9.15	0.41
Salt River	VaShly US	11.62	175000	1264	1288.84	1289.77	0.000824	7.75	0.34
Salt River	VaShly US	11.49	175000	1263.04	1287.7	1289.06	0.001294	9.37	0.42
Salt River	VaShly US	11.41	175000	1260	1286.98	1288.43	0.001625	9.65	0.46
Salt River	VaShly US	11.32	175000	1260	1286.33	1287.74	0.001351	9.81	0.43
Salt River	VaShly US	11.25	175000	1256	1285.68	1287.22	0.001171	10.17	0.41
Salt River	VaShly US	11.17	175000	1256	1285.1	1286.73	0.00116	10.34	0.41

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly US	11.14	175000	1256	1284.71	1286.41	0.003522	10.51	0.42
Salt River	VaShly US	11.1	175000	1256	1284.47	1285.86	0.00082	9.47	0.36
Salt River	VaShly US	11.05	175000	1256	1284.5	1285.63	0.000587	8.53	0.31
Salt River	VaShly US	11	175000	1254.01	1284.43	1285.43	0.00045	8.01	0.27
Salt River	VaShly US	10.95	175000	1252	1284.54	1285.24	0.0003	6.72	0.22
Salt River	VaShly US	10.9	175000	1250.83	1284.43	1285.17	0.000313	6.9	0.23
Salt River	VaShly US	10.86	175000	1248	1284.3	1285.09	0.000316	7.12	0.23
Salt River	VaShly US	10.81	175000	1248	1284.28	1285	0.000263	6.83	0.21
Salt River	VaShly US	10.78	175000	1248	1284.2	1284.94	0.00028	6.93	0.22
Salt River	VaShly US	10.73	175000	1248	1284.05	1284.87	0.000294	7.29	0.23
Salt River	VaShly US	10.67	175000	1248	1283.65	1284.73	0.000437	8.36	0.27
Salt River	VaShly US	10.61	175000	1244.2	1283.45	1284.58	0.000427	8.56	0.27
Salt River	VaShly US	10.56	175000	1244	1283.32	1284.48	0.000423	8.63	0.27
Salt River	VaShly US	10.52	175000	1234.97	1283.53	1284.28	0.000238	7.04	0.21
Salt River	VaShly US	10.46	175000	1240	1283.45	1284.19	0.0003	7.17	0.23
Salt River	VaShly US	10.41	175000	1247.67	1283.41	1284.1	0.000253	6.76	0.21
Salt River	VaShly US	10.36	175000	1253	1282.61	1283.94	0.000848	9.4	0.36
Salt River	VaShly US	10.26	175000	1252	1282.43	1283.5	0.000572	8.31	0.3
Salt River	VaShly US	10.18	175000	1256	1281.17	1283.05	0.001562	10.98	0.47
Salt River	VaShly US	10.06	175000	1256	1280.94	1282.09	0.000867	9.24	0.36
Salt River	VaShly US	9.96	175000	1254.13	1280.37	1281.6	0.00084	9.57	0.36
Salt River	VaShly US	9.87	175000	1254.92	1280.04	1281.16	0.000957	8.97	0.34
Salt River	VaShly US	9.8	175000	1252	1279.92	1280.7	0.001046	7.77	0.28
Salt River	VaShly US	9.73	175000	1252	1279.96	1280.22	0.000776	4.39	0.16
Salt River	VaShly US	9.67	175000	1250.78	1279.85	1280	0.000455	3.64	0.13
Salt River	VaShly US	9.64	175000	1252	1279.74	1279.93	0.000649	4.27	0.15
Salt River	VaShly US	9.61	175000	1248.2	1279.67	1279.85	0.00057	4.2	0.14
Salt River	VaShly US	9.59	175000	1244.4	1279.47	1279.75	0.000701	4.75	0.16
Salt River	VaShly US	9.55	175000	1251.37	1279.43	1279.59	0.000536	3.66	0.14
Salt River	VaShly US	9.49	175000	1248	1278.77	1279.3	0.001414	5.8	0.22
Salt River	VaShly US	9.44	175000	1247.05	1278.01	1278.85	0.002303	7.38	0.28
Salt River	VaShly US	9.39	175000	1236	1277.74	1278.18	0.001734	6.11	0.24
Salt River	VaShly US	9.33	175000	1244	1277.23	1277.69	0.001742	6.17	0.24
Salt River	VaShly US	9.26	175000	1247.57	1275.53	1276.76	0.003703	9.01	0.35
Salt River	VaShly US	9.2	175000	1248	1273.63	1275.28	0.005142	10.34	0.41
Salt River	VaShly US	9.13	175000	1248	1270.82	1272.96	0.007066	12.36	0.48
Salt River	VaShly US 2	9.04	111189.2	1248	1269.33	1272.82	0.008424	15.08	0.64
Salt River	VaShly US 2	8.98	111189.2	1250.19	1269.04	1270.2	0.003813	8.67	0.4
Salt River	VaShly US 2	8.92	111189.2	1244	1268.76	1269.24	0.001172	5.63	0.23
Salt River	VaShly US 2	8.88	111189.2	1248	1268.47	1269	0.001425	5.91	0.26
Salt River	VaShly US 2	8.85	111189.2	1248	1268.28	1268.73	0.001508	5.4	0.25
Salt River	VaShly US 2	8.81	111189.2	1248	1267.63	1268.34	0.001909	6.78	0.3
Salt River	VaShly US 2	8.77	111189.2	1245.26	1267.34	1267.95	0.001618	6.25	0.28
Salt River	VaShly US 2	8.74	111189.2	1248	1267.09	1267.62	0.001716	5.84	0.27

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly US 2	8.68	111189.2	1245.3	1266.73	1267.29	0.000482	6.02	0.26
Salt River	VaShly US 2	8.63	111189.2	1244	1266.48	1267.13	0.000601	6.46	0.28
Salt River	VaShly US 2	8.6	111189.2	1244	1266.42	1267.04	0.000626	6.36	0.27
Salt River	VaShly US 2	8.57	111189.2	1244	1266.42	1266.92	0.000454	5.67	0.25
Salt River	VaShly US 2	8.52	111189.2	1240	1266.5	1266.75	0.000216	4.02	0.16
Salt River	VaShly US 2	8.44	111189.2	1240	1266.11	1266.61	0.000407	5.68	0.24
Salt River	VaShly US 2	8.36	111189.2	1244	1265.64	1266.29	0.002595	6.48	0.31
Salt River	VaShly US 2	8.29	111189.2	1240	1264.4	1265.19	0.003124	7.12	0.35
Salt River	VaShly US 2	8.2	111189.2	1240	1263.44	1264.26	0.001103	7.48	0.32
Salt River	VaShly DS	8.1	172000	1237.27	1263.5	1264.24	0.000425	6.91	0.26
Salt River	VaShly DS	8.01	172000	1240	1262.55	1263.91	0.001149	9.34	0.4
Salt River	VaShly DS	7.91	172000	1244	1260.56	1262.96	0.002772	12.61	0.59
Salt River	VaShly DS	7.83	172000	1244	1259.53	1261.7	0.002635	12	0.56
Salt River	VaShly DS	7.71	172000	1243.41	1255.85	1259.42	0.005117	15.4	0.8
Salt River	VaShly DS	7.63	172000	1240	1254.55	1257.18	0.003209	13.06	0.65
Salt River	VaShly DS	7.55	172000	1239.6	1254.22	1255.82	0.001847	10.16	0.49
Salt River	VaShly DS	7.47	172000	1239.83	1253.04	1254.92	0.002585	11.01	0.55
Salt River	VaShly DS	7.45	Bridge						
Salt River	VaShly DS	7.44	172000	1238.53	1252.06	1253.96	0.002823	11.06	0.56
Salt River	VaShly DS	7.4	172000	1239.06	1251.66	1253.35	0.002433	10.53	0.55
Salt River	VaShly DS	7.36	172000	1238.07	1251.64	1252.77	0.001655	8.75	0.46
Salt River	VaShly DS	7.32	172000	1240	1251.12	1252.4	0.001981	9.16	0.49
Salt River	VaShly DS	7.28	172000	1236	1248.88	1251.67	0.006182	13.43	0.81
Salt River	VaShly DS	7.24	172000	1235.58	1245.75	1249.65	0.01012	15.85	1
Salt River	VaShly DS	7.17	172000	1197.93	1238.5	1238.63	0.000068	2.89	0.1
Salt River	VaShly DS	7.1	172000	1206.84	1238.45	1238.6	0.000072	3.08	0.11
Salt River	VaShly DS	7.03	172000	1210.44	1238.26	1238.55	0.000159	4.27	0.16
Salt River	VaShly DS	6.99	172000	1200	1238.34	1238.49	0.000055	3.09	0.1
Salt River	VaShly DS	6.91	172000	1198.45	1238.36	1238.44	0.000041	2.43	0.08
Salt River	VaShly DS	6.8	172000	1196	1238.2	1238.4	0.000076	3.63	0.12
Salt River	VaShly DS	6.69	172000	1197.62	1237.95	1238.32	0.000182	4.93	0.17
Salt River	VaShly DS	6.56	172000	1188.55	1237.99	1238.18	0.000066	3.48	0.11
Salt River	VaShly DS	6.5	172000	1192.83	1238.03	1238.13	0.000043	2.63	0.09
Salt River	VaShly DS	6.45	172000	1180	1238.04	1238.12	0.000024	2.32	0.07
Salt River	VaShly DS	6.4	172000	1196	1237.98	1238.11	0.000039	2.9	0.08
Salt River	VaShly DS	6.38	172000	1195.4	1237.7	1238.08	0.000144	4.69	0.15
Salt River	VaShly DS	6.35	172000	1194.53	1236.65	1237.94	0.000567	9.16	0.31
Salt River	VaShly DS	6.32	172000	1192	1236.68	1237.84	0.000485	8.68	0.29
Salt River	VaShly DS	6.27	172000	1194.49	1236.86	1237.59	0.000349	6.89	0.24
Salt River	VaShly DS	6.22	172000	1203.46	1236.82	1237.47	0.000377	6.52	0.24
Salt River	VaShly DS	6.18	172000	1192	1236.75	1237.4	0.000375	6.55	0.24
Salt River	VaShly DS	6.14	172000	1196	1236.78	1237.28	0.000229	5.74	0.19
Salt River	VaShly DS	6.09	172000	1200	1236.53	1237.2	0.000336	6.65	0.23
Salt River	VaShly DS	6.05	172000	1204	1236.26	1237.08	0.000489	7.27	0.27

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly DS	6.01	172000	1204	1235.84	1236.88	0.023402	8.19	0.33
Salt River	VaShly DS	5.99	172000	1200	1234.85	1235.58	0.000831	6.84	0.27
Salt River	VaShly DS	5.97	172000	1198.59	1234.76	1235.5	0.000662	6.9	0.27
Salt River	VaShly DS	5.95	172000	1196	1234.8	1235.37	0.000493	6.1	0.23
Salt River	VaShly DS	5.93	172000	1198.79	1234.83	1235.3	0.000461	5.57	0.21
Salt River	VaShly DS	5.91	172000	1203.31	1234.74	1235.23	0.000802	5.64	0.22
Salt River	VaShly DS	5.88	172000	1209.96	1234.33	1235.05	0.001521	6.85	0.3
Salt River	VaShly DS	5.87	172000	1206.22	1234.05	1234.93	0.001888	7.54	0.32
Salt River	VaShly DS	5.86	172000	1205.11	1233.58	1234.78	0.0039	8.76	0.36
Salt River	VaShly DS	5.85	172000	1208	1233.46	1234.55	0.002762	8.36	0.32
Salt River	VaShly DS	5.84	172000	1204	1233.16	1234.35	0.003081	8.76	0.34
Salt River	VaShly DS	5.82	172000	1204	1232.93	1234.09	0.001926	8.62	0.33
Salt River	VaShly DS	5.8	172000	1204	1232.68	1233.88	0.002052	8.79	0.33
Salt River	VaShly DS	5.76	172000	1204	1232.13	1233.58	0.000967	9.67	0.38
Salt River	VaShly DS	5.73	172000	1208	1231.33	1233.29	0.001479	11.26	0.46
Salt River	VaShly DS	5.69	172000	1206.01	1231.44	1232.96	0.000968	9.89	0.39
Salt River	VaShly DS	5.65	172000	1198.67	1231.67	1232.57	0.000888	7.65	0.28
Salt River	VaShly DS	5.6	172000	1194.35	1231.71	1232.31	0.000337	6.24	0.2
Salt River	VaShly DS	5.56	172000	1208	1230.47	1232.09	0.002464	10.21	0.43
Salt River	VaShly DS	5.53	172000	1192	1230.57	1231.51	0.001589	7.78	0.29
Salt River	VaShly DS	5.47	172000	1208	1228.97	1230.7	0.007394	10.6	0.46
Salt River	VaShly DS	5.4	172000	1196	1227.23	1228.99	0.001266	10.7	0.43
Salt River	VaShly DS	5.26	172000	1179.01	1227.01	1227.89	0.001043	7.87	0.28
Salt River	VaShly DS	5.15	172000	1204	1225.52	1226.96	0.0027	10.05	0.42
Salt River	VaShly DS	5.03	172000	1204	1223.7	1225.11	0.003027	10.07	0.43
Salt River	VaShly DS	4.88	172000	1200	1220.11	1222.53	0.003392	12.82	0.66
Salt River	VaShly DS	4.74	172000	1188	1219.57	1220.55	0.000802	8.1	0.34
Salt River	VaShly DS	4.59	172000	1192	1218.89	1219.82	0.000975	8.01	0.34
Salt River	VaShly DS	4.47	172000	1200	1218.21	1219.01	0.001396	7.9	0.37
Salt River	VaShly DS	4.31	172000	1199.24	1215.62	1217.17	0.004517	10.27	0.48
Salt River	VaShly DS	4.27	172000	1192	1215.45	1216.41	0.000795	7.92	0.34
Salt River	VaShly DS	4.22	172000	1178.19	1215.47	1216.15	0.00047	6.48	0.26
Salt River	VaShly DS	4.15	172000	1184	1215.09	1215.95	0.000687	7.44	0.31
Salt River	VaShly DS	4.09	172000	1188	1215.09	1215.68	0.000475	6.06	0.26
Salt River	VaShly DS	4.04	172000	1184	1215.13	1215.51	0.00028	4.93	0.2
Salt River	VaShly DS	3.89	172000	1174.66	1215.02	1215.32	0.000137	4.44	0.15
Salt River	VaShly DS	3.76	172000	1188	1214	1215.08	0.000922	8.36	0.36
Salt River	VaShly DS	3.64	172000	1192	1212.78	1214.27	0.001795	9.78	0.48
Salt River	VaShly DS	3.5	172000	1186.84	1212.16	1213.13	0.000821	7.91	0.34
Salt River	VaShly DS	3.48	Bridge						
Salt River	VaShly DS	3.46	172000	1184	1212	1212.85	0.000727	7.43	0.31
Salt River	VaShly DS	3.35	172000	1188	1210.53	1212.17	0.001698	10.28	0.43
Salt River	VaShly DS	3.23	172000	1183.78	1208.71	1210.86	0.002519	11.79	0.52
Salt River	VaShly DS	3.1	172000	1173.54	1207.29	1209.16	0.002068	10.97	0.48

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly DS	2.98	172000	1179.21	1206.8	1208.03	0.001057	8.92	0.35
Salt River	VaShly DS	2.87	172000	1175.62	1205.6	1207.32	0.001176	10.52	0.44
Salt River	VaShly DS	2.78	172000	1185.67	1205.15	1206.55	0.001539	9.5	0.42
Salt River	VaShly DS	2.71	172000	1185.2	1204.64	1206.06	0.001484	9.58	0.41
Salt River	VaShly DS	2.65	172000	1184.02	1203.37	1205.36	0.00228	11.34	0.5
Salt River	VaShly DS	2.59	172000	1183.07	1202.58	1204.71	0.002063	11.71	0.53
Salt River	VaShly DS	2.53	172000	1182.76	1202.17	1203.99	0.001695	10.82	0.49
Salt River	VaShly DS	2.47	172000	1180.75	1200.89	1203	0.015677	11.65	0.53
Salt River	VaShly DS	2.42	172000	1175.84	1199.05	1200.63	0.001235	10.11	0.42
Salt River	VaShly DS	2.41	172000	1175.97	1198.8	1200.56	0.001463	10.66	0.46
Salt River	VaShly DS	2.4	172000	1176.34	1198.49	1200.47	0.001777	11.29	0.5
Salt River	VaShly DS	2.38	172000	1176.14	1198.28	1200.21	0.001755	11.13	0.49
Salt River	VaShly DS	2.33	172000	1179.92	1196.62	1199.59	0.003357	13.83	0.67
Salt River	VaShly DS	2.31	Bridge						
Salt River	VaShly DS	2.29	172000	1170.86	1194.2	1196.57	0.002274	12.37	0.56
Salt River	VaShly DS	2.21	172000	1176	1193.04	1195.54	0.002547	12.68	0.59
Salt River	VaShly DS	2.13	172000	1175.43	1190.68	1194.12	0.004276	14.88	0.74
Salt River	VaShly DS	2.12	172000	1175.83	1188.38	1193.56	0.007589	18.26	1
Salt River	VaShly DS	2.1	172000	1158.27	1181.99	1183.71	0.001871	10.7	0.48
Salt River	VaShly DS	2.07	172000	1155.35	1182	1183.4	0.001088	9.65	0.4
Salt River	VaShly DS	2.04	172000	1153.78	1182.05	1183.13	0.000997	8.41	0.33
Salt River	VaShly DS	2.02	172000	1152.83	1181.88	1183.01	0.000969	8.59	0.31
Salt River	VaShly DS	1.95	172000	1153.57	1181.65	1182.62	0.000916	7.94	0.3
Salt River	VaShly DS	1.89	172000	1152.14	1181.35	1182.18	0.001657	7.33	0.29
Salt River	VaShly DS	1.86	172000	1148	1181.1	1181.93	0.001851	7.34	0.29
Salt River	VaShly DS	1.83	172000	1148	1180.66	1181.59	0.001986	7.77	0.33
Salt River	VaShly DS	1.8	172000	1147.44	1180.62	1181.24	0.001114	6.35	0.25
Salt River	VaShly DS	1.76	172000	1146.98	1180.57	1181.02	0.000596	5.41	0.2
Salt River	VaShly DS	1.65	172000	1144.47	1180.39	1180.73	0.000307	4.7	0.17
Salt River	VaShly DS	1.52	172000	1144	1180.06	1180.49	0.000367	5.27	0.18
Salt River	VaShly DS	1.39	172000	1146.14	1179.72	1180.16	0.000676	5.32	0.19
Salt River	VaShly DS	1.3	172000	1150.23	1179.33	1179.84	0.000641	5.75	0.22
Salt River	VaShly DS	1.22	172000	1150.27	1179.05	1179.56	0.00071	5.74	0.21
Salt River	VaShly DS	1.12	172000	1152	1178.55	1179.14	0.000795	6.18	0.24
Salt River	VaShly DS	1	172000	1148.57	1178.14	1178.68	0.000691	5.91	0.22
Salt River	VaShly DS	0.89	172000	1148	1177.74	1178.36	0.00038	6.34	0.24
Salt River	VaShly DS	0.78	172000	1152	1177.39	1178.1	0.000471	6.78	0.27
Salt River	VaShly DS	0.65	172000	1151.5	1177.18	1177.8	0.000352	6.32	0.23
Salt River	VaShly DS	0.51	172000	1152	1176.85	1177.51	0.000395	6.55	0.25
Salt River	VaShly DS	0.36	172000	1151.05	1176.51	1177.2	0.000411	6.67	0.25
Salt River	VaShly DS	0.23	172000	1150.96	1176.24	1176.92	0.000394	6.61	0.25
Salt River	VaShly DS	0.11	172000	1148	1175.9	1176.65	0.000442	6.92	0.26
Salt River	VaShly DS	0	172000	1148	1175.65	1176.39	0.000403	6.92	0.25

EXHIBIT H– AREA OF INUNDATION MAP, ALTERNATIVE O (MODEL 9)

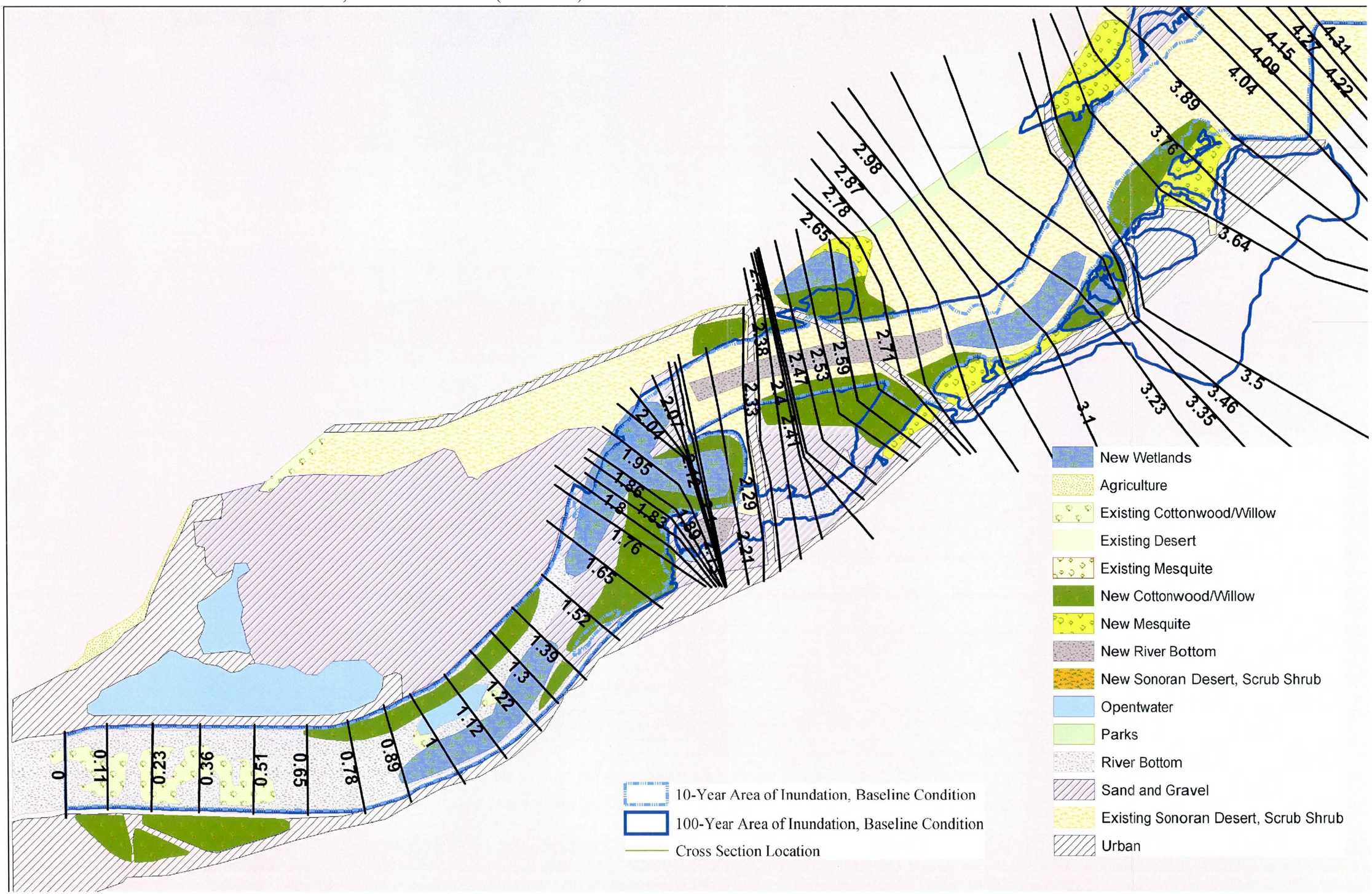


EXHIBIT H– AREA OF INUNDATION MAP, ALTERNATIVE O (MODEL 9)

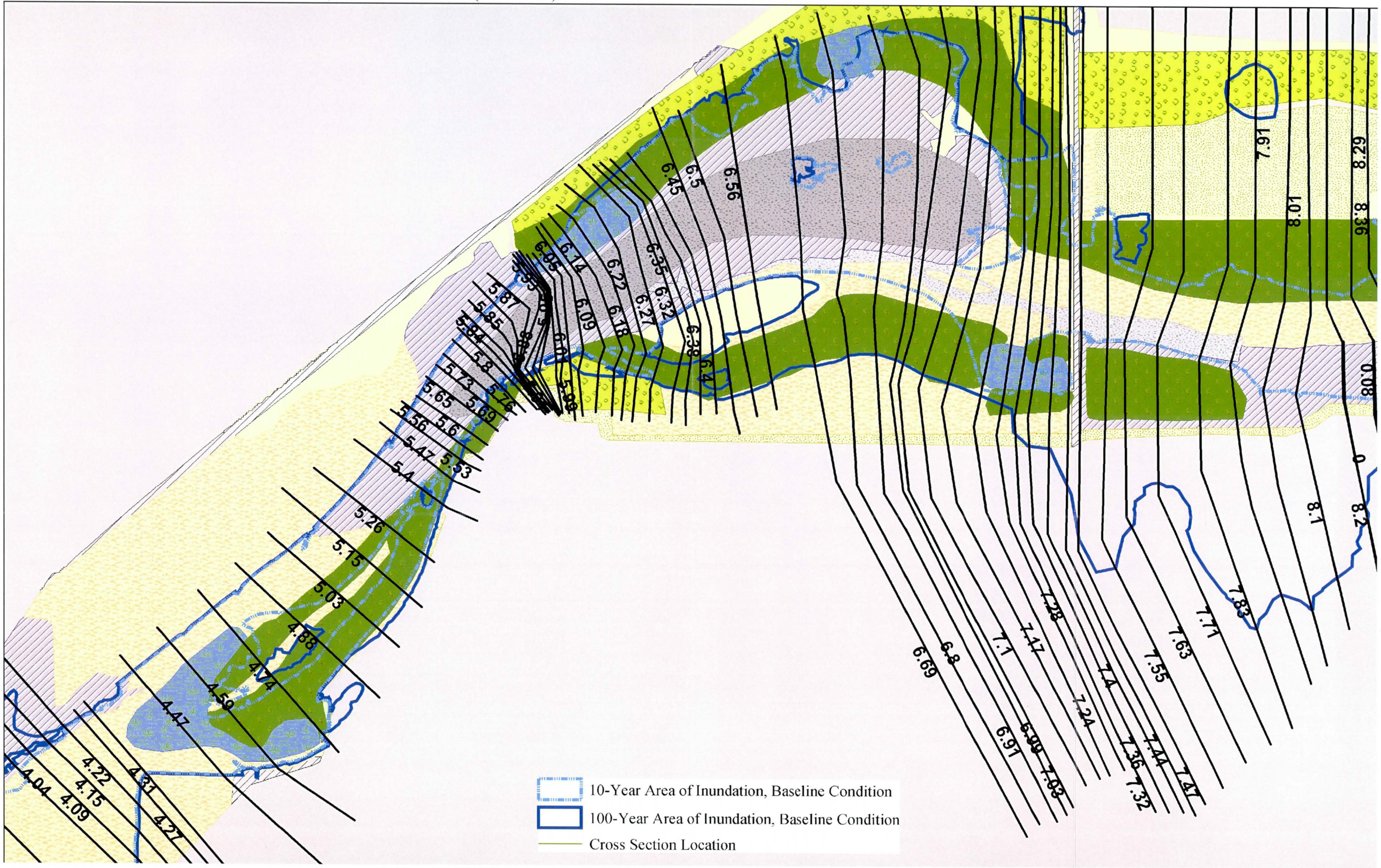
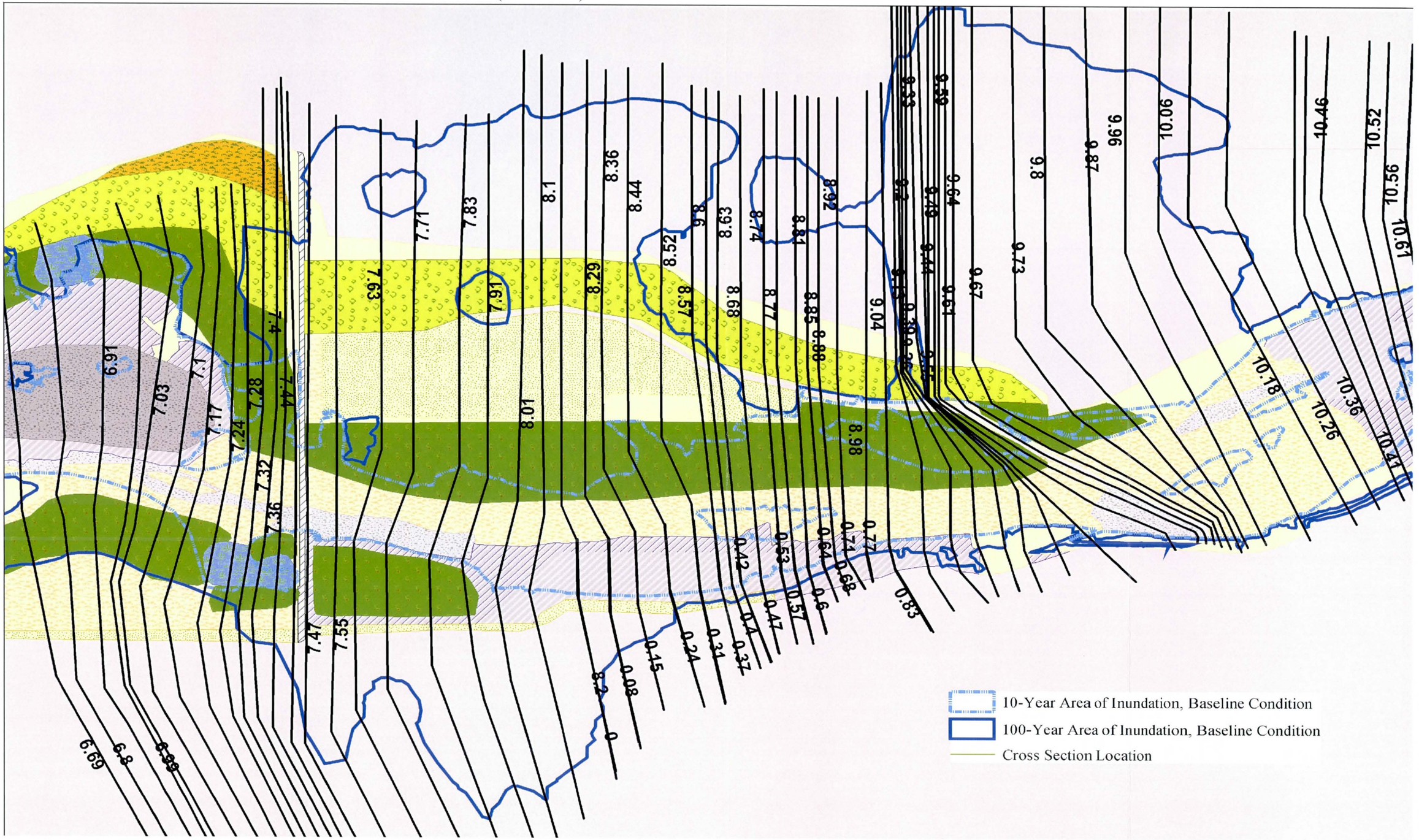


EXHIBIT H– AREA OF INUNDATION MAP, ALTERNATIVE O (MODEL 9)



APPENDIX

B

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

WATER BUDGET ANALYSIS

TABLE OF CONTENTS

WATER BUDGET ANALYSIS
WITH-PROJECT

INTRODUCTION 1
Purpose 1
Description of Study Area 1

PLANT WATER DEMAND 5

PROJECT FEATURES 7
Project Water Supply 7
Pump Stations 7
Water Distribution Channel 7
Water Distribution Pipe 7
Irrigation System 8
Wetland Feature 9

WATER BUDGET ANALYSIS 10
Vegetation Water Demand 10
Monthly Water Demand 10
Water Sources 13
Irrigation System 15

PREFERRED ALTERNATIVE 16

RECOMMENDATIONS 18

REFERENCES 19

EXHIBITS 20

Introduction

Purpose

1. The With Project Water Budget consisted of a preliminary design for the water distribution system and an estimation of the annual and monthly water demand takes into account plant water demand and irrigation losses. Monthly and annual water demand was estimated for cottonwood/willow, mesquite, upper sonoran desert and wetland vegetation types. Results were assessed for vegetation type, sub-areas and water sources. Five water sources were identified for project water: City of Mesa wastewater treatment effluent, stormwater runoff, agriculture tailwater, groundwater and Salt River Project (SRP) water made available by the Salt River Pima Maricopa Indian Community (SRPMIC). Features and results presented in this section are referenced with respect to sub-areas, sub-area locations are shown on Figure B-2.

Description of Study Area

2. The Va Shly'ay Akimel study area is located within Maricopa County in central Arizona. The study area includes the section of the Salt River that begins at Granite Reef Diversion Dam (Granite Reef) on the east side of the study area and extends downstream to the west for a distance of approximately 15 miles to the Pima Freeway (State 101), Figure B-1.

3. The majority of the study area is within the jurisdiction of the Salt River Pima-Maricopa Indian Community (SRPMIC). A portion of the project is within the jurisdiction of the City of Mesa located in the southwest part of the study area.

4. The channel of the Salt River within the study area contains several active and historic sand and gravel mining pits. Salt River Project (SRP) operates the Granite Reef Underground Storage Project (GRUSP) on the Salt River overbank area in the central part of the study area and the City of Mesa operates a recharge project on the west end of the study area.

5. The Salt River was a perennial stream until the construction of upstream dams, with associated reservoirs, regulated the flow. There are four dams on the Salt River and two dams on the Verde River, a tributary to the Salt River. These structures control the flow changed the character of the Salt River within the study area into an ephemeral stream. Granite Reef Dam is a diversion structure, not a water storage or flood control structure. This dam diverts the flow in the Salt River into two major irrigation canals, the Arizona Canal on the northside and the Southern Canal on the southside. Flows only occur through the study area when there are flood releases from the upstream reservoirs. The flood flows vary in duration, quantity and magnitude depending on the nature of the flood releases. Historically, the flood releases over Granite Reef Dam have gone from zero to 200,000 ft^3/s in less than a week. Due to these modifications the Salt River has become a ephemeral river with events occurring on average once every three years.

6. The winter months are typically when large regional storms or series of storms occur. These storms may include an accumulation and subsequent melt of the snow pack in the Salt River and Verde River watersheds and result in the releases of water into the Salt River system that can flow over Granite Reef Dam into the study area. While the river stages may be high for an extended period, the quantity and intensity of accompanying storm precipitation is generally reduced in the lower elevations, including the study area.

7. During the middle to late summer months the monsoon storm pattern is typical. These storms produce intense, short-duration thunderstorms with significant precipitation. During these storms the river stages are low because the storms are localized and because the upstream reservoirs usually have the capacity to store the local runoff from the watershed.

8. For a more detailed discussion on the runoff and surface water refer to Appendix A, Runoff Discussion, the without project water budget analysis (Piésold, 2002a) and interior drainage report (Piésold, 2002b)

9. Depth to the groundwater table varies throughout the study area as a result of the hydrogeologic conditions and dams constructed on the Salt and Verde Rivers. Granite Reef Dam was constructed to divert the Salt River flow into the Arizona Canal and the Southern Canal. This dam marks the upstream boundary of the project area. Although not intended to be a storage reservoir, some water is retained up stream of the dam at all times. Small flood flows can be released to the Salt River through radial gates while larger flood flows are allowed to pass over the dam crest. SRP reported that water seeps through the radial gates because the gates do not form a tight seal with the granite bedrock. The result is a continuous flow of water downstream from the dam. SRP does not monitor the seepage and does not have flow records.

10. On average the depth to groundwater ranges from 100 feet to 120 feet in the project area. In certain areas, downstream of Granite Reef Dam, near the GRUSP site and at the City of Mesa wastewater treatment facility, the depth to groundwater is much less. This is due to recharge from local surface water sources, seepage from Granite Reef Dam, SRP recharge water and recharge from wastewater effluent, respectively.

Figure B-1. VaShly Akimel Reach Map.

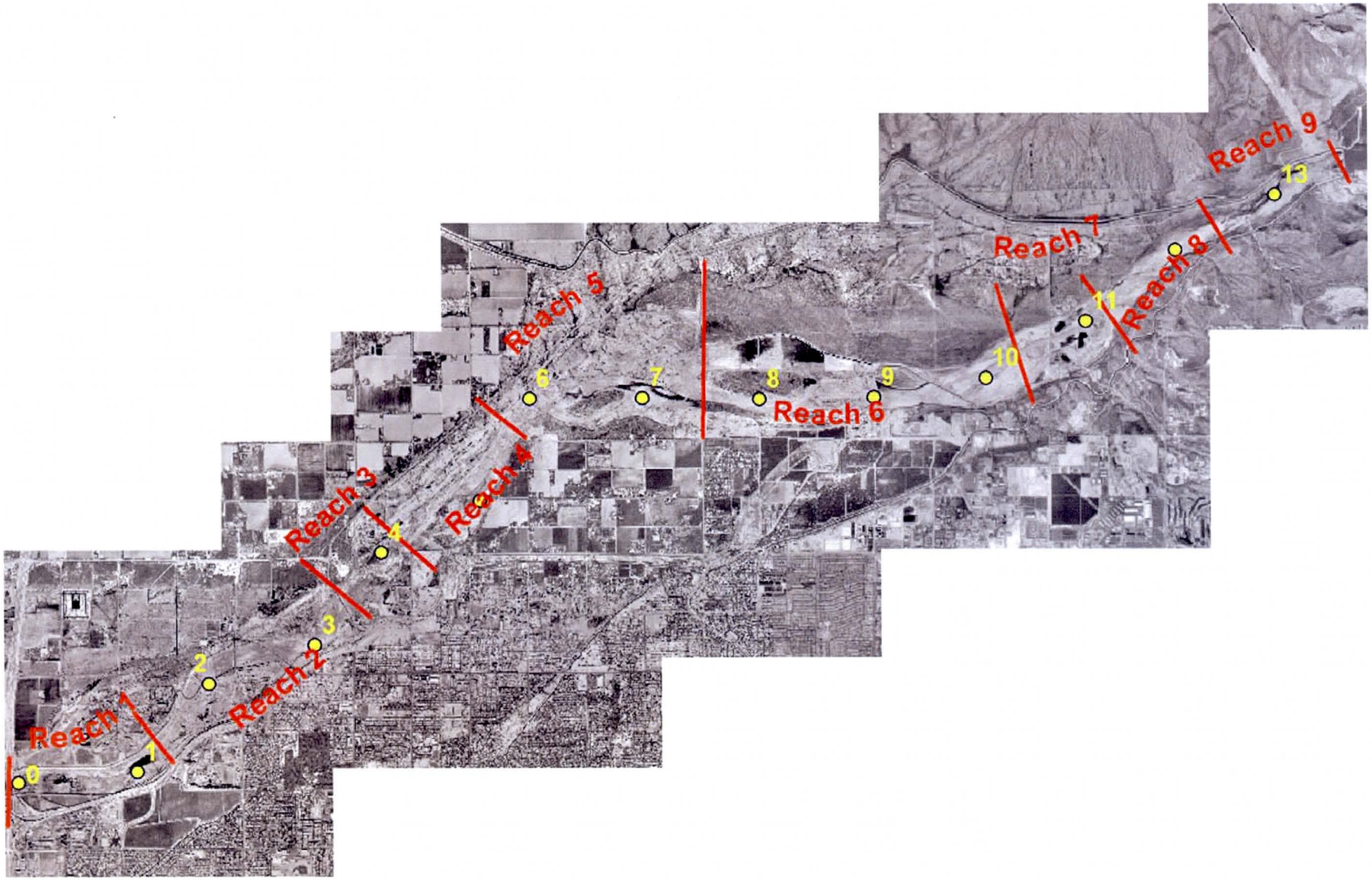
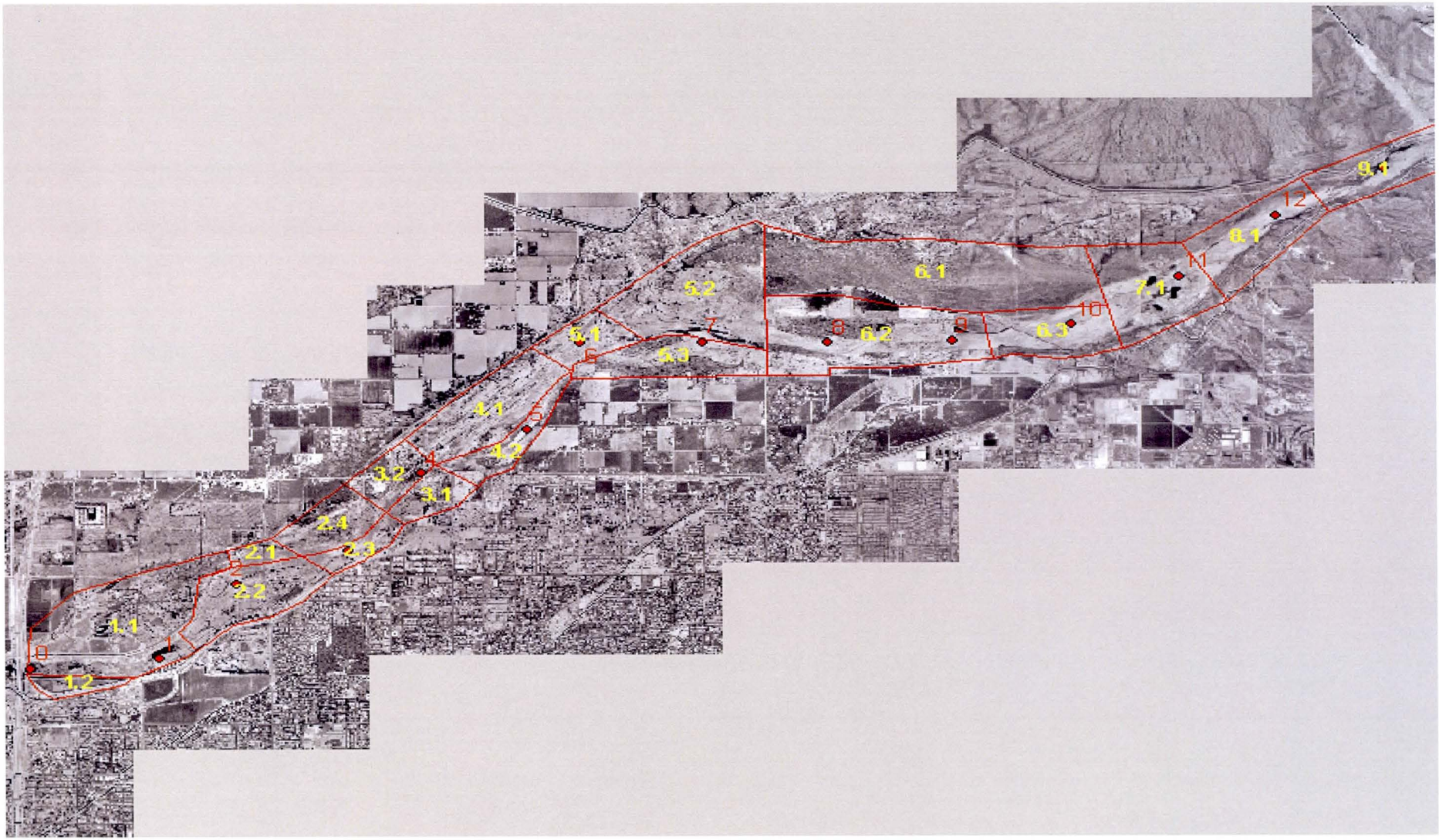


Table B-2. Project sub-area locations and river stations.



Plant Water Demand

11. Various sources were referenced to come up with an appropriate estimate for the water demand for cottonwood/willow, mesquite, upper sonoran desert and wetland vegetation types. It was decided that the annual average evapotranspiration rates presented in the USACE Feasibility Study reports for the Rio Salado and Tres Rios restoration projects best represented the water demand for this project area. Summary of the evapotranspiration rates are shown in Table B-1.

Table B-1. Annual Evapotranspiration Rate.

Source	Va Shly'ay	Paseo*	Tres Rios Del Norte**	Tres Rios***	Rio Salado****	John Moeur*****
Cottonwood/Willow	**6.3**	6	6.03	6.3	7-8.5	4-8.5
Mesquite	**3**	1.7	3	1.6	1.6	2-4.5
Sonoran Desert	**2**	2	4	2	3-4	0.5-2.5
Wetlands	**9**	12	6.5 (open water)	11.7	7.5-16.5	9-16

*"Paseo de las Iglesias Environmental Restoration Study Tucson, Arizona Draft Groundwater and Water Budget Analysis" (Present Condition), October 2002.
** "Tres Rios Del Norte Draft Groundwater and Water Budget Analysis", 8/20/2002.
***"Tres Rios, Arizona Feasibility Report April 2000";'Greeley & Hansen, 1998. Tres Rios, Arizona Fesibility Study, Salt/Gila Groundwater Analysis. Task-2 Water Budget Analyses and Development, Salt and Gila River Technical Memorandum, February 1998.
**** "Rio Salado Salt River, Arizona Feasibility Report, Technical Appendices", April 1998.
***** John Moeur, personal communciation, USACE, 2002.

12. The monthly evapotranspiration pattern for each of the vegetation types was assumed to be similar to the monthly consumptive use pattern, et, for the Salt River vegetation determined in the Tres Rios project study, Table B-2 (Piesold, 2002a).

Table B-2. Monthly evapotranspiration rate pattern.

Month	et (ft/month)
January	0.185
February	0.185
March	0.185
April	0.37
May	0.37
June	0.555
July	0.555
August	0.555
September	0.185
October	0.185
November	0.185
December	0.185
Annual	3.7

13. Assuming this pattern, the monthly evapotranspiration rate for the different vegetation types, et_i, for month i, corresponds to the normalized monthly

evapotranspiration rate, n_i, Table B-3, where n equals the monthly evapotranspiration rate divided by the annual evapotranspiration rate.

Table B-3. Monthly normalized evapotranspiration rate pattern.

Month	n_i
January	0.05
February	0.05
March	0.05
April	0.1
May	0.1
June	0.15
July	0.15
August	0.15
September	0.05
October	0.05
November	0.05
December	0.05

14. Thus, for a given month i the monthly evapotranspiration rate is,

$$et_i = n_i ET \qquad \text{eq. B-1}$$

15. where ET is the annual evapotranspiration rate, Table B-4.

Table B-4. Monthly vegetation evapotranspiration rate.

	Cottonwood/ Willow	Mesquite	Wetland	Upper Sonoran Desert
Month	et (ft/month)	et (ft/month)	et (ft/month)	et (ft/month)
January	0.3	0.2	0.5	0.1
February	0.3	0.2	0.5	0.1
March	0.3	0.2	0.5	0.1
April	0.6	0.3	0.9	0.2
May	0.6	0.3	0.9	0.2
June	0.9	0.5	1.4	0.3
July	0.9	0.5	1.4	0.3
August	0.9	0.5	1.4	0.3
September	0.3	0.2	0.5	0.1
October	0.3	0.2	0.5	0.1
November	0.3	0.2	0.5	0.1
December	0.3	0.2	0.5	0.1
Annual	6.3	3.0	9.0	2.0

Project Features

Project Water Supply

16. The water supply for the project will come from five water sources in varying amounts: City of Mesa wastewater treatment effluent, stormwater runoff, agriculture tailwater, groundwater and SRP water made available by the SRPMIC. The project will require commitments to provide an adequate water supply for at least 50 years.

Pump Station

17. A pumping station will be designed to pump groundwater to support sub-areas 5.2 and 6.1 and to have the capacity to support sub-area 5.1. The estimated pump capacity ranges from 1,500 to 5,000 gal/minute. Alternatives A, D and I do not have a pump station in the design.

18. A landfill located north of the project area, west of Gilbert Road, had groundwater guidelines that restricted raising the local groundwater table to a specified elevation. The pumping station can be used to control water levels near the landfill, offsetting incidental recharge caused by irrigation of vegetated areas.

19. Additional pumps will be needed to pump water from the SRPMIC irrigation channels on the north bank to vegetated areas along the main channel and on the south bank. Pump stations will be located at Alma School Road and Country Club Road.

Water Distribution Channel

20. A distribution channel will be designed to distribute surface water from water source to vegetated area. The distribution channel will be incorporated in Alternatives B, C, E, H and G. The channels will be lined have no water loss due to infiltration. The channel will be 40 feed wide and 3 feet deep. They will be designed to be a perennial source of water for project features.

Water Distribution Pipe

21. A 12-inch pvc pipe will be buried through out the project area to convey water from the pump station, wastewater effluent sources and existing SRPMIC irrigation system to the vegetated areas. Diversion structures will be designed to divert water to the distribution pipe from the SRPMIC system and the City of Mesa wastewater treatment source.

22. Stormwater and irrigation tailwater will be used when available. The diversion structures will be integrated into these sources where applicable. The diversion structures will be designed to divert both project water and excess water to the project area.

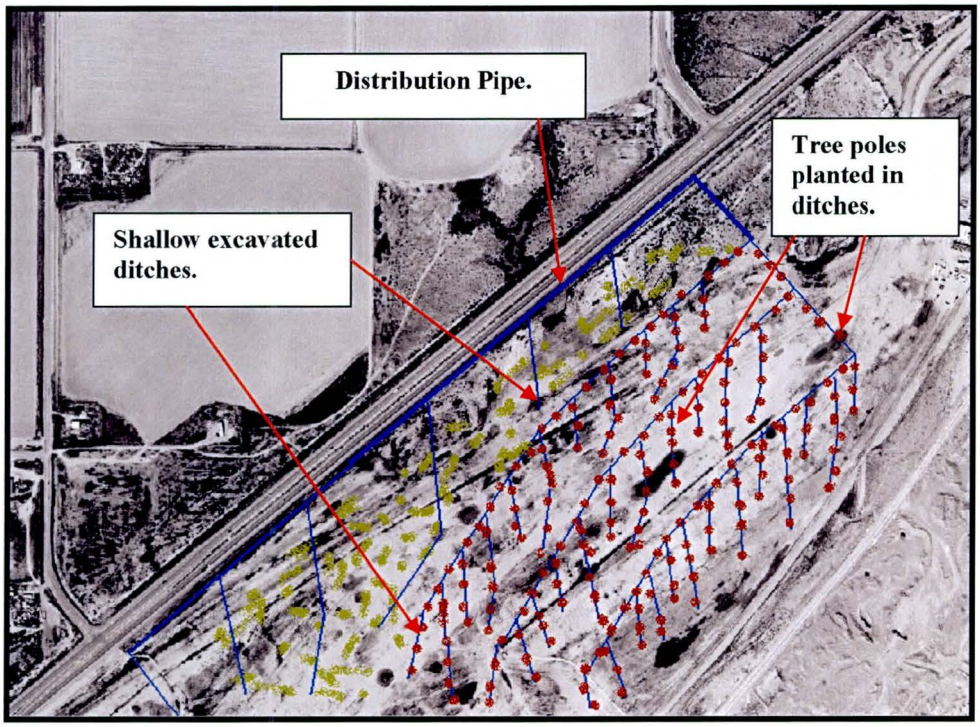
Irrigation Systems

23. Water distributed to the vegetated area will then be used for irrigation purposes using three systems: drip irrigation, flood irrigation and surface braided irrigation (SBIN).

24. Drip irrigation is a common system for irrigation however it is not an advantageous method for encouraging incidental growth and the irrigation of large areas. The drip irrigation system had an assumed irrigation efficiency of 80%.

25. SBIN distributes water through a network of shallow ditches, 6 inches deep and 2-3 ft wide. Channels maybe lined or unlined. Maintenance of these channels may be necessary after larger flow events. Water distribution will need to be manually controlled for the life of the project. The unlined SBIN method had an assumed irrigation efficiency of 50%. Note that the irrigation efficiency for a lined system will be higher than that of an unlined system.

Figure B-4. Surface Braided Irrigation Network (SBIN) Diagram.



26. The flood irrigation method consists of inundating an area by overland flow. This method has a low irrigation efficiency; vegetation water demand divided by total water demand (vegetation water demand plus water losses), but has low maintenance requirements and construction costs. Water distribution will need to be manually controlled for the life of the project. The flood irrigation method had an assumed irrigation efficiency of 20%. The flood irrigation method results can be assumed equal to the unlined SBIN system for the feasibility study.

Wetland Feature

27. Many of the alternatives will have wetland features in their design. For the feasibility study it was assumed that engineering of the wetland area will be required to create and maintain these area. It was assumed that 7 feet will be excavated at the wetland area. A 2 foot clay area will be placed to decrease the permeability at the wetland. A 2 foot gravel layer will be placed on top of the clay layer to prevent damage to the clay layer. Some topsoil may need to be placed on top of the coarse material to allow for the establishment of wetland vegetation.

28. An inlet structure will be designed to protect the wetland substrate from high velocity flows entering the wetland.

Water Budget Analysis

29. Water budget for the project alternatives were calculated based on the evapotranspiration rate for the vegetation cover type. The drip irrigation and SBIN irrigation systems were also evaluated for irrigation efficiency and water demand. Infiltration losses for the distribution channel and the wetland were not taken into account. Depending on the lining of the channel and the wetland, the infiltration loss can be substantial and will need to be taken into account in the final design.

30. It was assumed that precipitation, agriculture tailwater and stormwater runoff did not to contribute to the irrigation of vegetated area.

Vegetation Water Demand

31. Each Alternative was broken up into their vegetated area and multiplied by the annual evapotranspiration rate to estimate annual alternative vegetation water demand, Table B-5.

Table B-5. Annual alternative vegetation water demand.

	Wetland	Wetland	Cottonwood/ Willow	Cottonwood/Willow	Mesquite	Mesquite	Sonoran Desert	Sonoran Desert	Total	Total
Alternative	Area (acres)	Water Demand (acre-ft/yr)	Area (acres)	Water Demand (acre-ft/yr)	Area (acres)	Water Demand (acre-ft/yr)	Area (acres)	Water Demand (acre-ft/yr)	Area (acres)	Water Demand (acre-ft/yr)
A	0	0	0	0	0	0	496	992	496	992
B	0	0	0	0	267	802	685	1,370	952	2,172
C	29	260	238	1,500	166	497	720	1,440	1,152	3,696
D	103	930	259	1,635	313	939	63	126	739	3,629
E	52	229	287	1,808	296	888	808	1,615	1,416	4,540
F	187	1,682	701	4,418	558	1,673	266	531	1,711	8,304
G	64	578	470	2,959	454	1,363	395	790	1,383	5,690
H	64	578	9	55	870	2,609	395	790	1,338	4,032
I	196	1,765	443	2,788	6	18	174	348	819	4,920
J	82	735	556	3,501	556	1,668	92	183	1,285	6,087
K	146	1,318	493	3,103	558	1,675	104	208	1,301	6,304
L	143	1,286	495	3,117	400	1,199	0	0	1,037	5,602
M	222	2,002	412	2,598	587	1,762	63	126	1,285	6,488
N	131	1,178	853	5,371	380	1,139	24	47	1,387	7,736
O	200	1,798	883	5,566	380	1,139	24	47	1,486	8,550

32. The total water demand ranges from 990 acre-ft/yr (Alternative A) to 8,600 acre-ft/yr (Alternative O). Generally, cottonwood/willow vegetation type tends to have the largest annual water demand because of the high evapotranspiration rate, 6.3 ft/yr, and large areas of re-vegetation.

Monthly Water Demand

33. Monthly water demand was estimated for each alternative based on the monthly evaporation distribution presented in Plant Water Demand section, Table B-6.

Figure B-6. Annual alternative vegetation water demand.

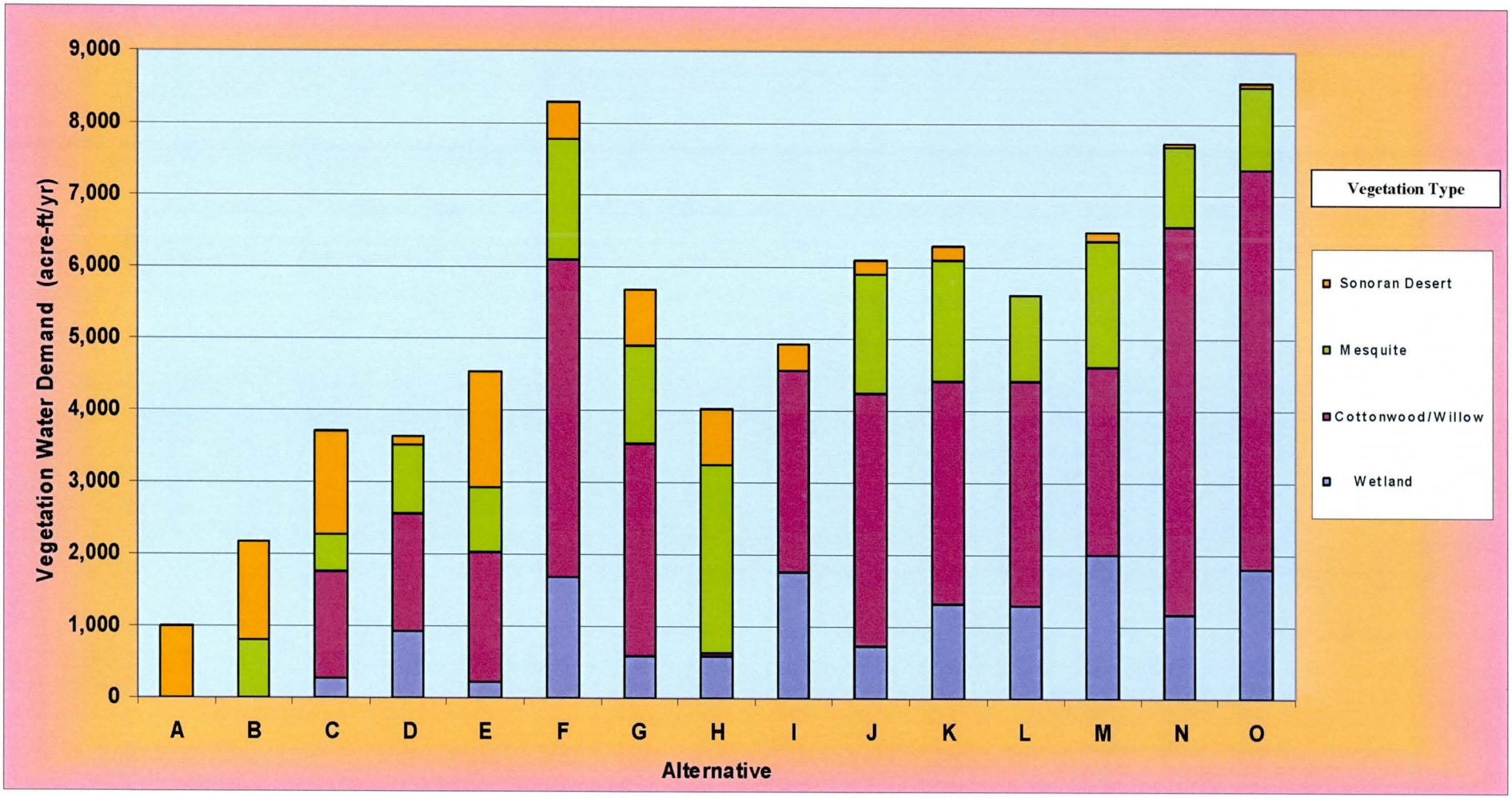
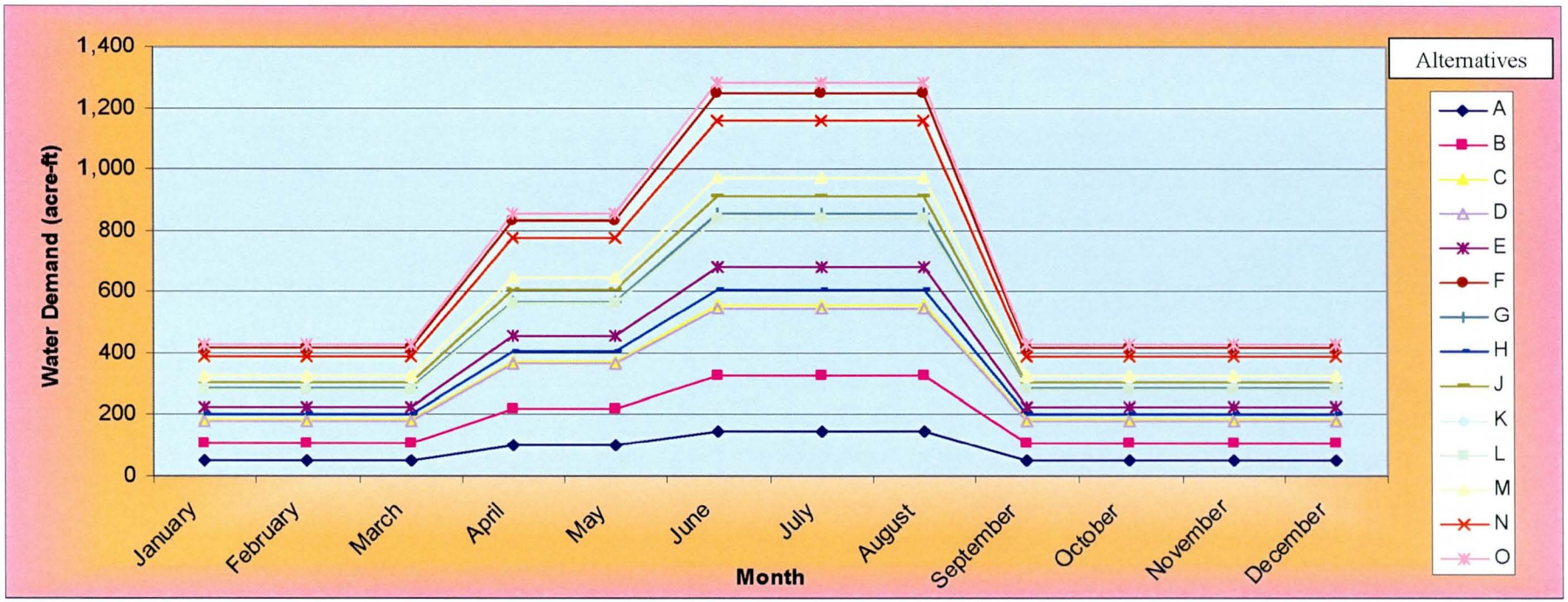


Table B-6. Monthly alternative water demand.

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Month	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)
January	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
February	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
March	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
April	99	217	370	363	454	830	569	403	492	609	630	560	649	774	855
May	99	217	370	363	454	830	569	403	492	609	630	560	649	774	855
June	149	326	554	544	681	1,246	854	605	738	913	946	840	973	1,160	1,282
July	149	326	554	544	681	1,246	854	605	738	913	946	840	973	1,160	1,282
August	149	326	554	544	681	1,246	854	605	738	913	946	840	973	1,160	1,282
September	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
October	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
November	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
December	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
Annual	992	2,172	3,696	3,629	4,540	8,304	5,690	4,032	4,920	6,087	6,304	5,602	6,488	7,736	8,550

Figure B-7. Monthly alternative water demand.



34. The maximum monthly water demand occurs during the months of June, July and August, the minimum period occurs from September to March, Figure B-7.

Water Sources

35. The water sources used were dependent on the source location, proximity to vegetated area and water availability. The water demand, not including irrigation efficiencies is shown on Table B-7. The water demand for each sub-area analysis is shown on Table B-8.

Table B-7. Alternatives water source water requirement.

	Effluent	Well Water	SRPMIC Surface Water	Total
Alternative	Water Requirment (acre-ft/yr)	Water Requirment (acre-ft/yr)	Water Requirment (acre-ft/yr)	Water Requirment (acre-ft/yr)
A	0	0	992	992
B	0	787	1,385	2,172
C	0	676	3,021	3,696
D	0	887	2,742	3,629
E	242	1,419	2,879	4,540
F	0	1,331	6,973	8,304
G	234	943	4,513	5,690
H	0	782	3,250	4,032
I	0	0	4,920	4,920
J	0	1,249	4,838	6,087
K	0	1,350	4,954	6,304
L	0	1,072	4,530	5,602
M	0	1,228	5,259	6,488
N	174	1,804	5,757	7,736
O	176	2,012	6,361	8,550

36. The largest source of water was SRPMIC surface water. Wastewater will only be used to support vegetation located in sub-area 1.2. The well was designed to support sub-area 5.2 and 50% of sub-area 6.1. Precipitation, stormwater runoff and agriculture tailwater were not accounted for in the water demand estimates.

Table B-8. Sub-area water demand.*

***Refer to Figure B-2 for sub-area locations.**

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Sub-area	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)
1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	146	410
1.2	0	0	0	0	242	0	234	0	0	0	0	0	0	174	176
2.1	0	0	0	0	2	91	0	0	76	17	0	0	14	8	53
2.2	0	0	40	0	164	581	327	289	522	279	254	440	534	464	932
2.3	0	46	96	0	96	310	227	173	189	140	140	147	140	150	339
2.4	0	0	0	0	0	316	0	0	66	258	257	413	260	284	195
3.1	0	0	0	0	0	181	207	190	105	124	159	0	147	181	154
3.2	0	0	0	0	0	0	0	0	0	0	147	0	0	0	98
4.1	0	242	486	657	384	950	810	696	494	461	462	0	463	337	0
4.2	0	0	0	705	0	718	274	169	710	652	651	389	694	719	1,033
5.1	83	179	284	341	275	242	282	280	240	126	263	287	209	364	0
5.2	263	699	676	887	876	1,076	943	726	272	994	576	1,007	638	1,169	1,670
5.3	50	50	330	1,040	311	887	614	466	591	997	1,013	1,000	1,053	691	948
6.1	262	326	0	0	450	510	0	0	0	510	510	65	590	595	683
6.2	224	486	1,362	0	1,455	1,670	1,563	898	1,142	960	1,291	1,618	1,164	1,834	1,758
6.3	109	144	422	0	286	771	210	145	514	570	580	236	582	619	99
Total	992	2,172	3,696	3,629	4,540	8,304	5,690	4,032	4,920	6,087	6,304	5,602	6,488	7,736	8,550

Water Budget Analysis

Irrigation System

37. To take into account inefficiencies in the irrigation and distribution system it was assumed that the drip irrigation was 80% efficient and the SBIN system was 50% efficient, Table B-9. Efficiency values were based on engineering judgment.

Table B-9. Annual alternative water demand including irrigation inefficiencies.

	Vegetation	Drip	SBIN
Alternative	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)
A	992	1,240	1,983
B	2,172	2,715	4,345
C	3,696	4,620	7,393
D	3,629	4,537	7,259
E	4,540	5,675	9,080
F	8,304	10,380	16,607
G	5,690	7,113	11,381
H	4,032	5,040	8,064
I	4,920	6,150	9,840
J	6,087	7,609	12,174
K	6,304	7,880	12,608
L	5,602	7,002	11,204
M	6,488	8,110	12,976
N	7,736	9,669	15,471
O	8,550	10,688	17,100

38. The drip irrigation is more effective for irrigating the vegetation features. However because of the size of the area that will be re-vegetated it may be difficult to install a drip irrigation system. The SBIN has less maintenance requirements than the drip system. In addition to lower maintenance demands, the SBIN system could be more effective to encourage vegetation growth that was not planted as part of the project.

Preferred Alternative

39. Alternative O with the SBIN irrigation system was determined as the preferred alternative. The total water, including the 50% irrigation efficiency, was on average 17,000 acre-ft per year. This assumes that there was no rainfall or surface runoff. Rainfall and surface runoff would normally reduce water demands. But to be conservative it was decided that these sources need to be treated as non-reliable.
40. The sub-area distribution of water was broken down into reach segments (e.g. 1, 2, 3…) which relates to the sub-area (e.g. 1.1, 1.2, 2.1…). The highest demand for water occurs within reaches 5 and 6, Table B-10.

Table B-10. Annual Reach water demand for Alternative O. See Figure B-1 for reach locations.

Reach	Area (acres)	Water Demand (acre-ft)
1	81	1174
2	217	3038
3	59	505
4	145	2066
5	486	5235
6	497	5081
Total	1,486	17099

41. The water sources necessary to support the vegetation are: SRPMIC irrigation water, groundwater from a new well and treated effluent. The largest volume of water comes from the SRPMIC irrigation water. Annual average total demand and maximum monthly demand for each source are shown in Table B-11.

Table B-11. Annual water demand for each source for Alternative O.

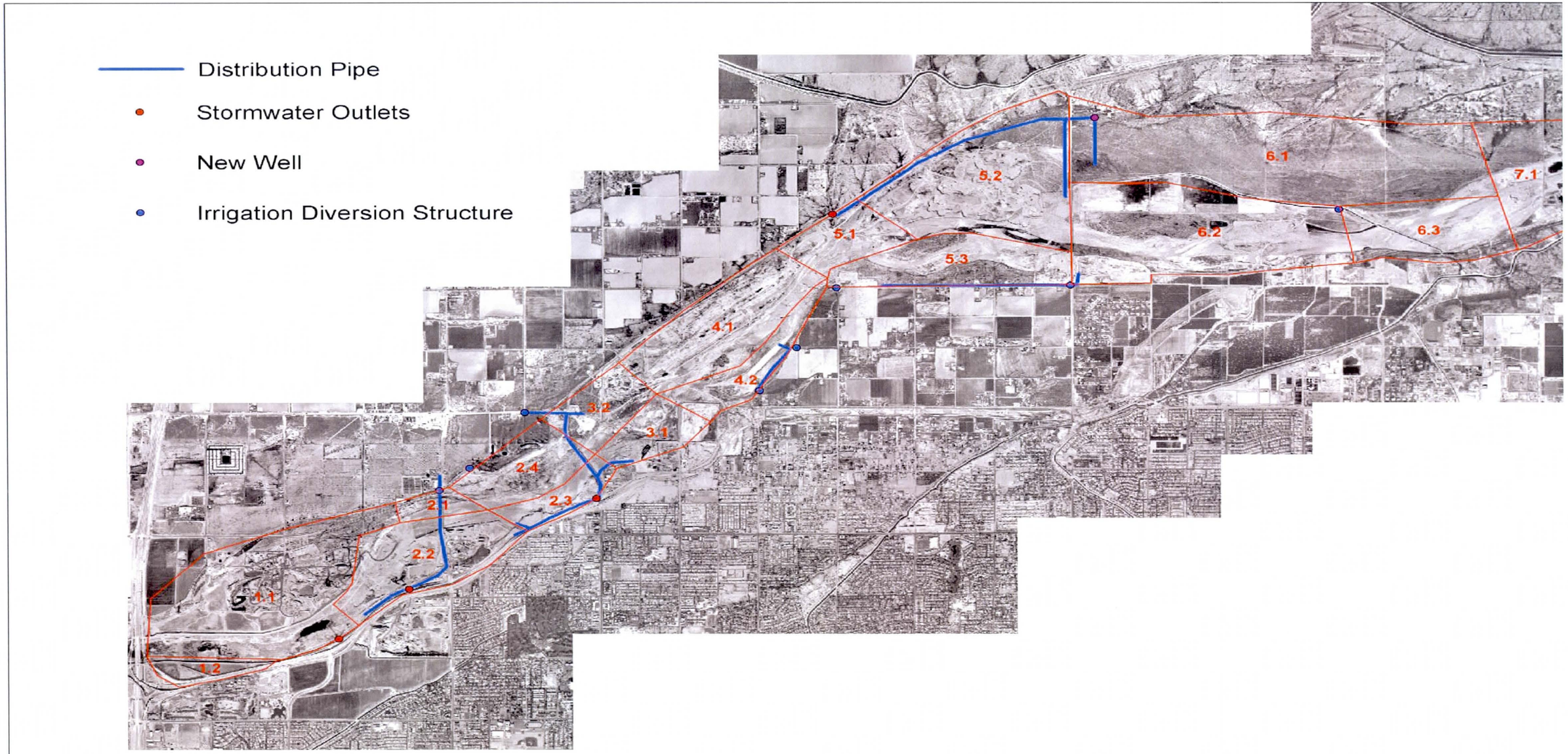
	WWTP Demand (acre-ft)	Well Water Demand (acre-ft)	SRPMIC Demand (acre-ft)
Total	353	4,023	12,723
Max Monthly	53	604	1,908

42. The new well was sized for Pump capacity of 10,600 gallons per minute with a depth of 150 ft.

43. The water distribution for Alternative O is shown on Figure B-8. The distribution system consists of one well, diversion structures to divert water from SRPMIC irrigation system to project features, 12" PVC pipe, and irrigation system which sill be a combination of drip and the SBIN methods. Losses throughout the system were taken into account when it was assumed that the irrigation efficiency was 50%

Preferred Alternative

Figure B-8. Alternative O water distribution system.



RECOMENDATIONS

Recommendations

44. There are some concerns regarding the water budget analysis. First, the water budget was based on long-term steady-state condition. It does not take into account the variability of starting up the project, initial growth of vegetation and eventual maturity of the plants. In addition, water demand assumes that precipitation, stormwater runoff and agriculture tailwater do not contribute to the irrigation of the project vegetation. Another concern is that losses due to infiltration were either taken into account in the irrigation efficiency estimates or assumed negligible, lined water distribution channel. Depending on the final design of the irrigation system and the distribution channel, the losses due to infiltration can greatly increase the overall water budget. It has been estimated that the daily infiltration loss rate can be as much as 1 ft/day or 365 ft/yr, almost 40 times that the annual evapotranspiration rate of wetland vegetation.

45. Alternative O was the preferred alternative. It requires 17,000 acre-ft/yr a majority of the water needed to support the project features comes from the SRPMIC irrigation waters. The largest water demand is found in reaches 5 and 6. In all, the preferred alternative consists of 200 new acres of wetland, 883 new acres of cottonwood/willow, 380 new acres of mesquite, 24 new acres of Sonoran desert, scrub shrub, and 225 new acres of river bottom.

REFERENCES

Hydrologic Engineering Center, 1998, User's Manual - HEC-FDA Flood Damage Reduction Analysis, Davis, California.

Knight Piésold, 2002a, "Va Shly'ay Akimel Salt River Restoration Project Feasibility Study JAB.01E Water Budget", Consultants Report.

Knight Piésold, 2002b, "Va Shly'ay Akimel Salt River Restoration Project Feasibility Study JAB.01G Interior Drainage", Consultants Report.

Knight Piésold, 2002c, "Va Shly'ay Akimel Salt River Restoration Project Feasibility Study JAB.01J Groundwater Model", Consultants Report

Julien, Pierre Y., 1998, Erosion and Sedimentation, Cambridge Press.

US Army Corps of Engineers, 1996a, "Section 7 Study for Modified Roosevelt Dam, Arizona (Theodore Roosevelt Dam) Hydrologic Evaluation of Water Control Plans, Slat River Project to Gila River at Gillespie Dam".

US Army Corps of Engineers, 1996b, EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies, Washington, D.C.

US Army Corps of Engineers, 1998a, User's Manual – HEC-RAS River Analysis System, Hydrologic Engineering Center, Davis, CA.

US Army Corps of Engineers, 1998b, Rio Salado Feasibility Report, Technical Appendices.

West Consultants, 2002, Va Shly' Ay Akimel, Hydraulic and Sedimentation Analysis, Consultants Report.

.

EXHIBIT B.1 – SUBAREA WATER DEMAND – ALTERNATIVE O

	wetland		Cotton/wood		Mesquit		Sonoran Desert		Total		River Bottom
Area	Area (acres)	Water Demand (acre-ft)	Area (acres)	Water Demand (acre-ft)	Area (acres)	Water Demand (acre-ft)	Area (acres)	Water Demand (acre-ft)	Area (acres)	Water Demand (acre-ft)	Area (acres)
1.1	27	246	26	165	0	0	0	0	53	410	0.0
1.2	0	0	28	176	0	0	0	0	28	176	0
2.1	0	0	8	53	0	0	0	0	8	53	6
2.2	47	427	78	493	4	12	0	0	130	932	17
2.3	24	216	14	88	12	35	0	0	50	339	6
2.4	10	86	15	93	5	15	0	0	30	195	2
3.1	0	0	17	109	15	45	0	0	32	154	0
3.2	0	0	6	36	21	62	0	0	26	98	0
4.1	0	0	0	0	0	0	0	0	0	0	3
4.2	44	395	101	638	0	0	0	0	145	1033	0
5.1	0	0	0	0	0	0	0	0	0	0	55
5.2	32	291	154	969	121	363	24	47	331	1670	135
5.3	15	139	117	740	23	69	0	0	156	948	0
6.1	0	0	23	146	179	538	0	0	202	683	0
6.2	0	0	279	1758	0	0	0	0	279	1758	0
6.3	0	0	16	99	0	0	0	0	16	99	0
Total	200	1802	883	5561	380	1140	24	47	1486	8550	225

EXHIBIT B.2 – MONTHLY WATER SURCE REQUIREMENT ALTERNATIVE O

	WWTP*	Well Water	SRPMIC**	Total
Month	Monthly (acre-ft)	Monthly (acre-ft)	Monthly (acre-ft)	Monthly (acre-ft)
January	18	201	636	855.0
February	18	201	636	855.0
March	18	201	636	855.0
April	35	402	1,272	1,709.9
May	35	402	1,272	1,709.9
June	53	604	1,908	2,564.9
July	53	604	1,908	2,564.9
August	53	604	1,908	2,564.9
September	18	201	636	855.0
October	18	201	636	855.0
November	18	201	636	855.0
December	18	201	636	855.0
Total	353	4,023	12,723	17,099
Maximum	53	604	1,908	2,565

*City of Mesa treatment plant effluent
**Salt River Pima Maricopa Indian Community irrigation water

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study August 2004

WATER BUDGET WITHOUT-PROJECT

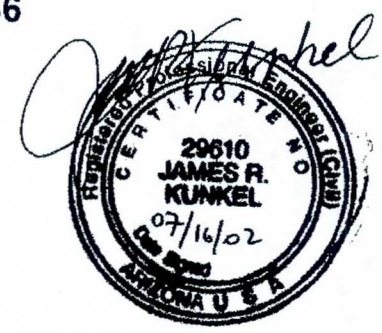
Knight Piésold
CONSULTING

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01E Water Budget
Final Report

July 17, 2002

Prepared for

Salt River Pima-Maricopa Indian Community
10005 East Osborn Road
Scottsdale, Arizona 85256
Telephone: (480) 850-8000
Facsimile: (480) 850-7366



Prepared by

Knight Piésold and Co.
1050 Seventeenth Street, Suite 650
Denver, Colorado 80265-0650
Telephone: (303) 629-8788
Facsimile: (303) 629-8789

Project 1889A/0110

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01E Water Budget
Final Report

Table of Contents

List of Tables iv

List of Photos iv

List of Drawings v

1.0 Introduction 1

2.0 Water Uses 2

2.1 Water Demands of Vegetation 2

2.2 Evaporation Losses 3

2.3 Infiltration Losses 4

3.0 Water Sources 5

3.1 In-situ Groundwater 5

3.1.1 Description of Source 5

3.1.2 Quantity Analyses 6

3.1.3 Quality Analyses 10

3.1.4 Water Rights 10

3.1.5 Assessment of In-situ Groundwater 11

3.2 Pumped Groundwater 12

3.2.1 Description of Source 12

3.2.2 Quantity Analyses 12

3.2.3 Quality Analyses 13

3.2.4 Water Rights 13

3.2.5 New Water Well Development 14

3.2.6 Assessment of Source 14

3.3 Salt River Flood Flows 15

3.3.1 Description of Source 15

Table of Contents *(Continued)*

3.3.2 Quantity Analyses 15
3.3.3 Quality Analyses 16
3.3.4 Water Rights 16
3.3.5 Assessment of Source 16
3.4 Storm Water Discharges 17
3.4.1 Description of Source 17
3.4.2 Quantity Analyses 18
3.4.3 Quality Analyses 19
3.4.4 Assessment of Source 19
3.5 Effluent 20
3.5.1 Description of Source 20
3.5.2 Quantity Analyses 20
3.5.3 Quality Analysis 21
3.5.4 Water Rights 21
3.5.5 Assessment of Source 21
3.6 Irrigation Return Flows 22
3.6.1 Description of Source 22
3.6.2 Quantity Analyses 24
3.6.3 Quality Analyses 25
3.6.4 Water Rights 25
3.6.5 Assessment of Source 26
3.7 Canal Drains 26
3.7.1 Description of Source 26
3.7.2 Quantity Analyses 28
3.7.3 Quality Analyses 28
3.7.4 Water Rights 28
3.7.5 Assessment of Source 28
3.8 Sand and Gravel Mining Operations Releases 29
3.8.1 Description of Source 29
3.8.2 Quantity Analyses 29

Table of Contents *(Continued)*

3.8.3 Quality Analyses 29
3.8.4 Water Rights 29
3.8.5 Assessment of Source 30
3.9 Salt River Project and Central Arizona Project Water 30
3.9.1 Description of Source 30
3.9.2 Quality Analyses 31
3.9.3 Water Rights 31
3.9.4 Assessment of Water Source 32
4.0 Evaluation of Water Sources 33
5.0 Recommendations 36
References R-1

List of Tables

Table	Title
2-1	Riparian and Constructed Wetland Vegetation Requirements
3-1	Summary of Historic Salt River Flood Flows
3-2	Storm Drains Average Annual Runoff Volumes
3-3	Canal Drains Average Annual Runoff Volumes
4-1	Water Budget Matrix
4-2	Restored Habitat Water Demands
4-3	Habitat Achievable Under Existing Conditions
4-4	Water Budget Projections

List of Photos

Photo	Title
3-1	Salt River Upstream of Granite Reef Dam
3-2	Seepage Downstream of Granite Reef Dam
3-3	Vegetated Areas Downstream of Granite Reef Dam
3-4	Salt River near Greenfield Road
3-5	Salt River at Alma School Road
3-6	Price Drain
3-7	SRPMIC's Evergreen Canal
3-8	Evergreen Drain Turnout
3-9	Hennessey Drain Turnout
3-10	SRP's Arizona Canal
3-11	SRP's Southern Canal

List of Drawings

Drawing	Title
100	Water Budget Map

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01E Water Budget
Final Report

1.0 Introduction

The Va Shly'ay Akimel Salt River Restoration Project (SRRP) is located along the Salt River between Granite Reef Diversion Dam (Granite Reef Dam) and the Pima Freeway (Loop SR-101). The success of this project is largely dependent on the water budget[1]. The water budget must identify each potential source, quantify the amount and seasonality of flow, and evaluate the quality of the water. The water budget required for this project, however, is more than just an inventory of water sources. It must also identify and quantify the water demands. Restoration projects involve wetlands and riparian vegetation, which have seasonal water demands that are greater in the summer than in the winter. In fact, the water demands vary by month. It is necessary to evaluate the water budget on a monthly basis because annual information does not contain sufficient detail to allow consideration of these monthly demands.

The Va Shly'ay Akimel project area encompasses the Salt River from Granite Reef Dam downstream to the Pima Freeway. This 15-mile reach has been divided into six smaller reaches for this study. Reach 1 extends from Granite Reef Dam to 2,500 feet downstream of Greenfield Road. Reach 2 continues to Gilbert Road and includes the Granite Reef Underground Storage Project (GRUSP), a 210-acre groundwater recharge project operated by the Salt River Project (SRP). Reach 3 extends from Gilbert Road to Horne Road and includes a large sand and gravel mining operation. Reach 4 continues to Country Club Drive. Reach 5 extends from Country Club Drive to 4,000 feet downstream of Alma School Road, encompasses several sand and gravel mining operations, and lies adjacent to the Old Tri-Cities Landfill. Lastly, Reach 6 continues to the Pima Freeway. This last reach has been confined between effluent recharge ponds on both sides of the river.

[1] The water budget is an accounting of water inflows to and outflows from the restored habitat areas. The model must inventory the potential water sources and water demands; in addition, the model must quantify the amount and timing of water available from each source and water required by each demand.

2.0 Water Uses

Three primary water demands were identified that are associated with a river restoration project. These include consumptive use by wetland vegetation, evaporation from open water bodies, and infiltration into the soil or riverbed. Consumptive use is defined as the water needed to account for plant evapotranspiration, which is the water required by the plant for growth along with the water that may be evaporated from both the plant itself and the soil in the immediate area surrounding the plant. The monthly and annual water demands were quantified for these water uses as a rate of water used per acre of vegetation or open water. When the project alternatives are finalized, the total demands can be projected by multiplying the per-acre demands by the number of acres for each land use category.

2.1 Water Demands of Vegetation

The water demand of vegetation varies depending on the individual and combination of plant species within a habitat unit. In the Tres Rios Project, a similar river restoration project in western Phoenix, the average annual evapotranspiration of river vegetation was projected to equal 3.70 acre-feet per acre. This general rate accounted for a mix of vegetation species that is similar to the expected mix for this project (Greeley and Hansen, 2001). The monthly demand is calculated as a percentage of the annual demand and defines the seasonality of the required water supply. The following values are based on water demand projections for the Tres Rios Project.

Consumptive Use for Salt River Habitat
(Southcentral Arizona)

Month	Percent of Annual Demand (%)	Consumptive Use (acre-feet/acre)
January	5	0.185
February	5	0.185
March	5	0.185
April	10	0.370
May	10	0.370
June	15	0.555
July	15	0.555
August	15	0.555
September	5	0.185
October	5	0.185
November	5	0.185
December	5	0.185
Annual	100	3.70

The root zone depth of vegetation is also an important criterion when assessing the adequacy of water supplies to meet demands. If the roots of plants have access to groundwater, it reduces the irrigation demand. Plants have different water requirements depending on the phase of development, seeding, sapling, and maturity. Table 2-1 (Wass, 2002) presents the root zone depth information for several species common within the Salt River environment. The table also presents the desirable ranges of inundation depth for aquatic plants. These data can be used to assess in-situ groundwater and to calculate irrigation demands during alternative development.

2.2 Evaporation Losses

The SRRP may include open water bodies, constructed wetlands, and marsh areas. In the central Arizona area, the annual evaporation from an open water body averages 72.4 inches or 6.03 feet per year, roughly 6 acre-feet per acre. However, evaporation is seasonal with the greatest evaporation in the summer months (Cooley, 1970). Constructed wetlands and marshes are open water bodies in which the surface area is shared by water and vegetation. The consumptive use of these areas closely approximates the open water body evaporation rate; thus, the evaporation rate can be used to calculate the water demand for the open water body, constructed wetland, or marsh.

Evaporation from Open Water
(Southcentral Arizona)

Month	Evaporation (acre-feet/acre)
January	0.183
February	0.258
March	0.417
April	0.550
May	0.750
June	0.825
July	0.825
August	0.750
September	0.575
October	0.442
November	0.275
December	0.183
Annual	6.03

2.3 Infiltration Losses

Infiltration accounts for the water that seeps or percolates into soil and geologic units that lie beneath the restored habitat areas. In southcentral Arizona, these rates are often significant and result in little or no water available for vegetation growth. The infiltration losses through the bottom of open-water and marsh areas for this study can be projected based on the percolation rates at the local recharge projects. At the GRUSP site, recharge rates have averaged between 1 and 3 feet per day. However, an organic mat typically forms on the bottom and sides of marsh areas; this mat restricts the percolation rate. Research for the Tres Rios Project has shown that the percolation rate in an unlined open water or marsh area is typically 1 to 2 feet per day. For this study, an infiltration rate of 1 foot per day will be assumed; this rate equates to 365 acre-feet of water infiltrated for each acre of open water or marsh areas.

3.0 Water Sources

The success of a habitat restoration project such as the SRRP is largely dependent upon the amount and quality of water that is available to sustain the riparian habitat. A sufficient and reliable supply of suitable water must be developed to support the aquatic, wetland, and upland plant species. Several potential water sources were identified for the SRRP area; two relate to groundwater resources and seven involve surface water. Groundwater can either be utilized by plant roots in place (in-situ), or it can be pumped to the surface and distributed to the restoration project. These represent the two potential groundwater sources identified. The potential surface water sources identified include Salt River flood flows, storm water discharges, effluent, irrigation return flows, canal drains, discharges from sand and gravel mining operations, and SRP or Central Arizona Project (CAP) water. These sources were each evaluated based on the quantity, reliability, and quality of flow available for habitat restoration. In general, the sources were classified into the following four categories.

- **Dependable Source.** A source is dependable if it is available on a continuous basis to meet the water demands of the habitat area and has acceptable water quality. Dependable sources constitute the baseline water supply.
- **Supplemental Source.** A source may be considered supplemental if it is available to augment the dependable baseline source. This could include infrequent and unreliable flows that can be put to beneficial use when they are available but cannot be relied upon as a dependable base flow. The supplemental flow must also have good water quality.
- **Problem Source.** Problem sources must be accounted for but may not be suitable as a water supply for the SRRP. These flows may inhibit the restoration project by potentially damaging restored vegetation or hindering the water quality within the Salt River.
- **Unacceptable Source.** A source is considered unacceptable if it has poor water quality or is not desireable for riparian habitat restoration.

3.1 In-situ Groundwater

3.1.1 Description of Source

In-situ groundwater is defined as groundwater that can be utilized, in place, by riparian vegetation. For this to occur, the groundwater table must be within the root zone depth of the desired plant species. The depth to groundwater as well as the water table fluctuations are important factors for establishing and maintaining riparian habitat.

Historically, the Salt River was a perennial stream and supported riparian and wetland vegetation. However, water storage and diversion projects have depleted the Salt River flows downstream of Granite Reef Dam and, in turn, have decreased the amount of water that gets recharged into the alluvial aquifer. Immediately downstream from Granite Reef Dam, the water table is still sufficiently close to the surface so that riparian vegetation can access this water through its root systems. These vegetated habitat areas in the Salt River suggest that in-situ groundwater may be a potential source of water for the habitat restoration project. Photo 3-1 shows the Salt River upstream of Granite Reef Dam; this area is similar to the historical conditions throughout the Salt River Valley.

Photo 3-1. Salt River Upstream of Granite Reef Dam

3.1.2 Quantity Analyses

The water table is variable throughout the study area and is impacted by both hydrogeologic and anthropogenic factors. One of these anthropogenic factors is Granite Reef Dam. The dam was constructed to divert Salt River water into the Arizona Canal and the Southern Canal. This dam marks the upstream boundary of the SRRP. Although not intended to be a storage reservoir, this dam inadvertently retains some water at all times.

Small flood flows can be released to the Salt River through radial gates while larger flood flows are allowed to pass over the dam crest. SRP has reported that water seeps through the radial gates as they do not form a tight seal with the granite bedrock. The result is a very low

continuous flow of water downstream from the dam. SRP does not monitor the seepage and does not have flow records. Photo 3-2 shows the seepage downstream of Granite Reef Dam.

Photo 3-2. Seepage Downstream of Granite Reef Dam

The local geology maintains this seepage as a surface flow. A bedrock shelf overlain by a veneer of sedimentary materials extends downstream from the dam. The seepage is sufficient to saturate these alluvial sediments to maintain a continuous surface flow. This flow has been sufficient to establish and support abundant vegetation. In addition, areas of open water provide riparian and aquatic habitat. This pattern continues for approximately one mile downstream. The existing vegetated areas are shown on the Water Budget Map (Drawing 100). Photo 3-3 shows the vegetated areas that extend for approximately one mile downstream from the dam.

Photo 3-3. Vegetated Areas Downstream of Granite Reef Dam

The depth to the bedrock shelf rapidly increases at the basin border fault, located approximately 1.5 to 2.0 miles downstream. As the bedrock depth increases, the surface flow that supports wetland vegetation upstream becomes subsurface water. Regional groundwater pumping has resulted in a general lowering of the water table throughout the area. In addition, dams located on the Verde River and Salt River upstream prevent perennial flow in the river channel and limit natural recharge. The result is that the general groundwater depth beneath the Salt River ranges from 60 to 80 feet below the surface for the majority of the study area (Knight Piésold, 2002a). Photo 3-4 shows the Salt River near Greenfield Road.

Photo 3-4. Salt River Near Greenfield Road

There are two groundwater recharge projects in the study area that have local impacts on the groundwater table. Toward the downstream end of Reach 2, SRP is recharging water into the upper alluvial aquifer through the GRUSP. SRP is recharging nearly 90,000 acre-feet of water annually. These recharge ponds encompass an area of approximately 216 acres. Their recharge permit allows them to recharge as much as 200,000 acre-feet per year; however, this rate would produce a groundwater mound that could impact other facilities. SRP has to limit the amount of water recharged in order to maintain the groundwater level at least 25 feet below the bottom of the Salt River Landfill on Gilbert Road and State Route 87. This results in a water level that is about 50 to 60 feet below the river channel in the immediate GRUSP area. The GRUSP site is shown on the Water Budget Map (Drawing 100).

The second recharge project is located near the downstream end of the project area. At this site, effluent from the Northwest Water Reclamation Plant (NWWRP), which is owned and operated by the City of Mesa (Mesa), is being discharged into a series of recharge ponds where the effluent is allowed to infiltrate into the Salt River sediments. Approximately 5,000 to 6,000 acre-feet of water has been recharged annually into these ponds. The Salt River Pima-Maricopa Indian Community (the Community) owns five ponds on the north side of the river totaling 75 acres; these ponds have received an average of 330 acre-feet of effluent each month since their inception in May 2001. Mesa owns four ponds on the south side of the river totaling 27 acres; these ponds have received an average of 140 acre-feet of effluent each month since

January 2000. The groundwater mound that results from this recharge raises the local water table in this area to within 50 to 60 feet below the river bed. The NWWRP and the percolation ponds are shown on the Water Budget Map (Drawing 100).

3.1.3 Quality Analyses

Long-term irrigation practices and landfills within the Salt River Valley have historically influenced water quality in the upper alluvial aquifer. High salinity, chloride, and nitrate concentrations were occasionally found in the shallow groundwater near irrigated or formerly irrigated areas. Also, some landfills have historically caused elevated levels of volatile halocarbons. More recently, the Community has developed a water quality management plan to protect and enhance surface water and groundwater quality (EcoPlan, 1997; EcoPlan, 1998). Since groundwater quality monitoring began in the 1980s, the water quality has significantly improved. Monitoring results from the first quarter of 2002 indicate that there were no exceedences of the maximum contaminant levels for volatile halocarbons in any of the sampled wells (Kenneth D. Schmidt and Associates, 2002). In addition, the concentrations of many volatile halocarbons were the lowest since monitoring commenced. It should also be noted that there are no superfund sites within the restoration project area. There is, however, an environmental investigation to assess the Old Tri-Cities Landfill located along the north bank of the Salt River near Country Club Road. Data are not yet available from this study. In-situ groundwater is generally suitable for agricultural uses and should be adequate for the habitat restoration project.

3.1.4 Water Rights

In this section and in all the following water rights assessment sections, water rights are discussed in relation to the Community as well as to non-Indian lands. The difference is that water rights established by the State of Arizona do not apply to the Community lands; however, federal water rights and court adjudications do apply. Non-Indian lands are subject to state water rights, federal water rights, and court adjudications.

The Community owns and controls the groundwater beneath their land, and it is not governed by state water rights. The federal government has established this right and has restricted pumping on non-Indian lands to prevent groundwater withdrawals from beneath the Community lands. Groundwater beneath the non-Indian lands is a state resource, and use is regulated via several groundwater rights and pumping permits.

Consumptive use of groundwater by vegetation (in-situ groundwater) is not included in state groundwater right categories. There are no water rights to define or restrict the direct use of groundwater by vegetation for habitat restoration projects in central Arizona. In-situ groundwater, when available, can be used as a part of the SRRP water supply.

The seepage at Granite Reef Dam is surface water and, until it percolates into the ground, could be subject to surface water appropriation rights. If this seepage flow is diverted before it percolates and used as a part of the water supply for the SRRP, it is possible that a downstream water user with rights to Salt River flow could protest. A claim by the downstream water users would be difficult to uphold because all of the seepage percolates into the ground about one mile downstream from the dam and is currently not available for diversion by downstream water users. If this water were used as a part of the SRRP water supply, it probably would be channeled to support vegetation along the north and south river banks just downstream from the dam rather than being diverted and delivered to a location farther downstream. The channelization is not a diversion and may not be subject to water appropriation regulations. In general, the use of the seepage flow to support in-stream vegetation does not appear to be contrary to existing water rights.

3.1.5 Assessment of In-situ Groundwater

In-situ groundwater can provide a reliable source of water for the area immediately downstream from Granite Reef Dam. In this area, seepage from the dam forms a local perched water table near the surface. Currently, wetland plant species are growing along this reach of the river and extend for approximately one mile downstream. This source of water could be used to restore native riparian vegetation in this area. This local supply is considered a dependable water source for Reach 1.

For the remaining reaches of this habitat restoration project, in-situ groundwater will not provide a reliable source of water. The intent of this project is to restore habitat areas for cottonwood, willow, and mesquite trees; these species require that the depth to groundwater be less than approximately 30 feet for survival. The depth to groundwater, however, exceeds 60 feet for most of the remaining area. In-situ groundwater is considered to be an unacceptable source of water for Reaches 2 through 5 of the SRRP.

3.2 Pumped Groundwater

3.2.1 Description of Source

Pumped groundwater is groundwater that lies below the root zone of the desired vegetation and must be pumped to the surface to be utilized. After the water is pumped to the surface, a distribution system must be developed to deliver this water to certain areas of the habitat restoration project.

3.2.2 Quantity Analyses

Groundwater in sufficient quantity to supply water wells is present throughout the majority of the SRRP area. This is demonstrated by the location and number of existing wells. Some of these wells are shown on the Water Budget Map (Drawing 100). The only area where groundwater is not present in sufficient quantity to supply a well is the initial 2 miles of the Salt River downstream from Granite Reef Dam. Bedrock is shallow in that area, and the saturated sediments may not contain sufficient water to maintain well pumping.

Pumped groundwater has been a reliable source of water for many years throughout the Salt River Valley including the SRRP area. These wells range in capacity from relatively small wells that produce 10 to 20 gallons per minute (gpm) to large irrigation wells producing more than 2,000 gpm. Many of the wells within the Community have not been used for many years. Recently, the Community has begun a maintenance program for these wells to ensure that they will be available for use in the future if desired.

Pumped groundwater can be provided using existing wells or new wells. The advantage of using an existing well is that the costs associated with constructing the well have been committed. The constraint is that the location of some wells requires construction of a distribution pipeline and may require a booster pump. The advantage of drilling a new well is that it could be located at a point within the project to minimize distribution pipeline costs. The constraints are the costs associated with constructing a new well and meeting the state regulations if the new well is located on non-Indian lands.

Pumped groundwater is available on a continuous basis and in sufficient quantity could provide a dependable supply of suitable water for the restoration project. The primary implication on using pumped groundwater is the impact that this pumping may have on other nearby groundwater wells.

3.2.3 Quality Analyses

Groundwater quality varies somewhat throughout the upper, middle, and lower alluvial units with the highest quality found in the lower units. As stated above for in-situ groundwater, groundwater from all alluvial units is generally suitable for agricultural purposes and is expected to be adequate for this habitat restoration project.

3.2.4 Water Rights

The Community regulates pumping of groundwater from beneath its land. They control where wells may be drilled and what the groundwater can be used for. The Community could permit the use of water from existing wells or the drilling of new wells to supply the SRRP. However, the Community is restricted in the quantity of groundwater it can pump and the total quantity of water it can use in any year through the Water Rights Settlement Agreement of 1988. This means that the Community can commit pumped groundwater to the SRRP but may need to reduce water use for another purpose.

The use of groundwater from beneath non-Indian land must be permitted by the state. Irrigation Grandfather Rights establish the right to pump and use groundwater for the growing of food and forage crops. These rights were established in 1980 on lands that were irrigated before that time and are tied to the specific parcels of land. The water pumped pursuant to the Irrigation Grandfather Right must be used on the land that was originally decreed for that right. The water cannot be used for irrigation on other lands. The lands within the Salt River channel do not fall into the Irrigation Grandfather Right category. Therefore, groundwater pumped pursuant to an Irrigation Grandfather Right is not a supply available to the SRRP.

The state also created specific permits to allow pumping of groundwater for new uses. These include poor quality groundwater permits, dewatering permits, mining permits, hydrologic testing permits, and general industrial use permits. The state has specific requirements and conditions that must be met for a water user to secure a pumping permit. It does not appear that the SRRP could meet all of the requirements and conditions. Therefore, groundwater permits are not available for this project.

Mesa can pump groundwater pursuant to a Service Area Right. This type of groundwater right is issued to public supply water providers. It allows the water provider to pump the quantity of water needed to meet a given demand, subject to water conservation requirements. The Arizona

Groundwater Code dictates that, except in times of surface water drought, all groundwater pumped by an entity, such as Mesa, with an Assured Water Supply designation must be replenished through the use of long-term storage credits, Irrigation Grandfather Right extinguishment credits, membership in the Central Arizona Groundwater Replenishment District, annual storage and recovery, or depletion of its groundwater allowance. Groundwater pumped under this right for habitat restoration would count toward Mesa's annual pumping total and would entail a depletion of their store of credits, making less water available to meet the needs of other current and future water users. Long-term storage credits and Irrigation Grandfather Right extinguishment credits are potential sources of water for the project but require an agreement between the parties to finance their creation.

3.2.5 New Water Well Development

If new wells are needed to pump groundwater, the Community could allow the wells to be drilled on their land. The wells should be located to produce minimal interference to existing wells. The well siting would involve a hydrogeologic investigation, but state permits are not required.

If new wells are to be drilled on non-Indian land, permits must be obtained from the ADWR. An impact study is required for all wells with a pump capacity of 500 gpm or greater. The study must demonstrate that the new well will not produce an additional 25 feet of drawdown in existing wells after five years of pumping. If the additional drawdown is less than 10 feet, the permit can be issued. If the drawdown is greater than 10 feet but less than 25 feet, the owner of the new well must obtain a release letter from the owner of each impacted well stating that an agreement has been reached to mitigate the drawdown. This can be a time consuming and expensive process.

Drilling new wells to pump groundwater is feasible and should be considered if there are no existing wells available to supply the project.

3.2.6 Assessment of Source

When the physical availability of pumped groundwater is considered, it is a dependable or supplemental water supply. There are no projections that the aquifer will be depleted, and water rights do not prevent its use for the SRRP. However, institutional commitments by the Community, Mesa, or SRP must be made to allow groundwater pumping. These considerations must be resolved before finalizing the design of the pump and delivery system.

3.3 Salt River Flood Flows

3.3.1 Description of Source

The SRRP is downstream from Granite Reef Dam, which is below the confluence of the Salt River and the Verde River. In the past, both rivers were perennial with consistent flow rates. The construction of dams and water storage reservoirs upstream allowed for the development of water resources to supply water for irrigation and urban use in the Phoenix Valley. Most of the time, all of the flow in the Salt River is diverted at Granite Reef Dam into the Arizona Canal and Southern Canal. The riverbed downstream is typically dry. Photo 3-5 shows the Salt River at Alma School Road.

Photo 3-5. Salt River at Alma School Road

The river, however, is still subject to floods because the reservoirs on the Verde River have no dedicated flood capacity, and only one of the four reservoirs on the Salt River has flood capacity. Due to the design of the dams, only limited flows can be released in anticipation of floods. When the water level reaches the spillway at Granite Reef Dam, substantial quantities of water are released, causing the downstream reaches of the Salt River to flood.

3.3.2 Quantity Analyses

The river downstream of Granite Reef Dam can be dry for long periods. For example, the Salt River flooded in 1941 and then was dry until it flooded again in 1966. The next flood occurred in 1973. The periods from 1978 to 1984 and from 1991 to 1995 were wet periods. Since 1995,

there have been no flood releases. Table 3-1 summarizes historic releases at Granite Reef Dam (Tres Rios River Management Plan Water Supply Technical Committee, 1997). This information demonstrates that, in the past, flood flows were more frequent and with less magnitude. Changes in the watershed and construction of additional dams have changed the pattern of flooding. Most of the largest recorded floods have occurred since 1978. Table 3-1 also demonstrates that there is no pattern to the frequency, duration, or magnitude of the flood flows.

3.3.3 Quality Analyses

The Tres Rios River Management Plan Water Quality Technical Committee (1998) reviewed the water quality records for the Salt River and focused on the Granite Reef Dam sampling location. That study found that there were no chemical water quality issues associated with Salt River water. However, during flood periods, sediments represented a water quality problem; the sediment load exceeded the standard established for the designated uses of the river. The problem was not because the sediments represented contamination. There are no known water quality issues that would prevent flood flows from being used as a water source for the SRRP.

3.3.4 Water Rights

Salt River flood water is subject to surface water rights for diversion. A right filed with the state or established by adjudication is required. However, during a flood, all diversion rights are typically fulfilled. Generally, all water demands are diverted into the two canals at Granite Reef Dam; a flood typically represents surplus water. Consequently, in order to encourage its use, SRP does not charge water users a fee to use Salt River flood water.

3.3.5 Assessment of Source

Flood flows do not occur on a regular basis or in predictable quantities; therefore, they do not represent a dependable water source. While the water may be available, it may be difficult to incorporate flood flows into the SRRP water supply. Flood flows do represent a supplemental source because they recharge the groundwater and replicate historic conditions in the river. Aquifer recharge is an indirect use of flood flows. During or shortly after a flood, it is possible that the water table will rise to the point where the vegetation roots can access it. However, when the flood subsides, the water table will return to depths greater than the root zone.

Flood flows have additional benefits to the natural habitat of the river. Small flows will saturate the soils and spread seeds to encourage the seedling germination and development of cottonwood and willow trees. Moderate flood flows will remove some vegetation and maintain open areas in

the river channel. The removal of vegetation is a natural occurrence in river systems. These flows can also redistribute sediments in the channel and help to replace nutrients in the riverbed soils.

Large floods, on the other hand, represent a problem source. The magnitude of these flows can damage restored habitat areas, degrade the reconstructed channels, and deposit excessive amounts of debris throughout the project. The peak flow during the 1980 flood was 200,000 cubic feet per second (cfs), which did extensive damage to the Salt River Valley. Flows of this magnitude are neither predictable nor preventable.

3.4 Storm Water Discharges

3.4.1 Description of Source

Storm water discharges represent runoff from urban and rural areas due to rainfall events. In general, storm water can enter the Salt River through defined outfall points from storm water drainage systems or as overland flow runoff from areas immediately adjacent to the river.

The Community does not currently have an extensive storm water management system to collect and convey storm water runoff to a designated outfall point. In general, roadside ditches and irrigation canals intercept the majority of storm runoff. These features retain most of this runoff, thus eliminating discharges into the Salt River. There are a few areas downgradient of roadside ditches and irrigation canals where runoff will reach the Salt River. However, these areas are relatively small, and little runoff is projected to occur during most storm events.

The only known storm drain in the Community is located near the intersection of Alma School Road and McKellips Road. This 60-inch pipe collects runoff from curb inlets along these roads and may intercept some irrigation return flows from nearby agricultural areas and the Cypress Golf Course. The Alma School Storm Drain is shown on the Water Budget Map.

Within Mesa, there are several storm drains that discharge to the Salt River (Haws, 2002). The most significant of these drains is the Price Drain. This open channel is located adjacent to the Price Road Freeway (Pima Freeway or Loop SR-101) and services a large drainage area. Inflows to this drain include a drainage channel along the Superstition Freeway (U.S. 60) and the drainage tunnel under the Price Road Freeway. Flow records for this drain were obtained from the Flood Control District of Maricopa County (FDCMC). Photo 3-6 shows the Price Drain near

the intersection of the Pima Freeway and the Red Mountain Freeway. The Price Drain is shown on the Water Budget Map.

Photo 3-6. Price Drain

Several other smaller storm drains exist along the south bank of the Salt River. Unfortunately, there are no flow records for these drains. There are also several areas adjacent to the river where overland flow runoff discharges directly to the river. These areas are generally undeveloped with the exception of the occasional sand and gravel mining operation.

3.4.2 Quantity Analyses

Knight Piésold conducted a site investigation to verify the location of storm drains that discharge into the Salt River. At the time of this investigation, approximately 1 to 2 cfs was flowing from the Community's storm drain on the north bank of the river near Alma School Road. It was also observed that natural vegetation was growing in the riverbed near this outfall. There are no flow records for this drain, and the exact drainage area that contributes runoff to the drain is not known. According to SRPMIC personnel, water rarely flows from this drain as most runoff from the Community is typically diverted to other water users such as sand and gravel mining operations. However, the presence of plant species indicates that this runoff is sufficient to maintain this vegetation.

Flow records for the Price Drain indicate that the mean flow to the river for the period from February 2001 to April 2002 was approximately 4.4 cfs. The peak flow during this period was 691 cfs. The records also show that there were only 24 days in which the average daily flow was less than 1 cfs, and there were only seven days in which the average day flow was less than 0.5 cfs. In addition, an area of significant size has recently become heavily vegetated immediately downstream of the Price Drain outfall. This vegetation is presumably due to the relatively continuous flow from that drain. Based on these facts, it is apparent that this drain receives flows from sources other than storm water runoff. It is possible that this drain collects lawn irrigation return flows from residential areas as well as return flows from other water users within the tributary area.

To quantify the average monthly and annual volumes of runoff from ungaged storm drains, the approach used in the Rio Salado project (USACE, 1998) was used to estimate the average annual volume of runoff. To estimate the average monthly volume of runoff, the annual amount was distributed according to the monthly rainfall distribution in the Phoenix area (Schmidli, 1996). This approach is described in detail in the Draft Report for the Interior Drainage Analyses (Knight Piésold, 2002b). Table 3-2 provides the monthly and annual runoff amounts estimated for these drains.

3.4.3 Quality Analyses

Storm water discharges from urbanized metropolitan areas are generally of poor quality. The quality varies depending on the land uses within the tributary area, the magnitude and duration of the storm event, and the length of time between consecutive storm events. Sediment and chemical pollutants tend to accumulate between storms and are washed from the streets, parking lots, ditches, or other features during the proceeding event; this occurrence is termed the "first flush." The quality of the "first flush" water is generally poor. As the runoff continues, the water quality improves. Mesa has reported that the base flow from the Price Drain may not have this first flush water quality problem.

3.4.4 Assessment of Source

Rainfall events are infrequent in the Phoenix area, so storm water runoff would generally not be considered as a dependable water source for a habitat restoration project. However, the Price Drain may be a dependable water supply. This drain has produced a consistent base flow, which can be incorporated into the restoration project. In addition, the Alma School Drain has produced

sufficient flow to support a small area of wetland plant species; unfortunately, there are no records to further evaluate this flow.

The remaining storm drains represent two categories of water supply – problem and supplemental. The first flush runoff generally has poor water quality and may not be suitable to nourish restored vegetation. Additionally, the peak flow rates emanating from these drains during major storm events may damage the habitat areas. These flows are both problem sources. After the first flush, the water quality generally improves. This runoff could be a supplemental source.

3.5 Effluent

3.5.1 Description of Source

Treated effluent represents a drought-tolerant water supply. During water shortage periods, most water conservation measures control the external use of water such as lawn watering, car washing, and landscape irrigation. These uses do not contribute to wastewater flow, so the amount of wastewater will only be reduced slightly during most drought periods.

3.5.2 Quantity Analyses

Mesa owns and operates the NWWRP located near the downstream end of the project area (Haws, 2002). The NWWRP currently produces about 8.5 to 9.0 million gallons per day (mgd) of effluent; however, the plant is currently being expanded to a design capacity of 18 mgd. This expansion is expected to be completed in late summer of 2002. In the future, the inflow to the NWWRP could grow to approximately 30 mgd. Currently, the effluent from the plant can be discharged to three locations:

- Four City-owned percolation ponds on the south side of the river (south ponds)
- Five Community-owned percolation ponds on the north side of the river (north ponds)
- Directly to the Salt River, just north of the plant site

In the future, a fourth receiving source will be a 36-inch reclaimed water line that is being constructed in conjunction with the Red Mountain Freeway (Loop SR-202). This reclaimed water line will provide landscape water for the freeway and potentially other uses as well as eventually deliver water to the Roosevelt Water Conservation District (RWCD) canal system east of Val Vista Drive. It is anticipated that this reclaimed water line will be active beginning in summer 2003.

Historically, the plant has discharged approximately 5,000 to 6,000 acre-feet of water into the percolation ponds. The five Community-owned ponds, totaling 75 acres, have received an average of 330 acre-feet of effluent each month since their inception in May 2001. The four Mesa-owned ponds, totaling 27 acres, have received an average of 140 acre-feet of effluent each month since January 2000. Effluent has also been discharged directly into the river; however, no releases have been made to the river since the Community-owned ponds have been in operation.

3.5.3 Quality Analysis

The quality of the effluent from the NWWRP meets aquifer recharge standards, surface water quality standards, and NPDES requirements. Having met all three of these authoritative standards, the quality of effluent is suitable for the restoration project.

3.5.4 Water Rights

The producer of effluent retains ownership until it is discharged and no longer under the control of the producer. If effluent is discharged to a river channel, a downstream water user can file for an appropriation to divert the water just like any other surface water source. The water user may be granted the surface water right to divert the effluent; however, this right does not guarantee that the effluent producer will continue to discharge to the river channel. The producer still has control as to where the effluent is discharged.

Normally, when effluent is discharged to the river, the producer loses control and hence the right to the effluent. However, if the receiving water channel is designated to be a part of the conveyance system, the producer can maintain the right to the flow. This could occur if Mesa discharged effluent to a receiving channel in the Salt River with the intent to transport the flow to the restoration project.

When Mesa discharges the effluent to the recharge ponds, they retain control of the effluent and maintain the right to this water. Once the effluent is recharged, Mesa's right to this effluent is protected pursuant to groundwater recharge legislation statutes.

3.5.5 Assessment of Source

Effluent from the NWWRP could be a dependable or supplemental supply for portions of the SRRP. The water source is drought-tolerant and can meet water quality standards for restoration. However, Mesa, which controls the right to the effluent flow, must make an institutional decision to commit water to the project. Currently, Mesa owes a substantial water debt to the RWCD.

Once the reclaimed water line to the RWCD canal line is in place, Mesa intends to use the majority of the effluent from the NWWRP to fulfill this debt. Mesa receives long-term storage credits from this delivery as well as from water recharged through the percolation ponds. Therefore, use of reclaimed water for habitat restoration would mean a depletion of the long-term storage credits that Mesa uses to comply with Assured Water Supply requirements and to meet current and future demands.

The direct use of effluent could be used in the western and central portions of the project area where gravity flow and the reclaimed water distribution system can be used to deliver the effluent. It may not be cost-effective, however, to deliver effluent to the eastern portions of the project near Granite Reef Dam. However, indirect use of effluent could be achieved throughout the study area by using recovery wells to pump groundwater accounted for as recharge credits.

3.6 Irrigation Return Flows

3.6.1 Description of Source

The SRRP lies adjacent to irrigated agricultural lands so that the potential exists to use irrigation return flows as a water source for the ecosystem and habitat restoration. Irrigation return flows constitute the water delivered to the agricultural areas that is not consumed by crops, evaporated, or infiltrated into the soils. These flows can occur under two scenarios.

The first scenario, termed tailwater, occurs when surplus irrigation water is applied to the fields but is not used by the crops. Irrigation in the project area is typically accomplished through a flood irrigation technique where sufficient water is applied at the top of the field to force water through the furrows to the other end. In some areas, sumps have been constructed to collect the excess water and pump it back to the top of the field or divert it to another water user. In other areas, the excess water drains from the fields and is either intercepted by irrigation canals, storm water ditches, other diversion structures, or discharged directly into the Salt River.

The second scenario occurs when surplus irrigation water is delivered to the canals but is not applied to the fields. This excess water then either remains in the canal where it evaporates or infiltrates, is diverted to other users, or is discharged into the Salt River. This scenario can occur if a rainfall event occurs after irrigation water is delivered to a lateral canal; the soils in the irrigated areas may be saturated by rainfall so that the canal water is no longer needed. In other

cases, the irrigation canals may intercept storm water runoff; if this storm water runoff is significant, water may need to be released from the canal to prevent overflowing the canal banks.

The existing agricultural lands adjacent to the study area are located primarily within the Community. These agricultural lands are divided into three distinct areas: (1) land north of the Arizona Canal, (2) land south of the Arizona Canal and north of the Salt River, and (3) land south of the Salt River.

The areas north of the Salt River receive irrigation water primarily from SRP's Arizona Canal. There are also several groundwater wells located within this area that have historically been used for irrigation. These wells, however, have not been utilized for many years. Recently, the Community has begun a maintenance program for these wells to ensure that they will be available for use in the future if desired. For the areas north of the Arizona Canal, daily orders are pumped from a diversion point approximately one-half mile upstream of the Evergreen turnout and delivered through turnouts along Stapley Drive.

South of the Arizona Canal, daily orders are released through an electronically-controlled gate into the Community's Evergreen Canal, which is located about 7 miles west of Granite Reef Dam. From the Evergreen Canal, irrigation water is then diverted or pumped into lateral canals between the Pima Freeway and Horne Road. These lateral canals are shown on the Water Budget Map. Photo 3-7 shows the Community's Evergreen Canal. There are six defined outfall points that discharge excess irrigation water into the Salt River from this area. Two of these are located between Hayden Road and the Pima Freeway; these outfalls are outside of the study area. The remaining four locations are shown on the Water Budget Map.

Photo 3-7. SRPMIC's Evergreen Canal

The areas within Mesa that were historically irrigated have since been urbanized. In addition, there are no agricultural areas south of the river upstream of the RWCD canal. The area south of the Salt River, referred to as the Lehi District, receives water from SRP's Southern Canal at a diversion point approximately 8 miles downstream of Granite Reef Dam. There are three canals throughout the Lehi area; each of these canals ultimately discharge into the Salt River. The location of these three canal and their outfall points are shown on the Water Budget Map.

The RWCD and SRP irrigate agricultural areas located in eastern Mesa, Chandler, and Gilbert. Because these areas are located a great distance from the Salt River and south of the Southern Canal, there are no irrigation return flows from these areas.

3.6.2 Quantity Analyses

Under the current configuration, the Community supplies approximately 60,000 acre-feet of irrigation water to agricultural users annually.

Approximately 14,000 acre-feet of this water are delivered to the areas north of the Arizona Canal. The canal intercepts all runoff from this area so that irrigation return flows from this area are not a potential source of water for the restoration project.

The remaining 46,000 acre-feet are delivered to farms, the Cypress Golf Course, and individual homeowners for lawn irrigation. The table below identifies water delivered to these entities.

SRPMIC Irrigation Water Use with Potential to Reach the Salt River (South of the Arizona Canal)

Water User	Annual Water Use (acre-feet)		
	1999	2000	2001
Associated Farms	18,511	27,009	27,061
Rogers Farms	9,130	17,731	16,645
Taylor Farms	13,786	0	0
Juan Montiel Farm	57	170	142
Lehi Farm	2,249	1,952	1,892
Cypress Golf Course	177	164	109
Homeowners Lawn Irrigation	125	91	31
Total Irrigation	44,035	47,117	45,880

The amount of irrigation return flow generating from these water users is not currently monitored and is difficult to quantify. SRPMIC personnel have suggested that approximately 10 percent of the water delivered to the farms may become irrigation return flow.

3.6.3 Quality Analyses

The quality of the irrigation return flows can meet the needs of the SRRP in most cases. The water is Salt River water and, as demonstrated in previous sections of this report, the quality is acceptable. In some locations, irrigation drainage water can be saline, but that problem usually occurs far downstream in the western portions of the SRP service area.

Localized water quality problems could occur if surface runoff drainage enters the irrigation drain canals and transports contaminants from surrounding areas into the drain canals. A review of the aerial photographs indicates there are no concentrated animal feeding operations in the area that could contribute contaminated runoff into the drainage canal system.

3.6.4 Water Rights

Irrigation return flows discharged to the river become available for use by other water users. If this water is diverted and directed into the SRRP, it could be utilized to support the wetland and riparian habitat.

3.6.5 Assessment of Source

Irrigation return flows may provide a supplemental source of water for the habitat restoration. However, nearly all irrigation return flow from within the Community are currently diverted to other water users, so this water is not available without an institutional decision to allocate this water to the project by the Community. In addition, several factors prohibit irrigation return flows from being a reliable source. Typically, only the amount of water necessary for irrigation is delivered to the fields, which minimizes the tailwater amount. Additionally, storm events that produce significant runoff are rare so that surplus canal water is not available on a regular basis. The irrigation flows that do occur, however, only take place during the irrigation season. When the flows are available, they could be incorporated to supplement the water supply for the SRRP. Since all irrigation within the study area takes place within the western portion of the Community, irrigation return flows would only be available to Reaches 4, 5, and 6.

3.7 Canal Drains

3.7.1 Description of Source

Canal drains are typically constructed along the major canals in the area to provide a means to discharge water from the canal other than the designated delivery turnouts. During storm events, the canals intercept storm water runoff; if this storm water runoff is significant, water may need to be released from the canal to prevent overflowing the canal banks. Additionally, the major canals occasionally convey more water than is needed by the downstream water users; in this case, the excess water can be released through the canal drains. Three significant canal drains were identified within the study area, namely the Evergreen Drain, Hennessey Drain, and Tempe Drain. Each of these canal drains is operated by the SRP. These drains are shown on the Water Budget Map. Photo 3-8 and Photo 3-9 show the turnouts to the Evergreen Drain and Hennessey Drain, respectively.

Photo 3-8. Evergreen Drain Turnout

Photo 3-9. Hennessey Drain Turnout

There are also several lateral canals that could ultimately drain into the Salt River. These canals, however, are generally relatively small and rarely have a surplus of water. There are no flow records available for these canals. Given the size and infrequent water surplus of these canals, they are not considered to be a potential water source for the habitat restoration project. These lateral canals are shown on the Water Budget Map.

The RWCD diverts water from the Southern Canal at a pumping station located approximately 5.0 miles downstream of Granite Reef Dam. Irrigation water is pumped from the Southern Canal into the Roosevelt Canal, which then flows toward the southeast. The areas irrigated by the RWCD irrigation water are located in eastern Mesa, eastern Chandler, and Gilbert. Because these areas are located a great distance from the Salt River and south of the Southern Canal, there are no canal drains that return water to the Salt River.

3.7.2 Quantity Analyses

Flow records for the SRP drains were evaluated for the period from January 1992 through December 2001. These records indicate that, for the Evergreen Drain, the average monthly volume of flow for this period ranged from 10.9 acre-feet in May to 74.5 acre-feet in September with an average annual total of 566.5 acre-feet. For the Hennessey Drain, the average monthly volume of flow ranged from 2,264.3 acre-feet in April to 4,937.4 acre-feet in August with an average annual total of 45,930.7 acre-feet. It should be noted that the flow records for the Hennessey Drain do not include the water delivered to the GRUSP project. For the Tempe Drain, the average monthly volume of flow ranged from 8.0 acre-feet in December to 2,607.2 acre-feet in January with an average annual total of 10,880.2 acre-feet. In addition, ponded water exists in the Salt River channel in the vicinity of the Tempe Drain outfall; this may indicate that the Tempe Drain may provide sufficient water to establish some restored habitat. Table 3-3 summarizes the average monthly and annual volumes of flow for these drains for the period of record evaluated.

3.7.3 Quality Analyses

The water discharged from canal drains is generally high quality and suitable for the habitat restoration project.

3.7.4 Water Rights

Irrigation return flows discharged to the river become available for use by other water users. If this water is diverted and directed into the SRRP, it could be utilized to support the wetland and riparian habitat.

3.7.5 Assessment of Source

Canal drains may provide a supplemental source of water for the restoration project. The amount of water released through these drains is relatively consistent from month to month; however, releases typically only occur for a few days each month. These releases are controlled by the

SRP and are not expected to be reliable. Canal drains are typically only utilized when a surplus of water exists in the major canals. When these releases do occur, however, they could be used to supplement the habitat restoration water supply.

3.8 Sand and Gravel Mining Operations Releases

3.8.1 Description of Source

There were four mining operations identified within the project study area; these operations use water to process aggregate materials. Three of these mining operations are operated by Salt River Sand and Rock (SRSR), and one is operated by United Metro Materials Corp. The SRSR Dobson Plant is located north of the river between the Pima Freeway (Loop SR-101) and Dobson Road. The SRSR Beeline Plant is located south of the Beeline Highway (U.S. 87) between Horne Road and Gilbert Road. The SRSR Higley Plant is located north of the Southern Canal between Greenfield Road and Higley Road, and the United Metro operation is located south of the Beeline Highway on the east side of Country Club Drive. To our knowledge, some of these operations discharge a negligible amount of water to the Salt River.

3.8.2 Quantity Analyses

The Community provides water to Salt River Sand and Rock for use in their Dobson Plant. The Community has provided approximately 450 acre-feet, 800 acre-feet, and 1,200 acre-feet of water to this plant during 1999, 2000, and 2001, respectively. This water is used for processing aggregates and stored in holding ponds when not in use. To our knowledge, a negligible amount of water is being discharged into the Salt River.

3.8.3 Quality Analyses

The quality of water discharged from sand and gravel mining operations is dependant partially on the original water supply. The most significant water quality impairment due to these mining operations is sediment.

3.8.4 Water Rights

Discharges from sand and gravel mining operations released to the river become available for use by other water users. If this water is diverted and directed into the SRRP, it could be utilized to support the wetland and riparian habitat.

3.8.5 Assessment of Source

Discharges from sand and gravel mining operations are not considered to be a potential water source for the restoration project. To our knowledge, there are no operations that currently discharge excess water into the Salt River.

3.9 Salt River Project and Central Arizona Project Water

3.9.1 Description of Source

SRP delivers water to the Community lands as well as non-Indian lands. SRP canals are subject to a two- to four-week dry-up period every year to allow for maintenance activities. The Arizona Canal and Southern Canal have separate dry-up periods. Photo 3-10 and Photo 3-11 show the Arizona Canal and Southern Canal, respectively.

Photo 3-10. SRP's Arizona Canal

Photo 3-11. SRP's Southern Canal

CAP water is diverted from the Colorado River and transported across Arizona. The CAP system crosses the Salt River immediately downstream of Granite Reef Dam, and there are turnouts that allow CAP water to be diverted into the SRP system. The CAP canal is not subject to periodic dry-up periods, but because the SRP system is needed to transport to the project area, the SRP dry up can impact the delivery.

3.9.2 Quality Analyses

The quality of both SRP and CAP water is suitable for use in the SRRP. Quality is not a constraint.

3.9.3 Water Rights

SRP is a delivery organization. The water rights associated with lands within the SRP area are tied to the land. These water rights were established by the Kent Decree and relate to normal flow of surface water and stored water. SRP lands also have pumped rights gained when the landowner funded well development. Lands in the Salt River do not have SRP rights, and SRP could not provide water to these lands. SRP delivers water to the Community, and the rights for this water were also established by the Kent Decree. There may be more flexibility to allow use of Community water on lands within the river.

Rights to CAP water are established by allocations made by the Secretary of the Interior. The Community has a contract with the federal government for CAP water. Mesa has a subcontract with the Central Arizona Water Conservation District and the Bureau of Reclamation for delivery of CAP water.

3.9.4 Assessment of Water Source

SRP water delivered to non-Indian lands should not be considered as a potential water source. CAP water delivered to Mesa could be considered a water source. However, Mesa would need to commit a portion of its allocated water to the project. Use of Mesa's CAP subcontract water for habitat restoration would mean a depletion of the water Mesa uses to comply with Assured Water Supply requirements and to meet current and future demands. This is an institutional issue rather than a water supply issue. It may also be possible to develop an agreement between the parties whereby excess CAP water is purchased and transported through the SRP/CAP interconnection facility for delivery to the SRRP. However, excess CAP water supplies are not projected to be available in the very long term.

There is a potential to use water delivered by SRP to the Community and the Community's CAP allocation to supply the SRRP. These are institutional decisions that must be made by the Community rather than a water supply issue. If committed to the project, this water could be diverted at Granite Reef Dam or via a pump station to supply the eastern portion of the project area. Deliveries to the central and western portion of the project could use the Community's irrigation water delivery system.

If SRP or CAP water is committed to the project, it will be a dependable supply for most of the year. However, a supplemental supply may be needed to augment the flow during the SRP dry-up periods. The need for a supplemental supply can be defined when the habitat alternatives are developed and the vegetation mix is proposed. The water demand of the vegetation may be very low when the dry up occurs, and the demand for supplemental water may be small or eliminated.

4.0 Evaluation of Water Sources

Each of the potential water sources has been evaluated based on the quantity and seasonality of flow, water quality, water rights, and institutional considerations. A few dependable and supplemental sources of water are available to supply the SRRP. For some of these, there is sufficient information to quantify the potential supply; however, others will require further monitoring to verify the quantity and seasonality of flow. In addition, the Community, Mesa, SRP, or CAP could make other water sources available upon institutional commitments. These entities will need to decide if, how much, and when they will commit water to the SRRP. Table 4-1 presents a summary of the analyses.

The habitat restoration alternatives for this project have not yet been developed; however, an estimate of the potential water demands can still be made. For the purposes of this evaluation, the water demands have been estimated for three types of habitat restoration: (1) unlined open water-marsh areas, (2) lined open water-marsh areas, and (3) cottonwood-willow-mesquite areas.

Unlined open water-marsh areas will have two principal water demands – infiltration and evaporation. The infiltration losses through the bottom of the open water-marsh area can be projected based on the local percolation rates. GRUSP has recharge rates that average between 1 and 3 feet per day. However, an organic mat typically forms on the bottom and sides of wetland areas that will restrict percolation. Research for the Tres Rios Project has shown that the percolation in an unlined open water-marsh can be 1 to 2 feet per day. Assuming a 1-foot-per-day percolation rate, a total of 365 feet (or acre-feet per acre) will infiltrate each year. With an annual evaporation rate of 6.033 feet per year and an annual precipitation rate of 0.638 feet per year, the net evaporation demands is 5.40 feet per year. Therefore, the total water demand of unlined open water-marsh areas will be 370.40 feet per year. This amount is equivalent to a continuous flow of 0.51 cfs per acre (0.33 mgd per acre). Table 4-2 shows the monthly water demands, per acre, for unlined open water-marsh habitat areas.

Lined open water-marsh areas can be designed to reduce and possibly eliminate infiltration. This technique drastically reduces the amount of infiltration and decreases the net water demand. If infiltration is eliminated, the lined open water-marsh areas will only have one water demand – evaporation. Thus, considering precipitation, the net water demand for lined open water-marsh areas will be 5.40 feet per year or 0.0075 cfs per acre (0.0048 mgd per acre). Evaporation rates are greatest during the summer months of June and July when the demand is 0.825 feet per

month. Coincidentally, June, with 0.011 feet, boasts one of the lowest monthly precipitation amounts. During June, a net water demand of 0.81 feet per month results in a peak flow demand of 0.0137 cfs per acre (0.0088 mgd per acre). Table 4-2 shows the monthly water demands, per acre, for lined open water-marsh habitat areas.

The cottonwood-willow-mesquite areas are projected to have a consumptive use of 3.70 feet per year (or acre-feet per acre each year) with no infiltration losses. Considering precipitation, this results in a net water demand of 3.06 feet per year. This amount is equivalent to a continuous flow of 0.0042 cfs per acre (0.0027 mgd per acre). Consumptive use values are greatest during June, July, and August when the demand is 0.555 feet per month. June experiences the least amount of precipitation, creating the largest net water demand. During June, a net water demand of 0.54 feet per year results in a peak flow demand of 0.0091 cfs per acre (0.0059 mgd per acre). Table 4-2 shows the monthly water demands, per acre, for cottonwood-willow-mesquite habitat areas.

From this water budget analysis, the only dependable water sources that are currently available include the Price Drain, the Alma School Drain, and seepage at Granite Reef Dam. The seepage at Granite Reef Dam is already supplying water to wetland areas similar to those proposed to be restored. Using only the flows from the Price Drain and Alma School Drain, the amount of habitat areas that could be restored were computed on a monthly basis; these results are shown in Table 4-3. The areas that these flows can support vary for each month, so the month with the lowest supply to demand ratio governs the amount of habitat area that can realistically be restored. During June, approximately 156 acres of lined open water-marsh areas or 233 acres of cottonwood-willow-mesquite areas could be restored. During other months, this water supply could fulfill the water demand for larger habitat areas; however, the peak water demands in June limit the acreage that this water supply can support without an additional water source. Table 4-3 shows the monthly water budget using only the Price Drain and Alma School Drain for water supply.

For the purposes of this evaluation, the Tres Rios Project can be used for comparison. The SRRP is approximately 15 miles long whereas the Tres Rios Project is approximately 9 miles long. However, it can be used to develop approximate water demands. Tres Rios contains approximately 440 acres of open water-marsh and approximately 2,400 acres of restored vegetation. If similar habitat restoration alternatives are proposed for this project, approximately

730 acres of open water-marsh and 4,000 acres of cottonwood-willow-mesquite areas would be restored. The water demand for lined open water-marsh areas would then be 3,938 acre-feet per year; this corresponds to a continuous rate of 5.44 cfs (3.52 mgd). The water demand for 4,000 acres of cottonwood-willow-mesquite would be 12,247 acre-feet per year; this corresponds to a continuous rate of 16.92 cfs (10.93 mgd). A total water demand of 16,185 acre-feet, equivalent to a continuous rate of 22.36 cfs (14.45 mgd), would be required to replicate the habitat areas similar to those for Tres Rios Project. During June, the peak water demand for both habitat types would be 46.57 cfs (30.10 mdg). Table 4-4 shows the monthly water demands for habitat areas similar to those for the Tres Rios Project.

An additional water supply is required to meet the water demands for restored vegetation patterns similar to those for the Tres Rios Project. The monthly and annual amounts needed are shown on Figure 4-4. During the peak month of June, an additional 43.27 cfs (27.97 mgd) is required. During the winter months, the additional supply required would be much less; for example, an additional 4.09 cfs (2.65 mgd) would be required in December.

To make up this deficit, a dependable source of water must be committed to the restoration project. Pumped groundwater, effluent, and SRP or CAP water could each feasibly supply all or a portion of this additional amount; however, an institutional commitment must be made by the owners of these water sources. If pumped groundwater is used to supply this deficit, utilizing existing wells or installing new wells will be necessary. Assuming an average well production of 1,200 gpm, 16 wells would be required during the peak month of June; fewer wells would be required at other times. The NWWRP, with its existing capacity, does not have sufficient effluent to meet the peak month demands; however, effluent could be used in conjunction with another source. If SRP or CAP water is used as a water source, this water would not be available for use by the Community or Mesa to meet other demands. For comparison, the long-term residential water use is approximately 140 gallons per person per day. A projected demand of 27.97 mgd is equivalent to the water supply for about 200,000 people.

This analysis demonstrates that limited water is currently available to supply the SRRP; these sources are dependable but are not of sufficient quantity to fulfill to total project needs. An additional source or combination of sources must be sought to provide adequate water for the restored habitat. This additional supply could feasibly come from pumped groundwater, effluent, SRP, or CAP sources given that the appropriate entities that control this water make a commitment to the project.

5.0 Recommendations

Knight Piésold has developed several recommendations related to the water budget.

1. Monitor the discharge from the Alma School Drain located on the north bank of the Salt River along Alma School Road to verify the quantity of water available and if the supply is fairly continuous over the year. Given the presence of wetland vegetation at the outlet, this drain could likely be a dependable water source.

2. Meet with SRP to develop a program to monitor the quantity of seepage from Granite Reef Dam. The seepage quantity is not measured at this time but potentially is a dependable water source for the eastern portion of the project area. This supply currently supports wetland vegetation, so, if quantified, the use of seepage could be optimized to provide the greatest amount of restored habitat.

3. Discuss with each potential water supplier (SRP, CAP, SRPMIC, NWWRP, and Mesa) the possibility of using their water as a source for the habitat restoration project.

4. Develop specific restoration alternatives using combinations of habitat types to adhere to the project water supply. For example, a mix of open water-marsh and cottonwood-willow (no mesquite) habitat areas would have a high water demand; a mix of cottonwood-willow-mesquite with some open water-marsh habitat areas would require a moderate water demand, and a mix of cottonwood-willow-mesquite with limited open water-marsh habitat would require a low water demand. Tailoring the habitat types to the water supply would optimize the total area that could be restored for this project.

References

Cooley, K.R., 1970, *Evaporation from Open Water Surfaces in Arizona*, U.S. Department of Agriculture, Agricultural Research Service.

EcoPlan Associates, Inc., 1997, "Salt River Pima-Maricopa Indian Community Water Quality Assessment Report."

EcoPlan Associates, Inc., 1998, "Salt River Pima-Mariocpa Indian Community Water Quality Management Plan."

Greeley & Hansen, 2001, "Salt/Gila Groundwater Analysis Project, Draft Summary Report."

Haws, G., 2002, "Final Document, Va Shly'ay Akimel Salt River Restoration Project, City of Mesa, Arizona."

Kenneth D. Schmidt and Associates, 2002, *Tri-Cities Landfill Groundwater Monitoring*.

Knight Piésold and Co., 2002a., "JAB01.G Interior Drainage, Draft Report."

Knight Piésold and Co., 2002b, "JAB01.J Groundwater Model, Draft Report."

Schmidli, R.J., 1996, *Climate of Phoenix, Arizona: An Abridged On-Line Version of NOAA Technical Memorandum NWS WR-177*, Weather Service Forecast Office, Phoenix, Arizona.

Tres Rios River Management Plan Water Quality Technical Committee, 1998, "Tres Rios River Management Plan: Water Quality Summary Report."

Tres Rios River Management Plan Water Supply Technical Committee, 1997, "Tres Rios River Management Plan: Draft Water Supply Summary Report."

U.S. Army Corps of Engineers, 1998, "Rio Salado, Salt River, Arizona, Feasibility Report and Environmental Impact Statement," Los Angeles District, South Pacific Division.

WASS Gerke + Associates, Inc., 2002, "Draft Memorandum on Riparian and Constructed Wetland Vegetation Root Zone Depth Requirements."

Tables

TABLE 2-1

RIPARIAN AND CONSTRUCTED WETLAND VEGETATION REQUIREMENTS

Vegetation Type		Seedling Establishment	Sapling Growth	Mature Survival
Trees (Groundwater Depth Requirements)				
Cottonwood	Populus freemontii	Moist soils in March/April	0.66 to 6.6 feet	16.5 feet
Willow	Salix gooddingii	Moist soils in April/May	0.66 to 6.6 feet	10 feet
Mesquite	Prospis sp.	< 4 inches	3.3 to 33 feet	< 33 feet
Salt Cedar	Tamarix sp.	Moist soils in May to September	0.66 to 8.2 feet	33 feet
Common Aquatic Plants (Inundation Depth Requirements)				
Shallow Emergent Marsh	Scirpus validus, Scirpus americanus, Scirpus acutus, Sagittaria greggii, Sagittaria latifloa, Alisma triviale, Typha latifola	Saturated soils to 2 inches	Saturated soils	Saturated soils to < 2.6 feet
Deep Emergent Marsh	Typha domingensis, Scirpus californicus, Phragmites australis	Saturated soils to 2 inches	Saturated soils	Saturated soils to < 4.9 feet
Floating Aquatic	Hydrocotyle sp., Ludwegia palustrus, Polygonum hydropeperoides, Potomogeton sp. Rorippa, Nasturtium-aquaticum	Moist soils to 4 inches	Moist soils to 8 inches	Moist soils to 8 inches
Transitional Marsh Plants	Eleocharisparishii, Eleocharis macrostachya, Equisetum laevigatum or similar sp., Cyperus niger, Cyperus laevigatus, Cypeus erythohizos or similar sp., Juncus balticus, Juncus bufonius, Juncius tenurs var. Dudleyi, Juncius inetrior, Juncus torreyi, or similar sp., Heteranthera limosa, Anemopsis californicus	Moist soils to 4 inches	Moist soils to 4 inches	Moist soils to 4 inches

Source: WASS Gerke + Associates, Inc.

TABLE 3-1

SUMMARY OF HISTORIC SALT RIVER FLOOD FLOWS
(floods with greater than 10,000 cfs discharge)

Period of Flow Start Date	Period of Flow End Date	Flow Event Maximum Daily Average Flow (cfs)
2/7/14	7/2/14	15,800
1/29/15	8/18/15	18,700
1/15/16	5/15/16	79,100
9/8/16	2/4/17	21,100
4/17/17	5/15/17	23,400
3/7/18	3/26/18	28,400
11/25/19	13/14/1919	46,200
1/4/20	4/25/20	87,800
12/26/21	1/9/22	24,100
2/8/22	2/18/22	10,000
3/16/22	4/10/22	18,000
9/18/23	9/22/23	24,100
12/26/23	1/8/24	42,800
3/31/26	4/16/26	28,800
2/14/27	3/19/27	49,800
9/12/27	9/20/27	16,200
4/4/29	4/19/29	17,200
2/12/31	2/20/31	22,900
2/9/32	3/29/32	48,700
2/6/37	3/25/37	36,981
2/28/39	3/17/39	58,739
2/5/41	5/25/41	32,206
12/21/65	1/12/66	64,000
2/20/73	6/5/73	22,273
2/28/78	4/11/78	95,800
12/16/78	4/19/79	110,000
1/29/80	6/3/80	137,725
2/2/83	6/17/83	30,000
9/27/83	10/24/83	39,878
12/24/83	1/24/84	11,200
12/21/84	6/1/85	25,604
12/22/91	6/21/92	12,898
8/21/92	9/8/19992	13,615
12/28/92	6/4/93	99,396
1/20/95	5/2/95	53,316

Source: U.S. Army Corps of Engineers' Tres Rios Project

TABLE 3-2

STORM DRAINS AVERAGE ANNUAL RUNOFF VOLUMES

(units are in acre-feet)

Interior Drain	Drainage Area (mi^2)[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Price Drain[2]	31.2	202.2	125.6	266.9	178.8	311.1	136.5	283.1	337.1	267.7	193.8	150.5	166.5	2,620
Tempe Drain[3,4]	10.0	64.6	66.6	84.9	21.2	11.6	12.5	80.1	92.6	83.0	62.7	63.7	96.5	740
Price Road Freeway Local Drainage[3,4]	0.4	2.6	2.7	3.4	0.9	0.5	0.5	3.2	3.8	3.4	2.5	2.6	3.9	30
Dobson Road Storm Drain[3,4]	1.8	12.2	12.6	16.1	4.0	2.2	2.4	15.1	17.5	15.7	11.9	12.0	18.3	140
McLellan Road Storm Drain[3,4]	1.0	7.0	7.2	9.2	2.3	1.3	1.4	8.7	10.0	9.0	6.8	6.9	10.4	80
Country Club/McKellips Storm Drain[3,4]	3.7	26.2	27.0	34.4	8.6	4.7	5.1	32.5	37.5	33.6	25.4	25.8	39.1	300
Red Mountain Freeway Local Drainage[3,4]	unknown							minimal						
Natural Drainage[3,4]	2.0							minimal						
Alma School Storm Drain	unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Percent of Annual Rainfall:		8.7	9.0	11.5	2.9	1.6	1.7	10.8	12.5	11.2	8.5	8.6	13.0	100.0

1. Drainage areas were estimated based on the drainage delineation made by personnel from the City of Mesa.
2. Monthly and annual storm water runoff volumes were computed from FCDMC flow records.
3. Monthly storm water runoff distributions were assumed to follow the monthly pattern of rainfall.
4. Annual runoff volumes were computed from the drainage area vs. average annual runoff relationships developed for the Rio Salado Study (Figure 3-3).

TABLE 3-3

CANAL DRAINS AVERAGE ANNUAL RUNOFF VOLUMES

(units are in acre-feet)

Interior Drain	Drainage Area (mi^2)[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL[2]
Evergreen Drain	~ 0	64.8	57.1	63.4	68.8	10.9	12.7	44.8	53.0	74.5	26.5	65.7	24.4	567
Hennessey Drain	~ 0	4,788	3,704	3,367	2,264	4,288	3,868	4,604	4,937	4,654	4,171	2,853	2,423	45,921
Tempe Drain	10.0	2,607	2,556	2,559	1,678	835	158	64.2	193	72.6	80.2	69.2	8.0	10,880

1. Drainage areas were estimated based on the drainage delineation made by personnel from the City of Mesa.
2. Annual and monthly runoff volumes for the canal drains were computed from the SRP daily flow records.

Source: Computed from SRP Daily Flow Records

TABLE 4-1

WATER BUDGET MATRIX

Water Source	Description/Location	Quantity Available	Availability	Supply Designation	Discussion/Issues
In-Situ Groundwater					
Regional water table	Throughout the study area; all reaches	None	Not available	Unacceptable	Regional groundwater is too deep for use by the desired vegetation. Depth exceeds 30 feet, which is the limit for mesquite.
Local or perched water table	Extends from Granite Reef Dam approximately 1 mile downstream; Reach 1	Not measured	Continuous	Dependable	Local supply available at the surface from Granite Reef to about one mile downstream.
Pumped Groundwater					
Community Lands	Throughout the Community; all reaches	Pending	Continuous	Dependable or Supplemental	Requires a reallocation of water resources to project by the Community.
Non-Indian Lands					
Irrigation Grandfather Rights	Tied to specific parcels of land for growing crops.	Not Available	None	Unacceptable	IGR water must be used on a historically specified parcel of land.
Type I Non-Irrigation Rights	Tied to specific parcels of land for changes in land use.	Not Available	None	Unacceptable	Type I water cannot be used off of the specific land parcel.
Type II Non-Irrigation Rights	Pumping for uses not associated with historic farmland.	Pending	Continuous	Dependable or Supplemental	Requires purchase and transfer of Type II right.
Groundwater Permits	Pumping for new uses.	Not Available	None	Unacceptable	Project can not meet permit requirements and conditions.
Service Area Right	Pumping for public water providers.	Pending	Continuous	Dependable or Supplemental	Pumped water will impact Mesa's overall water resources unless credits to offset the pumping are purchased or developed.
Salt River Flood Flows					
Direct Use	Flow in the Salt River due to spills over Granite Reef Dam; all reaches	Quantity varies with each flood event	Approximately once every 3 years	Problem	Due to the unpredictable nature of the flood flows, they are not a dependable supply, and may cause damage to restored areas.
Indirect Use	Groundwater recharge due to flood flows in the Salt River; all reaches	Quantity varies with each flood event	During floods and for a short time after	Supplemental	Recharge of groundwater allows for indirect use; and, surface soil saturation will augment seed germination.
Storm Water Discharges					
Alma School Road Storm Drain	Storm runoff from the Community, outfalls along the west side of alma School Road; Reach 5	1 to 2 cfs estimated (no flow records available)	May be fairly continuous	Supplemental	Wetland vegetation are present indicating a fairly continuos flow; flow monitoring may permit reclassification as a dependable source.
Natural Surface Drainage - SRPMIC	Uncontrolled surface runoff from the Community; all reaches	Minimal	During or immediate after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; most runoff is uncontrolled overland flow.
Price Drain	Storm runoff from Mesa, outfalls along the east side of the Pima Freeway (Loop 101); Reach 6	Averages 4 cfs; ~ 2,500 ac-ft per yr	Continuous	Dependable	Continuous base flow may be a dependable source; however, water quality may be a concern due to storm water runoff.
Tempe Drain (see Canal Drains)	Storm runoff from mesa, outfalls between Dobson Road and Alma School Road; Reach 5	(See Canal Drains)			This drain serves as a canal drain and intercepts storm water runoff from Mesa.
Price Road Freeway Local Drainage	Storm runoff from Mesa, outfalls along the east side of the Pima Freeway (Loop 101); Reach 6	~ 30 ac-ft per yr	During or immediate after rainfall events	Unacceptable to Supplemental	First flush is unacceptable due to potential water quality problems, but the remainder of the flow can be a supplemental water source.

TABLE 4-1 (CONTINUED)

WATER BUDGET MATRIX

Water Source	Description/Location	Quantity Available	Availability	Supply Designation	Discussion/Issues
Storm Water Discharges (continued)					
Dobson Road Storm Drain	Storm runoff from Mesa, outfalls along the east side of Dobson Road; Reach 6	~ 140 ac-ft per yr	During or immediate after rainfall events	Unacceptable to Supplemental	First flush is unacceptable due to potential water quality problems, but the remainder of the flow can be a supplemental water source.
McLellan Road Storm Drain	Storm runoff from Mesa, outfalls west of Alma School Road; Reach 5	~ 80 ac-ft per yr	During or immediate after rainfall events	Unacceptable to Supplemental	First flush is unacceptable due to potential water quality problems, but the remainder of the flow can be a supplemental water source.
Country Club/McKellips Storm Drain	Storm runoff from Mesa, outfalls along Country Club Drive; Reach 5	~ 300 ac-ft per yr	During or immediate after rainfall events	Unacceptable to Supplemental	First flush is unacceptable due to potential water quality problems, but the remainder of the flow can be a supplemental water source.
Red Mountain Freeway Local Drainage	Storm runoff from the Red Mountain Freeway (Loop 202); Reach 3, 4, 5, and 6	Minimal	During or immediate after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; most runoff is uncontrolled overland flow.
Natural Surface Drainage - Mesa	Uncontrolled runoff between Gilbert Road and Granite Reef Dam, south of the Salt River; Reach 1 and 2	Minimal	During or immediate after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; most runoff is uncontrolled overland flow.
Effluent					
Direct Use	Effluent from the NWWRP discharged directly into the project; Reach 6.	Pending; may be as high as 30 MGD (~34,000 ac-ft per yr)	Continuous	Dependable or Supplemental	The quantity and availability of effluent water is subject to an institutional commitment by Mesa; Mesa has existing commitments for this effluent.
Indirect Use	Effluent from the NWWRP recharged into the groundwater; Reach 6.	Pending	Continuous	Dependable or Supplemental	Mesa has incorporated the recharge credits for this effluent into its long-term water plan; it would require a reallocation to the project. Indirect use requires wells to recover the recharged water.
Irrigation Return Flows					
Irrigation Tailwater	Excess water applied to crops within the western portion of the Community; Reach 4, 5, and 6	Minimal	Irrigation season	Supplemental	Supply only available during irrigation season; unreliable because irrigation practices are designed to reduce the tailwater quantity.
Irrigation Drainage	Excess water in lateral canals within the Community; Reach 4, 5, and 6	Minimal	Irrigation season	Supplemental	Supply only available during irrigation season; unreliable because irrigation practices are designed to reduce the tailwater quantity.
Canal Drains					
Evergreen Drain	Drains the Arizona Canal, outfalls west of Horne Road; Reach 4	averages < 1 cfs; ~567 ac-ft per yr	In-frequent	Supplemental	Flow is due to controlled releases by SRP; releases only occur once or twice each month and are not reliable.
Hennessey Drain	Drains the Southern Canal, outfalls east of Val Vista Road; Reach 4	averages 63 cfs; ~ 45,921 ac-ft per yr	In-frequent	Supplemental	Flow is due to controlled releases by SRP; releases have occurred frequently in the past but only for two days since Nov. 2001; may not reliable in the future.
Tempe Drain	Drains the Tempe Canal, outfalls between Dobson Road and Alma School Road; Reach 5	averages 15 cfs; ~ 10,880 ac-ft per yr	In-frequent	Supplemental	This canal intercepts storm water so flow is due to controlled releases by SRP as well as rainfall events; releases occur on average 4 times each month and are not reliable.
Sand & Gravel Mining Releases					
	Within the Salt River; all reaches	None	Not available	Unacceptable	No known discharges from these operations.
Salt River Project & Central Arizona Project Water					
	Throughout the project area; all reaches	Pending	Pending	Dependable to Supplemental	The quantity and availability of water supply is subject to institutional commitments by SRP or CAP.

TABLE 4-2

RESTORED HABITAT WATER DEMANDS

Month	Days	Consumptive Use		Evaporation		Precipitation		Infiltration	Unlined Open Water-Marsh			Lined Open Water-Marsh			Cottonwood-Willow-Mesquite		
		%	acre-feet per acre	inches	acre-feet per acre	inches	acre-feet per acre	acre-feet per acre	acre-feet per acre	cfs per acre	mgd per acre	acre-feet per acre	cfs per acre	mgd per acre	acre-feet per acre	cfs per acre	mgd per acre
January	31	5	0.185	2.2	0.183	0.67	0.056	31	31.13	0.51	0.33	0.13	0.0021	0.0013	0.13	0.0021	0.0014
February	28	5	0.185	3.1	0.258	0.68	0.057	28	28.20	0.51	0.33	0.20	0.0036	0.0023	0.13	0.0023	0.0015
March	31	5	0.185	5.0	0.417	0.88	0.073	31	31.34	0.51	0.33	0.34	0.0056	0.0036	0.11	0.0018	0.0012
April	30	10	0.370	6.6	0.550	0.22	0.018	30	30.53	0.51	0.33	0.53	0.0089	0.0058	0.35	0.0059	0.0038
May	31	10	0.370	9.0	0.750	0.12	0.010	31	31.74	0.52	0.33	0.74	0.0120	0.0078	0.36	0.0059	0.0038
June	30	15	0.555	9.9	0.825	0.13	0.011	30	30.81	0.52	0.33	0.81	0.0137	0.0088	0.54	0.0091	0.0059
July	31	15	0.555	9.9	0.825	0.83	0.069	31	31.76	0.52	0.33	0.76	0.0123	0.0079	0.49	0.0079	0.0051
August	31	15	0.555	9.0	0.750	0.96	0.080	31	31.67	0.52	0.33	0.67	0.0109	0.0070	0.48	0.0077	0.0050
September	30	5	0.185	6.9	0.575	0.86	0.072	30	30.50	0.51	0.33	0.50	0.0085	0.0055	0.11	0.0019	0.0012
October	31	5	0.185	5.3	0.442	0.65	0.054	31	31.39	0.51	0.33	0.39	0.0063	0.0041	0.13	0.0021	0.0014
November	30	5	0.185	3.3	0.275	0.66	0.055	30	30.22	0.51	0.33	0.22	0.0037	0.0024	0.13	0.0022	0.0014
December	31	5	0.185	2.2	0.183	1.00	0.083	31	31.10	0.51	0.33	0.10	0.0016	0.0011	0.10	0.0017	0.0011
Annual	365	100	3.700	72.4	6.033	7.66	0.638	365	370.40	0.51	0.33	5.40	0.0075	0.0048	3.06	0.0042	0.0027
Peak	31		0.555		0.825		0.083	31	31.76	0.52	0.33	0.81	0.0137	0.0088	0.54	0.0091	0.0059

TABLE 4-3

HABITAT ACHIEVABLE UNDER EXISTING CONDITIONS

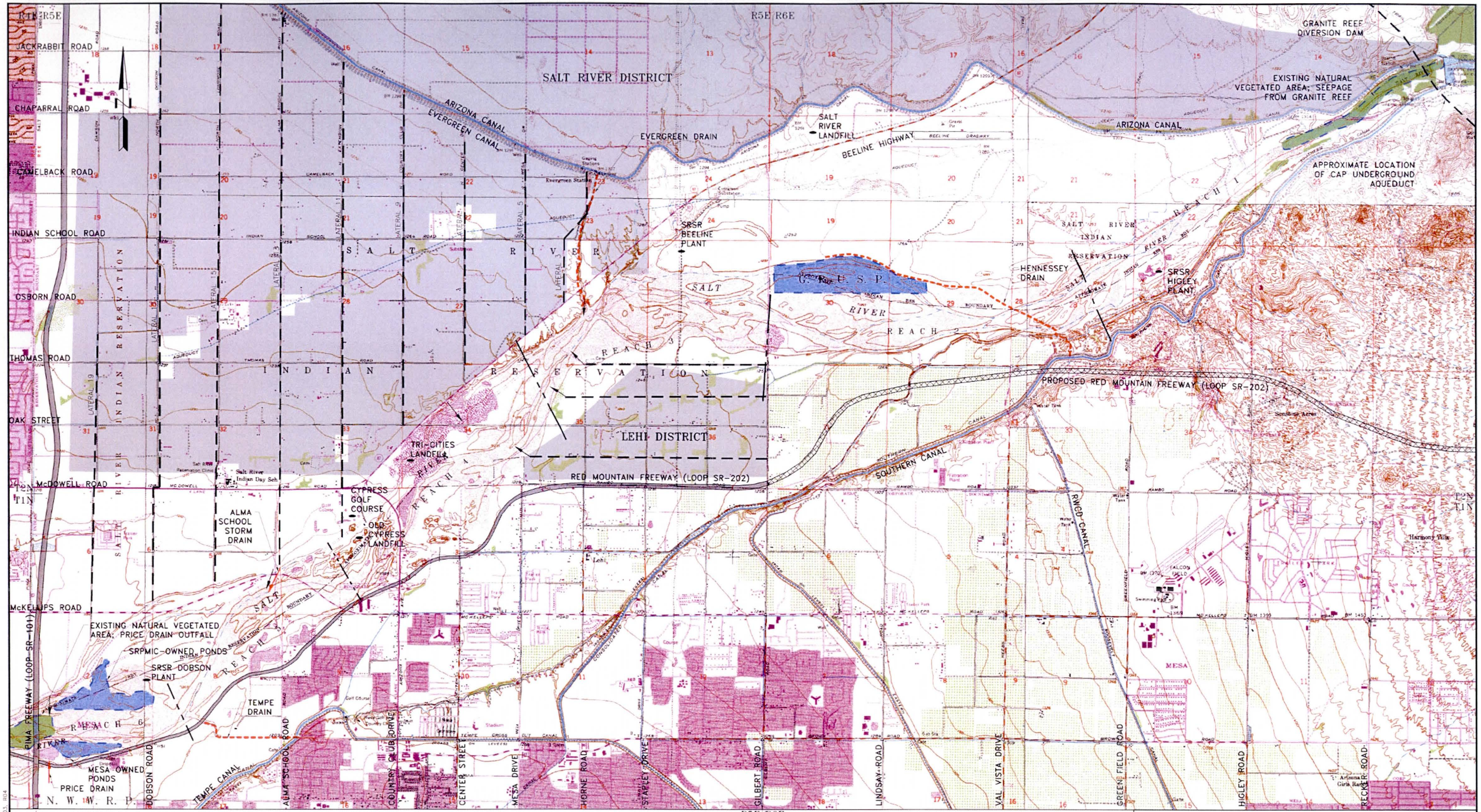
Month	Days	Price Drain			Alma School Drain			Total Water Available			Habitat Acres Achievable	
		acre-feet	cfs	mgd	acre-feet	cfs	mgd	acre-feet	cfs	mgd	Lined Open Water-Marsh	Cottonwood-Willow-Mesquite
January	31	202.19	3.29	2.13	61.49	1.00	0.65	263.68	4.29	2.77	1,337	1,319
February	28	125.58	2.26	1.46	55.54	1.00	0.65	181.12	3.26	2.11	580	912
March	31	266.86	4.34	2.81	61.49	1.00	0.65	328.34	5.34	3.45	618	1,900
April	30	178.75	3.00	1.94	59.50	1.00	0.65	238.26	4.00	2.59	290	438
May	31	311.10	5.06	3.27	61.49	1.00	0.65	372.59	6.06	3.92	325	669
June	30	136.49	2.29	1.48	59.50	1.00	0.65	195.99	3.29	2.13	156	233
July	31	283.07	4.60	2.98	61.49	1.00	0.65	344.56	5.60	3.62	295	458
August	31	337.12	5.48	3.54	61.49	1.00	0.65	398.60	6.48	4.19	385	542
September	30	267.75	4.50	2.91	59.50	1.00	0.65	327.25	5.50	3.55	420	1,866
October	31	193.77	3.15	2.04	61.49	1.00	0.65	255.26	4.15	2.68	426	1,261
November	30	150.54	2.53	1.64	59.50	1.00	0.65	210.05	3.53	2.28	617	1,044
December	31	166.48	2.71	1.75	61.49	1.00	0.65	227.97	3.71	2.40	1,473	1,449
Annual	365	2,619.69	3.62	2.34	723.97	1.00	0.65	279.83	4.62	2.99	401	706
Minimum		125.58	2.26	1.46	55.54	1.00	0.65	181.12	3.26	2.11	156	233

TABLE 4-4

WATER BUDGET PROJECTIONS

		Total Water Available			Restored Acreage = 730 Lined Open Water/Marsh			Restored Acreage = 4,000 Mesquite/Cottonwood/Willow			Restored Acreage = 4,730 Total Water Demand			Additional Water Needed		
Month	**Days**	**acre-feet**	**cfs**	**mgd**	**acre-feet**	**cfs**	**mgd**	**acre-feet**	**cfs**	**mgd**	**acre-feet**	**cfs**	**mgd**	**acre-feet**	**cfs**	**mgd**
January	31	263.68	4.29	2.77	93.08	1.51	0.98	516.67	8.40	5.43	609.74	9.92	6.41	346.06	5.63	3.64
February	28	181.12	3.26	2.11	147.22	2.65	1.71	513.33	9.24	5.97	660.55	11.89	7.69	479.43	8.63	5.58
March	31	328.34	5.34	3.45	250.63	4.08	2.63	446.67	7.26	4.70	697.30	11.34	7.33	368.96	6.00	3.88
April	30	238.26	4.00	2.59	388.12	6.52	4.22	1,406.67	23.64	15.28	1,794.78	30.16	19.49	1,556.53	26.16	16.91
May	31	372.59	6.06	3.92	540.20	8.79	5.68	1,440.00	23.42	15.14	1,980.20	32.20	20.81	1,607.61	26.15	16.90
June	30	195.99	3.29	2.13	594.34	9.99	6.46	2,176.67	36.58	23.64	2,771.01	46.57	30.10	2,575.01	43.27	27.97
July	31	344.56	5.60	3.62	551.76	8.97	5.80	1,943.33	31.61	20.43	2,495.09	40.58	26.23	2,150.54	34.98	22.60
August	31	398.60	6.48	4.19	489.10	7.95	5.14	1,900.00	30.90	19.97	2,389.10	38.85	25.11	1,990.50	32.37	20.92
September	30	327.25	5.50	3.55	367.43	6.17	3.99	453.33	7.62	4.92	820.77	13.79	8.91	493.52	8.29	5.36
October	31	255.26	4.15	2.68	282.88	4.60	2.97	523.33	8.51	5.50	806.21	13.11	8.47	550.95	8.96	5.79
November	30	210.05	3.53	2.28	160.60	2.70	1.74	520.00	8.74	5.65	680.60	11.44	7.39	470.55	7.91	5.11
December	31	227.97	3.71	2.40	73.00	1.19	0.77	406.67	6.61	4.27	479.67	7.80	5.04	251.70	4.09	2.65
Annual	365	279.83	4.62	2.99	3,938.35	5.44	3.52	12,246.67	16.92	10.93	16,185.02	22.36	14.45	15,905.19	17.74	11.46
Maximum		398.60	6.48	4.19	594.34	9.99	6.46	2,176.67	36.58	23.64	2,771.01	46.57	30.10	2,575.01	43.27	27.97

Drawings



R4E R5E

R5E R6E

PLAN

2000 0 2000 FEET

REFERENCE:

1) ECOPLAN ASSOCIATES, INC., WELLHEAD MANAGEMENT STRATEGY, IDENTIFICATION OF LOW RISK AREAS FOR SITING OF NEW WELLS AND/OR MODIFICATION OF EXISTING WELLS AS DOMESTIC WELLS, APRIL 2001.

2) TETRA TECH, INC., CITY OF MESA EXISTING AND CURRENTLY PROPOSED STORM DRAINAGE SYSTEM, SEPTEMBER 1999.

3) ECOPLAN, ASSOCIATES, INC., SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1998.

LEGEND:

- SRPMIC LATERAL CANAL (3)
- SRP CANAL DRAIN
- REACH BOUNDARY
- STORM DRAIN OUTFALL (2)
- AGRICULTURAL OUTFALL
- PERCOLATION PONDS
- EXISTING NATURAL VEGETATED AREAS
- AGRICULTURAL AREAS; POTENTIAL IRRIGATION RETURN FLOWS (3)

RWCD	ROOSEVELT WATER CONSERVATION DISTRICT
GRUSP	GRANITE REEF UNDERGROUND STORAGE PROJECT
SRPMIC	SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
NWWRP	NORTH WEST WATER RECLAMATION PLANT
SRP	SALT RIVER PROJECT

NOTES:

1. IN-SITU GROUNDWATER IS TOO DEEP IN MOST PLACES TO BE CONSIDERED AS A DEPENDABLE WATER SOUCE.
2. PUMPED GROUNDWATER COULD BE MADE AVAILABLE THROUGHOUT THE PROJECT AREA.

Registered Professional Engineer (Civil) CERTIFICATE NO 29610 JAMES R. KUNKEL 07/18/02 Date Signed ARIZONA U.S.A.

REV	DATE	DESCRIPTION	APP'D / CADD
C	7/15/02	ISSUED FOR FINAL REPORT	/ WA
B	5/24/02	ISSUED FOR REVIEW	/ TMF
A	5/16/02	ISSUED FOR REVIEW	MDS / WA

— DISCLAIMER —

KNIGHT PIESOLD AND CO. PRODUCED THE DATA SHOWN ON THE DRAWING FILES USING BOTH TECHNICAL INFORMATION AND KNOW HOW. RECEIPT OF THIS DRAWING DOES NOT MEAN THAT THE RECIPIENT HAS ANY RIGHTS TO EITHER SUCH TECHNICAL INFORMATION OR KNOW HOW. ANY ADAPTATION OR MODIFICATION OF THE DATA OR DRAWING SHALL BE AT USER'S SOLE RISK AND WITHOUT LIABILITY OR LEGAL EXPOSURE TO KNIGHT PIESOLD AND CO.

CLIENT: SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY

PROJECT: SALT RIVER RESTORATION FEASIBILITY STUDY

TITLE: WATER BUDGET MAP

Knight Piésold CONSULTING

DESIGNED BY	MDS	CHECKED BY		DRAWING No. 1889M06C - 100	REV C
DRAWN BY	WA	APPROVED BY			

PLOT SCALE 1:1 XREF. NO 1889X02, X03, R04

APPENDIX

C

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

INTERIOR DRAINAGE

Knight Piésold
CONSULTING

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01G Interior Drainage
Final Report

July 17, 2002

Prepared for

Salt River Pima-Maricopa Indian Community
10005 East Osborn Road
Scottsdale, Arizona 85256
Telephone: (480) 850-8000
Facsimile: (480) 850-7366

Prepared by

Knight Piésold and Co.
1050 Seventeenth Street, Suite 650
Denver, Colorado 80265-0650
Telephone: (303) 629-8788
Facsimile: (303) 629-8789

Project 1889A/0120

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01G Interior Drainage
Final Report

Table of Contents

List of Tables iii

List of Figures v

List of Photos v

List of Drawings v

List of Appendices v

1.0 Introduction 1

2.0 Canal Drains 2

2.1 Evergreen Drain 2

2.2 Hennessey Drain 4

2.3 Tempe Drain 5

2.4 Lateral Canal Drains 6

2.4.1 Salt River Pima-Maricopa Indian Community 6

2.4.2 Salt River Project 6

2.4.3 Roosevelt Water Conservation District 6

3.0 Storm Drains 7

3.1 Salt River Pima-Maricopa Indian Community 8

3.2 City of Mesa 9

3.2.1 Price Drain 9

3.2.2 Tempe Drain 11

3.2.3 Price Road Freeway Local Drainage 12

3.2.4 Dobson Road Storm Drain 12

3.2.5 McLellan Road Storm Drain 13

3.2.6 Country Club/McKellips Storm Drain 14

3.2.7 Red Mountain Freeway Local Drainage 15

Table of Contents *(Continued)*

3.2.8 Natural Surface Drainage 15
4.0 Summary and Evaluation 16
4.1 Damage to Restored Habitat 16
4.2 Water Source 17
References R-1

List of Tables

Table	Title
2-1a	Evergreen Drain – Average Daily Flow
2-1b	Evergreen Drain – Maximum Daily Flow
2-2a	Evergreen Drain – Average Daily Volume
2-2b	Evergreen Drain – Maximum Daily Volume
2-3	Evergreen Drain – Monthly Volume
2-4a	Hennessey Drain – Average Daily Flow
2-4b	Hennessey Drain – Maximum Daily Flow
2-5a	Hennessey Drain – Average Daily Volume
2-5b	Hennessey Drain – Maximum Daily Volume
2-6	Hennessey Drain – Monthly Volume
2-7a	Tempe Drain – Average Daily Flow
2-7b	Tempe Drain – Maximum Daily Flow
2-8a	Tempe Drain – Average Daily Volume
2-8b	Tempe Drain – Maximum Daily Volume
2-9	Tempe Drain – Monthly Volume
3-1a	Price Drain – Average Daily Flow
3-1b	Price Drain – Maximum Daily Flow
3-2a	Price Drain – Average Daily Volume
3-2b	Price Drain – Maximum Daily Volume
3-3	Price Drain – Monthly Volume

List of Tables *(Continued)*

Table	*Title*
3-4	Storm Drain Peak Flows for Various Return Periods
3-5	Storm Drain Average Annual Runoff Volumes
4-1a	Summary of Interior Drains – Canal Drains
4-2b	Summary of Interior Drains – Storm Drains
4-2a	Summary of Peak Flows – Canal Drains
4-2b	Summary of Peak Flows – Storm Drains
4-3a	Summary of Average Annual Runoff – Canal Drains
4-3b	Summary of Average Annual Runoff – Storm Drains

List of Figures

Figure	Title
3-1	Peak Flow Relationships for Various Return Periods
3-2	Typical Full-Flow Storm Drain Pipe Capacity
3-3	Average Annual Storm Drain Runoff for the Phoenix Metro Area

List of Photos

Photo	Title
2-1	Evergreen Drain Turnout
2-2	Hennessey Drain Turnout
3-1	Price Drain
3-2	McLellan Road Storm Drain

List of Drawings

Drawing	Title
100	Interior Drainage Map

List of Appendices

Appendix	Title
A	Evergreen Drain Daily Flow Records
B	Hennessey Drain Daily Flow Records
C	Tempe Drain Daily Flow Records
D	Price Drain Flow Records

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01G Interior Drainage
Final Report

1.0 Introduction

Interior drains, or side drains, that outfall into the Salt River between Granite Reef Diversion Dam (Granite Reef Dam) and the Pima Freeway (Loop SR-101) may have implications on the Va Shly'ay Akimel Salt River Restoration Project (SRRP). These drains have been evaluated to assess the potential damage that frequent inundation or high discharge velocities may cause to the restored habitat and the possibility of utilizing this water to support or nourish the reestablishment of riparian vegetation.

Two types of interior drains were identified that outfall into the Salt River within the project study limits – canal drains and storm drains. Canal drains are designed to release water from the major canals and discharge it into the Salt River. These drains are an operational mechanism to control flow in the canal system. Storm drains are designed to collect runoff generated by rainfall events. These drains are typically installed in urbanizing areas to protect developments from a design storm of a certain return period.

2.0 Canal Drains

Canal drains are often constructed along the major canals in the area to provide a means to discharge water from the canal other than the designated delivery turnouts. The drains may be used for a variety of reasons. During storm events, the canals intercept storm water runoff; if this storm water runoff is significant, water may need to be released from the canal to prevent overflowing the canal banks. Additionally, the major canals occasionally convey more water than is needed by the downstream water users; in this case, the excess water can be released through these drains. They also provide a mechanism to empty or lower the water level in the canal to allow for periodic inspection and maintenance or for repairs whenever necessary.

Several canal drains were identified within the study area. The most significant identified include the Evergreen Drain, the Hennessey Drain, and the Tempe Drain; all of these canal drains are operated by the Salt River Project (SRP). There were also several lateral canals identified that could ultimately drain into the Salt River. These lateral canals, along with the three major canal drains, are shown on the Interior Drainage Map (Drawing 100).

Flow records for the three major canals have been provided by the SRP. These records provide the average daily flow rate for each canal for the period from 1992 through 2001. The records do not, however, provide an indication of the instantaneous peak flow rate. The Evergreen Drain and the Hennessey Drain do not intercept significant amounts of storm water runoff, so the canal flows are not greatly influenced by storm events. The average daily flow rates are indicative of the peak flow rates that occur in these canals. The Tempe Drain, however, does intercept storm runoff. The ramifications of this additional flow are further evaluated in the Storm Drains section of this report.

2.1 Evergreen Drain

The Evergreen Drain is located along the Arizona Canal approximately 7.0 miles downstream of Granite Reef Dam near Horne Road and immediately upstream of the Evergreen Canal turnout. The Evergreen Canal is operated by the Salt River Pima-Maricopa Indian Community (the Community); however, the Evergreen Drain is operated by the SRP. This open channel extends from the Arizona Canal in Section 23 of Township 2 North and Range 5 East to the Salt River in Section 26 of Township 2 North and Range 5 East, a distance of approximately one mile. Three gates at the turnout from the Arizona Canal control discharges into the drain. The turnout to the

Evergreen Drain is shown in Photo 2-1. The Evergreen Drain is shown on the Interior Drainage Map (Drawing 100).

Photo 2-1. Evergreen Drain Turnout

Flow records for the Evergreen Drain were evaluated for the period from January 1992 through December 2001. These records indicate that the average daily flow rates, on a monthly basis, for this period ranged from 0.18 cubic feet per second (cfs) in May to 1.25 cfs in September with an average of 0.78 cfs. The maximum daily flow rate that occurred during this period was 313.34 cfs during September 1996. Table 2-1 summarizes the average daily and maximum daily flow rates for each month of the period of record evaluated. The complete daily flow records are provided in Appendix A.

The flow records also indicate that the average daily volume of flow, on a monthly basis, for this period ranged from 0.35 acre-feet in May to 2.48 acre-feet in September with an average of 1.55 acre-feet. The maximum daily volume that occurred during this period was 621.50 acre-feet during September 1996. Table 2-2 summarizes the average daily and maximum daily volumes of flow for each month of the period evaluated. The average monthly volume of flow for this period ranged from 10.9 acre-feet in May to 74.5 acre-feet in September with an average annual total of 566.5 acre-feet. Table 2-3 summarizes the average monthly and annual volumes of flow for the period of record evaluated.

2.2 Hennessey Drain

The Hennessey Drain is located along the Southern Canal approximately 4.5 miles downstream of Granite Reef Dam between Val Vista Drive and Greenfield Road. This open channel extends from the Southern Canal in Section 28 of Township 2 North and Range 6 East to the Salt River less than 0.5 miles away. Releases into the drain are controlled by three gates at the turnout from the Southern Canal. The turnout to the Hennessey Drain from the Southern Canal is shown in Photo 2-2. The Hennessey Drain is shown on the Interior Drainage Map (Drawing 100).

Photo 2-2. Hennessey Drain Turnout

Flow records for the Hennessey Drain were evaluated for the period from January 1992 through December 2001. These records indicate that the average daily flow rates, on a monthly basis, for this period ranged from 38.05 cfs in April to 80.30 cfs in August with an average of 63.34 cfs. The maximum daily flow rate that occurred during this period was 845.89 cfs during January 1993. Table 2-4 summarizes the average daily and maximum daily flow rates for each month of the period of record evaluated. It should be noted that these flow records do not include water delivered to the Granite Reef Underground Storage Project (GRUSP). The complete daily flow records are provided in Appendix B.

The flow records also indicate that the average daily volume of flow, on a monthly basis, for this period ranged from 75.48 acre-feet in April to 159.27 acre-feet in August with an average of 125.64 acre-feet. The maximum daily volume that occurred during this period was 1,677.80 acre-feet during January 1993. Table 2-5 summarizes the average daily and maximum

daily volumes of flow for each month of the period evaluated. The average monthly volume of flow for this period ranged from 2,264.3 acre-feet in April to 4,937.4 acre-feet in August with an average annual total of 45,920.7 acre-feet. Table 2-6 summarizes the average monthly and annual volumes of flow for the period of record evaluated.

2.3 Tempe Drain

The Tempe Drain is located along the Tempe Canal between Dobson Road and Alma School Road. This open channel extends from the Tempe Canal in Section 17 of Township 1 North and Range 5 East to the Salt River in Section 8 of Township 1 North and Range 5 East, a distance of less than one mile. This canal drain also intercepts storm water runoff from a portion of the City of Mesa (Mesa). The contributing storm flows include an 84-inch storm drain in Alma School Road that drains a significant portion of Mesa. The Tempe Drain is shown on the Interior Drainage Map (Drawing 100). Inspection of aerial photography indicates that ponded water exists in the Salt River channel in the vicinity of the Tempe Drain outfall; this may indicate that the Tempe Drain may provide sufficient water to establish some restored habitat.

Flow records for the Tempe Drain were evaluated for the period from January 1992 through December 2001. These records indicate that the average daily flow rates, on a monthly basis, for this period ranged from 0.13 cfs in December to 45.14 cfs in February with an average of 14.96 cfs. The maximum daily flow rate that occurred during this period was 530.63 cfs during January 1992. It should be noted that this flow rate is the maximum 24-hour flow rate that occurred and may not be indicative of the peak instantaneous flow rate. Table 2-7 summarizes the average daily and maximum daily flow rates for each month of the period of record evaluated. The complete flow records for this drain are provided in Appendix C.

The flow records also indicate that the average daily volume of flow, on a monthly basis, for this period ranged from 0.26 acre-feet in December to 89.53 acre-feet in February with an average of 29.67 acre-feet. The maximum daily volume that occurred during this period was 1,052.49 acre-feet in January 1992. Table 2-8 summarizes the average daily and maximum daily volumes of flow for each month of the period evaluated. The average monthly volume of flow for this period ranged from 8.0 acre-feet in December to 2,607.2 acre-feet in January with an average annual total of 10,880.2 acre-feet. Table 2-9 summarizes the average monthly and annual volumes of flow for the period of record evaluated.

2.4 Lateral Canal Drains

2.4.1 Salt River Pima-Maricopa Indian Community

The Community operates a network of irrigation canals that deliver water to agricultural lands throughout the Community. There were nine lateral canals identified north of the Salt River and three canals identified in the Lehi District. In addition, there were nine outfall points identified that discharge surplus irrigation or storm water into the habitat restoration project area. Two of these outfall points are located between Hayden Road and the Pima Freeway; these sites are outside of the study area. The remaining seven locations, four north of the river and three in the Lehi District, are shown on the Interior Drainage Map (Drawing 100). Each of the lateral canals distributes irrigation water to the individual farming areas south of the Arizona Canal and north of the Salt River as well as to the Lehi District. There are no flow records available; however, the lateral canals are generally relatively small and rarely have excess water. Given their size and infrequent water surplus, these canals are not considered to have implications on the habitat restoration project.

2.4.2 Salt River Project

The SRP maintains a series of lateral canals within the study area. The two largest identified by the SRP are located between Gilbert Road and Lindsay Road and near Mesa Drive. There are no flow records available for any of these canals; however, there is rarely any excess water, and they reportedly never discharge into the Salt River. These canals are not considered to have implications on the habitat restoration project.

2.4.3 Roosevelt Water Conservation District

The Roosevelt Water Conservation District (RWCD) diverts water from the Southern Canal at a pumping station located approximately 5.0 miles downstream of Granite Reef Dam between Val Vista Drive and Greenfield Road. Irrigation water is pumped from the Southern Canal into the Roosevelt Canal in Section 33 of Township 2 North and Range 6 East, which then flows toward the southeast. The RWCD has water rights for up to 5.1 percent of the Salt River flow upstream of Granite Reef Dam, additional water from the Central Arizona Project (CAP), and some groundwater wells. The areas irrigated by the RWCD irrigation water are located in eastern Mesa, eastern Chandler, and Gilbert. Because these areas are located a great distance from the Salt River and south of the Southern Canal, there are no canal drains that return water to the Salt River from the RWCD system.

3.0 Storm Drains

Storm drains were evaluated with regard to the potential damage that peak flow rates might have on the restored habitat areas as well as to the possibility of using storm water runoff as a water source. Storm drains are often constructed in urban areas to collect and convey storm water runoff safely through developed or urbanized areas. With increased urbanization, the overall imperviousness of the land generally increases, thus increasing both the peak flow rate and volume of storm water runoff. This storm water runoff can be conveyed through a network of open channels or storm drains to a designated outfall point.

To quantify the potential damage that storm drains may cause to the habitat restoration project, the peak flow rates that occur during or immediately after storm events were examined. Unfortunately, very little information is available from which reasonable peak flow rates can be quantified. Estimates of peak flows were made, however, using the approach defined for the Rio Salado Project (USACE, 1998). The Rio Salado Project is a similar habitat restoration project within the Salt River downstream. The drainage areas within the Rio Salado study area are similar to those within the Va Shly'ay Akimel project area. In the Rio Salado Project, a series of storm drains were evaluated in which sufficient data were available to model storm runoff using computer modeling techniques. The results were then used to generate a series of curves representing the relationship between peak flow rate and drainage area. Curves were developed for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year storm events. These curves are shown on Figure 3-1.

In many cases, the storm water runoff is conveyed to retention or detention basins. Retention basins are designed to completely capture the storm water runoff, thus eliminating flow to the outfall point. Detention basins are designed to temporarily capture storm water runoff in order to reduce the peak flow rate to a value that meets local drainage criteria, which is typically not greater than the historic peak flow. The detained storm water is then released gradually to the outfall point. The capacity of the outlet pipe is often used to control the rate at which water is released from the detention facilities. For these areas, the peak flow rate that can be discharged into the Salt River is governed by the capacity of the outlet pipe. The full-flow capacities for several pipe sizes were determined for a range of longitudinal slopes. These relationships are presented on Figure 3-2. For this analysis, a longitudinal slope of 0.5 percent was assumed to be typical for storm drains in this area.

To evaluate the possibility of using storm water as a water source, the approach used in the Rio Salado Project (USACE, 1998) was used to estimate the average annual volume of runoff. Curves similar to those developed that relate peak flow to drainage area were developed to represent the relationship between the average annual volume of runoff and the drainage area. These curves are shown on Figure 3-3. To estimate the average monthly volume of runoff, the annual amount was distributed according to the monthly rainfall distribution in the Phoenix area (Schmidli, 1996). The monthly pattern of rainfall is shown in the table below.

Rainfall Pattern for the Phoenix Area

Month	Rainfall Amount (inches)	Percent of Annual Amount
January	0.67	8.7
February	0.68	9.0
March	0.88	11.5
April	0.22	2.9
May	0.12	1.6
June	0.13	1.7
July	0.83	10.8
August	0.96	12.5
September	0.86	11.2
October	0.65	8.5
November	0.66	8.6
December	1.00	13.0
Annual Total	7.66	100.0

3.1 Salt River Pima-Maricopa Indian Community

The Community does not currently have an extensive storm water management system that collects and discharges storm water runoff. North of the Arizona Canal, storm water runoff flows overland southward and is intercepted by the Arizona Canal. South of the Arizona Canal and north of the Salt River, storm water is generally collected in roadside ditches or lateral canals where it becomes part of the irrigation system. In addition, storm water runoff from the areas immediately adjacent to the river will flow overland into the river bed. These areas, however, do not produce significant runoff. The areas that contribute storm water runoff to the Salt River as well as those that contribute to the Cypress Golf Course or the Salt River Sand and Rock Dobson Plant are depicted on the Interior Drainage Map (Drawing 100).

There is only one known storm drain with a defined outfall point that discharges into the Salt River from the Community. This outfall is comprised of a 60-inch reinforced concrete pipe located at the intersection of Alma School Road and McKellips Road. This outfall may also intercept some irrigation return flows from agricultural areas within the Community as well as from the Cypress Golf Course. There are no flow records for this outfall. At the time of the Knight Piésold site investigation, approximately 1 to 2 cfs was flowing from the drain, and natural plant species were developed near the outfall. From Figure 3-2, the maximum capacity of a 60-inch pipe is approximately 185 cfs; at this flow rate, a maximum discharge velocity of approximately 9.4 ft/sec would be attained at the outfall to the Salt River. The Alma School Road Storm Drain is shown on the Interior Drainage Map (Drawing 100).

3.2 City of Mesa

Within Mesa, several storm drains were identified that ultimately discharge into the Salt River (Haws, 2002). The two most significant drains are the Price Drain and the Tempe Drain (synonymous with the Tempe Canal drain described earlier in this report). The other, less significant drains include the Price Road Freeway Local Drainage, the Dobson Road Storm Drain, the McLellan Road Storm Drain, the Country Club/McKellips Storm Drain, the Red Mountain Freeway Local Drainage, and uncontrolled runoff from natural and undeveloped areas.

3.2.1 Price Drain

The Price Drain is located near the downstream end of the project area on the east side of the Price Road Freeway (Pima Freeway, Loop SR-101). Two significant storm water collection systems discharge into this drain: (1) a drainage channel along the north side of the Superstition Freeway (U.S. 60) that extends from the Price Road Freeway to the RWCD canal approximately one-half mile west of Power Road, and (2) a drainage tunnel under the Price Road Freeway. This drain receives runoff from approximately 31.2 mi^2. The Price Drain and its drainage area are shown on the Interior Drainage Map (Drawing 100).

Flow records for the Price Drain were obtained from the Flood Control District of Maricopa County (FCDMC). The gauge was installed in February 2001, and flow records from February 2001 through April 2002 were available. These records indicate that the average daily flow rates, on a monthly basis, for this period ranged from 2.29 cfs in June to 7.71 cfs in May with an average of 3.95 cfs. The maximum daily flow rate that occurred during this period was 195.33 cfs during May 2002. Table 3-1 summarizes the average daily and maximum daily flow

rates for each month of the period of record evaluated. Records from the FCDMC also indicate that the instantaneous peak flow rate for period of record was 691 cfs. Ordinarily, storm drains only intercept storm water runoff that occurs during or immediately after significant rainfall events. However, this drain apparently receives significant return flows as evidenced by the fact that there is usually some flow in the channel. The complete flow records are provided in Appendix D. Photo 3-1 shows the Price Drain near the intersection of the Pima Freeway and the Red Mountain Freeway.

Photo 3-1. Price Drain

The flow records indicate that the average daily volume of flow, on a monthly basis, for this period ranged from 4.55 acre-feet in June to 15.30 acre-feet in May with an average of 7.83 acre-feet. The maximum daily volume that occurred during this period was 387.44 acre-feet in May 2002. Table 3-2 summarizes the average daily and maximum daily volumes of flow for each month of the period evaluated. The average monthly volume of flow for this period ranged from 125.6 acre-feet in February to 337.1 acre-feet in August. The average annual volume of runoff is estimated to be between 2,300 acre-feet and 2,800 acre-feet. Table 3-3 summarizes the average monthly and annual volumes of flow for the period of record evaluated.

The Price Drain is a concrete-lined, trapezoidal channel with a longitudinal slope of 0.00035 ft/ft. The channel has a bottom width of 10 feet, side slopes of 2H:1V, and a maximum depth of 18 feet. According to the rating table provided by the FCDMC, the capacity of this

channel at a stage height of 16.0 feet is 5,142 cfs. Based on the channel geometric parameters, the maximum capacity of this channel was estimated to be approximately 6,800 cfs at a stage of 18 feet.

Because available records do not provide a long-term evaluation of the Price Drain flow, Figure 3-1 was also used to estimate the peak flow rates for a series of storm events. The results are provided in Table 3-4. A peak flow rate of approximately 10,000 cfs was estimated for the 100-year storm event. This rate is greater than the maximum capacity of the open channel. Thus, the peak flow that can realistically discharge from this drain is approximately 6,800 cfs. At this flow rate, a velocity of approximately 8.2 ft/sec would be attained at the outfall to the Salt River.

Figure 3-3 was also used to estimate the average annual volume of storm runoff. The average annual volume of runoff and the monthly distribution of annual runoff are provided in Table 3-5. Using this approach, the average annual volume of storm runoff was estimated to be approximately 2,240 acre-feet. This amount is similar to the actual amount measured by the FCDMC gauge.

3.2.2 Tempe Drain

The Tempe Drain is located along the Tempe Canal between Dobson Road and Alma School Road. This storm drain is synonymous with the canal drain described in Section 2.0 of this report. The primary intent of this drain is to provide a mechanism to release water from the Tempe Canal to the Salt River. However, the channel intercepts storm water runoff from a significant drainage area within Mesa. An area of approximately 10.0 mi^2 contributes runoff to this drain. The Tempe Drain and its drainage area are shown on the Interior Drainage Map (Drawing 100).

Flow records were obtained from SRP for the period from January 1992 through December 2001. These records, however, are more indicative of canal releases than storm water flows. In addition, these records provide the average daily flow rate and provide no indication to the instantaneous peak flow rates attributable to major storm events.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-4. A peak flow rate of approximately 4,000 cfs was estimated for the 100-year storm event. The geometric parameters for the open channel are not currently known, so it

is not currently possible to determine the maximum capacity and hydraulic characteristics of the channel. However, at a flow rate of 4,000 cfs, a velocity ranging from 6 ft/sec to 10 ft/sec could be attained at the outfall to the Salt River.

Figure 3-3 was used to estimate the average annual volume of storm runoff. The average annual volume of runoff and the monthly distribution of annual runoff are provided in Table 3-5. Using this approach, the average annual volume of storm runoff was estimated to be approximately 740 acre-feet.

3.2.3 Price Road Freeway Local Drainage

Local drainage from the Price Road Freeway is discharged into the Salt River via a 72-inch storm drain located on the west side of the freeway. This drain collects runoff from the Price Road Freeway between 8th Avenue and the Salt River. A drainage area of approximately 0.35 mi^2 contributes storm water runoff to this drain. There are no flow records available for this drain. The Price Road Freeway Local Drainage drain and its drainage area are shown on the Interior Drainage Map (Drawing 100).

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-4. A peak flow rate of approximately 270 cfs was estimated for the 100-year storm event. Additionally, Figure 3-2 indicates that the maximum capacity of a 72-inch pipe is also approximately 300 cfs. With a peak flow rate of 300 cfs, a maximum velocity of approximately 10.6 ft/sec would be attained at the outfall to the Salt River.

Figure 3-3 was used to estimate the average annual volume of storm runoff. The average annual volume of runoff and the monthly distribution of annual runoff are provided in Table 3-5. Using this approach, the average annual volume of storm runoff was estimated to be approximately 30 acre-feet.

3.2.4 Dobson Road Storm Drain

The Dobson Road Storm Drain is located east of Dobson Road. A 72-inch storm drain conveys runoff from this area under the Red Mountain Freeway and into the Salt River. This drain collects runoff from a drainage area of approximately 1.80 mi^2. There are no flow records available for this drain. The Dobson Road Storm Drain and its drainage area are shown on the Interior Drainage Map (Drawing 100).

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-4. A peak flow rate of approximately 1,000 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 72-inch pipe is approximately 300 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. With a peak flow rate of 300 cfs, a maximum velocity of approximately 10.6 ft/sec could be attained at the outfall to the Salt River.

Figure 3-3 was used to estimate the average annual volume of storm runoff. The average annual volume of runoff and the monthly distribution of annual runoff are provided in Table 3-5. Using this approach, the average annual volume of storm runoff was estimated to be approximately 140 acre-feet.

3.2.5 McLellan Road Storm Drain

The McLellan Road Storm Drain is located on the east side of the intersection of McLellan Road and Alma School Road. A wetland bottom detention facility is located immediately upstream of the Red Mountain Freeway. A 48-inch storm drain empties the detention facility into the Salt River. This drain collects runoff from a drainage area of approximately 1.04 mi^2. There are no flow records available for this drain. The McLellan Road Storm Drain and its drainage area are shown on the Interior Drainage Map (Drawing 100).

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-4. A peak flow rate of approximately 640 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 48-inch pipe is approximately 100 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the outlet pipe size. With a peak flow rate of 100 cfs, a maximum velocity of approximately 8.1 ft/sec could be attained at the outfall to the Salt River. Photo 3-2 shows the outlet from the wetland detention facility.

Photo 3-2. McLellan Road Storm Drain

Figure 3-3 was used to estimate the average annual volume of storm runoff. The average annual volume of runoff and the monthly distribution of annual runoff are provided in Table 3-5. Using this approach, the average annual volume of storm runoff was estimated to be approximately 80 acre-feet.

3.2.6 Country Club/McKellips Storm Drain

The Country Club/McKellips Storm Drain is located along Country Club Drive. A 72-inch pipe conveys runoff under the Red Mountain Freeway and into the Salt River. This storm drain serves an area adjacent to McKellips Road between Gilbert Road and Country Club Drive as well as along Country Club Drive between Main Street and the Salt River. The total drainage area for this drain is approximately 3.72 mi^2. There are no flow records available for this drain. The Country Club/McKellips Storm Drain and its drainage area are shown on the Interior Drainage Map (Drawing 100).

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-4. A peak flow rate of approximately 1,800 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 72-inch pipe is approximately 300 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. With a peak flow rate of 300 cfs, a maximum velocity of approximately 10.6 ft/sec could be attained at the outfall to the Salt River.

Figure 3-3 was used to estimate the average annual volume of storm runoff. The average annual volume of runoff and the monthly distribution of annual runoff are provided in Table 3-5. Using this approach, the average annual volume of storm runoff was estimated to be approximately 300 acre-feet.

3.2.7 Red Mountain Freeway Local Drainage

Local drainage from the Red Mountain Freeway (Loop SR-202) is discharged into the Salt River through several storm water systems. Storm runoff between Country Club Drive and Gilbert Road is initially conveyed to a retention basin near Center Street. The collected runoff is then pumped to the outfall point near Mesa Drive and discharged into the Salt River. Runoff from the remaining areas along the Red Mountain Freeway is discharged into the river through numerous smaller storm drains located sporadically along the freeway. The drainage area for the Red Mountain Freeway is not well defined; however, it is not expected to generate significant amounts of storm runoff. These areas are not expected to have implications on the habitat restoration project. The Red Mountain Freeway Local Drainage areas are shown on the Interior Drainage Map (Drawing 100).

3.2.8 Natural Surface Drainage

Natural surface drainageways east of Gilbert Road ultimately discharge into the Salt River. The Southern Canal intercepts all runoff from the areas south of the canal. The areas north of the canal, however, will discharge into the river. These areas encompass a total area of approximately 2 mi^2. Because runoff from these areas is not confined to a well defined drainageway, storm events will not generate significant flow rates at any location. These areas are not expected to have implications on the habitat restoration project.

4.0 Summary and Evaluation

4.1 Damage to Restored Habitat

The interior drains were evaluated to assess the potential damage that their flows may have on the habitat restoration project. A summary of the interior drains identified within the project area and their locations is provided in Table 4-1. These drains are shown on the Interior Drainage Map (Drawing 100).

The canal drains flow in response to controlled releases by the SRP. These releases are relatively consistent throughout the day and do not have instantaneous peak flow rates considerably greater than the average daily rate. Flow records for these drains indicate that the maximum daily flow rates recorded for these canals were 313 cfs, 846 cfs, and 531 cfs for the Evergreen Drain, the Hennessey Drain, and the Tempe Drain, respectively. The Evergreen Drain and the Hennessey Drain do not intercept a significant amount of storm runoff, so the average daily flow rates are indicative of the peak flow rates expected to occur. The Tempe Drain, however, does intercept storm runoff. For this drain, the peak flow rate that can be expected to occur is much greater than the average daily canal release. A summary of the peak flow rates recorded for each canal drain is provided in Table 4-2a.

The storm drains flow in response to rainfall events. The two major storm drains identified are the Price Drain and the Tempe Drain (synonymous with the Tempe Canal drain). For this study, the peak flow rate associated with the 100-year storm was assumed to represent the worst possible condition. The peak 100-year flow rates for these drains were estimated to be 10,000 cfs and 4,000 cfs, respectively. However, the maximum capacity of the Price Drain is considerably less. This open channel has a maximum capacity of 6,800 cfs. It is not currently possible to estimate the maximum capacity of the Tempe Drain. Thus, the peak flow rates that could realistically discharge from these drains are 6,800 cfs and 4,000 cfs, which would generate discharge velocities of 8.2 ft/sec and approximately 8 ft/sec, respectively.

The remaining storm drains within the project area could discharge peak flow rates as high as 300 cfs with velocities as high as 10.6 ft/sec into the Salt River. The peak flow rates generated by the drainage areas for these drains may be considerably greater; however, detention facilities or the maximum capacity of the outlet pipes govern the maximum rate at which storm water will be discharged into the restored habitat. A summary of peak flow rates for a series of storm events and the maximum capacities of each outlet is provided in Table 4-2b.

The peak flow rates and discharge velocities from the interior drains are sufficient to create localized damage at the outlet of each drain. However, this damage is not expected to extend beyond the immediate vicinity of the pipe outlet. There is little evidence to suggest that flows from these drains have historically done more than wet the river bed in the immediate vicinity of the drain outlet. Additionally, the maximum flow rates that could potentially discharge from these drains are significantly smaller in magnitude and occur less frequently than Salt River flood flows. The Salt River is expected to spill over Granite Reef Dam approximately once every three years, and the 5-year peak discharge from these spills is expected to exceed 20,000 cfs (USACE, 1998). To that regard, there is little advantage to providing extensive protection from the interior drainage discharge.

4.2 Water Source

The interior drains were also evaluated to assess the potential for using these flows as a water source to support and nourish the restored vegetation. For this evaluation, these drains were each evaluated based on the quantity, reliability, and quality of flow that is or may be available for habitat restoration. The water source analyses are described in further detail in the Water Budget Draft Report (Knight Piésold, 2002).

The canal drains, which flow in response to controlled releases, have received occasional flows throughout the period from 1992 through 2001. The average annual volumes of water released to the Salt River during this period were 567 acre-feet, 45,921 acre-feet, and 10,880 acre-feet for the Evergreen Drain, the Hennessey Drain, and the Tempe Drain, respectively. Although these amounts are sufficient to support some riparian vegetation, the timing of these flows is irregular. The Evergreen Drain and the Tempe Drain typically only receive flow for a few days each month. These releases are not reliable as the drains have historically been dry for long periods; for example, there were no releases to the Evergreen Drain during 1994. The Hennessey Drain flows were historically more frequent and reliable; however, there were no releases to this drain from February through December of 2001. Future releases to this drain are expected to be less frequent than the historic trend. Table 4-3a summarizes the average monthly and annual volumes of water released through the canal drains for the period of record evaluation.

The storm drains flow in response to rainfall events, so the discharge from these drains is typically infrequent and highly variable. The Price Drain, however, has discharged a relatively consistent supply of water since its inception in February 2001. Immediately downstream of the

Price Drain outfall, an abundance of vegetation has appeared since this drain was put into operation. This vegetation is presumably due to the consistent supply of water from the Price Drain. This supply is due to return flows from the adjacent urbanized areas. Over an 11-month period in 2001, this drain discharged 2,310 acre-feet of water into the river. These flows have also been relatively continuous for each month. The other storm drains provide an average annual volume of water to the Salt River ranging from 30 to 300 acre-feet. Table 4-3b summarizes the average monthly and annual volumes of water released through the storm drains.

The average monthly and annual volumes of water released from some of the interior drains are of sufficient magnitude to be considered as a potential water source. The three canal drains have historically supplied a significant amount of water to the Salt River. These drains, however, do not flow consistently, and releases into these drains may not be reliable. The Price Drain has historically supplied a relatively consistent flow to the river. However, long-term records are not available to ascertain this supply. The Evergreen Drain, the Hennessey Drain, the Tempe Drain, and the Price Drain should all be included in the water budget analyses.

References

Haws, G., 2002, *Final Document, Va Shly'ay Akimel Salt River Restoration Project.* City of Mesa, Arizona.

Knight Piésold and Co., 2002, *JAB01.E Water Budget, Draft Report.*

Schmidli, R.J., 1996, *Climate of Phoenix, Arizona: An Abridged On-Line Version of NOAA Technical Memorandum NWS WR-177*, Weather Service Forecast Office, Phoenix, Arizona.

U.S. Army Corps of Engineers, 1998, *Rio Salado, Salt River, Arizona, Feasibility Report and Environmental Impact Statement*, Los Angeles District, South Pacific Division.

Tables

TABLE 2-1a
EVERGREEN DRAIN
AVERAGE DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1992	0.06	6.41	0.30	0.00	0.00	0.00	3.81	2.83	0.00	0.00	0.00	1.05	1.18
1993	0.45	0.00	4.37	0.00	0.00	0.00	0.00	2.27	0.00	0.61	9.80	0.00	1.46
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	9.56	0.06	0.00	0.00	1.18	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.99
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.44	0.00	0.00	0.00	0.86
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	3.59	4.93	11.57	0.00	0.00	0.44	1.09	0.14	0.00	0.00	0.00	1.79
1999	0.00	0.00	0.00	0.00	0.00	0.00	1.58	1.26	0.00	0.71	0.00	0.00	0.30
2000	0.46	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	1.63	0.00	0.00	0.24
2001	0.00	0.00	0.00	0.00	0.60	2.13	1.44	1.16	1.03	1.36	1.24	2.92	1.00
Average	1.05	1.01	1.03	1.16	0.18	0.21	0.73	0.86	1.25	0.43	1.10	0.40	0.78

TABLE 2-1b
EVERGREEN DRAIN
MAXIMUM DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1992	2.00	94.50	9.17	0.00	0.00	0.00	112.58	60.19	0.00	0.00	0.00	21.71	112.58
1993	9.57	0.00	78.44	0.00	0.00	0.00	0.00	23.50	0.00	18.79	185.51	0.00	185.51
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	124.02	1.61	0.00	0.00	36.61	0.00	0.00	0.00	27.07	0.00	0.00	0.00	124.02
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	313.34	0.00	0.00	0.00	313.34
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.08
1998	0.00	44.37	70.39	139.41	0.00	0.00	11.58	22.10	4.16	0.00	0.00	0.00	139.41
1999	0.00	0.00	0.00	0.00	0.00	0.00	36.59	39.11	0.00	11.03	0.00	0.00	39.11
2000	9.73	0.00	22.38	0.00	0.00	0.00	0.00	0.00	0.00	50.66	0.00	0.00	50.66
2001	0.00	0.00	0.00	0.00	14.00	17.50	8.75	7.50	10.91	7.50	7.00	61.47	61.47
Maximum	124.02	94.50	78.44	139.41	36.61	17.50	112.58	60.19	313.34	50.66	185.51	61.47	313.34

Source: Computed from SRP Daily Flow Records

TABLE 2-2a
EVERGREEN DRAIN
AVERAGE DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1992	0.13	12.71	0.59	0.00	0.00	0.00	7.56	5.62	0.00	0.00	0.00	2.09	2.33
1993	0.89	0.00	8.66	0.00	0.00	0.00	0.00	4.50	0.00	1.22	19.43	0.00	2.89
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	18.95	0.11	0.00	0.00	2.34	0.00	0.00	0.00	1.79	0.00	0.00	0.00	1.96
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.72	0.00	0.00	0.00	1.70
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	7.13	9.77	22.94	0.00	0.00	0.88	2.15	0.28	0.00	0.00	0.00	3.54
1999	0.00	0.00	0.00	0.00	0.00	0.00	3.14	2.50	0.00	1.40	0.00	0.00	0.60
2000	0.92	0.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	3.24	0.00	0.00	0.47
2001	0.00	0.00	0.00	0.00	1.18	4.23	2.86	2.30	2.04	2.69	2.46	5.79	1.98
Average	2.09	2.00	2.04	2.29	0.35	0.42	1.44	1.71	2.48	0.86	2.19	0.79	1.55

TABLE 2-2b
EVERGREEN DRAIN
MAXIMUM DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1992	3.97	187.44	18.19	0.00	0.00	0.00	223.30	119.39	0.00	0.00	0.00	43.06	223.30
1993	18.98	0.00	155.58	0.00	0.00	0.00	0.00	46.61	0.00	37.27	367.95	0.00	367.95
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	245.99	3.19	0.00	0.00	72.61	0.00	0.00	0.00	53.69	0.00	0.00	0.00	245.99
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	621.50	0.00	0.00	0.00	621.50
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.16
1998	0.00	88.01	139.62	276.52	0.00	0.00	22.97	43.83	8.25	0.00	0.00	0.00	276.52
1999	0.00	0.00	0.00	0.00	0.00	0.00	72.58	77.57	0.00	21.88	0.00	0.00	77.57
2000	19.30	0.00	44.39	0.00	0.00	0.00	0.00	0.00	0.00	100.48	0.00	0.00	100.48
2001	0.00	0.00	0.00	0.00	27.77	34.71	17.36	14.88	21.64	14.88	13.88	121.92	121.92
Maximum	245.99	187.44	155.58	276.52	72.61	34.71	223.30	119.39	621.50	100.48	367.95	121.92	621.50

Source: Computed from SRP Daily Flow Records

TABLE 2-3
EVERGREEN DRAIN
MONTHLY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
1992	4.0	368.6	18.2	0.0	0.0	0.0	234.2	174.2	0.0	0.0	0.0	64.8	863.9
1993	27.7	0.0	268.4	0.0	0.0	0.0	0.0	139.6	0.0	37.7	582.9	0.0	1,056.3
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	587.6	3.2	0.0	0.0	72.6	0.0	0.0	0.0	53.7	0.0	0.0	0.0	717.1
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	621.5	0.0	0.0	0.0	621.5
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3
1998	0.0	199.5	302.8	688.3	0.0	0.0	27.3	66.8	8.3	0.0	0.0	0.0	1,293.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	97.3	77.6	0.0	43.4	0.0	0.0	218.3
2000	28.5	0.0	44.4	0.0	0.0	0.0	0.0	0.0	0.0	100.5	0.0	0.0	173.4
2001	0.0	0.0	0.0	0.0	36.7	126.8	88.5	71.4	61.3	83.4	73.7	179.5	721.5
Average	64.8	57.1	63.4	68.8	10.9	12.7	44.8	53.0	74.5	26.5	65.7	24.4	566.5

Source: Computed from SRP Daily Flow Records

TABLE 2-4a
HENNESSEY DRAIN
AVERAGE DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1992	9.67	0.14	0.88	0.52	0.20	0.00	2.43	4.43	0.00	0.55	0.00	1.97	1.76
1993	96.78	0.00	10.90	54.81	5.10	0.00	4.20	2.93	0.00	1.21	0.00	0.00	14.79
1994	1.59	0.00	0.00	0.00	1.18	38.51	199.22	198.97	184.72	0.50	0.00	0.00	52.44
1995	141.40	66.41	0.00	0.00	136.02	153.96	144.72	143.45	107.94	78.89	125.20	64.86	97.16
1996	199.07	180.70	159.37	149.71	162.00	89.47	12.48	5.08	0.63	54.95	6.98	61.69	89.75
1997	25.74	21.67	40.60	15.60	123.96	54.88	37.71	38.06	86.83	157.73	145.44	131.69	73.73
1998	116.63	166.00	128.38	0.00	67.87	85.37	76.34	80.77	78.40	70.54	22.19	30.46	76.51
1999	64.81	88.28	83.03	71.61	81.48	87.20	117.65	144.56	126.78	137.18	118.89	103.41	102.20
2000	121.02	132.60	124.48	88.28	119.50	140.59	154.00	184.73	196.80	176.75	60.67	0.00	124.93
2001	1.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Average	77.87	65.58	54.76	38.05	69.73	65.00	74.88	80.30	78.21	67.83	47.94	39.41	63.34

TABLE 2-4b
HENNESSEY DRAIN
MAXIMUM DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1992	157.33	4.00	12.30	15.63	6.29	0.00	59.19	92.62	0.00	17.17	0.00	48.04	157.33
1993	845.89	0.00	129.06	169.25	59.09	0.00	130.19	33.75	0.00	37.58	0.00	0.00	845.89
1994	28.25	0.00	0.00	0.00	19.90	217.68	234.41	231.58	240.14	15.53	0.00	0.00	240.14
1995	247.51	146.87	0.00	0.00	194.06	193.15	168.47	165.00	133.94	129.01	161.25	216.07	247.51
1996	273.15	198.21	181.77	156.36	166.03	163.96	28.56	42.39	18.86	371.82	70.10	100.64	371.82
1997	184.27	118.13	137.63	31.63	126.43	150.41	43.98	58.52	132.58	211.57	171.74	155.24	211.57
1998	128.13	442.24	355.82	0.00	82.08	86.97	81.27	87.59	89.62	80.56	214.37	49.80	442.24
1999	67.32	93.03	85.35	173.28	100.04	133.82	130.96	150.75	152.18	144.35	296.97	145.14	296.97
2000	128.71	151.50	133.02	90.51	126.83	148.48	182.62	197.10	204.13	202.03	86.07	0.00	204.13
2001	45.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.72
Maximum	845.89	442.24	355.82	173.28	194.06	217.68	234.41	231.58	240.14	371.82	296.97	216.07	845.89

Source: Computed from SRP Daily Flow Records

TABLE 2-5a
HENNESSEY DRAIN
AVERAGE DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1992	19.18	0.27	1.75	1.03	0.40	0.00	4.82	8.78	0.00	1.10	0.00	3.90	3.50
1993	191.97	0.00	21.62	108.72	10.12	0.00	8.33	5.81	0.00	2.40	0.00	0.00	29.34
1994	3.16	0.00	0.00	0.00	2.34	76.38	395.15	394.65	366.38	0.99	0.00	0.00	104.02
1995	280.46	131.71	0.00	0.00	269.79	305.38	287.04	284.54	214.10	156.48	248.33	128.64	192.71
1996	394.85	358.41	316.11	296.95	321.32	177.47	24.76	10.07	1.25	108.99	13.85	122.37	178.01
1997	51.05	42.98	80.52	30.94	245.88	108.86	74.80	75.49	172.23	312.85	288.48	261.21	146.23
1998	231.34	329.26	254.63	0.00	134.61	169.33	151.41	160.21	155.50	139.91	44.02	60.43	151.76
1999	128.55	175.09	164.70	142.03	161.62	172.96	233.36	286.74	251.47	272.09	235.82	205.12	202.71
2000	240.04	263.00	246.91	175.11	237.02	278.86	305.45	366.41	390.34	350.59	120.34	0.00	247.79
2001	3.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
Average	154.45	130.07	108.62	75.48	138.31	128.92	148.51	159.27	155.13	134.54	95.08	78.17	125.64

TABLE 2-5b
HENNESSEY DRAIN
MAXIMUM DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1992	312.06	7.93	24.40	31.00	12.48	0.00	117.40	183.71	0.00	34.06	0.00	95.29	312.06
1993	1,677.80	0.00	255.99	335.70	117.20	0.00	258.23	66.94	0.00	74.54	0.00	0.00	1,677.80
1994	56.03	0.00	0.00	0.00	39.47	431.76	464.95	459.33	476.31	30.80	0.00	0.00	476.31
1995	490.93	291.31	0.00	0.00	384.91	383.11	334.16	327.27	265.67	255.89	319.83	428.57	490.93
1996	541.79	393.14	360.54	310.14	329.32	325.21	56.65	84.08	37.41	737.49	139.04	199.62	737.49
1997	365.49	234.31	272.99	62.74	250.77	298.33	87.23	116.07	262.97	419.64	340.64	307.91	419.64
1998	254.14	877.17	705.76	0.00	162.80	172.50	161.20	173.73	177.76	159.79	425.20	98.78	877.17
1999	133.53	184.52	169.29	343.70	198.43	265.43	259.76	299.01	301.84	286.31	589.03	287.88	589.03
2000	255.29	300.50	263.84	179.52	251.56	294.51	362.22	390.94	404.89	400.72	170.72	0.00	404.89
2001	90.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	90.68
Maximum	1,677.80	877.17	705.76	343.70	384.91	431.76	464.95	459.33	476.31	737.49	589.03	428.57	1,677.80

Source: Computed from SRP Daily Flow Records

TABLE 2-6
HENNESSEY DRAIN
MONTHLY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
1992	594.7	7.9	54.4	31.0	12.5	0.0	149.4	272.3	0.0	34.1	0.0	121.0	1,277.3
1993	5,950.9	0.0	670.3	3,261.5	313.6	0.0	258.2	180.2	0.0	74.5	0.0	0.0	10,709.3
1994	98.0	0.0	0.0	0.0	72.4	2,291.4	12,249.8	12,234.0	10,991.3	30.8	0.0	0.0	37,967.7
1995	8,694.1	3,687.9	0.0	0.0	8,363.3	9,161.3	8,898.4	8,820.6	6,423.1	4,850.8	7,449.9	3,987.8	70,337.4
1996	12,240.5	10,393.8	9,799.3	8,908.4	9,960.9	5,324.1	767.5	312.2	37.4	3,378.8	415.6	3,793.4	65,331.7
1997	1,582.4	1,203.5	2,496.1	928.3	7,622.3	3,265.7	2,318.9	2,340.1	5,167.0	9,698.5	8,654.3	8,097.5	53,374.5
1998	7,171.5	9,219.4	7,893.6	0.0	4,173.0	5,079.8	4,693.8	4,966.5	4,665.1	4,337.1	1,320.5	1,873.2	55,393.4
1999	3,985.0	4,902.6	5,105.6	4,260.9	5,010.2	5,188.8	7,234.3	8,888.8	7,544.2	8,434.9	7,074.5	6,358.7	73,988.5
2000	7,441.3	7,627.0	7,654.3	5,253.3	7,347.5	8,365.8	9,468.8	11,358.8	11,710.3	10,868.2	3,610.3	0.0	90,705.7
2001	121.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	121.2
Average	4,788.0	3,704.2	3,367.3	2,264.3	4,287.6	3,867.7	4,603.9	4,937.4	4,653.8	4,170.8	2,852.5	2,423.2	45,920.7

Source: Computed from SRP Daily Flow Records

TABLE 2-7a
TEMPE DRAIN
AVERAGE DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1992	288.18	249.80	175.58	119.74	103.59	25.53	8.21	26.07	11.27	0.35	0.00	1.09	83.25
1993	118.56	191.96	219.92	108.72	31.87	0.99	0.00	3.15	0.00	0.23	0.36	0.00	55.51
1994	0.00	0.00	0.51	0.14	0.00	0.00	0.52	0.00	0.00	0.17	0.21	0.00	0.13
1995	16.60	1.54	16.58	26.07	0.00	0.00	0.00	1.84	0.92	0.00	9.79	0.00	6.12
1996	0.00	0.00	0.00	0.00	0.00	0.00	1.29	0.00	0.00	11.10	0.00	0.00	1.05
1997	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	1.16	0.00	0.00	0.17
1998	0.00	8.06	3.61	27.29	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	3.19
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.03	0.57	0.00	0.09
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.21	0.07
2001	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Average	42.40	45.14	41.62	28.20	13.57	2.65	1.04	3.14	1.22	1.30	1.16	0.13	14.96

TABLE 2-7b
TEMPE DRAIN
MAXIMUM DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1992	530.63	368.75	313.54	304.92	257.45	91.75	157.34	134.00	69.75	7.43	0.00	27.70	530.63
1993	377.88	304.84	394.73	228.54	79.93	21.61	0.00	44.19	0.00	7.18	8.21	0.00	394.73
1994	0.00	0.00	9.43	4.10	0.00	0.00	8.70	0.00	0.00	5.16	2.49	0.00	9.43
1995	165.04	37.78	52.39	69.13	0.00	0.00	0.00	24.65	27.65	0.00	40.22	0.00	165.04
1996	0.00	0.00	0.00	0.00	0.00	0.00	27.13	0.00	0.00	70.90	0.00	0.00	70.90
1997	17.51	0.00	0.00	0.00	0.08	0.00	0.00	3.80	0.00	34.08	0.00	0.00	34.08
1998	0.00	73.75	103.98	132.44	0.00	0.00	0.00	5.45	0.00	0.00	0.00	0.00	132.44
1999	0.00	0.00	0.00	0.00	0.00	0.00	13.19	0.00	0.00	0.91	10.74	0.00	13.19
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.43	6.66	9.43
2001	0.00	0.00	0.00	0.00	8.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.29
Maximum	530.63	368.75	394.73	304.92	257.45	91.75	157.34	134.00	69.75	70.90	40.22	27.70	530.63

Source: Computed from SRP Daily Flow Records

TABLE 2-8a
TEMPE DRAIN
AVERAGE DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1992	571.59	495.47	348.26	237.50	205.47	50.64	16.29	51.71	22.36	0.70	0.00	2.16	165.12
1993	235.15	380.75	436.21	215.65	63.21	1.96	0.00	6.25	0.00	0.46	0.72	0.00	110.11
1994	0.00	0.00	1.01	0.27	0.00	0.00	1.02	0.00	0.00	0.33	0.41	0.00	0.26
1995	32.93	3.06	32.88	51.71	0.00	0.00	0.00	3.65	1.83	0.00	19.42	0.00	12.13
1996	0.00	0.00	0.00	0.00	0.00	0.00	2.57	0.00	0.00	22.01	0.00	0.00	2.09
1997	1.36	0.00	0.00	0.00	0.01	0.00	0.00	0.24	0.00	2.31	0.00	0.00	0.33
1998	0.00	15.99	7.17	54.13	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	6.33
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.06	1.14	0.00	0.17
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36	0.43	0.15
2001	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Average	84.10	89.53	82.55	55.93	26.92	5.26	2.07	6.23	2.42	2.59	2.31	0.26	29.67

TABLE 2-8b
TEMPE DRAIN
MAXIMUM DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1992	1,052.49	731.40	621.90	604.80	510.64	181.98	312.08	265.79	138.35	14.74	0.00	54.94	1,052.49
1993	749.51	604.64	782.94	453.30	158.54	42.86	0.00	87.65	0.00	14.24	16.28	0.00	782.94
1994	0.00	0.00	18.70	8.13	0.00	0.00	17.26	0.00	0.00	10.23	4.94	0.00	18.70
1995	327.35	74.94	103.91	137.12	0.00	0.00	0.00	48.89	54.84	0.00	79.78	0.00	327.35
1996	0.00	0.00	0.00	0.00	0.00	0.00	53.81	0.00	0.00	140.63	0.00	0.00	140.63
1997	34.73	0.00	0.00	0.00	0.16	0.00	0.00	7.54	0.00	67.60	0.00	0.00	67.60
1998	0.00	146.28	206.24	262.69	0.00	0.00	0.00	10.81	0.00	0.00	0.00	0.00	262.69
1999	0.00	0.00	0.00	0.00	0.00	0.00	26.16	0.00	0.00	1.80	21.30	0.00	26.16
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.70	13.21	18.70
2001	0.00	0.00	0.00	0.00	16.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.44
Maximum	1,052.49	731.40	782.94	604.80	510.64	181.98	312.08	265.79	138.35	140.63	79.78	54.94	1,052.49

Source: Computed from SRP Daily Flow Records

TABLE 2-9
TEMPE DRAIN
MONTHLY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
1992	17,719.4	14,368.6	10,796.1	7,124.9	6,369.7	1,519.2	505.0	1,603.1	670.7	21.6	0.0	67.1	60,765.4
1993	7,289.8	10,661.0	13,522.4	6,469.5	1,959.4	58.7	0.0	193.7	0.0	14.2	21.6	0.0	40,190.3
1994	0.0	0.0	31.3	8.1	0.0	0.0	31.7	0.0	0.0	10.2	12.4	0.0	93.7
1995	1,020.8	85.7	1,019.4	1,551.4	0.0	0.0	0.0	113.2	54.8	0.0	582.7	0.0	4,428.1
1996	0.0	0.0	0.0	0.0	0.0	0.0	79.6	0.0	0.0	682.3	0.0	0.0	761.9
1997	42.1	0.0	0.0	0.0	0.2	0.0	0.0	7.5	0.0	71.6	0.0	0.0	121.4
1998	0.0	447.8	222.2	1,623.9	0.0	0.0	0.0	14.7	0.0	0.0	0.0	0.0	2,308.6
1999	0.0	0.0	0.0	0.0	0.0	0.0	26.2	0.0	0.0	1.8	34.2	0.0	62.2
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.7	13.2	54.0
2001	0.0	0.0	0.0	0.0	16.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.4
Average	2,607.2	2,556.3	2,559.1	1,677.8	834.6	157.8	64.2	193.2	72.6	80.2	69.2	8.0	10,880.2

Source: Computed from SRP Daily Flow Records

TABLE 3-1a
PRICE DRAIN
AVERAGE DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
2001		4.34	5.51	3.98	1.71	2.29	4.60	5.48	4.50	3.15	2.53	2.71	3.71
2002	3.29	2.82	3.17	2.03	13.72								4.32
Average	3.29	3.58	4.34	3.00	7.71	2.29	4.60	5.48	4.50	3.15	2.53	2.71	3.95

TABLE 3-1b
PRICE DRAIN
MAXIMUM DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
2001		14.09	47.72	18.12	4.67	4.27	22.67	20.17	7.96	11.16	5.49	21.87	47.72
2002	7.35	6.43	8.35	5.67	195.33								195.33
Maximum	7.35	14.09	47.72	18.12	195.33	4.27	22.67	20.17	7.96	11.16	5.49	21.87	195.33

Source: Computed from FCDMC Flow Records

TABLE 3-2a
PRICE DRAIN
AVERAGE DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
2001		8.61	10.92	7.89	3.39	4.55	9.13	10.87	8.92	6.25	5.02	5.37	7.36
2002	6.52	5.59	6.30	4.03	27.21								8.57
Average	6.52	7.10	8.61	5.96	15.30	4.55	9.13	10.87	8.92	6.25	5.02	5.37	7.83

TABLE 3-2b
PRICE DRAIN
MAXIMUM DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
2001		27.95	94.65	35.93	9.26	8.47	44.96	40.00	15.78	22.13	10.88	43.38	94.65
2002	14.58	12.75	16.56	11.25	387.44								387.44
Maximum	14.58	27.95	94.65	35.93	387.44	8.47	44.96	40.00	15.78	22.13	10.88	43.38	387.44

Source: Computed from FCDMC Flow Records

TABLE 3-3
PRICE DRAIN
MONTHLY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
2001		94.7	338.6	236.6	105.2	136.5	283.1	337.1	267.7	193.8	150.5	166.5	2,310.3
2002	202.2	156.5	195.1	120.9	517.0								1,191.7
Average	202.2	125.6	266.9	178.8	311.1	136.5	283.1	337.1	267.7	193.8	150.5	166.5	2,619.7

Source: Computed from FCDMC Flow Records

TABLE 3-4
STORM DRAIN PEAK FLOWS FOR VARIOUS RETURN PERIODS
(units are in cubic feet per second)

Interior Drain	Drainage Area (mi^2)[1]	Outlet Type and Size	N-Year Peak Flow[2] 2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	Capacity[3]
Price Drain	31.2	trapezoidal channel	800	1,800	3,000	4,100	6,500	10,000	6,800
Tempe Drain	10.0	trapezoidal channel	350	800	1,200	1,800	2,700	4,000	N/A
Price Road Freeway Local Drainage	0.4	72-inch Pipe	34	75	100	140	200	270	300
Dobson Road Storm Drain	1.8	72-inch Pipe	100	240	340	470	700	1,000	300
McLellan Road Storm Drain	1.0	48-inch Pipe	70	160	220	300	450	640	100
Country Club/McKellips Storm Drain	3.7	72-inch Pipe	180	400	600	800	1,200	1,800	300
Red Mountain Freeway Local Drainage	unknown	various			minimal				N/A
Natural Drainage	2.0	overland flow			minimal				N/A
Alma School Storm Drain	unknown	60-inch Pipe	N/A	N/A	N/A	N/A	N/A	N/A	185

1. Drainage areas were estimated based on the drainage delineations made by personnel from the City of Mesa.
2. N-Year peak flow rates were computed from the drainage area vs. peak flow relationships developed for the Rio Salado Study (Figure 3-1).
3. A longitudinal slope of 0.5% was assumed for the storm drain capacity estimates if the existing slope is unknown (Figure 3-2).

TABLE 3-5
STORM DRAIN AVERAGE ANNUAL RUNOFF VOLUMES
(units are in acre-feet)

Interior Drain	Drainage Area (mi^2)[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Price Drain[2,3]	31.2	195.7	201.5	257.0	64.3	35.0	38.0	242.4	280.4	251.2	189.8	192.8	292.0	2,240
Tempe Drain[2,3]	10.0	64.6	66.6	84.9	21.2	11.6	12.5	80.1	92.6	83.0	62.7	63.7	96.5	740
Price Road Freeway Local Drainage[2,3]	0.4	2.6	2.7	3.4	0.9	0.5	0.5	3.2	3.8	3.4	2.5	2.6	3.9	30
Dobson Road Storm Drain[2,3]	1.8	12.2	12.6	16.1	4.0	2.2	2.4	15.1	17.5	15.7	11.9	12.0	18.3	140
McLellan Road Storm Drain[2,3]	1.0	7.0	7.2	9.2	2.3	1.3	1.4	8.7	10.0	9.0	6.8	6.9	10.4	80
Country Club/McKellips Storm Drain[2,3]	3.7	26.2	27.0	34.4	8.6	4.7	5.1	32.5	37.5	33.6	25.4	25.8	39.1	300
Red Mountain Freeway Local Drainage[2,3]	unknown							minimal						
Natural Drainage[2,3]	2.0							minimal						
Alma School Storm Drain	unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Percent of Annual Rainfall:		8.7	9.0	11.5	2.9	1.6	1.7	10.8	12.5	11.2	8.5	8.6	13.0	100.0

1. Drainage areas were estimated based on the drainage delineations made by personnel from the City of Mesa.
2. Monthly storm water runoff distributions were assumed to follow the monthly pattern of rainfall.
3. Annual runoff volumes were computed from the drainage area vs. average annual runoff relationships developed for the Rio Salado Study (Figure 3-3).

TABLE 4-1a
SUMMARY OF INTERIOR DRAINS
CANAL DRAINS

Interior Drain	Outlet Type and Dimensions	Section	Township	Range	Location Description	Flow Records
Evergreen Drain	trapezoidal channel	23	T2N	R5E	Horne Road at Arizona Canal	Yes
Hennessey Drain	trapezoidal channel	28	T2N	R6E	Between Val Vista and Greenfield	Yes
Tempe Drain	trapezoidal channel	17	T1N	R5E	Between Dobson and Alma School	Yes
SRP Laterals	open channels				Throughout study area	No
SRPMIC Laterals	open channels				Throughout SRPMIC	No
RWCD Laterals	open channels				Outside of study area	No

TABLE 4-1b
SUMMARY OF INTERIOR DRAINS
STORM DRAINS

Interior Drain	Outlet Type and Dimensions	Section	Township	Range	Location Description	Flow Records
Price Drain	trapezoidal channel	18	T1N	R5E	East side of Price Road Freeway	Yes
Tempe Drain	trapezoidal channel	8	T1N	R5E	Between Val Vista and Greenfield	Yes
Price Road Freeway Local Drainage	72-inch pipe	18	T1N	R5E	West side of Price Road Freeway	No
Dobson Road Storm Drain	72-inch pipe	8	T1N	R5E	Along Dobson Road	No
McLellan Road Storm Drain	48-inch pipe	8	T1N	R5E	Along McLellan Road	No
Country Club/McKellips Storm Drain	72-inch pipe	4	T1N	R5E	Country Club Drive	No
Red Mountain Freeway Local Drainage	N/A				Along Red Mountain Freeway	No
Natural Drainage	N/A				East of Gilbert Road	No
Alma School Storm Drain	60-inch pipe	5	T1N	R5E	Alma School Road	No

TABLE 4-2a
SUMMARY OF PEAK FLOWS
CANAL DRAINS
(units are in cubic feet per second)

Interior Drain	Drainage Area (mi^2)[1]	Outlet Type and Size	Peak Flow for 10-year Period of Record[2]
Evergreen Drain	~ 0	trapezoidal channel	313
Hennessey Drain	~ 0	trapezoidal channel	846
Tempe Drain	10.0	trapezoidal channel	531

TABLE 4-2b
SUMMARY OF PEAK FLOWS
STORM DRAINS
(units are in cubic feet per second)

			N-Year Peak Flow[3]						
Interior Drain	Drainage Area (mi^2)[1]	Outlet Type and Size	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	Capacity[4]
Price Drain	31.2	trapezoidal channel	800	1,800	3,000	4,100	6,500	10,000	6,800
Tempe Drain	10.0	trapezoidal channel	350	800	1,200	1,800	2,700	4,000	N/A
Price Road Freeway Local Drainage	0.4	72-inch pipe	34	75	100	140	200	270	300
Dobson Road Storm Drain	1.8	72-inch pipe	100	240	340	470	700	1,000	300
McLellan Road Storm Drain	1.0	48-inch pipe	70	160	220	300	450	640	100
Country Club/McKellips Storm Drain	3.7	72-inch pipe	180	400	600	800	1,200	1,800	300
Red Mountain Freeway Local Drainage	unknown	various			minimal				N/A
Natural Drainage	2.0	overland flow			minimal				N/A
Alma School Storm Drain	unknown	60-inch pipe	N/A	N/A	N/A	N/A	N/A	N/A	185

1. Drainage areas were estimated based on the drainage delineations made by personnel from the City of Mesa.
2. Peak flow rates for the canal drains were computed from the SRP daily flow records.
3. N-Year peak flow rates for the storm drains were computed from the drainage area vs. peak flow relationships developed for the Rio Salado Study (Figure 3-1).
4. A longitudinal slope of 0.5% was assumed for the storm drain capacity estimates if the existing slope is unknown (Figure 3-2).

TABLE 4-3a
SUMMARY OF AVERAGE ANNUAL RUNOFF
CANAL DRAINS
(units are in acre-feet)

Interior Drain	Drainage Area (mi^2)[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Evergreen Drain[2]	~ 0	64.8	57.1	63.4	68.8	10.9	12.7	44.8	53.0	74.5	26.5	65.7	24.4	567
Hennessey Drain[2]	~ 0	4,788	3,704	3,367	2,264	4,288	3,868	4,604	4,937	4,654	4,171	2,853	2,423	45,921
Tempe Drain[2]	10.0	2,607	2,556	2,559	1,678	835	158	64.2	193	72.6	80.2	69.2	8.0	10,880

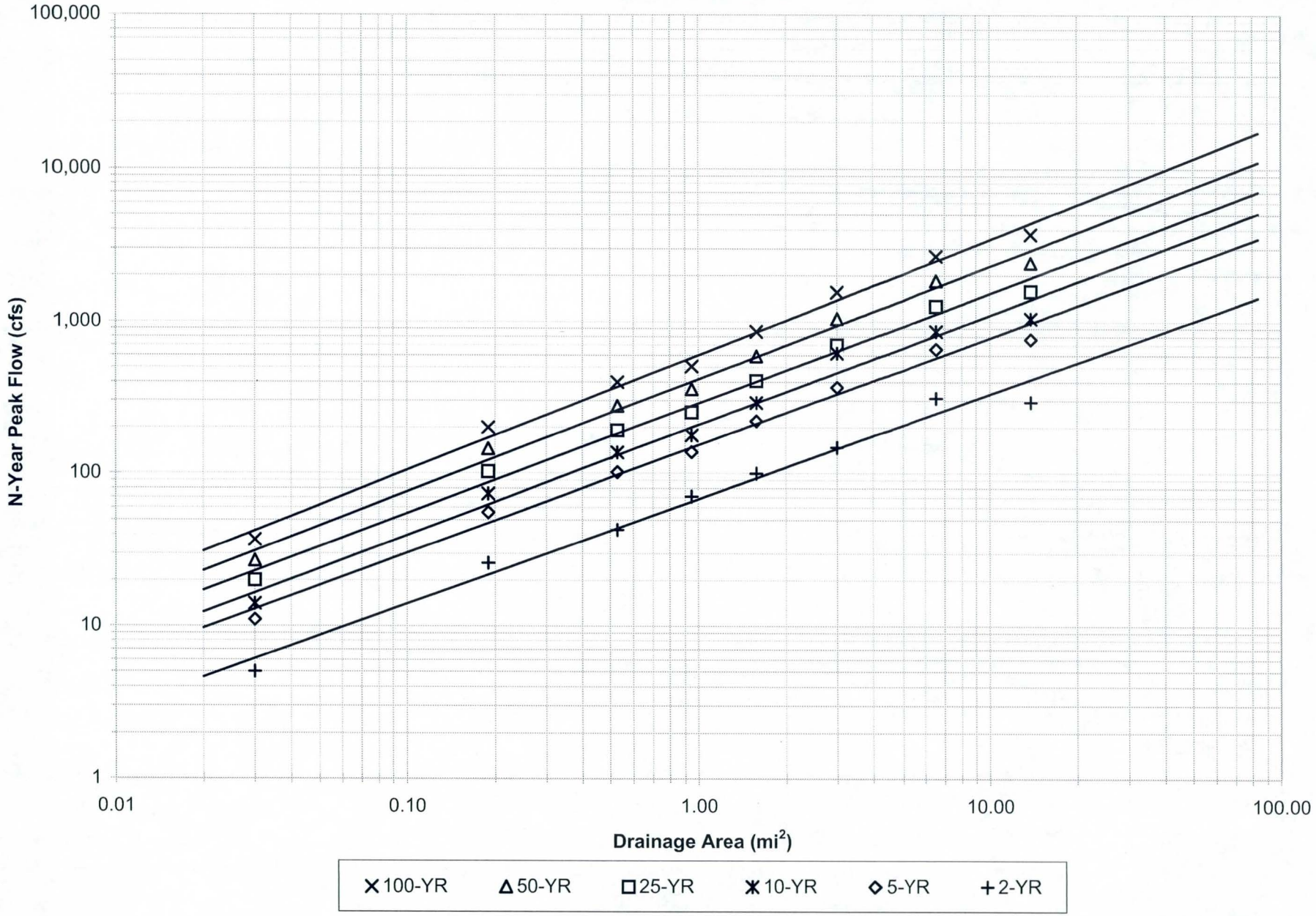
TABLE 4-3b
SUMMARY OF AVERAGE ANNUAL RUNOFF
STORM DRAINS
(units are in acre-feet)

Interior Drain	Drainage Area (mi^2)[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Price Drain[3]	31.2	202.2	125.6	266.9	178.8	311.1	136.5	283.1	337.1	267.7	193.8	150.5	166.5	2,620
Tempe Drain[4,5]	10.0	64.6	66.6	84.9	21.2	11.6	12.5	80.1	92.6	83.0	62.7	63.7	96.5	740
Price Road Freeway Local Drainage[4,5]	0.4	2.6	2.7	3.4	0.9	0.5	0.5	3.2	3.8	3.4	2.5	2.6	3.9	30
Dobson Road Storm Drain[4,5]	1.8	12.2	12.6	16.1	4.0	2.2	2.4	15.1	17.5	15.7	11.9	12.0	18.3	140
McLellan Road Storm Drain[4,5]	1.0	7.0	7.2	9.2	2.3	1.3	1.4	8.7	10.0	9.0	6.8	6.9	10.4	80
Country Club/McKellips Storm Drain[4,5]	3.7	26.2	27.0	34.4	8.6	4.7	5.1	32.5	37.5	33.6	25.4	25.8	39.1	300
Red Mountain Freeway Local Drainage[4,5]	unknown							minimal						
Natural Drainage[4,5]	2.0							minimal						
Alma School Storm Drain	unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

1. Drainage areas were estimated based on the drainage delineations made by personnel from the City of Mesa.
2. Monthly and annual runoff volumes for the canal drains were computed from the SRP daily flow records.
3. Monthly and annual storm water runoff volumes were computed from FCDMC flow records.
4. Monthly storm water runoff distributions were assumed to follow the monthly pattern of rainfall.
5. Annual runoff volumes for the storm drains were computed from the drainage area vs. average annual runoff relationships developed for the Rio Salado Study (Figure 3-3).

Figures

FIGURE 3-1
Peak Flow Relationships for Various Return Periods



Source: U. S. Army Corps of Engineers' Rio Salado Project.

FIGURE 3-2
Typical Full-Flow Storm Drain Pipe Capacity

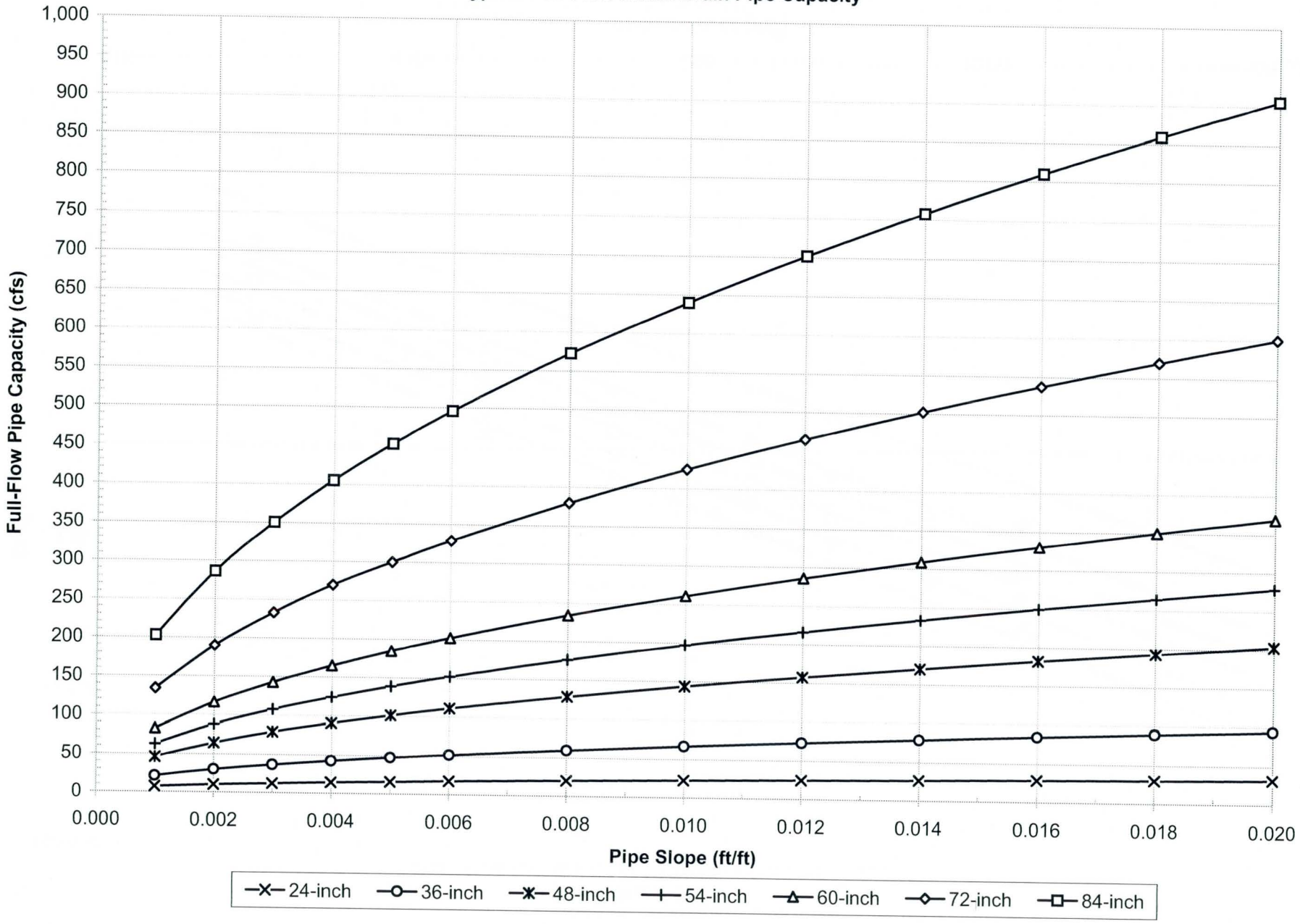
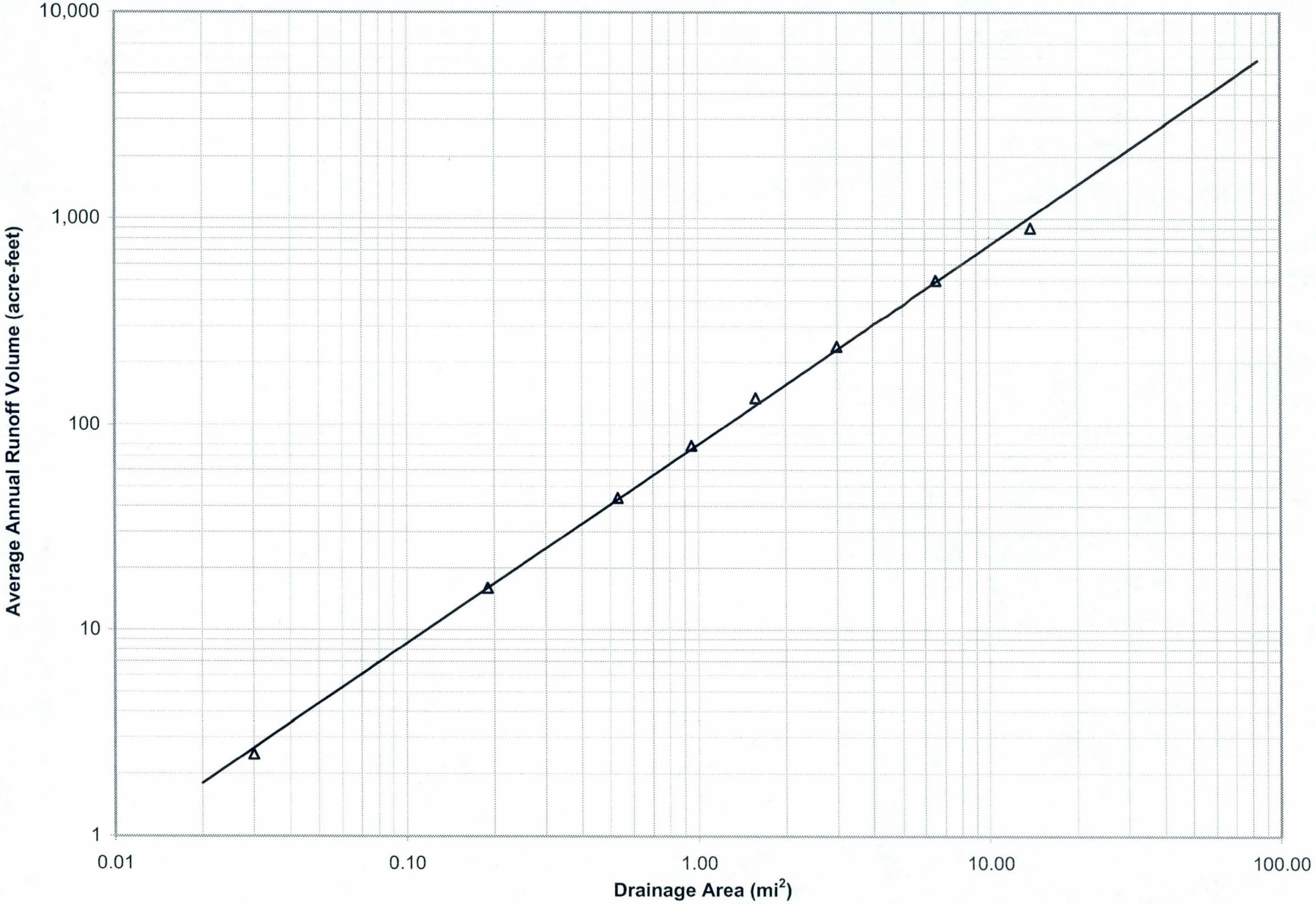
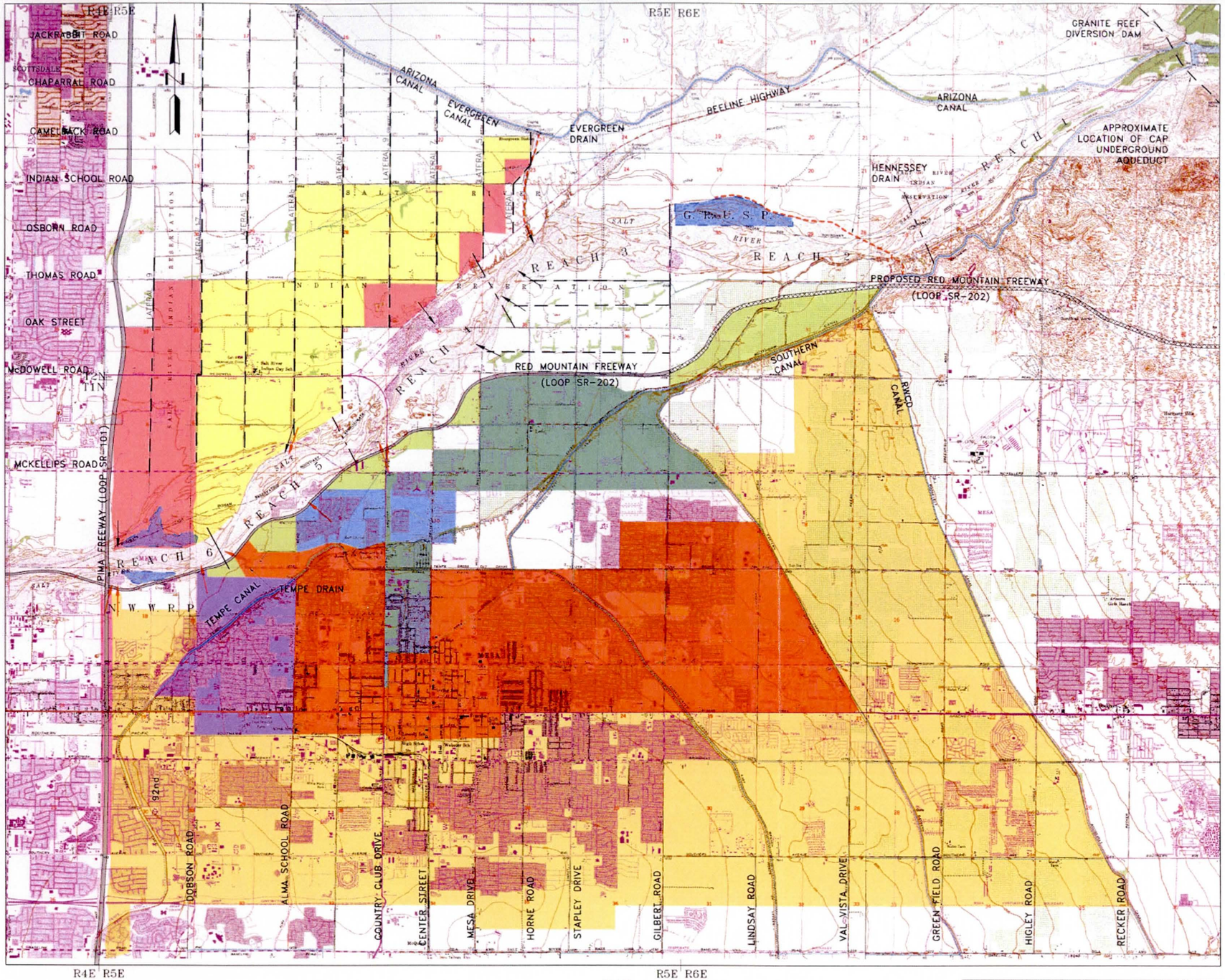


FIGURE 3-3
Average Annual Storm Drain Runoff for the Phoenix Metro Area



Source: U. S. Army Corps of Engineers' Rio Salado Project.

Drawings



PLAN

3000 0 3000 6000 FEET

LEGEND:

- SRPMIC LATERAL CANAL (3)
- SRP CANAL DRAIN
- REACH BOUNDARY
- STORM DRAIN OUTFALL
- AGRICULTURAL OUTFALL
- RECHARGE PONDS
- PRICE FREEWAY LOCAL DRAINAGE (2)
- PRICE DRAIN (2)
- TEMPE WASTEWAY/ALMA SCHOOL STORM DRAIN (2)
- DOBSON ROAD STORM DRAIN (2)
- McLELLAN ROAD STORM DRAIN (2)
- COUNTRY CLUB/McKELLIPS STORM DRAIN (2)
- WATER DRAINS INTO EITHER THE CYPRESS GOLF COURSE RESERVOIR OR THE SALT RIVER SAND AND ROCK RESERVOIR (1)
- WATER DRAINS DIRECTLY INTO SALT RIVER (1)
- RED MOUNTAIN FREEWAY LOCAL DRAINAGE

RWCD	ROOSEVELT WATER CONSERVATION DISTRICT
GRUSP	GRANITE REEF UNDERGROUND STORAGE PROJECT
SRPMIC	SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
NWWRP	NORTHWEST WATER RECLAMATION PLANT
SRP	SALT RIVER PROJECT

REFERENCE:

1) ECOPLAN ASSOCIATES, INC., WELLHEAD MANAGEMENT STRATEGY, IDENTIFICATION OF LOW RISK AREAS FOR SITING OF NEW WELLS AND/OR MODIFICATION OF EXISTING WELLS AS DOMESTIC WELLS, APRIL 2001.

2) TETRA TECH, INC., CITY OF MESA EXISTING AND CURRENTLY PROPOSED STORM DRAINAGE SYSTEM, SEPTEMBER 1999.

3) ECOPLAN ASSOCIATES, INC., SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1998.

Registered Professional Engineer (Civil) CERTIFICATE NO 29610 JAMES R. KUNKEL Date Signed 07/18/02 ARIZONA U.S.A.

REV	DATE	DESCRIPTION	APP'D / CADD
C	7/15/02	ISSUED FOR FINAL REPORT	WA
B	5/24/02	ISSUED FOR REVIEW	TMF
A	5/16/02	ISSUED FOR REVIEW	MDS / WA

DISCLAIMER

KNIGHT PIESOLD AND CO. PRODUCED THE DATA SHOWN ON THE DRAWING FILES USING BOTH TECHNICAL INFORMATION AND KNOW HOW. RECEIPT OF THIS DRAWING DOES NOT MEAN THAT THE RECIPIENT HAS ANY RIGHTS TO EITHER SUCH TECHNICAL INFORMATION OR KNOW HOW. ANY ADAPTATION OR MODIFICATION OF THE DATA OR DRAWING SHALL BE AT USER'S SOLE RISK AND WITHOUT LIABILITY OR LEGAL EXPOSURE TO KNIGHT PIESOLD AND CO.

CLIENT: SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY

PROJECT: SALT RIVER RESTORATION FEASIBILITY STUDY

TITLE: INTERIOR DRAINAGE MAP

Knight Piésold CONSULTING

DESIGNED BY	MDS	CHECKED BY		DRAWING No.	REV.
DRAWN BY	WA	APPROVED BY		1889M05C - 100	C

PLOT SCALE: 1:1 | XREF NO: 1889A02, X03, R04

Appendix A

Evergreen Drain
Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1992
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	94.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	11.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.71
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.96
9	0.00	0.00	9.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	80.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	60.19	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.63	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	112.58	5.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.11	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.13	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.76	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	5.50	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	2.00	185.83	9.17	0.00	0.00	0.00	118.08	87.82	0.00	0.00	0.00	32.67
Count	1	3	1	0	0	0	2	7	0	0	0	2
Average	0.06	6.41	0.30	0.00	0.00	0.00	3.81	2.83	0.00	0.00	0.00	1.05
Maximum	2.00	94.50	9.17	0.00	0.00	0.00	112.58	60.19	0.00	0.00	0.00	21.71
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1992
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	187.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	22.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.06
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	3.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.74
9	0.00	0.00	18.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	158.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	119.39	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.17	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	223.30	9.92	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.92	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.14	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.18	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.49	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	10.91	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	3.97	368.59	18.19	0.00	0.00	0.00	234.21	174.19	0.00	0.00	0.00	64.80
Count	1	3	1	0	0	0	2	7	0	0	0	2
Average	0.13	12.71	0.59	0.00	0.00	0.00	7.56	5.62	0.00	0.00	0.00	2.09
Maximum	3.97	187.44	18.19	0.00	0.00	0.00	223.30	119.39	0.00	0.00	0.00	43.06
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1993
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.64	0.00	18.79	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.21	0.00	0.24	0.00	0.00
8	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00
9	0.50	0.00	0.00	0.00	0.00	0.00	0.00	12.36	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.50	0.00	0.00	0.00	0.00
11	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.21	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.10	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	185.51	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.06	0.00
17	9.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	31.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	78.44	0.00	0.00	0.00	0.00	18.23	0.00	0.00	0.00	0.00
28	0.00	0.00	17.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		7.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.14		0.00		0.00	0.00		0.00		0.00
Total	13.95	0.00	135.33	0.00	0.00	0.00	0.00	70.37	0.00	19.03	293.88	0.00
Count	4	0	6	0	0	0	0	6	0	2	5	0
Average	0.45	0.00	4.37	0.00	0.00	0.00	0.00	2.27	0.00	0.61	9.80	0.00
Maximum	9.57	0.00	78.44	0.00	0.00	0.00	0.00	23.50	0.00	18.79	185.51	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1993
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.10	0.00	37.27	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.33	0.00	0.48	0.00	0.00
8	3.93	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00
9	0.99	0.00	0.00	0.00	0.00	0.00	0.00	24.52	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46.61	0.00	0.00	0.00	0.00
11	3.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.28	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85.49	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	367.95	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.34	0.00
17	18.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.83	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	62.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	155.58	0.00	0.00	0.00	0.00	36.16	0.00	0.00	0.00	0.00
28	0.00	0.00	35.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		14.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.28		0.00		0.00	0.00		0.00		0.00
Total	27.67	0.00	268.42	0.00	0.00	0.00	0.00	139.58	0.00	37.75	582.90	0.00
Count	4	0	6	0	0	0	0	6	0	2	5	0
Average	0.89	0.00	8.66	0.00	0.00	0.00	0.00	4.50	0.00	1.22	19.43	0.00
Maximum	18.98	0.00	155.58	0.00	0.00	0.00	0.00	46.61	0.00	37.27	367.95	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1994
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Count	0	0	0	0	0	0	0	0	0	0	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1994
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Count	0	0	0	0	0	0	0	0	0	0	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1995
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	36.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	21.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	124.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	118.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	17.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	9.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	4.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.07	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	296.23	1.61	0.00	0.00	36.61	0.00	0.00	0.00	27.07	0.00	0.00	0.00
Count	6	1	0	0	1	0	0	0	1	0	0	0
Average	9.56	0.06	0.00	0.00	1.18	0.00	0.00	0.00	0.90	0.00	0.00	0.00
Maximum	124.02	1.61	0.00	0.00	36.61	0.00	0.00	0.00	27.07	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1995
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	72.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	42.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	245.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	235.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	35.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	19.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	8.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	3.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	53.69	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	587.56	3.19	0.00	0.00	72.61	0.00	0.00	0.00	53.69	0.00	0.00	0.00
Count	6	1	0	0	1	0	0	0	1	0	0	0
Average	18.95	0.11	0.00	0.00	2.34	0.00	0.00	0.00	1.79	0.00	0.00	0.00
Maximum	245.99	3.19	0.00	0.00	72.61	0.00	0.00	0.00	53.69	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1996
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	313.34	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	313.34	0.00	0.00	0.00
Count	0	0	0	0	0	0	0	0	1	0	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.44	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	313.34	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1996
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	621.50	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	621.50	0.00	0.00	0.00
Count	0	0	0	0	0	0	0	0	1	0	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.72	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	621.50	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1997
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	58.83	8.48	120.19	142.98	33.17	36.31	2.64	124.20	50.37	134.65
2	0.00	24.91	6.67	14.33	124.76	150.41	39.23	37.22	2.58	124.67	96.64	132.88
3	90.33	43.29	6.77	8.55	125.86	76.03	39.40	36.74	21.81	124.74	116.05	131.93
4	0.00	85.10	6.90	8.16	125.28	27.15	39.75	36.43	38.15	124.53	143.33	131.34
5	0.00	104.51	127.33	31.40	125.36	26.03	38.01	36.56	38.46	125.48	144.56	131.46
6	0.00	106.24	131.59	31.23	125.10	25.60	37.03	37.23	38.53	144.00	143.07	130.95
7	0.00	105.44	132.53	31.63	125.67	25.30	37.00	37.13	37.96	142.32	155.35	130.51
8	0.00	0.00	133.49	31.25	124.79	26.26	36.91	48.02	38.91	142.93	150.01	130.55
9	22.91	0.00	137.63	30.80	125.34	26.75	37.64	52.92	65.09	144.22	149.61	130.25
10	22.62	0.00	137.57	29.69	126.02	47.55	37.35	52.27	80.76	143.01	150.40	131.12
11	22.74	0.00	135.12	29.54	124.76	55.32	36.58	53.03	79.58	169.50	151.86	131.71
12	22.08	0.00	81.62	29.95	126.41	55.38	37.47	52.92	79.53	179.84	151.69	131.04
13	22.93	0.00	6.07	29.80	124.93	54.36	36.58	51.59	79.87	183.88	151.35	130.06
14	23.59	0.00	7.15	30.01	125.46	53.66	37.84	58.52	79.80	189.13	152.50	130.48
15	24.13	0.00	7.19	31.56	124.56	54.90	37.71	54.39	79.15	183.75	160.60	130.08
16	24.31	0.00	7.24	30.71	124.44	54.36	36.60	53.84	95.69	181.26	157.44	130.82
17	22.71	0.00	7.06	30.81	125.20	55.49	38.02	52.02	117.71	177.94	151.57	131.15
18	23.79	0.00	7.21	30.10	126.43	55.13	37.48	52.36	124.41	179.41	151.72	130.87
19	23.62	0.00	7.16	0.00	125.91	54.45	37.52	52.13	123.42	177.78	153.82	130.23
20	22.78	0.00	7.23	0.00	125.26	55.20	37.64	53.34	122.83	177.97	155.18	131.22
21	22.47	0.00	6.83	0.00	125.82	54.53	37.85	53.42	123.34	188.94	152.71	131.51
22	22.47	0.00	22.98	0.00	125.84	55.57	38.30	39.09	124.48	195.76	151.70	142.09
23	22.37	0.00	9.09	0.00	125.04	56.19	38.75	55.96	124.36	196.07	151.60	155.24
24	0.00	0.00	8.59	0.00	122.92	55.99	43.98	55.56	125.47	86.90	147.22	129.11
25	0.00	0.00	8.62	0.00	123.02	55.28	37.98	13.92	125.04	41.41	142.91	129.13
26	0.00	0.00	8.64	0.00	123.92	55.83	38.23	3.49	132.58	136.72	141.96	128.50
27	0.00	19.15	8.58	0.00	122.55	56.08	37.06	3.45	127.81	211.57	141.88	126.87
28	0.00	118.13	7.92	0.00	121.73	56.08	36.29	3.15	125.81	210.97	154.71	125.88
29	184.27		8.44	0.00	104.69	51.74	37.29	2.56	124.97	209.95	169.64	129.00
30	177.68		8.21	0.00	123.22	26.84	37.53	2.79	124.29	207.94	171.74	130.38
31	0.00		8.19		122.41		36.93	1.46		62.85		131.49
Total	797.80	606.77	1,258.45	468.00	3,842.89	1,646.44	1,169.12	1,179.82	2,605.03	4,889.64	4,363.19	4,082.50
Count	18	8	31	18	31	30	31	31	30	31	30	31
Average	25.74	21.67	40.60	15.60	123.96	54.88	37.71	38.06	86.83	157.73	145.44	131.69
Maximum	184.27	118.13	137.63	31.63	126.43	150.41	43.98	58.52	132.58	211.57	171.74	155.24
Minimum	0.00	0.00	6.07	0.00	104.69	25.30	33.17	1.46	2.58	41.41	50.37	125.88

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1997
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	116.69	16.82	238.39	283.60	65.79	72.02	5.24	246.35	99.91	267.07
2	0.00	49.41	13.23	28.42	247.46	298.33	77.81	73.82	5.12	247.28	191.68	263.56
3	179.17	85.86	13.43	16.96	249.64	150.80	78.15	72.87	43.26	247.42	230.18	261.68
4	0.00	168.79	13.69	16.19	248.49	53.85	78.84	72.26	75.67	247.00	284.29	260.51
5	0.00	207.29	252.56	62.28	248.65	51.63	75.39	72.52	76.28	248.89	286.73	260.75
6	0.00	210.72	261.00	61.94	248.13	50.78	73.45	73.84	76.42	285.62	283.78	259.74
7	0.00	209.14	262.87	62.74	249.26	50.18	73.39	73.65	75.29	282.29	308.13	258.86
8	0.00	0.00	264.77	61.98	247.52	52.09	73.21	95.25	77.18	283.50	297.54	258.94
9	45.44	0.00	272.99	61.09	248.61	53.06	74.66	104.97	129.10	286.06	296.75	258.35
10	44.87	0.00	272.87	58.89	249.96	94.31	74.08	103.68	160.19	283.66	298.31	260.07
11	45.10	0.00	268.01	58.59	247.46	109.73	72.56	105.18	157.84	336.20	301.21	261.24
12	43.80	0.00	161.89	59.40	250.73	109.84	74.32	104.97	157.75	356.71	300.87	259.91
13	45.48	0.00	12.04	59.11	247.80	107.82	72.56	102.33	158.42	364.72	300.20	257.97
14	46.79	0.00	14.18	59.52	248.85	106.43	75.05	116.07	158.28	375.13	302.48	258.80
15	47.86	0.00	14.26	62.60	247.06	108.89	74.80	107.88	156.99	364.46	318.55	258.01
16	48.22	0.00	14.36	60.91	246.82	107.82	72.60	106.79	189.80	359.52	312.28	259.48
17	45.04	0.00	14.00	61.11	248.33	110.06	75.41	103.18	233.47	352.94	300.63	260.13
18	47.19	0.00	14.30	59.70	250.77	109.35	74.34	103.85	246.76	355.85	300.93	259.58
19	46.85	0.00	14.20	0.00	249.74	108.00	74.42	103.40	244.80	352.62	305.10	258.31
20	45.18	0.00	14.34	0.00	248.45	109.49	74.66	105.80	243.63	353.00	307.80	260.27
21	44.57	0.00	13.55	0.00	249.56	108.16	75.07	105.96	244.64	374.76	302.90	260.85
22	44.57	0.00	45.58	0.00	249.60	110.22	75.97	77.53	246.90	388.28	300.89	281.83
23	44.37	0.00	18.03	0.00	248.01	111.45	76.86	111.00	246.66	388.90	300.69	307.91
24	0.00	0.00	17.04	0.00	243.81	111.05	87.23	110.20	248.87	172.36	292.01	256.09
25	0.00	0.00	17.10	0.00	244.01	109.65	75.33	27.61	248.01	82.14	283.46	256.13
26	0.00	0.00	17.14	0.00	245.79	110.74	75.83	6.92	262.97	271.18	281.57	254.88
27	0.00	37.98	17.02	0.00	243.07	111.23	73.51	6.84	253.51	419.64	281.41	251.64
28	0.00	234.31	15.71	0.00	241.45	111.23	71.98	6.25	249.54	418.45	306.86	249.68
29	365.49		16.74	0.00	207.65	102.62	73.96	5.08	247.87	416.43	336.48	255.87
30	352.42		16.28	0.00	244.40	53.24	74.44	5.53	246.53	412.44	340.64	258.60
31	0.00		16.24		242.80		73.25	2.90		124.66		260.81
Total	1,582.41	1,203.51	2,496.10	928.26	7,622.26	3,265.67	2,318.92	2,340.14	5,167.00	9,698.46	8,654.26	8,097.52
Count	18	8	31	18	31	30	31	31	30	31	30	31
Average	51.05	42.98	80.52	30.94	245.88	108.86	74.80	75.49	172.23	312.85	288.48	261.21
Maximum	365.49	234.31	272.99	62.74	250.77	298.33	87.23	116.07	262.97	419.64	340.64	307.91
Minimum	0.00	0.00	12.04	0.00	207.65	50.18	65.79	2.90	5.12	82.14	99.91	249.68

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1998
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	2.18	0.00	4.16	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	11.58	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	139.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	125.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	27.36	0.00	81.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	1.37	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	11.03	0.00	0.00	0.00	0.00	0.00	11.57	0.00	0.00	0.00	0.00
18	0.00	4.21	0.00	0.00	0.00	0.00	0.00	22.10	0.00	0.00	0.00	0.00
19	0.00	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	1.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	1.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	4.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	44.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	44.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	36.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.08	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		70.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	100.60	152.68	347.02	0.00	0.00	13.76	33.67	4.16	0.00	0.00	0.00
Count	0	12	4	4	0	0	2	2	1	0	0	0
Average	0.00	3.59	4.93	11.57	0.00	0.00	0.44	1.09	0.14	0.00	0.00	0.00
Maximum	0.00	44.37	70.39	139.41	0.00	0.00	11.58	22.10	4.16	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1998
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	4.32	0.00	8.25	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	22.97	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	276.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	249.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	54.27	0.00	161.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	2.72	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	21.88	0.00	0.00	0.00	0.00	0.00	22.95	0.00	0.00	0.00	0.00
18	0.00	8.35	0.00	0.00	0.00	0.00	0.00	43.83	0.00	0.00	0.00	0.00
19	0.00	3.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	3.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	3.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	3.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	9.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	88.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	88.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	73.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.16	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		139.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	199.54	302.84	688.30	0.00	0.00	27.29	66.78	8.25	0.00	0.00	0.00
Count	0	12	4	4	0	0	2	2	1	0	0	0
Average	0.00	7.13	9.77	22.94	0.00	0.00	0.88	2.15	0.28	0.00	0.00	0.00
Maximum	0.00	88.01	139.62	276.52	0.00	0.00	22.97	43.83	8.25	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1999
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	36.59	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	12.48	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.85	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.03	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	39.11		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	49.07	39.11	0.00	21.88	0.00	0.00
Count	0	0	0	0	0	0	2	1	0	2	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	1.58	1.26	0.00	0.71	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	36.59	39.11	0.00	11.03	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1999
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	72.58	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	24.75	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.52	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.88	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	77.57		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	97.33	77.57	0.00	43.40	0.00	0.00
Count	0	0	0	0	0	0	2	1	0	2	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	3.14	2.50	0.00	1.40	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	72.58	77.57	0.00	21.88	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 2000
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	22.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	4.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	9.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.66	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	14.36	0.00	22.38	0.00	0.00	0.00	0.00	0.00	0.00	50.66	0.00	0.00
Count	2	0	1	0	0	0	0	0	0	1	0	0
Average	0.46	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	1.63	0.00	0.00
Maximum	9.73	0.00	22.38	0.00	0.00	0.00	0.00	0.00	0.00	50.66	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 2000
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	44.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	19.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.48	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	28.48	0.00	44.39	0.00	0.00	0.00	0.00	0.00	0.00	100.48	0.00	0.00
Count	2	0	1	0	0	0	0	0	0	1	0	0
Average	0.92	0.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	3.24	0.00	0.00
Maximum	19.30	0.00	44.39	0.00	0.00	0.00	0.00	0.00	0.00	100.48	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 2001
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	5.63	0.00	0.00	0.00	7.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	1.88	0.00	0.00	0.00	1.75	0.00
3	0.00	0.00	0.00	0.00	0.00	6.75	7.50	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	2.25	3.33	0.00	0.00	0.00	0.00	17.03
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.50	7.50	0.00	0.00	61.47
6	0.00	0.00	0.00	0.00	0.00	7.68	0.00	2.50	2.50	0.00	5.25	0.00
7	0.00	0.00	0.00	0.00	0.00	2.92	0.00	0.00	0.00	3.75	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	3.18	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77
12	0.00	0.00	0.00	0.00	0.00	17.50	8.75	0.00	0.00	5.25	6.00	0.50
13	0.00	0.00	0.00	0.00	0.00	7.33	2.55	0.00	0.00	1.75	2.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.50	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	7.50	7.50	0.00	3.75
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	3.13	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	3.75	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.00
20	0.00	0.00	0.00	0.00	0.00	12.90	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	6.61	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	3.75
25	0.00	0.00	0.00	0.00	0.00	0.00	7.50	0.00	10.91	0.00	0.18	1.25
26	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	3.75	0.00
27	0.00	0.00	0.00	0.00	14.00	0.00	0.00	6.00	0.00	0.00	1.25	0.00
28	0.00	0.00	0.00	0.00	4.49	0.00	0.00	2.00	0.00	6.00	3.75	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	1.25	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		4.50		0.00
Total	0.00	0.00	0.00	0.00	18.49	63.94	44.64	36.00	30.91	42.06	37.18	90.52
Count	0	0	0	0	2	8	9	8	5	11	12	7
Average	0.00	0.00	0.00	0.00	0.60	2.13	1.44	1.16	1.03	1.36	1.24	2.92
Maximum	0.00	0.00	0.00	0.00	14.00	17.50	8.75	7.50	10.91	7.50	7.00	61.47
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 2001
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	11.17	0.00	0.00	0.00	13.88	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	3.73	0.00	0.00	0.00	3.47	0.00
3	0.00	0.00	0.00	0.00	0.00	13.39	14.88	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	4.46	6.60	0.00	0.00	0.00	0.00	33.78
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.88	14.88	0.00	0.00	121.92
6	0.00	0.00	0.00	0.00	0.00	15.23	0.00	4.96	4.96	0.00	10.41	0.00
7	0.00	0.00	0.00	0.00	0.00	5.79	0.00	0.00	0.00	7.44	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.90	0.00	6.31	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.97	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.49
12	0.00	0.00	0.00	0.00	0.00	34.71	17.36	0.00	0.00	10.41	11.90	0.99
13	0.00	0.00	0.00	0.00	0.00	14.54	5.06	0.00	0.00	3.47	3.97	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.88	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.96	14.88	14.88	0.00	7.44
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.96	6.21	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	9.92	0.00	0.00	0.00	7.44	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.48	0.00
20	0.00	0.00	0.00	0.00	0.00	25.59	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	13.11	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.96	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.96	0.00	7.44
25	0.00	0.00	0.00	0.00	0.00	0.00	14.88	0.00	21.64	0.00	0.36	2.48
26	0.00	0.00	0.00	0.00	0.00	0.00	4.96	0.00	0.00	0.00	7.44	0.00
27	0.00	0.00	0.00	0.00	27.77	0.00	0.00	11.90	0.00	0.00	2.48	0.00
28	0.00	0.00	0.00	0.00	8.91	0.00	0.00	3.97	0.00	11.90	7.44	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.97	2.48	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		8.93		0.00
Total	0.00	0.00	0.00	0.00	36.67	126.82	88.54	71.40	61.31	83.42	73.75	179.54
Count	0	0	0	0	2	8	9	8	5	11	12	7
Average	0.00	0.00	0.00	0.00	1.18	4.23	2.86	2.30	2.04	2.69	2.46	5.79
Maximum	0.00	0.00	0.00	0.00	27.77	34.71	17.36	14.88	21.64	14.88	13.88	121.92
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

Appendix B

Hennessey Drain
Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1992
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.04
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.95
6	26.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	80.83	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	157.33	0.00	12.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	6.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	6.29	0.00	0.00	2.11	0.00	0.00	0.00	0.00
12	35.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	15.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	92.62	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	59.19	0.00	0.00	17.17	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	7.17	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	8.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.57	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	8.96	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	299.83	4.00	27.42	15.63	6.29	0.00	75.32	137.30	0.00	17.17	0.00	60.99
Count	4	1	3	1	1	0	3	3	0	1	0	2
Average	9.67	0.14	0.88	0.52	0.20	0.00	2.43	4.43	0.00	0.55	0.00	1.97
Maximum	157.33	4.00	12.30	15.63	6.29	0.00	59.19	92.62	0.00	17.17	0.00	48.04
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1992
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	95.29
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.69
6	51.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	160.32	7.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	312.06	0.00	24.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	13.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	12.48	0.00	0.00	4.19	0.00	0.00	0.00	0.00
12	70.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	31.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	183.71	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	117.40	0.00	0.00	34.06	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	14.22	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	16.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	84.44	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	17.77	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	594.70	7.93	54.39	31.00	12.48	0.00	149.40	272.33	0.00	34.06	0.00	120.97
Count	4	1	3	1	1	0	3	3	0	1	0	2
Average	19.18	0.27	1.75	1.03	0.40	0.00	4.82	8.78	0.00	1.10	0.00	3.90
Maximum	312.06	7.93	24.40	31.00	12.48	0.00	117.40	183.71	0.00	34.06	0.00	95.29
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1993
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	169.25	59.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	138.20	38.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	29.27	0.00	0.00	127.51	0.00	0.00	0.00	0.00	0.00	37.58	0.00	0.00
4	753.89	0.00	0.00	115.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	845.89	0.00	0.00	98.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	832.96	0.00	0.00	53.05	0.00	0.00	0.00	2.60	0.00	0.00	0.00	0.00
7	467.34	0.00	0.00	87.03	0.00	0.00	0.00	11.81	0.00	0.00	0.00	0.00
8	44.98	0.00	0.00	63.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	25.93	0.00	129.06	52.55	0.93	0.00	0.00	15.49	0.00	0.00	0.00	0.00
10	0.00	0.00	78.86	75.88	37.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	41.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	35.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	67.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	32.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	48.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	44.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	47.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	61.60	0.00	0.00	0.00	8.74	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	63.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	15.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.44	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	8.95	17.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	24.60	4.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	34.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	21.90	36.14	0.00	0.00	0.00	33.75	0.00	0.00	0.00	0.00
28	0.00	0.00	17.90	28.07	0.00	0.00	130.19	0.00	0.00	0.00	0.00	0.00
29	0.00		25.10	29.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		53.70	43.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		11.41		0.00		0.00	0.00		0.00		0.00
Total	3,000.26	0.00	337.93	1,644.36	158.12	0.00	130.19	90.83	0.00	37.58	0.00	0.00
Count	7	0	7	27	6	0	1	6	0	1	0	0
Average	96.78	0.00	10.90	54.81	5.10	0.00	4.20	2.93	0.00	1.21	0.00	0.00
Maximum	845.89	0.00	129.06	169.25	59.09	0.00	130.19	33.75	0.00	37.58	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1993
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	335.70	117.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	274.12	76.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	58.06	0.00	0.00	252.91	0.00	0.00	0.00	0.00	0.00	74.54	0.00	0.00
4	1,495.32	0.00	0.00	229.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1,677.80	0.00	0.00	194.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	1,652.15	0.00	0.00	105.22	0.00	0.00	0.00	5.16	0.00	0.00	0.00	0.00
7	926.96	0.00	0.00	172.62	0.00	0.00	0.00	23.42	0.00	0.00	0.00	0.00
8	89.22	0.00	0.00	126.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	51.43	0.00	255.99	104.23	1.84	0.00	0.00	30.72	0.00	0.00	0.00	0.00
10	0.00	0.00	156.42	150.51	75.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	81.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	70.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	133.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	64.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	96.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	87.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	94.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	122.18	0.00	0.00	0.00	17.34	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	126.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	30.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.58	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	17.75	34.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	48.79	8.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	68.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	43.44	71.68	0.00	0.00	0.00	66.94	0.00	0.00	0.00	0.00
28	0.00	0.00	35.50	55.68	0.00	0.00	258.23	0.00	0.00	0.00	0.00	0.00
29	0.00		49.79	58.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		106.51	86.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		22.63		0.00		0.00	0.00		0.00		0.00
Total	5,950.93	0.00	670.27	3,261.54	313.63	0.00	258.23	180.16	0.00	74.54	0.00	0.00
Count	7	0	7	27	6	0	1	6	0	1	0	0
Average	191.97	0.00	21.62	108.72	10.12	0.00	8.33	5.81	0.00	2.40	0.00	0.00
Maximum	1,677.80	0.00	255.99	335.70	117.20	0.00	258.23	66.94	0.00	74.54	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1994
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	32.98	227.59	195.23	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	136.76	228.83	194.65	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	171.61	231.58	196.38	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	176.44	218.47	193.77	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	196.59	202.50	193.62	0.00	0.00	0.00
6	21.14	0.00	0.00	0.00	0.00	0.00	227.23	201.61	194.35	0.00	0.00	0.00
7	28.25	0.00	0.00	0.00	0.00	0.00	231.35	210.78	196.95	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	233.80	210.85	196.88	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	234.41	211.75	193.88	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	231.87	207.53	203.49	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	231.53	193.10	203.01	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	227.86	185.82	191.99	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	231.56	198.72	191.51	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	229.31	206.06	197.82	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	194.02	221.11	219.76	15.53	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	167.36	226.49	207.55	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	164.64	223.60	205.71	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	163.40	196.81	212.32	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	163.43	163.82	219.16	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	27.31	176.85	174.75	240.14	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	40.37	189.01	159.20	199.28	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	41.55	194.88	168.75	184.87	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	107.06	192.87	179.66	189.46	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	16.60	210.66	206.49	179.29	202.61	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	19.90	217.68	216.78	183.53	209.33	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	199.70	216.60	182.96	233.96	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	196.11	219.46	202.87	180.07	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	114.79	230.95	190.86	51.59	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	230.41	193.76	24.17	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	229.38	189.09	17.95	0.00	0.00	0.00
31	0.00		0.00		0.00		226.09	196.26		0.00		0.00
Total	49.39	0.00	0.00	0.00	36.50	1,155.23	6,175.92	6,168.00	5,541.46	15.53	0.00	0.00
Count	2	0	0	0	2	9	31	31	30	1	0	0
Average	1.59	0.00	0.00	0.00	1.18	38.51	199.22	198.97	184.72	0.50	0.00	0.00
Maximum	28.25	0.00	0.00	0.00	19.90	217.68	234.41	231.58	240.14	15.53	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	32.98	159.20	17.95	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1994
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	65.41	451.42	387.23	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	271.26	453.88	386.08	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	340.38	459.33	389.51	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	349.96	433.33	384.34	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	389.93	401.65	384.04	0.00	0.00	0.00
6	41.93	0.00	0.00	0.00	0.00	0.00	450.70	399.89	385.49	0.00	0.00	0.00
7	56.03	0.00	0.00	0.00	0.00	0.00	458.88	418.08	390.64	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	463.74	418.21	390.51	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	464.95	420.00	384.56	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	459.91	411.63	403.62	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	459.23	383.01	402.66	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	451.95	368.57	380.81	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	459.29	394.16	379.85	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	454.83	408.71	392.37	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	384.83	438.57	435.89	30.80	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	331.95	449.24	411.67	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	326.56	443.50	408.02	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	324.10	390.37	421.13	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	324.16	324.93	434.70	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	54.17	350.78	346.61	476.31	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	80.07	374.90	315.77	395.27	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	82.41	386.54	334.71	366.68	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	212.35	382.55	356.35	375.79	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	32.93	417.84	409.57	355.62	401.87	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	39.47	431.76	429.98	364.03	415.20	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	396.10	429.62	362.90	464.05	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	388.98	435.29	402.39	357.16	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	227.68	458.08	378.57	102.33	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	457.01	384.32	47.94	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	454.97	375.05	35.60	0.00	0.00	0.00
31	0.00		0.00		0.00		448.44	389.28		0.00		0.00
Total	97.96	0.00	0.00	0.00	72.40	2,291.37	12,249.76	12,234.05	10,991.33	30.80	0.00	0.00
Count	2	0	0	0	2	9	31	31	30	1	0	0
Average	3.16	0.00	0.00	0.00	2.34	76.38	395.15	394.65	366.38	0.99	0.00	0.00
Maximum	56.03	0.00	0.00	0.00	39.47	431.76	464.95	459.33	476.31	30.80	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	65.41	315.77	35.60	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1995
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	120.35	0.00	0.00	0.00	185.37	132.80	136.16	133.94	97.76	127.57	174.02
2	0.00	119.29	0.00	0.00	0.00	186.11	132.36	136.79	118.12	101.48	130.32	179.35
3	0.00	121.61	0.00	0.00	0.00	190.55	151.19	134.49	116.19	98.34	129.97	103.80
4	25.74	114.98	0.00	0.00	24.02	190.10	156.15	135.87	113.21	97.91	129.90	0.00
5	109.32	135.29	0.00	0.00	35.03	154.22	154.56	136.30	114.26	96.42	128.82	0.00
6	200.76	146.87	0.00	0.00	68.85	139.18	165.89	135.07	112.62	100.55	144.93	0.00
7	209.14	144.75	0.00	0.00	84.97	134.14	162.34	133.40	110.36	98.73	154.56	0.00
8	214.06	145.13	0.00	0.00	116.37	128.84	164.51	137.02	103.86	101.54	130.03	0.00
9	208.48	143.22	0.00	0.00	131.35	136.36	164.72	139.07	107.16	100.71	154.83	0.00
10	207.94	143.09	0.00	0.00	133.85	139.71	168.47	138.80	104.45	111.18	144.32	0.00
11	228.34	145.83	0.00	0.00	134.89	134.83	168.44	137.74	106.29	118.37	147.68	0.00
12	247.51	143.69	0.00	0.00	135.59	135.65	165.27	136.02	106.25	116.40	150.54	0.00
13	207.70	142.72	0.00	0.00	133.57	170.54	166.53	134.22	105.91	118.77	158.77	0.00
14	185.38	92.52	0.00	0.00	134.49	193.05	147.82	131.68	107.76	119.07	0.00	0.00
15	181.27	0.00	0.00	0.00	132.52	187.88	135.03	136.41	106.65	116.32	0.00	0.00
16	198.96	0.00	0.00	0.00	132.53	193.15	132.49	136.10	105.83	114.44	0.00	0.00
17	38.09	0.00	0.00	0.00	168.69	185.53	132.99	135.74	105.37	115.53	104.60	0.00
18	156.48	0.00	0.00	0.00	183.07	190.45	129.80	138.61	103.78	116.36	120.03	0.00
19	195.50	0.00	0.00	0.00	191.03	168.06	129.67	142.44	108.69	111.99	121.78	0.00
20	194.49	0.00	0.00	0.00	188.36	157.40	129.72	145.31	105.47	93.35	139.42	0.00
21	185.49	0.00	0.00	0.00	191.38	141.49	133.08	142.78	107.90	0.00	141.73	0.00
22	184.14	0.00	0.00	0.00	193.26	130.61	136.05	144.29	108.13	0.00	145.99	0.00
23	189.27	0.00	0.00	0.00	189.75	130.27	135.04	149.66	105.92	0.00	143.55	0.00
24	139.37	0.00	0.00	0.00	189.73	128.15	134.22	153.93	104.96	0.00	142.69	92.81
25	117.15	0.00	0.00	0.00	189.70	128.21	138.09	160.84	104.67	0.00	147.10	203.24
26	92.17	0.00	0.00	0.00	187.91	130.18	134.22	160.10	102.71	0.00	138.70	205.52
27	90.01	0.00	0.00	0.00	190.28	130.95	135.86	162.92	101.36	0.00	137.27	210.80
28	90.54	0.00	0.00	0.00	194.06	130.65	138.22	165.00	102.80	0.00	140.26	207.03
29	92.08		0.00	0.00	186.49	134.68	136.69	163.03	102.18	57.32	139.39	207.78
30	92.74		0.00	0.00	187.99	132.51	137.23	154.31	101.51	114.08	161.25	210.10
31	101.16		0.00		186.79		136.82	152.97		129.01		216.07
Total	4,383.28	1,859.34	0.00	0.00	4,216.52	4,618.82	4,486.27	4,447.07	3,238.31	2,445.63	3,756.00	2,010.52
Count	28	14	0	0	28	30	31	31	30	23	27	11
Average	141.40	66.41	0.00	0.00	136.02	153.96	144.72	143.45	107.94	78.89	125.20	64.86
Maximum	247.51	146.87	0.00	0.00	194.06	193.15	168.47	165.00	133.94	129.01	161.25	216.07
Minimum	0.00	0.00	0.00	0.00	0.00	128.15	129.67	131.68	101.36	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1995
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	238.71	0.00	0.00	0.00	367.68	263.40	270.07	265.67	193.90	253.03	345.16
2	0.00	236.61	0.00	0.00	0.00	369.14	262.53	271.32	234.29	201.28	258.49	355.74
3	0.00	241.21	0.00	0.00	0.00	377.95	299.88	266.76	230.46	195.05	257.79	205.88
4	51.05	228.06	0.00	0.00	47.64	377.06	309.72	269.49	224.55	194.20	257.65	0.00
5	216.83	268.34	0.00	0.00	69.48	305.89	306.57	270.35	226.63	191.25	255.51	0.00
6	398.20	291.31	0.00	0.00	136.56	276.06	329.04	267.91	223.38	199.44	287.46	0.00
7	414.82	287.11	0.00	0.00	168.54	266.06	322.00	264.60	218.90	195.83	306.57	0.00
8	424.58	287.86	0.00	0.00	230.82	255.55	326.30	271.78	206.00	201.40	257.91	0.00
9	413.51	284.07	0.00	0.00	260.53	270.47	326.72	275.84	212.55	199.76	307.10	0.00
10	412.44	283.81	0.00	0.00	265.49	277.11	334.16	275.31	207.17	220.52	286.25	0.00
11	452.91	289.25	0.00	0.00	267.55	267.43	334.10	273.20	210.82	234.78	292.92	0.00
12	490.93	285.00	0.00	0.00	268.94	269.06	327.81	269.79	210.74	230.88	298.59	0.00
13	411.97	283.08	0.00	0.00	264.93	338.26	330.31	266.22	210.07	235.58	314.92	0.00
14	367.70	183.51	0.00	0.00	266.76	382.91	293.20	261.18	213.74	236.17	0.00	0.00
15	359.54	0.00	0.00	0.00	262.85	372.65	267.83	270.57	211.54	230.72	0.00	0.00
16	394.63	0.00	0.00	0.00	262.87	383.11	262.79	269.95	209.91	226.99	0.00	0.00
17	75.55	0.00	0.00	0.00	334.59	367.99	263.78	269.24	209.00	229.15	207.47	0.00
18	310.37	0.00	0.00	0.00	363.11	377.75	257.45	274.93	205.84	230.80	238.08	0.00
19	387.77	0.00	0.00	0.00	378.90	333.34	257.20	282.53	215.58	222.13	241.55	0.00
20	385.77	0.00	0.00	0.00	373.61	312.20	257.30	288.22	209.20	185.16	276.54	0.00
21	367.91	0.00	0.00	0.00	379.60	280.64	263.96	283.20	214.02	0.00	281.12	0.00
22	365.24	0.00	0.00	0.00	383.33	259.06	269.85	286.20	214.47	0.00	289.57	0.00
23	375.41	0.00	0.00	0.00	376.36	258.39	267.85	296.85	210.09	0.00	284.73	0.00
24	276.44	0.00	0.00	0.00	376.32	254.18	266.22	305.32	208.19	0.00	283.02	184.09
25	232.36	0.00	0.00	0.00	376.26	254.30	273.90	319.02	207.61	0.00	291.77	403.12
26	182.82	0.00	0.00	0.00	372.71	258.21	266.22	317.55	203.72	0.00	275.11	407.64
27	178.53	0.00	0.00	0.00	377.41	259.74	269.47	323.15	201.04	0.00	272.27	418.12
28	179.58	0.00	0.00	0.00	384.91	259.14	274.16	327.27	203.90	0.00	278.20	410.64
29	182.64		0.00	0.00	369.90	267.13	271.12	323.37	202.67	113.69	276.48	412.13
30	183.95		0.00	0.00	372.87	262.83	272.19	306.07	201.34	226.27	319.83	416.73
31	200.65		0.00		370.49		271.38	303.41		255.89		428.57
Total	8,694.11	3,687.95	0.00	0.00	8,363.35	9,161.30	8,898.39	8,820.63	6,423.09	4,850.84	7,449.92	3,987.81
Count	28	14	0	0	28	30	31	31	30	23	27	11
Average	280.46	131.71	0.00	0.00	269.79	305.38	287.04	284.54	214.10	156.48	248.33	128.64
Maximum	490.93	291.31	0.00	0.00	384.91	383.11	334.16	327.27	265.67	255.89	319.83	428.57
Minimum	0.00	0.00	0.00	0.00	0.00	254.18	257.20	261.18	201.04	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1996
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	237.12	162.99	171.84	146.06	157.75	155.37	21.95	10.44	0.00	0.00	0.00	97.71
2	235.30	161.93	174.50	146.03	155.45	157.76	28.56	42.20	18.86	0.00	0.00	100.64
3	234.81	160.90	175.69	147.75	155.05	159.87	27.41	42.02	0.00	0.00	0.00	96.91
4	233.02	159.69	172.74	151.01	155.85	158.34	27.14	42.39	0.00	0.00	0.00	95.88
5	235.62	178.15	176.11	147.95	158.71	159.06	26.42	0.00	0.00	0.00	0.00	97.80
6	245.78	193.50	176.38	149.09	158.77	160.78	27.29	0.00	0.00	0.00	0.00	96.69
7	234.59	194.68	177.95	147.50	159.59	161.11	27.09	0.00	0.00	4.05	0.00	96.63
8	242.76	192.92	181.77	144.39	161.24	160.84	27.03	0.00	0.00	0.00	0.00	96.21
9	273.15	194.34	158.24	145.57	160.92	160.43	27.03	0.00	0.00	0.00	0.00	96.56
10	239.40	191.65	150.08	143.95	165.23	160.10	27.29	0.00	0.00	0.00	0.00	96.01
11	241.25	195.54	150.78	146.67	162.05	162.63	27.17	0.00	0.00	0.00	0.00	96.12
12	235.29	193.55	149.85	148.39	161.11	162.30	28.27	0.00	0.00	0.00	0.00	96.00
13	241.33	193.98	148.62	148.92	163.70	162.88	28.09	0.00	0.00	0.00	0.00	92.68
14	245.63	196.41	148.45	151.66	165.34	163.96	20.91	0.00	0.00	0.00	0.00	94.89
15	246.00	196.13	153.37	149.08	165.24	163.66	7.12	0.00	0.00	0.00	0.00	95.65
16	227.57	196.76	151.34	149.37	163.48	163.94	0.00	0.00	0.00	0.00	0.00	95.35
17	210.42	198.21	151.47	154.32	165.06	78.91	0.00	0.00	0.00	0.00	0.00	96.13
18	215.76	197.07	152.78	156.36	166.03	0.00	0.00	4.86	0.00	0.00	0.00	95.21
19	227.69	179.47	158.30	154.91	165.57	0.00	0.00	0.00	0.00	0.00	0.00	94.02
20	223.67	170.36	158.25	153.53	164.61	0.00	0.00	0.00	0.00	0.00	0.00	85.41
21	220.10	167.98	163.44	149.13	163.08	0.00	0.00	0.00	0.00	16.00	0.00	0.00
22	209.40	172.82	178.68	150.28	164.33	0.00	0.00	0.00	0.00	149.89	0.00	0.00
23	181.25	169.62	168.82	150.37	165.24	0.00	0.00	11.09	0.00	153.11	0.00	0.00
24	78.31	172.36	149.78	148.88	164.95	7.31	0.00	0.00	0.00	153.80	0.00	0.00
25	0.00	171.32	146.65	150.21	163.51	20.20	8.20	0.00	0.00	103.02	0.00	0.00
26	0.00	166.13	145.17	149.30	162.79	4.76	0.00	0.00	0.00	101.66	0.00	0.00
27	101.05	170.41	150.01	152.88	163.09	0.00	0.00	4.38	0.00	129.01	0.00	0.00
28	162.96	171.30	150.49	151.04	164.91	0.00	0.00	0.00	0.00	128.80	70.10	0.00
29	163.75	170.04	149.86	154.10	160.89	0.00	0.00	0.00	0.00	128.48	69.68	0.00
30	164.41		149.77	152.63	160.08	0.00	0.00	0.00	0.00	263.82	69.75	0.00
31	163.84		149.29		158.32		0.00	0.00		371.82		0.00
Total	6,171.23	5,240.21	4,940.47	4,491.33	5,021.94	2,684.21	386.97	157.38	18.86	1,703.46	209.53	1,912.50
Count	29	29	31	30	31	20	16	7	1	12	3	20
Average	199.07	180.70	159.37	149.71	162.00	89.47	12.48	5.08	0.63	54.95	6.98	61.69
Maximum	273.15	198.21	181.77	156.36	166.03	163.96	28.56	42.39	18.86	371.82	70.10	100.64
Minimum	0.00	159.69	145.17	143.95	155.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1996
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	470.32	323.29	340.84	289.71	312.89	308.17	43.54	20.71	0.00	0.00	0.00	193.80
2	466.71	321.18	346.12	289.65	308.33	312.91	56.65	83.70	37.41	0.00	0.00	199.62
3	465.74	319.14	348.48	293.06	307.54	317.10	54.37	83.35	0.00	0.00	0.00	192.22
4	462.19	316.74	342.62	299.52	309.12	314.06	53.83	84.08	0.00	0.00	0.00	190.18
5	467.35	353.36	349.31	293.45	314.80	315.49	52.40	0.00	0.00	0.00	0.00	193.98
6	487.50	383.80	349.84	295.72	314.92	318.90	54.13	0.00	0.00	0.00	0.00	191.78
7	465.30	386.14	352.96	292.56	316.54	319.56	53.73	0.00	0.00	8.03	0.00	191.66
8	481.51	382.65	360.54	286.39	319.81	319.02	53.61	0.00	0.00	0.00	0.00	190.83
9	541.79	385.47	313.86	288.73	319.18	318.21	53.61	0.00	0.00	0.00	0.00	191.52
10	474.84	380.13	297.68	285.52	327.73	317.55	54.13	0.00	0.00	0.00	0.00	190.43
11	478.51	387.85	299.07	290.92	321.42	322.57	53.89	0.00	0.00	0.00	0.00	190.65
12	466.69	383.90	297.22	294.33	319.56	321.92	56.07	0.00	0.00	0.00	0.00	190.41
13	478.67	384.75	294.78	295.38	324.69	323.07	55.72	0.00	0.00	0.00	0.00	183.83
14	487.20	389.57	294.45	300.81	327.95	325.21	41.47	0.00	0.00	0.00	0.00	188.21
15	487.93	389.02	304.20	295.70	327.75	324.61	14.12	0.00	0.00	0.00	0.00	189.72
16	451.38	390.27	300.18	296.27	324.26	325.17	0.00	0.00	0.00	0.00	0.00	189.12
17	417.36	393.14	300.44	306.09	327.39	156.52	0.00	0.00	0.00	0.00	0.00	190.67
18	427.95	390.88	303.03	310.14	329.32	0.00	0.00	9.64	0.00	0.00	0.00	188.85
19	451.62	355.97	313.98	307.26	328.40	0.00	0.00	0.00	0.00	0.00	0.00	186.49
20	443.64	337.90	313.88	304.52	326.50	0.00	0.00	0.00	0.00	0.00	0.00	169.41
21	436.56	333.18	324.18	295.80	323.46	0.00	0.00	0.00	0.00	31.74	0.00	0.00
22	415.34	342.78	354.41	298.08	325.94	0.00	0.00	0.00	0.00	297.30	0.00	0.00
23	359.50	336.44	334.85	298.25	327.75	0.00	0.00	22.00	0.00	303.69	0.00	0.00
24	155.33	341.87	297.08	295.30	327.17	14.50	0.00	0.00	0.00	305.06	0.00	0.00
25	0.00	339.81	290.88	297.94	324.32	40.07	16.26	0.00	0.00	204.34	0.00	0.00
26	0.00	329.51	287.94	296.13	322.89	9.44	0.00	0.00	0.00	201.64	0.00	0.00
27	200.43	338.00	297.54	303.23	323.48	0.00	0.00	8.69	0.00	255.89	0.00	0.00
28	323.23	339.77	298.49	299.58	327.09	0.00	0.00	0.00	0.00	255.47	139.04	0.00
29	324.79	337.27	297.24	305.65	319.12	0.00	0.00	0.00	0.00	254.84	138.21	0.00
30	326.10		297.06	302.74	317.51	0.00	0.00	0.00	0.00	523.28	138.35	0.00
31	324.97		296.11		314.02		0.00	0.00		737.49		0.00
Total	12,240.46	10,393.80	9,799.28	8,908.42	9,960.87	5,324.05	767.54	312.16	37.41	3,378.76	415.60	3,793.39
Count	29	29	31	30	31	20	16	7	1	12	3	20
Average	394.85	358.41	316.11	296.95	321.32	177.47	24.76	10.07	1.25	108.99	13.85	122.37
Maximum	541.79	393.14	360.54	310.14	329.32	325.21	56.65	84.08	37.41	737.49	139.04	199.62
Minimum	0.00	316.74	287.94	285.52	307.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1997
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	58.83	8.48	120.19	142.98	33.17	36.31	2.64	124.20	50.37	134.65
2	0.00	24.91	6.67	14.33	124.76	150.41	39.23	37.22	2.58	124.67	96.64	132.88
3	90.33	43.29	6.77	8.55	125.86	76.03	39.40	36.74	21.81	124.74	116.05	131.93
4	0.00	85.10	6.90	8.16	125.28	27.15	39.75	36.43	38.15	124.53	143.33	131.34
5	0.00	104.51	127.33	31.40	125.36	26.03	38.01	36.56	38.46	125.48	144.56	131.46
6	0.00	106.24	131.59	31.23	125.10	25.60	37.03	37.23	38.53	144.00	143.07	130.95
7	0.00	105.44	132.53	31.63	125.67	25.30	37.00	37.13	37.96	142.32	155.35	130.51
8	0.00	0.00	133.49	31.25	124.79	26.26	36.91	48.02	38.91	142.93	150.01	130.55
9	22.91	0.00	137.63	30.80	125.34	26.75	37.64	52.92	65.09	144.22	149.61	130.25
10	22.62	0.00	137.57	29.69	126.02	47.55	37.35	52.27	80.76	143.01	150.40	131.12
11	22.74	0.00	135.12	29.54	124.76	55.32	36.58	53.03	79.58	169.50	151.86	131.71
12	22.08	0.00	81.62	29.95	126.41	55.38	37.47	52.92	79.53	179.84	151.69	131.04
13	22.93	0.00	6.07	29.80	124.93	54.36	36.58	51.59	79.87	183.88	151.35	130.06
14	23.59	0.00	7.15	30.01	125.46	53.66	37.84	58.52	79.80	189.13	152.50	130.48
15	24.13	0.00	7.19	31.56	124.56	54.90	37.71	54.39	79.15	183.75	160.60	130.08
16	24.31	0.00	7.24	30.71	124.44	54.36	36.60	53.84	95.69	181.26	157.44	130.82
17	22.71	0.00	7.06	30.81	125.20	55.49	38.02	52.02	117.71	177.94	151.57	131.15
18	23.79	0.00	7.21	30.10	126.43	55.13	37.48	52.36	124.41	179.41	151.72	130.87
19	23.62	0.00	7.16	0.00	125.91	54.45	37.52	52.13	123.42	177.78	153.82	130.23
20	22.78	0.00	7.23	0.00	125.26	55.20	37.64	53.34	122.83	177.97	155.18	131.22
21	22.47	0.00	6.83	0.00	125.82	54.53	37.85	53.42	123.34	188.94	152.71	131.51
22	22.47	0.00	22.98	0.00	125.84	55.57	38.30	39.09	124.48	195.76	151.70	142.09
23	22.37	0.00	9.09	0.00	125.04	56.19	38.75	55.96	124.36	196.07	151.60	155.24
24	0.00	0.00	8.59	0.00	122.92	55.99	43.98	55.56	125.47	86.90	147.22	129.11
25	0.00	0.00	8.62	0.00	123.02	55.28	37.98	13.92	125.04	41.41	142.91	129.13
26	0.00	0.00	8.64	0.00	123.92	55.83	38.23	3.49	132.58	136.72	141.96	128.50
27	0.00	19.15	8.58	0.00	122.55	56.08	37.06	3.45	127.81	211.57	141.88	126.87
28	0.00	118.13	7.92	0.00	121.73	56.08	36.29	3.15	125.81	210.97	154.71	125.88
29	184.27		8.44	0.00	104.69	51.74	37.29	2.56	124.97	209.95	169.64	129.00
30	177.68		8.21	0.00	123.22	26.84	37.53	2.79	124.29	207.94	171.74	130.38
31	0.00		8.19		122.41		36.93	1.46		62.85		131.49
Total	797.80	606.77	1,258.45	468.00	3,842.89	1,646.44	1,169.12	1,179.82	2,605.03	4,889.64	4,363.19	4,082.50
Count	18	8	31	18	31	30	31	31	30	31	30	31
Average	25.74	21.67	40.60	15.60	123.96	54.88	37.71	38.06	86.83	157.73	145.44	131.69
Maximum	184.27	118.13	137.63	31.63	126.43	150.41	43.98	58.52	132.58	211.57	171.74	155.24
Minimum	0.00	0.00	6.07	0.00	104.69	25.30	33.17	1.46	2.58	41.41	50.37	125.88

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1997
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	116.69	16.82	238.39	283.60	65.79	72.02	5.24	246.35	99.91	267.07
2	0.00	49.41	13.23	28.42	247.46	298.33	77.81	73.82	5.12	247.28	191.68	263.56
3	179.17	85.86	13.43	16.96	249.64	150.80	78.15	72.87	43.26	247.42	230.18	261.68
4	0.00	168.79	13.69	16.19	248.49	53.85	78.84	72.26	75.67	247.00	284.29	260.51
5	0.00	207.29	252.56	62.28	248.65	51.63	75.39	72.52	76.28	248.89	286.73	260.75
6	0.00	210.72	261.00	61.94	248.13	50.78	73.45	73.84	76.42	285.62	283.78	259.74
7	0.00	209.14	262.87	62.74	249.26	50.18	73.39	73.65	75.29	282.29	308.13	258.86
8	0.00	0.00	264.77	61.98	247.52	52.09	73.21	95.25	77.18	283.50	297.54	258.94
9	45.44	0.00	272.99	61.09	248.61	53.06	74.66	104.97	129.10	286.06	296.75	258.35
10	44.87	0.00	272.87	58.89	249.96	94.31	74.08	103.68	160.19	283.66	298.31	260.07
11	45.10	0.00	268.01	58.59	247.46	109.73	72.56	105.18	157.84	336.20	301.21	261.24
12	43.80	0.00	161.89	59.40	250.73	109.84	74.32	104.97	157.75	356.71	300.87	259.91
13	45.48	0.00	12.04	59.11	247.80	107.82	72.56	102.33	158.42	364.72	300.20	257.97
14	46.79	0.00	14.18	59.52	248.85	106.43	75.05	116.07	158.28	375.13	302.48	258.80
15	47.86	0.00	14.26	62.60	247.06	108.89	74.80	107.88	156.99	364.46	318.55	258.01
16	48.22	0.00	14.36	60.91	246.82	107.82	72.60	106.79	189.80	359.52	312.28	259.48
17	45.04	0.00	14.00	61.11	248.33	110.06	75.41	103.18	233.47	352.94	300.63	260.13
18	47.19	0.00	14.30	59.70	250.77	109.35	74.34	103.85	246.76	355.85	300.93	259.58
19	46.85	0.00	14.20	0.00	249.74	108.00	74.42	103.40	244.80	352.62	305.10	258.31
20	45.18	0.00	14.34	0.00	248.45	109.49	74.66	105.80	243.63	353.00	307.80	260.27
21	44.57	0.00	13.55	0.00	249.56	108.16	75.07	105.96	244.64	374.76	302.90	260.85
22	44.57	0.00	45.58	0.00	249.60	110.22	75.97	77.53	246.90	388.28	300.89	281.83
23	44.37	0.00	18.03	0.00	248.01	111.45	76.86	111.00	246.66	388.90	300.69	307.91
24	0.00	0.00	17.04	0.00	243.81	111.05	87.23	110.20	248.87	172.36	292.01	256.09
25	0.00	0.00	17.10	0.00	244.01	109.65	75.33	27.61	248.01	82.14	283.46	256.13
26	0.00	0.00	17.14	0.00	245.79	110.74	75.83	6.92	262.97	271.18	281.57	254.88
27	0.00	37.98	17.02	0.00	243.07	111.23	73.51	6.84	253.51	419.64	281.41	251.64
28	0.00	234.31	15.71	0.00	241.45	111.23	71.98	6.25	249.54	418.45	306.86	249.68
29	365.49		16.74	0.00	207.65	102.62	73.96	5.08	247.87	416.43	336.48	255.87
30	352.42		16.28	0.00	244.40	53.24	74.44	5.53	246.53	412.44	340.64	258.60
31	0.00		16.24		242.80		73.25	2.90		124.66		260.81
Total	1,582.41	1,203.51	2,496.10	928.26	7,622.26	3,265.67	2,318.92	2,340.14	5,167.00	9,698.46	8,654.26	8,097.52
Count	18	8	31	18	31	30	31	31	30	31	30	31
Average	51.05	42.98	80.52	30.94	245.88	108.86	74.80	75.49	172.23	312.85	288.48	261.21
Maximum	365.49	234.31	272.99	62.74	250.77	298.33	87.23	116.07	262.97	419.64	340.64	307.91
Minimum	0.00	0.00	12.04	0.00	207.65	50.18	65.79	2.90	5.12	82.14	99.91	249.68

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1998
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	116.05	115.48	109.13	0.00	0.00	86.37	73.03	76.25	0.00	80.56	83.36	0.00
2	116.24	115.43	106.73	0.00	36.40	86.97	75.17	76.34	0.00	77.51	91.54	0.01
3	113.49	123.64	107.76	0.00	69.05	86.92	74.97	76.18	0.00	76.44	214.37	0.00
4	110.79	146.85	107.45	0.00	78.99	86.90	74.87	75.30	58.93	75.61	0.00	0.00
5	110.63	153.28	107.00	0.00	78.96	86.36	74.80	75.39	89.41	76.01	0.00	0.00
6	110.71	159.24	108.67	0.00	78.96	86.00	73.72	75.74	89.62	76.69	0.00	0.00
7	111.10	159.49	111.38	0.00	78.95	86.13	71.23	75.22	89.18	76.89	0.00	0.00
8	109.85	165.54	107.69	0.00	79.17	86.39	71.04	75.20	88.61	76.78	0.00	0.00
9	111.08	172.21	108.33	0.00	78.38	86.46	70.51	74.19	89.26	76.79	0.00	0.00
10	108.80	171.05	161.24	0.00	77.99	86.18	70.34	74.48	88.65	76.42	0.00	16.75
11	110.34	141.83	189.71	0.00	80.18	85.26	69.66	74.69	88.50	76.22	0.00	49.80
12	109.87	145.06	135.80	0.00	80.16	84.92	70.53	74.52	88.90	76.57	0.00	49.18
13	113.80	150.98	134.61	0.00	79.05	85.04	70.04	74.87	89.08	76.95	0.00	48.79
14	118.41	158.99	123.12	0.00	78.63	85.33	69.82	75.22	89.16	77.12	0.00	46.73
15	118.99	168.33	116.59	0.00	78.85	84.11	77.58	75.26	89.06	76.30	0.00	45.66
16	119.67	189.34	120.09	0.00	78.70	83.60	80.88	84.06	88.79	75.81	0.00	45.64
17	120.35	442.24	193.75	0.00	79.53	84.39	81.21	85.32	88.39	74.74	0.00	44.62
18	120.83	211.79	355.82	0.00	82.08	84.86	80.65	84.61	88.14	75.98	0.00	44.00
19	123.03	197.30	158.81	0.00	81.07	84.64	79.36	85.73	88.49	75.90	0.00	45.12
20	123.28	199.64	168.08	0.00	79.86	85.10	79.23	85.41	87.69	75.79	0.00	45.34
21	125.23	140.90	143.16	0.00	80.25	84.80	79.96	85.84	87.85	76.04	0.00	45.24
22	128.13	139.14	117.11	0.00	80.66	85.73	80.02	85.91	88.10	76.03	0.00	44.32
23	124.57	138.94	135.78	0.00	81.07	85.34	79.79	85.64	87.64	77.14	0.00	43.86
24	120.42	140.91	107.10	0.00	80.81	84.84	79.08	85.75	87.02	78.49	21.52	41.58
25	120.56	153.16	96.77	0.00	80.79	84.97	79.93	85.66	86.61	80.08	42.48	40.24
26	120.21	150.67	89.75	0.00	81.92	84.29	81.27	85.69	87.00	23.13	42.06	41.22
27	119.42	147.10	92.66	0.00	81.86	84.72	79.45	86.99	87.34	27.46	42.01	41.19
28	118.50	149.57	91.72	0.00	81.57	84.90	79.57	86.98	87.17	51.85	43.57	41.59
29	118.57		91.79	0.00	0.00	84.53	79.55	86.82	86.89	46.82	42.33	40.72
30	118.17		91.27	0.00	0.00	85.04	79.34	87.09	86.53	41.62	42.49	42.07
31	104.52		90.81		0.00		79.85	87.59		76.89		40.73
Total	3,615.61	4,648.10	3,979.68	0.00	2,103.89	2,561.09	2,366.45	2,503.94	2,352.01	2,186.63	665.73	944.40
Count	31	28	31	0	27	30	31	31	27	31	10	23
Average	116.63	166.00	128.38	0.00	67.87	85.37	76.34	80.77	78.40	70.54	22.19	30.46
Maximum	128.13	442.24	355.82	0.00	82.08	86.97	81.27	87.59	89.62	80.56	214.37	49.80
Minimum	104.52	115.43	89.75	0.00	0.00	83.60	69.66	74.19	0.00	23.13	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1998
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	230.18	229.05	216.46	0.00	0.00	171.31	144.85	151.24	0.00	159.79	165.34	0.00
2	230.56	228.95	211.70	0.00	72.20	172.50	149.10	151.42	0.00	153.74	181.57	0.02
3	225.10	245.24	213.74	0.00	136.96	172.40	148.70	151.10	0.00	151.62	425.20	0.00
4	219.75	291.27	213.12	0.00	156.67	172.36	148.50	149.36	116.89	149.97	0.00	0.00
5	219.43	304.03	212.23	0.00	156.61	171.29	148.36	149.53	177.34	150.76	0.00	0.00
6	219.59	315.85	215.54	0.00	156.61	170.58	146.22	150.23	177.76	152.11	0.00	0.00
7	220.36	316.34	220.92	0.00	156.60	170.84	141.28	149.20	176.89	152.51	0.00	0.00
8	217.88	328.34	213.60	0.00	157.03	171.35	140.91	149.16	175.76	152.29	0.00	0.00
9	220.32	341.57	214.87	0.00	155.46	171.49	139.85	147.15	177.04	152.31	0.00	0.00
10	215.80	339.27	319.81	0.00	154.69	170.94	139.52	147.73	175.83	151.58	0.00	33.22
11	218.86	281.32	376.28	0.00	159.03	169.11	138.17	148.15	175.54	151.18	0.00	98.78
12	217.92	287.72	269.36	0.00	159.00	168.44	139.89	147.81	176.33	151.87	0.00	97.55
13	225.72	299.46	267.00	0.00	156.79	168.67	138.92	148.50	176.69	152.63	0.00	96.77
14	234.86	315.35	244.20	0.00	155.96	169.25	138.49	149.20	176.85	152.97	0.00	92.69
15	236.01	333.88	231.25	0.00	156.40	166.83	153.88	149.28	176.65	151.34	0.00	90.57
16	237.36	375.55	238.20	0.00	156.10	165.82	160.42	166.73	176.11	150.37	0.00	90.53
17	238.71	877.17	384.30	0.00	157.75	167.39	161.08	169.23	175.32	148.24	0.00	88.50
18	239.66	420.08	705.76	0.00	162.80	168.32	159.97	167.82	174.82	150.70	0.00	87.27
19	244.03	391.34	315.00	0.00	160.80	167.88	157.41	170.04	175.52	150.55	0.00	89.49
20	244.52	395.98	333.38	0.00	158.40	168.79	157.15	169.41	173.93	150.33	0.00	89.93
21	248.39	279.47	283.95	0.00	159.17	168.20	158.60	170.26	174.25	150.82	0.00	89.73
22	254.14	275.98	232.28	0.00	159.99	170.04	158.72	170.40	174.74	150.80	0.00	87.91
23	247.08	275.58	269.32	0.00	160.80	169.27	158.26	169.86	173.83	153.00	0.00	87.00
24	238.85	279.49	212.43	0.00	160.28	168.28	156.85	170.08	172.60	155.68	42.68	82.47
25	239.13	303.79	191.94	0.00	160.24	168.54	158.54	169.90	171.79	158.84	84.26	79.81
26	238.43	298.85	178.02	0.00	162.49	167.19	161.20	169.96	172.56	45.88	83.42	81.76
27	236.87	291.77	183.79	0.00	162.37	168.04	157.59	172.54	173.24	54.47	83.33	81.70
28	235.04	296.67	181.92	0.00	161.79	168.40	157.82	172.52	172.90	102.84	86.42	82.49
29	235.18		182.06	0.00	0.00	167.66	157.79	172.20	172.34	92.87	83.96	80.77
30	234.39		181.03	0.00	0.00	168.67	157.37	172.74	171.63	82.55	84.28	83.44
31	207.31		180.12		0.00		158.38	173.73		152.51		80.79
Total	7,171.46	9,219.37	7,893.58	0.00	4,173.00	5,079.85	4,693.79	4,966.49	4,665.14	4,337.12	1,320.46	1,873.19
Count	31	28	31	0	27	30	31	31	27	31	10	23
Average	231.34	329.26	254.63	0.00	134.61	169.33	151.41	160.21	155.50	139.91	44.02	60.43
Maximum	254.14	877.17	705.76	0.00	162.80	172.50	161.20	173.73	177.76	159.79	425.20	98.78
Minimum	207.31	228.95	178.02	0.00	0.00	165.82	138.17	147.15	0.00	45.88	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1999
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	54.01	81.60	83.17	146.74	79.36	0.00	74.45	140.91	150.47	123.72	146.37	145.14
2	63.64	90.03	82.14	170.46	79.73	0.00	99.02	147.28	152.18	129.58	162.87	115.51
3	64.38	89.21	83.26	170.69	78.82	100.64	99.59	144.75	146.67	135.49	185.79	106.02
4	64.22	88.84	83.04	170.10	78.05	133.06	99.43	143.27	128.09	135.86	183.27	106.07
5	65.42	89.59	83.53	172.57	79.09	133.14	100.41	144.19	127.73	137.83	196.85	103.69
6	64.88	90.01	85.35	170.86	79.65	133.82	99.61	145.24	129.29	136.78	238.83	103.84
7	64.70	90.31	82.51	172.45	79.56	132.96	98.68	145.15	129.39	130.25	220.12	104.78
8	63.53	90.74	84.77	172.56	79.54	132.29	98.07	147.43	128.46	130.20	296.97	104.48
9	63.00	91.30	85.10	173.28	79.23	133.22	99.49	142.48	125.71	128.30	165.52	103.37
10	64.62	89.93	84.79	172.69	78.75	0.00	120.45	146.82	125.62	128.53	170.11	104.11
11	65.59	90.21	83.77	172.28	80.03	0.00	122.21	142.23	123.15	129.87	107.22	101.93
12	65.22	90.75	84.03	0.00	78.59	0.00	121.65	144.10	122.53	137.33	13.48	101.64
13	65.99	91.08	84.96	0.00	79.79	90.78	122.23	143.65	122.72	137.91	0.00	101.45
14	67.13	91.70	84.02	0.00	79.01	119.05	122.64	145.29	123.98	137.51	0.00	102.78
15	66.15	90.76	84.35	0.00	79.32	119.97	124.53	146.10	123.03	137.24	0.00	104.84
16	66.14	90.13	84.95	0.00	79.74	119.71	124.94	146.44	119.80	136.03	0.00	104.24
17	66.04	90.42	84.48	0.00	80.57	118.33	125.82	146.51	121.14	135.60	0.00	104.99
18	64.88	91.80	84.52	0.00	90.02	118.17	125.77	147.34	120.36	138.24	0.00	104.58
19	64.04	91.23	83.33	0.00	98.86	117.99	126.70	145.79	121.92	140.86	0.00	104.35
20	67.23	91.23	81.78	0.00	99.19	117.95	126.07	144.00	121.40	141.87	0.00	103.98
21	64.99	91.55	81.71	0.00	100.04	118.45	128.98	145.55	121.82	140.84	0.00	103.65
22	64.41	93.03	81.86	0.00	98.44	118.96	127.34	146.94	120.14	141.63	115.73	103.31
23	64.73	89.87	82.27	0.00	99.15	117.18	127.81	146.22	118.52	141.71	172.45	102.06
24	65.26	59.82	82.63	0.00	99.17	117.42	127.27	147.93	117.20	141.27	172.65	103.37
25	64.35	77.92	82.27	0.00	99.82	89.22	127.20	150.75	123.78	141.87	169.86	103.67
26	64.29	85.98	81.49	0.00	99.18	46.77	130.53	149.16	126.02	141.54	170.23	105.10
27	66.78	86.10	80.19	38.01	98.52	47.09	128.79	147.73	127.36	141.86	170.50	103.12
28	65.50	86.61	81.22	81.17	97.92	46.03	127.96	134.89	128.18	141.82	170.36	101.87
29	64.90		81.37	81.87	96.82	46.66	129.35	135.14	129.03	144.35	168.04	102.03
30	65.78		81.34	82.47	0.00	47.18	130.96	137.49	127.85	142.94	169.51	94.98
31	67.32		79.87		0.00		129.35	140.66		143.75		50.89
Total	2,009.12	2,471.75	2,574.07	2,148.20	2,525.96	2,616.04	3,647.30	4,481.43	3,803.54	4,252.58	3,566.73	3,205.84
Count	31	28	31	15	29	25	31	31	30	31	21	31
Average	64.81	88.28	83.03	71.61	81.48	87.20	117.65	144.56	126.78	137.18	118.89	103.41
Maximum	67.32	93.03	85.35	173.28	100.04	133.82	130.96	150.75	152.18	144.35	296.97	145.14
Minimum	54.01	59.82	79.87	0.00	0.00	0.00	74.45	134.89	117.20	123.72	0.00	50.89

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1999
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	107.13	161.85	164.97	291.05	157.41	0.00	147.67	279.49	298.45	245.40	290.32	287.88
2	126.23	178.57	162.92	338.10	158.14	0.00	196.40	292.13	301.84	257.02	323.05	229.11
3	127.70	176.95	165.14	338.56	156.34	199.62	197.53	287.11	290.92	268.74	368.51	210.29
4	127.38	176.21	164.71	337.39	154.81	263.92	197.22	284.17	254.06	269.47	363.51	210.39
5	129.76	177.70	165.68	342.29	156.87	264.08	199.16	286.00	253.35	273.38	390.45	205.67
6	128.69	178.53	169.29	338.90	157.98	265.43	197.57	288.08	256.44	271.30	473.71	205.96
7	128.33	179.13	163.66	342.05	157.80	263.72	195.73	287.90	256.64	258.35	436.60	207.83
8	126.01	179.98	168.14	342.27	157.77	262.39	194.52	292.42	254.80	258.25	589.03	207.23
9	124.96	181.09	168.79	343.70	157.15	264.24	197.34	282.60	249.34	254.48	328.30	205.03
10	128.17	178.37	168.18	342.53	156.20	0.00	238.91	291.21	249.16	254.94	337.41	206.50
11	130.10	178.93	166.16	341.71	158.74	0.00	242.40	282.11	244.26	257.59	212.67	202.18
12	129.36	180.00	166.67	0.00	155.88	0.00	241.29	285.82	243.03	272.39	26.74	201.60
13	130.89	180.65	168.52	0.00	158.26	180.06	242.44	284.93	243.41	273.54	0.00	201.22
14	133.15	181.88	166.65	0.00	156.71	236.13	243.25	288.18	245.91	272.75	0.00	203.86
15	131.21	180.02	167.31	0.00	157.33	237.96	247.00	289.79	244.03	272.21	0.00	207.95
16	131.19	178.77	168.50	0.00	158.16	237.44	247.81	290.46	237.62	269.81	0.00	206.76
17	130.99	179.35	167.56	0.00	159.81	234.70	249.56	290.60	240.28	268.96	0.00	208.24
18	128.69	182.08	167.64	0.00	178.55	234.39	249.46	292.24	238.73	274.20	0.00	207.43
19	127.02	180.95	165.28	0.00	196.09	234.03	251.31	289.17	241.82	279.39	0.00	206.98
20	133.35	180.95	162.21	0.00	196.74	233.95	250.06	285.62	240.79	281.40	0.00	206.24
21	128.91	181.59	162.07	0.00	198.43	234.94	255.83	288.69	241.63	279.35	0.00	205.59
22	127.76	184.52	162.37	0.00	195.25	235.95	252.58	291.45	238.29	280.92	229.55	204.91
23	128.39	178.25	163.18	0.00	196.66	232.42	253.51	290.02	235.08	281.08	342.05	202.43
24	129.44	118.65	163.89	0.00	196.70	232.90	252.44	293.41	232.46	280.20	342.45	205.03
25	127.64	154.55	163.18	0.00	197.99	176.97	252.30	299.01	245.51	281.40	336.91	205.63
26	127.52	170.54	161.63	0.00	196.72	92.77	258.90	295.85	249.96	280.74	337.65	208.46
27	132.46	170.78	159.05	75.39	195.41	93.40	255.45	293.02	252.61	281.38	338.18	204.54
28	129.92	171.79	161.10	161.00	194.22	91.30	253.80	267.55	254.24	281.30	337.90	202.06
29	128.73		161.40	162.39	192.04	92.55	256.56	268.05	255.93	286.31	333.30	202.37
30	130.47		161.34	163.58	0.00	93.58	259.76	272.71	253.59	283.52	336.22	188.39
31	133.53		158.42		0.00		256.56	279.00		285.12		100.94
Total	3,985.03	4,902.64	5,105.59	4,260.89	5,010.17	5,188.84	7,234.31	8,888.79	7,544.21	8,434.87	7,074.51	6,358.69
Count	31	28	31	15	29	25	31	31	30	31	21	31
Average	128.55	175.09	164.70	142.03	161.62	172.96	233.36	286.74	251.47	272.09	235.82	205.12
Maximum	133.53	184.52	169.29	343.70	198.43	265.43	259.76	299.01	301.84	286.31	589.03	287.88
Minimum	107.13	118.65	158.42	0.00	0.00	0.00	147.67	267.55	232.46	245.40	0.00	100.94

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 2000
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	129.77	133.02	90.51	87.27	134.42	168.56	146.86	194.53	202.03	84.52	0.00
2	83.80	131.69	126.53	87.97	122.11	138.07	173.93	97.61	199.37	193.13	86.01	0.00
3	125.29	129.81	125.02	88.03	123.70	136.66	179.65	66.12	202.41	195.16	86.07	0.00
4	127.02	130.82	125.04	87.34	122.47	135.65	175.58	168.10	198.97	193.16	85.00	0.00
5	126.39	131.08	123.64	89.86	126.83	138.84	175.44	191.98	198.25	197.60	83.91	0.00
6	126.22	129.77	123.32	90.02	124.51	140.42	182.62	191.95	202.10	192.46	83.43	0.00
7	127.27	0.00	127.39	87.65	122.86	136.35	168.22	191.80	201.05	198.03	85.05	0.00
8	126.02	91.46	124.89	87.85	126.72	138.81	169.80	194.39	201.79	198.24	83.29	0.00
9	125.63	133.25	126.81	86.68	123.68	137.43	169.77	190.63	201.91	197.19	85.32	0.00
10	126.13	133.52	124.13	87.35	121.28	137.89	170.53	190.32	204.13	191.85	84.41	0.00
11	125.89	133.04	123.95	86.64	121.34	138.97	170.34	191.69	202.10	192.51	81.44	0.00
12	126.74	136.84	124.79	87.26	119.66	138.87	167.81	193.86	202.83	189.47	83.58	0.00
13	127.60	151.50	124.77	86.98	120.58	139.05	169.39	197.10	199.76	191.55	82.53	0.00
14	127.47	145.22	125.30	88.32	120.00	139.00	168.55	195.16	200.95	190.91	82.20	0.00
15	127.60	143.69	124.86	86.34	121.22	139.59	169.10	194.67	200.76	191.72	80.83	0.00
16	126.34	143.41	126.02	87.77	121.73	138.81	170.47	192.10	202.31	191.57	84.18	0.00
17	124.95	142.04	126.87	87.88	118.90	140.40	166.66	194.12	200.93	194.23	81.53	0.00
18	125.85	143.30	124.34	89.04	118.29	140.17	169.26	194.56	199.14	189.67	76.51	0.00
19	126.61	142.11	125.58	89.43	119.85	139.06	166.74	195.68	200.93	191.20	77.40	0.00
20	125.88	143.93	124.82	88.82	120.33	139.92	168.64	196.80	199.24	189.57	76.98	0.00
21	125.28	142.47	125.60	90.39	118.28	142.08	86.78	195.26	200.41	188.72	78.51	0.00
22	124.74	141.92	125.10	89.56	119.39	141.27	84.01	195.98	199.37	191.70	78.95	0.00
23	126.48	141.51	125.64	87.93	117.89	141.58	138.96	196.71	201.15	191.58	8.55	0.00
24	125.45	142.58	119.79	87.80	119.88	148.34	170.88	195.39	202.48	189.21	0.00	0.00
25	127.06	142.10	119.03	88.75	119.47	145.36	173.88	195.31	174.92	193.55	0.00	0.00
26	124.55	141.83	121.27	88.49	117.54	144.50	109.21	196.36	156.14	192.92	0.00	0.00
27	127.51	142.67	121.28	88.39	118.35	146.43	111.18	196.95	155.63	103.06	0.00	0.00
28	128.71	143.04	122.39	87.87	118.07	145.67	107.07	194.93	200.10	104.72	0.00	0.00
29	128.03	140.90	121.70	88.54	118.43	145.68	109.68	195.73	197.01	85.12	0.00	0.00
30	128.03		123.75	89.06	116.79	148.48	115.20	194.21	203.27	84.03	0.00	0.00
31	127.14		122.39		116.96		145.95	194.42		83.54		0.00
Total	3,751.68	3,845.27	3,859.03	2,648.52	3,704.38	4,217.77	4,773.86	5,726.75	5,903.94	5,479.40	1,820.20	0.00
Count	30	28	31	30	31	30	31	31	30	31	23	0
Average	121.02	132.60	124.48	88.28	119.50	140.59	154.00	184.73	196.80	176.75	60.67	0.00
Maximum	128.71	151.50	133.02	90.51	126.83	148.48	182.62	197.10	204.13	202.03	86.07	0.00
Minimum	0.00	0.00	119.03	86.34	87.27	134.42	84.01	66.12	155.63	83.54	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 2000
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	257.40	263.84	179.52	173.10	266.62	334.33	291.29	385.84	400.72	167.64	0.00
2	166.21	261.20	250.97	174.49	242.20	273.86	344.99	193.61	395.44	383.07	170.60	0.00
3	248.51	257.47	247.97	174.60	245.36	271.06	356.33	131.15	401.47	387.09	170.72	0.00
4	251.94	259.48	248.01	173.24	242.92	269.06	348.26	333.42	394.65	383.13	168.60	0.00
5	250.69	259.99	245.24	178.23	251.56	275.39	347.98	380.79	393.22	391.93	166.43	0.00
6	250.35	257.40	244.60	178.55	246.96	278.52	362.22	380.73	400.86	381.74	165.48	0.00
7	252.44	0.00	252.67	173.85	243.69	270.45	333.66	380.43	398.78	392.79	168.69	0.00
8	249.96	181.41	247.72	174.25	251.35	275.33	336.79	385.57	400.24	393.20	165.20	0.00
9	249.18	264.30	251.52	171.93	245.32	272.59	336.73	378.11	400.48	391.12	169.23	0.00
10	250.18	264.83	246.21	173.26	240.56	273.50	338.24	377.49	404.89	380.53	167.42	0.00
11	249.70	263.88	245.85	171.85	240.67	275.64	337.86	380.21	400.86	381.84	161.53	0.00
12	251.39	271.42	247.52	173.08	237.34	275.44	332.85	384.52	402.31	375.81	165.78	0.00
13	253.09	300.50	247.48	172.52	239.17	275.80	335.98	390.94	396.22	379.93	163.70	0.00
14	252.83	288.04	248.53	175.18	238.02	275.70	334.31	387.09	398.58	378.66	163.04	0.00
15	253.09	285.00	247.66	171.25	240.44	276.87	335.40	386.12	398.20	380.27	160.32	0.00
16	250.59	284.45	249.96	174.09	241.45	275.33	338.12	381.02	401.28	379.97	166.97	0.00
17	247.83	281.73	251.64	174.31	235.83	278.48	330.57	385.03	398.54	385.25	161.71	0.00
18	249.62	284.23	246.62	176.61	234.62	278.02	335.72	385.90	394.99	376.20	151.76	0.00
19	251.13	281.87	249.08	177.38	237.72	275.82	330.72	388.13	398.54	379.24	153.52	0.00
20	249.68	285.48	247.58	176.17	238.67	277.53	334.49	390.35	395.19	376.01	152.69	0.00
21	248.49	282.59	249.12	179.29	234.60	281.81	172.13	387.29	397.51	374.32	155.72	0.00
22	247.42	281.49	248.13	177.64	236.81	280.20	166.63	388.72	395.44	380.23	156.60	0.00
23	250.87	280.68	249.20	174.41	233.83	280.82	275.62	390.17	398.98	379.99	16.96	0.00
24	248.83	282.80	237.60	174.15	237.78	294.23	338.94	387.55	401.61	375.29	0.00	0.00
25	252.02	281.85	236.09	176.03	236.97	288.32	344.89	387.39	346.95	383.90	0.00	0.00
26	247.04	281.32	240.54	175.52	233.14	286.61	216.61	389.47	309.70	382.65	0.00	0.00
27	252.91	282.98	240.56	175.32	234.74	290.44	220.52	390.64	308.69	204.42	0.00	0.00
28	255.29	283.72	242.76	174.29	234.19	288.93	212.37	386.64	396.89	207.71	0.00	0.00
29	253.94	279.47	241.39	175.62	234.90	288.95	217.55	388.22	390.76	168.83	0.00	0.00
30	253.94		245.45	176.65	231.65	294.51	228.50	385.21	403.18	166.67	0.00	0.00
31	252.18		242.76		231.99		289.49	385.63		165.70		0.00
Total	7,441.35	7,626.98	7,654.27	5,253.26	7,347.53	8,365.82	9,468.81	11,358.84	11,710.29	10,868.23	3,610.31	0.00
Count	30	28	31	30	31	30	31	31	30	31	23	0
Average	240.04	263.00	246.91	175.11	237.02	278.86	305.45	366.41	390.34	350.59	120.34	0.00
Maximum	255.29	300.50	263.84	179.52	251.56	294.51	362.22	390.94	404.89	400.72	170.72	0.00
Minimum	0.00	0.00	236.09	171.25	173.10	266.62	166.63	131.15	308.69	165.70	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 2001
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	45.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	15.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	61.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Count	2	0	0	0	0	0	0	0	0	0	0	0
Average	1.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	45.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 2001
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	90.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	30.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	121.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Count	2	0	0	0	0	0	0	0	0	0	0	0
Average	3.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	90.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

Appendix C

Tempe Drain
Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1992
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	244.88	177.42	0.00	74.51	38.26	0.00	0.00	67.88	0.00	0.00	0.00
2	0.00	200.00	212.17	0.00	81.70	19.68	0.00	0.00	42.33	0.00	0.00	0.00
3	0.00	187.50	263.79	0.00	137.48	18.43	0.00	0.00	69.75	0.00	0.00	0.00
4	4.96	178.13	253.88	11.54	93.06	24.09	0.00	0.00	38.54	0.00	0.00	27.70
5	0.00	171.50	286.63	117.29	105.24	22.58	0.00	5.57	49.00	0.00	0.00	6.13
6	9.46	182.04	300.00	304.92	113.98	33.83	0.00	1.00	49.38	0.00	0.00	0.00
7	285.25	185.88	259.71	287.29	120.22	53.42	0.00	24.00	21.25	0.00	0.00	0.00
8	462.21	239.46	267.50	279.17	95.00	53.33	0.00	0.00	0.00	0.00	0.00	0.00
9	530.63	288.33	297.79	259.38	164.04	55.20	0.00	0.00	0.00	0.00	0.00	0.00
10	475.00	300.00	293.75	229.50	228.94	91.75	20.61	0.00	0.00	0.00	0.00	0.00
11	483.08	347.58	297.46	181.42	257.45	19.96	49.09	13.50	0.00	0.00	0.00	0.00
12	339.83	368.75	313.54	200.54	201.95	5.07	0.00	0.00	0.00	0.00	0.00	0.00
13	317.29	276.58	305.00	236.46	183.74	46.00	0.00	0.00	0.00	0.00	0.00	0.00
14	320.00	200.00	279.71	113.71	167.97	47.16	0.00	0.00	0.00	0.00	0.00	0.00
15	318.46	214.58	278.79	70.01	133.29	77.80	0.00	0.00	0.00	0.00	0.00	0.00
16	322.33	336.21	227.50	75.12	83.41	66.57	0.00	0.00	0.00	0.00	0.00	0.00
17	321.08	350.00	197.96	61.78	33.32	17.34	0.00	0.00	0.00	0.00	0.00	0.00
18	349.04	350.00	185.00	143.79	22.16	26.64	0.00	0.00	0.00	0.00	0.00	0.00
19	387.50	329.38	196.63	119.03	31.66	27.07	0.00	0.00	0.00	0.00	0.00	0.00
20	382.58	350.00	157.04	106.49	94.91	21.73	0.00	0.00	0.00	0.00	0.00	0.00
21	354.08	301.50	54.79	129.89	92.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	375.00	278.08	26.67	83.19	95.93	0.00	0.00	57.58	0.00	0.00	0.00	0.00
23	375.00	244.96	31.42	98.37	86.96	0.00	2.10	41.08	0.00	0.00	0.00	0.00
24	370.13	207.13	30.00	92.45	115.31	0.00	157.34	134.00	0.00	0.00	0.00	0.00
25	325.00	200.00	30.00	79.24	98.72	0.00	15.11	129.76	0.00	7.43	0.00	0.00
26	325.00	189.92	56.25	61.69	108.54	0.00	0.00	101.53	0.00	2.54	0.00	0.00
27	325.00	200.00	102.04	60.72	58.68	0.00	0.00	48.15	0.00	0.93	0.00	0.00
28	325.00	173.92	51.63	54.02	29.57	0.00	0.00	40.10	0.00	0.00	0.00	0.00
29	325.00	147.88	8.96	64.78	18.26	0.00	10.33	13.45	0.00	0.00	0.00	0.00
30	299.21		0.00	70.36	37.53	0.00	0.00	75.44	0.00	0.00	0.00	0.00
31	226.42		0.00		45.01		0.00	123.08		0.00		0.00
Total	8,933.54	7,244.19	5,443.03	3,592.15	3,211.40	765.91	254.58	808.24	338.13	10.90	0.00	33.83
Count	27	29	29	27	31	20	6	14	7	3	0	2
Average	288.18	249.80	175.58	119.74	103.59	25.53	8.21	26.07	11.27	0.35	0.00	1.09
Maximum	530.63	368.75	313.54	304.92	257.45	91.75	157.34	134.00	69.75	7.43	0.00	27.70
Minimum	0.00	147.88	0.00	0.00	18.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1992
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	485.71	351.91	0.00	147.79	75.89	0.00	0.00	134.64	0.00	0.00	0.00
2	0.00	396.69	420.83	0.00	162.05	39.03	0.00	0.00	83.96	0.00	0.00	0.00
3	0.00	371.90	523.22	0.00	272.69	36.56	0.00	0.00	138.35	0.00	0.00	0.00
4	9.84	353.32	503.56	22.89	184.58	47.78	0.00	0.00	76.44	0.00	0.00	54.94
5	0.00	340.17	568.52	232.64	208.74	44.79	0.00	11.05	97.19	0.00	0.00	12.16
6	18.76	361.07	595.04	604.80	226.08	67.10	0.00	1.98	97.94	0.00	0.00	0.00
7	565.79	368.69	515.13	569.83	238.45	105.96	0.00	47.60	42.15	0.00	0.00	0.00
8	916.78	474.96	530.58	553.73	188.43	105.78	0.00	0.00	0.00	0.00	0.00	0.00
9	1,052.49	571.89	590.66	514.47	325.37	109.49	0.00	0.00	0.00	0.00	0.00	0.00
10	942.15	595.04	582.64	455.21	454.10	181.98	40.88	0.00	0.00	0.00	0.00	0.00
11	958.18	689.41	590.00	359.84	510.64	39.59	97.37	26.78	0.00	0.00	0.00	0.00
12	674.04	731.40	621.90	397.77	400.56	10.06	0.00	0.00	0.00	0.00	0.00	0.00
13	629.34	548.59	604.96	469.01	364.44	91.24	0.00	0.00	0.00	0.00	0.00	0.00
14	634.71	396.69	554.80	225.54	333.16	93.54	0.00	0.00	0.00	0.00	0.00	0.00
15	631.66	425.61	552.97	138.86	264.38	154.31	0.00	0.00	0.00	0.00	0.00	0.00
16	639.33	666.86	451.24	149.00	165.44	132.04	0.00	0.00	0.00	0.00	0.00	0.00
17	636.85	694.21	392.65	122.54	66.09	34.39	0.00	0.00	0.00	0.00	0.00	0.00
18	692.31	694.21	366.94	285.20	43.95	52.84	0.00	0.00	0.00	0.00	0.00	0.00
19	768.60	653.32	390.01	236.09	62.80	53.69	0.00	0.00	0.00	0.00	0.00	0.00
20	758.84	694.21	311.48	211.22	188.25	43.10	0.00	0.00	0.00	0.00	0.00	0.00
21	702.31	598.02	108.67	257.63	184.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	743.80	551.56	52.90	165.00	190.27	0.00	0.00	114.21	0.00	0.00	0.00	0.00
23	743.80	485.87	62.32	195.11	172.48	0.00	4.17	81.48	0.00	0.00	0.00	0.00
24	734.14	410.84	59.50	183.37	228.71	0.00	312.08	265.79	0.00	0.00	0.00	0.00
25	644.63	396.69	59.50	157.17	195.81	0.00	29.97	257.38	0.00	14.74	0.00	0.00
26	644.63	376.70	111.57	122.36	215.29	0.00	0.00	201.38	0.00	5.04	0.00	0.00
27	644.63	396.69	202.39	120.44	116.39	0.00	0.00	95.50	0.00	1.84	0.00	0.00
28	644.63	344.97	102.41	107.15	58.65	0.00	0.00	79.54	0.00	0.00	0.00	0.00
29	644.63	293.32	17.77	128.49	36.22	0.00	20.49	26.68	0.00	0.00	0.00	0.00
30	593.47		0.00	139.56	74.44	0.00	0.00	149.63	0.00	0.00	0.00	0.00
31	449.10		0.00		89.28		0.00	244.13		0.00		0.00
Total	17,719.42	14,368.64	10,796.09	7,124.93	6,369.72	1,519.16	504.95	1,603.12	670.67	21.62	0.00	67.10
Count	27	29	29	27	31	20	6	14	7	3	0	2
Average	571.59	495.47	348.26	237.50	205.47	50.64	16.29	51.71	22.36	0.70	0.00	2.16
Maximum	1,052.49	731.40	621.90	604.80	510.64	181.98	312.08	265.79	138.35	14.74	0.00	54.94
Minimum	0.00	293.32	0.00	0.00	36.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1993
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	139.17	369.29	220.85	38.04	4.92	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	142.66	394.73	208.72	54.75	21.61	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	131.27	386.38	228.54	49.49	3.05	0.00	0.00	0.00	0.00	0.00	0.00
4	213.70	118.56	359.21	205.02	30.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	370.57	111.10	318.74	173.34	54.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	377.88	120.00	317.79	187.54	47.09	0.00	0.00	15.67	0.00	7.18	0.00	0.00
7	295.08	110.46	253.04	169.89	79.93	0.00	0.00	12.40	0.00	0.00	0.00	0.00
8	121.75	137.37	289.73	154.08	52.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	56.54	137.09	357.45	145.01	53.95	0.00	0.00	17.17	0.00	0.00	0.00	0.00
10	60.92	157.90	277.88	152.62	70.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	73.63	152.05	131.13	151.98	52.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	52.21	174.92	88.20	128.03	49.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	72.42	183.89	154.02	130.94	24.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	127.34	193.06	97.60	132.18	53.10	0.00	0.00	0.00	0.00	0.00	2.70	0.00
15	235.40	200.28	167.96	80.87	54.56	0.00	0.00	0.00	0.00	0.00	8.21	0.00
16	41.79	166.46	191.04	57.01	50.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	45.88	138.88	216.01	45.66	59.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	58.21	147.28	227.11	55.02	45.03	0.00	0.00	8.21	0.00	0.00	0.00	0.00
19	17.68	253.85	194.73	76.61	10.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	21.18	285.46	137.74	41.53	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	13.36	297.69	155.07	59.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	94.83	304.84	186.30	65.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	24.88	254.87	157.78	36.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	22.11	224.42	110.55	37.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	21.36	257.05	118.34	76.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	98.83	285.31	161.04	82.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	238.55	276.20	194.56	63.48	3.88	0.00	0.00	44.19	0.00	0.00	0.00	0.00
28	238.52	272.82	236.24	45.24	3.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	238.21		167.22	32.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	241.63		189.42	17.66	30.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	200.80		211.26		11.54		0.00	0.00		0.00		0.00
Total	3,675.26	5,374.91	6,817.56	3,261.69	987.88	29.58	0.00	97.64	0.00	7.18	10.91	0.00
Count	28	28	31	30	24	3	0	5	0	1	2	0
Average	118.56	191.96	219.92	108.72	31.87	0.99	0.00	3.15	0.00	0.23	0.36	0.00
Maximum	377.88	304.84	394.73	228.54	79.93	21.61	0.00	44.19	0.00	7.18	8.21	0.00
Minimum	0.00	110.46	88.20	17.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1993
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	276.04	732.48	438.05	75.45	9.76	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	282.96	782.94	413.99	108.60	42.86	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	260.37	766.37	453.30	98.16	6.05	0.00	0.00	0.00	0.00	0.00	0.00
4	423.87	235.16	712.48	406.65	60.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	735.01	220.36	632.21	343.81	107.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	749.51	238.02	630.33	371.98	93.40	0.00	0.00	31.08	0.00	14.24	0.00	0.00
7	585.28	219.09	501.90	336.97	158.54	0.00	0.00	24.60	0.00	0.00	0.00	0.00
8	241.49	272.47	574.67	305.61	103.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	112.15	271.91	708.99	287.62	107.01	0.00	0.00	34.06	0.00	0.00	0.00	0.00
10	120.83	313.19	551.17	302.72	139.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	146.04	301.59	260.09	301.45	103.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	103.56	346.95	174.94	253.94	98.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	143.64	364.74	305.49	259.72	48.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	252.58	382.93	193.59	262.18	105.32	0.00	0.00	0.00	0.00	0.00	5.36	0.00
15	466.91	397.25	333.14	160.40	108.22	0.00	0.00	0.00	0.00	0.00	16.28	0.00
16	82.89	330.17	378.92	113.08	99.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	91.00	275.46	428.45	90.57	117.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	115.46	292.13	450.47	109.13	89.32	0.00	0.00	16.28	0.00	0.00	0.00	0.00
19	35.07	503.50	386.24	151.95	21.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	42.01	566.20	273.20	82.37	14.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	26.50	590.46	307.58	118.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	188.09	604.64	369.52	130.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	49.35	505.53	312.95	72.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	43.85	445.13	219.27	73.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	42.37	509.85	234.72	151.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	196.03	565.90	319.42	163.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	473.16	547.83	385.90	125.91	7.70	0.00	0.00	87.65	0.00	0.00	0.00	0.00
28	473.10	541.13	468.58	89.73	7.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	472.48		331.68	63.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	479.27		375.71	35.03	61.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	398.28		419.03		22.89		0.00	0.00		0.00		0.00
Total	7,289.77	10,660.98	13,522.43	6,469.47	1,959.43	58.67	0.00	193.67	0.00	14.24	21.64	0.00
Count	28	28	31	30	24	3	0	5	0	1	2	0
Average	235.15	380.75	436.21	215.65	63.21	1.96	0.00	6.25	0.00	0.46	0.72	0.00
Maximum	749.51	604.64	782.94	453.30	158.54	42.86	0.00	87.65	0.00	14.24	16.28	0.00
Minimum	0.00	219.09	174.94	35.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1994
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	9.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.19	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.49	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.55	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	4.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	2.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	3.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	8.70	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	7.29	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		5.16		0.00
Total	0.00	0.00	15.77	4.10	0.00	0.00	15.99	0.00	0.00	5.16	6.23	0.00
Count	0	0	3	1	0	0	2	0	0	1	4	0
Average	0.00	0.00	0.51	0.14	0.00	0.00	0.52	0.00	0.00	0.17	0.21	0.00
Maximum	0.00	0.00	9.43	4.10	0.00	0.00	8.70	0.00	0.00	5.16	2.49	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1994
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	18.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.36	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.98	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.94	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.07	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	8.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	5.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	7.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	17.26	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	14.46	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		10.23		0.00
Total	0.00	0.00	31.28	8.13	0.00	0.00	31.72	0.00	0.00	10.23	12.36	0.00
Count	0	0	3	1	0	0	2	0	0	1	4	0
Average	0.00	0.00	1.01	0.27	0.00	0.00	1.02	0.00	0.00	0.33	0.41	0.00
Maximum	0.00	0.00	18.70	8.13	0.00	0.00	17.26	0.00	0.00	10.23	4.94	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1995
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.70	0.00
2	0.00	0.00	0.00	53.07	0.00	0.00	0.00	0.00	0.00	0.00	31.99	0.00
3	0.00	0.00	0.00	49.90	0.00	0.00	0.00	0.00	0.00	0.00	21.54	0.00
4	0.00	0.00	0.00	45.67	0.00	0.00	0.00	0.00	0.00	0.00	3.19	0.00
5	0.00	0.00	0.00	37.21	0.00	0.00	0.00	0.00	0.00	0.00	2.61	0.00
6	15.63	0.00	0.00	65.04	0.00	0.00	0.00	0.00	0.00	0.00	1.26	0.00
7	30.27	0.00	0.00	69.13	0.00	0.00	0.00	0.00	0.00	0.00	2.86	0.00
8	52.12	0.00	0.00	63.65	0.00	0.00	0.00	0.00	0.00	0.00	34.27	0.00
9	101.98	0.00	0.00	65.43	0.00	0.00	0.00	0.00	0.00	0.00	40.22	0.00
10	165.04	0.00	0.00	40.79	0.00	0.00	0.00	0.00	0.00	0.00	35.22	0.00
11	149.63	0.00	12.78	51.35	0.00	0.00	0.00	0.00	0.00	0.00	29.53	0.00
12	0.00	0.00	21.96	41.19	0.00	0.00	0.00	0.00	0.00	0.00	30.08	0.00
13	0.00	0.00	29.08	36.88	0.00	0.00	0.00	0.00	0.00	0.00	29.31	0.00
14	0.00	0.00	25.27	28.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	26.85	37.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	31.42	19.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	12.30	39.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	18.82	17.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	16.24	20.38	0.00	0.00	0.00	24.65	0.00	0.00	0.00	0.00
20	0.00	0.00	13.62	0.00	0.00	0.00	0.00	18.70	0.00	0.00	0.00	0.00
21	0.00	0.00	14.78	0.00	0.00	0.00	0.00	13.72	0.00	0.00	0.00	0.00
22	0.00	0.00	29.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	28.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	42.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	46.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	47.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	37.78	52.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	5.45	17.94	0.00	0.00	0.00	0.00	0.00	27.65	0.00	0.00	0.00
29	0.00		6.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		14.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		5.47		0.00		0.00	0.00		0.00		0.00
Total	514.67	43.23	513.93	782.15	0.00	0.00	0.00	57.07	27.65	0.00	293.78	0.00
Count	6	2	21	18	0	0	0	3	1	0	13	0
Average	16.60	1.54	16.58	26.07	0.00	0.00	0.00	1.84	0.92	0.00	9.79	0.00
Maximum	165.04	37.78	52.39	69.13	0.00	0.00	0.00	24.65	27.65	0.00	40.22	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1995
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	62.88	0.00
2	0.00	0.00	0.00	105.26	0.00	0.00	0.00	0.00	0.00	0.00	63.45	0.00
3	0.00	0.00	0.00	98.98	0.00	0.00	0.00	0.00	0.00	0.00	42.72	0.00
4	0.00	0.00	0.00	90.59	0.00	0.00	0.00	0.00	0.00	0.00	6.33	0.00
5	0.00	0.00	0.00	73.80	0.00	0.00	0.00	0.00	0.00	0.00	5.18	0.00
6	31.00	0.00	0.00	129.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00
7	60.04	0.00	0.00	137.12	0.00	0.00	0.00	0.00	0.00	0.00	5.67	0.00
8	103.38	0.00	0.00	126.25	0.00	0.00	0.00	0.00	0.00	0.00	67.97	0.00
9	202.27	0.00	0.00	129.78	0.00	0.00	0.00	0.00	0.00	0.00	79.78	0.00
10	327.35	0.00	0.00	80.91	0.00	0.00	0.00	0.00	0.00	0.00	69.86	0.00
11	296.79	0.00	25.35	101.85	0.00	0.00	0.00	0.00	0.00	0.00	58.57	0.00
12	0.00	0.00	43.56	81.70	0.00	0.00	0.00	0.00	0.00	0.00	59.66	0.00
13	0.00	0.00	57.68	73.15	0.00	0.00	0.00	0.00	0.00	0.00	58.14	0.00
14	0.00	0.00	50.12	56.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	53.26	75.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	62.32	38.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	24.40	77.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	37.33	35.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	32.21	40.42	0.00	0.00	0.00	48.89	0.00	0.00	0.00	0.00
20	0.00	0.00	27.01	0.00	0.00	0.00	0.00	37.09	0.00	0.00	0.00	0.00
21	0.00	0.00	29.32	0.00	0.00	0.00	0.00	27.21	0.00	0.00	0.00	0.00
22	0.00	0.00	58.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	56.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	84.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	92.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	94.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	74.94	103.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	10.81	35.58	0.00	0.00	0.00	0.00	0.00	54.84	0.00	0.00	0.00
29	0.00		12.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		27.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		10.85		0.00		0.00	0.00		0.00		0.00
Total	1,020.83	85.75	1,019.37	1,551.37	0.00	0.00	0.00	113.20	54.84	0.00	582.70	0.00
Count	6	2	21	18	0	0	0	3	1	0	13	0
Average	32.93	3.06	32.88	51.71	0.00	0.00	0.00	3.65	1.83	0.00	19.42	0.00
Maximum	327.35	74.94	103.91	137.12	0.00	0.00	0.00	48.89	54.84	0.00	79.78	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1996
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	27.13	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	9.89	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	3.12	0.00	0.00	23.35	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.90	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68.45	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.09	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		62.39		0.00
										60.81		
Total	0.00	0.00	0.00	0.00	0.00	0.00	40.14	0.00	0.00	343.99	0.00	0.00
Count	0	0	0	0	0	0	3	0	0	6	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	1.29	0.00	0.00	11.10	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	27.13	0.00	0.00	70.90	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1996
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	53.81	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	19.62	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	6.19	0.00	0.00	46.31	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	140.63	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	135.77	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	115.22	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	123.75	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		120.61		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	79.62	0.00	0.00	682.29	0.00	0.00
Count	0	0	0	0	0	0	3	0	0	6	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	2.57	0.00	0.00	22.01	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	53.81	0.00	0.00	140.63	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1997
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	17.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.80	0.00	34.08	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	21.25	0.00	0.00	0.00	0.08	0.00	0.00	3.80	0.00	36.08	0.00	0.00
Count	4	0	0	0	1	0	0	1	0	2	0	0
Average	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	1.16	0.00	0.00
Maximum	17.51	0.00	0.00	0.00	0.08	0.00	0.00	3.80	0.00	34.08	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1997
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	3.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	34.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.54	0.00	67.60	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.97	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	42.15	0.00	0.00	0.00	0.16	0.00	0.00	7.54	0.00	71.56	0.00	0.00
Count	4	0	0	0	1	0	0	1	0	2	0	0
Average	1.36	0.00	0.00	0.00	0.01	0.00	0.00	0.24	0.00	2.31	0.00	0.00
Maximum	34.73	0.00	0.00	0.00	0.16	0.00	0.00	7.54	0.00	67.60	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1998
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	20.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	48.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	35.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	4.29	0.00	48.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	73.75	0.00	48.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	43.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	15.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	27.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	51.46	0.00	36.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.97	0.00	63.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	1.07	0.00	67.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.23	0.00	94.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.37	0.00	132.44	0.00	0.00	0.00	1.97	0.00	0.00	0.00	0.00
15	0.00	33.72	0.00	102.23	0.00	0.00	0.00	5.45	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	34.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	1.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	53.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	2.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		103.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		5.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		2.33		0.00		0.00	0.00		0.00		0.00
Total	0.00	225.75	112.04	818.73	0.00	0.00	0.00	7.42	0.00	0.00	0.00	0.00
Count	0	14	3	16	0	0	0	2	0	0	0	0
Average	0.00	8.06	3.61	27.29	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00
Maximum	0.00	73.75	103.98	132.44	0.00	0.00	0.00	5.45	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1998
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	41.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	96.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	70.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	8.51	0.00	95.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	146.28	0.00	96.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	86.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	30.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	53.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	102.07	0.00	71.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	1.92	0.00	126.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	2.12	0.00	133.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.46	0.00	186.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.73	0.00	262.69	0.00	0.00	0.00	3.91	0.00	0.00	0.00	0.00
15	0.00	66.88	0.00	202.77	0.00	0.00	0.00	10.81	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	67.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	2.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	3.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	105.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	5.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		206.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		11.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		4.62		0.00		0.00	0.00		0.00		0.00
Total	0.00	447.77	222.23	1,623.93	0.00	0.00	0.00	14.72	0.00	0.00	0.00	0.00
Count	0	14	3	16	0	0	0	2	0	0	0	0
Average	0.00	15.99	7.17	54.13	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00
Maximum	0.00	146.28	206.24	262.69	0.00	0.00	0.00	10.81	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1999
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.50	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.74	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	13.19	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	13.19	0.00	0.00	0.91	17.24	0.00
Count	0	0	0	0	0	0	1	0	0	1	2	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.03	0.57	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	13.19	0.00	0.00	0.91	10.74	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1999
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.89	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.30	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	26.16	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	26.16	0.00	0.00	1.80	34.20	0.00
Count	0	0	0	0	0	0	1	0	0	1	2	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.06	1.14	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	26.16	0.00	0.00	1.80	21.30	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 2000
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.66
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.43	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.02	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.74	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.54	6.66
Count	0	0	0	0	0	0	0	0	0	0	4	1
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.21
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.43	6.66
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 2000
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.21
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.70	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.01	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.34	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.74	13.21
Count	0	0	0	0	0	0	0	0	0	0	4	1
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36	0.43
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.70	13.21
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 2001
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	8.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	8.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Count	0	0	0	0	1	0	0	0	0	0	0	0
Average	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	8.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 2001
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	16.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	16.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Count	0	0	0	0	1	0	0	0	0	0	0	0
Average	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	16.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

Appendix D

Price Drain Flow Records

PRICE DRAIN
DAILY FLOW RECORDS - 2001
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1			4.55	2.44	1.70	1.38	2.02	6.82	3.49	4.67	1.00	0.70
2			2.11	7.62	1.49	2.43	2.50	9.26	6.02	2.90	1.56	0.56
3			1.89	4.55	1.74	2.52	3.56	7.04	5.83	2.64	2.72	1.00
4			1.37	4.41	1.47	2.99	3.54	3.87	4.51	3.01	3.60	21.87
5			0.50	12.70	1.76	2.93	4.80	5.46	3.89	2.63	4.99	11.71
6			1.95	18.12	1.00	2.65	5.34	3.55	4.77	3.31	2.15	4.58
7			47.72	6.20	1.34	3.68	3.64	2.74	3.33	3.79	2.01	1.25
8			25.07	3.18	1.24	2.33	3.21	4.20	3.89	3.35	5.49	0.83
9			29.69	3.85	1.24	1.99	3.63	20.17	3.77	4.74	4.36	0.00
10			15.38	5.24	1.71	1.92	2.85	8.87	5.65	2.96	2.32	0.00
11			2.55	1.88	3.21	2.18	1.59	5.66	4.26	8.19	2.62	1.25
12			1.21	2.00	1.66	1.50	1.36	5.53	2.93	11.16	3.24	1.00
13			1.68	1.01	1.67	1.43	2.41	6.15	6.71	5.29	3.46	0.36
14			0.98	1.20	2.35	1.81	2.18	7.15	6.56	3.12	1.76	0.78
15			1.26	1.27	1.44	1.47	2.57	5.02	6.14	1.80	3.97	2.54
16			1.13	1.77	1.36	3.67	2.68	7.89	4.61	0.34	2.62	3.00
17			1.55	1.23	0.72	2.10	4.41	5.94	5.82	0.41	1.11	2.76
18		2.27	1.05	1.25	0.58	2.08	3.71	3.35	2.09	1.01	1.00	3.39
19		6.66	1.25	2.66	0.89	2.57	5.57	2.39	3.15	1.02	3.52	2.90
20		6.00	1.00	1.31	1.00	3.15	4.50	2.68	1.84	1.36	2.09	3.21
21		2.34	0.85	4.40	1.00	4.27	4.17	2.16	2.80	1.18	3.46	2.64
22		1.32	1.00	7.80	1.48	2.96	3.77	1.81	3.20	2.43	5.10	2.18
23		1.34	3.30	3.88	1.71	1.73	2.94	3.60	3.40	3.17	3.08	2.56
24		3.55	2.53	2.59	4.32	1.93	1.90	3.20	3.89	4.92	2.00	2.35
25		2.27	2.21	1.92	4.67	2.55	3.15	3.08	4.48	4.60	1.00	2.06
26		3.80	2.86	2.28	2.56	1.94	4.07	3.49	5.33	3.00	1.22	1.95
27		4.09	2.42	4.68	2.33	1.80	2.56	3.65	7.96	3.00	0.78	1.00
28		14.09	3.71	2.89	2.10	2.44	2.38	4.12	5.02	2.58	1.00	1.65
29			3.13	3.59	1.29	1.24	17.93	4.33	4.58	1.57	1.15	1.56
30			2.18	1.39	1.00	1.18	22.67	10.27	5.07	1.43	1.50	1.14
31			2.60		1.00		11.13	6.53		2.11		1.15
Total		47.75	170.69	119.31	53.03	68.81	142.71	169.96	134.99	97.69	75.90	83.93
Count		11	31	30	31	30	31	31	30	31	30	30
Average		4.34	5.51	3.98	1.71	2.29	4.60	5.48	4.50	3.15	2.53	2.71
Maximum		14.09	47.72	18.12	4.67	4.27	22.67	20.17	7.96	11.16	5.49	21.87
Minimum		1.32	0.50	1.01	0.58	1.18	1.36	1.81	1.84	0.34	0.78	0.00

Source: FCDMC Flow Records

PRICE DRAIN
DAILY FLOW RECORDS - 2001
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1			9.03	4.83	3.38	2.73	4.00	13.54	6.92	9.26	1.98	1.38
2			4.18	15.12	2.96	4.82	4.95	18.37	11.95	5.76	3.10	1.10
3			3.75	9.02	3.44	4.99	7.06	13.96	11.57	5.24	5.39	1.98
4			2.72	8.75	2.92	5.93	7.01	7.68	8.94	5.96	7.13	43.38
5			0.99	25.19	3.49	5.82	9.52	10.83	7.71	5.22	9.89	23.22
6			3.87	35.93	1.98	5.25	10.60	7.04	9.47	6.57	4.26	9.08
7			94.65	12.31	2.66	7.31	7.21	5.43	6.60	7.52	3.99	2.49
8			49.73	6.32	2.46	4.63	6.36	8.32	7.71	6.64	10.88	1.65
9			58.90	7.63	2.47	3.94	7.20	40.00	7.49	9.41	8.65	0.00
10			30.51	10.39	3.39	3.81	5.66	17.60	11.21	5.88	4.61	0.01
11			5.06	3.73	6.38	4.33	3.16	11.22	8.44	16.24	5.20	2.48
12			2.40	3.97	3.29	2.97	2.69	10.97	5.80	22.13	6.43	1.99
13			3.33	2.00	3.31	2.83	4.78	12.20	13.32	10.49	6.87	0.71
14			1.95	2.38	4.65	3.60	4.32	14.18	13.02	6.19	3.50	1.54
15			2.49	2.52	2.86	2.92	5.09	9.95	12.17	3.57	7.88	5.04
16			2.24	3.51	2.70	7.28	5.32	15.64	9.14	0.67	5.20	5.94
17			3.08	2.45	1.42	4.16	8.74	11.77	11.55	0.82	2.20	5.47
18		4.51	2.08	2.48	1.14	4.12	7.35	6.64	4.14	2.00	1.99	6.73
19		13.21	2.48	5.28	1.76	5.09	11.04	4.75	6.25	2.03	6.98	5.75
20		11.90	1.98	2.59	1.98	6.25	8.93	5.32	3.65	2.71	4.14	6.36
21		4.64	1.68	8.73	1.98	8.47	8.27	4.29	5.55	2.33	6.86	5.23
22		2.62	1.99	15.46	2.93	5.87	7.48	3.59	6.34	4.81	10.12	4.32
23		2.66	6.54	7.70	3.40	3.44	5.82	7.13	6.75	6.29	6.12	5.07
24		7.04	5.02	5.13	8.57	3.83	3.77	6.35	7.72	9.76	3.98	4.67
25		4.51	4.37	3.81	9.26	5.05	6.24	6.12	8.89	9.12	1.98	4.09
26		7.54	5.67	4.52	5.08	3.84	8.07	6.92	10.57	5.95	2.42	3.88
27		8.11	4.80	9.28	4.62	3.56	5.08	7.24	15.78	5.95	1.55	1.98
28		27.95	7.37	5.72	4.17	4.84	4.73	8.16	9.96	5.12	1.98	3.27
29			6.21	7.13	2.56	2.46	35.56	8.59	9.09	3.11	2.28	3.10
30			4.32	2.75	1.98	2.34	44.96	20.36	10.05	2.85	2.97	2.27
31			5.15		1.98		22.07	12.95		4.19		2.29
Total		94.70	338.56	236.64	105.18	136.49	283.07	337.12	267.75	193.77	150.54	166.48
Count		11	31	30	31	30	31	31	30	31	30	30
Average		8.61	10.92	7.89	3.39	4.55	9.13	10.87	8.92	6.25	5.02	5.37
Maximum		27.95	94.65	35.93	9.26	8.47	44.96	40.00	15.78	22.13	10.88	43.38
Minimum		2.62	0.99	2.00	1.14	2.34	2.69	3.59	3.65	0.67	1.55	0.00

Source: FCDMC Flow Records

PRICE DRAIN
DAILY FLOW RECORDS - 2002
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1.30	2.97	2.52	1.00	1.59							
2	2.30	2.55	3.46	0.66	4.79							
3	4.00	2.24	3.22	1.50	5.46							
4	6.26	2.29	2.20	3.40	2.33							
5	7.35	2.09	0.94	3.08	2.40							
6	5.08	1.71	1.67	2.46	1.71							
7	5.13	1.00	1.18	4.48	1.27							
8	3.87	1.34	3.64	1.93	4.15							
9	2.17	2.29	3.20	1.71	4.81							
10	3.40	0.69	1.74	2.25	195.33							
11	3.91	2.16	6.05	2.28	7.15							
12	3.61	4.60	7.69	2.92	8.23							
13	4.64	4.94	8.35	1.16	4.61							
14	3.93	6.43	6.99	0.15	3.26							
15	4.00	5.84	4.56	1.11	3.36							
16	3.20	3.73	3.45	5.67	3.98							
17	2.22	3.31	2.63	2.62	2.71							
18	1.91	2.50	3.94	1.11	1.84							
19	1.08	2.24	4.22	1.00	1.70							
20	1.11	2.89	1.67	1.40								
21	1.00	1.99	0.79	1.71								
22	0.76	2.17	1.59	1.50								
23	1.00	3.85	2.62	1.41								
24	0.61	2.95	2.83	1.00								
25	1.60	2.68	1.76	1.89								
26	5.03	2.80	2.08	3.00								
27	3.90	2.77	3.06	2.63								
28	5.56	1.90	3.92	2.61								
29	2.75		2.88	1.81								
30	4.96		1.99	1.49								
31	4.28		1.55									
Total	101.94	78.88	98.39	60.94	260.66							
Count	31	28	31	30	19							
Average	3.29	2.82	3.17	2.03	13.72							
Maximum	7.35	6.43	8.35	5.67	195.33							
Minimum	0.61	0.69	0.79	0.15	1.27							

Source: FCDMC Flow Records

PRICE DRAIN
DAILY FLOW RECORDS - 2002
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2.59	5.88	5.00	1.98	3.15							
2	4.57	5.05	6.86	1.30	9.50							
3	7.94	4.43	6.38	2.97	10.82							
4	12.43	4.54	4.37	6.74	4.62							
5	14.58	4.15	1.86	6.11	4.76							
6	10.07	3.38	3.30	4.87	3.39							
7	10.17	1.98	2.34	8.89	2.51							
8	7.68	2.65	7.22	3.84	8.23							
9	4.31	4.54	6.35	3.39	9.54							
10	6.74	1.36	3.46	4.46	387.44							
11	7.76	4.29	12.00	4.53	14.19							
12	7.16	9.12	15.25	5.78	16.32							
13	9.21	9.81	16.56	2.30	9.14							
14	7.80	12.75	13.86	0.30	6.47							
15	7.93	11.59	9.05	2.20	6.67							
16	6.36	7.39	6.85	11.25	7.89							
17	4.40	6.56	5.22	5.19	5.37							
18	3.80	4.96	7.81	2.21	3.65							
19	2.13	4.45	8.38	1.98	3.38							
20	2.20	5.73	3.32	2.78								
21	1.98	3.95	1.57	3.39								
22	1.50	4.30	3.16	2.97								
23	1.98	7.64	5.20	2.80								
24	1.21	5.86	5.60	1.98								
25	3.17	5.31	3.48	3.76								
26	9.98	5.54	4.13	5.94								
27	7.74	5.49	6.07	5.22								
28	11.03	3.77	7.77	5.17								
29	5.46		5.71	3.59								
30	9.85		3.94	2.95								
31	8.48		3.07									
Total	202.19	156.46	195.15	120.86	517.01							
Count	31	28	31	30	19							
Average	6.52	5.59	6.30	4.03	27.21							
Maximum	14.58	12.75	16.56	11.25	387.44							
Minimum	1.21	1.36	1.57	0.30	2.51							

Source: FCDMC Flow Records

APPENDIX

D

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

GROUNDWATER MODEL

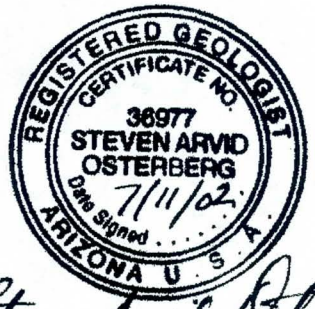
Knight Piésold
CONSULTING

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01J Groundwater Model
Final Report

July 17, 2002

Prepared for

Salt River Pima-Maricopa Indian Community
10005 East Osborn Road
Scottsdale, Arizona 85256
Telephone: (480) 850-8000
Facsimile: (480) 850-7366



Prepared by

Knight Piésold and Co.
1050 Seventeenth Street, Suite 650
Denver, Colorado 80265
Telephone: (303) 629-8788
Facsimile: (303) 629-8789

Project 1889A/0130

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01J Groundwater Model
Final Report

Table of Contents

List of Figures ii

List of Appendices ii

1.0 Introduction 1

2.0 Hydrogeologic System 2

2.1 Geologic Framework 2

2.2 Conceptual Hydrogeologic Model 3

3.0 Numerical Model 4

3.1 Model Approach 4

3.2 Model Area 4

3.3 Model Selection 4

3.4 Model Grid and Layers 5

3.5 Aquifer Parameters 5

3.6 Aquifer Recharge 6

3.7 Wells 7

3.7.1 Groundwater Levels 7

3.7.2 Well Pumping Rates 8

3.8 Boundary Conditions 9

3.9 Other Model Considerations 9

4.0 Model Calibration 10

4.1 Steady-State Calibration 10

4.2 Sensitivity Analysis 11

4.3 Transient Calibration 11

5.0 Conclusions and Recommendations 14

References R-1

List of Figures

Figure	Title
1-1	Project Location Map
3-1	Flow Chart of Groundwater Modeling Approach
3-2	Refined Groundwater Model Area Finite Difference Grid, Boundary Conditions, Calibration Targets, and Wells
3-3	Refined Groundwater Model Area Recharge Zone Map
3-4	Depth to Groundwater Map
3-5	Hydrographs for Tri-Cities Landfill Monitoring Wells
3-6	Hydrographs for ADWR Monitoring Wells
4-1	Steady-State Potentiometric Surface in the Upper Alluvial Unit
4-2	Sensitivity Analysis for 50% Increase in Groundwater Model Input Parameters

List of Appendices

Appendix	Title
A	Water Level Records
B	Pumping Well Records

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01J Groundwater Model
Final Report

1.0 Introduction

A numerical groundwater model[1] has been developed of the Salt River-Pima Maricopa Indian Community (the Community) for the Salt River Restoration Project (SRRP). The model is intended to guide development of habitat and riparian restoration along the Salt River and can be utilized by the Community for future groundwater-related investigations. It is also intended that the model be used by the U.S. Army Corps of Engineers (Corps) in their F3 analysis of options for ecosystem restoration along the Salt River. The project area is centered along the historic channel of the Salt River along the southern extent of the Community (Figure 1-1).

Specific objectives of this investigation include:

- To assess the depth to groundwater along the river channel for comparison to root zone depths
- To assess likely changes in groundwater depth in the future

The approach to the project includes an empirical analysis of the depth to groundwater along the river channel and development of a calibrated numerical groundwater model of the project area by refinement of the Arizona Department of Water Resources (ADWR) regional groundwater model (Corell and Corkhill, 1994). The model has been calibrated to steady-state conditions reflective of groundwater levels that have stabilized in response to long-term stresses on the hydrogeological system. In addition, a transient calibration was completed to evaluate the response of the aquifer to stresses prior to stabilization.

[1] The model represents a simplified description of the aquifer through a series of mathematical equations used to simulate groundwater position and movement. The model is designed to analyze natural conditions of the aquifer and to simulate the effects of groundwater recharge and discharge stresses.

2.0 Hydrogeologic System

2.1 Geologic Framework

Geologically, the project area is situated within the regional Basin and Range Physiographic Province. Within the province, extensional tectonics resulted in development of extensive basin-fill sedimentary deposits and uplifted north-northwest-trending bedrock ranges.

Bedrock exposed in the project area comprises Precambrian to Tertiary-aged crystalline and metamorphic rocks. These rocks crop out along the northeast edge of the project area and extend at depth to the southwest beneath extensive basin-fill sedimentary deposits. Basin-fill deposits range in thickness from 0 feet at the basin margins to several thousand feet within the project area. The deposits generally thicken to the southwest (Corkhill, et al., 1993). The sediments are largely unconsolidated clay, silt, sand, and gravel deposits that developed from erosion of the uplifted crystalline and metamorphic bedrock.

Corkhill, et al. (1993) subdivided the basin-fill deposits into three primary stratigraphic units including the following:

1. **Upper Alluvial Unit (UAU).** The UAU consists mainly of deposits of gravel, sand, and silt. The deposits typically range in thickness from 100 to 300 feet but thin out at contacts with exposed bedrock. Regionally, the UAU represents an unconfined aquifer for which hydraulic conductivity (K) is estimated to vary widely from approximately 20 to 250 ft/day and specific yield (S_y) from 8 to 22 percent.

2. **Middle Alluvial Unit (MAU).** The MAU is overlain by the UAU and comprises mainly clay, silt, and mudstone with some interbedded sand and gravel especially developed near margins of the basin. Within the refined model, the MAU ranges from 100 to approximately 600 feet in thickness and is a major aquifer from which groundwater is extracted. The aquifer has been regionally characterized as unconfined to leaky confined. Regional estimates of K range from 5 to 50 ft/day and S_y from 3 to 14 percent for the MAU.

3. **Lower Alluvial Unit (LAU).** The LAU underlies the MAU and consists mainly of conglomerate and sand near basin margins and mudstone and anhydrite distal from edges of the basin. Volcanic rocks are interbedded within the stratigraphic section. Within the refined model area, the LAU ranges in thickness from 0 feet at the basin margins to 2,000 feet within the basin. The LAU aquifer is described as leaky confined, and hydraulic properties are estimated to regionally be K = 5 to 60 ft/day and S_y = 3 to 15 percent.

Stratigraphically, the entire UAU-MAU-LAU sequence is underlain by crystalline bedrock. Hydrogeologically, the crystalline bedrock represents an impermeable boundary to groundwater within the alluvial sequence.

2.2 Conceptual Hydrogeologic Model

Groundwater flux through the project area is generally northeast to southwest as described by the ADWR (Corkhill, et al., 1993). Recharge of the groundwater comes from several sources including mountain front infiltration, alluvial underflow along the Salt River channel, urban and agricultural irrigation, and groundwater recharge projects at the Granite Reef Underground Storage Project (GRUSP) and Northwest Water Reclamation Plant (NWWRP) (Figure 1-1). As evapotranspiration rates are high (72.4 in/year [Cooley, 1970]) and precipitation relatively low (7.66 in/year [Schmidli, 1996]) within the project area, direct infiltration of precipitation does not contribute to aquifer recharge. Although rare in occurrence, flooding of the Salt River channel does provide some recharge but only on an isolated basis.

Aquifer discharge within the project area occurs by two primary methods. These include pumping wells used for domestic and agricultural purposes and groundwater discharge from the project area by aquifer flow.

3.0 Numerical Model

The ADWR developed a regional numerical (3D-MODFLOW) groundwater model (Corell and Corkhill, 1994) which covered an area of approximately 2,240 mi^2 within the Phoenix AMA including a major portion of the Salt River Valley. Its purpose was, in part, to provide a regional framework upon which groundwater management scenarios could be tested. The model contained grid-cells of 1 mi^2 and three layers corresponding to UAU, MAU, and LAU. For the SRRP, a refined groundwater model has been developed by modification of the regional ADWR model.

3.1 Model Approach

Development of the refined groundwater model includes modeling and calibration of steady-state and transient conditions. The calibrated model simulates the baseline conditions. In the future, when alternative project options are identified by the Corps, the model can be utilized to evaluate the effects on the depth of the water table. The modeling approach is schematically illustrated on Figure 3-1.

3.2 Model Area

The refined model encompasses approximately 85 mi^2 centered on the Salt River (Figure 3-2). The model area extends from approximately the Pima Freeway (the R4E-R5E boundary) on the west to approximately Powers Road on the east. The south edge of the model area occurs along Southern Avenue. At the north edge, the model area generally follows the north boundary of the Community. The model has been developed through refinement of the ADWR model grid, model layers, boundary conditions, recharge, and a compilation of wells as defined by the ADWR "55-series" well database.

3.3 Model Selection

As an initial step in development of a refined groundwater model in the project area, the ADWR 3D-MODFLOW regional groundwater model of the Salt River Valley was acquired. Groundwater Vistas (Environmental Simulations Inc., 2002) was utilized as the modeling pre-processing software to allow compatibility with the ADWR model and specialized capability for telescopic mesh refinement.

3.4 Model Grid and Layers

Using the telescopic mesh refinement tool of Groundwater Vistas, the ADWR regional 1-mi^2 model grid was refined within the present model area to comprise 96 rows, 112 columns, and three model layers to total 32,256 individual cells (Figure 3-2). This represents a subdivision of the regional grid in the area of interest into cells of 1/8- × 1/8-mile dimension. As in the ADWR model, each layer in the refined model corresponds to a single hydrostratigraphic unit representative of the UAU, MAU, and LAU (Corkhill, et al., 1993). The thickness of each layer was taken directly from the ADWR regional model. Within the refined model, the UAU, MAU, and LAU range in thickness from approximately 0 to 300 feet, 100 to 600 feet, and 500 to 2,000 feet, respectively. For simplicity, in the model the layers are not intermixed; however, each layer generally thins toward the east-northeast toward the basin margins and exposed bedrock.

Crystalline and metamorphic bedrock crops out at the east-northeast end of the refined model area. The exposed bedrock is modeled as inactive cells (Figure 3-2).

3.5 Aquifer Parameters

Aquifer properties selected for the refined model were based on calibration (Section 4.0) to existing groundwater level, pumping, and aquifer recharge rates and are generally comparable to those of the ADWR regional model (Corkhill, et al., 1993). Hydraulic conductivities have been modeled as single zones across the model area corresponding to each aquifer layer. The conductivities (K_x, K_y, K_z) and storage parameters (S_y, S) were defined as follows:

Layer	K_x (ft/day)	K_y (ft/day)	K_z (ft/day)	S_y	S
1 (UAU)	150	150	20	0.08	0.001
2 (MAU)	20	20	10	0.03	0.001
3 (LAU)	100	100	50	0.03	0.0001

In final development of the refined groundwater model since the 80 percent completion report (Knight Piésold, 2002), vertical leakage between layers was reconsidered as vertical hydraulic conductivity (K_z) within Groundwater Vistas. This allowed better model calibration to empirical data than the use of leakage factors.

3.6 Aquifer Recharge

As noted in the Conceptual Hydrogeologic Model (Section 2.2), aquifer recharge occurs within the study area at several sites and is considered within the refined model. Rates of recharge are related in the model to land use (Figure 3-3). Two primary sites of focused recharge include:

1. **Granite Reef Underground Storage Project (GRUSP).** GRUSP is an aquifer recharge system where canal surface water is recharged to the UAU aquifer through 216 acres of rapid infiltration basins operated by the Salt River Project (SRP).

2. **Northwest Water Reclamation Plant (NWWRP) Ponds.** Infiltration of treated wastewater effluent from the NWWRP occurs through percolation ponds or directly into the adjacent Salt River channel near the southwest end of the model area near the interchange between the Pima and Loop 202 Highways. Two sets of ponds occur including:

    a. Five ponds totaling 75 acres operated by the Community and located north of the Salt River

    b. Four ponds totaling 27 acres operated by Mesa and located south of the Salt River

A third site of focused recharge (wetlands below Granite Reef) was previously considered in the 80 percent completion report (Knight Piésold, 2002). In final modeling, for simplicity, this source was incorporated in a general head boundary along the Salt River (Section 3.8).

Based on available records (Haws, 2002; Lluria, pers. comm., 2002; Correll and Corkhill, 1994), the modeled rates of recharge at these two sites of focused recharge are as follows:

Site	Recharge Rate (ft/day)
GRUSP	1.17
NWWRP	0.40

In addition to sites of focused recharge, aquifer recharge in the model is also considered to occur as irrigation at varying rates dependent on land use. Three categories of land use are defined in the model as: (1) Urban, (2) Agricultural, and (3) Mixed Agricultural/Residential. Urbanized land use occurs primarily south of the Salt River channel and immediately west of the Community in the cities of Mesa, Tempe, and Scottsdale. Agricultural land with relatively heavy irrigation occurs in the southeast end of the model area and within the Community north of the Evergreen Canal. Land immediately north and south of the Salt River channel in the western

portion of the Community and at the far eastern and southeastern end of the model area is used primarily for mixed agricultural/residential use (Figure 3-3).

Based on the available ADWR records and the regional model (Corell and Corkhill, 1994), the rates of recharge used in the model are as follows:

Site	Recharge Rate (ft/day)
Urban	0.002
Agricultural	0.008
Mixed Agricultural/Residential	0.003

No recharge was considered to occur within the channel of the Salt River (except that associated with NWWRP) as flooding occurs only sporadically in relatively short-lived events. The impact of surface flooding on aquifer recharge is estimated to be relatively minor compared to other recharge sources.

Mountain front recharge is recognized to occur but is non-sensitive in the refined model. For simplicity, it was therefore not included as an input parameter. Also, no infiltration is considered within natural open space areas (Figure 3-3).

3.7 Wells

Groundwater level information from monitoring wells has been utilized within the model for steady-state and transient calibrations. In addition, information on pumping wells, including production rates and pumping periods, has been included.

3.7.1 Groundwater Levels

Water level data utilized in development of the refined model were taken from Community monitoring well records provided by Abel Ramirez (2002, pers. comm.) and from ADWR records (Appendix A). The Community wells are primarily located immediately adjacent to the channel of the Salt River (Figure 3-2). The records include potentiometric data generally from the period March-April of 2001. Based on these data, a depth to groundwater map (Figure 3-4) was constructed for the immediate area of the Salt River channel. The map indicates that groundwater depth ranges from approximately 50 feet near the GRUSP and NWWRP recharge sites to approximately 175 feet north of GRUSP.

Transient groundwater level data provided by Rameriz (2002) from eight monitoring wells that are located near the Tri-Cities Landfill (Appendix A) were also reviewed. ADWR water level records of five monitoring wells located off the Community were also examined. These wells are located within or in close proximity to the model area. For the Tri-Cities Landfill (Figure 1-1) wells, semi-continuous groundwater level records exist since 1990. In these records, a trend of steady increase is noted in all wells from 1994 through approximately early 1996 (Figure 3-5). Thereafter, the trends in water levels are generally stable except for apparent fluctuation related to inflow during 1997. The increase is approximately coincident with initiation of aquifer recharge at the GRUSP facility that is located approximately 2 to 3 miles upgradient of the landfill monitoring wells.

Water level records from the ADWR (Appendix A) of wells on or in the near vicinity of the refined model area were examined. These records are generally from the period 1998 through 2001 and were reviewed for relatively long-term trends. These wells are located greater than 4 miles from the GRUSP site, and some are slightly outside of the refined model area. Records for four of five wells indicate relatively stable trends (Figure 3-6). In a fifth well (No. 607702), the trend is stable to slightly increasing from early 1998 through 2000; no record exists after 2000. This well is located approximately 2 miles south of the Tri-Cities Landfill and approximately 5 miles southwest of the GRUSP site; the slight increasing trend may reflect the delayed effect of aquifer recharge at GRUSP. It is possible that a drop of approximately 25 feet in early 1998 that is evident on this well hydrograph may be reflective of an unidentified nearby pumping well or a mistaken water level measurement.

3.7.2 Well Pumping Rates

Groundwater pumping from wells was simulated in the refined model. One hundred and thirty-six wells for which locations and pumping rates were identified within the ADWR "55-series" database have been included in the refined groundwater model (Appendix B). These wells are located south and west of the Community. Within the refined model where more than one well exists per cell, pumpage was summed as a total per cell. Well depths vary with most wells penetrating all aquifer layers. As well screen information is not available in the ADWR database, pumping was estimated to be proportionally distributed to each aquifer unit intersected. Within the refined model area, wells of the Community were modeled as inactive (non-pumping) according to available records (Roche and Ramirez, 2002, pers. comm.).

3.8 Boundary Conditions

To define the hydrologic conditions at the margins of the model, two major types of boundary conditions were applied within Groundwater Vistas as follows (Figure 3-2):

1. **Constant Head.** Constant head conditions were applied to all boundary cells at the downgradient margins of the model. In Layer 1 (UAU), the head conditions as applied were derived or extrapolated from the potentiometric information (Appendix A) provided by the Community (Ramirez, 2002). For Layers 2 (MAU) and 3 (LAU), as no potentiometric maps were available, head values were set at levels deemed reasonable from 1988 year results in the ADWR regional model.

2. **General Head Boundaries (GHB).** A general head boundary was employed across the aquifer of the Salt River Valley near the upgradient margin of the model. In the model, the GHB accounts for alluvial underflow beneath the Salt River channel. The flux was initially estimated by completion of a flow net analysis utilizing hydraulic conductivity values consistent with the ADWR model for the UAU and an estimated aquifer thickness and width. The GHB was confirmed with mass balance calculations to ensure reasonable flux rates. The steady-state flux was estimated in the model at 4.1 million ft^3/day and is inclusive of a recharge zone at the base of Granite Reef. This value approximates that used in the ADWR regional model for alluvial underflow at the Salt River.

3.9 Other Model Considerations

Phreatophytic vegetation does not presently exist along the channel of the Salt River through the refined model area. As such, no evapotranspiration was considered within the refined model.

4.0 Model Calibration

The model was calibrated to measured water levels in a specific set of monitoring wells to ensure that the refined groundwater model for the Salt River area accurately simulates actual observed field conditions. In the calibration process, input parameters were adjusted to allow the simulated water levels to match the field data. A steady-state calibration of the refined numerical model was completed with the best available record of groundwater levels. These levels reflect relatively stable groundwater conditions at an approximate "snapshot" in time. In addition, a transient calibration has been completed utilizing limited available transient records of groundwater changes along the Salt River.

4.1 Steady-State Calibration

Groundwater levels have been approximately steady since 1998 as noted in hydrographs of the Tri-Cities Landfill monitoring wells (Figure 3-5). Hydrograph records of wells located more regionally (Figure 3-6) also indicate that the hydrogeologic system is in an approximate steady-state condition. As such, a steady-state calibration was completed to water levels in eight representative monitoring wells located primarily adjacent to the Salt River channel (Figures 3-3 and 4-1). The wells are generally distributed from the southwest to northeast extent of the model area.

The available record of stresses on the hydrogeological system and actual associated groundwater levels that best approximate steady-state conditions include the following:

Record	Data/Date	Source
Static Water Levels	Monitoring Well Potentiometric Data (Appendix A)/February-May 2001	Ramirez, 2002
Well Pumping Records	136 wells (Appendix B)/Monthly Average for Year 2000	ADWR database (2001)
GRUSP Recharge	1.17 feet/day / April 2001 record	SRP, pers. comm.. (2000)
NWWRP Recharge	0.40 feet/day (South Ponds and River Channel)/2000 record	Haws, 2002, Mesa report

Steady-state calibration has resulted in simulation of the water table reflecting a general northeast to southwest gradient with recharge mounds developed at the GRUSP and NWWRP sites (Figure 4-1). Comparison of the groundwater table elevations in the selected monitoring wells and elevations calculated in the model for each well are as follows:

Well No.	Groundwater Elevation: Model Observed (ft)	Groundwater Elevation: Model Calculation (ft)	Groundwater Elevation Difference (ft)
WGR-2	1,166	1,160	6
7cbd	1,129	1,124	5
8AAA	1,121	1,116	5
WGR-3	1,202	1,202	0
GW	1,200	1,199	1
MW-3TC	1,121	1,137	-16
MW-1	1,137	1,138	-1
MW-3	1,137	1,136	1

Calibration indicates an average absolute groundwater elevation difference of 4.38 feet between observed and modeled groundwater table levels. One well, MW-3TC, is notably poor in calibration. This may reflect an inaccurately observed or recorded groundwater level during the February-May record period or local, heterogeneous conditions.

If this well is discounted from the calibration well set, an average absolute difference of 2.7 feet occurs between observed and modeled groundwater levels. For a saturated thickness of 100 to 300 feet in the UAU, this represents an approximately 3 to 1 percent error.

4.2 Sensitivity Analysis

To evaluate the sensitivity of the refined model to various aquifer parameters, an analysis was completed of the steady-state model to the effects of variations in several aquifer parameters. These parameters included K; urban, agricultural, mixed agricultural/residential recharge; and GRUSP recharge. In the evaluation, each parameter was increased individually by 50 percent above the steady-state calibrated value. The model was executed after each parameter increase, and the overall change in absolute error was noted. Analysis indicates that the modeled groundwater levels are dominantly sensitive to changes in Layer 3 (LAU) horizontal K (K_x, K_y) and recharge rates at GRUSP (Figure 4-2).

4.3 Transient Calibration

To further test the refined numerical model for the Salt River area beyond the steady-state calibration, a calibration to limited available transient data was completed. This calibration was intended to document that the model responds to changes in stresses in the hydrogeologic system.

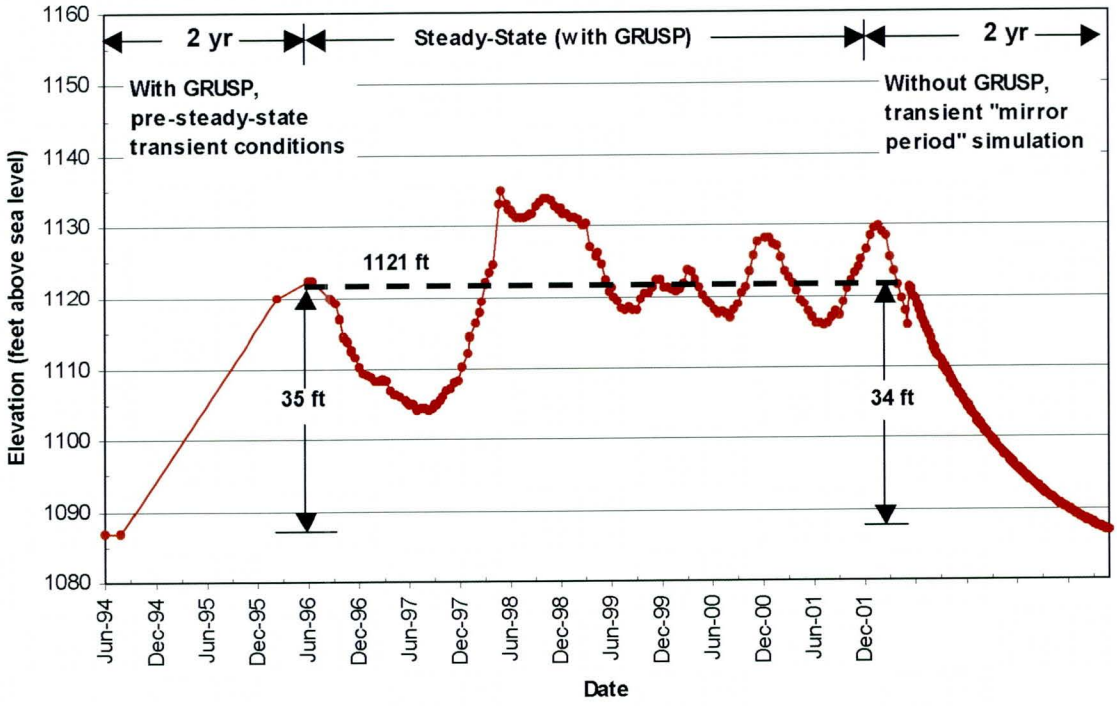
Available transient water level records for the model area are limited to eight Tri-Cities Landfill monitoring wells (Figure 3-5). These records indicate generally consistent trends of increasing water levels from mid-1994 through mid-1996, after which approximate steady-state conditions were reached. Well MW-3TC was chosen as representative of the eight wells as it was also used in steady-state calibration of the groundwater model. All of the eight wells are located in relative proximity to the landfill (within a 2.5-mile radius). Groundwater levels were observed to change in well MW-3TC from 1,087 feet in June 1994 to 1,122 feet in June 1996 for a total of 35 feet over the two-year period. The increased water levels in 1996 were in response to aquifer recharge at the nearby GRUSP site.

To test the reaction of the model to the GRUSP recharge, the model was run using steady-state (post-June 1996) groundwater levels as a baseline reference point for a two-year transient period simulation. This simulation was completed without the GRUSP recharge component. This was intended to simulate the "mirror opposite" reaction of the hydrogeologic system noted between mid-1994 and mid-1996 that resulted from GRUSP recharge. Several transient model trial calibrations were completed by changing the storativity (S) and S_y parameters. Optimum results were achieved for three model layers with the following values:

Layer	S_y	S
1	0.08	0.001
2	0.03	0.001
3	0.03	0.0001

After transient modeling of a two-year period "mirror opposite" simulation without GRUSP, water levels at MW-3TC were calibrated at 34 feet below steady-state levels as graphically shown below. This transient calibration resulted in an absolute error of one foot, indicating that the selected values of S and S_y are reasonable.

Well MW-3TC Hydrograph: Water Levels: With GRUSP (Observed); Without GRUSP (Transient Model)



GRUSP Forward Trans MW-3TC.xls

5.0 Conclusions and Recommendations

Four primary conclusions and recommendations are made based on the analysis of the Salt River aquifer in the vicinity of the Community. These include:

1. The depth to groundwater along the Salt River channel ranges from approximately 50 feet at GRUSP and NWWRP to 175 feet north of GRUSP based on empirical data. Hydrographs within the project area suggest that the water table has been relatively stable since approximately 1996.

2. A refined numerical groundwater model predicts a relatively stable water table if no additional major stresses are added to the hydrogeological system.

3. To further develop the refined numerical groundwater model, additional data should be systematically collected. Together with the ongoing collection of pumping and aquifer recharge records, these data should include seasonal records of groundwater levels in monitoring wells in the project area. Records from wells along the Salt River channel would be especially useful data.

4. As new stresses in the hydrogeological system such as "with Project Alternatives" are identified, the refined groundwater model can be run forward under transient conditions to evaluate changes in groundwater levels through the project period.

References

Cooley, K.R., 1970, "Evaporation from Open Water Surfaces in Arizona," U.S. Department of Agriculture, Agricultural Research Service.

Corell S.W., and E.F. Corkhill, 1994, "A Regional Groundwater Flow model of the Salt River Valley – Phase II Phoenix Active Management Area Numerical Model, Calibration, and Recommendations, Arizona Department of Water Resources, Hydrology Division, Modeling Report No. 8," Phoenix, Arizona, March.

Corkhill, E.F., S. Correll, B.M. Hill, and D.A. Carr, 1993, "A Regional Groundwater Flow model of the Salt River Valley – Phase I Phoenix Active Management Area Hydrogeologic Framework and Basic Data Report, Arizona Department of Water Resources, Hydrology Division, Modeling Report No. 6," Phoenix, Arizona, April.

Environmental Simulations Inc., 2002, *Groundwater Vistas, Version 3.*

Haws, G., 2002, "Final Document, Va Shly'ay Akimel Salt River Restoration Project," April.

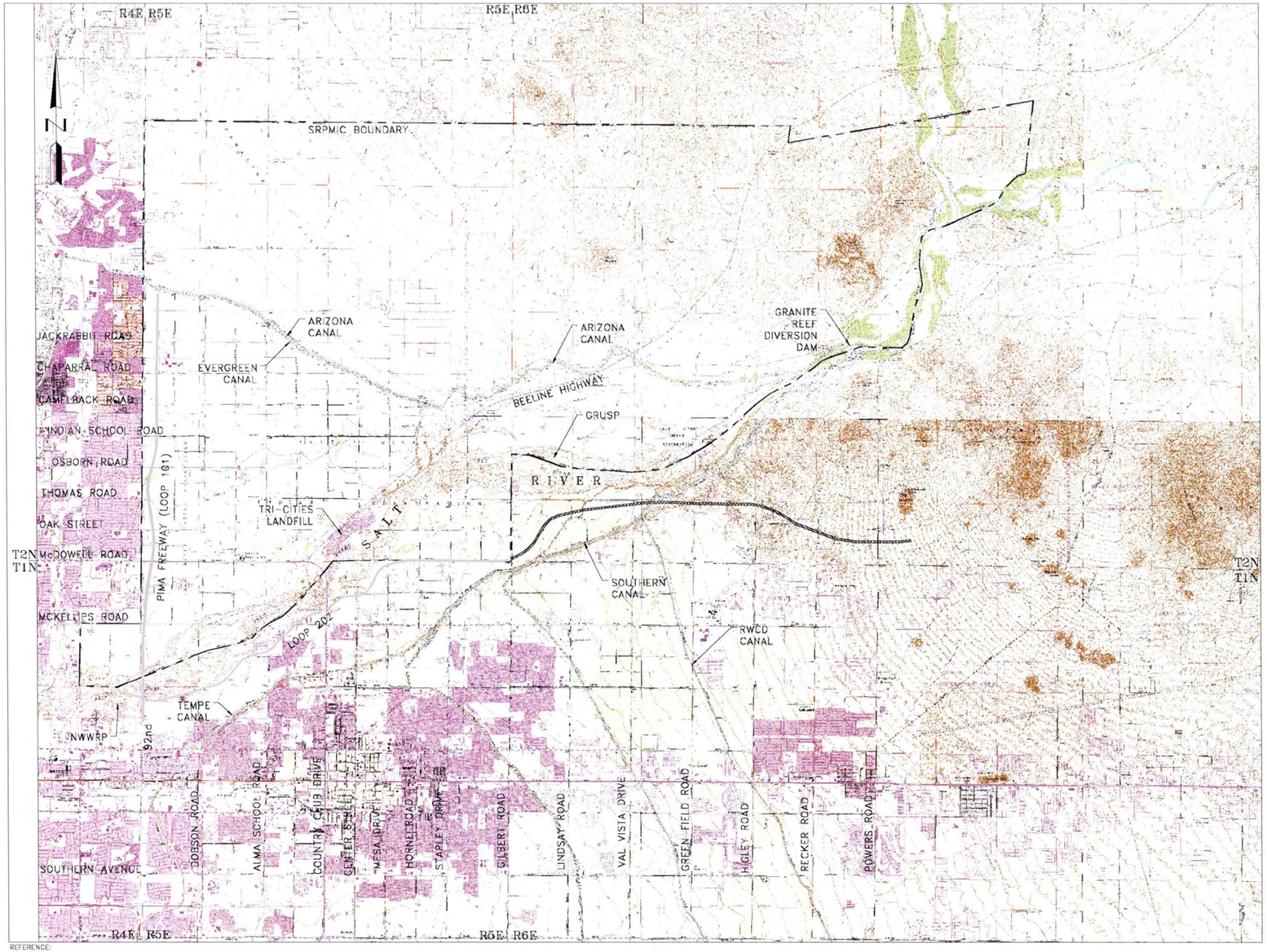
Knight Piésold, 2002, "Task 3 JAB01.J Groundwater Model – 80 Percent Completion Report."

Lluria, M., 2002, pers. comm.., GRUSP Hydrogeologist, Salt River Project.

Ramirez, A., 2002, pers. comm., Salt River Pima-Maricopa Indian Community, Cultural & Environmental Services, Environmental Engineer, Water Quality

Roche, M., and A. Ramirez, 2002, pers. comm., Salt River Pima-Maricopa Indian Community, May.

Schnidli, R.J., 1996, Climate of Phoenix, Arizona: An Abridged On-line Version of NOAA Technical memorandum NWS WR-177, Weather Service Forecast Office, Phoenix, Arizona.



REFERENCE:

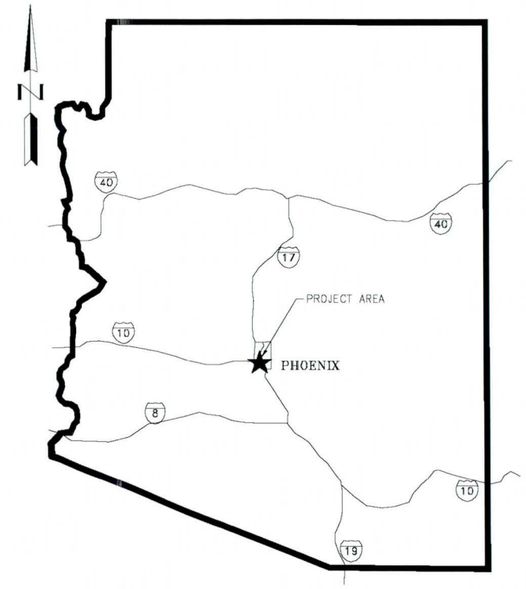
1) ECOPLAN ASSOCIATES, INC., WELLHEAD MANAGEMENT STRATEGY, IDENTIFICATION OF LOW RISK AREAS FOR SITING OF NEW WELLS AND/OR MODIFICATION OF EXISTING WELLS AS DOMESTIC WELLS, APRIL 2001.

2) TETRA TECH, INC., CITY OF MESA EXISTING AND CURRENTLY PROPOSED STORM DRAINAGE SYSTEM, SEPTEMBER 1999.

3) ECOPLAN, ASSOCIATES, INC., SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1998.

VICINITY MAP

5000 0 5000 10,000 FEET



LOCATION MAP
NTS

LEGEND:

RWCD	ROOSEVELT WATER CONSERVATION DISTRICT
GRUSP	GRANITE REEF UNDERGROUND STORAGE PROJECT
SRPMIC	SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
NWWRP	NORTH WEST WATER RECLAMATION PLANT
SRP	SALT RIVER PROJECT
ADWR	ARIZONA DEPARTMENT OF WATER RESOURCES

CLIENT: SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY

PROJECT: SALT RIVER RESTORATION FEASIBILITY STUDY

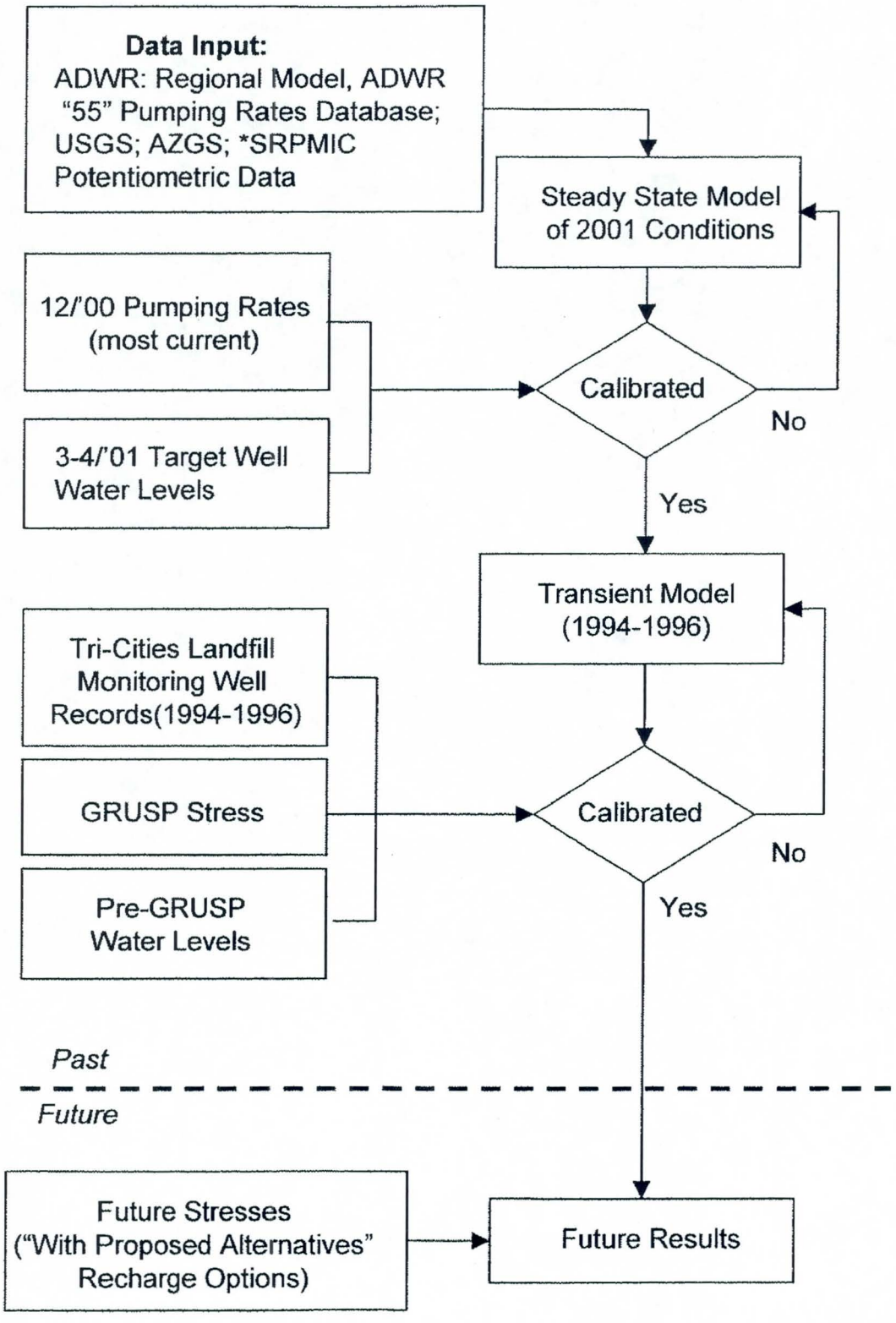
TITLE: PROJECT LOCATION MAP

Knight Piésold CONSULTING

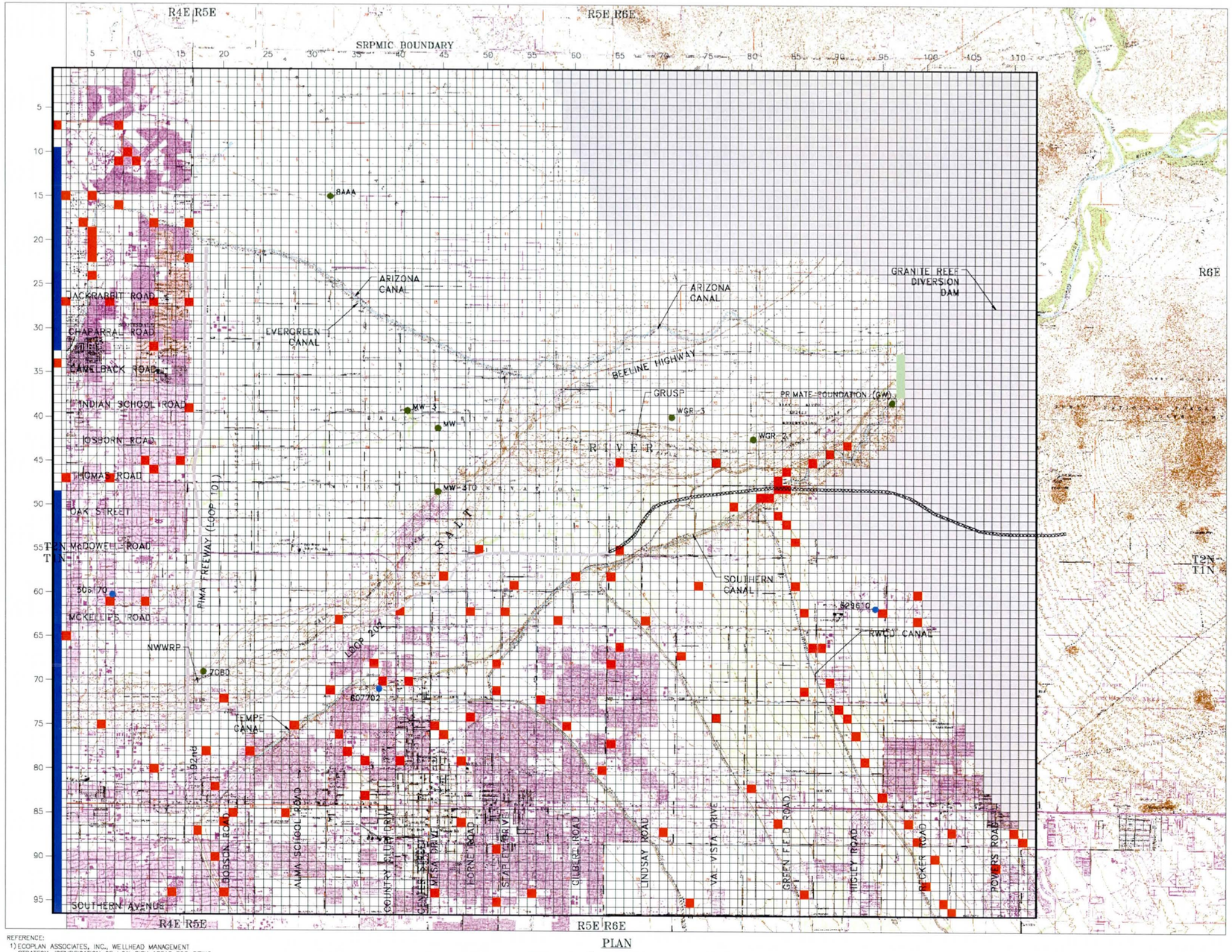
DESIGNED BY	MDS	CHECKED BY		DATE	DRAWING No.	FIGURE No.	REV.
DRAWN BY	WA	APPROVED BY	SAO	5/24/02	1889M10A	1-1	A

PLOT SCALE: 1:2 | XREF NO M2A X03

Figure 3-1. Flow Chart of Groundwater Modeling Approach



* Salt River Pima-Maricopia Indian Community



PLAN

4000 0 4000 8000 FEET

REFERENCE:

1) ECOPLAN ASSOCIATES, INC., WELLHEAD MANAGEMENT STRATEGY, IDENTIFICATION OF LOW RISK AREAS FOR STING OF NEW WELLS AND/OR MODIFICATION OF EXISTING WELLS AS DOMESTIC WELLS, APRIL 2001.

2) TETRA TECH, INC., CITY OF MESA EXISTING AND CURRENTLY PROPOSED STORM DRAINAGE SYSTEM, SEPTEMBER 1999.

3) ECOPLAN, ASSOCIATES, INC., SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1998.

PLOT SCALE 1:2 XREF NO1 XO2 XO3

LEGEND:

- GENERAL HEAD
- CONSTANT HEAD
- PUMPING WELL
- REFINED GROUNDWATER MODEL AREA BOUNDARY
- FINITE DIFFERENCE GRID (5 x 5)
- MW-3TC — COMMUNITY WELL CALIBRATION TARGET
- 629610 — ADWR MONITORING WELL CALIBRATION TARGET
- INACTIVE CELLS

RWCD	ROOSEVELT WATER CONSERVATION DISTRICT
GRUSP	GRANITE REEF UNDERGROUND STORAGE PROJECT
SRPMIC	SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
NWWRP	NORTH WEST WATER RECLAMATION PLANT
SRP	SALT RIVER PROJECT
ADWR	ARIZONA DEPARTMENT OF WATER RESOURCES

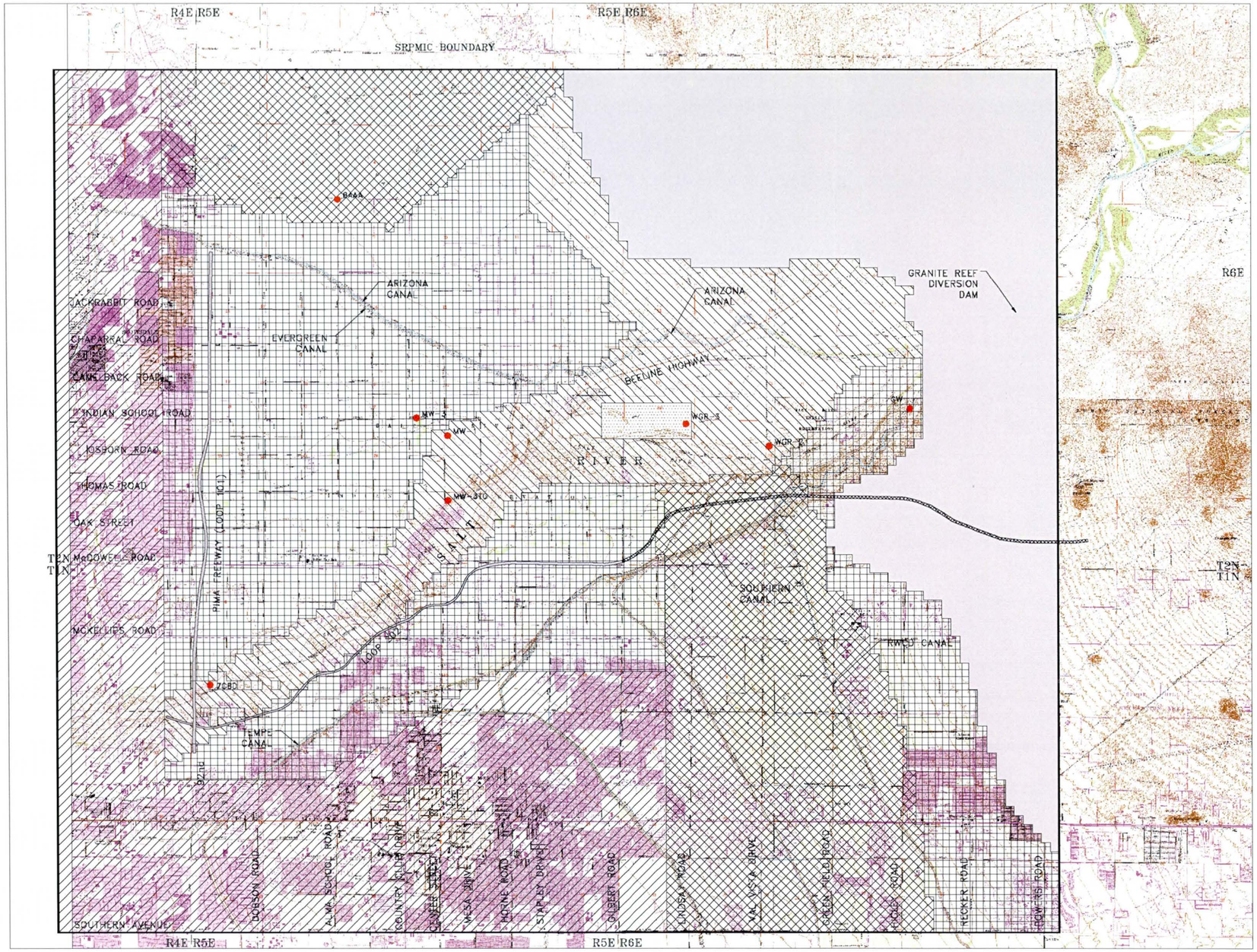
CLIENT: SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY

PROJECT: SALT RIVER RESTORATION FEASIBILITY STUDY

TITLE: REFINED GROUNDWATER MODEL AREA, FINITE DIFFERENCE GRID, BOUNDARY CONDITIONS, CALIBRATION TARGETS AND WELLS

Knight Piésold CONSULTING

DESIGNED BY	MDS	CHECKED BY		DATE	DRAWING No.	FIGURE No.	REV.
DRAWN BY	WA	APPROVED BY	SAD	5/24/02	1889M08A	3-2	A



PLAN

4000 0 4000 8000 FEET

LEGEND:

- REFINED GROUNDWATER MODEL AREA BOUNDARY
- URBAN
- OPEN SPACE – NO RECHARGE
- MIXED AGRICULTURE/RESIDENTIAL
- AGRICULTURE
- GRUSP
- NWWRP
- INACTIVE CELLS

RWCD	ROOSEVELT WATER CONSERVATION DISTRICT
GRUSP	GRANITE REEF UNDERGROUND STORAGE PROJECT
SRPMIC	SALT RIVER PIMA–MARICOPA INDIAN COMMUNITY
NWWRP	NORTH WEST WATER RECLAMATION PLANT
SRP	SALT RIVER PROJECT
MW–3TC	COMMUNITY WELL CALIBRATION TARGET

REFERENCE:

1) ECOPLAN ASSOCIATES, INC., WELLHEAD MANAGEMENT STRATEGY, IDENTIFICATION OF LOW RISK AREAS FOR SITING OF NEW WELLS AND/OR MODIFICATION OF EXISTING WELLS AS DOMESTIC WELLS, APRIL 2001.

2) TETRA TECH, INC., CITY OF MESA EXISTING AND CURRENTLY PROPOSED STORM DRAINAGE SYSTEM, SEPTEMBER 1999.

3) ECOPLAN, ASSOCIATES, INC., SALT RIVER PIMA–MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1998.

XREF NO1 X02 X03

PLOT SCALE 1:2

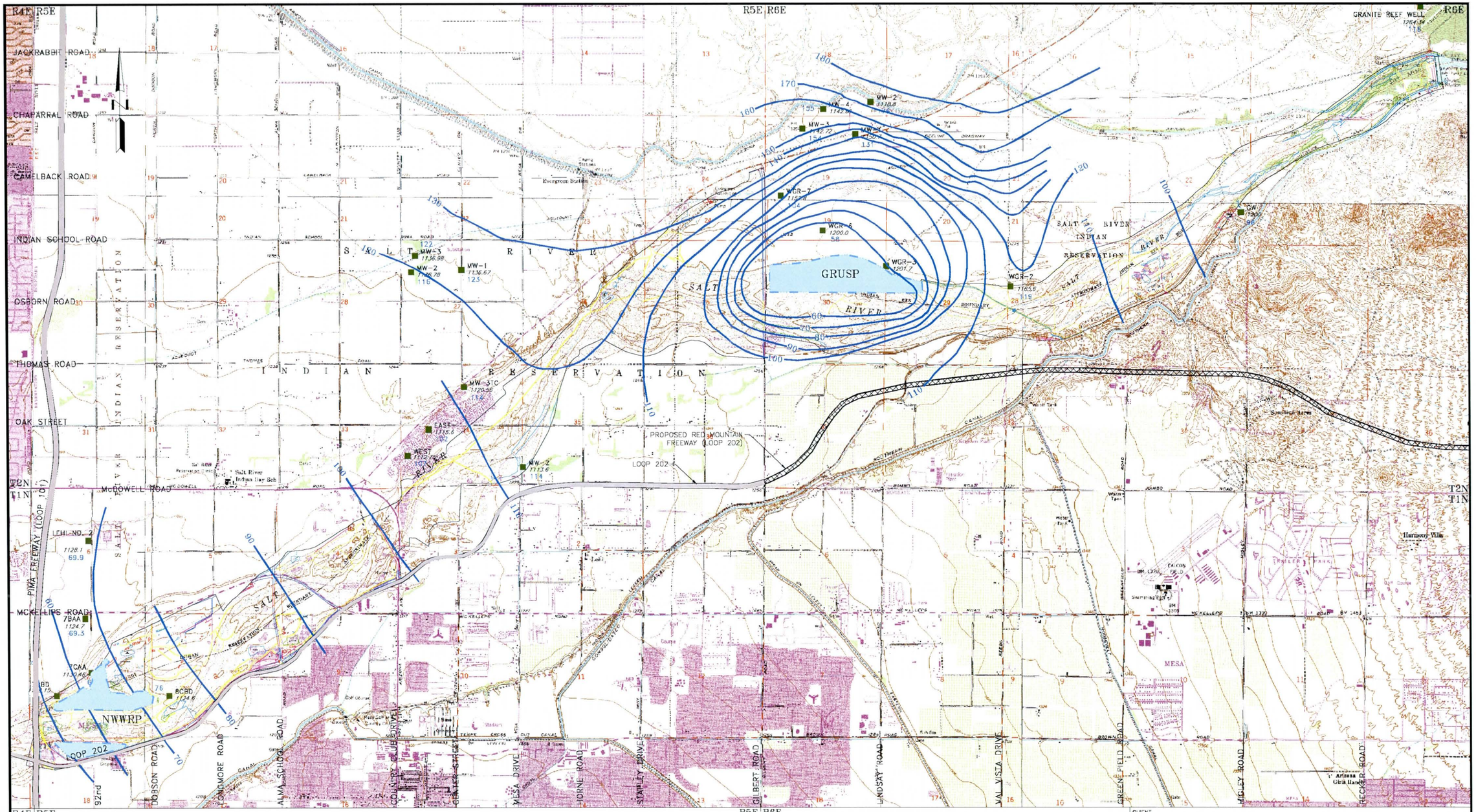
CLIENT: SALT RIVER PIMA–MARICOPA INDIAN COMMUNITY

PROJECT: SALT RIVER RESTORATION FEASIBILITY STUDY

TITLE: REFINED GROUNDWATER MODEL AREA, RECHARGE ZONE MAP

Knight Piésold CONSULTING

DESIGNED BY	MDS	CHECKED BY		DATE	DRAWING No.	FIGURE No.	REV.
DRAWN BY	WA	APPROVED BY	SAO	6/27/02	1889M07B	3–3	B



R4E R5E

R5E R6E

REFERENCE:

1) ECOPLAN ASSOCIATES, INC., WELLHEAD MANAGEMENT STRATEGY, IDENTIFICATION OF LOW RISK AREAS FOR SITING OF NEW WELLS AND/OR MODIFICATION OF EXISTING WELLS AS DOMESTIC WELLS, APRIL 2001.

2) TETRA TECH, INC., CITY OF MESA EXISTING AND CURRENTLY PROPOSED STORM DRAINAGE SYSTEM, SEPTEMBER 1999.

3) ECOPLAN, ASSOCIATES, INC., SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1998.

LEGEND:

110	CONTOUR OF ESTIMATED DEPTH TO GROUNDWATER
MW-2 113.6	MONITORING WELL WITH DESIGNATION AND GROUNDWATER ELEVATION (FEET ABOVE SEA LEVEL)
69.9	DEPTH TO GROUNDWATER (FEET BELOW GROUND SURFACE)

RWCD	ROOSEVELT WATER CONSERVATION DISTRICT
GRUSP	GRANITE REEF UNDERGROUND STORAGE PROJECT
SRPMIC	SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
NWWRP	NORTH WEST WATER RECLAMATION PLANT
SRP	SALT RIVER PROJECT

PLAN

2000 0 2000 4000 FEET

CLIENT: SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY

PROJECT: SALT RIVER RESTORATION FEASIBILITY STUDY

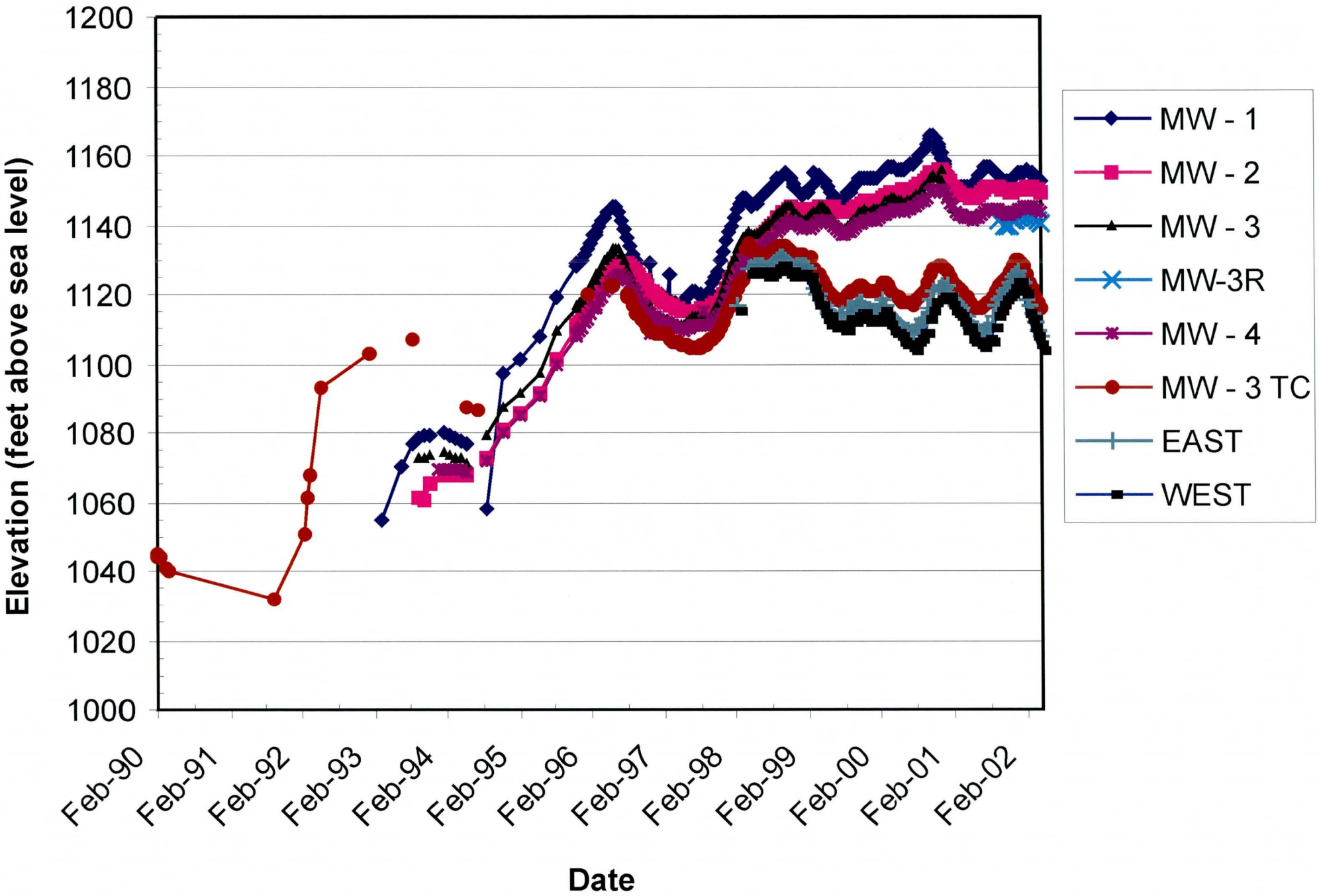
TITLE: DEPTH TO GROUNDWATER MAP (MARCH - APRIL, 2001 DATA)

Knight Piésold CONSULTING

DESIGNED BY	MDS	CHECKED BY		DATE	DRAWING No.	FIGURE No.	REV.
DRAWN BY	WA	APPROVED BY	SAD	6/27/02	1889M01B	3-4	B

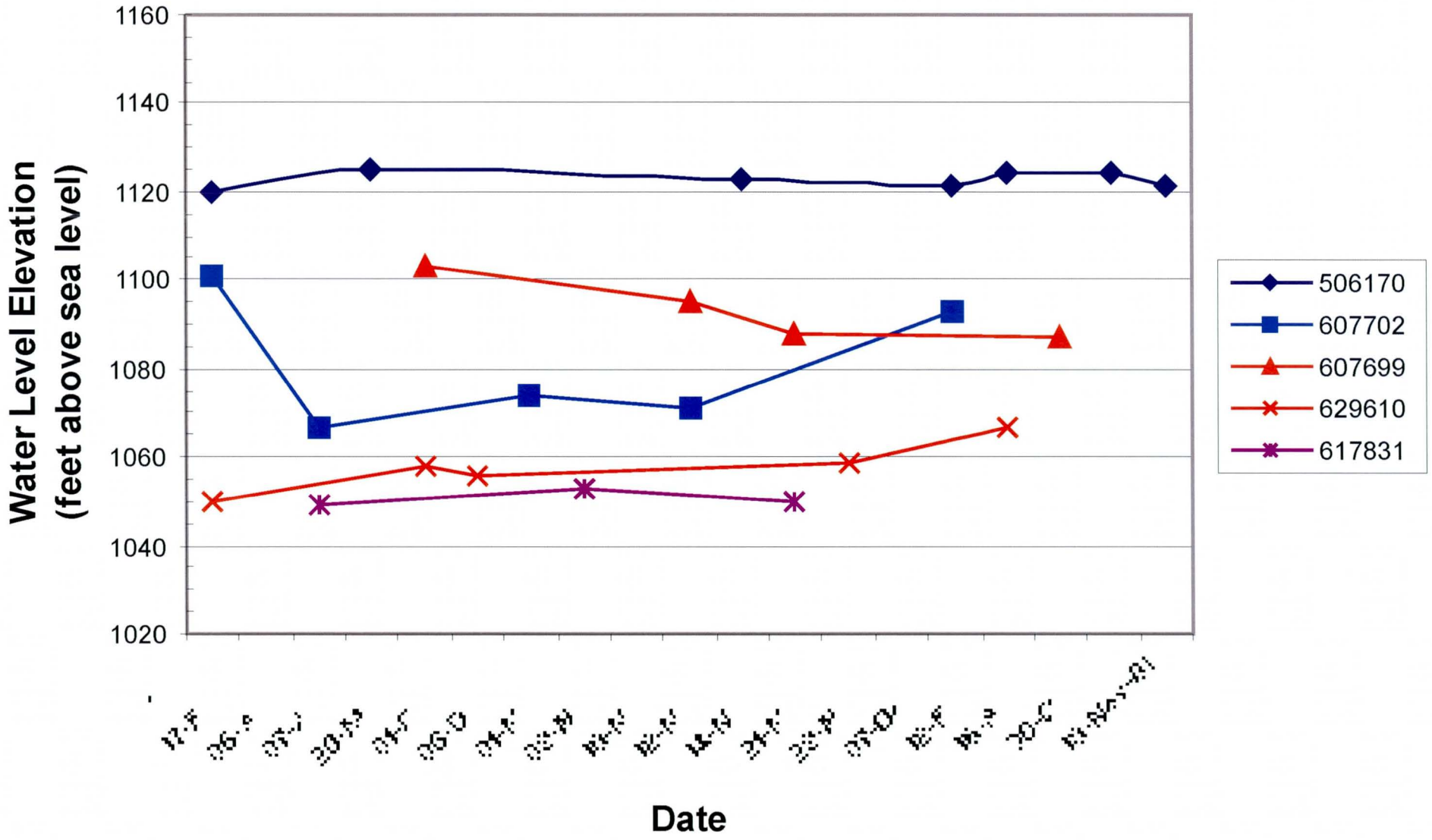
PLOT SCALE 1:2 XREF: NO XRD, XIM3

Figure 3-5. Hydrographs for Tri Cities Landfill Monitoring Wells

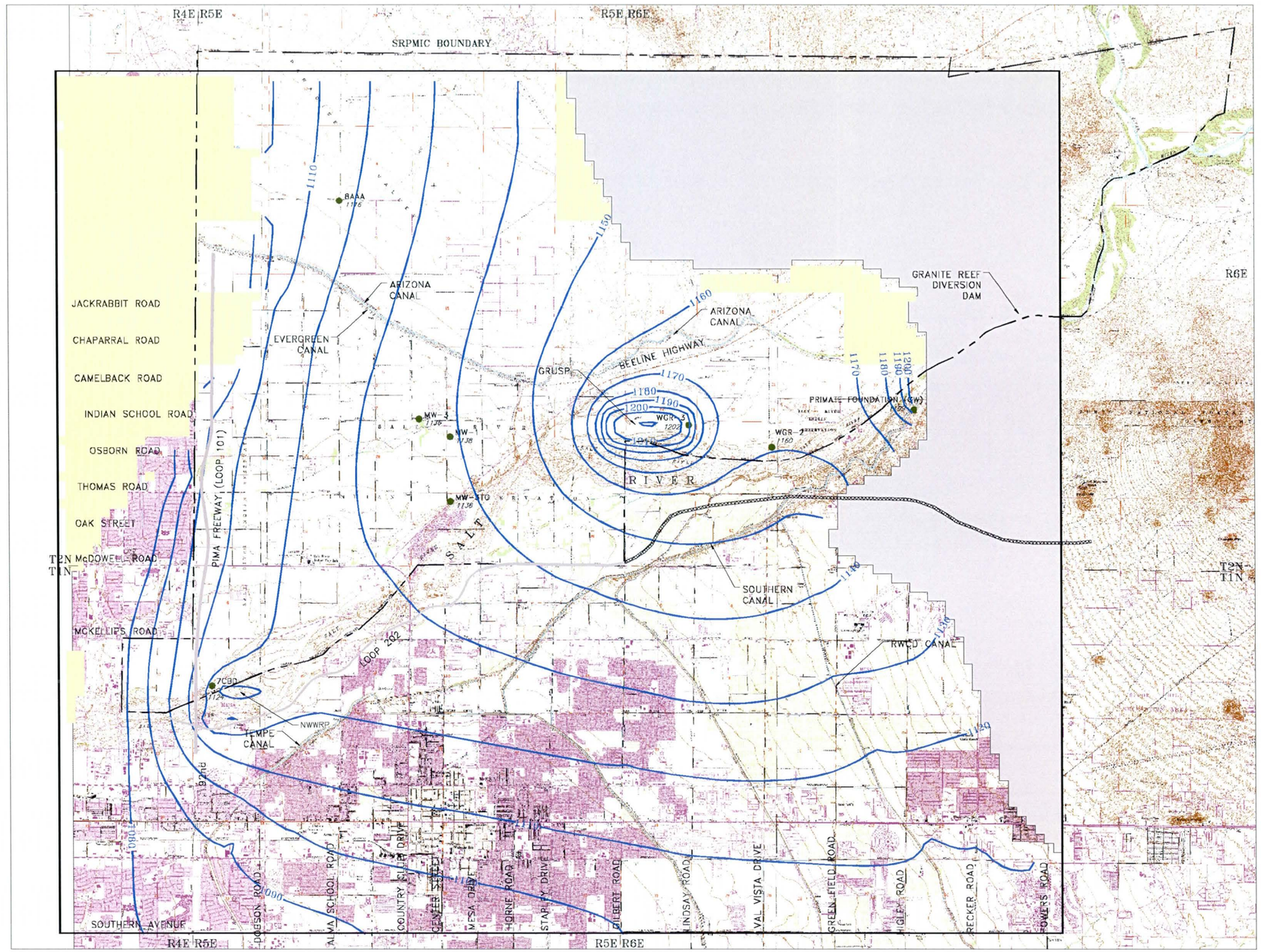


TriCities Landfill GWELEVS.xls Hydrograph form

Figure 3-6. Hydrographs for ADWR Monitoring Wells



MichaelSWaterLevels.xls



PLAN

4000 0 4000 8000 FEET

REFERENCE:

1) ECOPLAN ASSOCIATES, INC., WELLHEAD MANAGEMENT STRATEGY, IDENTIFICATION OF LOW RISK AREAS FOR SITING OF NEW WELLS AND/OR MODIFICATION OF EXISTING WELLS AS DOMESTIC WELLS, APRIL 2001.

2) TETRA TECH, INC., CITY OF MESA EXISTING AND CURRENTLY PROPOSED STORM DRAINAGE SYSTEM, SEPTEMBER 1999.

3) ECOPLAN, ASSOCIATES, INC., SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1998.

LEGEND:

- 1120 — POTENTIOMETRIC SURFACE CONTOURS IN UPPER ALLUVIAL UNIT (FEET ABOVE SEA LEVEL)
- REFINED GROUNDWATER MODEL AREA BOUNDARY
- MW-3TC 1136 — CALIBRATION TARGET AND COMPUTED WATER LEVEL IN FEET
- DRY CELLS
- INACTIVE CELLS
- RWCD — ROOSEVELT WATER CONSERVATION DISTRICT
- GRUSP — GRANITE REEF UNDERGROUND STORAGE PROJECT
- SRPMIC — SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
- NWWRP — NORTH WEST WATER RECLAMATION PLANT
- SRP — SALT RIVER PROJECT

CLIENT: SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY

PROJECT: SALT RIVER RESTORATION FEASIBILITY STUDY

TITLE: STEADY-STATE POTENTIOMETRIC SURFACE IN UPPER ALLUVIAL UNIT

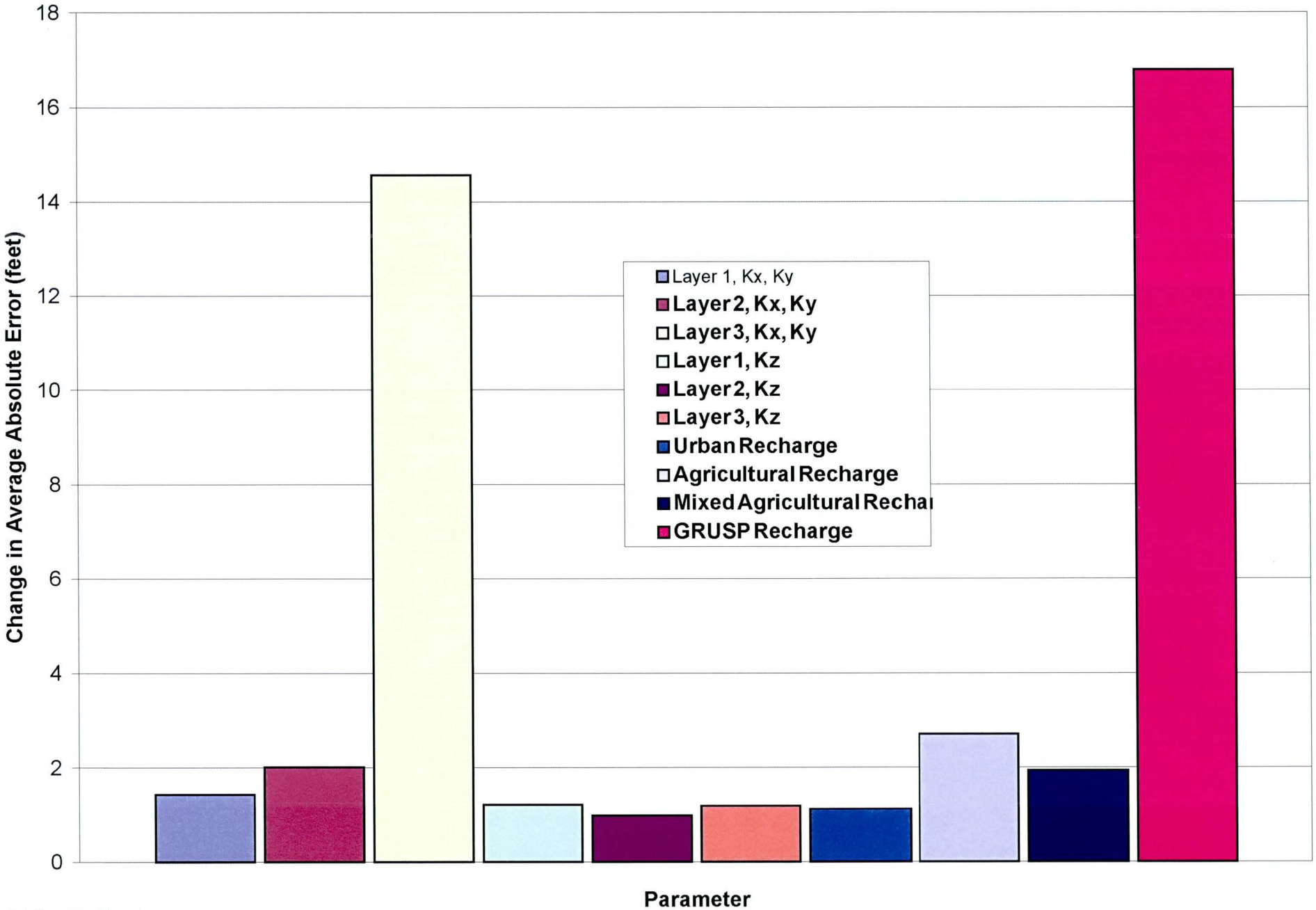
Knight Piésold CONSULTING

DESIGNED BY	MDS	CHECKED BY		DATE	DRAWING No.	FIGURE No.	REV.
DRAWN BY	WA	APPROVED BY	SAD	5/24/02	1889M09A	4-1	A

XREF NO1 X12 X03

PLOT SCALE 1:2

Figure 4-2. Sensitivity Analysis for 50% Increase in Groundwater Model Input Parameters



Sensitivity results.xls

Appendix A

Water Level Records

Appendix A.
Monitoring Well Water Levels, SRPMIC*
(February-May, 2001 Record Period)

MONITORING WELL	EASTING	NORTHING	DATE:	ELEVATION (FT)	GROUND ELEVATION (FT)	GROUNDWATER DEPTH (FT)
WEST	723944	898612	5/29/2001	1112.75	1220	107
Lehi No.2	710107	894965	2/18/2001	1128.10	1198	70
7BAA	709951	891580	4/6/2001	1124.70	1194	69
7CAA	710211	889254	4/6/2001	1130.46	1195	65
7CBD	708723	888262	3/1/2001	1129.15	1180	51
8CBD	713584	888262	3/1/2001	1124.60	1201	76
MW-2 (North of River)	724145	906546	3/9/2001	1136.78	1253	116
MW-3	724313	907251	3/21/2001	1136.98	1259	122
MW-1	726321	906638	3/21/2001	1136.67	1260	123
MW-3TC	726398	901581	3/29/2001	1120.56	1235	114
EAST	724850	899744	3/29/2001	1115.60	1218	102
MW-2 (South of River)	728934	898127	3/9/2001	1113.60	1228	114
8AAA	721084	923884	3/21/2001	1120.75	1308	187
MW-2 (North of GRUSP)	744076	913871	3/01	1118.80	1295	176
MW-4 (GRUSP area)	742002	913562	3/01	1142.60	1298	155
MW-3 (GRUSP area)	741127	912713	3/01	1142.72	1297	154
MW-1 (GRUSP area)	743416	912471	3/01	1150.70	1282	131
WGR-7	740170	909832	3/01	1152.80	1257	104
WGR-6	741962	908338	3/29/2001	1200.00	1258	58
WGR-3	744722	906776	3/29/2001	1201.70	1262	60
WGR-2	750121	905905	3/29/2001	1165.60	1285	119
GRANITE-REEF-WELL	767967	917960	3/1/2001	1264.34	1380	116
Primate Foundation (GW)	760132	909113	3/01	1200.00	1296	96

* Data Souce: "March/April" 2001 Regional Groundwater Map of SRPMIC, from Abel Ramirez, May, 2002

Appendix A.

ADWR Monitoring Well Water Levels

	Well No.*				
Date:	**506170**	**607702**	**607699**	**629610**	**617831**
17-Feb-98	1120				
06-Apr-98				1050	
07-Apr-98		1101			
20-May-98	1125				
01-Dec-98		1067	1103		1055
08-Dec-98				1058	
01-Nov-99				1056	
02-Nov-99					1049
10-Nov-99		1074			
12-Nov-99			1095		
14-Nov-00	1123				
21-Nov-00		1071	1088		
22-Nov-00					1053
07-Dec-00				1059	
12-Feb-01	1121				
16-Aug-01	1124				
30-Oct-01		1093	1087	1067	1050
13-Nov-01	1124				
13-Feb-02	1121				

***Well Location**

Well No.	Town	Range	Section	160	40	10
506170	1N	4E	1	NW	SE	NE
607702	1N	5E	9	SE	SW	SE
607699	1N	5E	26	SE	SE	SE
629610	1N	6E	3	NE	SE	SE
617831	1N	6E	21	NW	SW	SW

Appendix A.

Tri-Cities Landfill Monitoring Well Water Levels (Elevation-Feet)

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
2/22/1990						1044.00		
2/27/1990						1045.00		
3/1/1990						1043.80		
4/5/1990						1041.10		
4/17/1990						1040.20		
9/25/1991						1032.00		
3/4/1992						1050.70		
3/20/1992						1061.40		
3/30/1992						1067.90		
5/28/1992						1093.30		
2/2/1993						1102.60		
Apr-93	1054.45							
Jul-93	1070.57							
Sep-93	1076.53					1107.30		
Oct-93	1078.43	1061.40	1072.59					
Nov-93	1079.39	1060.66	1072.86					
Dec-93	1078.93	1065.58	1073.46					
Jan-94					1069.52			
Feb-94	1079.81	1067.59	1074.04		1069.40			
Mar-94	1079.15	1067.37	1073.66		1069.56			
Apr-94	1078.34	1067.56	1073.01		1069.33			
May-94	1077.87	1068.14	1072.61		1069.22			
Jun-94	1076.67	1067.81	1071.41		1068.47	1087.00		
Jul-94						1086.80		
Sep-94	1058.08	1072.90	1079.12		1072.16			
Dec-94	1097.46	1080.65	1087.62		1080.38			
Mar-95	1101.62	1086.04	1091.14		1085.05			
Jun-95	1107.56	1091.36	1097.52		1090.22			
Sep-95	1119.41	1100.91	1109.31		1099.42			
12/1/1995	1128.47	1109.93	1116.01		1107.50			
12/12/1995	1129.08	1110.96	1116.68		1108.31			
12/15/1996	1129.20	1111.12	1116.95		1108.66			
12/29/1995	1128.92	1112.12	1117.41		1109.54			
1/12/1996	1129.56	1113.09	1117.98		1110.45			
1/25/1996	1131.27	1114.38	1119.15		1111.58			
2/6/1996						1119.80		
2/9/1996	1133.03	1115.78	1120.67		1112.89			
2/23/1996	1134.80	1116.99	1122.11		1114.12			
3/8/1996	1136.82	1118.47	1124.04		1115.72			
3/12/1996	1137.08	1118.63	1124.47		1115.97			

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
3/21/1996	1138.33	1119.50	1125.53		1116.89			
4/4/1996	1139.71	1120.72	1126.91		1118.10			
4/18/1996	1141.02	1122.03	1128.26		1119.43			
5/1/1996	1141.99	1123.28	1129.39		1120.45			
5/17/1996	1143.27	1124.74	1130.61		1121.87			
5/29/1996						1122.30		
5/31/1996	1144.32	1126.01	1131.66		1123.04			
6/13/1996	1145.02	1126.98	1132.49		1123.82			
6/14/1996	1145.24	1127.26	1132.69		1124.20			
6/18/1996						1122.20		
6/28/1996	1145.21	1128.27	1133.13		1125.05			
7/12/1996	1143.85	1128.98	1132.69		1125.63			
7/26/1996	1141.63	1129.21	1131.36		1125.65			
8/9/1996	1138.95	1129.07	1129.54		1125.05			
8/20/1996						1119.90		
8/23/1996	1136.41	1128.67	1127.55		1124.18	1119.56		
9/5/1996	1134.06	1128.14	1125.59		1123.10	1118.92		
9/20/1996	1131.21	1127.33	1123.46		1121.80	1116.92		
9/30/1996	1129.43	1126.57	1121.98		1119.06			
10/3/1996	1129.06	1126.58	1121.61		1120.63	1114.45		
10/17/1996	1126.80	1125.47	1119.64		1119.15	1113.95		
11/1/1996	1124.53	1124.28	1117.88		1117.75	1112.66		
11/5/1996						1112.50		
11/14/1996	1124.07	1123.69	1116.89		1116.69	1111.70		
11/27/1996	1121.55	1122.18	1115.26		1115.31	1110.35		
12/13/1996	1120.12	1120.93	1113.93		1114.12	1109.31		
12/26/1996	1120.61	1120.48	1113.78		1113.66	1109.18		
12/31/1996	1120.35	1119.84	1113.52		1113.09			
1/10/1997	1120.73	1119.61	1113.74		1113.07	1108.80		
1/24/1997	1120.13	1118.88	1113.32		1112.44	1108.45		
2/7/1997	1119.63	1118.33	1112.99		1112.20	1108.28		
2/21/1997	1119.04	1117.78	1112.51		1111.72	1108.18		
2/24/1997						1108.60		
3/7/1997	1118.65	1117.63	1112.38		1111.64	1108.21		
3/19/1997	1125.32	1116.93	1111.81		1111.07			
3/21/1997	1118.15	1117.13	1112.03		1111.25	1106.90		
4/3/1997	1117.65	1116.58	1111.54		1110.80	1106.29		
4/16/1997	1117.27	1116.20	1111.24		1110.50	1106.27		
4/30/1997	1117.04	1115.86	1110.99		1110.20	1106.25		
5/16/1997	1116.68	1115.38	1110.72		1109.80	1105.67		
5/22/1997						1105.17		
5/29/1997	1117.58	1115.26	1110.97		1109.76	1105.08		
6/11/1997	1118.99	1115.10	1111.72		1109.85			

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
6/13/1997	1119.23	1115.21	1111.89		1109.94	1105.07		
6/26/1997	1119.87	1115.03	1112.31		1110.05	1104.20		
7/11/1997	1120.60	1115.43	1113.09		1110.63	1104.34		
7/24/1997	1120.62	1115.49	1113.18		1110.71	1104.44		
8/8/1997	1120.34		1113.34		1111.11	1104.17		
8/21/1997	1119.75	1115.61	1112.66		1110.80	1104.60		
8/28/1997						1105.00		
9/5/1997	1119.45	1115.78	1112.51		1110.82	1104.98		
9/15/1997	1119.26	1115.73	1112.40		1114.90			
9/19/1997	1119.20	1115.86	1112.34		1110.91	1105.60		
10/2/1997	1119.22	1115.71	1112.09		1110.67	1106.00		
10/16/1997	1121.00	1116.08	1112.94		1111.03	1106.94		
10/30/1997	1123.20	1116.47	1114.16		1111.53	1107.30		
11/13/1997	1124.94	1117.20	1115.70		1112.47	1107.93		
11/25/1997	1126.85	1117.84	1117.12		1113.30	1108.36		
11/27/1996						1110.30		
12/11/1997	1129.57	1118.57	1119.11		1114.48			
12/11/1997	1129.56	1118.70	1119.22		1114.52	1110.15		
12/26/1997	1132.50	1120.38	1121.84		1116.56	1112.13		
1/8/1998	1135.40	1122.03	1124.34		1118.65	1114.30		
1/23/1998	1137.77	1123.73	1126.89		1120.51	1116.18		
2/6/1998	1139.80	1125.26	1128.73		1122.48	1117.70		
2/19/1998	1141.85	1127.14	1130.75		1124	1119.22		
3/3/1998						1121.72	1116.8	1115.4
3/5/1998	1144.67	1129.13	1133.2		1126.3	1122.15		
3/19/1998	1146.08	1130.4	1135.08		1127.68	1123.39		
4/1/1998	1147.6	1132.11	1136.73		1129.43	1124.40		
4/17/1998	1147.54	1133.17	1137.49		1130.76	1133.01		
4/30/1998	1147.05	1134.22	1137.81		1131.68	1134.85	1127.27	1125.55
5/15/1998	1145.47	1134.58	1136.85		1131.92	1133.15	1127.68	1126.2
5/29/1998	1145.9	1135.47	1137.06		1132.36	1132.25	1128.15	1126.04
6/2/1998						1132.10	1127.8	1126.7
6/11/1998	1146.19	1135.93	1137.12		1132.59			
6/12/1998	1146.4	1135.93	1137.09		1132.5	1131.55	1127.94	1125.75
6/26/1998	1147.42	1136.51	1137.74		1133.27	1131.20	1127.81	1126.53
7/10/1998	1148.6	1137.51	1138.61		1133.75	1131.14	1127.85	1125.42
7/24/1998	1149.2	1138.25	1139.34		1134.4	1131	1127.68	1125.27
8/7/1998	1149.9	1139.07	1140.02		1135.24	1131.51	1127.65	1125.24
8/14/1998						1131.7	1127.7	1126.6
8/21/1998	1150.75	1139.72	1140.74		1136.02	1131.77	1127.97	1125.6
9/4/1998	1151.77	1140.64	1141.72		1136.72	1132.77	1129.23	1126.82
9/16/1998	1152.36	1141.29	1142.32		1137.57	1133.4	1129.97	1127.53
9/23/1998	1153.18	1141.89	1142.9		1138.12			

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
10/1/1998	1153.49	1142.23	1143.29		1138.45	1133.98	1130.47	1128
10/15/1998	1154.35	1143.37	1144.42		1139.4	1133.9	1130.51	1127.85
10/29/1998	1155.15	1143.74	1145.19		1140.13	1133.55	1129.43	1126.55
11/13/1998	1154.5	1144.28	1145.14		1140.7	1132.66	1128.58	1125.95
11/25/1998	1153.85	1144.93	1144.99		1141	1132.11	1127.78	1125.1
11/30/1998						1132.4	1127.6	1126.3
12/11/1998	1151.53	1144.74	1143.51		1140.38	1131.8	1127.68	1125.24
12/16/1998	1150.94	1144.68	1143.36		1140.51			
12/23/1998	1150.2	1144.43	1142.74		1140.3	1131.57	1128.11	1125.42
1/8/1999	1149.2	1144.04	1141.89		1139.85	1131.1	1127.98	1125.52
1/22/1999	1148.53	1143.64	1141.19		1139.12	1131.06	1127.97	1125.64
2/5/1999	1149.01	1143.8	1141.25		1139.28	1130.94	1128.23	1125.14
2/19/1999	1149.55	1144.13	1142.24		1139.43	1130.13	1127.13	1124.55
2/24/1999						1130.1	1125.4	1124.2
3/5/1999	1150.87	1143.97	1142.67		1139.16	1130.27	1124.17	1121.62
3/17/1999	1154.78	1144.1	1143.09		1139.83			
3/19/1999	1151.54	1143.87	1143.46		1139.78	1127	1121.69	1118.81
4/5/1999	1153	1144.61	1143.94		1140.36	1125.75	1119.99	1116.8
4/15/1999	1154.21	1145.24	1144.91		1141.11	1126.05	1120.28	1117.07
4/29/1999	1153.69	1145.63	1145.05		1141.51	1124.45	1117.93	1114.45
5/14/1999	1152.38	1145.68	1144.39		1141.56	1122.25	1116.33	1112.69
5/28/1999	1151.05	1145.58	1143.49		1140.92	1120.75	1114.23	1110.77
5/31/1999						1121.2	1115	1113.1
6/11/1999	1149.6	1145.33	1142.04		1140.17	1119.77	1114.35	1111.12
6/24/1999	1148.15	1144.73	1140.89		1139.58			
6/25/1999	1148.44	1145.08	1140.69		1139.9	1119.26	1113.78	1110.27
7/9/1999	1146.9	1143.94	1139.69		1138.75	1118.16	1112.98	1109.87
7/23/1999	1146.64	1143.6	1138.9		1137.98	1118.05	1113.16	1109.88
8/6/1999	1146.82	1143.6	1138.61		1137.51	1118.59	1114.29	1111.16
8/20/1999	1147	1143.42	1138.86		1137.26	1117.91	1112.84	1109.47
9/3/1999	1148.05	1143.36	1139.03		1137.48	1117.89	1112.95	1109.53
9/17/1999	1149.01	1143.59	1139.69		1138	1119.7	1115.57	1112.43
9/24/1999	1149.61	1143.86	1140.17		1138.09			
10/1/1999	1150.27	1143.99	1140.74		1138.14	1120.41	1115.68	1112.57
10/14/1999	1151.08	1144.26	1141.24		1138.71	1120.53	1115.53	1112.17
10/28/1999	1152.19	1144.97	1142.14		1139.35	1121.3	1116.78	1113.7
11/11/1999	1153.65	1145.63	1143.27		1140.12	1122.25	1117.48	1114.13
11/23/1999	1153.5	1145.74	1143.73		1140.53	1122.37	1117.59	1114.48
12/8/1999	1153.41	1146.48	1144.12		1141.15			
12/9/1999	1153.24	1146.67	1143.72		1140.98	1121.31	1116.11	1112.85
12/22/1999	1153.12	1146.48	1144.02		1141.19	1121.14	1115.19	1111.89
1/7/2000	1153.21	1146.91	1143.76		1141.5	1121.03	1115.39	1112.4
1/21/2000	1153.3	1147.03	1144.35		1141.65	1120.7	1115.21	1111.66

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
2/2/2000	1153.55	1146.88	1144.09		1141.49	1121	1115.18	1111.66
2/18/2000	1154	1147.17	1144.74		1141.79	1121.9	1116.36	1113.13
3/3/2000	1155.06	1147.53	1145.44		1142.52	1123.66	1118.37	1115.18
3/15/2000	1156.08	1148.46	1146.54		1143.3			
3/17/2000	1155.67	1148.13	1146.15		1143.05	1123.41	1117.13	1113.62
3/29/2000	1156.57	1148.73	1146.96		1143.57	1122.2	1114.68	1110.8
4/13/2000	1156.8	1149.15	1147.38		1144.03	1121.13	1113.28	1109.27
4/27/2000	1156.4	1149.45	1147.44		1144.3	1120.19	1112.25	1108.42
5/11/2000	1156.18	1149.48	1147.1		1144.32	1119.45	1112.08	1108.22
5/18/2000						1119	1110.6	1107.8
5/24/2000	1156.11	1149.66	1146.71		1144.28	1118.73	1111.34	1107.65
6/8/2000	1156.12	1149.92	1146.76		1144.25	1117.93	1109.96	1105.99
6/22/2000	1156.1	1149.77	1146.53		1144.06	1117.42	1109.47	1105.37
7/5/2000	1156.7	1150.08	1146.73		1144.3	1117.7	1109.74	1105.63
7/21/2000	1157.6	1150.38	1147.28		1144.6	1117.29	1108.68	1104.48
8/3/2000	1157.82	1150.28	1147.63		1144.94	1116.97	1108.28	1103.72
8/17/2000	1158.56	1151.08	1148.33		1145.11	1117.99	1110.08	1105.92
8/31/2000	1159.9	1151.5	1148.96		1145.83	1118.86	1110.93	1106.82
9/14/2000	1160.8	1151.88	1150.13		1146.6	1120.35	1112.51	1108.26
9/27/2000	1162.03	1152.35	1150.77		1147.1	1121.11	1112.98	1108.85
10/12/2000	1163.63	1153.52	1152.19		1148.09	1123.35	1116.08	1112.29
10/24/2000	1164.92							
10/25/2000	1165.25							
10/26/2000	1165.3	1154.7	1153.82		1149.67	1125.6	1118.61	1114.78
10/27/2000	1165.56							
10/30/2000	1165.6							
10/31/2000	1165.53							
11/1/2000	1165.3							
11/2/2000	1165.55							
11/3/2000	1165.59							
11/6/2000	1165.63							
11/7/2000	1165.45							
11/8/2000	1165.2	1155.15	1154.51		1150.1	1127.48	1120.98	1117.42
11/9/2000	1165.37							
11/10/2000	1165.46							
11/13/2000	1164.96							
11/14/2000	1165.1							
11/15/2000	1165							
11/16/2000	1164.82							
11/17/2000	1164.56							
11/20/2000	1164.51							
11/21/2000	1164.5							
11/22/2000	1164.38							

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
11/27/2000	1163.96							
11/28/2000	1163.8							
11/30/2000	1163.7							
12/1/2000	1163.36							
12/4/2000	1163.02							
12/5/2000	1163.12							
12/6/2000	1162.83							
12/7/2000	1162.78	1156.01	1153.57		1150.53	1128.05	1121.95	1118.61
12/8/2000	1162.73							
12/11/2000	1162.06							
12/14/2000	1161.61							
12/18/2000	1160.68							
12/21/2000	1160.75	1155.73	1152.28		1150.2	1128.03	1122.43	1119.18
12/21/2000	1160.6	1155.87	1155.56		1150.18			
12/28/2000	1159.28							
1/2/2001	1158.1							
1/4/2001	1158.05	1154.86	1150.44		1149.06	1127.35	1122.02	1118.9
1/8/2001	1157.43							
1/11/2001	1156.81							
1/15/2001	1156.15							
1/18/2001	1155.5	1153.69	1148.22		1147.69	1126.9	1122.05	1119.09
1/22/2001	1154.8							
1/25/2001	1154.12							
1/29/2001	1153.43							
2/1/2001	1152.9	1152.63	1146.26		1146.25	1125.27	1120.28	1117.01
2/8/2001	1151.73							
2/15/2001	1150.37	1151.08	1144.43		1144.94	1123.56	1118.22	1115
3/1/2001	1149.76	1150.21	1143.31		1143.86	1122.52	1117.39	1114.13
3/5/2001						1122.5	1116.6	1114.6
3/15/2001	1149.35	1149	1142.73		1142.83	1121.75	1116.81	1113.67
3/22/2001	1150.18	1148.98	1143.14		1142.75			
3/29/2001	1150.65	1148.73	1142.72		1142.55	1120.64	1115.69	1112.15
4/12/2001	1150.85	1148.4	1142.86		1142.28	1119.26	1113.23	1109.64
4/26/2001	1150.88	1148.32	1142.79		1142.22	1118.87	1113.33	1109.99
5/10/2001	1150.28	1148.31	1141.91		1141.79	1117.65	1111.49	1108.15
5/24/2001	1150.87	1148			1141.74	1116.81	1110.53	1106.88
6/7/2001	1151.43	1147.86			1141.49	1115.97	1110.07	1106.35
6/19/2001	1152.85	1148.42			1142.05			
6/21/2001	1152.53	1148			1141.72	1116.04	1109.49	1105.96
7/5/2001	1154.12	1148.53			1142.2	1115.8	1108.78	1105.07
7/19/2001	1155.38	1149.35			1142.97	1115.97	1108.93	1104.87
8/2/2001	1156.57	1150.06			1143.74	1116.77	1109.76	1105.82
8/16/2001	1156.99	1150.65			1144.41	1117.6	1110.79	1106.94

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
8/30/2001	1156.55	1151.23			1144.76	1117.2	1109.78	1106.02
9/13/2001	1155.62	1151.21			1144.76	1119.07	1113.65	1110.07
9/27/2001	1154.75	1151.08			1144.46	1120.86	1116.34	1113.17
10/3/2001	1154.5	1151.2		1140.84	1144.48			
10/11/2001	1153.91	1150.83			1144.1	1122.16	1118.31	1115.37
10/25/2001	1153.4	1150.41			1143.88	1123.1	1119.59	1116.4
11/8/2001	1152.94	1150.21		1139.66	1143.4	1124.1	1120.93	1118.07
11/20/2001	1152.53	1149.83		1139.7	1143.2	1125.2	1121.88	1119.22
12/6/2001	1152.6	1149.73		1139.86	1143.1	1126.48	1123.18	1120.27
12/20/2001	1153.56	1149.69		1140.83	1143.41	1128.37	1124.83	1121.9
12/31/2001	1154.3	1149.98		1141.61	1143.94			
1/3/2002	1154.35	1149.82		1141.62	1143.8	1129.47	1125.83	1123.12
1/17/2002	1154.81	1149.97		1142.26	1144.2	1129.82	1126.16	1123.37
1/31/2002	1154.82	1149.95		1142.56	1144.42	1128.8	1124.31	1121.17
2/14/2002	1155.39	1150.55		1143.26	1144.9	1128.45	1123.18	1119.94
2/28/2002	1155.55	1150.81		1143.52	1145.35	1125.34	1118.39	1114.59
3/14/2002	1155.16	1150.72		1143.26	1145.25	1123.46	1116.41	1112.62
3/28/2002	1154.71	1150.64		1142.83	1145.05	1121.53	1114.14	1110.24
4/11/2002	1154.12	1150.36		1142.27	1144.72	1119.55	1111.91	1107.92
4/25/2002	1153.51	1150.08		1141.45	1144.32	1117.55	1109.71	1105.55
5/9/2002	1152.85	1149.73		1140.71	1143.79	1115.64	1107.74	1103.62

Data Source: Ramirez, May, 2002

Appendix B

Pumping Well Records

Appendix A.

Tri-Cities Landfill Monitoring Well Water Levels (Elevation-Feet)

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
2/22/1990						1044.00		
2/27/1990						1045.00		
3/1/1990						1043.80		
4/5/1990						1041.10		
4/17/1990						1040.20		
9/25/1991						1032.00		
3/4/1992						1050.70		
3/20/1992						1061.40		
3/30/1992						1067.90		
5/28/1992						1093.30		
2/2/1993						1102.60		
Apr-93	1054.45							
Jul-93	1070.57							
Sep-93	1076.53					1107.30		
Oct-93	1078.43	1061.40	1072.59					
Nov-93	1079.39	1060.66	1072.86					
Dec-93	1078.93	1065.58	1073.46					
Jan-94					1069.52			
Feb-94	1079.81	1067.59	1074.04		1069.40			
Mar-94	1079.15	1067.37	1073.66		1069.56			
Apr-94	1078.34	1067.56	1073.01		1069.33			
May-94	1077.87	1068.14	1072.61		1069.22			
Jun-94	1076.67	1067.81	1071.41		1068.47	1087.00		
Jul-94						1086.80		
Sep-94	1058.08	1072.90	1079.12		1072.16			
Dec-94	1097.46	1080.65	1087.62		1080.38			
Mar-95	1101.62	1086.04	1091.14		1085.05			
Jun-95	1107.56	1091.36	1097.52		1090.22			
Sep-95	1119.41	1100.91	1109.31		1099.42			
12/1/1995	1128.47	1109.93	1116.01		1107.50			
12/12/1995	1129.08	1110.96	1116.68		1108.31			
12/15/1996	1129.20	1111.12	1116.95		1108.66			
12/29/1995	1128.92	1112.12	1117.41		1109.54			
1/12/1996	1129.56	1113.09	1117.98		1110.45			
1/25/1996	1131.27	1114.38	1119.15		1111.58			
2/6/1996						1119.80		
2/9/1996	1133.03	1115.78	1120.67		1112.89			
2/23/1996	1134.80	1116.99	1122.11		1114.12			
3/8/1996	1136.82	1118.47	1124.04		1115.72			
3/12/1996	1137.08	1118.63	1124.47		1115.97			

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
3/21/1996	1138.33	1119.50	1125.53		1116.89			
4/4/1996	1139.71	1120.72	1126.91		1118.10			
4/18/1996	1141.02	1122.03	1128.26		1119.43			
5/1/1996	1141.99	1123.28	1129.39		1120.45			
5/17/1996	1143.27	1124.74	1130.61		1121.87			
5/29/1996						1122.30		
5/31/1996	1144.32	1126.01	1131.66		1123.04			
6/13/1996	1145.02	1126.98	1132.49		1123.82			
6/14/1996	1145.24	1127.26	1132.69		1124.20			
6/18/1996						1122.20		
6/28/1996	1145.21	1128.27	1133.13		1125.05			
7/12/1996	1143.85	1128.98	1132.69		1125.63			
7/26/1996	1141.63	1129.21	1131.36		1125.65			
8/9/1996	1138.95	1129.07	1129.54		1125.05			
8/20/1996						1119.90		
8/23/1996	1136.41	1128.67	1127.55		1124.18	1119.56		
9/5/1996	1134.06	1128.14	1125.59		1123.10	1118.92		
9/20/1996	1131.21	1127.33	1123.46		1121.80	1116.92		
9/30/1996	1129.43	1126.57	1121.98		1119.06			
10/3/1996	1129.06	1126.58	1121.61		1120.63	1114.45		
10/17/1996	1126.80	1125.47	1119.64		1119.15	1113.95		
11/1/1996	1124.53	1124.28	1117.88		1117.75	1112.66		
11/5/1996						1112.50		
11/14/1996	1124.07	1123.69	1116.89		1116.69	1111.70		
11/27/1996	1121.55	1122.18	1115.26		1115.31	1110.35		
12/13/1996	1120.12	1120.93	1113.93		1114.12	1109.31		
12/26/1996	1120.61	1120.48	1113.78		1113.66	1109.18		
12/31/1996	1120.35	1119.84	1113.52		1113.09			
1/10/1997	1120.73	1119.61	1113.74		1113.07	1108.80		
1/24/1997	1120.13	1118.88	1113.32		1112.44	1108.45		
2/7/1997	1119.63	1118.33	1112.99		1112.20	1108.28		
2/21/1997	1119.04	1117.78	1112.51		1111.72	1108.18		
2/24/1997						1108.60		
3/7/1997	1118.65	1117.63	1112.38		1111.64	1108.21		
3/19/1997	1125.32	1116.93	1111.81		1111.07			
3/21/1997	1118.15	1117.13	1112.03		1111.25	1106.90		
4/3/1997	1117.65	1116.58	1111.54		1110.80	1106.29		
4/16/1997	1117.27	1116.20	1111.24		1110.50	1106.27		
4/30/1997	1117.04	1115.86	1110.99		1110.20	1106.25		
5/16/1997	1116.68	1115.38	1110.72		1109.80	1105.67		
5/22/1997						1105.17		
5/29/1997	1117.58	1115.26	1110.97		1109.76	1105.08		
6/11/1997	1118.99	1115.10	1111.72		1109.85			

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
6/13/1997	1119.23	1115.21	1111.89		1109.94	1105.07		
6/26/1997	1119.87	1115.03	1112.31		1110.05	1104.20		
7/11/1997	1120.60	1115.43	1113.09		1110.63	1104.34		
7/24/1997	1120.62	1115.49	1113.18		1110.71	1104.44		
8/8/1997	1120.34		1113.34		1111.11	1104.17		
8/21/1997	1119.75	1115.61	1112.66		1110.80	1104.60		
8/28/1997						1105.00		
9/5/1997	1119.45	1115.78	1112.51		1110.82	1104.98		
9/15/1997	1119.26	1115.73	1112.40		1114.90			
9/19/1997	1119.20	1115.86	1112.34		1110.91	1105.60		
10/2/1997	1119.22	1115.71	1112.09		1110.67	1106.00		
10/16/1997	1121.00	1116.08	1112.94		1111.03	1106.94		
10/30/1997	1123.20	1116.47	1114.16		1111.53	1107.30		
11/13/1997	1124.94	1117.20	1115.70		1112.47	1107.93		
11/25/1997	1126.85	1117.84	1117.12		1113.30	1108.36		
11/27/1996						1110.30		
12/11/1997	1129.57	1118.57	1119.11		1114.48			
12/11/1997	1129.56	1118.70	1119.22		1114.52	1110.15		
12/26/1997	1132.50	1120.38	1121.84		1116.56	1112.13		
1/8/1998	1135.40	1122.03	1124.34		1118.65	1114.30		
1/23/1998	1137.77	1123.73	1126.89		1120.51	1116.18		
2/6/1998	1139.80	1125.26	1128.73		1122.48	1117.70		
2/19/1998	1141.85	1127.14	1130.75		1124	1119.22		
3/3/1998						1121.72	1116.8	1115.4
3/5/1998	1144.67	1129.13	1133.2		1126.3	1122.15		
3/19/1998	1146.08	1130.4	1135.08		1127.68	1123.39		
4/1/1998	1147.6	1132.11	1136.73		1129.43	1124.40		
4/17/1998	1147.54	1133.17	1137.49		1130.76	1133.01		
4/30/1998	1147.05	1134.22	1137.81		1131.68	1134.85	1127.27	1125.55
5/15/1998	1145.47	1134.58	1136.85		1131.92	1133.15	1127.68	1126.2
5/29/1998	1145.9	1135.47	1137.06		1132.36	1132.25	1128.15	1126.04
6/2/1998						1132.10	1127.8	1126.7
6/11/1998	1146.19	1135.93	1137.12		1132.59			
6/12/1998	1146.4	1135.93	1137.09		1132.5	1131.55	1127.94	1125.75
6/26/1998	1147.42	1136.51	1137.74		1133.27	1131.20	1127.81	1126.53
7/10/1998	1148.6	1137.51	1138.61		1133.75	1131.14	1127.85	1125.42
7/24/1998	1149.2	1138.25	1139.34		1134.4	1131	1127.68	1125.27
8/7/1998	1149.9	1139.07	1140.02		1135.24	1131.51	1127.65	1125.24
8/14/1998						1131.7	1127.7	1126.6
8/21/1998	1150.75	1139.72	1140.74		1136.02	1131.77	1127.97	1125.6
9/4/1998	1151.77	1140.64	1141.72		1136.72	1132.77	1129.23	1126.82
9/16/1998	1152.36	1141.29	1142.32		1137.57	1133.4	1129.97	1127.53
9/23/1998	1153.18	1141.89	1142.9		1138.12			

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
10/1/1998	1153.49	1142.23	1143.29		1138.45	1133.98	1130.47	1128
10/15/1998	1154.35	1143.37	1144.42		1139.4	1133.9	1130.51	1127.85
10/29/1998	1155.15	1143.74	1145.19		1140.13	1133.55	1129.43	1126.55
11/13/1998	1154.5	1144.28	1145.14		1140.7	1132.66	1128.58	1125.95
11/25/1998	1153.85	1144.93	1144.99		1141	1132.11	1127.78	1125.1
11/30/1998						1132.4	1127.6	1126.3
12/11/1998	1151.53	1144.74	1143.51		1140.38	1131.8	1127.68	1125.24
12/16/1998	1150.94	1144.68	1143.36		1140.51			
12/23/1998	1150.2	1144.43	1142.74		1140.3	1131.57	1128.11	1125.42
1/8/1999	1149.2	1144.04	1141.89		1139.85	1131.1	1127.98	1125.52
1/22/1999	1148.53	1143.64	1141.19		1139.12	1131.06	1127.97	1125.64
2/5/1999	1149.01	1143.8	1141.25		1139.28	1130.94	1128.23	1125.14
2/19/1999	1149.55	1144.13	1142.24		1139.43	1130.13	1127.13	1124.55
2/24/1999						1130.1	1125.4	1124.2
3/5/1999	1150.87	1143.97	1142.67		1139.16	1130.27	1124.17	1121.62
3/17/1999	1154.78	1144.1	1143.09		1139.83			
3/19/1999	1151.54	1143.87	1143.46		1139.78	1127	1121.69	1118.81
4/5/1999	1153	1144.61	1143.94		1140.36	1125.75	1119.99	1116.8
4/15/1999	1154.21	1145.24	1144.91		1141.11	1126.05	1120.28	1117.07
4/29/1999	1153.69	1145.63	1145.05		1141.51	1124.45	1117.93	1114.45
5/14/1999	1152.38	1145.68	1144.39		1141.56	1122.25	1116.33	1112.69
5/28/1999	1151.05	1145.58	1143.49		1140.92	1120.75	1114.23	1110.77
5/31/1999						1121.2	1115	1113.1
6/11/1999	1149.6	1145.33	1142.04		1140.17	1119.77	1114.35	1111.12
6/24/1999	1148.15	1144.73	1140.89		1139.58			
6/25/1999	1148.44	1145.08	1140.69		1139.9	1119.26	1113.78	1110.27
7/9/1999	1146.9	1143.94	1139.69		1138.75	1118.16	1112.98	1109.87
7/23/1999	1146.64	1143.6	1138.9		1137.98	1118.05	1113.16	1109.88
8/6/1999	1146.82	1143.6	1138.61		1137.51	1118.59	1114.29	1111.16
8/20/1999	1147	1143.42	1138.86		1137.26	1117.91	1112.84	1109.47
9/3/1999	1148.05	1143.36	1139.03		1137.48	1117.89	1112.95	1109.53
9/17/1999	1149.01	1143.59	1139.69		1138	1119.7	1115.57	1112.43
9/24/1999	1149.61	1143.86	1140.17		1138.09			
10/1/1999	1150.27	1143.99	1140.74		1138.14	1120.41	1115.68	1112.57
10/14/1999	1151.08	1144.26	1141.24		1138.71	1120.53	1115.53	1112.17
10/28/1999	1152.19	1144.97	1142.14		1139.35	1121.3	1116.78	1113.7
11/11/1999	1153.65	1145.63	1143.27		1140.12	1122.25	1117.48	1114.13
11/23/1999	1153.5	1145.74	1143.73		1140.53	1122.37	1117.59	1114.48
12/8/1999	1153.41	1146.48	1144.12		1141.15			
12/9/1999	1153.24	1146.67	1143.72		1140.98	1121.31	1116.11	1112.85
12/22/1999	1153.12	1146.48	1144.02		1141.19	1121.14	1115.19	1111.89
1/7/2000	1153.21	1146.91	1143.76		1141.5	1121.03	1115.39	1112.4
1/21/2000	1153.3	1147.03	1144.35		1141.65	1120.7	1115.21	1111.66

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
2/2/2000	1153.55	1146.88	1144.09		1141.49	1121	1115.18	1111.66
2/18/2000	1154	1147.17	1144.74		1141.79	1121.9	1116.36	1113.13
3/3/2000	1155.06	1147.53	1145.44		1142.52	1123.66	1118.37	1115.18
3/15/2000	1156.08	1148.46	1146.54		1143.3			
3/17/2000	1155.67	1148.13	1146.15		1143.05	1123.41	1117.13	1113.62
3/29/2000	1156.57	1148.73	1146.96		1143.57	1122.2	1114.68	1110.8
4/13/2000	1156.8	1149.15	1147.38		1144.03	1121.13	1113.28	1109.27
4/27/2000	1156.4	1149.45	1147.44		1144.3	1120.19	1112.25	1108.42
5/11/2000	1156.18	1149.48	1147.1		1144.32	1119.45	1112.08	1108.22
5/18/2000						1119	1110.6	1107.8
5/24/2000	1156.11	1149.66	1146.71		1144.28	1118.73	1111.34	1107.65
6/8/2000	1156.12	1149.92	1146.76		1144.25	1117.93	1109.96	1105.99
6/22/2000	1156.1	1149.77	1146.53		1144.06	1117.42	1109.47	1105.37
7/5/2000	1156.7	1150.08	1146.73		1144.3	1117.7	1109.74	1105.63
7/21/2000	1157.6	1150.38	1147.28		1144.6	1117.29	1108.68	1104.48
8/3/2000	1157.82	1150.28	1147.63		1144.94	1116.97	1108.28	1103.72
8/17/2000	1158.56	1151.08	1148.33		1145.11	1117.99	1110.08	1105.92
8/31/2000	1159.9	1151.5	1148.96		1145.83	1118.86	1110.93	1106.82
9/14/2000	1160.8	1151.88	1150.13		1146.6	1120.35	1112.51	1108.26
9/27/2000	1162.03	1152.35	1150.77		1147.1	1121.11	1112.98	1108.85
10/12/2000	1163.63	1153.52	1152.19		1148.09	1123.35	1116.08	1112.29
10/24/2000	1164.92							
10/25/2000	1165.25							
10/26/2000	1165.3	1154.7	1153.82		1149.67	1125.6	1118.61	1114.78
10/27/2000	1165.56							
10/30/2000	1165.6							
10/31/2000	1165.53							
11/1/2000	1165.3							
11/2/2000	1165.55							
11/3/2000	1165.59							
11/6/2000	1165.63							
11/7/2000	1165.45							
11/8/2000	1165.2	1155.15	1154.51		1150.1	1127.48	1120.98	1117.42
11/9/2000	1165.37							
11/10/2000	1165.46							
11/13/2000	1164.96							
11/14/2000	1165.1							
11/15/2000	1165							
11/16/2000	1164.82							
11/17/2000	1164.56							
11/20/2000	1164.51							
11/21/2000	1164.5							
11/22/2000	1164.38							

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
11/27/2000	1163.96							
11/28/2000	1163.8							
11/30/2000	1163.7							
12/1/2000	1163.36							
12/4/2000	1163.02							
12/5/2000	1163.12							
12/6/2000	1162.83							
12/7/2000	1162.78	1156.01	1153.57		1150.53	1128.05	1121.95	1118.61
12/8/2000	1162.73							
12/11/2000	1162.06							
12/14/2000	1161.61							
12/18/2000	1160.68							
12/21/2000	1160.75	1155.73	1152.28		1150.2	1128.03	1122.43	1119.18
12/21/2000	1160.6	1155.87	1155.56		1150.18			
12/28/2000	1159.28							
1/2/2001	1158.1							
1/4/2001	1158.05	1154.86	1150.44		1149.06	1127.35	1122.02	1118.9
1/8/2001	1157.43							
1/11/2001	1156.81							
1/15/2001	1156.15							
1/18/2001	1155.5	1153.69	1148.22		1147.69	1126.9	1122.05	1119.09
1/22/2001	1154.8							
1/25/2001	1154.12							
1/29/2001	1153.43							
2/1/2001	1152.9	1152.63	1146.26		1146.25	1125.27	1120.28	1117.01
2/8/2001	1151.73							
2/15/2001	1150.37	1151.08	1144.43		1144.94	1123.56	1118.22	1115
3/1/2001	1149.76	1150.21	1143.31		1143.86	1122.52	1117.39	1114.13
3/5/2001						1122.5	1116.6	1114.6
3/15/2001	1149.35	1149	1142.73		1142.83	1121.75	1116.81	1113.67
3/22/2001	1150.18	1148.98	1143.14		1142.75			
3/29/2001	1150.65	1148.73	1142.72		1142.55	1120.64	1115.69	1112.15
4/12/2001	1150.85	1148.4	1142.86		1142.28	1119.26	1113.23	1109.64
4/26/2001	1150.88	1148.32	1142.79		1142.22	1118.87	1113.33	1109.99
5/10/2001	1150.28	1148.31	1141.91		1141.79	1117.65	1111.49	1108.15
5/24/2001	1150.87	1148			1141.74	1116.81	1110.53	1106.88
6/7/2001	1151.43	1147.86			1141.49	1115.97	1110.07	1106.35
6/19/2001	1152.85	1148.42			1142.05			
6/21/2001	1152.53	1148			1141.72	1116.04	1109.49	1105.96
7/5/2001	1154.12	1148.53			1142.2	1115.8	1108.78	1105.07
7/19/2001	1155.38	1149.35			1142.97	1115.97	1108.93	1104.87
8/2/2001	1156.57	1150.06			1143.74	1116.77	1109.76	1105.82
8/16/2001	1156.99	1150.65			1144.41	1117.6	1110.79	1106.94

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
8/30/2001	1156.55	1151.23			1144.76	1117.2	1109.78	1106.02
9/13/2001	1155.62	1151.21			1144.76	1119.07	1113.65	1110.07
9/27/2001	1154.75	1151.08			1144.46	1120.86	1116.34	1113.17
10/3/2001	1154.5	1151.2		1140.84	1144.48			
10/11/2001	1153.91	1150.83			1144.1	1122.16	1118.31	1115.37
10/25/2001	1153.4	1150.41			1143.88	1123.1	1119.59	1116.4
11/8/2001	1152.94	1150.21		1139.66	1143.4	1124.1	1120.93	1118.07
11/20/2001	1152.53	1149.83		1139.7	1143.2	1125.2	1121.88	1119.22
12/6/2001	1152.6	1149.73		1139.86	1143.1	1126.48	1123.18	1120.27
12/20/2001	1153.56	1149.69		1140.83	1143.41	1128.37	1124.83	1121.9
12/31/2001	1154.3	1149.98		1141.61	1143.94			
1/3/2002	1154.35	1149.82		1141.62	1143.8	1129.47	1125.83	1123.12
1/17/2002	1154.81	1149.97		1142.26	1144.2	1129.82	1126.16	1123.37
1/31/2002	1154.82	1149.95		1142.56	1144.42	1128.8	1124.31	1121.17
2/14/2002	1155.39	1150.55		1143.26	1144.9	1128.45	1123.18	1119.94
2/28/2002	1155.55	1150.81		1143.52	1145.35	1125.34	1118.39	1114.59
3/14/2002	1155.16	1150.72		1143.26	1145.25	1123.46	1116.41	1112.62
3/28/2002	1154.71	1150.64		1142.83	1145.05	1121.53	1114.14	1110.24
4/11/2002	1154.12	1150.36		1142.27	1144.72	1119.55	1111.91	1107.92
4/25/2002	1153.51	1150.08		1141.45	1144.32	1117.55	1109.71	1105.55
5/9/2002	1152.85	1149.73		1140.71	1143.79	1115.64	1107.74	1103.62

Data Source: Ramirez, May, 2002

APPENDIX

E

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

GEOTECHNICAL

Contents

Page

1.0 Study purpose 4
2.0 Location 4
3.0 Land Usage 4
4.0 Regional setting 6
4.1 Physiography 6
4.2 Geology 7
4.3 Faulting 7
5.0 Study area 9
5.1 Physiography and topography 9
5.2 Geomorphology 9
5.2.1 Slope features 9
5.2.2 Channel shifts 10
5.2.3 Sediment transport 10
5.2.4 Stream sinuosity 10
5.2.5 Gradient 10
5.2.6 Bed sediments 10
5.2.7 Channel types 11
5.2.8 Terrace deposits 11
5.3 Geology 13
5.3.1 Geologic units 13
5.3.2 Geologic structure 14
5.3.3 Depth and nature of alluvium 14
5.3.4 River sediments 16
5.3.5 Depth to bedrock 16
6.0 Soils 17
7.0 Geohydrology and groundwater 17
7.1 Basins 17
7.2 Aquifers 18
7.3 Bedrock 19
7.4 Gradient 19
7.5 Depth to groundwater 20
7.6 Contamination of groundwater 20
8.0 HTRW 22
8.1 Specific sites assessed beyond the Phase I EA level, with regard to potential environmental impact on the study area 23
8.1.1 Talley Defense Systems site 23
8.1.1.1 Potential contaminants of concern, releases, pathways 24
8.1.1.2 Releases 24
8.1.1.2.1 Heavy metals in soils and analysis of risk to groundwater 27
8.1.1.2.2 Perchlorate in soils and risk to groundwater 28
8.1.1.2.3 Halogenated solvents and other wastes 33
8.1.1.3 Proximity to the study area and planned restoration features 33
8.1.1.4 Conclusions by Geology & Investigations regarding potential risks from Talley Defense Systems operations 34
8.1.2 Landfills 36
8.1.2.1 Recommended groundwater equilibrium conditions modeling 41
8.1.2.2 Increased proclivity to overbank flooding 45
8.1.3 Drum dump site 45
8.1.4 VOCs in groundwater, including the Indian Bend Wash Superfund sites 45
8.1.5 DBCP in groundwater 47
8.1.6 LUSTs 47
8.1.7 Minor TSD issues 49
8.1.8 Regulated materials use 50
9.0 Non-hazardous wastes 50
9.1 Concrete, cement, and asphalt dumps 56
9.2 Illegal dumps 56
9.3 Analysis of non-hazardous waste sites 56
10.0 Geologic hazards 56
10.1 Faulting and seismicity 56
10.2 Subsidence 57
10.3 Slope stability 58

Contents, contin.

Page

10.4 Foundation conditions ... 58
11.0 Sources of construction materials ... 58
11.1 Concrete Materials ... 59
11.2 Cement ... 60
11.3 Pozzolan ... 60
11.4 Admixtures ... 60
11.5 Water ... 60
11.6 Soil Cement ... 60
12.0 References ... 61

Figures

Fig. 1. Location of the Va Shly'ay Akimel study area ... 5
Fig. 2. Location of USACE projects and study areas along the Salt River ... 6
Fig. 3. Geologic map of the Phoenix Basin ... 8
Fig. 4. Diagrammatic transverse profile of paired terraces on the lower Salt River Valley ... 12
Fig. 5. Terraces of the Lower Salt River in the Va Shly'ay Akimel study area ... 12
Fig. 6. Salt River Valley generalized hydrogeologic cross-section ... 15
Fig. 7. Depth to bedrock in the lower Salt River Valley ... 16
Fig. 8. Talley defense Systems location ... 25
Fig. 9. Detail map of the burn pits, Talley Defense Systems ... 26
Fig. 10. Lead in soil, Talley Defense Systems burn pits ... 29
Fig. 11. Copper in soil, Talley Defense Systems burn pits ... 30
Fig. 12. Lead in soil, adjacent to Talley Defense Systems burn pits ... 32
Fig. 14. Geologic map of the burn pits, Talley Defense Systems ... 35
Fig. 15. Exposed landfill debris on the south bank, Salt River, in the study area ... 37
Fig. 16. Cypress landfill ... 38
Fig. 17. GRUSP groundwater recharge mound ... 42
Fig. 18. Treated wastewater recharge ponds ... 43
Fig. 19. Irrigation canal outlets ... 44
Fig. 20. DBCP in groundwater ... 48
Fig. 21. Non-hazardous waste locations in the study area ... 53
Fig. 22. Additional non-hazardous waste locations in the study area ... 54
Fig. 23. Detail map of non-hazardous wastes in the vicinity of Cypress landfill ... 55
Fig. A-1 Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses ... 80

Tables

Table 1. Geologic units of the Phoenix Basin ... 8
Table 2. Other wastes produced at Talley Defense Systems site ... 33
Table 3. Summary data on landfills in the study area ... 39
Table 4. Non-hazardous wastes and debris catalog, Va Shly'ay Akimel study area ... 51
Table A-1. Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses ... 67

Attachment

Attachment A. Assessment of sites of potential HTRW and non-hazardous waste concerns, with regard to each of the 30 study area Alternatives ... 64
A-1.1 Background ... 64
A-1.2 Overall study concepts and objectives ... 66
A-1.3 Summary of environmental concerns ... 66
A-1.4 Assessment of each study Alternative, in relation to environmental concerns ... 81
A-1.5. Non-hazardous wastes impacts with the footprint of Alternative O ... 92

1.0 Study Purpose. The U.S. Army Corps of Engineers Los Angeles District (USACE LAD), the Salt River Pima-Maricopa Indian Community (SRPMIC), and the City of Mesa have initiated this study to assess the feasibility of ecosystem restoration along the Salt River from Granite Reef Dam downstream to the Pima Freeway (SR 101).

This Geotechnical Appendix for the Feasibility Phase, post AFB ("AFB" is "alternative formulation briefing"), represents the initial and subsequent input to the study by the Corps' Geotechnical Branch with contribution by the Salt River Pima-Maricopa Indian Community and presents the existing geologic conditions of the Va Shly'ay Akimel study area.

2.0 Location. The Va Shly'ay Akimel[1] study area is located on the Salt River Pima-Maricopa Indian Community (SRPMIC), adjacent to the City of Mesa in Maricopa County, Arizona, 18 miles east of the City of Phoenix (see Figure 1). The area is approximately 14 miles long and 2 miles wide, centered on the Salt River, and comprises approximately 17,435 acres. The upstream boundary of the Va Shly'ay Akimel study area is Granite Reef Dam. From here the study area extends southwest to the Pima Freeway (SR 101). The Rio Salado Phoenix environmental restoration project area lies downstream to the west, and extends to about one mile from the western limit of the study area.

3.0 Land Usage. The proposed Va Shly'ay Akimel project activities will occur mostly within the Salt River floodplain. However the study area encompasses overbank lands north and south of the river. The majority of the central and eastern portions of the study area that are located directly north of the Salt River is a combination of natural preserve areas and agricultural lands (USACE, 2002). The west and central portions of the study area south of the river are largely made up of very low density rural residential areas to higher density suburban residential areas. Industrial and commercial development, with some agricultural uses, has a strong influence on land use patterns in the eastern portion of the study area. Four gravel mining operations are located along the Salt River, with processing operations occurring along its banks. The river contains a large groundwater recharge basin in the central portion of the study area. Also along the banks of the river are located two closed landfills, a shooting range, a recreational vehicle park, private farms, and a commercial golf course. The land uses throughout the study area are within the boundaries of the following local government jurisdictions:

- County of Maricopa,
- City of Mesa, and
- Salt River Pima-Maricopa Indian Community (SRPMIC).

The land area north of the Salt River is within the SRPMIC. The SRPMIC lands extend to the south side of the river in places, but this area is mostly within the City's jurisdiction, along with several isolated areas of unincorporated Maricopa County. There are no Federally-owned lands within the study area.

[1] meaning, "the River People"

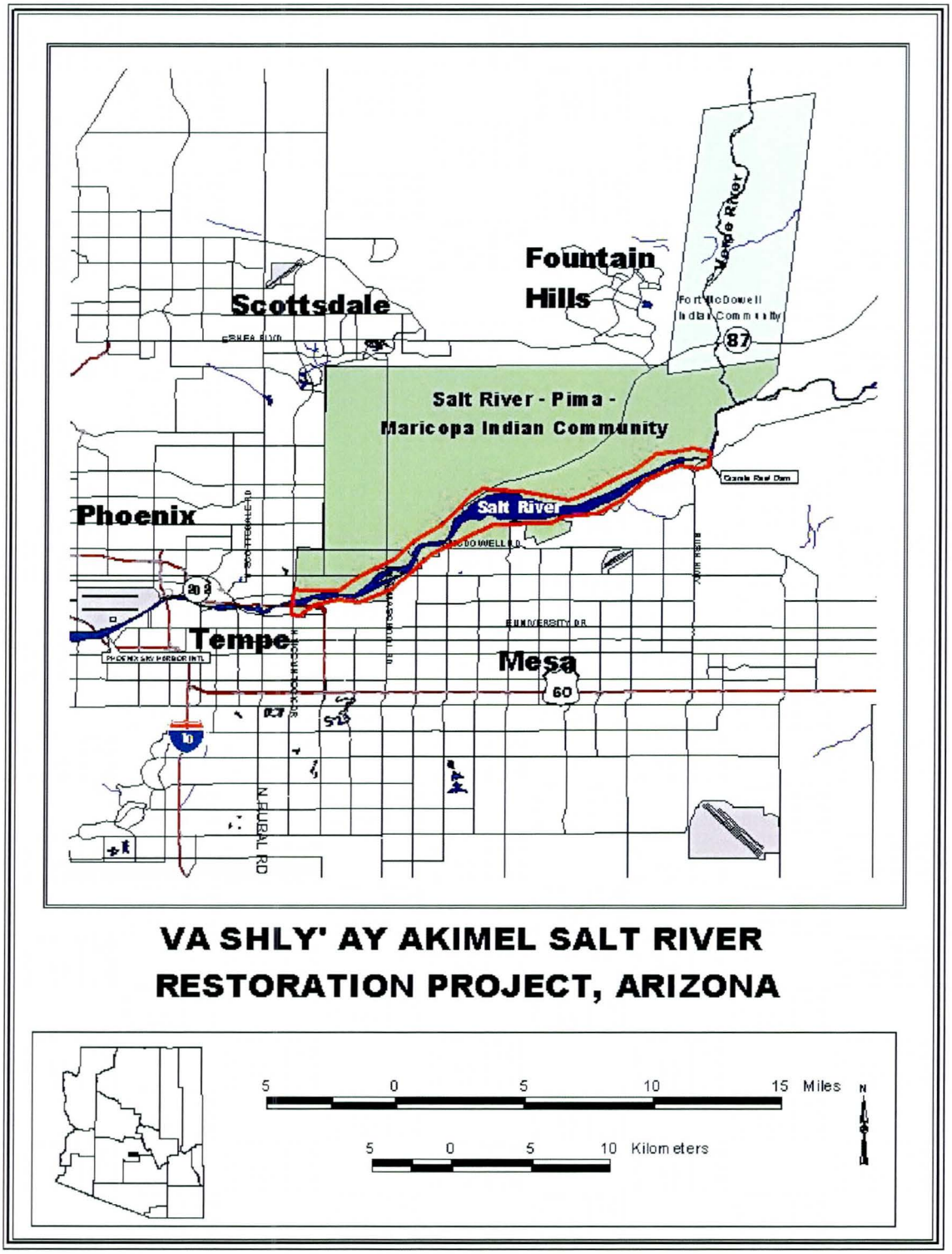


Figure 1. Location of the Va Shly'ay Akimel study area.

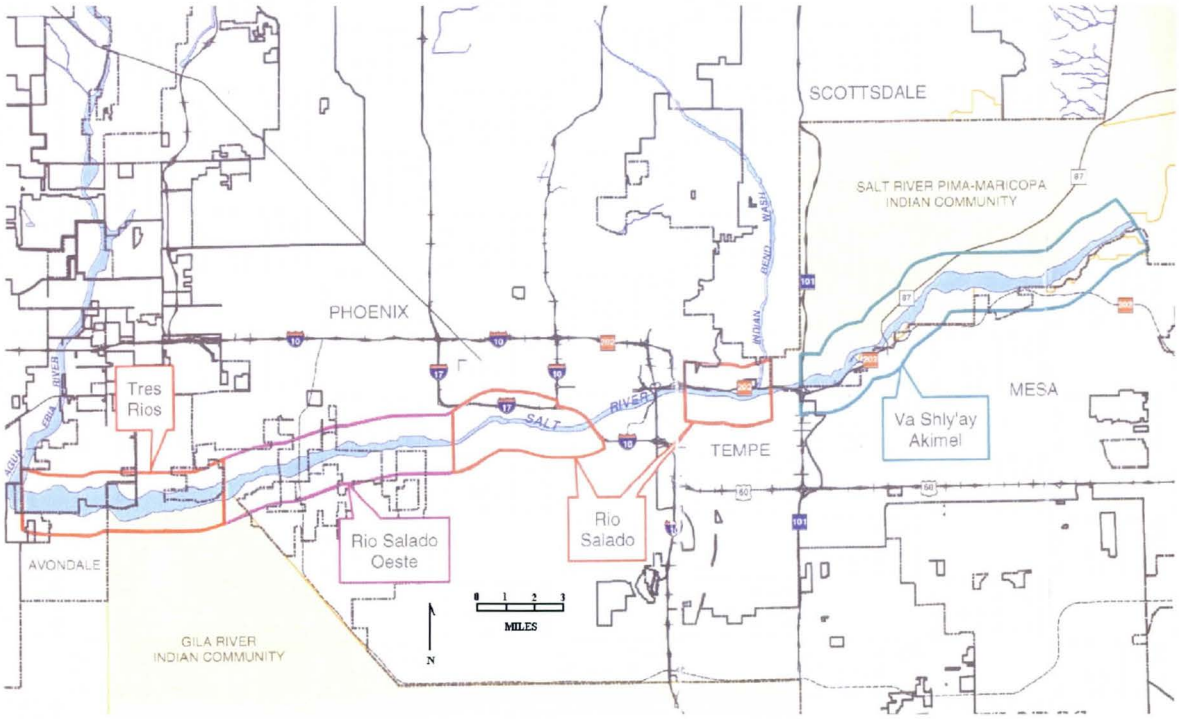


Figure 2. Location of USACE projects and study areas along the Salt River in the Phoenix Area.

4.0 Regional Setting

4.1 ***Physiography.*** The Va Shly'ay Akimel study area lies in the Salt River valley within the eastern part of the Phoenix Basin of south-central Arizona, and is located geomorphically within the Gila Lowland Section of the Sonoran Desert Subprovince, a part of the Southern Basin and Range physiographic province. This province is characterized by broad, gently sloping, interconnected alluvial basins bounded by generally northwest-southeast trending mountain ranges.

The Phoenix Basin is a term loosely applied to a series of topographical and structural basins bounded on the north and east by the Bradshaw-Mazatzal-Superstition Mountains, on the west by the Hassayampa River, on the southwest by the Buckeye Hills, and on the south by the Sierra Estrella and South Mountains (Salt River Mountains on some maps) (Péwé, 1978). Internally, the Phoenix Basin contains several small ranges, including the Phoenix, South, and White Tank Mountains. Several major rivers pass through the area, including the Salt, Gila, Verde, and Agua Fria Rivers. The Salt River enters the basin on the east side, flowing southwestward to its junction with the south-flowing Verde River near the west edge of the Mazatzal Mountains. From this junction near Mesa, the Salt River flows westward across the broad Salt River Valley to its confluence with the Gila River. This reach of the Salt River between the Verde and Gila confluences is herein referred to as the "lower" Salt River. The Gila River continues westward along the northern edge of the Buckeye Hills to its confluence with the Hassayampa River where it turns south toward Gila Bend and exits the basin on its way to the Colorado River. The Agua

Fria River enters the basin from the north near the Hieroglyphic Mountains, and flows south to its confluence with the Gila River near the center of the basin, 15 miles west of Phoenix and 28 miles west of the study area.

Elevations range from over 7,000 feet for the highest peaks of the Mazatzal Mountains, 4,500 feet in the Sierra Estrella, and 2,540 feet in the South Mountains, to a low of about 800 feet on the Gila Riverbed where it exits the basin on the southwest. Interbasin ranges range in height from 3,780 feet in the White Tank Mountains to 2,440 feet in the Phoenix Mountains, to 1,750 feet in the Buckeye Hills.

4.2 *Geology.* The study area lies within the East Salt River sub-basin, part of the larger Phoenix Basin of south-central Arizona, within the Southern Basin and Range Province (Figure 3). Geologic structure in the area is dominated by block faulting, which produces a topography of sharp contrasts, in which isolated, almost parallel mountain ranges rise in stark contrast above low-lying desert plains. In many cases, the basin areas are filled with thousands of feet of sediment and debris eroded from the adjacent mountains. However, some of the basin areas are pediments- erosional surfaces cut into the edges of nearby uplands.

The mountain ranges in the Phoenix Basin area consist mostly of Tertiary age sedimentary and volcanic rocks that lie unconformably upon an ancient Precambrian igneous and metamorphic basement complex.

The Precambrian complex is composed predominantly of schist, gneiss, metasedimentary and metavolcanic rocks intruded by granitic to granodioritic plutons. Widespread granitic intrusives were emplaced into this Precambrian basement during the late Cretaceous and early Tertiary Laramide orogeny. Middle Tertiary sedimentary and volcanic rocks rest unconformably on older rocks, and consist of sandstones, siltstones, tuffs, and cemented alluvial fanglomerates. The entire basement is cut by numerous middle Tertiary dikes ranging in composition from granite to diorite. These rocks are overlain and cut by a Miocene volcanic assemblage of basalt and andesite dikes, sills, and flows, latite and rhyolite flows and lithic tuffs, and volcaniclastic rocks.

Late Tertiary Basin-and-Range block faulting formed many of the present-day basins and ranges. Mountain ranges were deeply eroded and shed variably sized clastics into adjacent down-dropped basins. Valley fill reaches up to nearly 12,000 feet thick in the interior of the Phoenix valley. Numerous low-lying isolated hills (inselbergs) project above the valley surfaces. These hills represent peaks of former mountain ranges that are now almost completely buried by alluvial material. Valley fill consists mostly of poorly- to well-consolidated (cemented) and unconsolidated gravel, sand, silt, and clay, representing several environments and ages of deposition. In the Salt River valley area, the sediments were deposited in fluviatile and lacustrine environments and consist of clastic and evaporite sequences. The valley fills tend to be coarser near the mountain fronts, and finer in the interior of the valley. Calcium carbonate cementation is common, and considerable caliche is present near the mountain fronts. In the interior of the valley, most of the valley floor is covered by coarse to fine grained alluvium. This material has been continuously deposited and reworked by the shifting channels of streams draining the mountains.

4.3 *Faulting.* Geologic structure in the area is dominated by block faulting attributable to the late Tertiary Basin and Range tectonic event. This extensional event began between 13-10 Ma in

the southern Basin and Range Province, and resulted in formation of most of the present structural basins in southern and central Arizona (Pearthree and Scarborough, 1984). Major extension ceased in the area during the late Miocene or Pliocene.

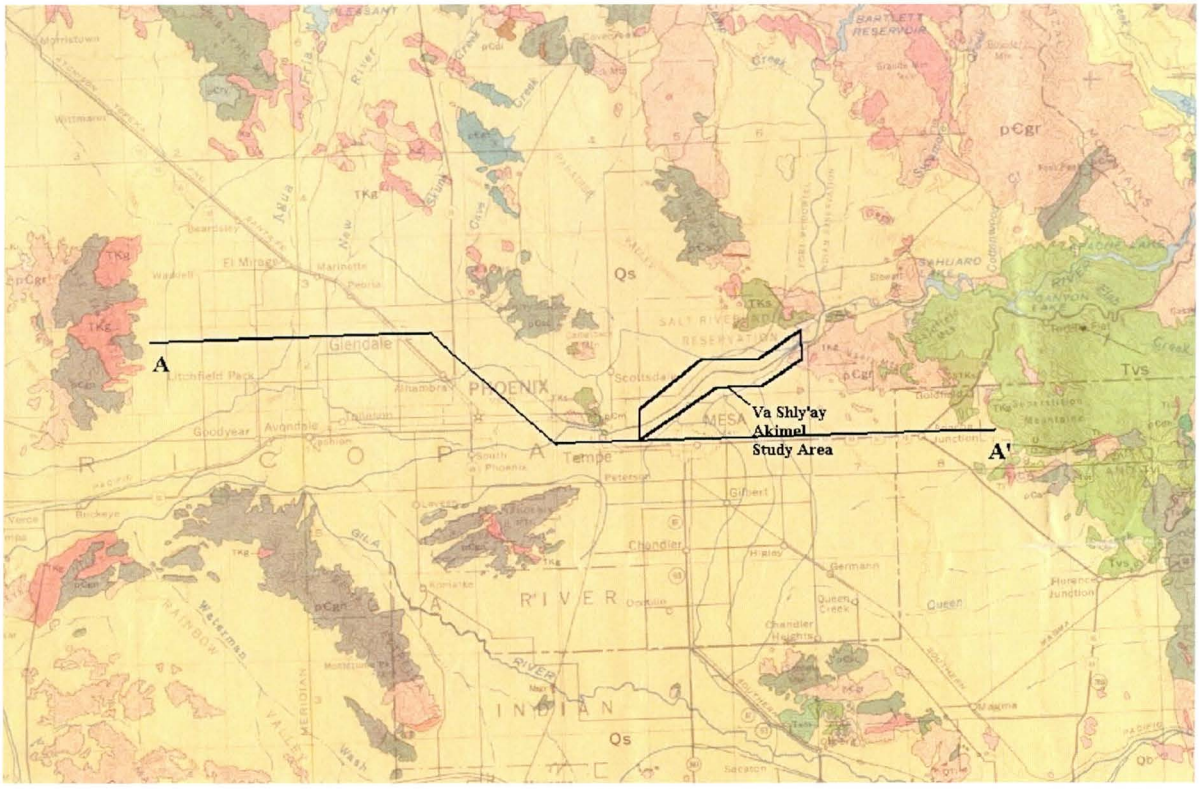


Figure 3. Geologic Map of the Phoenix Basin (from Wilson, et al., 1969). See Table 1 for explanation. See Figure 4 for Hydrogeologic Section A-A'.

Table 1. Geologic Units of the Phoenix Basin (from Wilson, et al., 1969)

Map Symbol	Geologic Time	Lithology
Qs	Quaternary	Alluvial gravel, sand, and silt in flood plains, terraces, fans, and pediment cappings.
QTb	Quaternary/Tertiary	Basaltic flows, agglomerate, tuff, and cinders.
Tvs	Tertiary	Silicic volcanic rocks.
Ti	Tertiary	Dikes, sills, and plugs of rhyolitic to basaltic composition.
TKs	Late Cretaceous Early Tertiary	Sedimentary rocks, and local volcanic rocks. Includes Cloudburst Formation in Pinal County.
TKg	Late Cretaceous Early Tertiary	Intrusive igneous rocks consisting of granite, quartz monzonite, granodiorite, quartz diorite, and porphyry equivalents. Laramide Orogeny.
pCgr	Precambrian	Intrusive igneous rocks consisting of granite, quartz monzonite, granodiorite, and quartz diorite.
pCm	Precambrian	Mazatzal Quartzite.
pCgs	Precambrian	Nonfoliated greenstone.
pCsc	Precambrian	Yavapai Series mica schist, phyllite, slate, and amphibolite.

pCgn	Precambrian	Gneiss.

Quaternary-age faulting in Arizona is mostly confined by a northwest-trending belt, which bisects the state, separating domains of little or no neotectonic faulting in the northeast (Colorado Plateau Province) and southwest (Southern Basin and Range Province) (Menges, 1984). Historically, the Phoenix area possesses a very low level of seismicity, and evidence of late Quaternary faulting is sparse (Pearthree and Scarborough, 1984). Quaternary faults in southern and central Arizona consistently show evidence of very long recurrence intervals, on the order of 100,000+ years, and displacement rates of <0.03mm/yr (Pearthree and Scarborough, 1984). The nearest mapped Quaternary faults are found to the north of the study area along the western flanks of the Mazatzal Mountains (Pearthree and Scarborough, 1984). These faults are composed of short northeast and north-south segments, the nearest of which is the Carefree Fault 20 miles due north of Mesa and 16-17 miles north and northwest of the study area.

5.0 Study area

5.1 ***Physiography and Topography.*** The study area includes river channel and overbank areas. The width of the Salt River floodplain in the study area ranges from 0.25 mile to 1.0 mile wide. Topographic relief is generally very low to flat, with 0-2% slopes, ranging from an elevation of 1,300 feet in the Salt River bed at Granite Reef Dam at the upstream (east) end of the area, gently sloping down to about 1,175 feet elev. at the downstream (west) end. In the eastern portion of the project, low hills of the Usury Mountains form the banks and uplands south of the Salt River, and rise to 50 to 150 feet above the riverbed. The highest of these, Schlechts Butte on the southeast side of Granite Reef Dam, rises to 1,798 feet elevation. The lower flanks of Mount McDowell extend into the northeast corner of the project area, where they rise about 100 feet above the riverbed at Granite Reef Dam.

The Va Shly'ay Akimel study area is located within Township 1 North, Range 5 East, Sections 3, 4, 7, 8, and 9, Township 2 North, Range 5 East, Sections 25, 26, 33, 34, and 35, and Township 2 North, Range 6 East, Sections 13, 14, 22, 23, 24, 27, 28, 29, and 30 of the Gila and Salt River Baseline and Meridian.

The study area is covered by the following topographic map sheets: Mesa, Arizona 1:250,000 sheet; Mesa, Ariz. 1:62,500 sheet; and Tempe, Mesa, Buckhorn, and Granite Reef Dam, Ariz. 1:24,000 sheets. The Flood Control District of Maricopa County possesses more detailed (4-foot contour interval) topographic maps of the Salt River channel areas and the overbank areas.

5.2 ***Geomorphology.*** A discussion of the geomorphology along the lower Salt River can be found in the 2000 Tres Rios Feasibility Study Environmental Impact Statement, Section 3.2 Geology and Geomorphology. Topics covered include slope features, channel shifts, sediment transport, sinuosity, gradient, bed sediments, and channel types. The following sections 5.2.1-5.2.7 are largely summarized from this report. Drosendahl (1988) provides a good overview of the terrace deposits along the Salt River, as well as other geomorphic features.

5.2.1 *Slope Features*. The lower Salt River is associated with three pediment-inselberg complexes in the surrounding terrain: the Spook, Papago, and Bush Pediments (Drosendahl, 1988). A pediment is a ramp-like erosional feature common in semiarid regions. Pediments form at the base of mountains or extend outward from the base of an inselberg (e.g. Papago Buttes). Pediments are characterized by: (1) a well-defined break in slope between the pediment surface and the inselberg hillslope of the same rock type, and (2) a bedrock surface, in some

cases covered with a layer of alluvium with a thickness that is no more than 1/100 of the width of the pediment.

5.2.2 *Channel Shifts*. The geomorphologic history of the lower Salt River is very complex. It is characterized by scour-and-fill events, floods, and channel shifts. Historically, the Salt River has been characterized by the meandering nature of the river system. However, more recently, urban development in the region has changed the lower Salt River from a meandering channel to a straight channel with high banks in several reaches downstream from the study area.

Comparative photographs show that the Salt River channel has shifted within the floodplain several times from the 1880s to the present, meandering on the north side of the floodplain during some periods and on the south side during others. Channel shifts have distributed alluvial material across the entire width of the floodplain. The alluvium deposited by the river consists of cobbles, sands, silts, and clays from numerous tributary streams within the watershed. Well log data show that this depositional history has been continuous over a long period of time.

5.2.3 *Sediment Transport*. The Salt River is dominated by scour-and-fill events, which degrade the river in some areas and aggrade it in others. The scour-and-fill transportation of sediment has produced numerous thick deposits within the fluvial system: cobble lag surfaces, sand sheets (macro-forms), channel side bars, midchannel bars, point bars, and overbank deposits. Many of these deposits have been disturbed by intensive mining for sand and gravel within the study area. Mining alters later transportation events by removing and compacting material, thereby reducing the amount of sediment transported, and loosening other sediments; also, sand pits serve as depositional traps for fine sediments.

Sediment transported in a scour-and-fill setting tends to move in waves or pulses, rather than at a constant rate through time. In essence, slugs of sediment are moving downstream periodically during flow events. The historical photography confirms that floodflows are probably the most important events in the transportation of sediment. Floodflows have the highest potential to move material. During a flood, the bulk of the sediment is moved as bedload, but there is also movement of sediment as washload, in solution and suspension. Prior to damming of the Salt River, smaller flow events moved sediment (fine sands, silts, and clays) by incising downward into the larger slugs of sediment found in the channel. However, the amount of sediment moved in these smaller events is small in comparison with the amount of material moved during a flood.

5.2.4 *Stream Sinuosity*. Despite notable location changes from time to time, the main channel of the lower Salt River has had a consistent sinuosity over the past century. Deviations in the sinuosity of the lower Salt River have been surprisingly small over the last 125 years. The channel may radically adjust its position, but overall it generally preserves the mean sinuosity-a meander eliminated in one location is almost always replaced by a meander in a different but nearby position.

5.2.5 *Gradient*. The average gradient of the lower Salt River between Granite Reef Dam and the confluence with the Gila River is about 9.5 feet of vertical drop per mile of horizontal distance, although there are numerous local variations. The gradient has decreased a small amount because of erosion in the upper reaches and deposition in the lower reaches.

5.2.6 *Bed Sediments*. Channel degradation in Mesa and Tempe has resulted in substantial changes in bed sediments in the Salt River in that area. As the channel cut downward, it exposed a series of well-defined strata. Numerous historical photographs show that the channel was sandy before 1978, except at a few locations where cobble bars were common, such as McDowell Crossing (about 2 miles east of Gilbert Road, below Granite Reef Dam). Downcutting during the 1978 floods removed this sandy layer and began exposing a cobble layer. The 1980 flood further excavated the channel bed, in some places cutting completely through the cobble layer and extending into a mixed sand and cobble zone beneath. Later, smaller flows continued the excavation, in some places down to still another cobble layer.

Part of the explanation of the downcutting of the Salt River channel in Tempe and Mesa is that upstream dams are storing sediments once carried by floodflows, so the relatively clear water entering the study area is capable of entraining sediments that are not replaced by materials from upstream. The 1978-1980 flows may also have been so large that degradation would have occurred in any case.

5.2.7 *Channel Types*. The channel of the lower Salt River exhibits a variety of geomorphologically defined segments, with each segment having distinctive characteristics. These channel segments fall into two broadly defined categories: braided and compound.

Those segments that are braided channels have more than one low flow channel, usually one that is clearly the thalweg and additional channels that are occupied only at moderate or high flows. These channels are separated from each other by sand bars, sand sheets, or "midchannel" bars. In general, the braided configuration is the natural product of four controlling factors, all of which occur in the study area channels. First, braided channels typically carry large amounts of sediment compared with the capacity of the stream, and the lower Salt River appears to be "overloaded" with sediment in the lower reaches (downstream of the study area). Second, such streams also have gradients that are relatively steep, or they generate high amounts of stream power. The lower Salt River has a relatively shallow gradient, but during floodflows, those discharges that shape the channel and accomplish sediment transport on a large scale, stream power is likely to be high. Third, braided channels have erodible banks, a condition common along parts of the lower Salt River. Finally, braiding usually results from highly variable discharges, such as those found dryland rivers such as the Salt River. For these reasons, braiding of at least parts of the lower Salt River channel is the natural tendency of the system.

The second general channel type found in the lower Salt River is the compound form (also referred to as "channel in channel"). Compound channels function with two modes of operation: one at low flow, when water occupies a single, meandering channel, and the other at high flow, when water occupies a much broader "braided" channel. Compound channels are common in dryland settings downstream from dams, irrigation areas, and urban areas because wastewater and occasional natural low flows maintain the low flow meandering channel. If this low flow channel has sufficient discharge, it becomes unstable and is an erosion hazard. When meanders are abandoned, they are known locally as sloughs or oxbows. They are the sites of standing water for a period and eventually fill with sediment during moderate floods. Upstream dams prevent moderate flows, but occasional catastrophic floods (perhaps accompanied by spills from the dam) form the broad, braided part of the channel.

5.2.8 *Terrace Deposits*. Prominent terraces of the Salt River are conspicuous upstream from Tempe (Péwé, 1978). The terraces represent episodic regional uplift of the ranges surrounding the Phoenix Basin during late Cenozoic time. The terraces consist of thick, well-cemented to non-cemented sand and gravel, and are considered older than the alluvium within the confines of the Salt River. The terraces form gently sloping (0-2%), undulatory surfaces of low relief. Four terraces are present rising eastward from Tempe to Stewart Mountain Dam (approximately 10 miles upstream from Granite Reef Dam). From oldest to youngest, these are the Sawik, Mesa, Blue Point, and Lehi Terraces (see Figure 4).

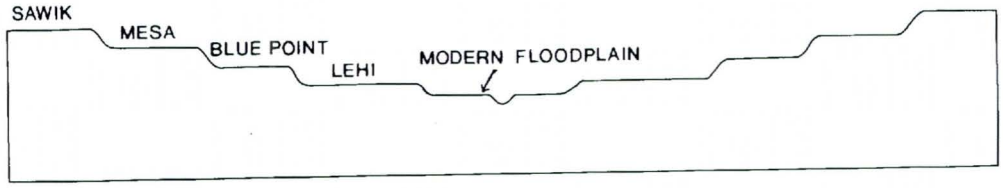


Figure 4. Diagrammatic transverse profile of paired terraces on the lower Salt River (after Péwé, 1978).

The Sawik Terrace is the oldest Salt River terrace, and ranges from 120 to 180 feet above the river from west to east across the greater study area. A 60 to 80 foot high scarp separates the Sawik Terrace from the younger Mesa Terrace. Highly dissected remnants of the Sawik Terrace can be found capping the foothills of Mount McDowell northwest of Granite Reef Dam, and in the hills southwest of the dam (Figure 5). Caliche is very strongly developed within Sawik alluvium, in layers up to 45 feet thick (Péwé, 1978), with lamellar caliche occurring at the surface locally.

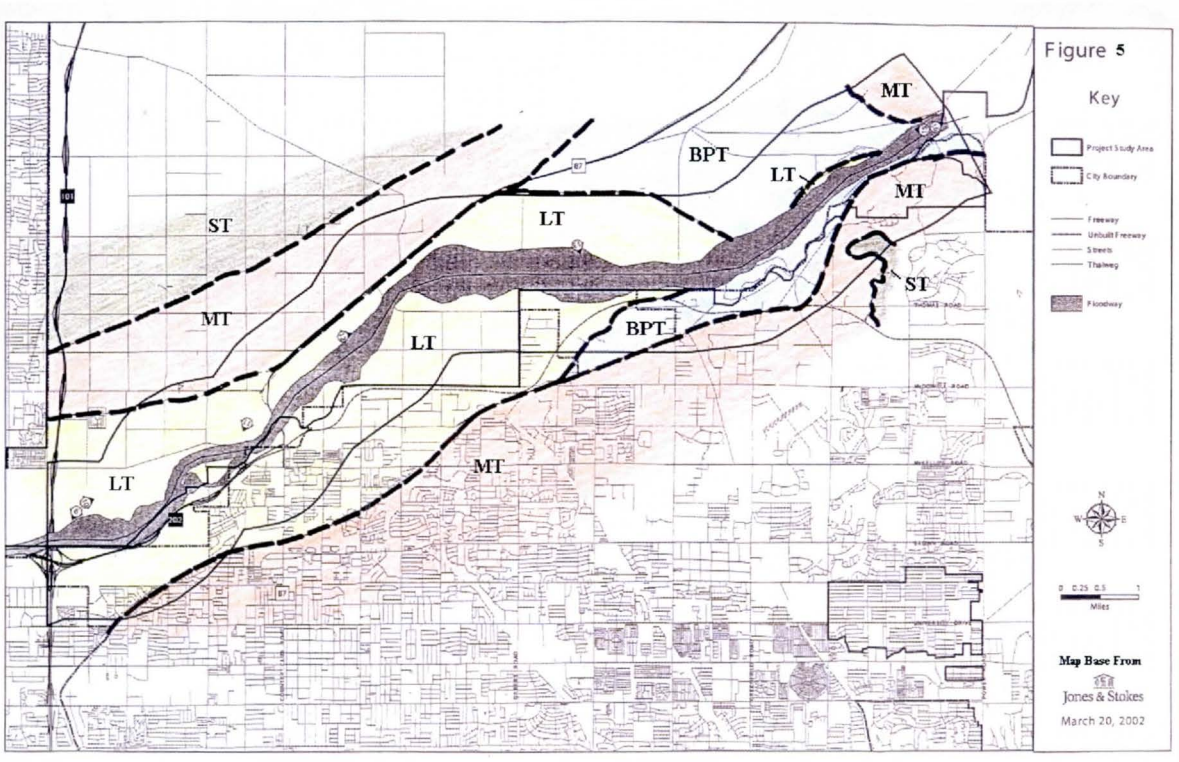


Figure 5. Terraces of the Lower Salt River in the Va Shly'ay Akimel study area (after Péwé, 1978). LT= Lehi Terrace, BPT= Blue Point Terrace, MT= Mesa Terrace, ST= Sawik Terrace.

Highly dissected remnants of the Mesa Terrace can be found in the central part of the study area on the north side of the Salt River, and on the north bank at Granite Reef Dam (Figure 5). The Mesa Terrace ranges from 80 feet to 160 feet above the present Salt River bed across the study area. Like the Sawik Terrace, caliche is extensively developed within Mesa Terrace alluvium, showing horizons with well-developed laminar layers up to many feet thick (Péwé, 1978). A 40 foot scarp separates the Mesa Terrace from the younger Blue Point Terrace.

The Blue Point Terrace is the second largest terrace of the Salt River. A 10 to 20 foot high scarp separates this terrace from the younger Lehi Terrace, and it is approximately 20 to 40 feet above the present river channel in the area (Drosendahl, 1988). Caliche development is weak. The largest remnants of the Blue Point Terrace in the study area are located on the north and south sides of the river in the eastern portion of study area, where they are covered by up to 60 feet of slope wash, alluvial, and eroded pediment material (Figure 5).

The Lehi Terrace is the youngest Salt River Terrace, and is actually part of the modern floodplain of the Salt River; however, it has not been inundated since the completion of the upstream dams. The terrace is approximately 5-10 feet above the river channel in the study area. The back scarp between this terrace and the older Blue Point Terrace marks the limit of flooding (Drosendahl, 1988). Lehi Terrace remnants form most of the terrace deposits in the study area can be found flanking the Salt River in the western ¾ of the study area (Figure 5). Only incipient caliche development is present within the terrace alluvium, which is covered by a deposit (up to 10 feet thick) of extremely fine-grained Salt River alluvial material.

5.3 ***Geology.*** The following geologic maps covering the study area were reviewed as part of this report: Cooley (1967), Arizona Highway Geologic Map, scale 1:1,000,000; Wilson, et al. (1969), Geologic Map of Arizona, scale 1:500,000; Pearthree, et al. (1997), Surficial Geologic Map of the Theodore Roosevelt Lake 30' x 60' Quadrangle, scale 1:100,000; Spencer, et al. (1996), Geologic Map of the Mesa Quadrangle, East-Central Arizona, scale 1:100,000; and Péwé and Drosendahl (1985), Rio Salado Development District – Eastern Part, Maricopa County, Arizona, scale 1:24,000.

A good summary of the geology of the Va Shly'ay Akimel study area and immediate surroundings can be found in Drosendahl (1988).

5.3.1. *Geologic Units*. The geology of the Va Shly'ay Akimel study area is dominated by valley fills and alluvium associated with the Salt River channel (Figure 3). On the extreme eastern edge of the project, at Granite Reef Dam, the southern tip of the McDowell Mountains, and the northwest tip of the Usury Mountains bound the Salt River on the north and south, respectively, and are composed of Precambrian granitic rocks.

The predominant surface materials within the Va Shly'ay Akimel study area consist of Quaternary age river sediment deposited as alluvium and to a lesser extent sheet wash deposited alluvium and slope deposited colluvium. Thick layers of alluvium have accumulated within the major streams, tributaries and flood plains of the Salt River. The alluvium thins in the direction of local mountains.

Sand and gravel, moderately well sorted and stratified, compose the bulk of the deposits left by the Salt River. These deposits consist of well-rounded clasts and are locally interbedded with irregular sand, silt, and clay lenses. The fine sediments are derived from overbank flows.

Colluvium is formed of loose to well-cemented gravel, sand, silt, and clay. The colluvium and alluvial deposits rest upon bedrock consisting of Tertiary sedimentary and volcanic rocks, as well as the Precambrian basement complex.

The bedrock exposures at the eastern margin of the study area are composed of Precambrian Camelback Granite (Péwé and Drosendahl, 1985). The Camelback Granite is composed of pink, coarse-grained to porphyritic granite locally cut by quartz veins, and aplite and greenstone dikes.

5.3.2 *Geologic Structure*. There are no mapped faults within the study area (Cooley, 1967; Péwé and Drosendahl, 1985; Spencer, et al., 1996; Wilson, et al., 1969). However, the northwest trending valley bounded on the east by the McDowell, Usery, and Superstition Mountains, and on the west by the Union Hills, Phoenix Mountains, Camelback Butte, and Tempe Butte, probably represents a graben, or downthrown block within the Central Arizona Basin of the Basin and Range Physiographic Province. The Basin and Range Province in the Phoenix area consists of a series of upthrown blocks, or horsts, composed of late Tertiary and Precambrian bedrock, and adjacent downthrown blocks, or grabens which form the topographic valleys, and contain deep accumulations of Quaternary and Late Tertiary unconsolidated sediments. It is probable that the west and east margins of this basin (the East Salt River structural basin) are controlled by Tertiary age basin and range normal faults lying concealed beneath alluvium of the Salt River.

5.3.3 *Depth and Nature of Alluvium*. Basin fill of the Salt River structural basin is the predominant sedimentary material in the Va Shly'ay Akimel study area. The basin fill is comprised of unconsolidated sediments composed of gravel, sand, silt, and clay. These sediments have been grouped into three major and one minor hydrogeological units. The U.S. Bureau of Reclamation, the U.S. Geological Survey, and the Arizona Department of Water Resources have independently identified the following units, although the descriptions and nomenclature used by these agencies differ slightly:

- Upper Alluvial Unit (UAU),
- Middle Alluvial Unit (MAU),
- Lower Alluvial Unit (LAU), and
- Red Sub-Unit

The following description of the units is mostly reproduced from ADWR (1994).

1) The UAU consists of mostly unconsolidated gravel, sand, and silt in stream channel, terrace, floodplain, and alluvial fan deposits. The unit was formed during the final stages of alluvial development of the Phoenix Basin, approximately late Pleistocene to recent (Holocene) time. Sediment within the unit was derived from the ancestral Salt and Gila Rivers and other streams, and from the surrounding mountains. Caliche cementation occurs locally in alluvial fan deposits and stream terrace deposits. The thickness of the UAU is relatively uniform, and is typically between 200 and 300 feet thick in the East Salt River Valley (see Figure 6). The unit is between

100 and 200 feet thick near the Salt River and becomes thinner near mountain fronts (ADWR, 1993).

2) The MAU underlies the UAU, and consists mainly of clay, silt, mudstone, and gypsiferous mudstone with some interbedded layers of sand and gravel. The finer grained sediments of silt and clay dominate the MAU; however, near the margins of the alluvial basins the MAU consists mainly of sand and gravel and is difficult or impossible to distinguish from the other units. The MAU is interpreted to consist of alluvial fan deposits near the mountain fronts grading into fluvial, playa, and evaporite deposits in the central areas of the basins.

The MAU generally thickens toward the center of the basins, and ranges from 0 feet along the edges of the basin fill areas nearer to the mountains, up to 1,600 feet in the deeper parts of the basins. In the East Salt River Valley, the MAU is thickest southeast of Gilbert, the deepest part of the basin. Where the MAU is not present, due to non-deposition, the LAU is directly beneath the UAU. The unit was formed during the middle stages of alluvial development of the Phoenix Basin, approximately late Tertiary to late Pleistocene time. The increasing thickness and decreasing particle size of the MAU toward the centers of the basins suggest that the alluvial basins were still closed and subsiding during deposition of the unit (ADWR, 1994).

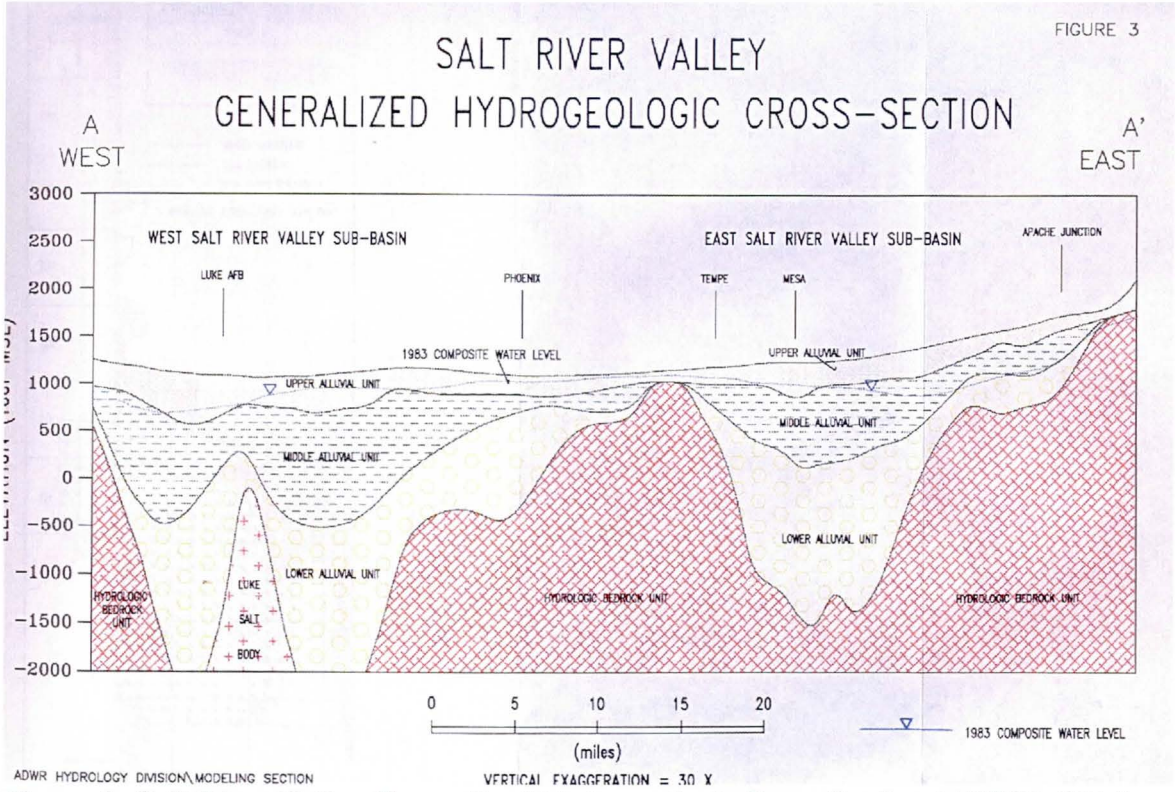


Figure 6. Salt River Valley Generalized Hydrogeologic Cross-Section (ADWR, 1994). Elevation in feet MSL. See Figure 3 for location.

The contact between the MAU and LAU is gradational, and differentiation is based on a number of factors, including bedding frequency, color, geophysical resistivity, and presence of gypsum. The unit is indistinguishable from the underlying LAU in some areas, indicating uninterrupted depositional processes.

3) The LAU underlies the MAU and overlies Tertiary and Precambrian basement rocks. This unit was formed during the early stages of alluvial development of the Phoenix Basin, approximately late to middle Tertiary time. Unit lithology consists of weakly to strongly cemented gravel and sand near the basin margins, grading into silt, mudstone, gypsum, and evaporates in the central areas of the basins. The LAU locally contains interbedded volcanic rocks. Like the overlying MAU, the LAU is interpreted to have been deposited as alluvial fan deposits near the mountain fronts grading into fluvial, playa, and evaporite deposits in the central areas of the basins. Radiometric dating of volcanic rocks within the LAU indicate that the unit may be as old as 16.6 million years (Brown and Pool, 1989 *in* ADWR, 1994). The LAU ranges from 0 feet thickness near the basin margins to several thousands of feet thick in the central areas of the basins. The increasing thickness and decreasing particle size of the MAU toward the centers of the basins suggest that the alluvial basins were closed and subsiding during deposition of the unit (ADWR, 1994).

4) The lowermost part of the LAU, the "Red Unit", is present locally, and is often described as a sub-unit. The Red Sub-Unit is in direct or fault contact with the overlying LAU at an unknown depth. The Red Sub-Unit was formed during the earliest stages of alluvial development of the Phoenix Basin, approximately late Miocene (Tertiary) time. The Red Unit lithology consists of debris flow materials comprised of reddish well-cemented breccia, conglomerate, sandstone and siltstone (ADWR 1993).

5.3.4 *River Sediments*. River sediments in the Salt River channel predominantly consist of moderately- to well-sorted, well-stratified sand and gravel, locally interbedded with silt in vegetated low flow areas near the river banks. The gravel is composed of well-rounded clasts (2-12 inches) of Precambrian metamorphic rocks (48.4%), Tertiary volcanic rocks (36.3%), and Precambrian granitic rocks (15.3%) (Drosendahl, 1988).

River bed materials are exposed in the cut banks of gravel mines. The materials form layers that range in thickness from 1 to 5 feet. Individual layers are discontinuous and thin and thicken along the mine walls. This is typical of river bed materials. The layers contain cobbles and sand, however the proportion of each vary within the individual layers. Some have a greater percentage of cobbles while others are primarily sand (Greeley and Hansen, 2001).

5.3.5 *Depth to Bedrock*. The alluvial, terrace, and colluvium deposits lie upon bedrock consisting of Tertiary sedimentary and volcanic rocks, as well as the Precambrian basement complex. The depth to bedrock in the project varies from 0 feet on the east end of the project site, deepening to over 9,000 feet north of Mesa, and rising to the west to about 1,000 feet on the west end of the project as shown on the depth to bedrock map in Figure 7. A bedrock shelf (pediment) overlain by a thin veneer of sedimentary materials extends downstream from Granite Reef Dam (USACE, 2002). The depth to bedrock rapidly increases at the basin border fault, located approximately 1.5 to 2.0 miles downstream.

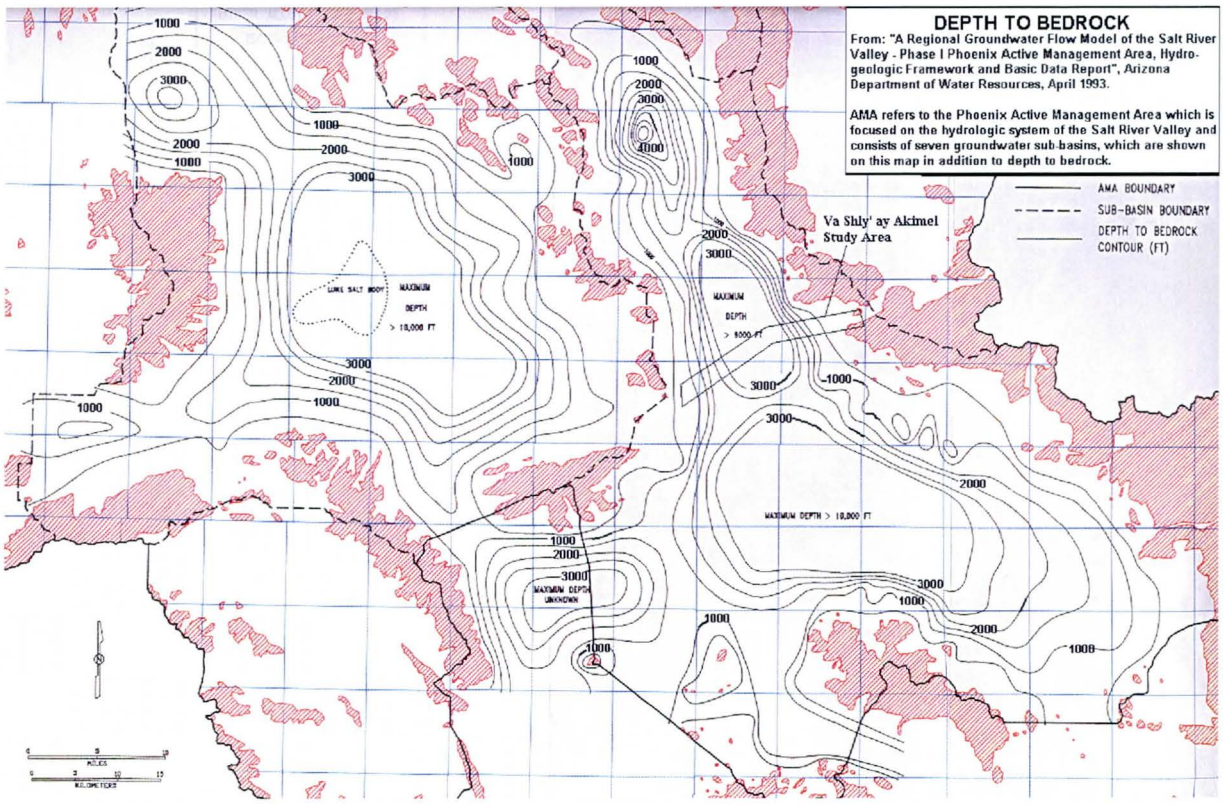


Figure 7. Depth to bedrock in the lower Salt River Valley, showing generalized location of the Va Shly'ay Akimel study area within the East Salt River structural sub-basin of the Phoenix Active Management Area (ADWR, 1993).

6.0 Soils. Soils in the study area have been mapped in great detail by the Natural Resources Conservation Service (NRCS) (formerly called the U.S. Soil Conservation Service) on aerial photographs at a scale of 1:20,000 (U.S. Soil Conservation Service, 1974). These maps provide a view of soil conditions in and near the river channels in the early 1970's. Since that time, conditions in the channels have changed in many areas, but the floodplain and terrace soils have remained generally unchanged. The soils in the vicinity of the river channels in the study area are of the hypothermic torrifluvents association, a group of soils that are well-drained to excessively well-drained on nearly level or gently sloping surfaces. The texture of the surface layer ranges from gravelly sand or very gravelly sand to fine sandy loam. The material beneath the surface layer is very gravelly sand to very fine sandy loam or loam. These soils are often redistributed by blowing wind and the shifting of stream channels, making mapping of individual areas as soil units unfeasible. Permeability ranges from very rapid to moderate, runoff is slow, and soil blowing is generally a hazard (U.S. Soil Conservation Service, 1974).

7.0 Geohydrology and Groundwater. The principal drainage through the Phoenix Basin is the Salt River. Dams located upstream from the study area (controlled and operated by the Salt River Project) prevent perennial flow in the river channel and limit natural recharge. The Salt River in this reach is ephemeral, flowing only in response to local flooding and releases from upstream reservoirs. Granite Reef Dam at the upstream boundary of the study area was constructed to divert Salt River water into the Arizona and Southern Canals. The dam is not a storage reservoir. Several irrigation run-off collection ponds and distribution ponds for mining

operations are present within the project boundaries. The study area receives stormwater runoff from hills on the undeveloped land on the north side of the Salt River from numerous small ephemeral drainage channels. The Buckhorn Mesa Project in the City of Mesa consolidates and directs stormwater drainage to the Salt River through a single discharge channel immediately downstream of Granite Reef Dam.

Regional groundwater pumping for irrigation has resulted in a general lowering of the water table throughout the area. Recharge to the groundwater basin is derived from seepage of irrigation waters, Salt River flows, rainfall, and underflow of groundwater. Recharge from stream flow and rainfall is minor, and the amount of recharge from irrigation seepage and underflow has not been high enough to offset progressive lowering of the water table.

Two groundwater recharge projects are located within the study area, the Granite Reef Underground Storage Project (GRUSP), and the Northwest Water Reclamation Plant (NWWRP).

7.1 ***Basins.*** Groundwater is regulated by the Arizona Department of Water Resources (ADWR). The groundwater basin underlying the lower Salt River Valley is identified as the Phoenix Active Management Area (see Figure 7). The Phoenix AMA comprises two distinct but interconnected alluvial groundwater basins: West Salt River Valley (WSRV) and East Salt River Valley (ESRV). These two units are separated by a mostly buried bedrock ridge located near Priest Road in Tempe (see Figure 4). Tempe Butte, south of the Salt River, and the Papago Buttes and Camelback Mountain north of the river are the outcropping expressions of this geologic feature.

The study area lies within the East Salt River Valley of the Central Arizona Basin, in the Basin and Range Physiographic Province. The Basin and Range Province in the Phoenix area consists of a series of upthrown blocks, or horsts, composed of late Tertiary and Precambrian bedrock, and adjacent downthrown blocks, or grabens which form the topographic valleys, and contain deep accumulations of Quaternary and Late Tertiary unconsolidated and semiconsolidated sediments. These depositional basins filled with unconsolidated sediments are referred to as alluvial basins. The ESRV alluvial basin represents a graben which trends north to northwest, and is bounded on the east by the McDowell, Usery, and Superstition Mountains, and on the west by the Union Hills, Phoenix Mountains, Camelback Butte, and Tempe Butte.

7.2 ***Aquifers.*** In the Salt River Valley groundwater occurs within three major and one minor hydrogeological units that are bounded below by impermeable Tertiary and Precambrian basement rocks which provide a physical boundary to the alluvial aquifer and to groundwater movement. These units are:

- The Upper Alluvial Unit (UAU),
- The Middle Alluvial Unit (MAU),
- The Lower Alluvial Unit (LAU), and
- The Red Sub-Unit

The amount of storage and flow within the units varies considerably with area and depth. The three hydrogeologic units are derived from Phoenix Basin alluvial materials. The geology of the units is described in Section 5.3.3. Hydrologic characteristics of the units are described as the following (their age increasing with descending order) (ADWR 1993):

1) The UAU comprises all alluvial materials at the ground surface, and extends to depths of 100 to 200 feet under the Salt River, and is thinnest near mountain fronts and bedrock outcrops. It consists of unconsolidated sand, gravel, cobble and boulders with local thin interlayered beds of clay and silt. The unit is a semi-perched to unconfined aquifer that is both saturated and unsaturated.

The Salt River flows over the UAU and was once the most important source of groundwater recharge for this unit. Water within the UAU is legally referred to as subflow to differentiate it from groundwater in the MAU and LAU. Historically, surface flows from streams and washes provided most water to recharge the UAU. Presently, the minor recharge sources-such as seepage from Granite Reef Dam, canals and irrigated land, underflow along major streams, and rainfall-have become more important. Approximately 25% of the groundwater pumpage in the Phoenix basin is directed towards this unit. A very large portion of the groundwater is used for agriculture. Little or none of the water is used for drinking water purposes (Wilson, 1991, *in* USACE, 1998).

2) The MAU underlies the UAU. At the project site the MAU's contact with the LAU varies from approximately 100 feet to 200 feet below ground surface. The thickness of the unit varies from 0 feet to approximately 1,600 feet. Unit lithology consists of weakly cemented interlayered beds of clay, silt, sand and gravel. This unit is a semi-confined saturated aquifer comprised of more than several discontinuous semi-confining layers that consist predominantly of silt and clay (USEPA 1993). Approximately 50% of the groundwater pumpage in the Phoenix basin is directed towards this unit. A large portion of the groundwater is used for agriculture. A smaller portion of the groundwater is used for drinking water purposes (Wilson, 1991, *in* USACE, 1998).

3) The LAU underlies the MAU, and ranges in thickness within the study area from 0 feet along the mountain front at the eastern margin, to several thousand feet in the deepest part of the basin. Unit lithology consists of weakly to strongly cemented gravel, boulders, sand, sandy clay, silty sand and interlayered beds of clay. This unit is a semi-confined saturated aquifer comprised of more than several discontinuous semi-confining layers that consist predominantly of clay and mudstone. Approximately 25% of the groundwater pumpage in the Phoenix basin is directed towards this unit. A large portion of the groundwater is used for agriculture. A smaller portion of the groundwater is used for drinking water purposes (Wilson, 1991, *in* USACE, 1998)

The LAU possesses a direct or fault contact with the Red Sub-Unit at an unknown depth. The Red Sub-Unit lithology consists of debris flow materials comprised of reddish well-cemented breccia, conglomerate, sandstone and siltstone. The Red Unit is a saturated aquifer and it is not know whether it is confined or unconfined. Aquifer characteristics for the Red Unit are unknown, except that it's groundwater likely originates from within faults and fracture zones within bedrock (ADWR 1993).

Groundwater movement and connection within the three principal alluvial units is mostly lateral and somewhat vertical. Vertical groundwater flow occurs through a combination of leakage through all three unit geologic contacts and through water wells that extend vertically across more than one unit.

7.3 ***Bedrock.*** In the Va Shly'ay Akimel area, bedrock is formed primarily by a Precambrian basement complex composed mainly of metamorphosed gneiss and granite. This material

possesses relatively low water storage and transmission characteristics and usually yields small quantities of water compared to the unconsolidated sediments in the basins. Bedrock does not form aquifer units and in fact forms a barrier that prevents or restricts the flow of groundwater.

The depth to bedrock influences groundwater movement in the overlying basin fill by constraining the geometry of the basin fill. The depth of the down-dropped bedrock graben controls the thickness of the unconsolidated basin fill materials in the graben. A greater thickness of basin fill occurs where bedrock is deep, and relatively thin basin fill overlies shallow bedrock. At Granite Reef Dam, granitic bedrock occurs near the surface, and extends downstream from the dam, covered by a thin veneer of alluvium, for 1.5 to 2.0 miles where the depth to bedrock rapidly increases at the basin border fault. Seepage from Granite Reef Dam into the thin alluvial sediments produces a continuous surface flow in this area. At the edge of the bedrock shelf, this water movement changes from surface flow and becomes subsurface flow.

7.4. ***Gradient***. Groundwater at the Va Shly'ay Akimel project site varies in depth and flow direction by location. The direction of flow is highly variable, however groundwater flow is generally to the west-southwest (ADWR, 1993). Groundwater is being replenished at the Granite Reef Underground Storage Project (GRUSP). The GRUSP is a groundwater recharge area located approximately in the center of the study area. In addition, the City of Mesa recharges treated water at the west end of the study area. These two areas exhibit localized groundwater mounding. Groundwater flow around these two recharge areas is radially outward in each direction. Groundwater flow on the west side of the area is generally northwest toward Scottsdale which generates a cone of depression, except around recharge areas. Groundwater in the east Salt River valley flows towards two groundwater depressions. One is north of Scottsdale (7 miles northwest of the project) and one is east of Mesa (7 miles east-southeast of the project) (Jones and Stokes, 2002).

7.5 ***Depth to Groundwater.*** Long-term groundwater withdrawal for irrigation purposes has resulted in a general decline in water levels from 100 feet to 400+ feet throughout the Phoenix Basin. However, water-level declines have usually been less than 50 feet near the Salt River. From 1923 to 1976, groundwater levels have been lowered 340 feet near Luke Air Force Base, 28 miles west-northwest from the project area; 330 feet just north of Scottsdale, 7 miles northwest of the project; 370 feet east of Mesa, 7 miles east-southeast of the project; and up to 420 feet in the Queen Creek area, 20 miles southeast of the project (Laney, 1976).

According to the ADWR well registration database, dated July 2001, depth to groundwater in the project area varies from around 10 to 440 feet below the ground surface (Liesch, 2002), and is at approximately 260 feet depth (in crystalline bedrock) near Granite Reef Dam (Jones and Stokes, 2002). Beneath the Salt River, the general groundwater depth (within alluvium) ranges from 60 to 80 feet below the surface for the majority of the study area (Knight Piésold, 2000, *in* USACE, 2002). (A depth to groundwater map is included as Figure 6 of the main report.) Jones and Stokes (2002) report that depth to groundwater ranges from 120 feet below land surface near the Loop 101 Interchange to 350 feet below land surface near Power Road. For the period from 1987 to 1992, water levels fluctuated from year to year, on average 7-19 feet (Jones & Stokes, 2002). Local features affecting the groundwater depth and flow direction include: the NWWRP wastewater treatment recharge ponds, GRUSP, quarry operation distribution ponds, water well pumping, and canals.

The GRUSP, located near the center of the study area, recharges water into the upper alluvial unit from a series of ponds. The Salt River Project (SRP) permit requires it to limit water discharge to maintain the groundwater level at least 25 feet below the bottom of the Salt River Landfill on Gilbert Road and State Route 87, about 1 mile to the north (USACE, 2002, pp. IV-18 and IV-26). This results in a groundwater level that is 50 to 60 feet below the river channel in the immediate GRUSP area.

Effluent from the NWWRP (City of Mesa), located near the downstream end of the study area, is discharged into a series of recharge ponds where it is allowed to infiltrate the Salt River sediments. The groundwater mound that results from this recharge raises the local water table in this area to within 50 to 60 feet below the riverbed (USACE, 2002).

Perched water tables exist along the river at various depths. Seepage from the Granite Reef Dam forms a local perched water table near the surface (USACE, 2002). Wetland plants grow within this area just below the dam, and extend for about one mile downstream. A local red clay located along the western portion of the project area carries a perched water level at about 10 feet below the river bottom elevation, and recent measurements near the Verde and Salt River confluence, a few miles upstream from Granite Reef Dam, are about 20 feet below ground surface (SRPMIC, 2002).

7.6 ***Contamination of Groundwater.*** Long-term irrigation practices and landfills within the Salt River Valley have historically influenced water quality in the upper alluvial aquifer. High salinity, chloride, and nitrate concentrations were occasionally found in the shallow groundwater near irrigated or formerly irrigated areas (USACE, 2002). More recently the SRPMIC has developed a water quality management plan to protect and enhance surface and ground water quality. Since groundwater quality monitoring began in the 1980s, the water quality has significantly improved. Monitoring results from the first quarter of 2002 indicate that there were no exceedences of the maximum contaminant levels for volatile halocarbons in any of the sampled wells (Kenneth D. Schmidt and Associates, 2002). In addition, the concentrations of many volatile halocarbons were the lowest since monitoring commenced. It should be noted that there are no Superfund sites within the study area, however several of these sites are present downstream.

In the Environmental Impact Statement for the Va Shly'ay Akimel F-3 Study, Jones and Stokes (2002) summarized several surface and groundwater contaminants of concern in the area, including: volatile organic compounds (VOC's), metals, nutrients, ions, and total dissolved solids.

Jones and Stokes (2002) state that the most prevalent water contaminants in the lower Salt River are VOC's (e.g. from landfills, leaking underground storage tanks, high-tech, small, and large industries). The Arizona Department of Environmental Quality (ADEQ) records show the presence of VOC's in groundwater in areas near every reach of the lower Salt River, especially in the Central Phoenix area (Jones and Stokes, 2000).

Metals as contaminants (e.g. from landfills, mines, metal finishing, naturally occurring) have been detected in some Salt River Project groundwater wells, but their concentrations did not exceed their maximum allowable limits (Jones and Stokes, 2002).

Several ions and nutrients exceed maximum allowable levels in groundwater, surface water, and effluent in the study reach (Jones and Stokes, 2002). These include nitrates (e.g. runoff from agricultural fertilizer, animal feed-lot wastes, effluent from wastewater treatment plants, and subsurface septic leachate); bicarbonate, chloride, and boron (generally naturally occurring).

Jones and Stokes (2002) state that total dissolved solids (TDS) probably warrant the least concern among all contaminants, and that although TDS in surface waters and groundwater may cause problems for salt-sensitive plants, the present concentrations do not significantly differ from more natural conditions along the Salt River.

At present, all known groundwater HTRW contamination (see footnote 2, below) along the entire Salt River has been attributed to Volatile Organic Carbons (VOCs) leaching into the groundwater (USACE, 2000). VOC leaching has occurred from either mismanaged storage, pumping into ground water and/or improper dumping of VOC and related chemical compounds at Superfund sites located near the study area boundary. VOCs have been detected within the UAU and MAU, but not the LAU or Red Unit. There is no direct evidence that surface water recharge from the Salt River has contaminated the three alluvial aquifers with HTRW unless such recharge has been associated with the Superfund sites, downstream from the study area. The closest of these VOC sites is the Indian Bend Wash NPL site, discussed in more under the "HTRW" report sections, below.

8.0 HTRW[2]. The U.S. Army Corps of Engineers assesses risks and problems posed by potential HTRW (*h*azardous, *t*oxic, or *r*adioactive *w*aste) in study areas under the following criteria. If the conceptual or planned study area activities (i.e., the "construction of a project") would require moving or mobilizing HTRW-contaminated water or soil, this situation needs to be qualified and quantified as soon as possible in the study process. This is so that the associated costs can be estimated and a team decision made regarding whether or not it is viable to continue to include the suspect or contaminated zone in the overall study plan. General examples of conceptual activities that have to be considered are the increase of groundwater elevation or the directing of irrigation water in such a way that the water reaches and mobilizes some previously non-mobile contaminant. Actions that could mobilize contaminants in adjoining property also have to be considered.

A Phase I Environmental Site Assessment (*hereafter*, "Phase I EA") for this study was completed by Liesch (2002) under contract to SRPMIC, as an in-kind services product. By necessity, a Phase I EA is a generalized document when it addresses a study area of this size in the early stages of conceptual alternative evolution. Some of the perspective *30* specific study-area Alternatives under consideration (A_1 through O_1 and A_2 through O_2) had not been developed at the time Liesch (2002) did the Phase I EA research. This is the natural course of HTRW site identification and the developing of risk assessment: refining it further as the study evolves. The Liesch (2002) effort included database searches, aerial photo examination, interviews, a walk-over survey, visits to some of the businesses and quarries, a listing of all uses of land in the study area, and an assessment of the overall findings. Leisch (2002, p. i), in the Phase I EA, compiled a list of over 50 different sites of "development" and/or "utilization", apparently so as to completely document existing and known past land use and practices in the study area. That

[2] "HTRW" is "potentially *h*azardous, *t*oxic, or *r*adioactive *w*aste". There are no known or suspected radioactive sites in this study area.

listing by Leisch was assessed by the Corps' Geotechnical Branch, Geology & Investigations Section (*hereafter*, "Geology & Investigations"), site-by-site, with regard to perceived potential environmental risk to each of the 30 conceptual study Alternatives. This assessment was based solely on data presented in the Phase I EA, and the assessment was presented in the F-4 level feasibility study document (table A-1, figure A-1, in *Attachment A* of the 15 Oct. 2003 Geotechnical Appendix to the F-4 feasibility for this study). Leisch (2002, pp. ii, 30, 31) had concluded that 14 specific businesses or landfills were "environmental issues", and that an unspecified number of unspecified properties also had "environmental issues" regarding ASTs[3], USTs[4], and potential TSD[5] issues; plus environmental issues at unspecified locations throughout the study area regarding debris dumping, other illegal dumping, and the potential interactions between study area activities and existing irrigation runoff water, wastewater recharge ponds, water wells, septic tanks, water wells. Geology & Investigations cut through the Phase I EA data in a different manner, having the advantage of knowing all the nuances of all 30 Alternatives under consideration. Geology & Investigations did not think that several properties on the Leisch final list of environmental issues actually presented potential risk to the study area, but, on the other hand, Geology & Investigations added several other items to a list of sites that required additional research and assessment.

The conclusion presented in the Oct. 2003 F-4 feasibility report by Geology & Investigations was that additional information on several specific properties must be gathered, assessed, and folded into the overall environmental assessment in the geotechnical appendix for the final iteration of the feasibility report, and that by doing so, it likely could be deduced that many of the sites offer no risk to the environmental restoration activities planned for this study area. It fell to the local sponsor to gather this information as part of their on-going role as provider of environmental data as an in-kind-services product. In the interim months since Oct. 2003, all ITR and internal review feedback regarding HTRW reasserted what Geology & Investigations already had called for in the F-4 feasibility report: get the additional environmental data on the sites specified previously. As of mid-January 2004, Geology & Investigations teamed with the local sponsor's Environmental Services staff to collect the data, then prepared an independent assessment of the data. Results are presented below. Issues regarding debris dumping are covered in a new, separate section, under the heading of "non-hazardous waste", on pages below.

8.1. *Specific sites assessed beyond the Phase I EA level, with regard to potential environmental impact on the study area.*

8.1.1. *Talley Defense Systems site*. **[Draft Feasibility Note: Shortly before publication time for this document, late-March 2004, the footprint of Alternative O was changed, ELIMINATING all the features of Alternative O shown on fig. 8, below; that change includes ELIMINATION of the only planned constructed wetland near the Talley Defense site. This change serves to ELIMINATE any chance of impact on the *current* Alternative O features by the Talley Defense site. Nevertheless, this assessment is presented as is, because future Alternative iterations may change, possibly once again encompassing lands near Talley Defense. Since the time already has been spent to find the actual locations of the Talley Defense facilities of concern (unknown at the F-4 phase), and collect and analyze all**

[3] AST is "above ground storage tank".
[4] UST is "underground storage tank".
[5] TSD is "treatment, storage and disposal".

the existing data on the site, and to assess the potential risk to the study area, this assessment is presented intact. Remember there are 28 other Alternatives besides Alternative O, all, technically, still "in-play" with regard to final conceptual planning. Until all 28 are officially eliminated from the planning process, this assessment has pertinence, and the Talley Defense site presents some element of risk, as qualified, below—the author, 23 March 2004].

Talley Defense Systems[6] received mention in the 2002 Phase I EA report for its testing of rocket propellants and its history of numerous (unspecified) TSD (***t***reatment, ***s***torage, and ***d***isposal) violations. No precise location for the facility was provided in that Phase I EA. These facts prompted Geology & Investigations to collect and assess the following additional information about the Talley Defense Systems site.

As of Jan. 1988, the facility comprised nearly 37,000 square feet of industrial space, separated into five, non-contiguous plants and a waste propellant burn pit area (SAIC, 1994, pp. 2-1 and 2-3), all shown on figs. 8, 9. All are south of the Salt River and outside of the study area, but all are upgradient from the study area; the waste propellant burn pits adjoin SRPMIC land. Since 1965 or 1966, the firm has been manufacturing solid-phase rocket propellants on location, including: ammonium perchlorate (AP), ammonium nitrate (AN), NaN (a component of sodium azide), and magnesium Teflon (Smith Consultants, 2000-a, p. 1; SAIC, 1994, p. 2-3). The main effort at the facility is the design, development, and manufacture of aircraft escape rocket motors and catapults, including the propellants, but sodium azide (NaN_3) propellants for automobile airbags also have been manufactured there (SAIC, 1994, p. 2-2).

Beginning in 1980, the facility was regulated under various EPA and Arizona Dept. of Environmental Quality hazardous waste oversights, and since the 1990s has received various ADEQ air quality permits for the open burning of waste propellants (SAIC, 1994, pp. 3-1 through 3-7). As of Aug. 30, 1991, a Consent Judgment limited this burning to 1,000 lbs of waste propellants per burn event and to one burn event per day, and also required submittal of a plan for removal of any hazardous waste release that may be discovered as a result of the burning. Documentation that provides a rough scope of the scale of burning that had been intended prior to the 1991 Consent Judgment includes: a 1980 permit application for burning 32,000 lbs/year of solid composite propellants; a 1985 application for burning 500,000 lbs per year of hazardous waste. In the history of regulatory oversight, "[Talley Defense Systems] generally demonstrated improper handling of hazardous wastes in the majority of the inspections," (SAIC, 1994, p. 3-7). Among the documented TSD problems is a May 10, 1989 "fire and explosion" at the facility (SAIC, 1994, p. 3-8).

The objective is to assess the potential risk that the study area has been impacted by releases of wastes from any of the Talley Defense Systems operations. To assess this risk, factors considered were: 1) potential contaminants of concern; 2) documented and possible releases of those contaminants of concern; 3) potential contaminant pathways to the study area; 4) the type of hazard associated with the potential contaminant of concern; and 5) proximity to the study area.

[6] The firm operated under the name Talley Industries of Arizona, Inc., until June 1984, when it became Talley Defense Systems (SAIC, 1994, p. 2-2).

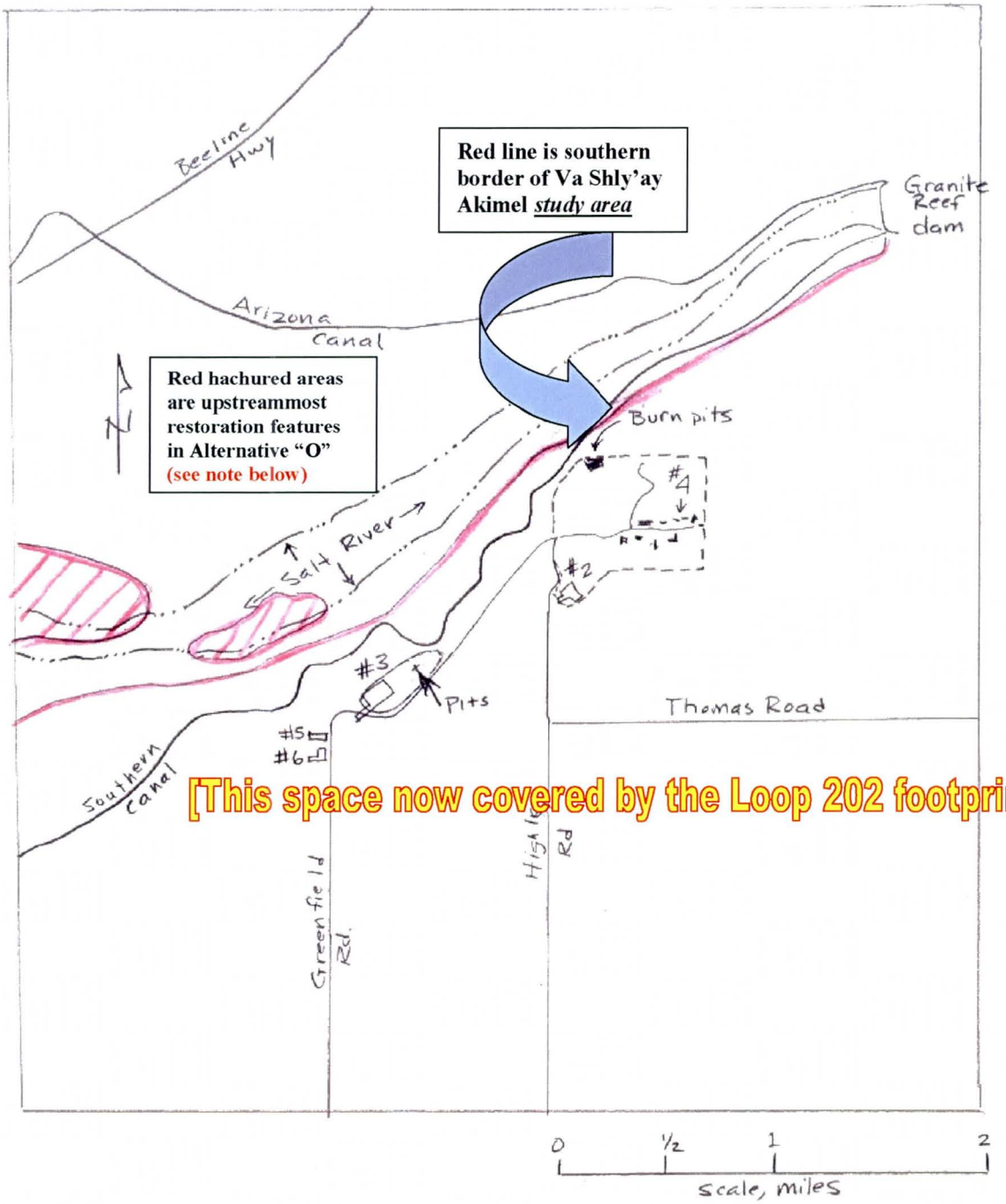


Figure 8.–Relative locations of the Talley Defense System facilities (plants #2, 3, 4, 5, 6), note the "burn pits", another pit area (by plant #3); the Salt River; the Va Shly'ay Akimel study area; and upstreammost environmental restoration features of Alternative "O". Data from Basin and Range Hydrogeologists, 1997, exhibit 2. "Pits" at plant #3 are washwater evaporation and percolation pits. Plant #1 is 3 miles away from this view and was never considered to be in need of environmental oversight. Plant #5 is comprised of administrative buildings (SAIC, 1994, pp. 2-1 and 2-2). Note detail of burn pits in fig. 9. Both hachured areas shown were eliminated from Alternative O's footprint shortly before this document was to be released for publication.

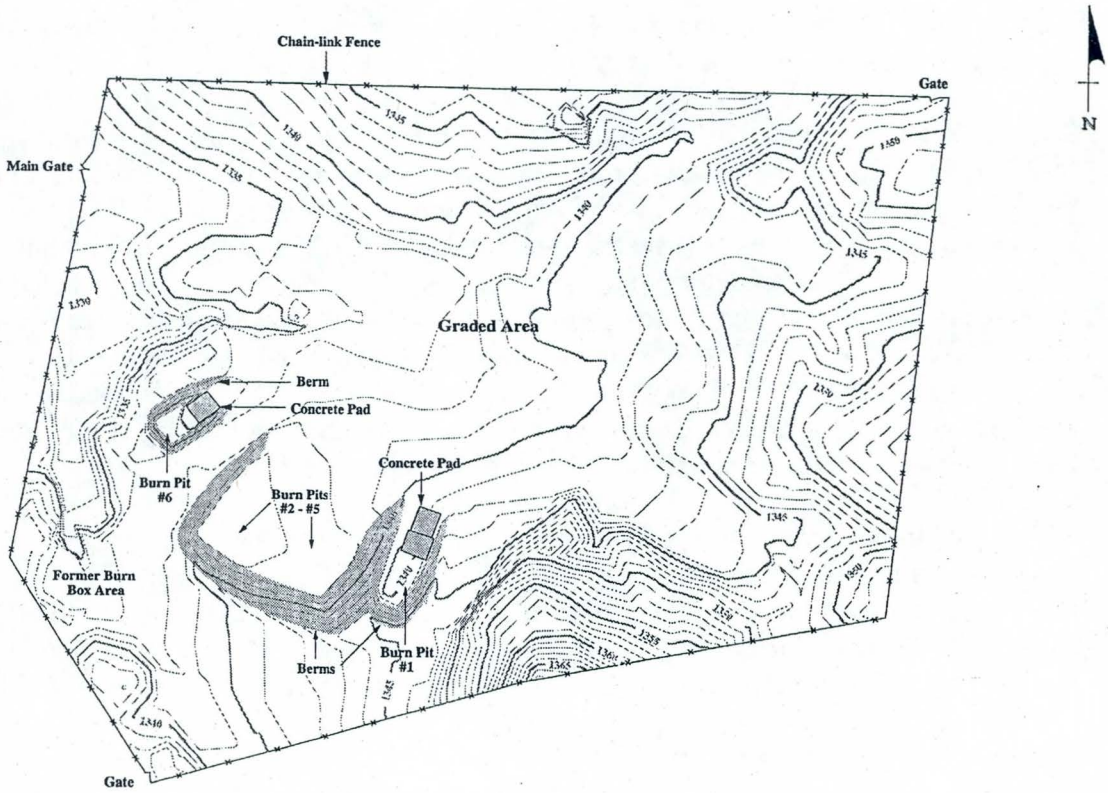


Fig. 9.--Detail map of the burn pits at Talley Defense Systems (map scanned from Basin and Range Hydrogeologists, 1997, exhibit 3). See fig. 8 for larger area view.

8.1.1.1. Potential contaminants of concern, releases, pathways. The facility[7] has been documented to have used the following potential contaminants of concern in operations:

- halogenated and non-halogenated solvents, which are RCRA-listed wastes (SAIC, 1994, p. 4-2);
- chromium-containing paint (SAIC, 1994);
- perchlorate and other propellants, including sodium-azide, a RCRA-listed waste;
- other heavy metals (lead, copper).

8.1.1.2. Releases. There have been at least four different studies of the contamination situation from 1994 to 2000, all of which require some judgment with regard to what has impacted and what may impact the study area in the future. There are no "final answers" at this point, as there has been little to no testing beyond the known release points, and none of the studies were carried out with regard to determining whether *this study area* is or is not impacted by releases. Releases of perchlorate, chromium, copper, and lead have been documented as occurring from Talley Defense System operations, and release of halogenated and non-halogenated spent solvents was assigned a "high potential" to have occurred in past, but assigned a very low potential to have occurred in recent operations due to improved handling of the solvents. Details, and cited references to these facts, are listed below.

Releases of the heavy metals has been proven by analyzing sludge in open, unlined, evaporation-and-percolation pits at plant #3 (see fig. 8 for location). The wash-water with the sludge was allowed to percolate directly into local soils from those pits, and to evaporate. The pit sludge originated in the high-pressure washing of spent rocket housings, which was then directed to the pits. As needed, that propellant-containing sludge was burned off, in the open, on location in the pits when propellant concentrations in the sludge became too high. The other documented release relates to the past practice of Talley Defense Systems of burning (and sometimes exploding) waste propellants in open pits at the boundary of the SRPMIC lands, an action possibly dating back to the mid 1960s (see fig. 8 for location of burn pits). A private-industry investigation relayed that the waste propellants are a source of heavy metals and perchlorate and that they are hazardous waste due to their reactivity (Basin & Range Hydrogeologists, 1997, cited in Smith Consultants, 2000-a, p. 1, and Smith Consultants, 2000-b, p. 1). These releases are discussed below, in detail.

8.1.1.2.1. *Heavy metals in soil and analysis of risk to groundwater.* A 1994 investigation by private industry, which was based on the statistical use (kriged) of previously gathered[8], substantial soil testing, concluded that the primary point of release of contaminants (the company's propellant burn pits--see fig. 9) *likely* has been the source of storm-runoff-borne soil-lead contamination that spread at least 250 northwestward into SRPMIC lands, and *likely* has been the source of both storm-runoff-borne and fugitive-dust-borne copper contamination that spread more than 600 ft northward, over 250 ft northwestward, and more than 600 ft eastward into SRPMIC lands, and roughly 100 ft into the study area (see figs. 10, 11, 12). The uncertainty is based on the facts that concentrations encountered for each of these metals in the testing is *close* to exceeding background levels in soil for those metals, plus these determinations were made by kriging and there are limitations to interpretation of kriging. The cited investigators

[7] see figs. 8, 9, and location with relation to the entire study area on fig. A-1, site 26

[8] By Basin and Range Hydrogeologists, Inc, presented in a March 3, 1997 report entitled, *Site assessment report, Thermal Treatment Unit, Talley Defense Systems*, a consultation report done for Talley Defense Systems.

based their conclusion that the pits were a source of release because high concentrations of the metals were found in areas most affected by surface runoff and ponding. Their analysis also indicated elevated beryllium, nickel, and zinc in soils. Chromium also is mentioned as a released metal. Their study concluded five things:

- The propellant burn pits, which occupy 2.5 acres of surface area, do not comply with Federal regulations;
- Future metals releases from these burn pits will occur because the surface soils are erodible and have high metal concentrations;
- Runoff of surface water has been the primary transport route of contaminants into land adjoining the burn pits, *possibly* bringing with it beryllium, chromium, copper, nickel, and zinc;
- Lead dispersed by surface runoff into lands adjoining the pits exceeds residential PRGs (*preliminary remediation guidelines*) then in effect (in 2000);
- Heavy metals in the soils probably do not affect groundwater, based on the facts that underlying bedrock has a low hydraulic conductivity, the groundwater surface is deep (200 ft), vertical mobility of metals in Arizona soils traditionally is limited[9], and sampling suggests attenuation of heavy metal concentrations at shallow depth (Smith Consultants, 2000-b, pp. 2, 9, 12, and maps 1, 7, and 8).

Not investigated in the Smith Consultants' study were open waste evaporation/percolation pits at plant #3 (see "pits" on fig. 8). At plant #3, solid rocket propellant was washed from the insides of spent rocket motor casings at high pressures. The wash water, after being screened twice to remove large pieces of solid propellant, then flowed into the two 15-by-40 ft, 3-ft-deep pits, where it percolated into the ground and evaporated. As needed, propellant residues were burned in the open at the pits to reduce rocket propellant residue that accumulated. These processes took place for twenty years, ending in 1990 (SAIC, 1994, pp. 6-35 through 6-37). Tests revealed cadmium, chromium, and lead in soil at these pits, all below draft ADEQ guidance levels for soil in effect at the time (<100 mg/kg Cd, <2,000 mg/kg Cr, <400 mg/kg Pb) (SAIC, 1994, p. 6-37). Geology & Investigations considered that possible sources of the heavy metals in those wash evaporation pits may be these: chromium may have come from the paint used on rocket assemblies; cadmium may be from the casings; lead was thought possibly to be from a lead-containing propellant (but Talley Defense stated no such propellants were burned there (SAIC, 1994, p. 6-37)). The propellant concentration level in these same residues was high (discussed below, under *perchlorate*).

8.1.1.2.2. *Perchlorate in soils and risk to groundwater*. The situation regarding potential perchlorate release from the burn pits area is perhaps less completely studied than the metals situation, based on the presence of only a "draft" report on the subject, again by Smith Consultants (2000-a), but this time using new soil samples to test for perchlorate, collected by Smith Consultants in 2000. No water samples were taken, but some speculation on risk to groundwater was made by Smith Consultants, nevertheless. The perchlorate was identified as a component of the propellants burned at the pits (Basin & Range Hydrogeologists, 1997, cited in Smith Consultants 2000-a, p. 1). The soil samples revealed perchlorate in 19 of the 23 soil samples collected *in the runoff-impacted area west of the burn pits*; it had migrated at least 250 ft northeastward into SRPMIC lands (see fig. 13). Concentrations in that entire test

[9] Heavy metals are cations (positively charged particles) with a low solubility and are readily adsorbed by clay particles in soil (Smith Consultants, 2000-a, p. 5).

0

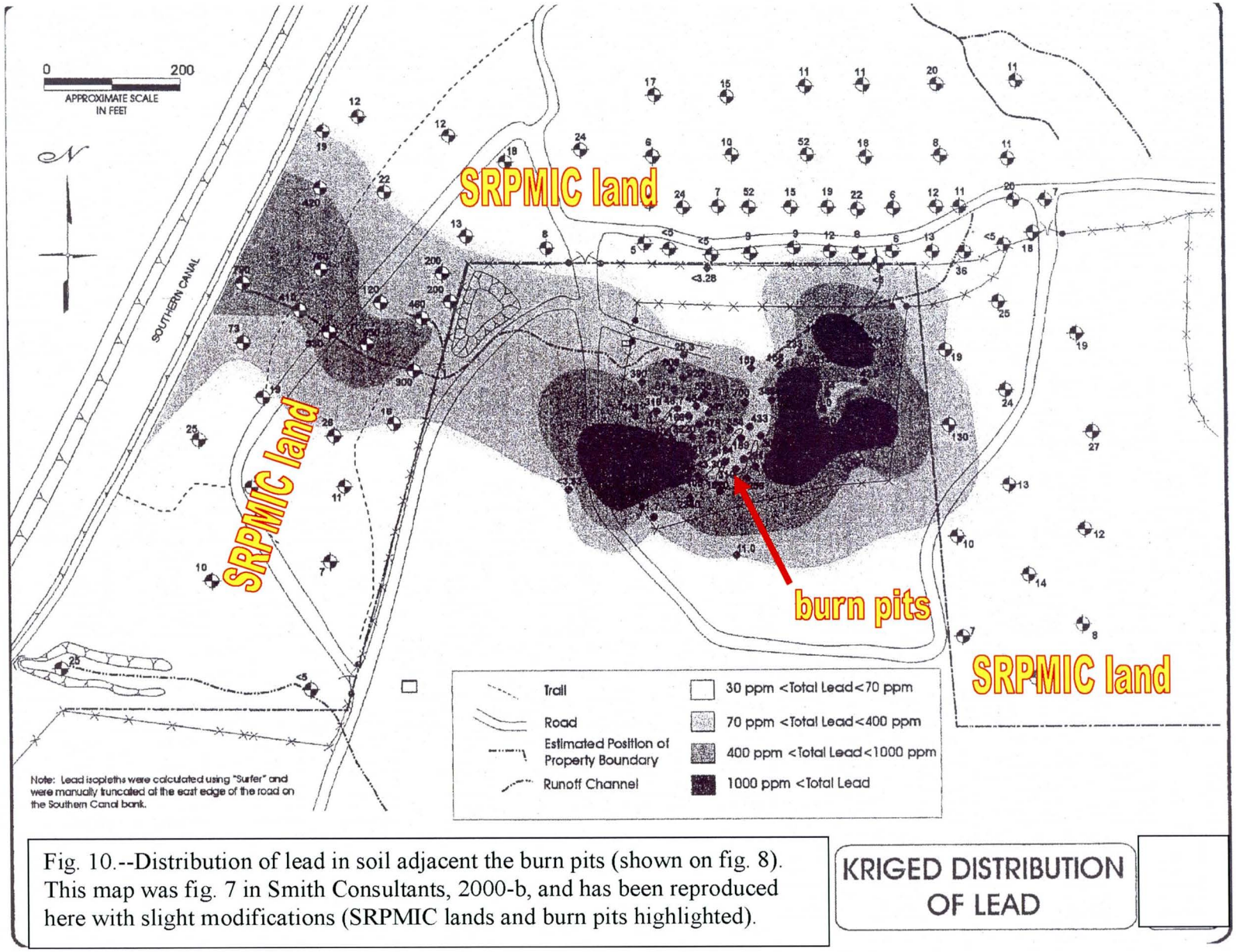


Fig. 10.--Distribution of lead in soil adjacent the burn pits (shown on fig. 8). This map was fig. 7 in Smith Consultants, 2000-b, and has been reproduced here with slight modifications (SRPMIC lands and burn pits highlighted).

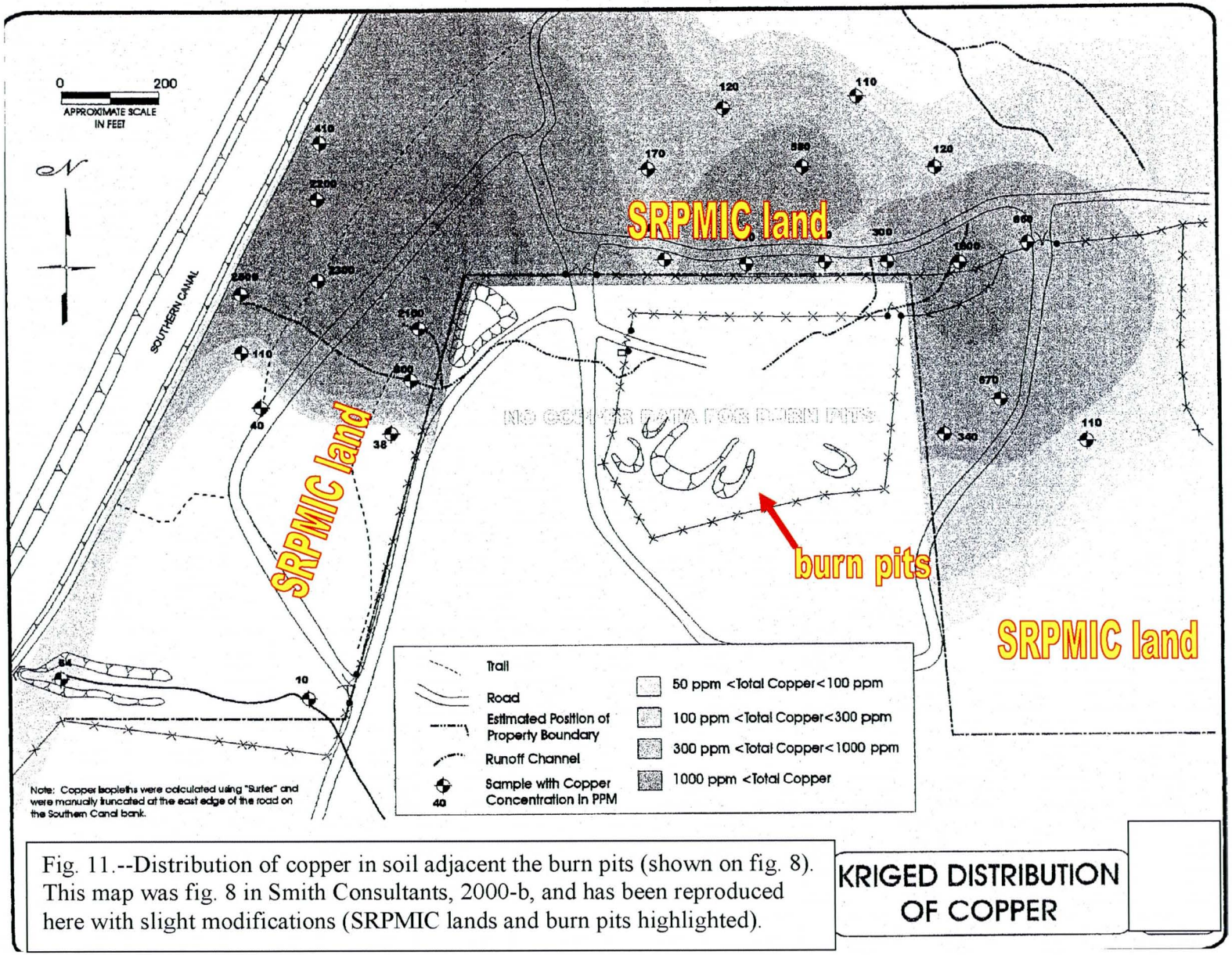


Fig. 11.--Distribution of copper in soil adjacent the burn pits (shown on fig. 8). This map was fig. 8 in Smith Consultants, 2000-b, and has been reproduced here with slight modifications (SRPMIC lands and burn pits highlighted).

0

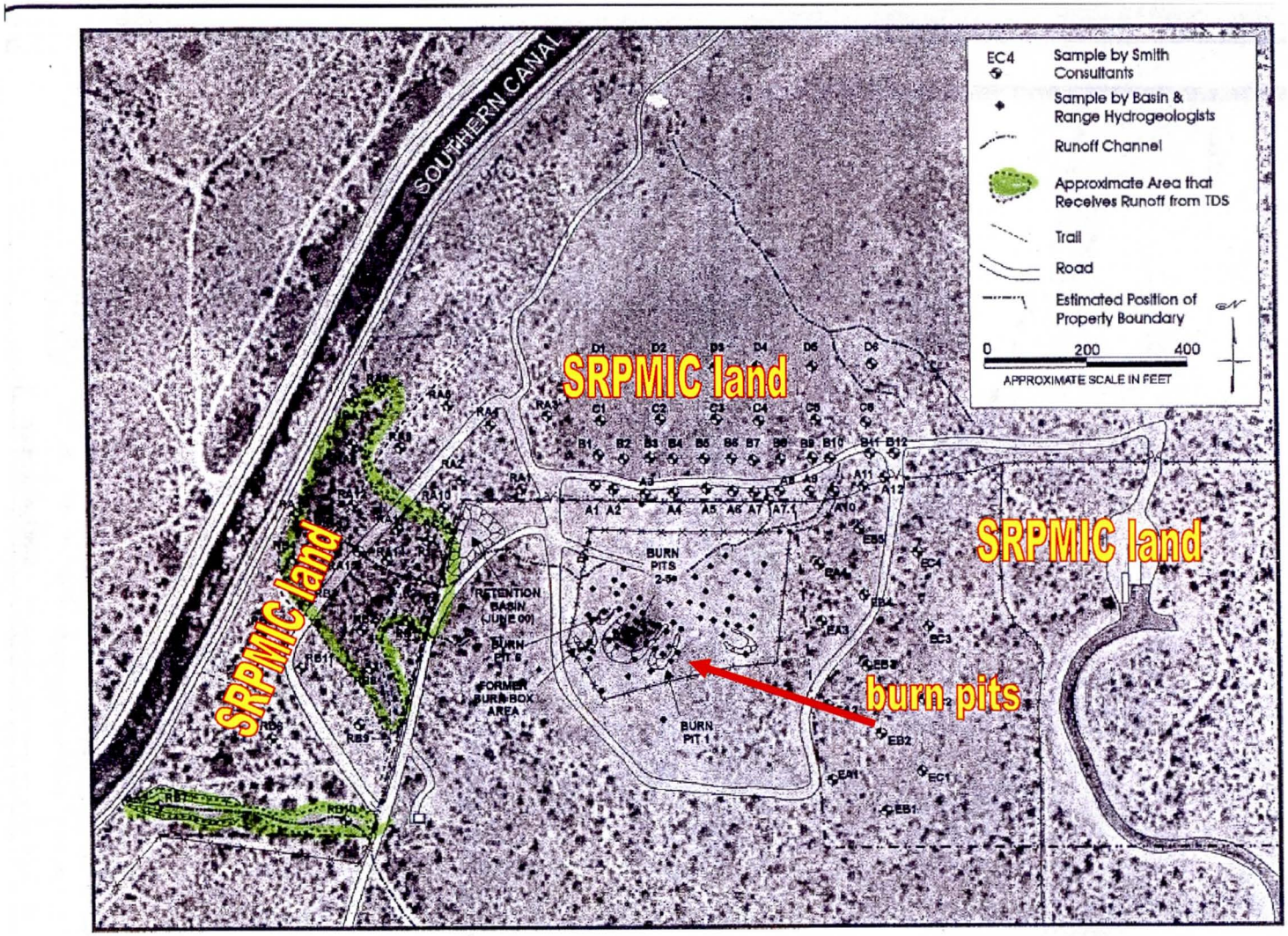


Fig. 12.--Distribution of lead in soil adjacent the burn pits (shown on fig. 8). This map was fig. 2 in Smith Consultants, 2000-b, and has been reproduced here with slight modifications (SRPMIC lands, runoff-receiving area, and burn pits highlighted).

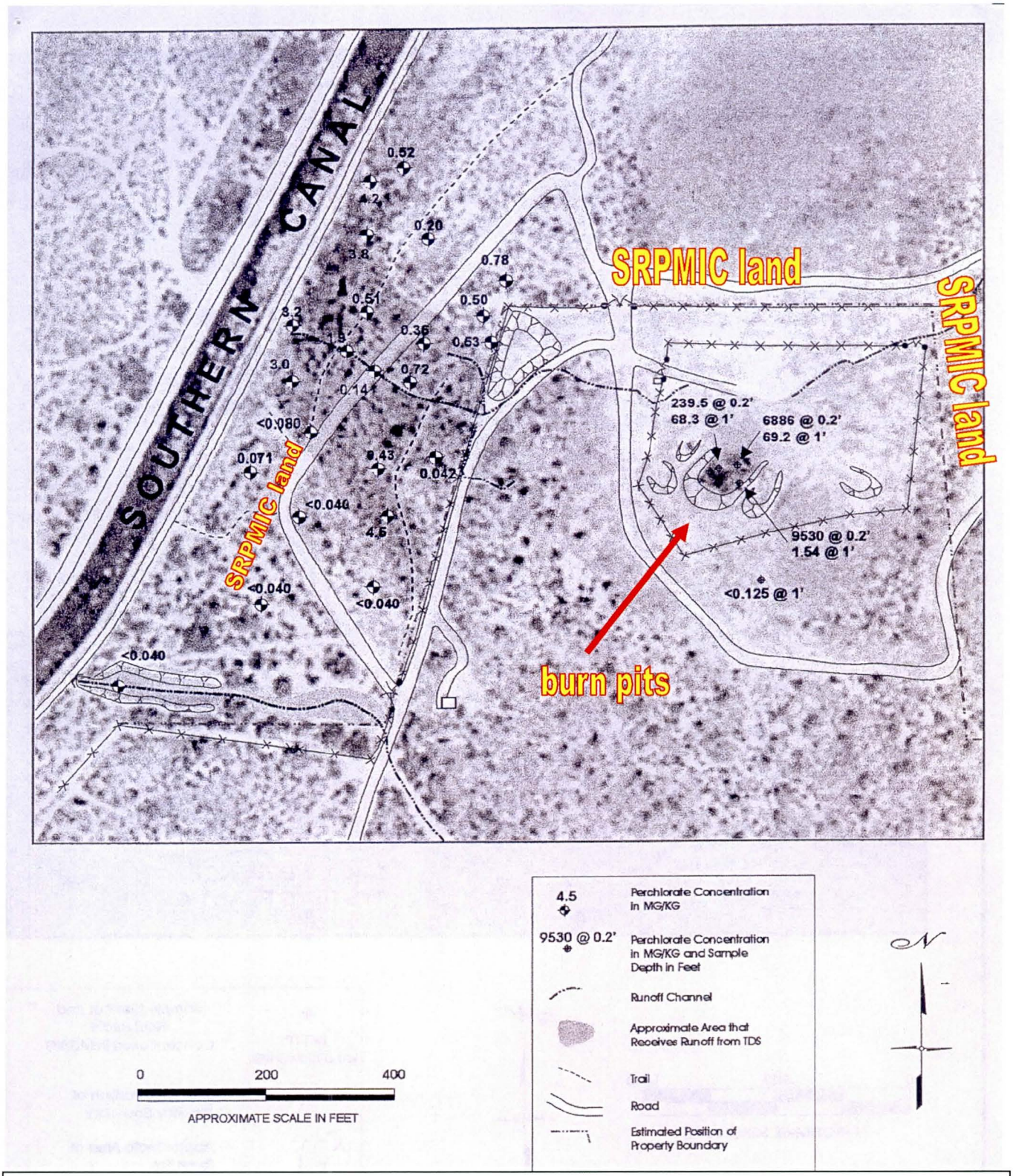


Fig. 13.--Distribution of perchlorate in soil adjacent the burn pits (shown on fig. 8). This map was fig. 3 in Smith Consultants, 2000-a, and has been reproduced here with slight modifications (SRPMIC lands, runoff-receiving area, and burn pits highlighted). A background perchlorate-in-soil sample, collected approximately 2,000 ft northeast of the burn pits for the Smith Consultants study contained <0.040 mg/kg perchlorate (Smith Consultants, 2000-a, fig. 4).

suite (samples outside the burn pits) were 0.042 to 4.5 mg/kg perchlorate, none of which exceed the PRGs in effect as of mid 2000. Perhaps most importantly, the conclusion by the Smith Consultants investigators is essentially that much of the highly mobile perchlorate probably was *missed* by the sampling technique, having migrated readily to soil horizons deeper in the soil profile than were caught up in the shallow soil sampling program (Smith Consultants, 2000-a, pp. 3-4, and maps 2, 3). This correlates to some degree with the seeming paradox: perchlorate concentrations showed an increase at the maximum distances sampled, away from the burn pits. Possibly the perchlorate reached a less permeable layer at depth or thinner soils away from the burn pits, and in response was closer to the surface when laterally more distant from the burn pits, where it could be more readily captured in the shallow soil samples. Smith Consultants assign risk of groundwater contamination to SRPMIC lands, *and to the Salt River in particular*, due to perchlorate migration, citing that the alluvial soils in the release area have high hydraulic conductivity and the general absence of vertical migration barriers (Smith Consultants, 2000-a, p. 6).

8.1.1.2.3. *Halogenated solvents and other wastes*. Other documented wastes produced at Talley Defense Systems include:

- the halogenated solvent 1,1,1-TCA[10], which is a RCRA-listed waste (type F001);
- type F002 and F003 non-halogenated solvents, which are RCRA-listed wastes, and, in the case of F003, are ignitable wastes;
- and type P105 (sodium azide), a RCRA-listed, hazardous waste.

Locations where each was produced or used in the facility are pertinent, shown in table 2.

Table 2.—Other wastes from Talley Defense Systems, Mesa, AZ.

Plant	Type waste	Name of waste	Description	Uses
At Plant #2	F001	1,1,1-TCA	A halogenated solvent	Used in degreasing
At Plant #2	F002	Could be any of several spent halogenated solvents listed in 40 CFR §261.31, Jul 1, 1992	Uncertain	Non-specific source
At Plant#2	P105	NaN_3 (sodium azide)	Hazardous waste; RCRA-listed waste	Automobile safety air-bag propellant
At Plants #3 and #6	F001	1,1,1-TCA	RCRA-listed waste	Metal working at plant #3, non-specific source, plant #6; probably used in degreasing
At Plants #3	F002	Could be any of several spent halogenated solvents listed in 40 CFR §261.31, Jul 1, 1992		
At Plant #6	F003	Could be any of several spent non-halogenated solvents listed in 40 CFR §261.31, Jul 1, 1992	RCRA-listed waste; Ignitable waste	

Source: SAIC, 1994, pp. 4-2, 6-18.

[10] Trichloroethane, phased out of use by 1995 due to risk for ozone depletion, according to: PACIFIC NW POLLUTION PREVENTION RESEARCH CENTER POLLUTION PREVENTION RESEARCH PROJECTS DATABASE, at website http://www.pprc.org/pprc/rpd/statefnd/sce/recyclab.html.

Assessment of the release potential of these wastes, according to SAIC (1994) is that release potential was low at the time of the study, but may have been high in the past for TCA at plant #2, and for liquid wastes at plant #3 due to past practices. What that past, speculative high potential may translate into, as far as actual contamination in the study area, has not been determined. There has been no testing.

8.1.1.3. *Proximity to the study area and planned environmental restoration features*. Talley Defense Systems plants are spread along a more than 2-mile-long line (fig. 8), all upgradient from the study area. No part of Talley Defense Systems facilities is any closer to any Alternative "O" environmental restoration feature than ½ mile. That point includes the washwater perc pits at plant #3. The waste propellant burn pits are farther away from Alternative O--no closer than 1-¾ mile--but these burn pits are in part *adjacent* to SRPMIC *lands*, and are just 500 ft outside the Va Shly'ay Akimel *study area* boundary.

8.1.1.4. *Conclusions by Geology & Investigations regarding potential risks from Talley Defense Systems operations*. Available data are highly *in*conclusive regarding whether or not any released contaminants from Talley Defense Systems operations have impacted the currently (early 2004) planned environmental restoration features of the Va Shly'ay Akimel study area, or any other parts of the study area that are downstream of Talley Defense Systems burn pits.

As a result, it must be assumed that there is risk for some perchlorate contamination in the study area, where excavation, construction, and groundwater level manipulation are planned via Alternative O. The two potential sources of contaminant release (based on available data) have to be assumed as the washwater pits at plant #3, and the burn pits. Due to the high mobility of perchlorate, no greater or lesser risk is assigned to one source or the other. The burn pits, while farther away from the Alternative O features, probably saw more total release than did the washwater pits. To a lesser degree than assigned to perchlorate, a risk of contamination of the from heavy metals has to be considered as possible for the study area, foremost from cadmium, chromium, and lead from the washwater pits, and to a lesser degree (due to greater distance) from copper, lead, and possibly cadmium from the burn pits. Unless or until direct sampling of soil and groundwater for these contaminants is undertaken in a manner that will determine contaminant concentrations (or the absence of contaminant) in the study area and in and near planned features for Alternative O, the presence or absence of contaminants will remain an unknown. None of the previous sampling, testing, and numerical analysis by others was designed to answer this question, nor did it answer this question. Precautionary sampling and testing of soil to be moved and groundwater to be dewatered, for perchlorate and these heavy metals, should be a part of the construction of features most upstream in Alternative O**[no longer needed as long as the late March 2004 decrease in the footprint of Alternative O remains in effect, as per the fig. on the last page of this document, and as long as Alternative O remains the likely direction this study will take]**. A line of exploratory borings immediately upstream of the upstreammost wetlands and/or constructed features of Alternative O would be a wise investment, at the nearest opportunity **[no longer needed as long as the late March 2004 decrease in the footprint of Alternative O remains in effect, as per the fig. on the last page of this document, and as long as Alternative O remains the likely direction this study will take]**. Such work *could* serve to remove most all of this potential risk with regard to the study at hand, by proving that contaminant migration did not proceed far enough downstream to impact the study.

Distance, barriers, and geochemical reactions will work together to allow any contaminants that may be migrating to either migrate to the study area or be stopped prior to reaching the study

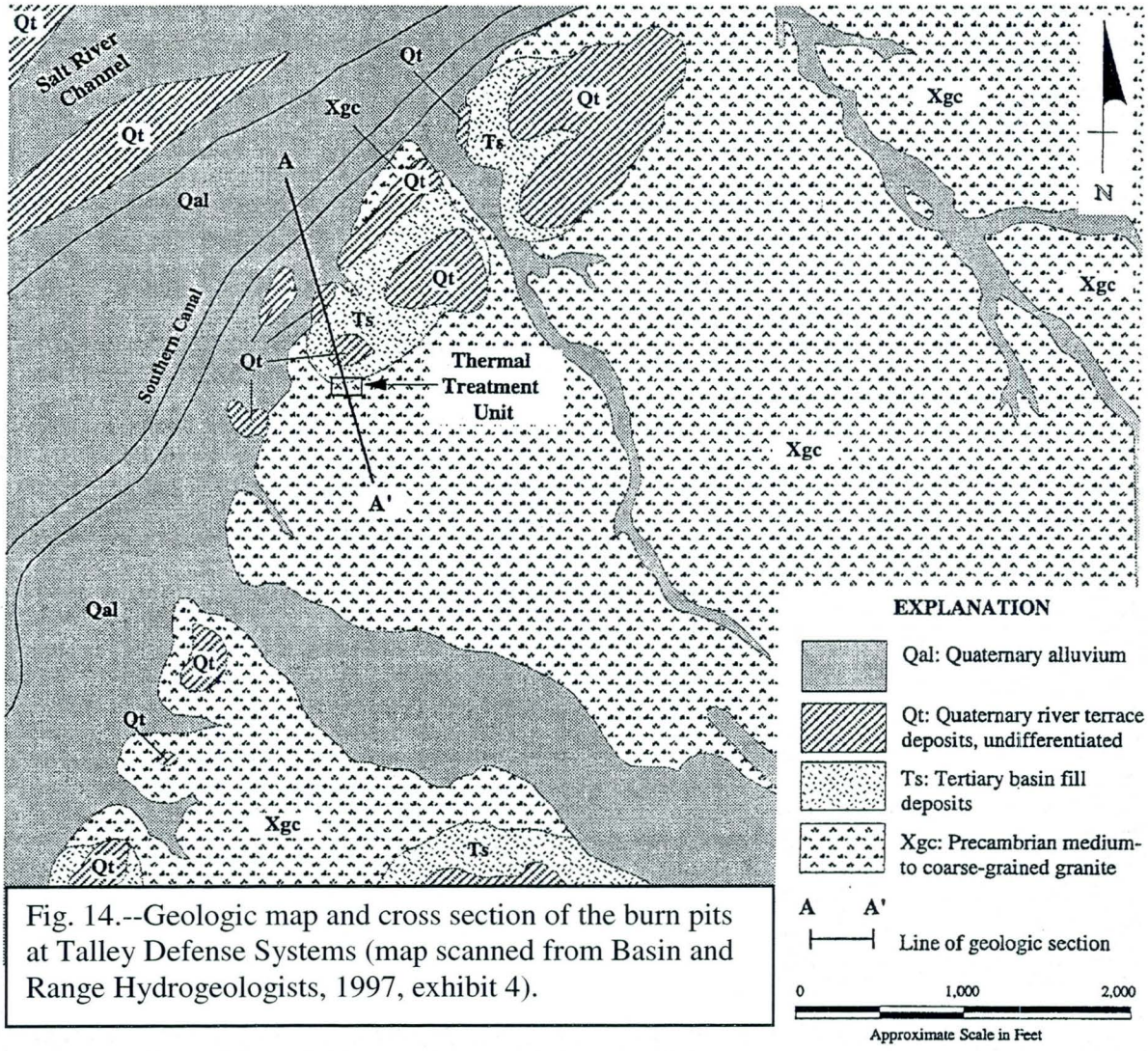
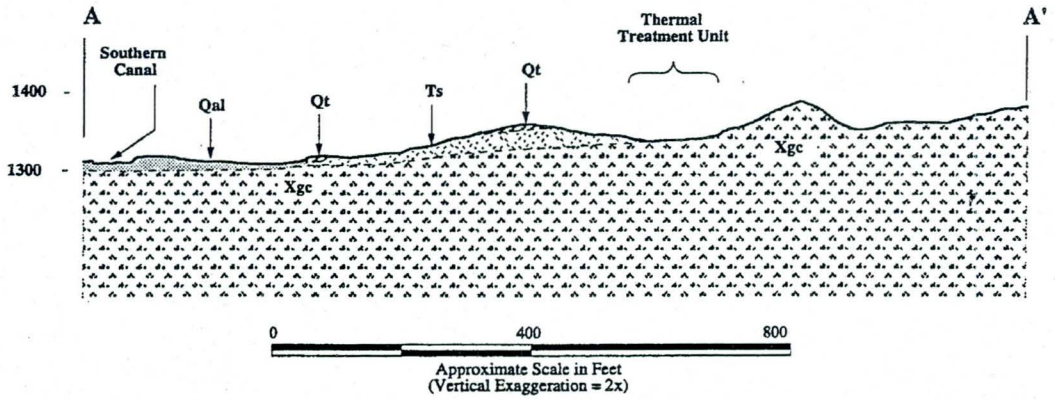


Fig. 14.--Geologic map and cross section of the burn pits at Talley Defense Systems (map scanned from Basin and Range Hydrogeologists, 1997, exhibit 4).



area. Groundwater[11] is about 450 feet deep and flows southeast (away from the study area) at 13.83 ft/day (SAIC, 1994, pp. 5-2 through 5-4). But the fact that all Alternative O features are down-gradient of surface runoff from the plant and are downgradient from the two known release areas has to be considered as increasing the risk to the study area, as the contaminants likely would travel such a route. The presence of Talley Defense's runoff retention basin shown on figs. 10 and 11, which was new as of June 2000 (Smith Consultants, 2000-a, p. 4), should be expected to provide some manner of barrier to contaminant migration, especially the metals. The observed attenuation in copper and lead contamination at depth coincides with what is known about the geochemistry of those metals and suggests that the soil between the burn pits and the study area probably serves to some degree as a barrier to metals migration. The potential mitigation feature of soil stabilization, discussed by Smith Consultants (2000-b, p. 10) is worthy of additional consideration. The location of the Southern Canal (fig. 8) between the Salt River and the contamination also may serve as a partial barrier to mitigation of contaminants to the study area. That canal's depth, lining type, etc., were not determined for this assessment. It is unclear whether the local geology (see fig. 14) would contribute to or impede contaminant migration. Smith Consultants report that the hydraulic conductivity of granitic, Precambrian-age basement bedrock below the alluvial soils at the burn pits is many magnitudes of order less than that of the thin, overlying soils developed from weathering of the granitic bedrock (Smith Consultants, 2000-a, p. 6). This rock, if unfractured, *may* represent a sort of lower, partial, containment to migration; if fractured, it could provide addition, faster routes of migration to the study area.

The Talley Defense Systems facility is within both the 50-year and 100-year flood plains (SAIC, 1994, p. 5-5), so a risk exists of contaminant movement to the study area via surface inundation of the burn and washwater pits, and other facilities as well.

The risk from halogenated and non-halogenated solvents probably should be considered a very low potential risk at this point, not worthy of follow-up at this time, based on available data about past practice at the facility. This should be tempered with the fact that no testing was done in any of the past studies for these potential contaminants of concern.

8.1.2 *Landfills* (sites 8, 15, 18, 30, 31, 32C, on fig. A-1). Five landfills are within the study area; all are near the current array of conceptual environmental features of Alternative O. See the summary of these landfills, below, in table 3. All landfill sites for which there is any information are unlined, so there is concern regarding what might be leached from them if they are inundated as part of the conceptual environmental restoration. Potential riverbank erosion and breach of landfill contents deserves consideration as an issue. Only the Tri-Cities landfill has bank protection. A reported debris pile at site 2 on fig. A-1 (Salt River Sand and Rock quarry) is the load from one such breach. The risk of others to breach is not known. USACE, 2002 (p. III-4) notes two of the landfills (unspecified) were improved with bank hardening under a FEMA program subsequent to 1992-93 flood breaches. The river bank segment that is essentially composed of Cypress landfill trash (figs. 15, 16) is evidence that is has been breached in the past and is susceptible in the future.

[11] As of the time of the research (1994), there were 22 groundwater withdrawal wells within a 1.5-mile radius of the burn pits, with the closest downgradient well, one mile to the southeast from plant #3, extending to –731 ft below ground surface. There were no injection wells (SAIC, 1994, p. 5-4).

Fig. 15.—Top and bottom frames. Exposed landfill debris comprising the north bank, Salt River, at the perimeter of the Cypress landfill. Note tires, plastic garbage bags, construction debris. Photo, looking north, of the toe of the bank, by Geology & Investigations, 31 Oct. 2003.

0

0

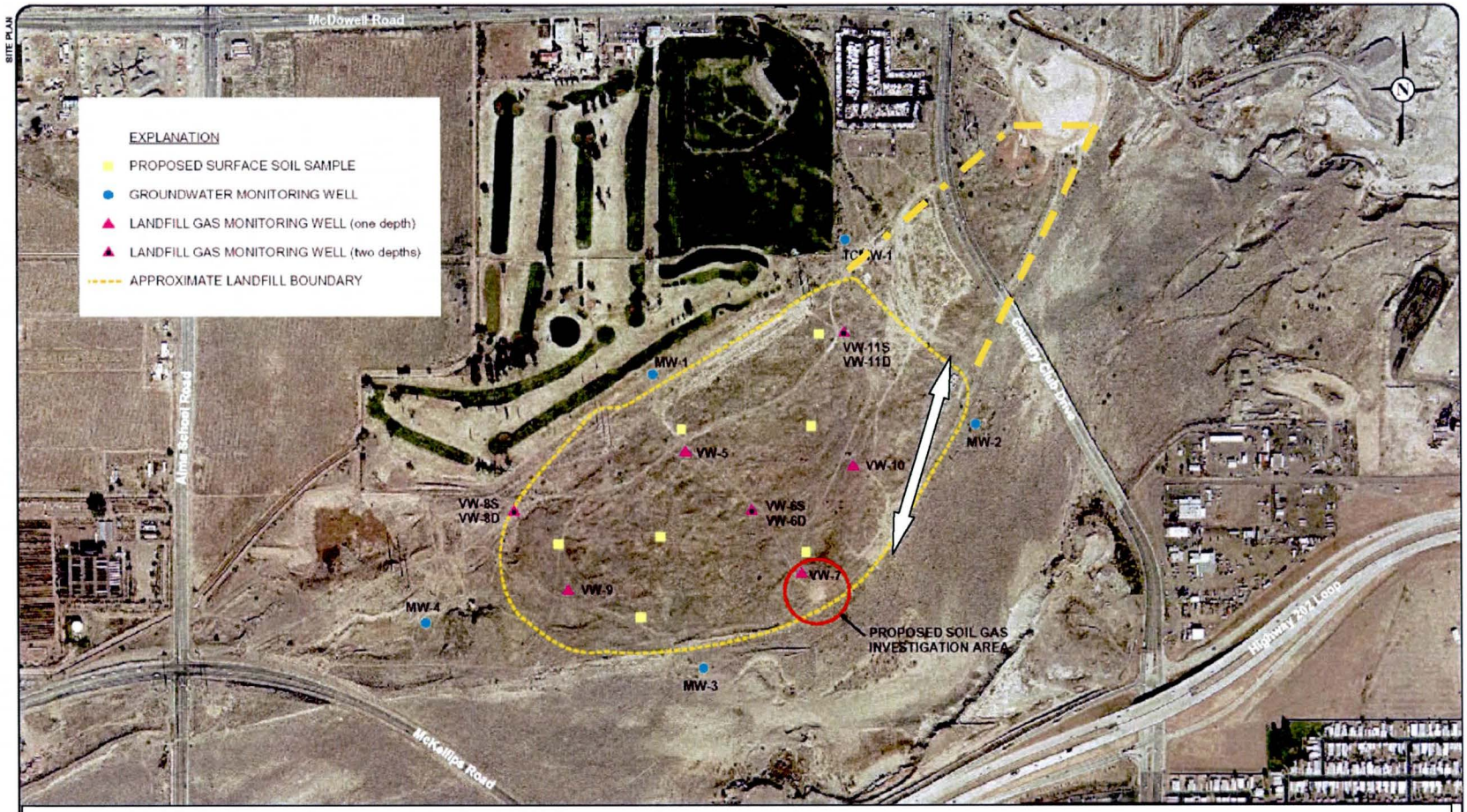


Fig. 16.—Aerial photo of the Cypress landfill (yellow circle) supplied by SRPMIC staff. The white arrow is the approximate area along the north bank o Salt River where Cypress landfill contents comprised the river bank (refer to photos, fig. 15). The red circle is the approximate area where an underground ignition is thought to have occurred within the landfill.

Table 3.—Summary data on landfills in the study area			
Name	Status	Actions	Contents, pollutants (if any)
Tri-Cities, forms the north bank of Salt River in the study area Site 15, fig. A-1	Closed, operated from 1972-1993	Reclaimed, unlined, possibly capped. A soil cement barrier was constructed along the side facing Salt River so as to prevent bank erosion if the river flows. That toe is reportedly 15 ft deep (SRPMIC staff, 2003)	40-million cu yds of waste including demolition debris and residential waste. VOCs in groundwater were a problem until methane collection system installed; then VOCs dropped and no longer exceed MCLs. (Liesch 2002).
Cypress (informally known as "old Tri-Cities" or "Country Club" landfill and many older references will use those terms Site 8, fig. A-1	Operated from early 1960's to about 1980	No closure procedures undertaken; never permitted. Reportedly will receive brownfield funding for cleanup, according to SRPMIC staff, Jan. 2004. Contains wildcat barrel dumping, on top of the landfill after it ceased to be a landfill; this has been partially cleanup up by ADEQ (just the liquid-containing drums), and the rest of the drum cleanup will be covered under the brownfield funding, according to SRPMIC staff, Jan. 2004. More on this barrel site under "wildcat dumping".	Precise boundaries / depth of the landfill not specified and likely unknown. Contains an underground fire (Erroll L. Montgomery & Associates, 2002, p. fig. 1), probably in the waste, near the toe of the north bank of the Salt River channel. The waste forms at least a ¼ mile segment of the north bank of Salt River (see photo, fig. 15), including the toe of the bank, as observed by Geology & Investigations, 31 Oct. 2003. Two VOCs (TCE, 0.6 ppb, and PCE, 0.8 ppb) were detected in groundwater from a well (4ddd) located downgradient of this landfill, but the location is such that the readings could have been from any of three landfills (data excerpted from a 1986 K.D. Schmidt & Assoc. report that we have not been able to obtain). Acetone (dimethylketone) detected in 2002 groundwater sampling in two monitoring wells. There is no EPA MCL for acetone. Its source could be in-laboratory contamination of instruments (Erroll L. Montgomery & Associates, 2002, p. 11)
North Center St. landfill (informally known as "Tri-Cities, south side" or "Salt River" landfill Site 30, fig. A-1	Operated from early 1979s to 1980 by SRPMIC; also used in 1981	A 1994 closure report exists for the Tri-Cities landfill and shows this site on its maps (as "south side"), but all data available suggest no bank stabilization or cap was ever constructed for this landfill	3 million cu yds of waste deposited, incl. asphalt, demolition materials and residential waste. Bank has not been breached Groundwater contamination and methane migration are two risks suggested (Liesch, 2002, p. iii, 10). See note about TCE and PCE in groundwater for the "Cypress" landfill, above; the same applies to this site.
Vulcan demolition debris landfill	No data	Liesch (2002, p. 11, iii) lists no details and suggests no data are available	The size and contents are unknown.

Table 3.—Summary data on landfills in the study area			
Name	Status	Actions	Contents, pollutants (if any)
Site 31, fig. A-1			
"Old Mesa", North Center Street landfill (under the police firing range) Site 32C, fig. A-1	Inactive, dates back to at least the 1960's (Liesch, 2002, pp. 9)		Contents unknown
Salt River landfill Site 18, fig. A-1	Active	An active landfill (Liesch, 2002, p. 14); approx. location from SRPMIC staff, May 2003. Probably the same site as the Salt River landfill at Gilbert Rd. and State Rte. 87, mentioned in USACE, 2002 (p. IV-26).	None known or suspected.

0

0

EPA rules governing the remediation and stability of existing landfills (Criteria for Municipal Solid Waste Landfills (40 CFR part 258)), particularly with regard to the necessity that they be stabilized so as to not wash out, do not apply to landfills that were not active after 1991, nor to those closed after 1991 that were installed with a final cover prior to 1994 (§258.1) (Source of data: http://www.epa.gov/epaoswer/non-hw/muncpl/landfill/techman/subpartb.pdf). Thus, this regulation applies only to the Tri-Cities landfill, the one landfill that is in relatively good condition and the one landfill that has been armored against washout.

There is an informal, non-regulatory agreement between the operators of the GRUSP and the operators of the active Salt River landfill (see table 3 for data), such that the local groundwater recharge mound created by the GRUSP recharge activities will in no case be raised to an elevation closer than 25 feet below the bottom of the Salt River landfill. The objective is to assure that no leaching of Salt River landfill contents will occur due to inundation from below by groundwater. The agreement never has been formalized. The above is according to staff of the SRPMIC, as of mid-January 2004.

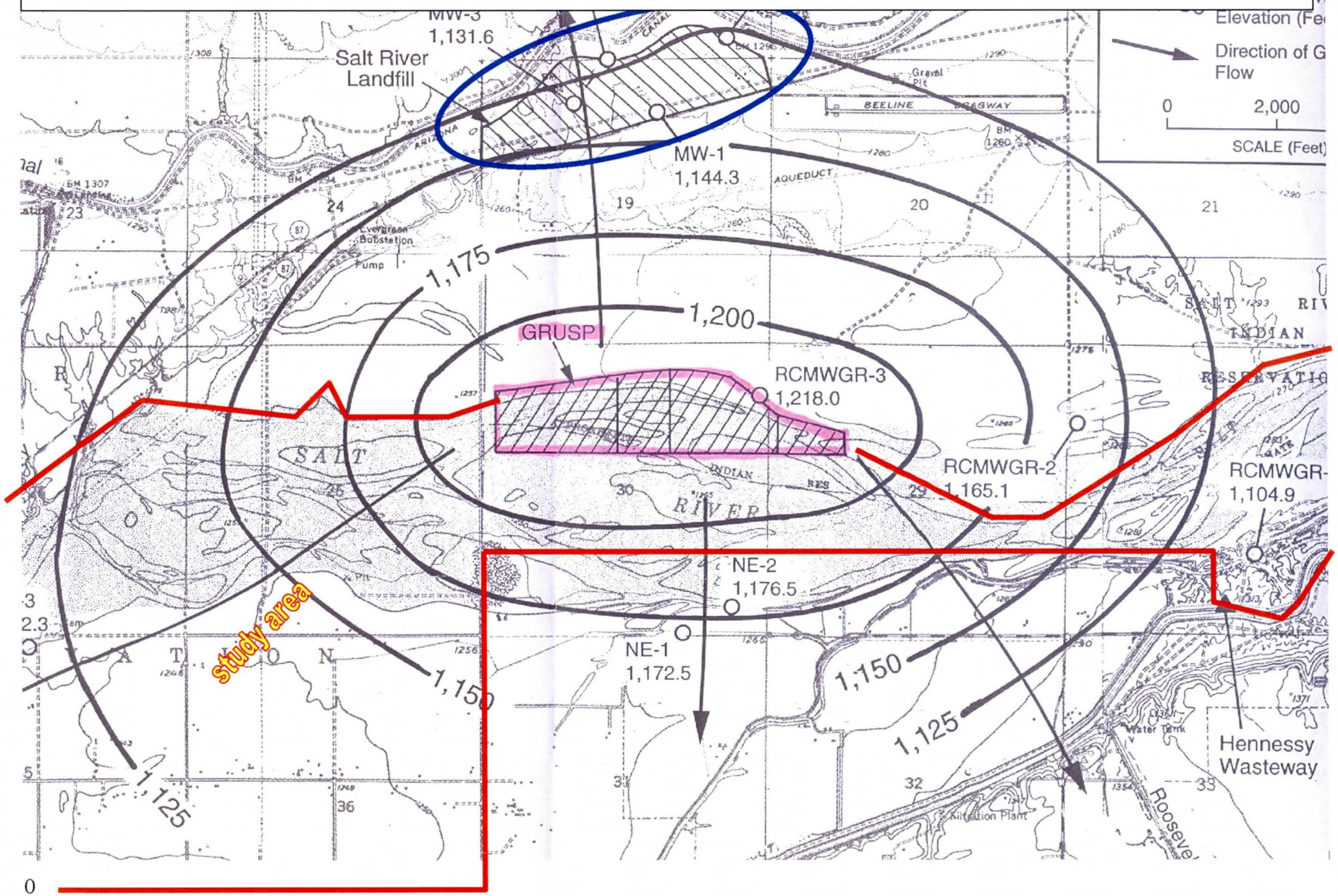
8.1.2.1 *Recommended groundwater equilibrium conditions modeling*. Throughout the feasibility process, the Geology & Investigations recommendation concerning the unlined landfills has been that infiltrating groundwater equilibrium conditions and zone of influence of that water be modeled for all features that will be irrigated and for wetlands that will be created as a part of this conceptual environmental restoration. The objective should be to avoid any inundation of landfill contents so as to avoid the risk of creating any landfill effluent. It was the opinion of previous researchers of two of those landfills that the one reason effluent from all the landfills in this vicinity is not a problem is that the landfills *do not receive any water*. Most environmental restoration features of this study are based on irrigation throughout project life.

The recommended task of modeling is complicated by the fact that the boundaries of the landfills are imprecisely known. The following data are provided as some background data that should help any effort to model the infiltrating groundwater equilibrium conditions and zone of influence. Since all the conceptual Alternatives include irrigation, many for the entire project life, there likely will be interaction between on-going groundwater recharge of other projects and irrigation of the Va Shly'ay Akimel study area. As long as the groundwater interaction remains undefined, mobilization of HTRW, most likely landfill leachate, has to be considered as a possibility.

A map of groundwater recharge mound from the GRUSP (location 17 on fig. A-1), as provided by SRPMIC Environmental Services, is reproduced here as fig. 17. Note the active Salt River landfill, the closest landfill to the GRUSP, which has an existing agreement that groundwater recharge due to the GRUSP will not inundate the landfill (see text section 8.2.2, above). Locations of the Mesa/SRPMIC groundwater recharge ponds (locations 53 and 4, respectively, on fig. A-1), which recharge treated wastewater, are shown on fig. 18. There are not any study area landfills downstream of them, but it should be documented that there will be no combined influence that will adversely impact existing situations, such as the South Indian Bend Wash Superfund groundwater contamination site (detailed below under section 8.2.4).

In the F-4 feasibility report, Geology & Investigations recommended including potential cumulative impacts from irrigation runoff ponds in the groundwater modeling. None of the pond locations were known at that time, although they were in general discussed in the Phase I EA.

Fig. 17.--GRUSP area (pink), and groundwater table elevation contours outward from the GRUSP, which, collectively, connote the groundwater mounding from the GRUSP. Note red lines (in between is the study area;; and blue circle (Salt River landfill—active). Note scale, and arrows (direction of groundwater flow). Data from SRPMIC Environmental Services files.



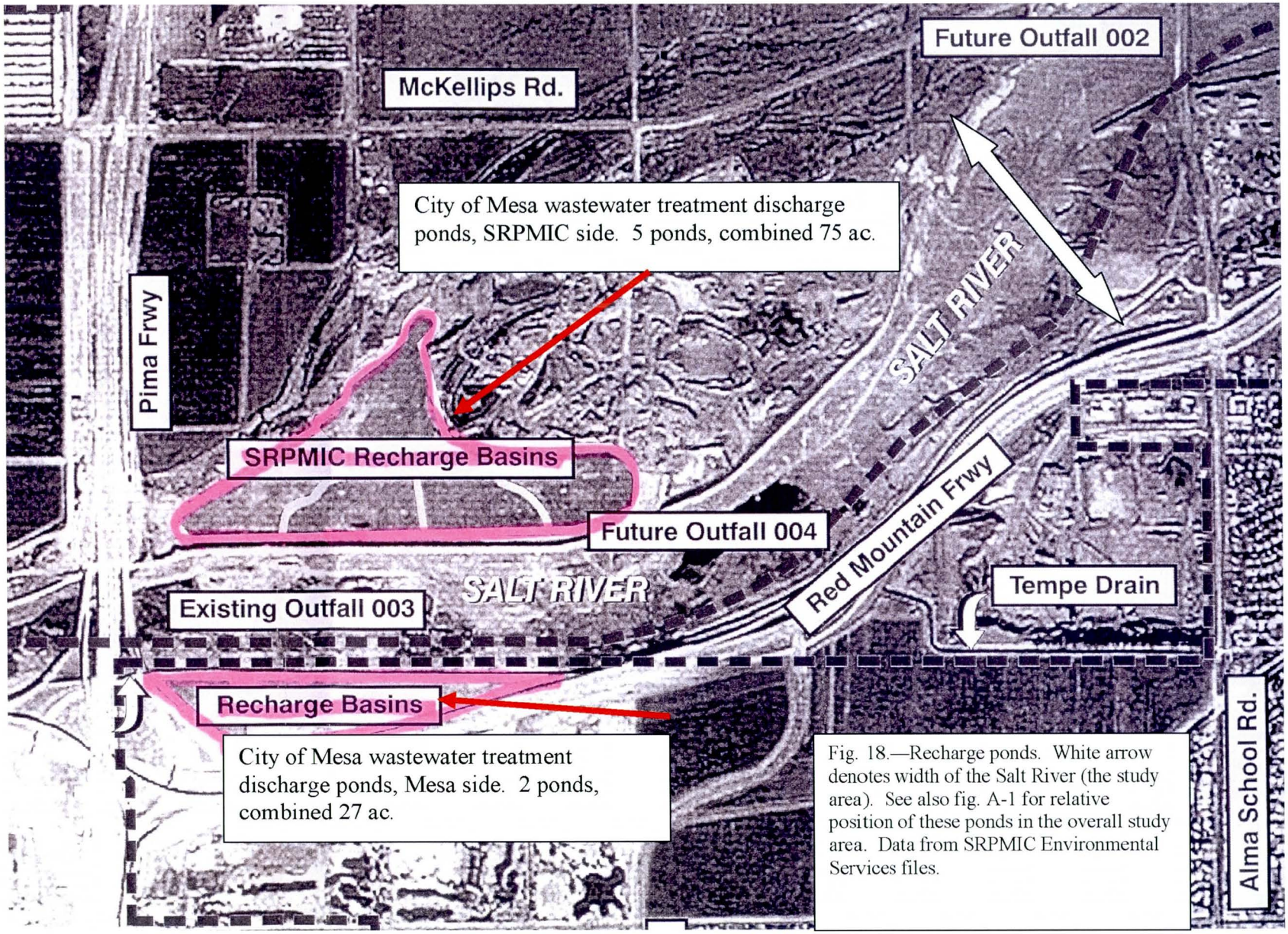


Fig. 18.—Recharge ponds. White arrow denotes width of the Salt River (the study area). See also fig. A-1 for relative position of these ponds in the overall study area. Data from SRPMIC Environmental Services files.

0

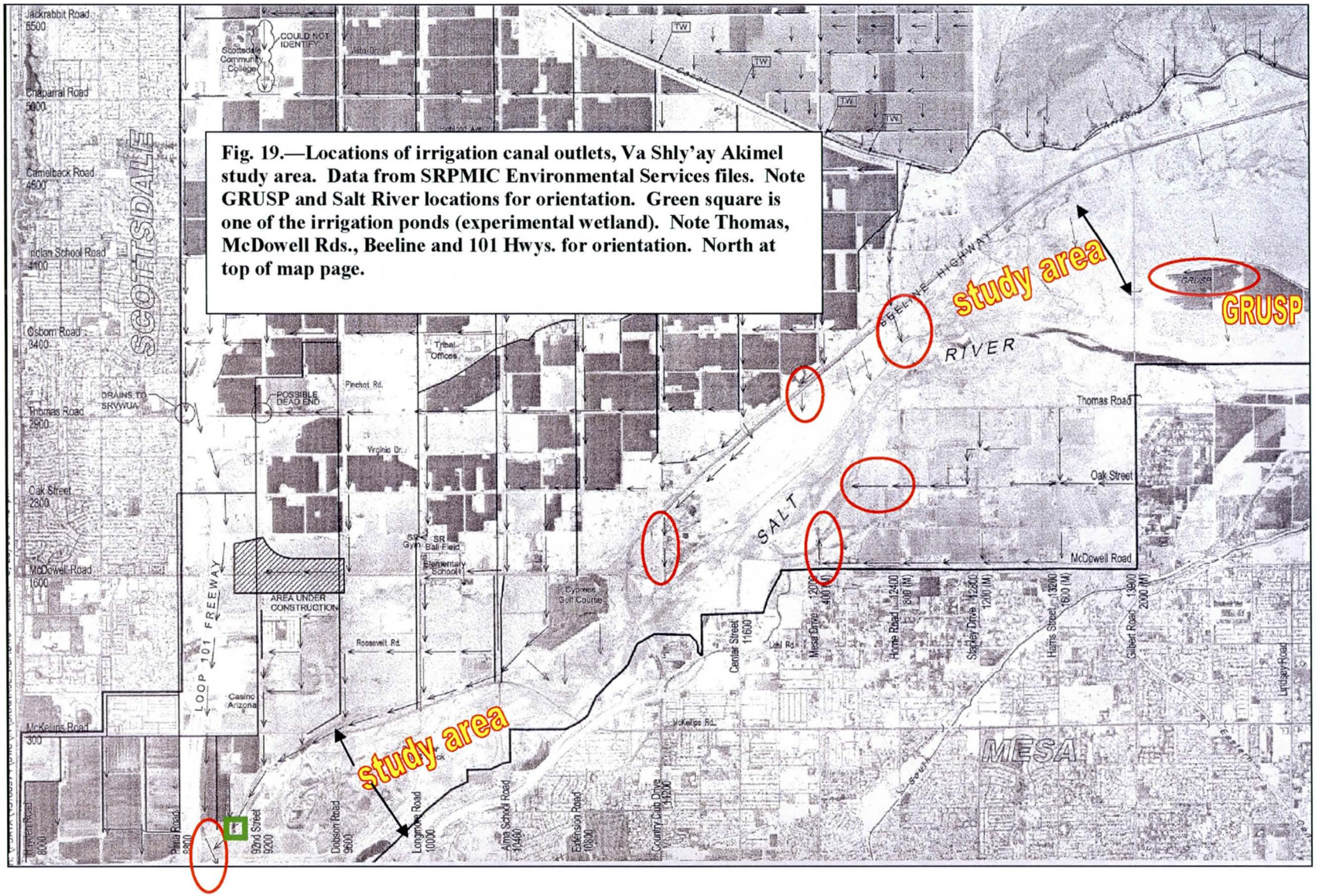


Fig. 19.—Locations of irrigation canal outlets, Va Shly'ay Akimel study area. Data from SRPMIC Environmental Services files. Note GRUSP and Salt River locations for orientation. Green square is one of the irrigation ponds (experimental wetland). Note Thomas, McDowell Rds., Beeline and 101 Hwys. for orientation. North at top of map page.

0

The locations of most have been determined since: one pond, operated as an experimental wetland, adjoins the study area near the downstream end (see fig. 19); no acreage for that pond was discovered in research. Five others (including one yet to be built) are no closer than 3,500 ft from the study area; the next closest is 6,000 feet away from the study area. With such distances involved, impact from any of those five is unlikely. SRPMIC Environmental Services file data suggest one other pond exists; no location for it has been determined. Geology & Investigations has been recommending that the cumulative impact of irrigation drainage outlets also be factored into the groundwater modeling. Locations have been determined since the F-4 level geotechnical appendix was prepared and are shown on fig. 19. There are seven such outlets that drain into the Salt River within the study area; 21 others drain into the Arizona Canal and are not considered pertinent and were not counted.

8.1.2.2 *Increase in proclivity to overbank flooding*. For the same reasons applied to the issue of modeling of groundwater infiltration equilibrium conditions and zone of influence, Geology & Investigations recommends that consideration be given to any potential that may exist for this study's conceptual irrigation to decrease the capacity for infiltration during high flow events on the Salt River, and thus possibly exacerbate the risk of overbank flooding. Overbank flooding could increase the risk of mobilization of HTRW discussed in sections both in preceding and following sections.

8.1.3 *Drum dump site*. Some 60 to 65 metal drums with various liquid and solid wastes were illegally dumped on top of the Cypress landfill at some unknown time (site 11, fig. A-1), although some probably were dumped after that landfill was closed, which was in 1979. The dump location has received partial cleanup under RCRA[12] with the work done by ADEQ[13] in May 1990, when approximately 14 drums with liquid wastes that registered organic vapors in tests were removed from the site; it was speculated they were drums of recently dumped waste solvents. Other drums, badly deteriorated and breached in some cases already in 1990, had solid wastes, observed (and reinforced by testing) probably to be paint residues, resins, and possibly smelter slag (Benson (1990(?)). They remain as they were, exposed to the surface, some now spilled or completely decomposed. SRPMIC Environmental Services staff reports they are counting on the future brownfield cleanup of the underlying Cypress landfill to address this drum dump.

8.1.4 *VOCs in groundwater, including the Indian Bend Wash Superfund sites*. The North Indian Bend Wash and South Indian Bend Wash Superfund sites (no. 1, shown as the large blue rectangle on fig. A-1), are contaminated with TCE[14] in both soil and groundwater. The official, outer perimeter of these sites adjoins the downstreammost point of the study area (it is the large blue rectangle shown on fig. A-1, this report), but it has been verified that neither the soil contamination nor the groundwater contamination from North Indian Bend Wash site actually adjoins the study area, and the same likely is true of the South Indian Bend Wash site. Remediation is underway at these sites. The Superfund goal is to remove industrial solvents containing volatile organic compounds (VOCs) that were typically disposed of directly onto the ground or in dry wells. These disposal practices, along with other releases, resulted in the present groundwater contamination, all occurring prior to the existence of current, applicable

[12] "RCRA" is "Resource Conservation and Recovery Act".
[13] "ADEQ" is "Arizona Dept. of Environmental Quality".
[14] "TCE" is "trichloroethylene", also called trichloroethene, a volatile organic compound.

environmental regulations, which date from the 1970's. All three aquifers in the vicinity of these sites, the Upper, Middle, and Lower Alluvial Units, are contaminated, a situation that has been known since 1981 when elevated levels of VOCs including trichloroethylene (TCE), tetrachloroethylene (PCE) and chloroform were found in several Scottsdale-area drinking water wells (local water providers stopped using those wells for drinking water, in response). The entire site was placed on EPA's National Priorities List (NPL) in 1983. The southern area was administratively separated by EPA into a *South* Indian Bend Wash Superfund Site, which then took on a separate cleanup track from the *North* Indian Bend Wash site.

The North Indian Bend Wash groundwater contaminant plumes (which also contains PCE) are no closer than 8,000 ft from the Va Shly'ay Akimel study area boundary. This includes contamination in the UAU (Upper Alluvial Unit, essentially the uppermost aquifer (unconfined) present in the Phoenix area. Upgradient soil contamination at the site (exclusively from TCE) is no closer to the study area than 7,000 ft (EPA, 2001). **Monitoring of clean-up activities and monitor well test data by SRPMIC Environmental Services has led them to conclude that this site has not impacted the study area and likely will not in the future; pollutants are contained by current efforts and have not crossed into the study area** (Ramirez, 2004, p. 2).

At South Indian Bend Wash, Solvent Vapor Extraction (SVE) is the method being used for soil cleanup. The risk due to soil contamination is low, except in cases where direct contact with the soil may occur. Groundwater contamination is decidedly more serious, according to the EPA and is being studied further via monitoring wells, and with at least some focus still on PRP (potentially responsible party) identification (EPA website section on Superfund properties, March 22, 2004). There is no map of either the soil or the groundwater contamination areas posted anywhere on the EPA website, so a groundwater contaminant plume map from in a 1986 report attributed to K.D. Schmidt and Associates must be utilized to close the data gap (Geology & Investigations has not been able to acquire a copy of this report, only a copy of some data that were excerpted from the report). This data source shows the VOC groundwater contaminant plume to be in the Salt River but 1,350 ft down river from the downstreammost edge of the study area. That position places the groundwater contaminant plume from this Superfund site outside of the study area and, in the opinion of Geology & Investigations, should remove any potential risk of it contaminating the study area, based on the logic that groundwater beneath the Salt River is not going to travel in the upstream direction under any imaginable circumstance. The location of the soil contamination related to this Superfund site is not known and is not presented on the EPA website as of March 22, 2004. (EPA website data source, March 22, 2004: http://yosemite.epa.gov/r9/sfund/overview.nsf/507c94f730e0ebf488256958005cda5f/5128cd5fa52005aa88256dd3006a75c0.) **SRPMIC Environmental Services has concluded that this site has not impacted the study area and cannot, due to the downgradient location of all known pollutants** (Ramirez, 2004, p. 4).

Two other VOC-groundwater contamination sites are in the general vicinity of the Va Shly'ay Akimel study area. Neither appear to have impacted the study area or pose any foreseeable risk of doing so, primarily due to their distance and their position downgradient of the study area, with regard to groundwater flow direction. The South Mesa WQARF[15] site is successfully contained for the time being, via in-place remediation activities, according to data in the WQARF section on the ADEQ website as of March 19, 2004. The groundwater contaminant

[15] WQARF is "water quality assurance revolving fund", essentially a State "Superfund" site.

plume remains generally in the position shown in 1986 data attributed to K.D. Schmidt and Associates. That data suggest the plume is no closer to the study area than 23,000 ft to the southeast of the study area (about 4.3 miles). A second VOC-in-groundwater site is much closer to the southeast of the study area: the "Motorola Mesa WQARF" site, again according to data excerpted from the K.D. Schmidt & and Associates report mentioned above, is about 8,000 ft (1.5 miles) from the study area boundary. No such listing can be found as of March 2004 on the ADEQ website listing of WQARF locations, even under an alternative name, nor under any NPL locations in Phoenix. It has not been ascertained whether this site may have been completely cleaned up, and possibly dropped from the WQARF listings. Regardless, its distance and location downgradient of known groundwater flow removes this site from being a potential risk to the study area.

8.1.5 *DBCP contamination in groundwater*. DBCP[16] (which is, "dibromochloropropane") has been detected in groundwater over a large area south of the Salt River (fig. 20), and this area is as close as 1,700 ft south of the study area boundary, directly south of the GRUSP. The location once was known as the "Mesa DBCP WQARF Site", but no such listing can be found as of March 2004 on the ADEQ website listing of WQARF locations, nor can any be found in listings of all NPL locations in Phoenix. It was not ascertained whether this site may have been completely cleaned up, and possibly dropped from the WQARF listings. Favorable information that is available is the following. According to data from a 1986 report by K.D. Schmidt and Associates, the DBCP-contaminated groundwater apparently remains south of the Salt River and the study area; data suggest that groundwater flow is southeastward, away from the study area. Unfortunately, depths of the wells and of the contaminated samples is not in the excerpted K.D. Schmidt & Associates data available to Geology & Investigations, but this is the most logical conclusion that can be reached by evaluating the available data. Geology & Investigations has not been able to acquire a copy of this report, only a copy of some well test data that were excerpted from the report. The cited report data show that DBCP, measured to 0.2 ppb and lower, had not reached the study area or the Salt River. The 0.2 ppb concentration is the EPA's MCL (maximum contaminant level for drinking water) and was set at that level because "EPA believes, given present technology and resources, this is the lowest level to which water systems can reasonably be required to remove this contaminant should it occur in drinking water." (http://www.epa.gov/OGWDW/dwh/c-soc/dibromoc.html). Web-based data sources used to prepare this section are: http://www.epa.gov/OGWDW/dwh/c-soc/dibromoc.html and http://www.safetyinfo.com/safetyinfo/html/osha/Standards/z/1910_1044_APP_A.html.

8.1.6 *LUSTs*[17]. In the Phase I EA, eleven LUST properties are listed, including five clustered in a commercial business district along Country Club Dr. at the 202 highway, and along McKellips Rd. near Country Club Dr.; and two others along Alma School Rd. All of those are outside of the study area or at the study area periphery. Four others are in or adjacent the Salt River

[16] DBCP is a soil fumigant, applied to control nematodes and applied to crops such as cotton, soybeans, fruits, nuts, vegetables (cucumbers, summer squash, cabbage, cauliflower, carrots, snap beans, okra), plus aster, shasta daisy, lawn grasses and ornamental shrubs. Formerly heavily used in the agriculture industry, its use was stopped in 1979 except for application to pineapple crops in Hawaii (stopped in 1985). EPA lists the following as the health effects related to exposure: when people are exposed to it at levels above the MCL for relatively short periods of time: kidney and liver damage and atrophy of the testes.

Sources: http://www.epa.gov/OGWDW/dwh/c-soc/dibromoc.html;
http://www.safetyinfo.com/safetyinfo/html/osha/Standards/z/1910_1044_APP_A.html

[17] "LUST" is the acronym for "***L***eaking ***u***nderground ***s***torage ***t***ank".

bottom, associated with the sand and gravel quarry or batch plant operations, and those are considered probably more important, as they are inside the study area. According to the

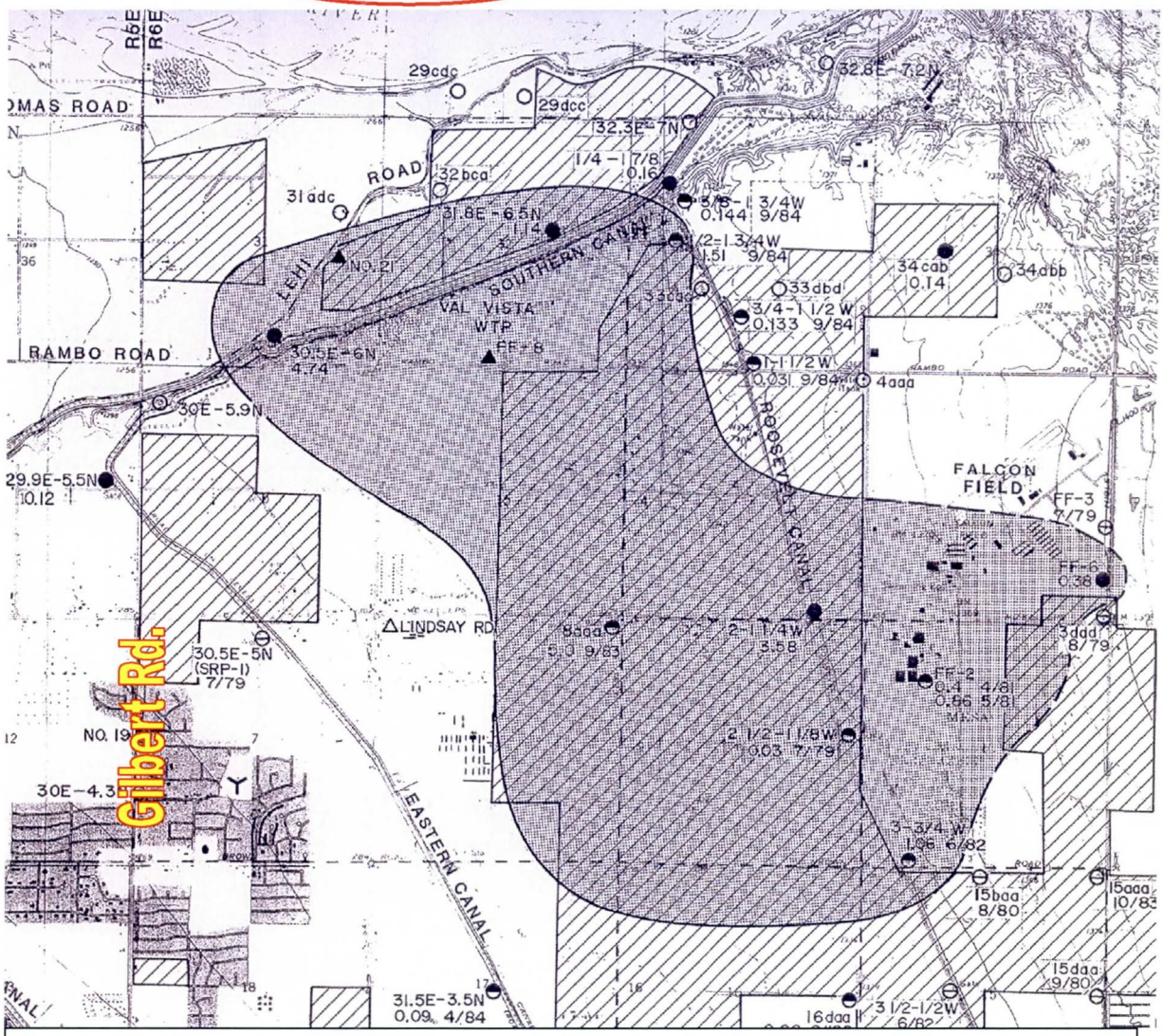


Fig. 20.—Map showing the DBCP plume (dark gray), from US Army Corps of Engineers, Planning Section C file data. This work has been attributed to a 1986 report by K.D. Schmidt & Associates. The hachured areas are early 1950's citrus orchard locations, perhaps the source of the DBCP releases. For scale, note that the squares are 1 mile across. Darkened circles, half circles, and triangles indicate wells and test pits where DBCP was detected; the white circles, triangles, half circles are test locations free of DBCP. Note Gilbert Rd., and the red oval (GRUSP location) for orientation. North at top of map page.

regulatory database summary in the Phase I EA, eight of these eleven LUSTs have been remediated to the point they are "case closed" and no longer under regulatory oversight as an environmental concern for ADEQ; only one involved any groundwater contamination (site 33 on fig. A-1). There is no suggestion that any sites currently are under remediation.

The unresolved LUSTs (i.e., those not yet documented beyond data presented in the Phase I EA, and with no proof of a "case-closed" status) include:

- Site 2, Salt River Sand and Rock, Metro (or Dobson) Operations, which is inside the study area; status is unclear from reading the Phase I EA;
- Site 14, United Metro, inside the study area; status is unclear from reading the Phase I EA;
- Site 48 (fig. A-1), classed as "undefined" in the regulatory database reported in the Phase I EA; it is near, but outside the study area.

Geology & Investigations has recommended further research into regulatory oversight files on these sites, such as those of the ADEQ in Phoenix, to be done in conjunction with the existing in-kind services arrangement for HTRW work for this study. This avenue of research likely would obtain more current data than would normally be available through the generalized, electronic database search that characterizes a Phase I EA, and it is thought by Geology & Investigations that the most current data on those sites may show they are indeed "case closed" or otherwise be informative as to risk assessment. SRPMIC staff reported in May 2003 that other regulatory file data exist showing that all three of these sites have been resolved; documentation has not been provided as of publication time. Also recommended is additional research into the details surrounding the other two known LUSTs in or adjacent the Salt River (3 (Vulcan), and site 28 (Chandler Ready Mix), both of which are "case closed". Regardless of the fact that they are "case closed", when planning groundwater manipulation, irrigation, and infiltrating water manipulation, as do the Alternatives of this study, it is wise to learn the details on former LUSTs that are within the study confines. SRPMIC staff have been tasked with this research on all the aforementioned LUST properties as part of the in-kind services agreement for geotechnical issues; data will be included in this report when provided.

8.1.7 *Minor TSD[18] issues*. There are several, minor, TSD issues reported in the Phase I EA, all associated with sand and gravel, cement, asphalt quarry operations and/or their plant operations (sites 2, 3, 14, 16, 22, 23, and 51 on fig. A-1). All are in the Salt River or adjacent to it. All or most owned by SRPMIC, but there are some three or four operating lessees involved. Boundaries of the operations (presumably the quarry perimeters) are shown on fig. A-1, all apparently recently mapped (Jones and Stokes, 2002). Most of the sites were defined by Liesch (2002) to have minor TSD issues related to washing and maintaining vehicles and chemical storage, but not all were visited by Liesch and one (site 16) was not listed in Liesch (2002), so there are unknowns to be addressed. It is the Geology & Investigations opinion that the sites possibly could release chemicals into the environment if there were to be flooding or high flows in the Salt River, but that the impact likely would be small. Whether or not that risk is acceptable to study goals needs to be determined by other disciplines on the team. As before, Geology & Investigations recommends additional research into the details of the operations and TSD issues, and documentation of the findings, all as a part of the existing HTRW in-kind services arrangement with SRPMIC.

[18] "TSD" is "treatment, storage, and disposal".

The same Geology & Investigations recommendation (additional documentation under the existing HTRW in-kind services arrangement) holds for the SPILLS database listing for the SRPMIC Cypress golf course (site 9, fig. A-1), where some unspecified 60-gal. release occurred. It likely is just a matter of documenting the substance released and the clean-up that was enacted. At a separate location, there is an issue with the surface debris scraped off the Arizona Propane site (no. 6 on fig. A-1); more information should be obtained to assure it is not a RCRA site.

8.1.8 *Regulated materials use*. Numerous sites among those listed in table A-1 use some types of regulated materials, which could become hazardous waste if released into the environment. These sites are not listed as problem sites in any regulatory database, and most, if not all, have *no* environmental problems associated with them. For the purposes of US Army Corps of Engineers criteria, a complete listing of these sites and the materials they use/treat/store/dispose of should be compiled. If construction is to occur in or adjacent to such sites, the Construction Division needs to be made aware of them. Much, if not all of this information is in the Phase I EA. The data should be drawn onto one, concise list. The Geology & Investigations recommendation is that this task be done as a part of the existing HTRW in-kind services arrangement with SRPMIC.

9.0 Non-hazardous waste. Non-hazardous waste is **not** an HTRW issue, but it is an important issue with regard to estimating project costs, and could easily become a monetary issue with regard to construction schedule delays, if time has to be taken to classify unexpected wastes as encountered. Even if eventually shown to be not hazardous, stockpiling and removal of those wastes can become a noticeable and unexpected project cost increase. For this reason, Geology & Investigations has recommended that debris / illegal dumps scattered in the study area need to be accurately located, cataloged, and that their quantities need to be estimated. The Phase I EA made reference to "wildcat" or unregulated waste dumping, but was not specific as to location. In the first quarter of 2004, Environmental Services staff of the SRPMIC carried out a detailed field survey to meet these goals and supplied existing, additional documentation from their files from their earlier survey of waste concrete dumps in and along the Salt River. Their field notes and their pre-existing file data on this subject of non-hazardous waste, or debris, are the sole source of data used to compile the following summary.

While some debris discussed below, such as tires and some appliances[19] may not wholly fall into the category of *non-hazardous waste*, the view is that such items are readily identifiable, large objects that readily can be segregated when processing waste streams, and afford little risk of release into this environment. For example, tires can be expected to be removable intact and can then be handled appropriately. So can refrigerators, if there are any, and if they contain CFCs. If there were any CFCs in refrigerators that no longer are intact, those CFCs likely already have volatilized.

[19] Refrigerators, for example, if they contain and have not been drained of CFCs. While numerous household appliances were noted in the survey, the notes were not specific as to whether those observed included any refrigerators.

Table 4.—Non-hazardous waste and debris catalog, Va Shly'ay Akimel study area.

See figs. 21, 22, 23 for numbered site locations. This debris, etc., were mapped and quantities estimated by Environmental Services staff, SRPMIC, in Jan.-Mar. 2004, and earlier. The drum dump on top of Cypress landfill is addressed under a separate section in this report (as a RCRA site), but other, non-hazardous surface dumping that occurred on top of the closed Cypress landfill is addressed in this table.

#	Type	Map	Contents
1	Possibly an illegal dump	See fig. 21	Estimated 750 cu yds of metal, concrete, and tires; scattered; boundary as shown in red on inset map of fig. 21. According to the Phase I EA and SRPMIC staff, landfilled waste washed out from unspecified upstream landfill(s) as they breached in past floods, collecting at the Dobson operations and that debris has not been removed since; this polygon likely is that area. USACE (2002, p. III-4) notes two landfills breached in 1992-93 (location not specified).
2	Northern part: concrete/cement waste at Salt River Sand & Rock, Dobson operations	See fig. 21	Estimated 43,000 cu yds of hardened concrete and cement wastes, within the white area encircled on fig. 21. Covers approximately 5.2 acres.
2	Southern part: concrete/cement waste at Salt River Sand & Rock, Dobson operations	See fig. 21	Estimated 6,700 cu yds of hardened concrete and cement wastes, within the white area encircled on fig. 21.
3	Illegal dump	See fig. 21	Outside of the study area; boundary as shown in red on inset map of fig. 21; extensive area with scattered, usually small loads of wide variety of illegally dumped materials, including bricks, wood, other refuse. Estimated total of 50 cu yds. Likely of little relevance to the study area as it is north of McKellips Rd.
4	Concrete debris	See figs. 23, 21	Estimated 370 cu yds of concrete debris.
5	Illegal dump	See figs. 23, 21	Small area with construction debris. Quantity not estimated.
6	Illegal dump	See figs. 23, 21	Small areas with dumped trash bags of household refuse. Quantity not estimated.
7	Concrete debris	See figs. 23, 21	Estimated 250 cu yds of scattered concrete debris, possibly washed out from the adjoining Cypress landfill.
8	Illegal dumping on top of Cypress landfill	See figs. 23, 21	Scattered refuse, household appliances, tires, estimated total of 3,000+ cu yds.
9	Illegal dump	See figs. 23, 21	Furniture and household appliances, 64 pieces, total, estimated to total 1 ½ tons in mass.
10	Concrete/cement waste, two, non-contiguous areas	See figs. 23, 21	On south bank of Salt River and in the river bottom. Total for both areas numbered "10" on fig. 23 is estimated to be 11,400 cu yds. The material is dried in eight different "fans" or separate deposits, varying from 1.5 ft to 6 ft in thickness, and typically about 3 ft thick. Most is down the south Salt River bank, but one area, a slab of about 550 cu yds, is within the Salt River bottom and the study area near the Mesa city property line.
11	Illegal dump	See figs. 23, 21	Furniture and household appliances, 9 pieces, total, estimated to total ¼ ton in mass.
12	Debris from Cypress landfill washout	See figs. 23, 21	Miscellaneous debris washed out from landfill; estimated 800 cu yds, total.

Table 4.—Non-hazardous waste and debris catalog, Va Shly'ay Akimel study area.

See figs. 21, 22, 23 for numbered site locations. This debris, etc., were mapped and quantities estimated by Environmental Services staff, SRPMIC, in Jan.-Mar. 2004, and earlier. The drum dump on top of Cypress landfill is addressed under a separate section in this report (as a RCRA site), but other, non-hazardous surface dumping that occurred on top of the closed Cypress landfill is addressed in this table.

#	Type	Map	Contents
13	Concrete debris	See figs. 23, 21	Estimated 80 cu yds of scattered concrete debris, within the blue oval area shown on fig. 23.
14	Metal debris	See figs. 23, 21	Metal grizzlies used for screening large rock at portable sand and gravel operations; uncertain if this is dumped or stored material. No quantity estimated.
15	Concrete/cement waste at "Rinker" operations	See fig. 21	Estimated 48,400 cu yds of hardened concrete and cement wastes, within the white area encircled on fig. 21. Extends into the river bottom. Covers and estimated 3.8 acres. May date from the time this was a United Metro operation.
15	Asphalt waste at "Rinker" operations	See fig. 21	Estimated 3,500 cu yds of asphalt wastes, within the white area encircled on fig. 21. Does not extend into the river bottom. Has been dumped on top of concrete/cement wastes. May date from the time this was a United Metro operation.
16	Tire dump, 300 tires, uncertain if this is an illegal dump	See fig. 21	Two, non-contiguous areas within the blue circle shown on fig. 21; one area has 100 tires, and the other area, farther to the north has an estimated total of 200 tires in three different non-contiguous places.
17	Calcium soil additive, uncertain if this is an illegal dump	See figs. 21, 22	Crushed sea shells, a calcium soil additive, within the white area encircled in blue on fig. 21. Unclear if this is a stockpile for future agriculture operations, or a dump of unwanted material. Estimated 1,800 cu yds of material, total. Red, elongate polygon shown on fig. 22.
18	Metal tower	See figs. 21, 22	Electric transmission tower, downed, dismembered into two pieces, approximately 100 ft long, estimated 2 tons of metal in total.
19	Illegal dump	See fig. 22	On the south river bank near Thomas Rd. Comprised of PVC pipe, cement bags, furniture. Estimated total mass is 5 tons. Red, roundish polygon shown on fig. 22.
20	Illegal dump	See fig. 22	On the west side of Gilbert Rd. Un-cataloged refuse and debris. Estimated total 50 cu yds. Yellow polygon shown on fig. 22.
21	Concrete debris	See fig. 22	On the east side of Gilbert Rd. Estimated total 375 cu yds. Very small, red polygon shown on fig. 22, also with a white "6" nearby.
22	Illegal dump	See fig. 22	East of Gilbert Rd. Refuse and debris, including tires. Estimated total 200 cu yds. In the areas shown by two red polygons, each with a separate number "22", shown on fig. 22.
23	Illegal dump	See fig. 22	Refuse and debris, scattered along Gilbert Rd., both sides, as per the two long red lines shown on fig. 22. Estimated total 80+ cu yds. The material is scattered by the winds and likely will blow into the restoration area unless cleaned up, according to SRPMIC Environmental Services staff.
24	Illegal dump	See fig. 22	Debris scattered along the Salt River bottom, as far as 2,000 ft downstream of Granite Reef Dam, in area shown as large red polygon, fig. 22. Estimated total quantities: galvanized metal pipe, 3 tons; concrete rubble, 12 tons; 2 empty drums.

0

0

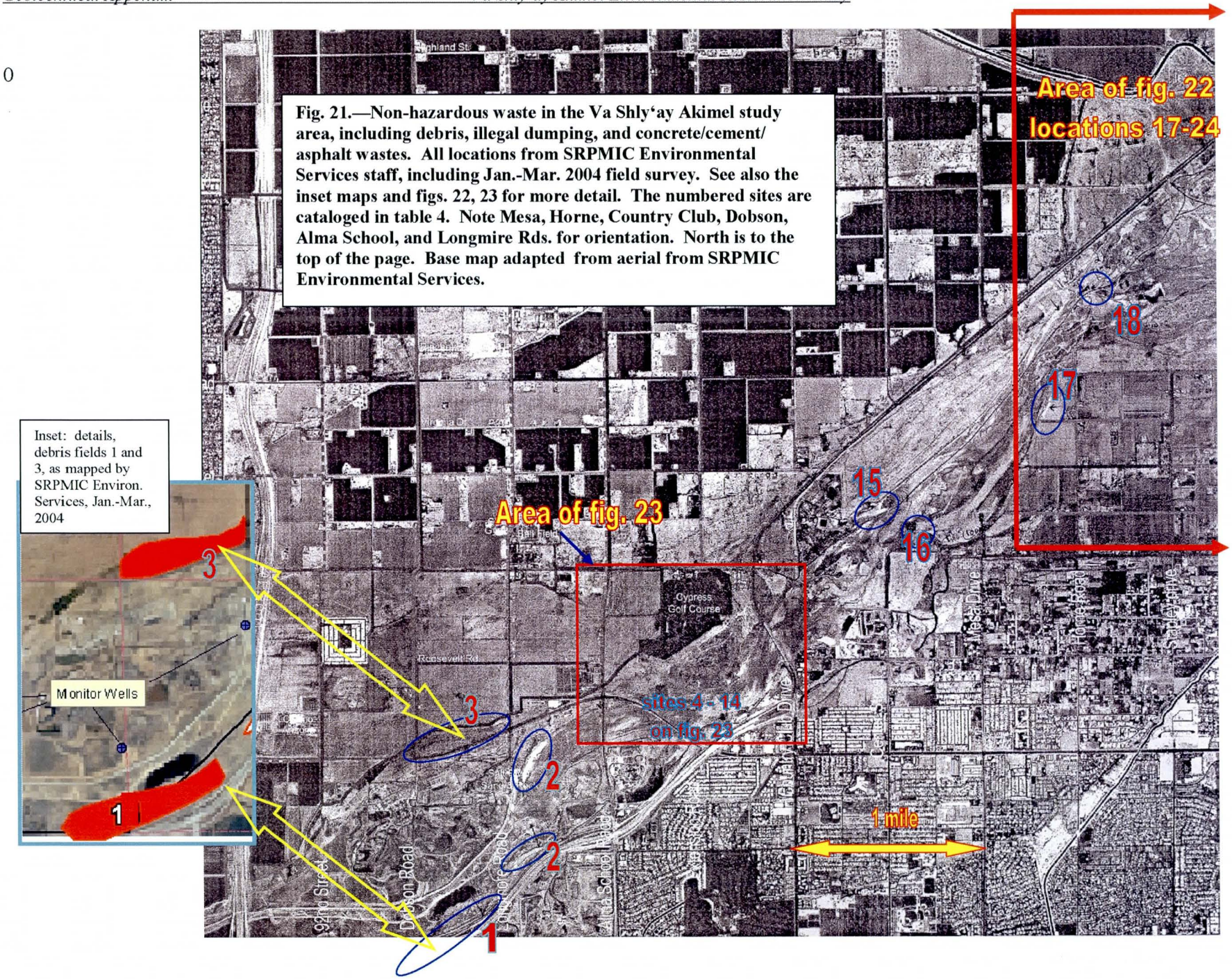


Fig. 21.—Non-hazardous waste in the Va Shly'ay Akimel study area, including debris, illegal dumping, and concrete/cement/ asphalt wastes. All locations from SRPMIC Environmental Services staff, including Jan.-Mar. 2004 field survey. See also the inset maps and figs. 22, 23 for more detail. The numbered sites are cataloged in table 4. Note Mesa, Horne, Country Club, Dobson, Alma School, and Longmire Rds. for orientation. North is to the top of the page. Base map adapted from aerial from SRPMIC Environmental Services.

0

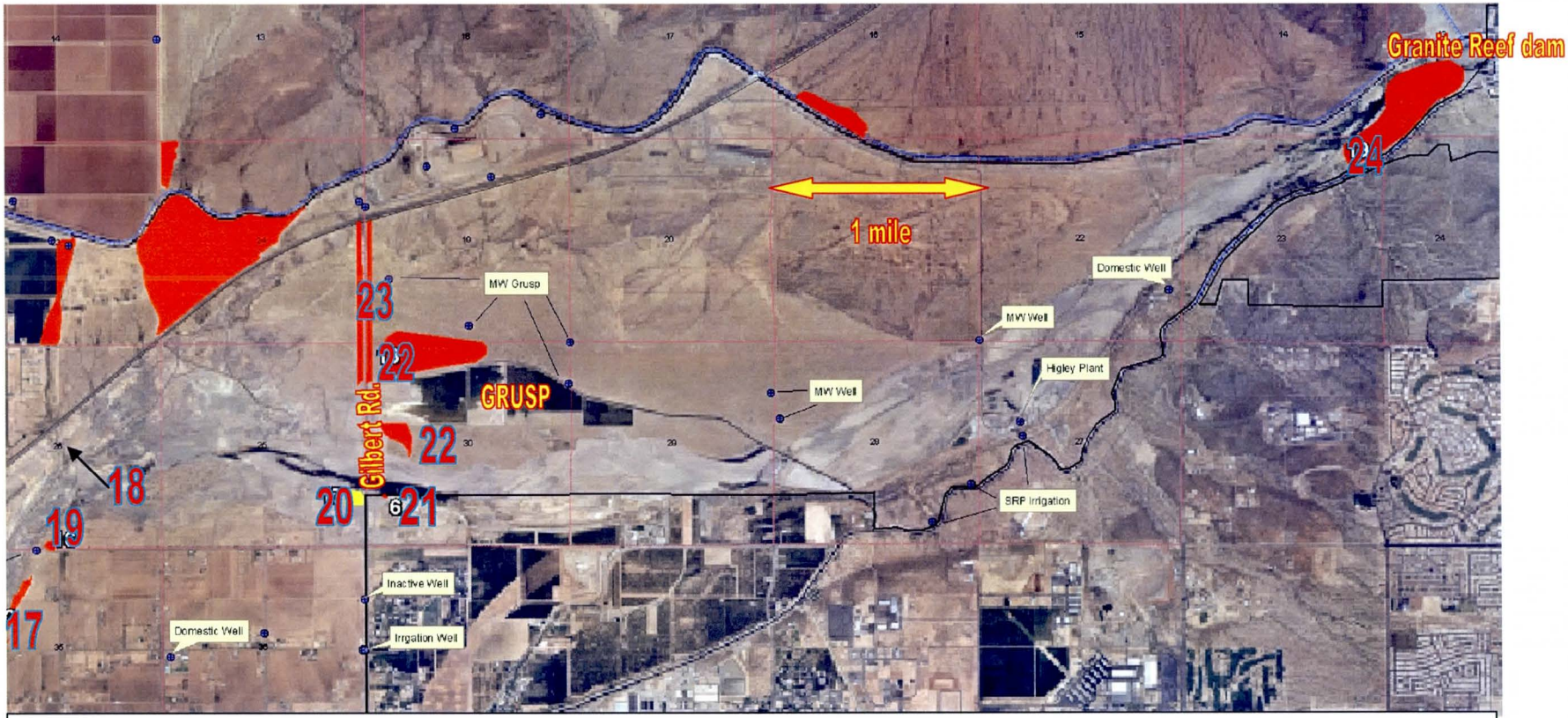


Fig. 22.—Additional non-hazardous waste sites in the Va Shly'ay Akimel study area, upstream of the Rinker sand and gravel facility and downstream of Granite Reef dam. Base, data from SRPMIC Environmental Services. Note GRUSP, the dam, Gilbert Rd. for orientation. North is to the top of page.

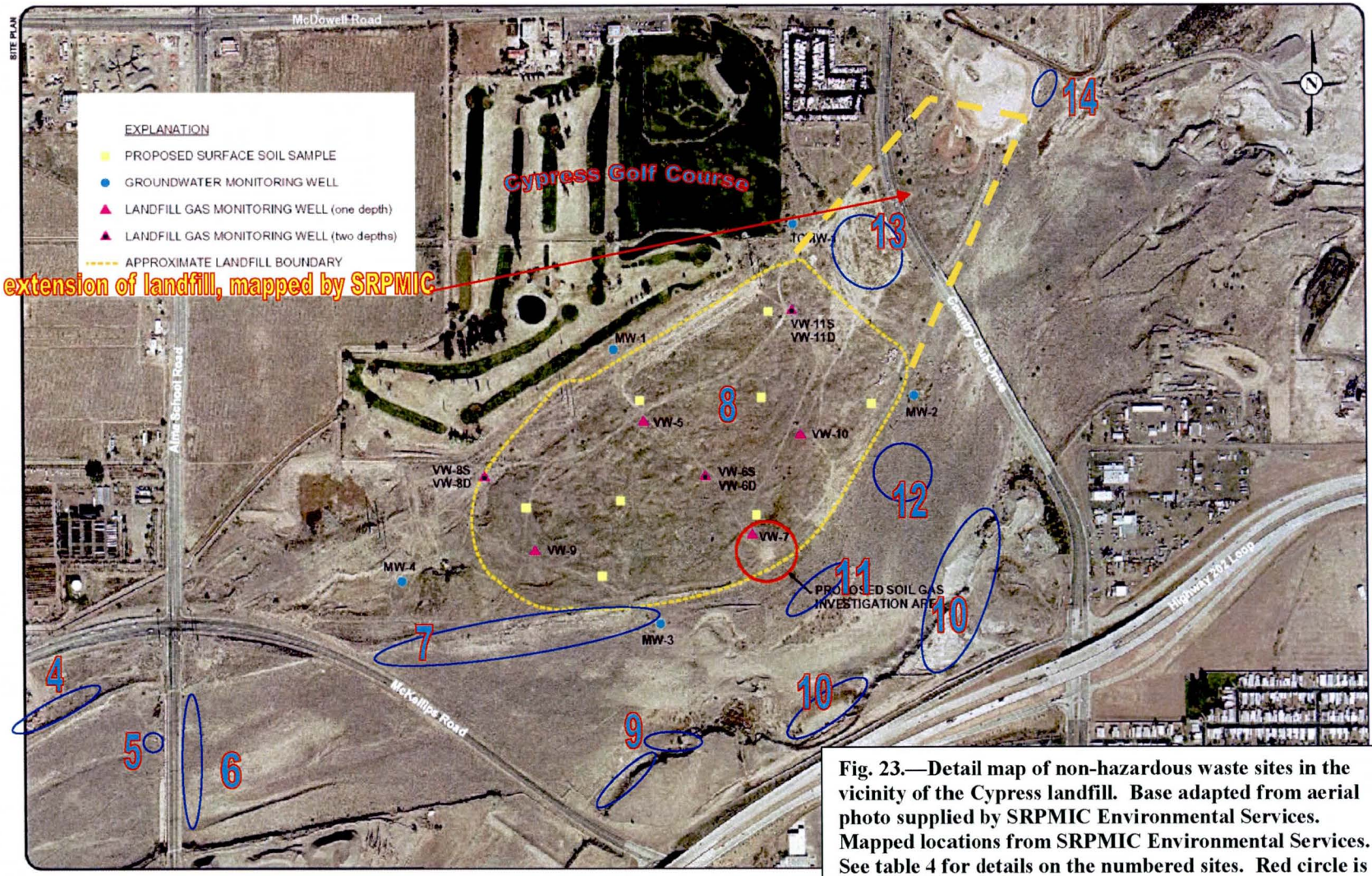


Fig. 23.—Detail map of non-hazardous waste sites in the vicinity of the Cypress landfill. Base adapted from aerial photo supplied by SRPMIC Environmental Services. Mapped locations from SRPMIC Environmental Services. See table 4 for details on the numbered sites. Red circle is probable underground fire in the landfill.

0

9.1 ***Concrete, cement, and asphalt dumps***. There are several cement batching plants and one asphalt plant in the study area, and, as is typical of that type of industry, there is the continual need to wash concrete from cement trucks as they return from deliveries, and, sometimes, there is the need to dispose of unused concrete, cement, or asphalt. There are several debris areas populated by concrete and cement, and one area of asphalt. Some of the cement/concrete waste areas cover multiple *acres*, both on the banks of the Salt River and, in places, the river bottom (see figs. 21, 22).

9.2 ***Illegal dumping***. Materials including household debris, construction materials, green waste, appliances, furniture, and tires are found in the study area. Known sites are shown on figs. 21-23, and detailed in table 4.

9.3 ***Analysis of the non-hazardous waste situation***. **There is significant overlap/impact between waste areas and the footprint of Alternative O** (late Mar. '04 version); details in Attachment A-1, pg. 92. The primary concern to the study, regarding non-hazardous waste, should be the thick concrete and cement layers of sites 2, 10, and 15 (figs. 21-23). Shaping banks, placing irrigation water supply wells, locating pumps, or laying irrigation water supply lines in those areas could be substantially more costly than similar work in natural bank materials. Plantings may be impossible in these areas. Design team members were notified by Geology & Investigations as to the locations of these concrete/cement dump areas as soon as the information became available (January 2004). This report is a situation update. The sites should be kept in the forefront of planning as conceptual designs are modified in the future.

Of a secondary level of importance are the non-hazardous materials that readily could be mobilized into a completed restoration area, should river flow take place, or that could be mobilized by other means. From the list in table 4, those that appear to represent the highest risk of mobilization are the Cypress landfill (loc. 8, fig. 23, and fig. 15); materials already released from the Cypress landfill into the wash (loc. 12, and possibly loc. 7, fig. 23); materials released from an unspecified landfill washout that collected near the Dobson plant (loc. 1, fig. 21); the 300 tires (loc. 16, fig. 22); and blowing materials from trash thrown along Gilbert Rd. (loc. 23, fig. 22). Consideration should be given to cleaning up these specific sites (and perhaps others), regardless of whether or not they fall within the confines of the environmental restoration areas.

10.0 Geologic Hazards. Geologic hazards considered in this report include faulting and seismicity, as well as subsidence.

10.1 ***Faulting and Seismicity.*** Faults in central Arizona are generally short, discontinuous normal faults, some of which displace Quaternary formations. Most of these faults are within the Jerome-Wasatch Structural Zone, a 50-mile-wide band that extends from Utah to Mexico. In Arizona, the zone includes the Main Street Fault in the northwest corner of the state and the Verde Fault about 50 miles north of Tempe. Both of these faults are considered to be potentially active.

A zone (approximately ¼ mile wide) of exposed, Tertiary age inactive normal faults, exists immediately north of Tempe Butte gap, approximately 2.5 miles west of the western boundary of the Va Shly'ay Akimel study area. The zone trends northwest to southeast, and extends northwestward for a distance of 2.7 miles. Additionally, an east- to west-trending (1.1 miles

long) Tertiary age fault lies concealed below the alluvium, in the middle of the Salt River, at Tempe Butte Gap (USACE, 1998).
The Va Shly'ay Akimel study area is located in an area of low seismicity as referenced in Zone 1 of the Seismic Zone Map of the Contiguous States (U.S. Army Corps of Engineers, 1983). DuBois, et al. (1982) list 29 earthquakes with maximum epicentral intensities between II and VI on the Modified Mercalli Intensity Scale (MM) which have occurred within a 100 mile radius of the study area from 1870 through 1980 (I-III represent slight shaking, IV-VI represent non-damaging, widely perceptible shaking). The largest of these known earthquakes occurred southeast of Ajo in 1961, northeast of Globe in 1969, and northwest of Prescott in 1976. The 1961 event, 95 miles from the study area, had a Richter magnitude of 4.7 (No known reports from the Phoenix area). The 1969 event, 72 miles from the study area, had a Richter magnitude between 4.4 and 5.1 (assigned an MM intensity of II at Phoenix). The 1976 event, 81 miles from the site, had a Richter magnitude of 5.1 (assigned an MM intensity of IV at Phoenix).

From 1980 through 1998, additional earthquake information can be found on the Arizona Earthquake Information Center (Northern Arizona University) website ww4.nau.edu/geology/aeic. Numerous small earthquakes are listed within a 100 mile radius of the project. All of these are at the extreme limits of the search area, including the Jerome-Prescott area to the north, and the Mogollon Rim area to the northeast. The highest Richter magnitude quake occurred along the Mogollon Rim in 1989, registering a 3.4 value.

The largest known earthquake to occur in Arizona was of Richter magnitude 5.7 recorded in 1959 near Fredonia, 240 miles from the study area. The seismic historical record for the last 125 years indicates that only one major damaging earthquake (1887 Sonora, Mexico) has occurred and was located outside the 100 mile radius. This earthquake measured a Richter magnitude of 7.2, and was located more than 255 miles from Tempe, AZ, causing rockfalls (MM VI) near the study area. The most recent (1974) nearby events, the "New River earthquakes", located 15 miles north of the study area, had recorded Richter magnitudes of only 2.5 and 3.0 (DuBois, et el., 1982).

In conclusion, the study area is located within a region of low seismicity, and ground rupture and shaking are not expected to significantly impact the design at Va Shly'ay Akimel.

10.2 ***Subsidence.*** Earth fissures and subsidence are both produced by groundwater (pumping) withdrawal, whereby ground (soil) compresses (subsides) because it has lost the support of water within its pores. In Arizona, earth fissures have developed in unconsolidated sediments, typically near the margins of basins where groundwater levels have declined from 180 feet to more than 500 feet (Péwé, et al., 1987). Differential surface subsidence and horizontal extension occurs over buried bedrock hills, ridges and fault scarps, as well as where there are lateral variations in type and thickness of alluvium, or caliche.

Ground failure in the form of (pumping) subsidence and earth-fissures has occurred in nearby areas of the Phoenix Basin. Near Luke Air Force Base, 28 miles west-northwest from the project area, extensive removal of groundwater for irrigation purposes lowered the groundwater level 340 feet from 1923-1976 (Laney, 1976). The resultant 1 to 3 feet of subsidence has been measured and exhibits the shape of a 2-mile diameter bowl-shaped depression. In the Queen Creek area, 20 miles southeast of the project area, the water table has declined up to 420 feet during the same period (the greatest decline in the Phoenix region). The land surface in the

Queen Creek area subsided 3-5 feet from 1948 to 1967 (Raymond, et al., 1978). A compaction recorder installed by the U.S.G.S. in the area has measured compaction of about 0.2 feet per year, with water levels falling about 5 feet per year from 1976 to 1986 (Péwé, et al., 1987).

Groundwater levels were lowered 330 feet from 1923-1976 just north of Scottsdale, 7 miles northwest of the study area, with up to 1 foot of subsidence recorded along the trace of the Arizona Canal to the east (Laney, 1976).

Numerous earth fissures have been mapped in the Queen Creek area, and a less extensive area east of Buckhorn, 12 miles east-southeast of the study area. Péwé, et al. (1987) state that the deepest and widest earth fissure observed in Arizona (up to 1980) was located at Chandler Heights in the Queen Creek area, and was 15 feet wide at the surface, and up to 50 feet deep. Péwé, et al. (1987) state that the maximum measured subsidence between 1948 and 1981 of a benchmark about 1 mile west of Buckhorn is 5.1 feet. Fissuring in the area in the 1970's and 1980's damaged U.S. Highway 60 and threatened the Central Arizona Project Aqueduct.

In the last four decades, an increasing portion of groundwater withdrawal from Scottsdale, SRP, Tempe, Arcadia Water Co., and Arizona American Water Co. and the NIBW area has raised concerns about land subsidence (primarily west of SRPMIC). Land subsidence is not an immanent threat to NIBW Area, but rather a condition from historical groundwater pumping. The ADWR initiated a regional subsidence program in 1999. ADWR will develop the necessary baseline data to verify and quantify any future subsidence (SRPMIC, 2002).

Available information suggests that subsidence within the study area has not occurred in the past and there is not expected to occur in the future. Therefore, subsidence is not expected to significantly influence design at Va Shly'ay Akimel.

10.3 ***Slope stability***. Slope stability may be an issue with regard to conceptual wetlands construction that would adjoin existing incised river banks or that would adjoin existing sand and gravel pits. Local increases in the water table, sufficient to support these conceptual wetlands, may result in some slope instability in places. The topic needs to be addressed. Such an assessment cannot be made with available data concerning the conceptual construction because existing design-type information and influence-type information simply are too sparse. For example, for each wetland this type of information would be needed for the assessment, "feature *x* will raise the local groundwater to *y* elevation over an influence area of *z*". Locations of existing hardened structures in the riverbed and nearby areas have not been compiled. They may mitigate slope stability problems. These data gaps should be closed so that an assessment can be made.

10.4 ***Foundation conditions***. The latest Alternatives to be added to the list of 30 Alternatives under consideration (Alternatives O_1 and O_2) include a 2,000-ft-long grade control structure. At the time of this writing, design and location information for this structure is not available to the US Army Corps of Engineers Geotechnical Branch. At some future date, an assessment of the foundation conditions under this structure will have to be made. Several smaller dikes also are features of the newest Alternatives. Similarly, their locations are not known at this time and an assessment of foundation conditions will have to be made later.

11.0 Sources of Construction Materials. Two stone borrow sites have been identified as sources of construction material and are available for use, in the event an engineering design is proposed for Va Shly'ay Akimel. The two quarries have produced stone for previous Corps flood control projects at the Arizona Diversion Canal and Indian Bend Wash areas. Stone from both quarries exhibit a good service record and passed all rock quality compliance tests. The quarries are listed as:

Sun State Rock and Materials	and	Salt River Sand & Rock (Mesa or Dobson Oprns.)
-located 20th St. and E. Beardsley Rd, Phx, AZ.		-located at Dobson & McKellips Rds, Phx, AZ.
-passed 1990 rock quality tests		-passed 1994 rock quality tests
-passed 1994 visual inspection		-passed 1994 visual inspection
-produces granite.		-produces green schist (cobbles and boulders).

The Salt River Sand and Rock operation is owned by the SRPMIC, and is the largest stone borrow site in the study area. The Corps of Engineers utilized SRSR materials for flood control projects at the Arizona Diversion Canal and Indian Bend Wash areas. Stone from the quarry exhibit a good service record and passed all rock quality compliance tests.

Two quarries operated by the Granite Express Company were visited by a USACE LAD Geotechnical Branch geologist in 2003. Granite Express Pit #1, approximately 35 miles southeast of the study area between Florence and Gold Canyon, produces a hard rhyolite, predominately for landscaping purposes. Abrasion test results are available, but no specific gravity or absorption testing was submitted. A Granite Express gravel pit, located near the intersection of Highway 87 and Gilbert Road (approximately 1 mile north of the study area), was also visited. The operation produces gravel and cobbles up to a 24 inch limit. Granite Express operates another quarry, Saddle Crown, which produces a more expensive white granite, used predominately for landscaping. This quarry was not visited, and no test results were submitted.

11.1 ***Concrete Materials***. Concrete aggregate sources investigated in previous studies are described below (SRPMIC, 2002). Each source is identified by the stream from which materials are taken. Future studies would require reevaluation of these sources in accordance with SPD policy. On-site sources will be investigated and evaluated for production of aggregates for use in construction.

- Salt River. Sands and gravels from the Salt River are historically the oldest producing sources of aggregates for the Phoenix area. Coarse aggregates and cobbles are generally present in sizes to 12 inches. In some cases material as large as 24 inches is available. Some deposits have run out of sizes larger than gravel. The percentage of sand in these sources is adequate for economical concrete construction.

- Cave Creek. The Cave Creek sources have cobbles to 24 inches. A sufficient quantity of coarse aggregates is available. Some of the plants are importing sand from the Agua Fria River.

- Agua Fria River. The Agua Fria sources are the youngest sources being mined in the Phoenix area at this time. The maximum size of material generally varies between 12 to 18 inches, with a larger proportion of sand than other sources.

11.2 ***Cement.*** There are two major producers of cement in the state of Arizona who are presently producing cements which are pre-qualified by the Waterways Experiment Station for use in Corps of Engineers projects. These plants are the Phoenix Portland Cement Corporation at Clarkdale, approximately 130 miles north of the study area; and the Arizona Portland Cement Company at Rillito, approximately 130 miles southeast of the study area. Additional cements would be available from the California Portland Cement Company at Colton, California, approximately 360 miles west of the study area. Recently, cements produced in Mexico have been imported to the United States and have been used in the Tucson area. The Clarkdale site likely would be used for any project needs, as it is owned by the SRPMIC.

There are two cement plants producing Type III cement which conforms to ASTM Specification C 150. These are the Genstar Cement Company plant at Stockton, California, approximately 540 miles northwest of the study area, and the Calaveras Cement Company at San Andreas, California, approximately 775 miles northwest of the study area.

11.3 ***Pozzolan.*** In accordance with current Federal regulations, the option to use fly ash, a pozzolanic admixture, as a substitute for Portland cement will be allowed in the production of concrete for the study. Concrete generally produced in the area at the present time uses pozzolan to offset reactivity between the cement and silicates in the aggregate and to reduce the heat of hydration. Fly ash, proven to be suitable in the past, would be available from a plant near Page, Arizona, approximately 400 miles north of the study area, and from a plant at Cochise, Arizona, approximately 185 miles southeast of the study area.

11.4 ***Admixtures.*** Two types of admixtures are used extensively by concrete producers in the Phoenix area. These are air-entraining admixtures and water reducing admixtures, Some high range water reducing admixtures have been used. It is anticipated that all classes of admixtures will be used in construction of the project.

11.5 ***Water.*** Sufficient water suitable for concrete construction would be available at existing concrete plants. Concrete is produced at the SRSR facilities (which is on-site) by numerous local concrete companies and suitable water is available.

11.6 ***Soil Cement.*** Soil cement has been used extensively in the Southwest, particularly in Arizona, as stream bank protection (USACE, 2000). There are several examples of this type of construction along the Salt River in the nearby area which have exploited the use of soil cement. Some of these projects were protection of the 19th Ave. landfill, protection for ADOT structures through the Tempe area, and a soil cement levee at Sky Harbor International Airport.

Additionally, the Corps of Engineers constructed soil cement lined levees along the Agua Fria River in the middle 1980's. The Salt River has historically been the source of the majority of aggregates used in concrete construction in the Phoenix area. No detailed surveys of potential borrow sources for soil cement aggregates have been completed. Based on previously available information and the performance of the above-cited projects, it is likely that suitable materials would be available from excavation in the stream bed. One of the possibilities which could increase the cost of the soil cement is the lack of sufficient fine grained materials. Excavated materials from some of the sources being exploited, in the Salt River, are primarily gravels and cobbles.

12.0 References

Basin & Range Hydrogeologists, Inc., 1997, Site assessment report, Thermal Treatment Unit, Talley Defense Systems, Mesa, AZ: consultation report prepared for Talley Defense Systems, 3500 N. Greenfield Rd., P.O. Box 849, Mesa, AZ 85211-0849, Mar. 1997, by Basin & Range Hydrogeologists, Inc., 5080 N. 40th St., Ste. 105, Phoenix, AZ, 85018, ph. (602) 840-3333, 7 pp., plus a substantial quantity of non-paginated material.

Benson, C. C., 1990(?), Country Club Drive drum site, Salt River Indian Reservation, Maricopa County, Arizona: letter of advisement from Ecology and Environment, Inc., Los Angeles, CA to William E. Lewis, US EPA, San Francisco, CA.

Cooley, M.E., 1967, Arizona Highway Geologic Map, Arizona Geologic Society (AGS), scale 1:1,000,000.

Corkhill, E.F., Corell, S., Hill, B.M., Carr, D.A., for the Arizona Department of Water Resources (ADWR) 1993, A Regional Groundwater Flow Model of the Salt River Valley - Phase I Phoenix Active Management Area Hydrogeologic Framework and Basic Data Report.

Corkhill, S.W. and Corkhill, E.F., for the Arizona Department of Water Resources (ADWR) 1994, A Regional Groundwater Flow Model of the Salt River Valley - Phase II Phoenix Active Management Area Numerical Model, Calibration, and Recommendations, March, 1994.

Drosendahl, J.K., 1988, Environmental Geology of the Rio Salado Development District-Eastern Part, Maricopa County, Arizona: Arizona State Univ., Tempe, Unpub. M.S.. Thesis, May, 1988.

Errol L. Montgomery & Associates, Inc., 2002, Site characterization for the former Tri-City landfill at Country Club Road, brownfield assessment demonstration pilot, Salt River Pima-Maricopa Indian Community, Maricopa County, Arizona: consultation report of Sept. 2002 for SRPMIC by Errol L. Montgomery & Associates, Inc., 7949 E. Acoma Dr., Ste. 100, Scottsdale, AZ 85260, ph. (480) 948-7747.

Greeley and Hansen, 2001, Salt/Gila Groundwater Analysis Project, Project Number WS90140004-S, Draft Summary Report, March, 2001. Prepared for the U.S. Army Corps of Engineers.

Jones & Stokes, 2000, Tres Rios Feasibility Study, Environmental Impact Statement, March, 2000. Prepared for the U.S. Army Corps of Engineers.

Jones & Stokes, 2002, Va Shly'ay Akimel Feasibility Study, Environmental Impact Statement (F-3 Submittal), March, 2002. Prepared for the U.S. Army Corps of Engineers.

Kenneth D. Schmidt and Associates, 2002, Tri-Cities Landfill Groundwater Monitoring.

Knight Piésold, 2000, JAB01.G Interior Drainage, Draft Report.

Laney, R.L., 1976, Water Level Declines, Land Subsidence and Earth Fissures in South-Central Arizona, *in* 20th Annual Arizona Watershed Symposium Proceedings, Phoenix, Arizona: Arizona Water Commission Report No. 8, p. 30-39.

Liesch Companies, 2002, Phase I Environmental Site Assessment, Approximate 17-Mile Portion of the Salt River, Salt River Pima-Maricopa Indian Community, June 21, 2002. Prepared for the Salt River Pima-Maricopa Indian Community.

Menges, C.M., 1984, The Neotectonic Framework of Arizona: Implications for the Regional Character of Basin-Range Tectonism, Arizona Bur. Geol. and Min. Tech. Open-file Report 83-19.

Montgomery Watson, 2000, Rio Salado Low Flow Channel Design Documentation Report, October, 2000. Prepared for the U.S. Army Corps of Engineers.

Raymond, R.H., Winikka, C.C., and Laney, R.L., 1978, Earth Fissures and Land Subsidence, Eastern Maricopa and Northern Pinal Counties, Arizona, *in* Burt, D.M. and Péwé, T.L., Eds., Guidebook to the Geology of Central Arizona for the Geol. Soc. America, 74th Cordilleran Section Meeting, Tempe, Arizona: Arizona Bur. Geol. and Min. Tech. Special Paper No. 2, p. 107-113.

Pearthree, P.A. and Scarborough, R.B., 1984, Reconnaissance Analysis of Possible Quaternary Faulting in Central Arizona, Arizona Bur. Geol. and Min. Tech. Open-file Report 85-4.

Pearthree, P.A., Skotnicki, S.J., and Demsey, K.A., 1997, Surficial Geologic Map of the Theodore Roosevelt Lake 30' x 60' Quadrangle, Arizona, Arizona Geol. Surv. Open-file Report 97-17, scale 1:100,000.

Péwé, T.L., 1978, Terraces of the Lower Salt Valley in Relation to the Late Cenozoic History of the Phoenix Basin, Arizona, *in* Burt, D.M. and Péwé, T.L., Eds., Guidebook to the Geology of Central Arizona for the Geol. Soc. America, 74th Cordilleran Section Meeting, Tempe, Arizona: Arizona Bur. Geol. and Min. Tech. Special Paper No. 2, p. 1-13.

Péwé, T.L., and Drosendahl, J.K., 1985, Rio Salado Development District – Eastern Part, Maricopa County, Arizona, unpublished folio of maps prepared for the Rio Salado Development District, scale 1:24,000.

Péwé, T.L., Raymond, R.H., and Schumann, H.H., 1987, Land Subsidence and Earth-Fissure Formation in Eastern Phoenix Metropolitan Area, Arizona, *in* Davis, G.H. and Vandendolder, E.M., Eds., Geologic Diversity of Arizona and Its Margins: Excursions to Choice Areas, Field-Trip Guidebook for the Geol. Soc. America, 100th Annual Meeting, Phoenix, Arizona: Arizona Bur. Geol. and Min. Tech. Special Paper No. 5, p. 199-204.

Ramirez, Abel, 2004, North Indian Bend Wash Superfund site (NIBW) effects on the proposed Salt River Restoration Project, Salt River Pima-Maricopa Indian Community: analysis prepared for the current (2004) US Army Corps of Engineers Va Shly'ay Akimel environmental restoration study by the Salt River Pima-Maricopa Indian Community,

Cultural and Environmental Services Division, 10500 E. Osborn Rd., Bldg. 26, Scottsdale, AZ, 85256, 22 March, 2004.

S.A.I.C., 1994, RCRA facility assessment for Talley Defense Systems, Inc., Mesa, AZ: consultation report prepared for US EPA, Region IX, San Francisco, Apr. 1994, by Science Applications International Corporation, 20 California St., Ste. 400, San Francisco, CA, a non-totaled quantity of paginated material which restarts with page "1" in each report section.

Smith Consultants, 2000-a, *DRAFT*, Perchlorate sampling near Talley Defense Systems burn pits: consultation report prepared for SRPMIC, Aug. 2000, by Smith Consultants, 1423 S. College Ave., Tempe, AZ, ph. (480) 829-6861, 6 pp., plus un-paginated material.

Smith Consultants, 2000-b, Soil investigation on Salt River Pima-Maricopa Indian Community lands near Talley Defense Systems burn pits: consultation report prepared for SRPMIC, Jul. 2000, by Smith Consultants, 1423 S. College Ave., Tempe, AZ, ph. (480) 829-6861, 12 pp., plus un-paginated material.

Spencer, J.E., Richard, S.M., and Pearthree, P.A., 1996, Geologic Map of the Mesa Quadrangle, East-Central Arizona, Arizona Geol. Surv. Open-file Report 96-23, scale 1:100,000.

S.R.P.M.I.C., 2002, Va Shly'ay Akimel, Salt River Arizona Interim Feasibility Report, Appendix F, Geotechnical Analysis, prepared for F-3 Milestone Report, Va Shly'ay Akimel Restoration Study, 2002.

U.S. Army Corps of Engineers, 1983, Earthquake Design and Analysis for Corps of Engineers Projects, ER 1110-2-1806, May, 1983.

U.S. Army Corps of Engineers, 1998, Rio Salado, Salt River, Arizona Feasibility Report, April, 1998.

U.S. Army Corps of Engineers, Los Angeles District, 2000, Tres Rios, Arizona Feasibility Study, April, 2000.

U.S. Army Corps of Engineers, Los Angeles District, 2002, Va Shly'ay Akimel Restoration Study, Salt River Pima-Maricopa Indian Community and the City of Mesa Arizona, Draft F-3 Milestone Report, June, 2002.

U.S. Soil Conservation Service, 1974. Soil Survey, Eastern Maricopa and Northern Pinal Counties Area, Arizona. U.S. Government Printing Office, Washington, DC.

Wilson, E.D., Moore, R.T., and Cooper, J.R., 1969, Geologic Map of Arizona, U.S. Geological Survey, scale 1:500,000.

Attachment A.

Assessment of sites of potential HTRW and non-hazardous waste concerns, with regard to each of the 30 study area Alternatives under consideration as of March 2004. Note that the assessment regarding HTRW was updated from the Oct. 2003 edition for this March 2004 edition only for Alternative O, which was the only Alternative modified after Oct. 2003. But the lack of update was necessitated primarily by another factor: insufficient time was allotted to allow this detailed analysis to be made for the 28 other Alternatives. The assessment with regard to non-hazardous waste was made **only** with regard to Alternative O, a decision again dictated by the calendar: with crucial data delivered to Geology & Investigations less than 24 hours before "publication time" for the final feasibility documents, this was all the analysis that could be done with the time available. Should any Alternatives besides Alternative O move forward in the planning process, they can be addressed as needed and this section can be updated. Geology & Investigations should be informed directly (see phone numbers and e-mail on the cover of this report), should such a need arise.

A-1.1 **Background**. The US Army Corps of Engineers, Geotechnical Branch, Los Angeles District (*hereafter* "USACE-Geotech") was tasked by the USACE Planning Division[20] with evaluating the to-date findings on potential HTRW[21] in the Va Shly'ay Akimel study area. The data source on the to-date findings on HTRW used by USACE-Geotech to make this evaluation was almost exclusively the June 2002 Phase I Environmental Site Assessment (*hereafter* "Phase I EA") by Liesch Southwest, Inc. The Phase I EA was supplied for this study as an in-kind service by the Salt River Pima-Maricopa Indian Community (SRPMIC), the Local Sponsor teamed with USACE for this study. SRPMIC contracted out this in-kind service work to Liesch Southwest, Inc.

Considered in this HTRW assessment was the possible impact by current[22] study alternatives designated A through O on existing or potential HTRW sites and *vise versa*, based on what information is found in the Phase I EA, plus much smaller amounts of data input from the USACE's Planning Div., and Hydrology and Hydraulics Branch. A color map of the 15 basic[23] Alternatives is available as a .jpg file, but these files are so large (between 10 and 18+ MB *each*) that implanting them as figures into this report would be technically impossible. The reader's computer likely would never be able to open the resulting massive digital document. To solve this problem, USACE-Geotech posted a separate .jpg file for each of the Alternatives which should be in the same subdirectory where the reader found this report, be it on a CD, hard-drive, ftp site, etc. The chart below lists each Alternative; posted .jpg files use the acronym designations (for example, "LOAD", or "MAX"). Alternatives N and O are new as of Oct. 2003 and have no acronym designations.

---

[20] The Planning Division, Section C, Phoenix AZ, which is providing the oversight and direction for this study.

[21] "HTRW" = "potentially hazardous, toxic, or radioactive waste". There are no known or suspected radioactive sites in this study area.

[22] The Feb.-Mar. 2003 time frame.

[23] By October 2003, the basic Alternatives ("A", "B", "C", etc., through "O") each had been subdivided into two sub-alternatives, giving 30 Alternatives in all. "A_1" now represents the features shown on the "LOAD" illustration, with drip irrigation; "A_2" represents those same features, supported by "braided" irrigation. The same pattern follows with all the other letter designations: each has B_1, B_2, C_2, C_3, etc., irrigation options.

Chart listing the 30[15] Alternatives being given consideration by study stakeholders as of October 2003 (see separate .jpg files for color map of each alternative)				
New Alt desig.[15]	Old Alt. #	former acronym	Name	Level of vegetative restoration
A	1	LOAD	Xero-riparian dominate; low water requirements	Minimal
B	2	MEAD	Xero-riparian dominate; medium water requirements	Moderate
C	3	HIAD	Xero-riparian dominate; high water requirements	Extensive
D	4	MINE	Meso-riparian dominate (cottonwood, mesquite, and xero-riparian) with channelized stream to avoid mining area	Moderate
E	5	VHAD	Meso-riparian dominate (cottonwood, mesquite, and xero-riparian)	Extensive
F	6	MAX	Meso-riparian dominate (cottonwood, mesquite, and xero-riparian) with reshaped and channelized stream	Maximum
G	7	CWAD	Cottonwood dominate with braided channel network	Extensive
H	8	MSAD	Mesquite dominate with braided channel network	Extensive
I	9	CHNL	Cottonwood dominate with channelized stream	Moderate
J	10	BRAD	Cottonwood dominate with reshaping of sand and gravel pits	Extensive
K	11	NODL	Cottonwood dominate without reshaping of sand and gravel pits	Extensive
L	12	POCK	Cottonwood and mesquite dominate with high visibility from roads	Moderate
M	13	WET	Hydro-riparian dominate	Extensive
None	14	(none)	No action	None
N	no #	n/a	not under consideration in Feb.-Mar. 2003 time frame	--
O	no #	n/a	not under consideration in Feb.-Mar. 2003 time frame	--
Note that Alternative "14" from the Feb.-Mar. 2003 time frame has been discarded from the alternatives list of Oct. 2003.				

In the Jan.-March 2004 time frame, data were sent to Geology & Investigations by SRPMIC Environmental Services staff, regarding a SRPMIC field survey of non-hazardous wastes in the study area. This included older data from Environmental Services files on the extensive concrete and cement dumps that cover multiple acres of the Salt River banks and some of the invert, and a new, more extensive field survey of all types non-hazardous wastes in the study area. Many of these survey results were made available to Geology & Investigations at "publication time" for this document, and so their assessment is limited to Alternative O. No time was available for such detailed analysis for all 28 other alternatives. But the reader is referred to the text sections under section "9" (non-hazardous wastes") and figs. 21-23, which, collectively are an assessment of the non-hazardous waste situation, looking at the study area as a whole.

A-1.2 ***Overall study concepts and objectives***. To understand the relative importance of the potential HTRW sites, they must be considered in context with conceptual plans for the study area. The current study does not involve any flood-control work. The objectives of the Study Alternatives include raising the groundwater level to varying degrees in varying parts of the study area for the purpose of supporting new, emplaced, plant communities. Consideration must be given to the impacts of that raising of the groundwater level. Specifically, the question to be considered for each alternative is, "with the projected increase in the level of groundwater, would or could contaminants at any of the potential sites of environmental concern be mobilized?" If the answer is, "yes", consideration has to be made regarding the impact of that study feature. As one example, there are several landfills in and near the river. The objective should be to prevent wetting and possible migration of contaminants in the landfills by added water. Other conceptual study area actions, beyond planting and irrigating of target plant communities, include channelizing flow to varying degrees (that is, small channels *within* the existing and much larger, incised Salt River bottom). Any channel that would be constructed, according the USACE H&H, would be no more than 6 ft deep and would contain flows no greater than the 5- to 10-year flood event. Any additional water would overflow these constructed channel banks. In some alternatives, there would be channel re-directing to avoid the existing recharge ponds of the GRUSP, and bank hardening to prevent channel migration into one of the existing in-river sand and gravel operations (Chandler Ready Mix, site 28 on fig. A-1)

Most of the sites of potential environmental concern fall within the 10-year-level flood floodplain boundary, and even more are within the 100-year-level flood floodplain boundary. Should flooding of those levels occur, surface soil contaminants could be mobilized and would travel downstream, possibly impacting some part of the study area. Mitigating this is the fact that the study's basic concept is development of plant communities, including wetlands. Wetlands naturally remove some water-borne contaminants. Thus, the study's basic concept serves to mitigate contamination mobilized from flooding, that is, provided the plant community survives the flood. It is possible that capacity for infiltration at flood stages may be reduced by the elevated groundwater level. This needs to be determined. It potentially is an issue because the overall amount or frequency of overbank flooding could be increased by completing this study's conceptual plan elements. Possibly, erosional impacts on riverbanks could increase. There could be increased risk of breakthrough into the banks that protect the several landfills on the banks in the study area. Some breached previously. Cypress landfill contents comprise the north bank of the Salt, in the study area. A large pile of debris reported at the Salt River Sand and Rock Mesa Operations is from another breach, according to data in the Phase I EA.

A-1.3 ***Summary of environmental concerns***. Fifty-six different sites of existing activities, many with some relation to environmental concerns, were identified. Nearly all were reported in the Phase I EA, or in supplementary data attached to the Phase I EA. These sites and their significance have been summarized by USACE-Geotech and are listed in table A-1, below; a map showing the locations of each site is fig. A-1. **Updates from Jan.-Mar.'04 additional research and data collection included now in this table.**

o

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
	ACTIVITY AND DEVELOPED SITES, INCLUDING SOME SITES OF ENVIRONMENTAL CONCERN ON THE NORTH SIDE OF THE SALT RIVER OR IN THE SALT RIVER AND GENERALLY TOWARD THE NORTH SIDE						
1	**North Indian Bend Wash and South Indian Bend Wash**	Low to none	yes	yes	Two Superfund sites with various VOCs in groundwater and soil; under EPA-directed remediation. **Will not** impact Alternative O (Ramirez, 2004).	There is a need to monitor contaminant plumes in future with regard to groundwater elevation level increases caused by conceptual study actions, and interactions with existing groundwater recharge (locations 4, 53, this table).	E, F, G, H, I, J, K, L, M, N, O should be aware of this site
2	**Salt River Sand & Rock, MESA OPERATIONS**. A.k.a "Dobson" operations. 160ac quarry site with SRPMIC oprns. since 1985 and subleases to Vulcan, Hansen, United Metro (all with cement batch plants), and JD Excavating (dynamite storage). Vulcan has asphalt batch plant too, which apparently is same site as entry #3, below	Low	no	no	Data suggest the contamination, *if any*, could be cleaned readily, mostly by pick up and removal and/or install secondary containment, perhaps with some surface soil removal. Potential problems mostly related to practices at vehicle maintenance and washing sites, and chemical storage practices at all 4 quarry/batch plant operations; problems extend to sand blasting practices and cement dumping at SRSR oprn., which has a LUST (repaired?, closed?[25]). Debris piles are from u/s landfill washouts (Liesch (2002)	Numerous ASTs on site with fuel, automotive chemicals. If potential flood-release risk of them is deemed unacceptable to study goals, team should check regulatory databases to assure all are meeting inspection requirements; and get written documentation that SRSR LUST case has been closed; and get details on United Metro cesspool. SRPMIC reportedly can document this LUST site as "case closed" via EPA data.	B, C, D, E, F, G, H, I, J, K, L, M, N, O
3	**Vulcan asphalt batch plant** and maintenance yard	Low	no	no	Data suggest the contamination, *if any*, could be cleaned readily, mostly by pick up and removal and/or install secondary containment, perhaps with some surface soil removal. Potential problems related to practices at equipment washing sites, and chemical storage practices, debris. LUST, associated with former operator CalMat, was remediated by 1993	ASTs on site with burner fuel, 20,000 gal. of asphalt; USTs present and formerly present. If potential flood-release risk of them is deemed unacceptable to study goals, team should check regulatory databases to assure all are meeting / have met inspection requirements / closure requirements; an get details on 1999	B, C, D, E, F, G, H, I, J, K, L, M, N, O

[24] A preliminary ranking regarding potential to impact some element within the 30 study Alternatives under consideration, or some potential to be impacted by those study elements. Ranking based on the Phase I information and other limited data sources available to USACE-Geotech as of March 2003.

[25] SRPMIC environmental team members quoted as saying ALL LUST cases on the SRPMIC land have been remediated to completion.

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
					(Liesch, 2002, p. 23) (i.e., "case closed").	site explosion, which resulted in rebuilding a new asphalt batch plant here.	
4	SRPMIC's 5 **groundwater recharge ponds** (see detail on location, fig. 18)	None **but combined effects with conceptual study water addition should be modeled**	No (apparently protected by dikes)	No (apparently protected by dikes)	No environmental problems. Receives wastewater from City of Mesa (Liesch, 2002). A foreseeable issue might be bacteria and nitrate levels induced by effluent, but this is a biological issue, not a geotechnical issue. SRPMIC reports the ponds total 75 acres.	Modeling of cumulative infiltrating water / zone of influence with conceptual study features (see text, section 8.1.2.1).	E, F, G, H, I, J, K, L, M, N, O
5	Six or seven **irrigation runoff detention ponds**; only one pond is in the study area, or close enough to potentially impact it; that location is shown on fig. 19 only.	None **but combined effects with conceptual study water addition should be modeled (for one pond only)**	No (apparently protected by dikes)	No (apparently protected by dikes)	No environmental problems specified (Liesch, 2002). Site is outside of Alternative O, but there is a cumulative effect on local groundwater, along with that from SRPMIC wastewater retention ponds (site 4, this table). That impact likely should be modeled. Runoff likely nutrient-rich but no data. Nutrient absorbing capacity of study elements is a biological issue, not a geotechnical issue.	Modeling of cumulative infiltrating water / zone of influence with conceptual study features (see text, section 8.1.2.1).	B, C, D, E, F, G, H, I, J, K, L, M, N, O
6	**Arizona Propane** (former Forest Homes site)	Low	no	no	Liesch (2002) implies that the disposition has not been documented for Forest Homes waste abandonment problems (drums of chemicals). Abandonment documented in pre-1995 EAs, not addressed in 1995 EA. Some scrap-off of surface waste exists in stockpile(s). Issues probably could be addressed by more interviews with Arizona Propane reps. (likely the ones who cleaned up the abandoned waste), some soil samples, and examination of the scrap-off stockpile(s).	Should check regulatory databases to assure 6,000 and 10,000-gal. diesel ASTs and maintenance sump all are meeting inspection requirements.	B, C, D, E, F, G, H, I, J, K, L, M, N, O
7	**Saddleback Communications** (the SRPMIC telecom oprn.)	None	no	no	Liesch (2002) reports no potential environmental concerns	--	none

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
8	**Cyprus landfill** (a.k.a. "old" Tri-Cities landfill, a.k.a Country Club landfill)	High, **exposed landfill contents comprise north river bank in study area**	yes	yes	SRPMIC reports this site will receive Brownfields funding for remediation of "known contamination" (contamination unspecified in Liesch (2002)). Operated from early 1960's to about 1980; no closure procedures undertaken; never permitted.	Precise boundaries / depth of the landfill, contents, not specified and likely unknown. Modeling of study features (irrigation immediately upstream and wetlands adjoining and nearby downstream) should be done to determine potential inundation/mobilizing of contaminants (see this text, section 8.1.2.1.	B, C, D, E, F, G, H, I, J, K, L, M, N, O
9	**Cypress golf course**	Minor to none	no	no	A facility of the SRPMIC (Benson, 1990(?), p. 2). FirstSearch lists 10 April 2001 60-gal. release of unknown substance	Check the SPILLS database for more information.	B, C, D, E, F, G, H, I, J, K, L, M, N, O
10	**RV storage facility**	None	no	no	Liesch (2002) reports no potential environmental concerns	--	none
11	**Dumped drum site (this is on top of site #8 Cypress landfill)** also a former gravel pit	High, surface-exposed contents could leach into adjoining study wetlands, be mobilized by adjacent study irrigation	no	yes	According to Benson (1990(?)): Illegally dumped group of 60-65 drums in the "bank flood plain" of the Salt River on SRPMIC land was discovered, along with stained areas of completely disintegrated drums. On- site tests determined organic vapors around 14 of the drums, all immediately removed (May 1990) under WQARF, and speculated to be recently dumped waste solvents. Remaining drums were corroded or badly decayed and held solids (paint wastes, resins, smelter slag(?) observed in breached drums. All in NE part of apparent historic landfill, exhibiting "uneven topography and occasional "breakthrough" of municipal waste". Interviewee quoted as saying this site was the "Tri-City landfill", and operated from late 1960's until 1972, taking household waste from Tempe and Mesa; also the drums post-date the landfill. SRPMIC was planning to expand the golf course (site 9, above, and cover this area with 5 ft of soil)—this was not done according to SRPMIC staff, 2004. Tests on the non-VOC drums showed no pesticides or PCBs but did show percent levels of Cr, Pb, Zn, suggestive of old paint residues. It was	SRPMIC Environmental Services staff (2004) reports the liquid-waste drums were removed by ADEQ in the early 1990s and that the solid waste drums remain as they were, exposed on the surface and deteriorating. SRPMIC Environmental Services is counting on cleanup of this waste to be done in conjunction with brownfields work on the Cypress landfill.	B, C, D, E, F, G, H, I, J, K, L, M, N, O

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
					concluded that site would be classed as a RCRA hazardous materials site. Notes in Benson (1990(?), attachment C, which has 1993 data in it) appear to be made from a combination of aerial photo review notes and interview notes, though interviewee is not identified: 1962 undeveloped; 1963 gravel operations (inundated in 1996); 1969 gravel operations to adjoining land on the west side; 1970 gravel exhausted; 1972 landfilling in progress; 1973 drums appear (but apparently not the drums removed in 1990); 1979 landfilling ends. And these notes: landfill unlined and may have impacted groundwater; some areas never covered; some cover eroded, some drums where they were placed as per air photos; some landfilling started as early as 1966. Best estimate boundary shown on air photo.		
12	**JRs Convenience Store**	None	no	no	Liesch (2002) reports no potential environmental concerns	A check regulatory databases could be made to assure the three 10,000-gal. fuel USTs are meeting inspection requirements. No releases reported as of 2002 databases (Liesch, 2002, p. 23)	none
13	**Enviro-Systems** (former Defiance of Arizona site)	None	no	no	Enviro-Systems, former land user, produced pre-cast concrete, operating from 1978-2001, approximately. Form used form oil. SRPMIC identified stains, had soil removal done; successful results documented (Liesch, 2002, p. 13)	No apparent further needs.	none

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
14	**United Metro** (170 ac. leased for quarry and cement batch plant; asphalt batch plant; in operation since 1954; United Metro since 1995) Apparently the current name of this facility is "Rinker"	Medium	no	no	Data suggest the contamination, *if any*, could be cleaned readily, mostly by pick up and removal and/or install secondary containment, perhaps with some surface soil removal. Potential problems mostly related to practices at vehicle washing sites and chemical storage practices. There is overbank dumping of asphalt and cement, former USTs (Liesch (2002). LUST[26] on site, associated with Union Rock and Materials has been cleaned up, according to SRPMIC rep. (Liesch, 2002, p. 23).	Obtain written documentation that LUST closure requirements met and add to study files. SRPMIC reportedly can document this LUST site as "case closed" via EPA data. Verify that the washdown area / asphalt release agent use is not impacting the study area. Consider the viability of continued overbank dumping of asphalt and cement, with regard to study goals.	B, C, D, E, F, G, H, I, J, K, L, M, N, O
15	**Tri-Cities landfill** and SRP methane gas power plant	Moderate to high, depending on the Alternative; **concern is with conceptual irrigation interaction**	no	no	Received 40-million cu yds of waste from 1972-1993, including demolition debris and residential waste (Liesch 2002). VOCs in groundwater were a problem until methane collection system installed; then VOCs dropped and no longer exceed MCLs. UST has been removed without incident. Power plant, new in 2002 has ASTs in secondary containment (Liesch 2002). UST had no record of releases (Liesch, 2002, p. 23). Bank hardened to prevent washout. Conceptual study plantings and irrigation for some Alternatives would involve the entire site, but not Alternative O.	Boundaries reported in local-sponsor-supplied data (Liesch 2002). "Final closure report", 1994, states no cap has been built. Documentation could not be obtained that the cap has been completed. Modeling should be done of infiltrating water / zone of influence from conceptual study features (see text, section 8.1.2.1).	All
16	**Salt River Sand and Rock Beeline One Plant, a.k.a. "Gilbert quarry"**	uncertain	yes	yes	Location from Jones and Stokes (2002); names from USACE-ED-HH contacts and PD Alternatives map. Not mentioned in Liesch (2002). No information with which to assess this site.	Need to determine if site has any of the potential environmental concerns as do the other quarry and cement / asphalt plant sites.	unknown, possibly all
17	**GRUSP** (Granite Reef Underground Storage Project) groundwater recharge ponds	None **but combined effects with conceptual study**	yes	yes	No HTRW environmental concerns. Banks CAP water in seven recharge ponds. Many study concepts include wetlands around this site, so the resulting amount of groundwater increase must be calculated.	Monitored by SRPMIC and GRUSP to assure minimum distance between top of groundwater and bottom of active Salt River landfill is maintained (Liesch, 2002). What is that elevation?	All

[26] "LUST" is "leaking underground storage tank".

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
		water addition should be modeled				Modeling should be done of cumulative infiltrating water / zone of influence with conceptual study features (see text, section 8.1.2.1).	
18	**Salt River landfill**	High	no	no	An active landfill (Liesch, 2002, p. 14); location shown on fig. 17.	Modeling should be done of cumulative infiltrating water / zone of influence with conceptual study features (see text, section 8.1.2.1).	All
19	**Arizona Canal**	None	no	no	No HTRW environmental concerns. Conveys water stored by Granite Reef dam for municipal and agricultural uses (Liesch, 2002)	None	None
20	**Granite Reef dam**	None	yes	yes	No HTRW environmental concerns. Stores water for municipal and agricultural use (Liesch, 2002)	None	None
	ACTIVITY AND DEVELOPED SITES, INCLUDING SOME SITES OF ENVIRONMENTAL CONCERN ON THE SOUTH SIDE OF THE SALT RIVER OR IN THE SALT RIVER, GENERALLY TOWARD THE SOUTH SIDE						
21	**Primate Research Center**	None to minor	ad-joins	proba-bly	On site of early 1900's hydro-generating station. Bio-waste from primates is reportedly removed daily from the site; taken to landfill. The only foreseeable issue might be bacteria and nitrate levels induced by bio-waste that might escape clean-up, but this is a biological issue, not a geotechnical issue.	The location in Liesch (2002, fig. 1) is imprecise but text reports it is on the river bank; USACE-PD alt map suggests such a location due to visible land alteration.	None with regard to HTRW
22	**Salt River Sand & Rock, HIGLEY OPERATIONS**. with leases to Vulcan, Hansen, United Metro (all with cement batch plants), and JD Excavating (dynamite storage).	Minor to low	no	no	Data suggest the contamination, *if any*, could be cleaned readily, mostly by pick up and removal and/or install secondary containment, perhaps with some surface soil removal. Potential problems related to practices at vehicle maintenance and washing sites, and chemical storage practices at all 4 quarry/batch plant operations; reported data unclear if SRSR has its own oprn. here, as it does at Beeline One plant and Mesa oprns. / (Liesch (2002)	Three ASTs on site with fuel. Should check regulatory databases to assure all are meeting inspection requirements. Liesch (2002) reports oil and lubricant containers are in secondary containment already.	All
23	**Salt River Sand and Rock offices** (for Higley oprns.)	None	uncer-tain	uncer-tain	It is not clear why Liesch (2002, p. i) discusses these offices separately from the Higley operations quarry in the Phase I EA exec. summary; it may or may not	None	probably none

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
					be a separate site, but logic would suggest it is the same site as site #22, above. Liesch reports no problems and may be mentioning the site solely to complete the list of land use practices. In that regard the precise location is not critical information		
24	**South Canal**	None	no	no	No HTRW environmental concerns. Conveys water stored by Granite Reef dam for municipal and agricultural uses (Liesch, 2002)	None	None
25	**Southern canal**	None	no	no	No HTRW environmental concerns. Conveys water stored by Granite Reef dam for municipal and agricultural uses; is the same as the South canal and is an outmoded name for the South canal (Liesch, 2002, p. 16) (site #24 listed above), so assessment is the same. Unclear why this gets a separate listing in the Phase I EA	None	None
26	**Talley Defense Systems** Several locations south of the South Canal	Low to high, depending on the Alternative	no	no	Risk of perchlorate release into the Salt River considered very likely (see text documentation, sec. 8.1.1.2.2) and perchlorate is highly mobile in groundwater; could impact overall river ecology. Metals releases possible, not proven to have reached the study area.	Refer to the analysis in text sec. 8.1.1.4 as the planning iteration process proceeds. This will not impact Alternative O (as modified, late March 2004, and shown on last page of this document), but if Alternative footprint expands, it may be necessary to test soil and groundwater during construction for perchlorate, primarily, and for several metals (on a less prioritized need).	All
27	**horse farm**	None to minor	uncer-tain	uncer-tain	The only foreseeable issue might be bacteria and nitrate levels induced by bio-waste, enhanced since this site is apparently adjacent to a alt. #13 proposed wetland, but this is a biological issue, not a geotechnical issue.	The location in Liesch (2002, fig. 1) is imprecise but is suggestive that the farm is on the riverbank; USACE-PD alt map photo base reaffirms this as the likely location due to visible land alteration.	None with regard to HTRW
28	**Chandler Ready Mix quarry**	Low	ad-joins	yes	Boundaries are not supplied in the EA but USACE-PD alts. map base suggests a large area in and adjacent to the river channel. Potential problems observed at sites 2, 3, 14, 22, were presumed to occur here also by Liesch (2002, p. 14), but more importantly, summary of Environmental FirstSearch results (Liesch, 2002, p. 22) lists 6 LUST incidents,	LUSTs are all "case closed", and so are not an issue, but no data have yet been collected on the day-to-day operations, as they were for sites 2, 3, 14, and 22. Such data should be obtained.	All

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
					all closed due to soil levels meeting RBCA Tier I.		
29	**Lehi Cemetery**	None	no	no	Liesch (2002, p. 13) reports no problems or suspected problems.	None	none
30	**North Center St. landfill (a.k.a. "Tri-Cities landfill (south side) and the "Salt River landfill")**	High **and the effect of conceptual study water addition should be modeled**	ad-joins	ad-joins	The SRPMIC-operated or administered site contains 3 million cu yds of waste deposited in 1979-1980, incl. asphalt, demolition materials and residential waste. Groundwater contamination and methane migration are two risks suggested (Liesch, 2002, p. iii, 10,) A memo from an unlisted agency (written by Bill Johnson on 20 Aug. 1991) reveals this same site also was named the "Salt River landfill". The 1994 closure report gives no evidence any work has been done on this landfill, only on the one on the opposite side of the river. This landfill did NOT wash out (i.e., no bank breach), and also was used in 1981, reports Johnson. It is obvious from Johnson's writing that there is much more data beyond this memo, but none is within the EA by Liesch, (2002). Adjoins large proposed study wetland alt 13. Regulatory category: CERCLIS NFRAP (Liesch, 2002, p. 21).	Boundaries reported in local-sponsor-supplied data (Liesch 2002, appendix B, "client-supplied information"; map and some data pages bound out of place in the report). Modeling should be done of infiltrating water / zone of influence from conceptual study features (see text, section 8.1.2.1).	B, C, D, E, F, G, H, I, J, K, L, M, N, O
31	**Vulcan demolition debris landfill**	Unknown but prelim-inarily Medium to High	no	partial-ly	Liesch (2002, p. 11, iii) lists no details and suggests no data are available	The size and contents are unknown. It is close enough to conceptual study area irrigation and wetland that some details of size, depth, and contents are needed.	B, C, D, E, F, G, H, I, J, K, L, M, N, O
32 A	**Mesa Police dept. firing range**	None to low	ad-joins	yes	City of Mesa will be installing lead recovery system in the near future to take existing lead from the embankments. Asphalt covering of the range surface has been installed to prevent lead dust dispersal. Has a septic system. Berms are of various soil, including much landfill waste (site was a landfill prior to becoming the firing range (Liesch, 2002, p. 9). Existence of plans to clean up the lead contamination and (apparently) control it in the future leads USAE-Geotech to conclude this site will not be an environmental concern for any study alternatives.	Monitor progress to ensure the future clean-up discussed in the EA actually happens	B, C, D, E, F, G, H, I, J, K, L, M, N, O (if not cleaned up)

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
32 B	**Mesa (City) storage yard**	None to low	ad-joins	yes	Same location as site 32A, above, the firing range. Just a separated zone of land usage. Has vehicles, including impounds, and empty trash dumpsters, also a large supply of ground asphalt.	None	none
32 C	**"Old Mesa" North Center St. landfill** (under Mesa Police firing range)	High **and the effect of conceptual study water addition should be modeled**	ad-joins	yes	Landfill name according to Mesa is North Center St. landfill but it is NOT the same as the North Center St. landfill shown on the EA map, which was operated by SPRMIC. There are maps with the City of Mesa showing approximate boundaries but these were not put into the EA. It has not been investigated, dates back to at least the 1960's (Liesch, 2002, pp. 9) and so may be one of the older landfills around. No knowledge of contents is suggested.	Get the data on the landfill from City of Mesa. Modeling should be done of infiltrating water / zone of influence from conceptual study features (see text, section 8.1.2.1).	B, C, D, E, F, G, H, I, J, K, L, M, N, O
33	**ADOT storage yard** (a.k.a. ADOT Mesa Maintenance and Ariz. Dept. of Public Safety in databases, all at 2409 N Country Club Dr Mesa, AZ	Low to none	no	yes	Summary of Environmental FirstSearch results (Liesch, 2002, p. 21) lists 2 in place USTs, 4 removed USTs, 2 LUSTs: one "unknown or soil contamination", and one 1993 "free product on groundwater and/or surface water", CLOSED OUT on 5-10-95; also 1997 LUST incident closed on 3-16-98 due to soil levels meeting RBCA Tier I. Apparently all LUST cases combined and closed.	None. LUST cases closed out	none
34	**Bingo Hall / Ray station** 2435 N Country Club Dr Mesa, AZ	None	no	yes	Summary of Environmental FirstSearch results (Liesch, 2002, p. 21) lists 1 LUST incident, closed due to soil levels meeting RBCA Tier I, and lists 3 removed USTs.	None. LUST case closed out	none
35	**Cashway Concrete and Materials** 650 W. McKellips Rd. Mesa, AZ (probably south of Hwy. 202)	None	no	no	Summary of Environmental FirstSearch results (Liesch, 2002, p. 22) lists 1 LUST incident, closed due to soil levels meeting RBCA Tier I.	None. LUST case closed out	none
36	**Valley Wide Contracting** 620 W. McKellips Rd. Mesa, AZ	None	no	no	Summary of Environmental FirstSearch results (Liesch, 2002, p. 21) lists 1 LUST incident, closed due to soil levels meeting RBCA Tier I.	None. LUST case closed out	none

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
	(probably south of Hwy. 202)						
37	**Alumi-Cover Awning Company, Inc.** 604 W. McKellips Rd. #A Mesa, AZ 85201 ph. (480) 969-2286 (south of Hwy. 202)	None	no	no	No listings of USTs or LUSTs in Environmental FirstSearch results at this address Liesch, 2002, p. 21-22 summary).	--	none
38	**Allpride Marble and Granite** 556 W McKellips Rd Mesa, AZ 85201 ph. (480) 962-7743 (south of Hwy. 202)	None	no	no	No listings of USTs or LUSTs in Environmental FirstSearch results at this address Liesch, 2002, p. 21-22 summary).	--	none
39	**Carports, Etc.** 550 W McKellips Rd Mesa, AZ 85201 ph. (480) 649-0982 (south of Hwy. 202)	None	no	no	No listings of USTs or LUSTs in Environmental FirstSearch results at this address Liesch, 2002, p. 21-22 summary).	--	none
40	**Superstition Springs Crushing** (a.k.a. Sun Valley Crushing Co.) 2343 N. Country Club Mesa, AZ (north of Hwy. 202)	None	no	yes	Environmental FirstSearch summary in Liesch (2002, p. 22) lists one removed UST and one inactive UST at this address; no LUSTs listed.	--	none
41	**Redburn Tire Company** 2339 N Country Club Dr Mesa, AZ 85201 ph. (602) 272-7601 (north of Hwy. 202)	None	no	yes	No listings of USTs or LUSTs in Environmental FirstSearch results at this address Liesch, 2002, p. 21-22 summary).	--	none
42	**Pete's Diesel Repair** 2333 N. Country Club Dr Mesa, AZ 85201 ph. (480) 964-2001 apparently shared property with	Low to none	no	yes	Environmental FirstSearch summary in Liesch (2002, p. 22) lists one removed UST at this address under the operator name of "W R Skousen Contractor, Inc."; no remaining USTs or LUSTs listed.	Due to nature of the businesses on site, proximity of the property to the river, likely should check to see if any automotive chemicals are stored and assure they are stored properly.	E, F, G, H, I, J, K, L, M

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
	another business of same current address: **Heritage Trucking** ph. (480) 964-7577 property also formerly was WR Skousen Contractor (north of Hwy. 202)						
43	**Little Dealer-Little Prices** 2038 N. Country Club Dr. Mesa, AZ 85201 ph. (480) 834-9581 (south of Hwy. 202)	None	no	no	No listings of USTs or LUSTs in Environmental FirstSearch results at this address Liesch, 2002, p. 21 summary). Type of business not specified in Liesch.	--	none
44	**Karl Watkins** 2116 N. Country Club Mesa, AZ (south of Hwy. 202)	None	no	no	Summary of Environmental FirstSearch results (Liesch, 2002, p. 21) lists 1 LUST incident, closed due to soil levels meeting RBCA Tier I.	None. LUST case closed out	none
45	**Contreras Contractors** 2110 N. Country Club Mesa, AZ (south of Hwy. 202)	None	no	no	Summary of Environmental FirstSearch results (Liesch, 2002, p. 21) lists 7 LUST incidents, all closed due to soil levels meeting RBCA Tier I.	None. LUST cases closed out	none
46	**Car Smart** (business of unspecified nature) no listing can be found in Mesa on or near Country Club Dr.; no address can be determined and none provided by Liesch (2002) (south of Hwy. 202)	Unknown, probably low to none	no	yes	Liesch (2002) is imprecise but suggests *possibly* a former UST or LUST at this site; Environmental FirstSearch summary does not list any property for UST or LUST as under the name "Car Smart". Only chance to compare the database is through the street address, which is not provided in Liesch (2002).	No way to compare with existing data until the address of the business is determined. No listing can be found after exhaustive search through Internet business listings by Geology & Investigations.	possibly E, F, G, H, I, J, K, L, M
47	**Artistic Ice Creations** (business of unspecified nature) no listing can be found in Mesa on or near Country Club Dr.; no address can be determined and none provided by Liesch (2002) (south of Hwy. 202)	Unknown, probably low to none	no	yes	Liesch (2002) is imprecise but suggests *possibly* a former UST or LUST at this site; Environmental FirstSearch summary does not list any property for UST or LUST as under the name "Artistic Ice Creations". Only chance to compare the database is through the street address, which is not provided in Liesch (2002).	No way to compare with existing data until the address of the business is determined. No listing can be found after exhaustive search through Internet business listings by Geology & Investigations.	possibly E, F, G, H, I, J, K, L, M
48	**Tevizo Hay Company**	Medium	no	no	Summary of Environmental FirstSearch results	Check regulatory files (ADEQ UST	none

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
	1747 N. Alma School Rd. Mesa, AZ				(Liesch, 2002, p. 21) lists 3 USTs, all removed, and one LUST incident with undefined soil contamination. SRPMIC reportedly can document this site as "case closed" via EPA data.	SECTION?) to see if LUST exists, or case closed, etc. SRPMIC Environmental Services staff has the assignment to complete this research as part of in-kind services on HTRW.	
49	**Sunward Materials / BCW** 1564 N. Alma School Rd. Mesa, AZ	Low	no	no	Summary of Environmental FirstSearch results (Liesch, 2002, p. 21) lists one LUST incident closed due to soil levels meeting RBCA Tier I.	None. LUST case closed out	none
50	Unspecified **other businesses** at unspecified addresses **(see note 1)**	Likely low to none	no data	no data	Liesch (2002) mentions this more in a comprehensive land-use manner than in an environmental concern manner.	No apparent needs.	none
51	**Cemex quarry operations**	Medium to high	no	yes	Liesch (2002) admits having no data and assuming that the washwater, maintenance, and perhaps chemical storage and UST/AST situations that characterize sites 2, 3, 14, and 22, above, probably exist here too.	No data. Visit the site. Perhaps can be documented as a non-issue	B, C, D, E, F, G, H, I, J, K, L, M
52	**Mesa Northwest Wastewater Treatment Plant**	Minor to none	no	no	No environmental problems cited (Liesch, 2002). The only foreseeable issue might be bacteria and nitrate levels induced by effluent, but this is a biology issue, not a geotechnical issue.	No apparent need for data regarding the plant; the recharge ponds (see # 53, below) are of interest.	None
53	City of Mesa's 2 **groundwater recharge ponds**	None, **but combined effects with conceptual study water addition should be deter-mined**	No (appar ently protect ed by dikes)	No (appar ently protect ed by dikes)	No environmental problems cited. Receives wastewater from City of Mesa (Liesch, 2002). The only foreseeable issue might be bacteria and nitrate levels induced by effluent, but this is a biological issue, not a geotechnical issue. SRPMIC reports the ponds total 27 acres.	Modeling of cumulative infiltrating water / zone of influence with conceptual study features (see text, section 8.1.2.1).	E, F, G, H, I, J, K, L, M, N, O
54	Non-specific **residential property** locations **(see note 1)**	Likely low to none	no data	no data	Liesch (2002) mentions this more in a comprehensive land-use manner than in an environmental concern manner.	No apparent needs.	None
55	Non-specific **agricultural land** locations **(see note 1)**	None with regard to HTRW	no data	no data	Liesch (2002) reports no problems, details, or specific locations. The only foreseeable issue might be enhanced nutrient levels in surface runoff water an	None apparent	None with regard to HTRW

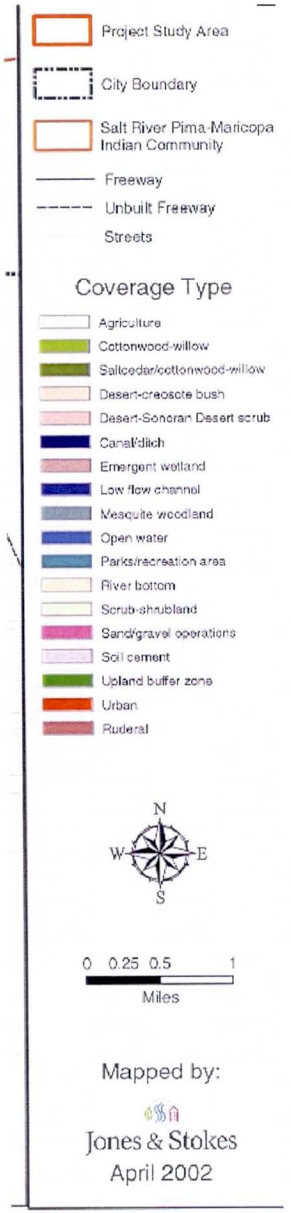
Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
					perched groundwater (if any), but this is a biology issue, not a geotechnical issue.		
56	**Hwy 202 constr**. & storage area **(see note 1)**	None to unknown	uncer-tain	uncer-tain	Liesch (2002) reports no problems or details (or specific location) and may be mentioning the site solely to complete the list of land use practices. In that regard the precise location is not critical information	No location provided in Liesch (2002)	probably none

Note 1: Site not shown o fig. A-1. No location provided in the data source.

Legend and scale for fig. 1, which follows on the next page. To see this legend or the map in greater detail, use the "zoom" feature in Microsoft's WORD word-processing program. If your zoom feature is not activated, go to the standard tool bar in WORD, click the down arrow at the far right side of the toolbar, click "add or remove buttons", and then click "zoom". The source for fig.1 is the Jones and Stokes (2002) EIS for this study. The map is used here as a base because it is the only known viable map base that shows the boundaries of the existing seven sand and gravel operations in the study area. Note the magenta-colored polygons, which are the sand and gravel operations.



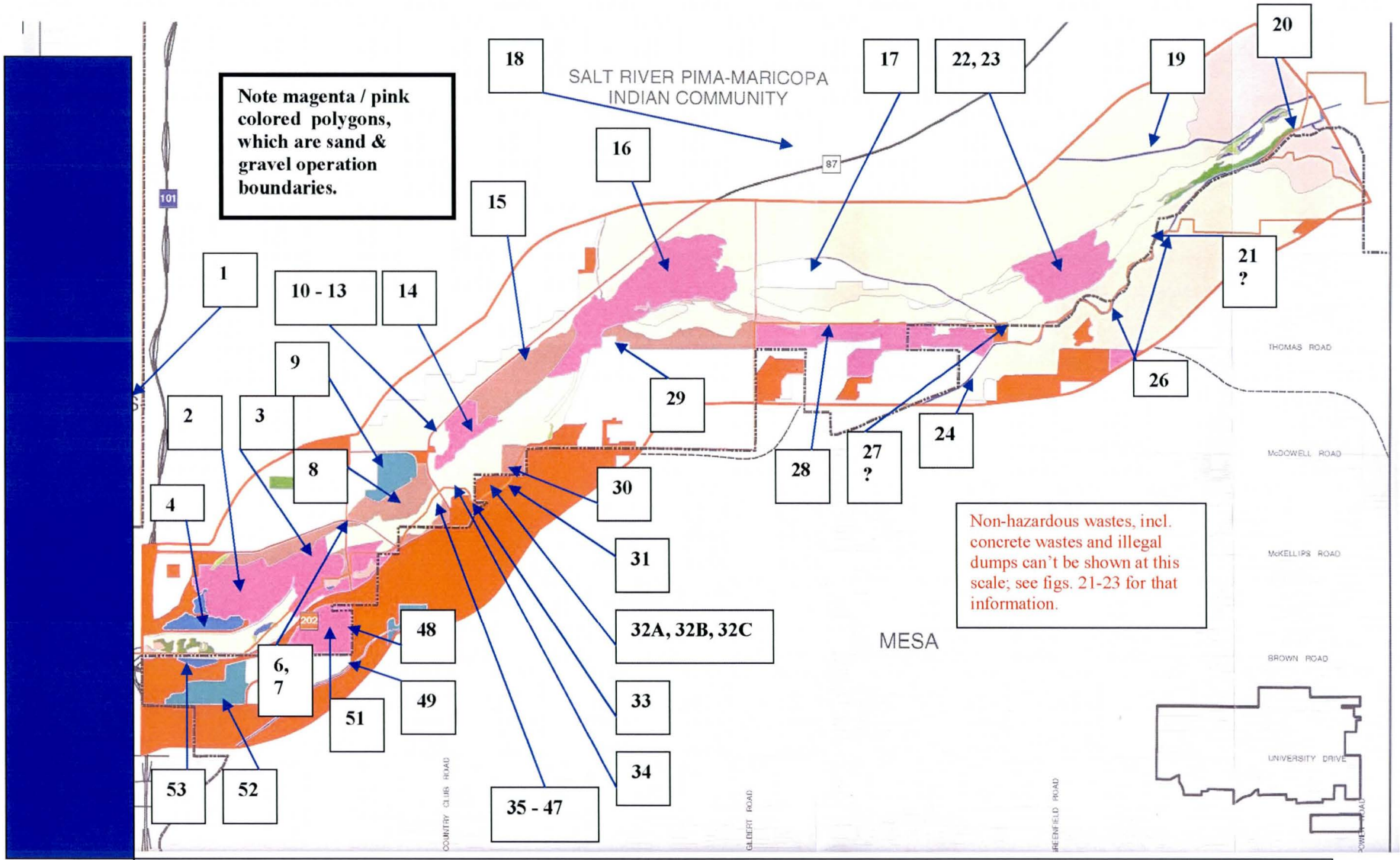


Fig. A-1.—Land use activities in and near the Va Shly'ay Akimel study area, reported in the Phase I EA (Leisch, 2002). These include e some that are or at one time had potential to be HTRW sites, some that are non-hazardous waste sites, and some that are unrelated to environmental concerns. See table A-1 for details on the numbered sites. See text, sections 8, 9 for assessment of potential problems.

o

A-1.4 ***Assessment of each study Alternative, in relation to environmental concerns***. These are the USACE-Geotech assessments of Alternatives A through O.

A-1.4.1 *Alternative A* (acronym designation "*LOAD*"). Descriptive title on the PD graphic of early Feb. 2003, "Sonoran desert dominate, minimal vegetation". Other PD data descriptions include, "Xero-riparian dominate; low water requirements", and "Minimal level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallLOAD.jpg*". For this Alternative, as with all the Alternatives, no separate assessment is made of the A_1 (drip irrigation) and A_2 (braided irrigation) options because: a) the issue is the amount that the local zone of influence of infiltrating waster that would be created by irrigation or other addition (not quantified in the conceptual plans to date); and b) no quantified difference in the volume of water to be added has been specified for the $_1$ and $_2$ options.

Summary of conceptual study actions, Alternative A: "Soronan desert" vegetation surrounding the GRUSP (site 17) and overtop at least half of the Tri-Cities landfill (site 15). "River bottom" vegetation to be added to about a quarter of a square mile immediately river-side and upstream of the Tri-Cities landfill. This is the alternative with the least vegetation, the least conceptual actions, and the least water added to the ecosystem. Irrigation will have to continue for the first three to four years to establish the vegetation according to USACE-ED-HH team members.

USACE-Geotech's list of environmental concerns, Alternative A.

1. Interaction between study-induced irrigation and the local GRUSP-supported water table must be determined and coordination must be done. The GRUSP-supported local water must remain at least 25 ft below the bottom of the Tri-Cities landfill, to avoid any leaching of landfill contents. The cumulative effects of this study action will have to be considered and documented as it would certainly be under the same regulatory restrictions as those controlling the GRUSP (site 17).

- 3. Plantings overtop the Tri-Cities landfill (site 15) also will be a concern due to irrigation. Both leaching through the landfill and impacts of rising groundwater elevation from below in response to the irrigation need to be considered and documented.3. The surface runoff from irrigation may impact the study-adjoining Chandler Ready Mix site (site no. 28). A detailed site map with the relative elevations of the river bottom and the Chandler operations needs to be obtained. That surface pollutants and potential surface pollutants from vehicle maintenance and wash-rack practices, and chemical storage practices *may* exist at the site was suggested in the Phase I EA, but this was not ascertained as the site was not visited inside property boundaries. These data should be collected and assessed. If there are potential surface pollutants that could be mobilized *by* this study's elements, or that could be mobilized *into* the study elements in flood events, this should be assessed. Will the results be acceptable for the functioning of the study elements or not?
- 4. The same issues and questions in item no. 3, above, also may apply to the Salt River Sand and Rock Beeline One operations (site 16), which were not included in the Phase I EA (a.k.a. the Gilbert quarry). Details of the operation need to be determined and documented.

- 5. The downstream extent of the expected groundwater elevation change, if any, should be determined, so as to make sure potential impacts such as nos. 3 and 4, above, will not occur farther downstream at other sites.
- 6. While more distant from the planned study actions than the sites discussed above, Talley Defense Systems (site 26) is suspected, by previous investigators, of releasing perchlorate into groundwater in the Salt River (which would be inside the study area if it has occurred), and possibly releasing heavy metals into soil, all resulting from TSD practices, such as burning and exploding waste rocket propellants at the boundary of SRPMIC lands. Specific testing would have to occur at the future construction excavation or dewatering zones in the study area in order to ascertain if contaminants would impact any given feature. Pasty testing by others was not designed to answer such a study-area-specific question and has not answered the question.

USACE-Geotech's recommended follow-on work, Alternative A.

- 1. More data exist concerning the Tri-Cities landfill than what has been collected by the study team to date would be useful; documentation that construction of its barrier cap has been completed has been particularly elusive, as has all documentation of the cap construction methods. If potential hydrocarbon-containing surface runoff is an issue with the study elements, get the information on the Beeline and Chandler sand and gravel operations. Some of this could be done by research of regulatory agency files, other information could be gathered by sites visits.
- 2. Modeling should be done regarding the infiltrating water conditions/equilibrium/and zone of influence that would/could result from constructing study area features, and the results assessed for potential impacts on landfills.

A-1.4.2 *Alternative B* (acronym designation "*MEAD*"). Descriptive title on the PD graphic of early Feb. 2003, "Mesquite and Sonoran desert dominate, moderate vegetation". Other PD descriptions include, " Xero-riparian dominate; medium water requirements", and "Moderate level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallMEAD.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative B: Similar to but substantially more extensive than those for Alternative A. More "Soronan desert" vegetation, plus "mesquite" vegetation surrounding the GRUSP (site 17). Those two types of vegetation are planned to cover the entire Tri-Cities landfill and more, extending downstream to about the upstream end of the United Metro sand, gravel, cement, and asphalt operations (site 14). "River bottom" vegetation immediately river-side and upstream of the Tri-Cities landfill is slightly reduce in size relative to Alternative A, with its place taken by Sonoran desert vegetation. A small area of Sonoran desert vegetation is to be added to the south bank of the river, adjoining the Lehi Cemetery. Irrigation will have to continue for the first three to four years to establish the vegetation according to USACE-ED-HH team members.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative B. All of USACE-Geotech's listed environmental concerns and recommended

follow-on work for Alternative A also apply to Alternative B. Since the area to be planted under Alternative B is more extensive, the amount of irrigation, if any, will be more and the potential impact from infiltrating water and its zone of influence will be more. In addition, due to the increased area of irrigation, there is potential to impact an additional six sites by irrigating and possibly raising the local groundwater elevation. Those sites include the United Metro sand, gravel, cement, and asphalt operations (site 14), which has overbank dumping of unwanted asphalt and cement, and formerly had a LUST[27] classification. Also potentially impacted are several landfills, including the landfill under the drum site (site 11), the Cypress, North Center St. ("Tri-Cities south"), "Old Mesa", and Vulcan demolition debris landfills (sites 8, 30, 32C, and 31, respectively). Additional research and evaluation would be needed with regard to the following.

- 1. Barrier cap and other constructed closure documentation for the Tri-Cities landfill (site 15); existing closure report of 1994 does not answer these questions. Modeling should be done regarding the infiltrating water conditions/equilibrium/and zone of influence that would/could result from constructing study area features, and the results assessed for potential impacts on landfills.
- 2. The same information needs and considerations listed in issue no. 1, above, also apply to The Cypress landfill (site 8).
- 3. As above, for sites 11 and 32C.
- 4. A decision will have to be made regarding whether or not potentially mobilized hydrocarbons and other chemicals from runoff, if any, at the United Metro site are acceptable to the study elements, and whether overbank dumping of cement and asphalt at United Metro is an issue or not.

A-1.4.3 *Alternative C* (acronym designation "*HIAD*"). Descriptive title on the PD graphic of early Feb. 2003, " Sonoran desert dominate, extensive vegetation". Other PD descriptions include, "Xero-riparian dominate; high water requirements ", and "Extensive level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallHIAD.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative C: More extensive study area alteration than Alternative B. In comparison to Alternative B, Alternative C eliminates much of the mesquite and some of the Sonoran desert plantings, in favor of cottonwood-willow plantings; increases the amount of river bottom plantings by a factor of more than two, including such that is immediately adjacent to the Tri-Cities landfill (site 15); adds two wetlands, including one nearly adjacent to the Tri-Cities landfill (site 15) on the upstream side, and another adjacent to the horse farm (site 27) (as implied in the Phase I EA) and Talley Defense Systems site. The amount of plantings within the main channel increases sharply from the plan of Alternative B, as does the amount of plantings on the south bank, extending upstream from near Lehi Cemetery. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative C. All of USACE-Geotech's concerns and recommendations listed under Alternatives A and B, above, also apply to Alternative C. Since more water would be added to

[27] "LUST" is the acronym for "leaking underground storage tank".

the system to achieve the goals of alternative C and the area of surface impact also is greater, the potential to impact or be impacted by the landfills, the GRUSP and Tri-cities landfill groundwater elevation limits, and quarry operations runoff, all are enhanced relative to Alternative B. Similarly, the potential to mobilize any Talley Defense Systems pollutants in groundwater or soil, if any, is enhanced.

A-1.4.4. *Alternative D* (acronym designation "*MINE*"). Descriptive title on the PD graphic of early Feb. 2003, "Channelized stream, avoiding mining". Other PD descriptions include, "Meso-riparian dominate (cottonwood, mesquite, and xero-riparian) with channelized stream to avoid mining area", and "Moderate level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallMINE.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative D: A substantially more geographically compact study area alteration than Alternative C, eliminating entirely the Gilbert Rd. to 40th zone of south-bank plantings as well as the study elements north, south, and east of the GRUSP. Alternative C includes wetlands and south bank alterations between Center St. and Horne Rd., and includes more wetlands adjacent or near the Tri-Cities landfill (site 15). Includes channelization within the river between Gilbert and Horne Rds. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative D. All of USACE-Geotech's concerns and recommendations listed under Alternatives A and B, above, also apply to Alternative D. For Alternative D, the potential for impacting or being impacted by the Chandler quarry drops out and the potential impact of the Talley Defense Systems site diminished sharply, both due to increased distance. Conversely, the potential to impact the Tri-Cities landfill (site 15) and the other landfills farther downstream, is enhanced, due to adding much more water. This is particularly so for the North Center St. landfill (site 30), and the Old Mesa and Vulcan Demolition Debris landfills due to enhanced plans for altering the south bank. The potential for impact with the "drum site" (site 11) and the Cypress landfill (site 8) also are enhanced, relative to Alternative C.

A-1.4.5 *Alternative E* (acronym designation "*VHAD*"). Descriptive title on the PD graphic of early Feb. 2003, "Sonoran desert dominate, moderate vegetation". Other PD descriptions include, "Meso-riparian dominate (cottonwood, mesquite, and xero-riparian)", and "Extensive level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallVHAD.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative E: Alternative E is very similar to Alternative C, in geographic area altered and somewhat similar in the types / degrees of alteration. Alternative E, though, uses less water and has more Sonoran-desert-type vegetation. The only two wetlands in Alternative E are the same as those for Alternative C (one by the horse farm (site 27) and one near the upstream end of the Tri-Cities landfill (site 15)). Alternative E includes a large cottonwood-willow planting area outside of the SRPMIC boundary and on the south bank of the river. While the re-planting zone at the downstream end of the study area does adjoin the official outer perimeter of the Indian Bend Wash Superfund sites, SRPMIC Environmental

Services has reported that the pollutants have not and likely will not impact the study area due to downgradient locations and distance. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative E. Identical to those mentioned above for Alternative C, plus the following.

- 1. Additional modeling should be done regarding the infiltrating water conditions/equilibrium/and zone of influence that would/could result from constructing study area features, and the potential impact on Indian Bend Wash groundwater contaminant plumes should be assessed. The most recently encountered data in research suggest that the plumes are far distant and that impact likely will be nil. It is considered wise to do the modeling and document that there will be no conflict.

A-1.4.6 *Alternative F* (acronym designation "*MAX*"). Descriptive title on the PD graphic of early Feb. 2003, "Cottonwood dominate with reshaping and channelized stream". Other PD descriptions include, "Meso-riparian dominate (cottonwood, mesquite, and xero-riparian) with reshaped and channelized stream", and "Maximum level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallMAX.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative F: Alternative F is a combination of essentially all the elements of Alternatives C and D plus more. The additions beyond Alternatives C and D include more than doubling the length of the channelized stream, extending it upstream from Gilbert Rd. to Val Vista Dr. Wetlands are larger and more numerous in those areas. Alternative F extends substantially farther downstream than any of Alternatives A through E, extending about one-quarter mile downstream of Alma School Rd., and this Alternative includes a third segment of channelized stream, from Center St. downstream to Alma School Rd. The most extensive wetlands of any in the first five alternatives are planned in Alternative F, immediately downstream of Alma School Rd. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative F. Identical to those mentioned above for Alternatives C and D, plus the following.

- 1. While the channelization downstream from Center St. to Alma School Rd. *may* reduce the chances for washout of the banks at the various landfills downstream of Center St. (proposed depth of channelization is not known to USACE-Geotech), the enhanced wetlands area increases the potential for interaction between study- elevated groundwater and the landfills beyond that of any of Alternatives A through E. Therefore, modeling should be done regarding the infiltrating water conditions/equilibrium/and zone of influence that would/could result from constructing study area features, and the results assessed for potential impacts on landfills potentially impacted specifically by these additional Alternative F features.
- 2. An additional data need arises with Alternative F, that of potential groundwater interaction with the existing Mesa Wastewater Treatment recharge ponds (site53) and existing SRPMIC recharge ponds (site 4). Groundwater already is being elevated in the vicinity of those ponds. Modeling should be done to determine the cumulative effects with infiltrating water conditions/equilibrium/and zone of influence that would/could

result from constructing study area features; the same holds for modeling with regard to impacting Indian Bend Wash groundwater contaminant plumes.

A-1.4.7 *Alternative G* (acronym designation "*CWAD*"). Descriptive title on the PD graphic of early Feb. 2003, "Cottonwood dominate, braided channel network". Other PD descriptions include, "Cottonwood dominate with braided channel network", and "Extensive level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallCWAD.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative G: Alternative G is similar to Alternative F in areal extent, but has substantially less wetlands, in both number and in size. The zones where Alternative G differs the most from Alternative F are three in number. One concerns channelization. There is none in Alternative G. The other main difference is between Center St. and Alma School Rd., where Alternative G has much less planting on the south-side river bank area. A third area of difference between Alternatives F and G is at the downstreammost end of the study area, where Alternative G includes a large cottonwood-willow planting area outside of the SRPMIC boundary and on the south bank of the river. This re-planting zone is immediately adjacent the Indian Bend Wash NPL site, so research and potential problems regarding Indian Bend Wash that are detailed under Alternative F, above, are even more urgently in need of resolution for Alternative G. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative G. Identical to those mentioned above for Alternatives F, with enhanced need to model infiltrating water equilibrium conditions related to cumulative effects with Mesa Wastewater Treatment recharge.

A-1.4.8 *Alternative H* (acronym designation "*MSAD*"). Descriptive title on the PD graphic of early Feb. 2003, "Mesquite dominate, braided channel network". Other PD descriptions include, "Mesquite dominate with braided channel network", and "Extensive level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallMSAD.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative H: Alternative H covers essentially the same geographic area as Alternative G, with one major exception: there is no planned activity at the downstreammost end of the study area, where Alternative G includes a large cottonwood-willow planting area outside of the SRPMIC boundary and on the south bank of the river (and adjacent the Indian Bend Wash NPL site). Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative H. Identical to those mentioned above for Alternatives G, but with a reduced need to model the impacts on Indian Bend Wash NPL site. Indian Bend Wash data needs here are identical to those expressed for Alternative F.

A-1.4.9 *Alternative I* (acronym designation "*CHNL*"). Descriptive title on the PD graphic of early Feb. 2003, "Channelized stream". Other PD descriptions include, "Cottonwood dominate with channelized stream", and "Moderate level of vegetative restoration". For a map of this

Alternative, see the separate electronic .jpg file named "*SmallCHNL.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative I: Alternative I covers much of the same geographic area as Alternative F, with reduced areas of plantings and reduced sizes of some of the wetlands between Center St. and Alma School Rd. A major difference between Alternatives I and F is at the Tri-Cities landfill area (site 15). Alternative I does *not* plan any plantings over *top* of the Tri-Cities landfill. This planting overtop of the Tri-Cities landfill, in full or in part, is a study element for all the other Alternatives designated A through H, making Alternative I nearly unique in that regard (Alternative L also has this feature, see below). Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative I. Identical to those mentioned above for Alternatives F.

A-1.4.10 *Alternative J* (acronym designation "*BRAD*"). Descriptive title on the PD graphic of early Feb. 2003, "Cottonwood dominate, extensive vegetation with reshaping". Other PD descriptions include, "Cottonwood dominate, with reshaping of sand and gravel pits", and "Extensive level of vegetative restoration". Irrigation will have to continue through the project life. For a map of this Alternative, see the separate electronic .jpg file named "*SmallBRAD.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative J: Alternative J is essentially Alternative F *less* all the channel work and in-channel wetlands from Alma School Rd. upstream to Center St., and from Horne St. upstream to Val Vista Dr., covers much of the same geographic area as Alternative F, with reduced areas of plantings and reduced sizes of some of the wetlands between Center St. and Alma School Rd.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative J. Identical to those mentioned above for Alternative F, but with less impact with the GRUSP (site 17), from the Tri-Cities landfill (site 15), and from the group of landfills on both banks of the river between Country Club Dr. and the alignment of Extension Rd. (sites 8, 11, 30, 31, and 32C).

A-1.4.11 *Alternative K* (acronym designation "*NODL*"). Descriptive title on the PD graphic of early Feb. 2003, "Cottonwood dominate, extensive vegetation NO reshaping". Other PD descriptions include, " Cottonwood dominate without reshaping of sand and gravel pits", and "Extensive level of vegetative restoration". Irrigation will have to continue through the project life. For a map of this Alternative, see the separate electronic .jpg file named "*SmallNODL.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative K: Alternative K is essentially the same as Alternative J and, *additionally*, planting work around the United Metro quarry operations (site 14).

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative K. Identical to those mentioned above for Alternative J.

A-1.4.12 *Alternative L* (acronym designation "*POCK*"). Descriptive title on the PD graphic of early Feb. 2003, "High visibility from road, cottonwood and mesquite dominate". Other PD descriptions include, "Cottonwood and mesquite dominate with high visibility from roads", and "Moderate level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallPOCK.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative L: Alternative L is very similar to Alternative M (see below), *less* all work on the south bank of the river upstream from Gilbert Rd., and less all planting overtop the Tri-Cities landfill (site 15). Plans and vegetation types to be used in and around the GRUSP (site 17) also vary. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative L. Identical to those mentioned above for Alternative F, with reduced emphasis on the Talley Defense Systems location (site 26) and less chance to impact the Tri-Cities landfill (site 15).

A-1.4.13 *Alternative M* (acronym designation "*WET*"). Descriptive title on the PD graphic of early Feb. 2003, "Wetland dominate". Other PD descriptions include, "Hydro-riparian dominate", and "Extensive level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallWET.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative M: Alternative M is essentially the same as Alternative F, *less*, all the channel work. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative M. Identical to those mentioned above for Alternative F.

A-1.4.14 *Alternative 14* (no acronym designation). Description: None. **This alternative was not included in the alternatives list of Oct. 2003 and therefore is given no further consideration here**.

Summary of conceptual study actions, Alternative 14: No action

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative 14. None.

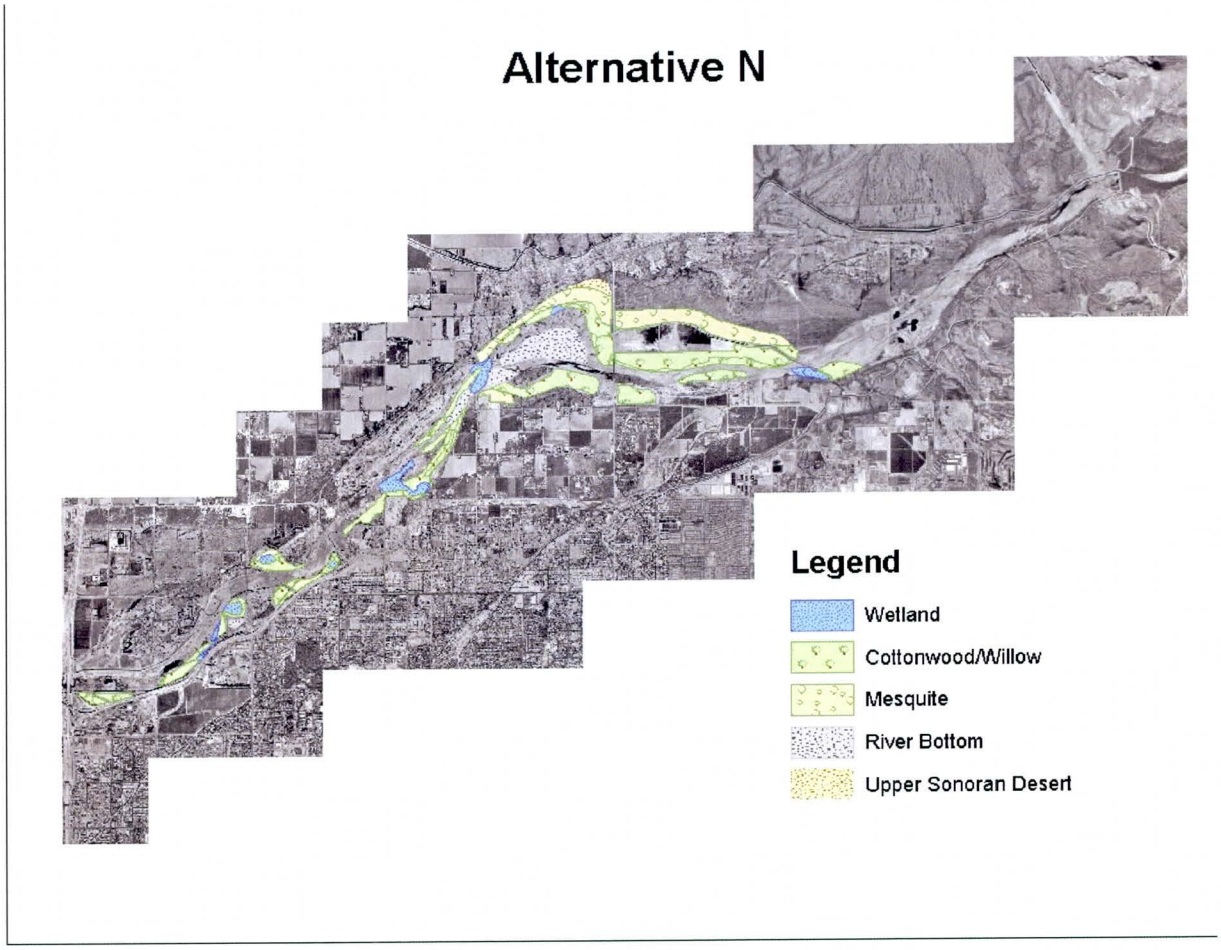
A-1.4.15 *Alternative N* (no acronym designation). Description: see figure, following page. See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative N. Issues relate to potential conflicts with potential increases in groundwater elevation caused by the planned irrigation:

- Model cumulative influences of infiltrating water and zone of influence with the impacts from existing GRUSP (site 17) groundwater recharge. The GRUSP recharge is limited such that the top of the water table is always at least 25 ft below the bottom of the active Salt River landfill.
- The largest of all the planned wetlands construction adjoins the north side of the North Center St. landfill (site 30) raises potential conflicts with inundating the landfill contents with the groundwater. Modeling should be done to develop the infiltrating water equilibrium conditions and zone of influence resulting from conceptual features and to determine whether this will impact the landfill contents; the same holds true for the TriCities landfill (site 15), where the second largest of all the planned wetlands construction is nearly adjoining.

In addition to the above HTRW considerations, there are geotechnical issues with regard to slope stability questions that eventually will have to be addressed (refer to text, paragraphs 9.3 and 9.4).

- Planned wetlands construction both upstream and downstream of adjoining sand and gravel operations (sites 2, 3) raises potential slope stability questions. Assess the potential impacts.
- Planned wetlands construction adjoins sand and gravel operations at site 28 (Chandler Ready Mix) raising potential slope stability questions. Assess the potential impacts.


Alternative N
Legend
Wetland
Cottonwood/Willow
Mesquite
River Bottom
Upper Sonoran Desert

A-1.4.16 *Alternative O* (no acronym designation). Description: see figure, following page. **It is clear that US Army Corps of Engineers, Geotechnical Branch does not have access to the full conceptual design. It has been stated by study management that there are to be in the river channel several constructed features, including a 2,000-ft long, approximately 20-ft-deep grade control structure, and several small berms** Alternative O is very much like Alternative N, but has, additionally, more and larger planned wetlands adjoining existing sand and gravel operations (sites 2, 3), which makes slope stability issues of even greater importance than they are for Alternative N. See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative O. Issues relate to potential conflicts with potential increases in groundwater elevation caused by the planned irrigation:

- Modeling should be done to develop the infiltrating water equilibrium conditions and zone of influence resulting from conceptual features and to determine whether this will impact the GRUSP (site 17), North Center St. landfill (site 30) or TriCities landfill (site 15).

In addition to the above HTRW considerations, there are geotechnical issues with regard to slope stability questions that eventually will have to be addressed (refer to text, paragraphs 9.3 and 9.4).

- Planned wetlands construction both upstream and downstream of adjoining sand and gravel operations (sites 2, 3) raises potential slope stability questions. Assess the potential impacts.
- Planned wetlands construction adjoins sand and gravel operations at site 28 (Chandler Ready Mix) raising potential slope stability questions. Assess the potential impacts.

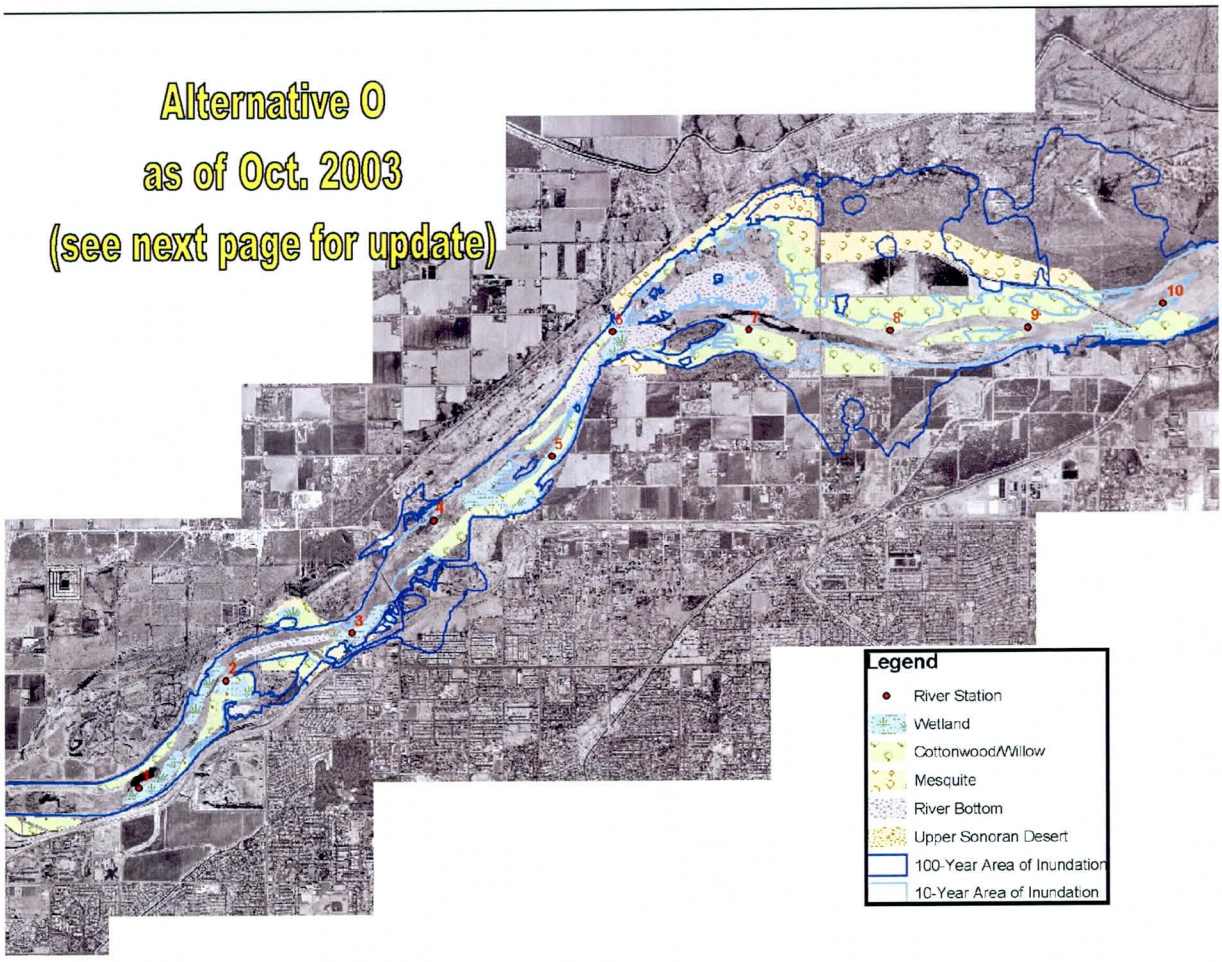
The main change from the Oct. 2003 version of Alternative O, assessed above, and the late March 2004 version is that the upstreammost wetland and willow bog have been eliminated. This is favorable with regard avoiding any potential Talley Defense Systems conflict, if any, and eliminates the need to do testing for potential Talley Defense Systems releases at construction sites for "new" Alternative O, because the next closest downstream to-be-constructed wetland is very far away.

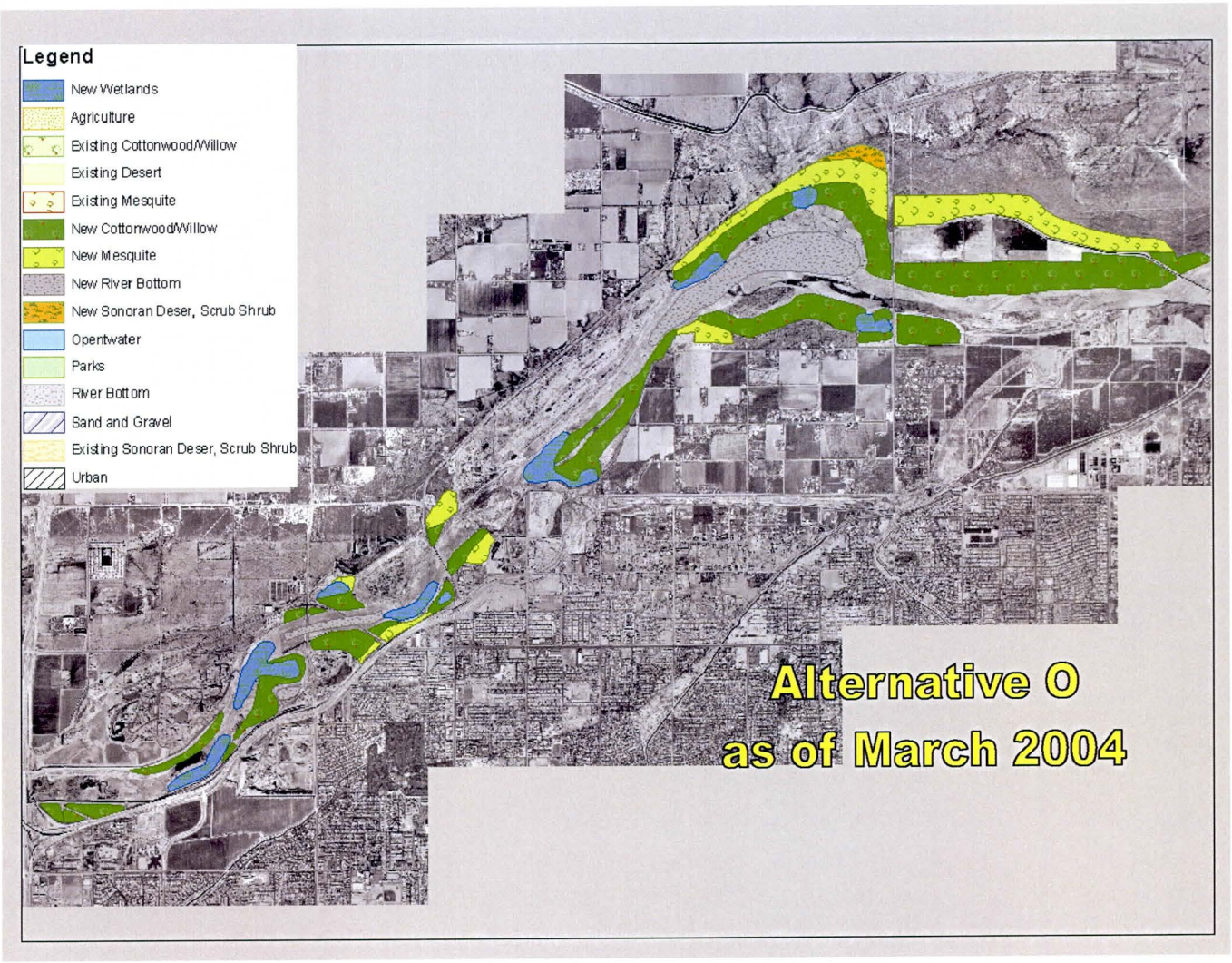
A-1.5. ***Non-hazardous wastes impacts with the footprint of Alternative O (version of late March 2004)*** (see features map, below). Refer to table 4 and figs. 21-23 in the above text for more details on the numbered sites of wastes.

Conflicts are extensive between the Alternative O footprint (ver. Of late March 2004) and the non-hazardous wastes in the study area (refer to numbered sites on table 1 and on figs. 21-23 for details and locations):		
# (on table 4)	Waste	Conflict
1	Possibly an illegal dump	Half covered by a conceptual wetland
2	Northern part: concrete/cement waste at Salt River Sand & Rock, Dobson operations	Mostly covered by a conceptual wetland

Conflicts are extensive between the Alternative O footprint (ver. Of late March 2004) and the non-hazardous wastes in the study area (refer to numbered sites on table 1 and on figs. 21-23 for details and locations):		
# (on table 4)	Waste	Conflict
2	Southern part: concrete/cement waste at Salt River Sand & Rock, Dobson operations	Completely covered by a conceptual wetland and a cottonwood/willow planting area
3	Illegal dump	No conflict, no impact
4	Concrete debris	Completely covered by a conceptual wetland and a cottonwood/willow planting area
5	Illegal dump	Completely excavated by conceptual new channel bottom
6	Illegal dump	About one-third excavated by conceptual new channel bottom
7	Concrete debris	About one-half would be covered by a conceptual cottonwood/willow planting area
8	Illegal dumping on top of Cypress landfill	Upgradient of and close to a large, conceptual wetland
9	Illegal dump	Nearly all covered by new, conceptual plantings, including willow, and a new, large, conceptual wetland
10 !	Concrete/cement waste, two, non-contiguous areas	(Downstream part): Nearly all covered by new, conceptual plantings, including willow, and a new, large, conceptual wetland; (Upstream part): All except the bank slope will be covered by a large, conceptual wetland (including all the material on the toe of the bank and the invert), and all material on top of the bank will be covered by a conceptual willow planting; it is unclear whether bank shaping will be necessary; if so, the entire mass of this concrete waste pile likely will have to be moved to carry out Alternative O.
11	Illegal dump	About half covered by a new, large, conceptual wetland
12	Debris from Cypress landfill washout	About half covered by a new, large, conceptual wetland; the remainder is immediately upgradient of this wetland, approximately in line with the center of channel flow
13	Concrete debris	Will be immediately downstream of conceptual willow bog (presumably irrigated); probably no significant impact
14	Metal debris	Under the footprint of a new, conceptual mesquite bosque
15	Concrete/cement waste at "Rinker" operations	Probably no impact; nearly adjoins the largest conceptual wetland of this study
15	Asphalt waste at "Rinker" operations	Possibly a water-quality/runoff issue, as it nearly adjoins the largest conceptual wetland of this study; perhaps the asphalt could be removed for water quality concerns and the underlying concrete left in place?
16	Tire dump, 300 tires, uncertain if this is an illegal dump	Over half inside the footprint of a new, conceptual wetland, the largest of the entire study; the remainder would be on the downstream edge of this wetland.
17	Calcium soil additive, uncertain if this is an illegal dump	Completely under the footprint of a new, conceptual willow bog
18	Metal tower	Within a new, conceptual wetland footprint
19	Illegal dump	Completely under the footprint of a new, conceptual willow bog
20	Illegal dump	Totally beneath the footprint of a new, conceptual willow bog and wetland.
21	Concrete debris	Immediately adjoining and downgradient of a new, conceptual willow bog; if any bank shaping is planned, this site almost certainly will be totally under the footprint of the reshaping
22	Illegal dump	Totally beneath the footprint of new, conceptual plantings, including

Conflicts are extensive between the Alternative O footprint (ver. Of late March 2004) and the non-hazardous wastes in the study area (refer to numbered sites on table 1 and on figs. 21-23 for details and locations):		
# (on table 4)	Waste	Conflict
		mesquite (all the northern area of dump #22), and willow (all the southern area of dump #22)
23	Illegal dump	About three-quarters is under the footprint of new, conceptual plantings, including willow, and (mostly) under mesquite
24	Illegal dump	No conflict, no impact


Alternative 0
as of Oct. 2003
(see next page for update)
1
2
3
4
5
6
7
8
9
10
Legend
River Station
Wetland
Cottonwood/Willow
Mesquite
River Bottom
Upper Sonoran Desert
100-Year Area of Inundation
10-Year Area of Inundation


Legend
New Wetlands
Agriculture
Existing Cottonwood/Willow
Existing Desert
Existing Mesquite
New Cottonwood/Willow
New Mesquite
New River Bottom
New Sonoran Deser, Scrub Shrub
Opentwater
Parks
River Bottom
Sand and Gravel
Existing Sonoran Deser, Scrub Shrub
Urban
Alternative O
as of March 2004

APPENDIX

F

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

DESIGN

APPENDIX D - ENGINEERING DESIGN
FOR
VA SHLY'AY AKIMEL SALT RIVER RESTORATION PROJECT
FEASIBILITY STUDY
MARICOPA COUNTY, ARIZONA

CONTENTS

1.0	OBJECTIVE		3
2.0	STUDY AREA		3
3.0	DESIGN CRITERIA		3
	3.1	Structural Requirements	3
	3.2	Hydrology and Hydraulic Requirements	3
	3.3	Geotechnical Requirements	3
	3.4	Environmental Considerations	4
	3.5	Dumped Materials	4
4.0	DESIGN FEATURES		4
	4.1	Low Flow Channel	4
	4.2	Reshaping the Salt River Riverbed	4
	4.3	Bank Stabilization	5
	4.4	Wetland	5
	4.5	Control Invasive Vegetation	5
	4.6	Planting	5
	4.7	Water Well	5
	4.8	Grade Control Structure	5
	4.9	Water Distribution System	6
	4.10	Planting Irrigation System	6
	4.11	Diversion Structures	6
5.0	CONSTRUCTABILITY		6
	5.1	Construction Materials	6
	5.2	Access Roads	7
	5.3	Borrow Sites	7

6.0 UTILITY RELOCATION 7

7.0 CONSTRUCTION TIME 7

8.0 OPERATION AND MAINTENANCE 7

8.1 Structures 7
8.2 Plants 7

1.0 OBJECTIVE

The objective of the Va Shly'ay Akimel Salt River Ecosystem Restoration project is to implement environmental restoration by restoring riparian habitat within the Salt River from Granite Reef Dam downstream to the Pima Freeway (US 101). The purpose of this appendix is to present feasibility study results of the civil design effort. Design data and calculations were developed sufficient to determine the technical and economic feasibility of each alternative and in the event the project is authorized, to provide a base design leading to the development of the construction plans and specifications.

2.0 STUDY AREA

The Va Shly'ay Akimel Salt River Restoration project is located in the Salt River Pima-Maricopa Indian Community adjacent to the City of Mesa in Maricopa County, Arizona, 18 miles east of the City of Phoenix. The study area is approximately 14miles long extending from immediately downstream of the Granite Reef Dam to the Pima Freeway (US101). The study area averages 1,500 feet wide, and encompasses approximately 5,633 acres.

3.0 DESIGN CRITERIA

3.1 Structural Requirements

The structural materials required for grade control structural and wetland features involve concrete, back fill gravel, riprap, wetland clay material, and coarser gravel.

The structural requirements for the bank stabilization and concrete spillway include static and dynamic stability, refer to Geotechnical Appendix for details.

3.2 Hydrology and Hydraulic Requirements

Hydrology and hydraulic design criteria are discussed in their respective appendices. The Hydrology Appendix provides the design discharges for the existing drainage structures that discharge into the study reaches. Evaluations of the hydraulic conditions of the low flow channel and drainage areas are discussed in the Hydraulic Appendix.

3.3 Geotechnical Requirements

Geotechnical analysis examined low flow channel stability based on both side slopes of 1V:3H and 5 feet channel depth. Borrow material from the

streambed may or may not be used for the fill. Refer to Geotechnical Appendix for commercial source of borrow material.

3.4 Environmental Considerations

The project area includes approximately 14 miles of river channel and encompasses approximately 5,633 acres of over bank areas. Existing vegetation includes Cottonwood/Willow, Mesquite and Sonoran Desert Scrub Shrub. Refer to Environmental Appendix for with project environmental considerations.

3.5 Dumped Materials

There are several possible opportunity uses for the excavated material from construction of the low flow channel and reshaping the Salt River riverbed. The excavated material is considered to be valuable as a mineral resource for sand, gravel and aggregate materials. The possible uses include backfilling of existing gravel pits adjacent to the river, and reshaping the riverbed.

4.0 DESIGN FEATURES

Table D-1 shows the design features vs. Alternatives.

4.1 Low Flow Channel

The low flow channel located in the middle of Reach 2 has a length of approximately 4000 feet with bottom width of 300 feet, side slopes of 1V to 3H, and a depth of 5 feet. A typical cross section of the low flow channel is shown in Plate D-1. The location of the low flow channel is shown in Plate D-7.

4.2 Reshaping the Salt River riverbed

Reshaping the Salt River riverbed is required in Reaches 1,2, 4, 5 and 6 with a total cutting volume of approximately 1,320,500 cubic yards, and filling volume of approximately 751,800 cubic yards. The locations of the riverbed required reshaping are shown in Plates D-8 and D-9. To minimize the cost of reshaping the quarry sites, the recommended configuration of the "left shaped" existing quarry sites should have a minimum side slopes of 3H: 1V with a more preferable side slopes of 5H: 1V. A terracing effect is recommended for the quarry site where the slope has a vertical drop of approximately 15–20 feet then terrace for a minimum horizontal distance of approximately 30-40 feet. This pattern should then continue toward the riverbed.

4.3 Bank Stabilization

Soil cement bank stabilization is needed on the south bank in reach 6 of the Salt River. Cross section of eight feet wide and approximately 20 feet deep of soil cement is shown in Plate D-3. The location of the bank stabilization is shown in Plate D-10.

4.4 Wetland

New Wetlands are restored in the reaches of 1, 2, 4, 5 and 6 with a total area of approximately 200 acres. The locations of new wetlands are shown in Plates D-6, D-7, D-8, and D-9. Typical cross section of restored new wetland is shown in plate D-5.

4.5 Control Invasive Vegetation

Control invasive vegetation is required in the reaches of 1, 8 and 9 with a total area of approximately 150 acres. The locations will be defined in the next phase study.

4.6 Planting

Planting includes approximately 883 acres of Cottonwood/Willow, 380 acres of Mesquite, and 24 acres of Sonoran Desert Scrub Shrub. The locations of plantings are shown in Plates D-6, D-7, D-8, D-9, D-10, and D-11.

4.7 Water Well

To support the planting areas of 5.1, 5.2 and 6.1, a water well with annual capacity of 1,800 ac-ft is added in reach 6 with a design depth of approximately 150 feet deep. The yield of the well has an average flow rate of 5,000 gallons per minute. The location of the water well is shown in Plate D-9.

4.8 Grade Control Structure

A grade control structure is needed to protect the project features. It provides incidental benefit to the Gilbert Road Bridge. The concrete grade control structure has a dimension of 30' in depth, 8' in width, and 3,500' in length. On the upstream face of the structure, the invert is aligned with the top of the grade control structure. On the downstream side of the

structure, the grade control structure has a toe down of 15' and a grouted riprap toe protection of 20' in width, 6' in thickness, and 3,500' in length. A typical cross section is shown in plate D-4. The location of the grade control structure is shown in plate D-9.

4.9 Water Distribution System

The water distribution system consists of 1) approximately 40,600 feet of 12" diameter buried up to 3 feet deep PVC pipeline, 2) a 1,500 gallons per minute pump station at Alma School road and another 1,500 gallons per minute pump station at Country Club road, and 3) a 1,700 feet long bridge crossing at Country Club road and another 1,700 feet long bridge crossing at Gilbert road. The locations of pump stations are shown in plate D-7. Backup pump will be provided at both pump stations. The locations of the distribution pipeline are shown in plates D-7, D-8, D-9, and D-10.

4.10 Planting Irrigation System

Drip irrigation system is used for planting areas in reaches 1, 2, 3, 4, 5, and 6 during the first three years of the project life. From the fourth year on, surface braided irrigation system will be used to sustain the vegetated areas. Same pipeline arrangements are used for both the drip irrigation system and the surface braided irrigation system. Refer to the surface braided irrigation network diagram in the main report for the pipeline arrangement. Water will be distributed to the vegetated areas through the distribution channel network.

4.11 Diversion Structures

To divert surface water from the Salt River Pima Maricopa Indian Community (SRPMIC) to the project areas, T-junction diversion structures are required at nine locations to divert from the triangular irrigation channel with 4' top width and 2' deep to 12" diameter buried PVC pipeline. The diversion structures are shown in Plates D-7, D-8, D-9, and D-10.

5.0 Constructability

5.1 Construction Materials

The construction materials required for the design features described above include soil and gravel for structural fill, soil for soil cement, cement, water, concrete, clay, PVC pipe, pumps and specified plants. All of these materials are available locally. Plants can be purchased locally or

can be grown locally from native seed sources in advance of up to 2 years to develop healthy rootstock.

5.2 Access Roads

Environmental corridors or recreational trails will be used as access roads for operation and maintenance purposes. Horse ramps will be used to connect from the access road to the low flow channel and river bottom for operation and maintenance purposes.

5.2 Borrow Sites

Construction materials are most cost effectively available from two local borrow sites. Refer to section 10 of Geotechnical Appendix for borrow sites locations and details.

6.0 Utility Relocation

No utility relocation has been identified in this study. Any possible utility relocation will be defined in the PED phase. Local sponsor will be responsible for constructing the utility relocation.

7.0 Construction Time of the Recommended Plan

Construction time of the recommended plan is being estimated to be approximately three years.

8.0 Operation and Maintenance Requirements

8.1 Structures

Operational inspections for structural cracking and functional capability are made periodically, with at least one official annual inspection, and as needed during flood season. Inspections should include unwanted wild plants that if allowed to grow may exacerbate a structural crack. These plants are controlled by cutting or spray.

8.2 Plants

Replacement for plants will be required due to occasional flooding events and other natural causes. To support the plantings over the life of the project, the water budget and estimated annual costs for the selected plan are included in the Cost Engineering Appendix.

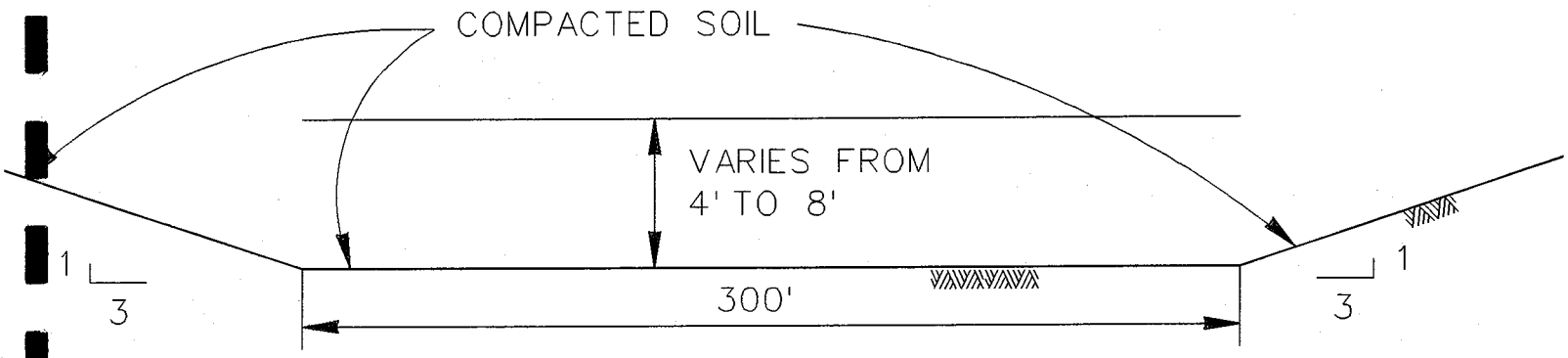
Va Shly, Maricopa County, Arizona
Environmental Restoration Study
Phase - F5
Design Features vs. Alternatives

Design Features	Alternatives														
	A1	B1	C1	D1	E1	F1	G1	H1	I1	J1	K1	L1	M1	N1	O1
1. Low Flow Channel Excavation						X			X						X
2. Reshaping the Salt River Riverbed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3. Bank Stablization		X	X	X	X	X	X	X	X	X		X	X		
4. Wetland Features			X	X	X	X	X	X	X	X	X	X	X	X	X
5. Control Invasive Vegetation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6. Planting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7. Concrete Spillways		X	X	X		X	X	X		X		X	X		
8. New Water Well		X		X	X	X	X	X		X	X	X	X	X	X
9. Grade Control Structure				X		X			X			X	X	X	X
10. Water Distribution System	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11. Road Crossings for the Pipeline System		X	X		X	X	X	X	X	X	X	X	X	X	X
12. Drip Irrigation System	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13. Braided Irrigation System															
14. SRPMIC T-Junction to Pipe Diversion Structures	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
15. Remediation to Vegetate 4.1 Landfill Areas		X	X	X	X	X	X	X	X	X	X		X		
16. Distribution Channel Network Excavation		X	X		X		X	X	X				X		
17. Debris Removal	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Design Features	A2	B2	C2	D2	E2	F2	G2	H2	I2	J2	K2	L2	M2	N2	O2
1. Low Flow Channel Excavation						X			X						X
2. Reshaping the Salt River Riverbed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3. Bank Stablization		X	X	X	X	X	X	X	X	X		X	X		
4. Wetland Features			X	X	X	X	X	X	X	X	X	X	X	X	X
5. Control Invasive Vegetation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6. Planting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7. Concrete Spillways		X	X	X		X	X	X		X		X	X		
8. New Water Well		X		X	X	X	X	X		X	X	X	X	X	X
9. Grade Control Structure				X		X			X			X	X	X	X
10. Water Distribution System		X	X	X	X	X	X	X	X	X	X	X	X	X	X
11. Road Crossings for the Pipeline System		X	X		X	X	X	X	X	X	X	X	X	X	X
12. Drip Irrigation System															
13. Braided Irrigation System	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14. SRPMIC T-Junction to Pipe Diversion Structures	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
15. Remediation to Vegetate 4.1 Landfill Areas		X	X	X	X	X	X	X	X	X	X		X		
16. Distribution Channel Network Excavation		X	X		X		X	X	X				X		
17. Debris Removal	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table D-1 Design Features vs. Alternatives

PLATES

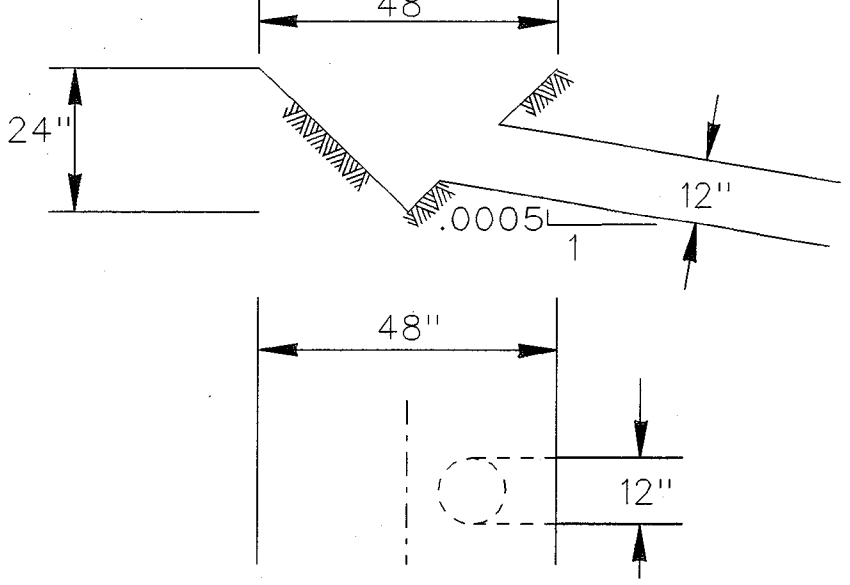


TYPICAL SALT RIVER LOW FLOW
CHANNEL CROSS SECTION

Va Shly 'Ay
SALT RIVER RESTORATION PROJECT

PLATE D-1

PLATE D-2



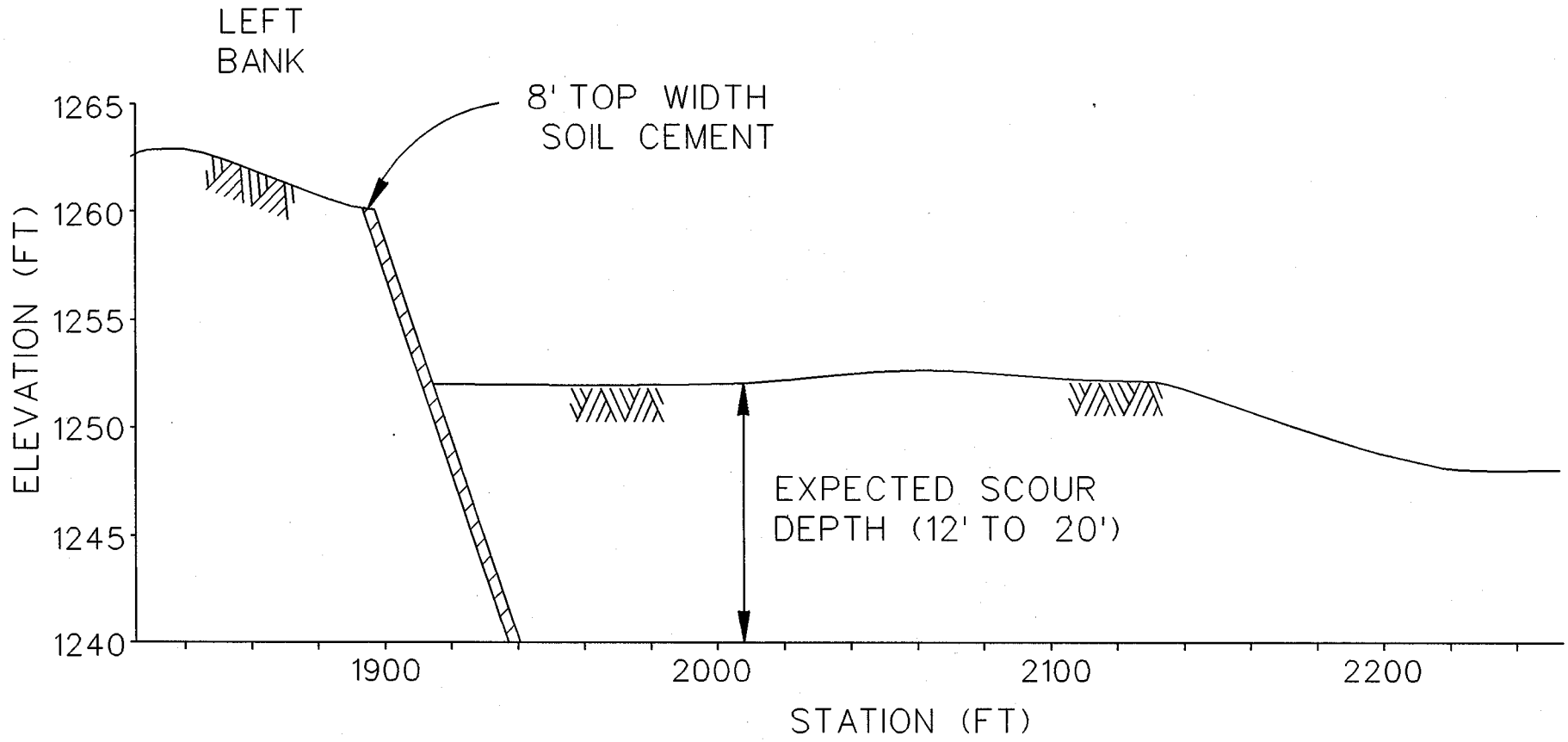
CROSS SECTION

TOP VIEW

T-JUNCTION DIVERSION STRUCTURE FROM THE TRIANGULAR IRRIGATION CHANNEL, 48" TOP WIDTH AND 24" DEEP TO 12" DIAMETER PVC DISTRIBUTION PIPE

ALTERNATIVES	WATER DISTRIBUTION SYSTEM PIPE LINE LENGTH - 12" PVC
A	8,965
B	23,526
C	31,865
D	33,378
E	38,491
F	55,176
G	52,568
H	52,568
I	52,568
J	49,976
K	49,976
L	29,846
M	49,976
N	40,617
O	40,617

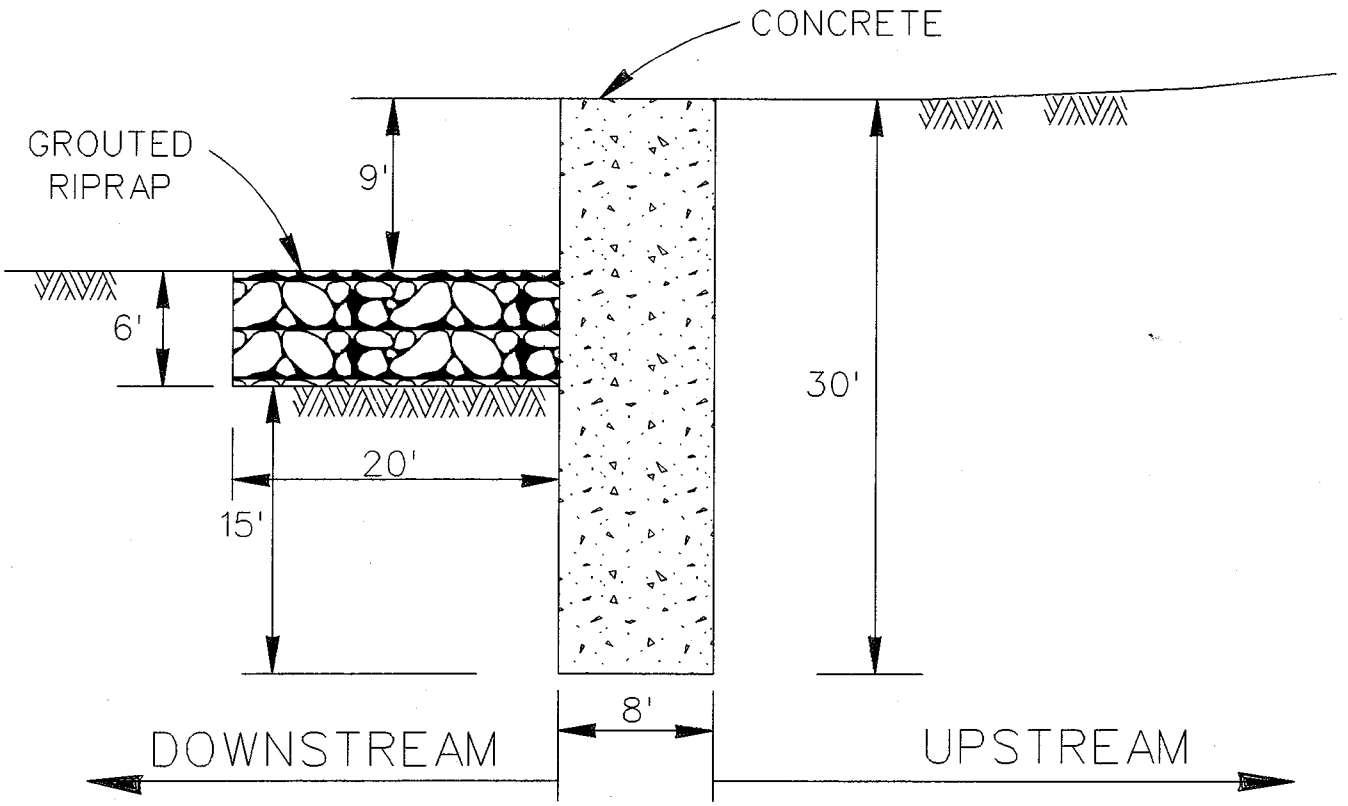
Va Shly 'Ay
SALT RIVER RESTORATION PROJECT



TYPICAL CROSS SECTION OF
SOIL CEMENT BANK STABILIZATION AT REACH 62

Va Shly 'Ay
SALT RIVER RESTORATION PROJECT

PLATE D-3

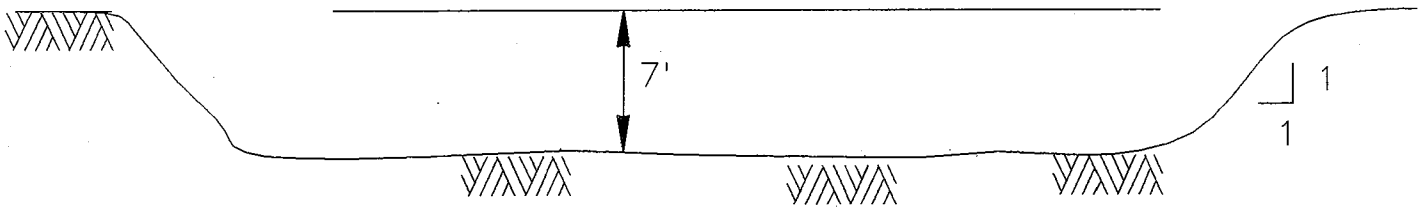


GRADE CONTROL STRUCTURE
CROSS SECTION

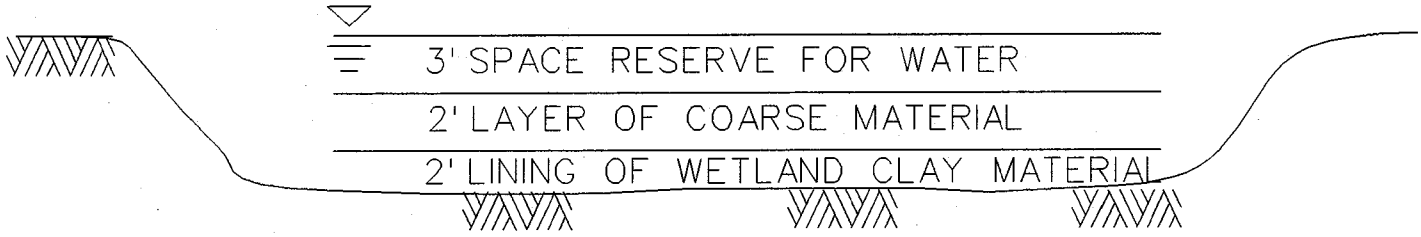
Va Shly 'Ay
SALT RIVER RESTORATION PROJECT

PLATE D-4

a. EXISTING GROUND PROFILE



b. REMOVE 7' TOP LAYER



c. RESTORE WETLAND CROSS SECTION

WETLAND FEATURES

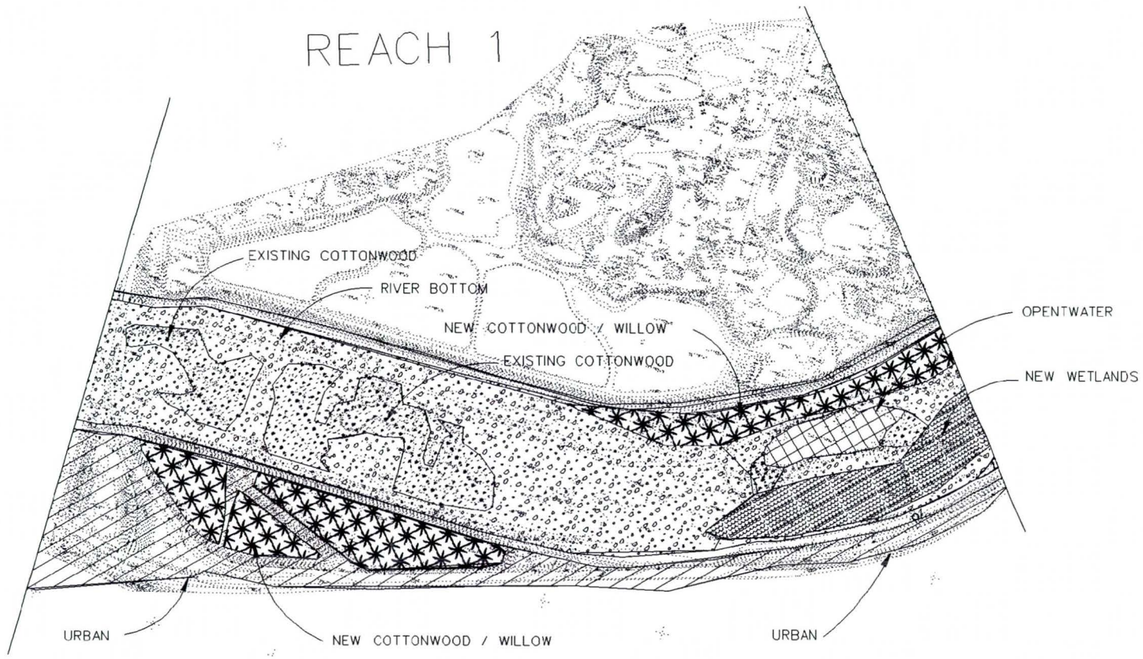
NOTES:

1. Side drains are part of irrigation system.
2. Location and design of side drains will be completed in PED Phase.

Va Shly 'Ay
SALT RIVER RESTORATION PROJECT

PLATE D-5

REACH 1



NORTHWEST WATER RECLAMATION PLANT

- BANK STABILIZATION (REACH 6)
- WELL LOCATION F4
- GRADE CONTROL STRUCTURE (REACH5)
- DISTRIBUTION PIPE F4
- REACH BOUNDRY
- NEW WETLANDS
- AGRICULTURE
- EXIST. COTTONWOOD/ WILLOW
- EXIST. DESERT
- EXIST. MESQUITE
- NEW COTTON WILLOW
- N MESQUITE
- NEW RIVER BOTTOM
- N SONORAN DESER.SCRUB SHRUB
- OPENTWATER
- PARKS
- RIVER BOTTOM
- SAND AND GRAVEL
- EXIST. SONORAN DESER. SCHRUB SHRUB
- URBAN

600 300 0 600 1200FT
SCALE: 1" = 600'

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

Va Shly Ah SALT RIVER PROJECT, MARICOPA COUNTY, ARIZONA

VA SHLY' AY AKIMEL SALT RIVER
RESTORATION PROJECT

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

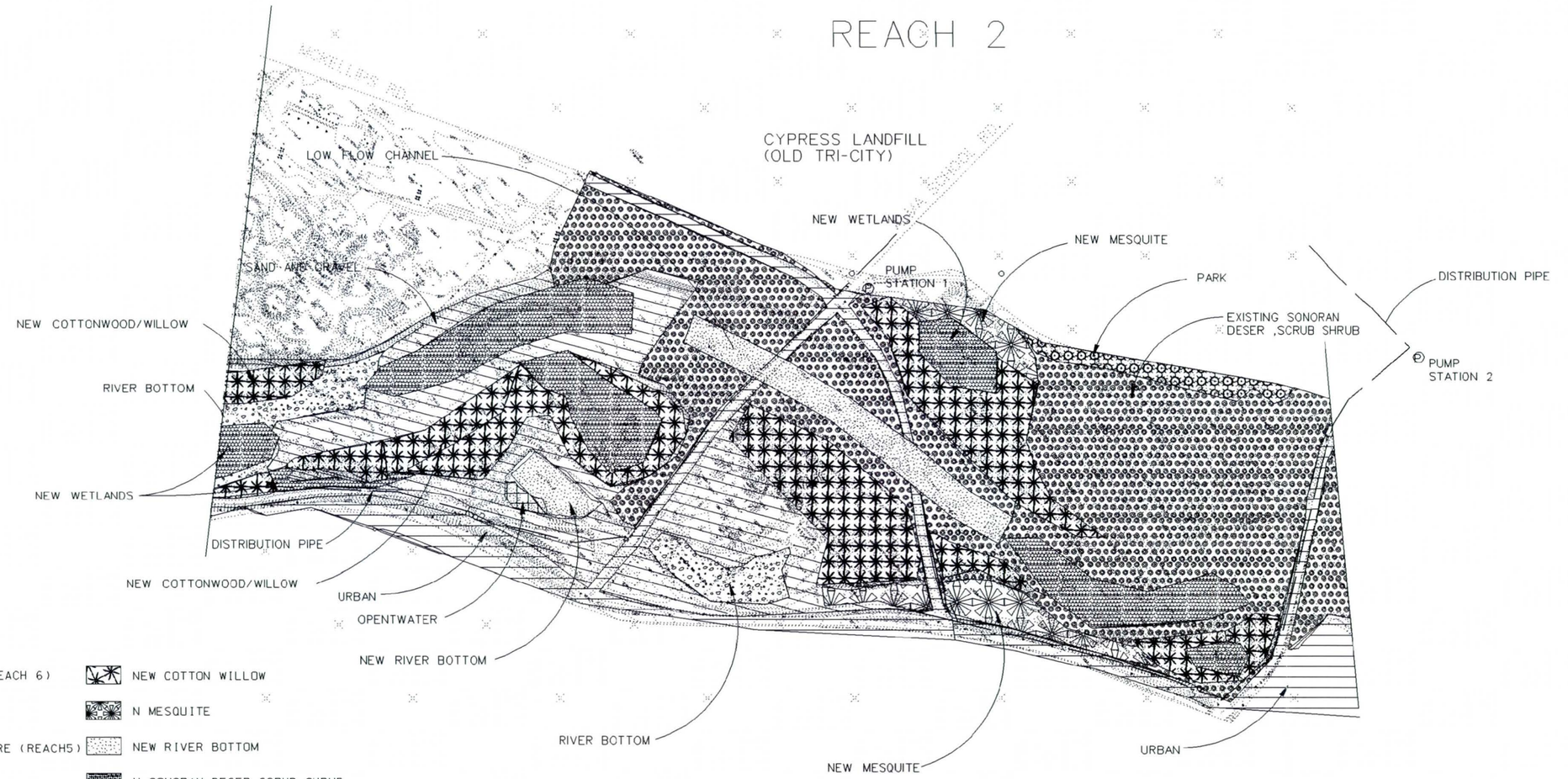
SUBMITTED BY:
THOMAS H. SAGE, P.E.
CHIEF, DESIGN BRANCH

DESIGNED BY:
DRAWN BY:
CHECKED BY:

DISTRICT FILE NO. XXX/XX
SPEC. NO. DACW09-XX-B-XXXX
FILE NAME:

SCALE:
PLATE D-6

REACH 2



- BANK STABILIZATION (REACH 6)
- WELL LOCATION F4
- GRADE CONTROL STRUCTURE (REACH5)
- DISTRIBUTION PIPE F4
- REACH BOUNDRY
- NEW WETLANDS
- AGRICULTURE
- EXIST. COTTONWOOD/ WILLOW
- EXIST. DESERT
- EXIST. MESQUITE
- NEW COTTON WILLOW
- N MESQUITE
- NEW RIVER BOTTOM
- N SONORAN DESER,SCRUB SHRUB
- OPENTWATER
- PARKS
- RIVER BOTTOM
- SAND AND GRAVEL
- EXIST. SONORAN DESER, SCHRUB SHRUB
- URBAN

600 300 0 600 1200FT
SCALE: 1"= 600'

REVISIONS			
SYMBOL	DESCRIPTIONS	DATE	APPROVAL

Va Shly Ah SALT RIVER PROJECT, MARICOPA COUNTY, ARIZONA

VA SHLY' AY AKIMEL SALT RIVER
RESTORATION PROJECT

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SUBMITTED BY:
THOMAS H. SAGE, P.E.
CHIEF, DESIGN BRANCH

DESIGNED BY:
DRAWN BY:
CHECKED BY:

FILE NAME:

SPEC. NO. DACW09-XX-B-XXXX

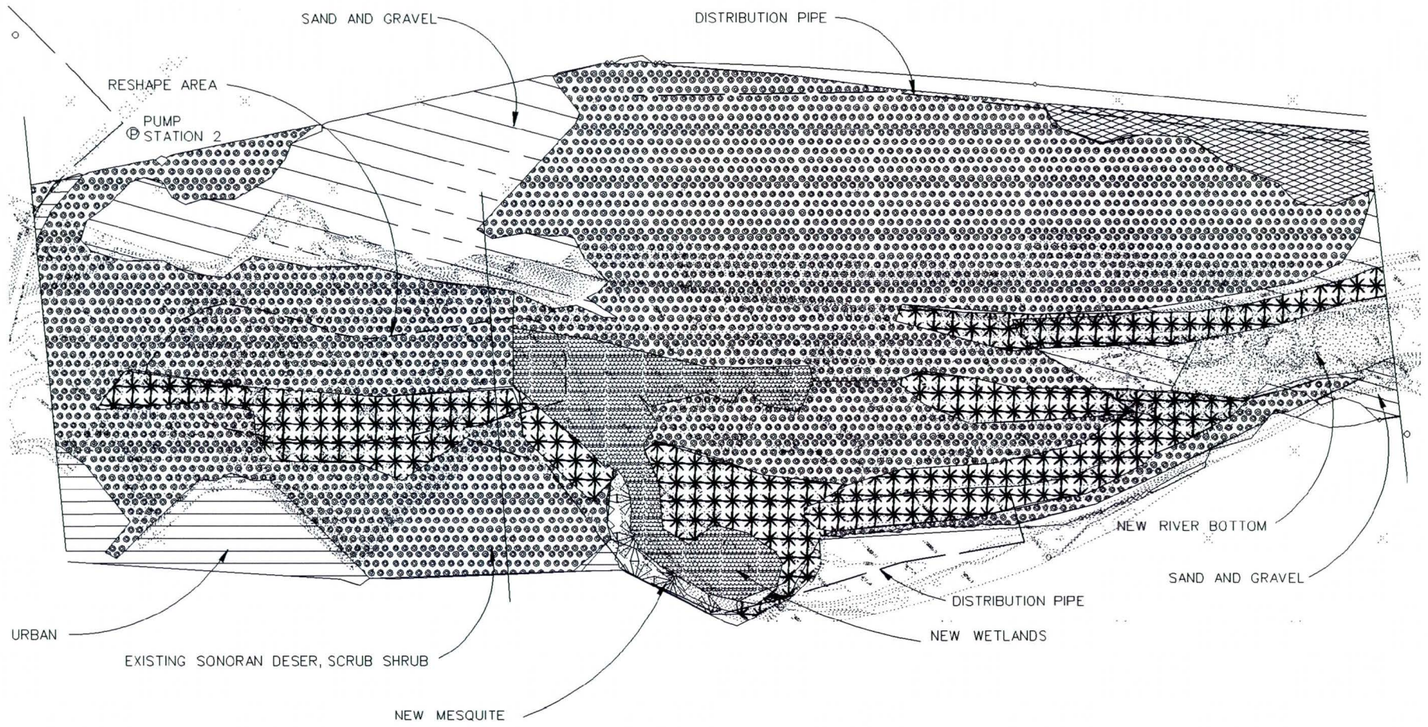
DISTRICT FILE NO. XXX/XX

SCALE:

PLATE D-7

REACH 3

REACH 4



- BANK STABILIZATION (REACH 6)
- WELL LOCATION F4
- GRADE CONTROL STRUCTURE (REACH5)
- DISTRIBUTION PIPE F4
- REACH BOUNDRY
- NEW WETLANDS
- AGRICULTURE
- EXIST. COTTONWOOD/ WILLOW
- EXIST. DESERT
- EXIST. MESQUITE
- NEW COTTON WILLOW
- N MESQUITE
- NEW RIVER BOTTOM
- N SONORAN DESER.SCRUB SHRUB
- OPENTWATER
- PARKS
- RIVER BOTTOM
- SAND AND GRAVEL
- EXIST. SONORAN DESER. SCHRUB SHRUB
- URBAN

600 300 0 600 1200FT
SCALE: 1"= 600'

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

Va Shly Ah SALT RIVER PROJECT, MARICOPA COUNTY, ARIZONA

VA SHLY'AY AKIMEL SALT RIVER
RESTORATION PROJECT

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SUBMITTED BY:
THOMAS H. SAGE, P.E.
CHIEF, DESIGN BRANCH

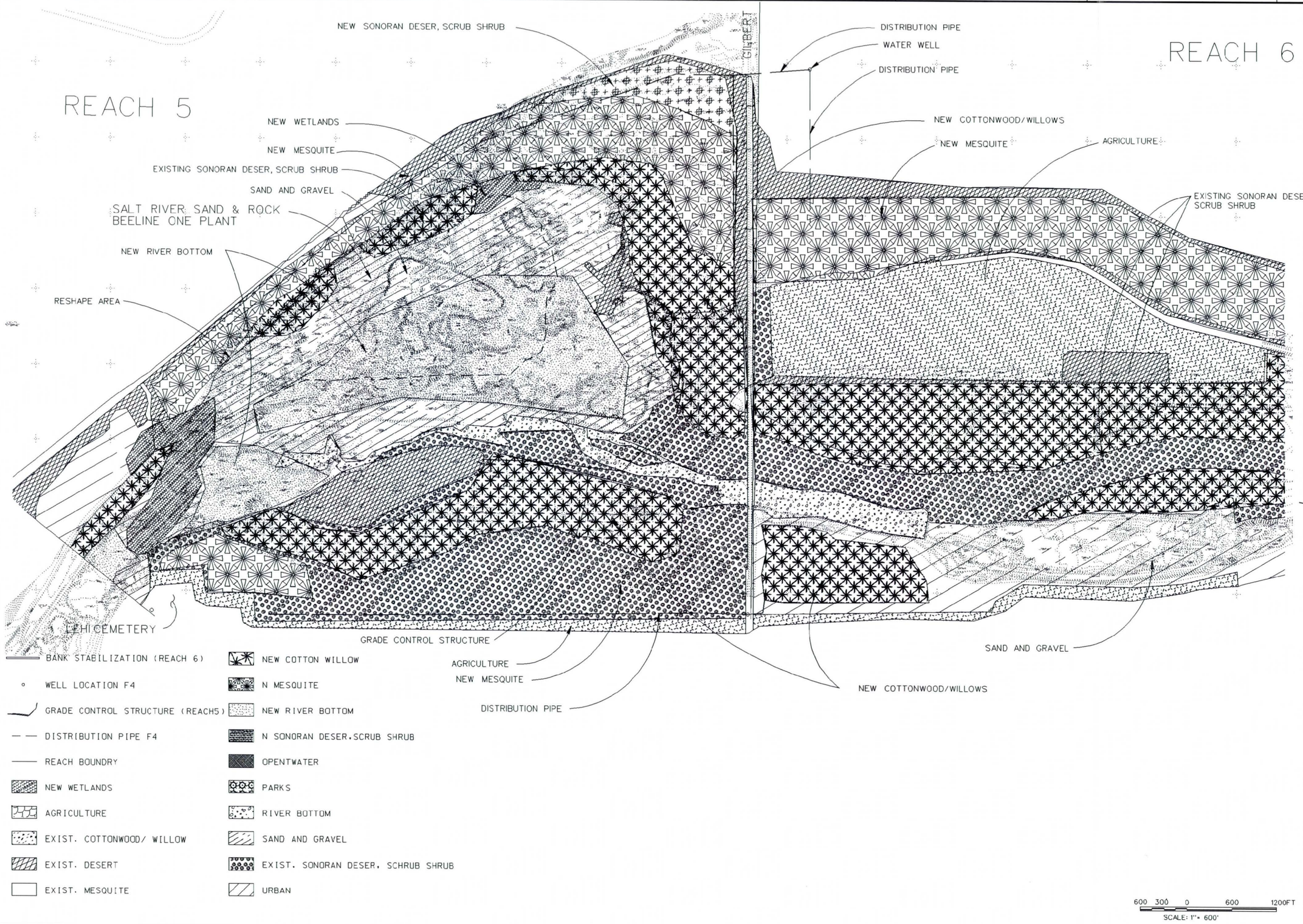
DESIGNED BY:
DRAWN BY:
CHECKED BY:

FILE NAME:

DISTRICT FILE NO. XXX/XX
SPEC. NO. DACW09-XX-B-XXXX

SCALE:

PLATE
D-8



- BANK STABILIZATION (REACH 6)
- WELL LOCATION F4
- GRADE CONTROL STRUCTURE (REACH5)
- DISTRIBUTION PIPE F4
- REACH BOUNDRY
- NEW WETLANDS
- AGRICULTURE
- EXIST. COTTONWOOD/ WILLOW
- EXIST. DESERT
- EXIST. MESQUITE
- NEW COTTON WILLOW
- N MESQUITE
- NEW RIVER BOTTOM
- N SONORAN DESER.SCRUB SHRUB
- OPENTWATER
- PARKS
- RIVER BOTTOM
- SAND AND GRAVEL
- EXIST. SONORAN DESER. SCHRUB SHRUB
- URBAN

600 300 0 600 1200FT
SCALE: 1"= 600'

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

Va Shly Ah SALT RIVER PROJECT, MARICOPA COUNTY, ARIZONA

VA SHLY' AY AKIMEL SALT RIVER RESTORATION PROJECT

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SUBMITTED BY:
THOMAS H. SAGE, P.E.
CHIEF, DESIGN BRANCH

DESIGNED BY:
DRAWN BY:
CHECKED BY:

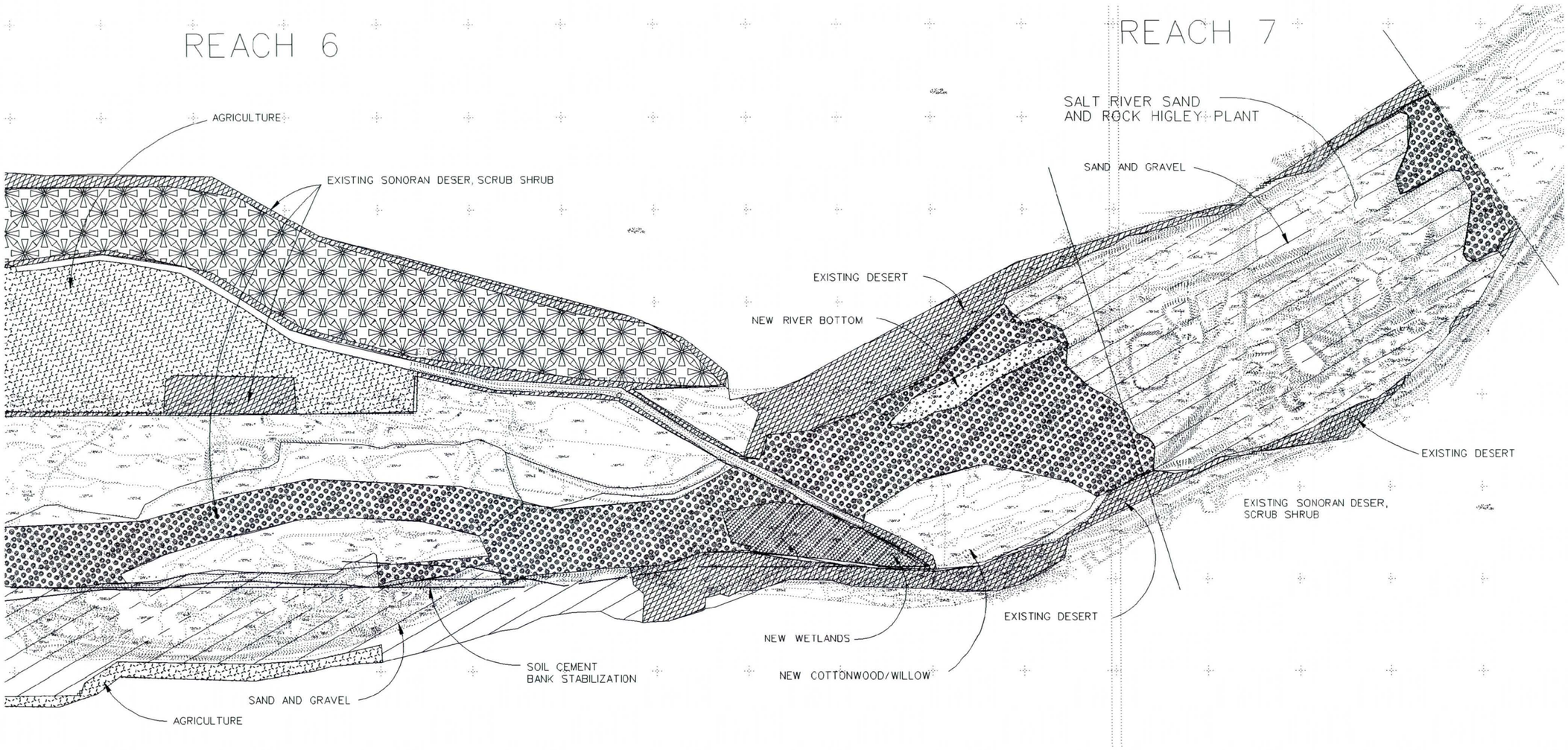
FILE NAME:

SPEC. NO. DACW09-XX-B-XXXX

DISTRICT FILE NO. XXX/XX

SCALE:

PLATE D-9



- BANK STABILIZATION (REACH 6)
- WELL LOCATION F4
- GRADE CONTROL STRUCTURE (REACH5)
- DISTRIBUTION PIPE F4
- REACH BOUNDRY
- NEW WETLANDS
- AGRICULTURE
- EXIST. COTTONWOOD/ WILLOW
- EXIST. DESERT
- EXIST. MESQUITE
- NEW COTTON WILLOW
- N MESQUITE
- NEW RIVER BOTTOM
- N SONORAN DESER,SCRUB SHRUB
- OPENTWATER
- PARKS
- RIVER BOTTOM
- SAND AND GRAVEL
- EXIST. SONORAN DESER, SCHRUB SHRUB
- URBAN

600 300 0 600 1200FT
SCALE: 1"= 600'

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

Va Shly Ah SALT RIVER PROJECT, MARICOPA COUNTY, ARIZONA

VA SHLY'AY AKIMEL SALT RIVER RESTORATION PROJECT

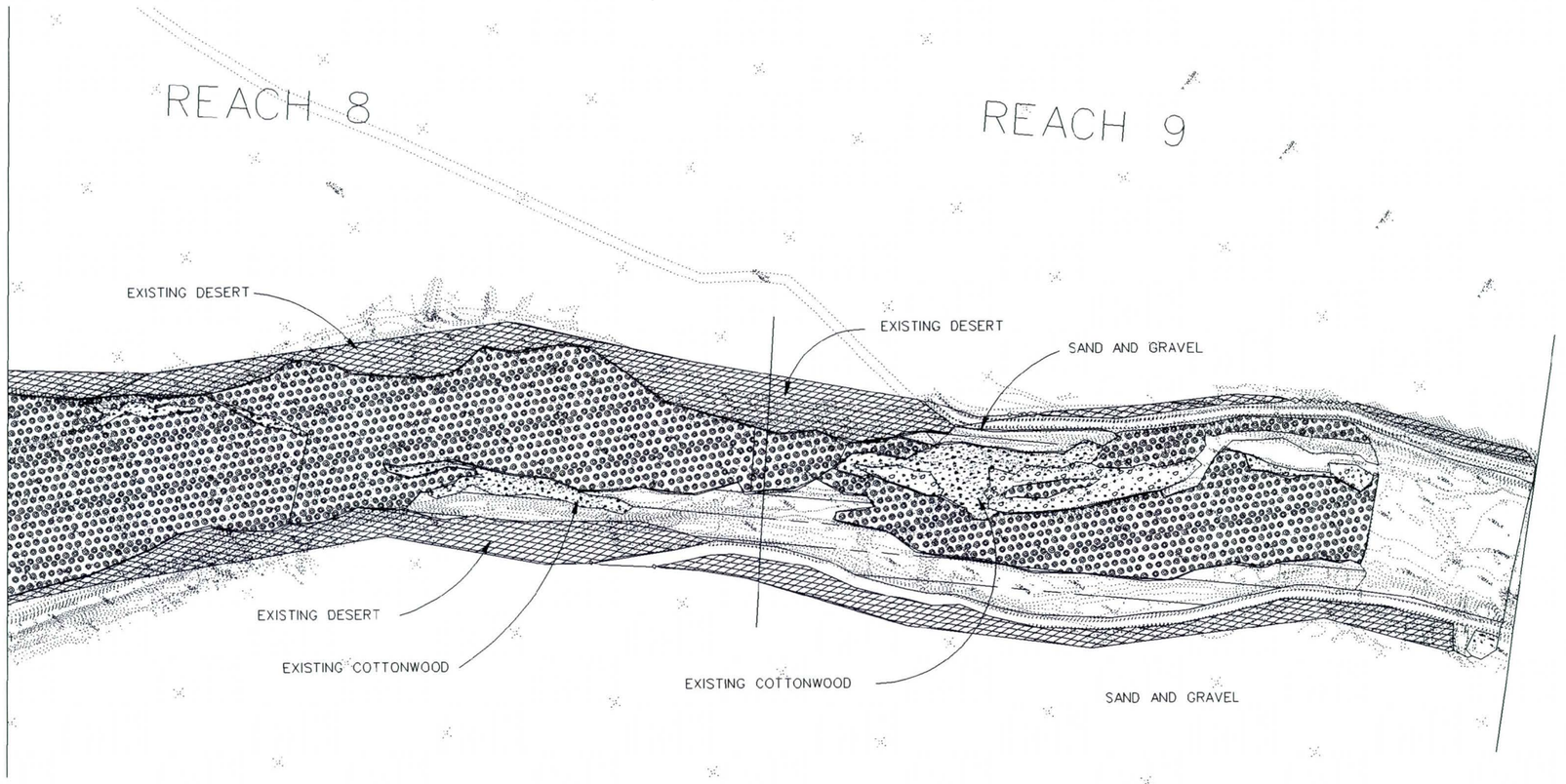
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SUBMITTED BY:
THOMAS H. SAGE, P.E.
CHIEF, DESIGN BRANCH

DESIGNED BY:
DRAWN BY:
CHECKED BY:

DISTRICT FILE NO. XXX/XX
SPEC. NO. DACW09-XX-R-XXXX
FILE NAME:

SCALE:
PLATE D-10



- BANK STABILIZATION (REACH 6)
- WELL LOCATION F4
- GRADE CONTROL STRUCTURE (REACH5)
- DISTRIBUTION PIPE F4
- REACH BOUNDRY
- NEW WETLANDS
- AGRICULTURE
- EXIST. COTTONWOOD/ WILLOW
- EXIST. DESERT
- EXIST. MESQUITE
- NEW COTTON WILLOW
- N MESQUITE
- NEW RIVER BOTTOM
- N SONORAN DESER, SCRUB SHRUB
- OPENTWATER
- PARKS
- RIVER BOTTOM
- SAND AND GRAVEL
- EXIST. SONORAN DESER, SCHRUB SHRUB
- URBAN

600 300 0 600 1200FT
SCALE: 1"= 600'

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

Va Shly Ah SALT RIVER PROJECT, MARICOPA COUNTY, ARIZONA

VA SHLY'AY AKIMEL SALT RIVER RESTORATION PROJECT

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SUBMITTED BY:
THOMAS H. SAGE, P.E.
CHIEF, DESIGN BRANCH

DESIGNED BY:
DRAWN BY:
CHECKED BY:

DISTRICT FILE NO. XXX/XX
SPEC. NO. DACW09-XX-B-XXXX
FILE NAME:

SCALE:
PLATE D-11

APPENDIX

G

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

COST

The purpose of this Basis of Cost Estimate is to document the sources of data and assumptions used in developing the study cost estimates for the alternatives formulated in the Va Shly'ay Akimel Feasibility Study.

Where possible, unit cost information was established from actual cost data provided by manufacturers. Additional historical data were derived from similar projects. The cost estimate quantity items were developed for each Alternative for the 50-year design discharge.

A. CONSTRUCTION COSTS

1. Excess Excavated Material: It is assumed that all excess material will be spread on site.

2. Backfill Material: In order to assure the suitability of backfill material, a processing fee will be applied.

3. Landfill Cap: Cost was obtained from historical data provided by Omaha District.

4. Contingency: A 25% contingency was included, in accordance with Corps of Engineers regulations for feasibility study construction cost estimates.

5. Planning, Engineering & Design (PED) and Engineering During Construction (EDC): The PED and EDC were 10% and 1%, respectively.

6. Supervision & Administration (S&A): A 6.5% S&A cost was taken on the construction cost. This percentage is required by the Corps of Engineers regulations.

B. OPERATION AND MAINTENANCE COSTS

The wetland areas are designed as close as possible to a natural riparian ecosystem and should be self-sustaining as long as sufficient amounts of water are provided. However, as in any manmade, controlled system, maintenance will be required.

1. Invasive Control: $59/acre as recommended by Parks & Recreation, Pima County.

2. Low Flow Channel:
   a. For 16,500-ft long channel
      i. Clear & Grub – Every 10 years.
         Total area = 125 acres
         Cost = $2,400 * 125 = $300,000 or $30,000/yr

      ii. Grading – Once during project life

Assume 1-ft layer
Total volume = 200,000 CY
Cost = $5 * 200,000 = $1,000,000 or $20,000/yr

iii. Total cost = $50,000/yr

b. For 4,000-ft long channel
   i. Clear & Grub – Every 10 years.
      Total area = 30 acres
      Cost = $2,400 * 30 = $72,000 or $7,200/yr

   ii. Grading – Once during project life
      Assume 1-ft layer
      Total volume = 49,000 CY
      Cost = $5 * 49,000 = $245,000 or $4,900/yr

   iii. Total cost = $12,100/yr

3. Wetland: Assume sediment will be removed every 10 years. Crew consists of 3 laborers ($160/day/ea) plus 3 equipment operators ($256/day/ea) plus 3 backhoe loaders ($160/day/ea). Total crew cost is $1,728/day. Allow 10 days or total cost is $17,280. Also, assuming $100,000 for hauling.

Total cost = $117,280/10 yr or $11,728/yr

4. New Water Well:
   a. Pump Operation – Assume $1,000/pump/month or $2,000/month.

   b. Pump Replacement – Assume lifespan is 25 yrs. Replacement cost is $80,000/ea or $160,000 for 2 pumps. Cost = $160,000/25 = $6,400/yr

   c. Total cost = $24,000 + $6,400 = $30,400/yr

5. Irrigation System Maintenance: Assuming crew needs to clean site once every 2 months. Use 2 laborers @ $160/day/ea plus $200/day for equipment and allow 3 days.
   Cost = $1,560/2 months * 12 months or $9,360/yr

6. Water: $75/acre-ft as recommended by SRPMIC.

7. Patrol/Biological Survey/Replanting:

   Patrol: Assume one day/week or 416hr/year @15/hr or $6,240/year

   Biological Survey:

- Qualitative Survey - Assume one biologist reviews site one day per month and writes brief report. Total cost = 16hr/month or 192hr/year at $30/hr or $5,760/year

- Quantitative Survey – Assume 2 biologists sample for 2 weeks, twice a year and write brief report. Total cost = 320hr/year at $30/hr or $9,600/year

Total cost = $6,240 + $5,760 + $9,600 = $21,600/yr

8. Landfill Area:
   a. Hydroseed – $4,356/acre.
      i. For 120-acre site, the total cost is $522,720 or $10,454/yr
      ii. For 130-acre site, the total cost is $566,280 or $11,326/yr
      iii. For 170-acre site, the total cost is $740,520 or $14,810/yr
      iv. For 180-acre site, the total cost is approx. $784,000 or $16,000/yr
      v. For 250-acre site, the total cost is approx. $1.1M or $22,000/yr
   b. Permanent Irrigation System – Assume drip irrigation system @ $16,700/acre.
      i. For 120-acre site, the total cost is $2,004,000 or $40,080/yr
      ii. For 130-acre site, the total cost is $2,171,000 or $43,420/yr
      iii. For 170-acre site, the total cost is $2,839,000 or $56,780/yr
      iv. For 180-acre site, the total cost is $3,006,000 or $60,120/yr
      v. For 250-acre site, the total cost is $4,175,000 or $83,500/yr
   c. Monitoring Wells (4 total, 4-in dia by 100-ft deep ea)
      i. Drilling @ $30/lf or $12,000
      ii. Casing @ $15/lf or $6,000
      iii. Sand packed $1,000/ea or $4,000
      iv. Plugs @ $100/ea or $400
      v. Vented caps @ $50/ea or $200
      vi. Protective enclosure @ $2,500/ea or $10,000

      Cost = $32,600 or $652/yr
   d. Daily Monitor – Assume 2 hrs/day @ $40/hr for an industrial hygiene technician. Cost = $80/day or $400/wk or $20,800/yr
   e. Sample Collection – Assume to take place every 2 months, 3 samples @ $1,000/ea or $3,000/2 mo or $18,000/yr

Total cost = $89,986/yr or $90,000/yr for 120-acre site
= $94,198/yr or $94,000/yr for 130-acre site
= $111,042/yr or $111,000/yr for 170-acre site
= $115,572/yr or $116,000/yr for 180-acre site
= $144,952/yr or $145,000/yr for 250-acre site

C. RECREATION COSTS

Recreation consists of 5.13 miles of trail with concrete curb, signs, parking lots, concrete benches, rest stops, gates, guard posts and mileage markers. In addition, cost sharing elements (restroom, habitat interpretive center, shade structure, parking lot, etc.) are included.

Va Shly' Akimel
Maricopa County, Arizona

Designed By: Corps of Engineers
Estimated By: Don D. Nguyen

Prepared By: Los Angeles District

Preparation Date: 08/23/04
Effective Date of Pricing: 08/23/04
Est Construction Time: 365 Days

Sales Tax: 0.00%

This report is not copyrighted, but the information
contained herein is For Official Use Only.

M C A C E S f o r W i n d o w s
Software Copyright (c) 1985-1997
by Building Systems Design, Inc.
Release 1.2

09. Construction
09.01. Low Flow Channel
09.01.001. Excavation & Stockpile

(02224 0010 Excavating, bulk, dozer)
(02224 0999 Open site)
(02224 5449 335 HP)

09.01. Low Flow Channel	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
L USR AA <02224 5455 > Stockpile material					0.02	0.62	1.08	0.00	0.00	1.70	
	233333	CY	CODTB15	150.00	5,437	144,830	251,650	0	0	396,479	1.70

(02232 0010 Excavate and load)
(02232 0011 Hydraulic excavator)
(02232 0114 1-1/2 CY)

L MIL AA <02232 0120 > Excavate & load, hydr excavator, 1.5 CY, medium matl					0.02	0.66	0.65	0.00	0.00	1.31	
	233333	CY	CODEB12B	90.00	5,180	154,490	152,226	0	0	306,716	1.31
TOTAL Excavation & Stockpile	233333	CY			10,617	299,320	403,876	0	0	703,196	3.01

09.01. Low Flow Channel	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.01.002. Spread Excess Mat'l on Site											
(02214 0000 Excavation/Backfill/Compaction)											
(02220 0010 Compaction)											
(02220 5799 Steel wheel tandem roller)											
AF AA <02220 5800 > Compaction, steel wheel tandem roller, 5 ton	233333	CY	COFCB10E	212.50	0.01 1,657	0.20 46,387	0.22 52,360	0.00 0	0.00 0	0.42 98,747	0.42
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L CIV AA <02224 5455 > Spread material	233333	CY	CODTB10M	150.00	0.01 2,333	0.28 65,730	0.66 155,003	0.00 0	0.00 0	0.95 220,733	0.95
TOTAL Spread Excess Mat'l on Site	233333	CY			3,990	112,117	207,363	0	0	319,480	1.37
TOTAL Low Flow Channel					14,607	411,436	611,239	0	0	1,022,675	

09.02. Reshaping Salt River Riverbed	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.02. Reshaping Salt River Riverbed											
09.02.001. Cut & Stockpile											
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L USR AA <02224 5455 > Stockpile material					0.02	0.62	1.08	0.00	0.00	1.70	
	1320489	CY	CODTB15	150.00	30,767	819,628	1424147	0	0	2,243,775	1.70
(02232 0010 Excavate and load)											
(02232 0011 Hydraulic excavator)											
(02232 0114 1-1/2 CY)											
L MIL AA <02232 0120 > Excavate & load, hydr excavator, 1.5 CY, medium matl	1320489	CY	CODEB12B	90.00	0.02 29,315	0.66 874,296	0.65 861,487	0.00 0	0.00 0	1.31 1,735,783	1.31
TOTAL Cut & Stockpile	1320489	CY			60,082	1693923	2285634	0	0	3,979,558	3.01

09.02. Reshaping Salt River Riverbed	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.02.002. Fill											
USR AA < > Processing of excess excav. matl	751803	CY		0.00	0.00 0	0.00 0	0.00 0	0.00 0	1.25 939,754	1.25 939,754	1.25
(02214 0000 Excavation/Backfill/Compaction) (02215 0009 Backfill) (02215 1199 Dozer or front end loader)											
USR AA <02215 2500 > Waste, backfill, excess excavated on-site material	751803	CY	CODTB10M	150.00	0.01 7,518	0.28 211,783	0.66 499,423	0.00 0	0.00 0	0.95 711,206	0.95
(02214 0000 Excavation/Backfill/Compaction) (02220 0010 Compaction) (02220 5899 Self propelled roller)											
MIL AA <02220 5900 > Compaction of backfill, structural, SP roller, 6" lift	751803	CY	COFCB10F	117.50	0.01 9,623	0.36 270,348	0.40 297,714	0.00 0	0.00 0	0.76 568,062	0.76
(02220 0010 Compaction) (02220 8999 Water)											
M MIL AA <02220 9030 > Compaction, water, wagon, 6000 gal, 3 mile haul	751803	CY	COFWB59	250.00	0.00 3,007	0.10 76,458	0.22 168,554	0.20 150,361	0.00 0	0.53 395,373	0.53
TOTAL Fill	751803	CY			20,148	558,590	965,691	150,361	939,754	2,614,395	3.48

09.02. Reshaping Salt River Riverbed	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.02.003. Spread Excess Mat'l on Site											
(02214 0000 Excavation/Backfill/Compaction)											
(02220 0010 Compaction)											
(02220 5799 Steel wheel tandem roller)											
AF AA <02220 5800 > Compaction, steel wheel tandem roller, 5 ton	568686	CY	COFCB10E	212.50	0.01 4,038	0.20 113,055	0.22 127,613	0.00 0	0.00 0	0.42 240,668	0.42
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L CIV AA <02224 5455 > Spread material	568686	CY	CODTB10M	150.00	0.01 5,687	0.28 160,199	0.66 377,778	0.00 0	0.00 0	0.95 537,977	0.95
TOTAL Spread Excess Mat'l on Site	568686	CY			9,725	273,254	505,391	0	0	778,645	1.37

09.02. Reshaping Salt River Riverbed	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.02.004. Vegetation Grading											
(02214 0000 Excavation/Backfill/Compaction) (02215 0009 Backfill) (02215 1199 Dozer or front end loader)											
USR AA <02215 2500 > Waste, backfill, excess					0.01	0.28	0.66	0.00	0.00	0.95	
excavated on-site material	2186969	CY	CODTB10M	150.00	21,870	616,069	1452804	0	0	2,068,873	0.95
(02214 0000 Excavation/Backfill/Compaction) (02220 0010 Compaction) (02220 5899 Self propelled roller)											
MIL AA <02220 5900 > Compaction of backfill,					0.01	0.36	0.40	0.00	0.00	0.76	
structural, SP roller, 6" lift	2186969	CY	COFCB10F	117.50	27,993	786,434	866,040	0	0	1,652,474	0.76
(02220 0010 Compaction) (02220 8999 Water)											
M MIL AA <02220 9030 > Compaction, water, wagon, 6000					0.00	0.10	0.22	0.20	0.00	0.53	
gal, 3 mile haul	2186969	CY	COFWB59	250.00	8,748	222,415	490,318	437,394	0	1,150,127	0.53
(02232 0010 Excavate and load) (02232 0011 Hydraulic excavator) (02232 0114 1-1/2 CY)											
L MIL AA <02232 0120 > Excavate & load, hydr excavator,					0.02	0.66	0.65	0.00	0.00	1.31	
1.5 CY, medium matl	2186969	CY	CODEB12B	90.00	48,551	1447992	1426779	0	0	2,874,771	1.31
TOTAL Vegetation Grading	2186969	CY			107,161	3072910	4235940	437,394	0	7,746,244	3.54
TOTAL Reshaping Salt River Riverbed					197,117	5598677	7992657	587,754	939,754	15,118,842	

09.04. Wetland Features	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.04. Wetland Features											
09.04.001. Excavation & Stockpile, 7' Layer											
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L USR AA <02224 5455 > Stockpile material					0.02	0.62	1.08	0.00	0.00	1.70	
	1689960	CY	CODTB15	150.00	39,376	1048958	1822622	0	0	2,871,580	1.70
(02232 0010 Excavate and load)											
(02232 0011 Hydraulic excavator)											
(02232 0114 1-1/2 CY)											
L MIL AA <02232 0120 > Excavate & load, hydr excavator,					0.02	0.66	0.65	0.00	0.00	1.31	
1.5 CY, medium matl	1689960	CY	CODEB12B	90.00	37,517	1118923	1102530	0	0	2,221,452	1.31
TOTAL Excavation & Stockpile, 7' Layer	1689960	CY			76,893	2167881	2925152	0	0	5,093,032	3.01

09.04. Wetland Features	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.04.002. 2' Lining of Wetland Clay Mat'l											
(02262 0000 Slope/Erosion Control)											
(02266 0009 Erosion control)											
(02266 1299 Soil cement)											
B MIL AA <02266 1300 > Clay Material					0.30	7.94	5.19	5.00	0.00	18.13	
	422490	CY	COFCB70A	20.00	126,747	3353641	2193399	2112450	0	7,659,490	18.13
TOTAL 2' Lining of Wetland Clay Mat'l	422490	CY			126,747	3353641	2193399	2112450	0	7,659,490	18.13

09.04. Wetland Features	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.04.003. 2' Layer of Coarser Mat'l on Top											
(02262 0000 Slope/Erosion Control)											
(02266 0009 Erosion control)											
(02266 1299 Soil cement)											
B MIL AA <02266 1300 > Coarser Material					0.02	0.53	0.35	6.50	0.00	7.38	
	422490	CY	COFCB70A	300.00	8,450	223,582	146,224	2746185	0	3,115,990	7.38
TOTAL 2' Layer of Coarser Mat'l on Top	422490	CY			8,450	223,582	146,224	2746185	0	3,115,990	7.38

09.04. Wetland Features	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.04.004. Spread Excess Mat'l on Site											
(02214 0000 Excavation/Backfill/Compaction)											
(02220 0010 Compaction)											
(02220 5799 Steel wheel tandem roller)											
AF AA <02220 5800 > Compaction, steel wheel tandem roller, 5 ton	1689960	CY	COFCB10E	212.50	0.01 11,999	0.20 335,964	0.22 379,227	0.00 0	0.00 0	0.42 715,191	0.42
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L CIV AA <02224 5455 > Spread material	1689960	CY	CODTB10M	150.00	0.01 16,900	0.28 476,062	0.66 1122640	0.00 0	0.00 0	0.95 1,598,702	0.95
TOTAL Spread Excess Mat'l on Site	1689960	CY			28,898	812,026	1501867	0	0	2,313,893	1.37
TOTAL Wetland Features					240,988	6557129	6766642	4858635	0	18,182,406	

09.05. Planting	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.05. Planting											
09.05.001. Cottonwood/Willow											
84 poles/acre											
(02946 0000 Trees/Plants/Ground Cover)											
(02950 0010 Ground cover and vines, planting only, no prep)											
(02950 0559 Liriope)											
					0.15	3.22	0.92	10.00	0.00	14.14	
M USR AA <02950 0560 > CW Poles	74172	EA	ULABA2	20.00	11,126	238,782	68,594	741,720	0	1,049,096	14.14
TOTAL Cottonwood/Willow	74172	EA			11,126	238,782	68,594	741,720	0	1,049,096	14.14

09.05. Planting	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.05.002. Mesquite 85 poles/acre											
(02946 0000 Trees/Plants/Ground Cover) (02950 0010 Ground cover and vines, planting only, no prep) (02950 0559 Liriope)											
M USR AA <02950 0560 > Mesquite Poles					0.15	3.22	0.92	10.00	0.00	14.14	
	24700	EA	ULABA2	20.00	3,705	79,517	22,843	247,000	0	349,359	14.14
TOTAL Mesquite	24700	EA			3,705	79,517	22,843	247,000	0	349,359	14.14

09.05. Planting	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.05.003. Sonoran Desert 127 poles/acre											
(02946 0000 Trees/Plants/Ground Cover) (02950 0010 Ground cover and vines, planting only, no prep) (02950 0559 Liriope)											
M USR AA <02950 0560 > Sonoran Desert Poles					0.15	3.22	0.92	10.00	0.00	14.14	
	3048.00	EA	ULABA2	20.00	457	9,812	2,819	30,480	0	43,111	14.14
TOTAL Sonoran Desert	3048.00	EA			457	9,812	2,819	30,480	0	43,111	14.14

09.05. Planting	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.05.004. Wetland Vegetation											
(02946 0000 Trees/Plants/Ground Cover)											
(02951 0010 Mulch)											
(02951 0759 Pine straw)											
B USR AA <02951 0760 > 2" Pot at 2' OC					0.02	0.41	0.00	0.32	0.00	0.73	
	2178000	EA	ALABCLAB2	100.00	43,560	900,385	0	696,960	0	1,597,345	0.73
TOTAL Wetland Vegetation	200.00	ACR			43,560	900,385	0	696,960	0	1,597,345	7986.73
TOTAL Planting					58,848	1228496	94,256	1716160	0	3,038,912	

09.07. New Water Well		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.07. New Water Well												
(02670 0000 Water Wells)												
(02674 0010 Wells)												
(02674 0299 Drilled in rock)												
CIV AA <02674 0340 >	Well, domestic water, drilled in rock, 24" dia	150.00	LF	ULABB23A	0.48	6.32 947	156.33 23,449	235.76 35,364	0.00 0	0.00 0	392.08 58,813	392.08
(02674 0010 Wells)												
(02674 8109 Well screen assembly)												
(02674 8109 Stainless steel)												
M CIV AA <02674 8230 >	Well, domestic water, screen assembly, sst, 24" dia	150.00	LF	ULABB23A	2.98	1.01 151	24.96 3,744	37.64 5,646	338.87 50,831	0.00 0	401.47 60,221	401.47
(02674 0010 Wells)												
(02674 8399 Artificial gravel pack)												
M CIV AA <02674 8440 >	Well, domestic water, 24" casing, 2" screen, artificial gravel pack	150.00	LF	ULABB23B	3.21	0.93 140	23.11 3,467	41.83 6,275	12.17 1,826	0.00 0	77.11 11,567	77.11
(02674 0010 Wells)												
(02674 8549 Pump test well)												
M CIV AA <02674 8550 >	Well, domestic water, pump test well	20.00	HR	ULABB23B	1.00	3.00 60	74.25 1,485	134.40 2,688	46.62 932	0.00 0	255.28 5,106	255.28
(15153 0000 Plastic Pipe)												
(15155 0010 Pipe plastic, no couplings and hangers)												
(15155 1839 PVC schedule 40)												
B USR AA <15155 1990 >	Pipe PVC sched 40 no coupling/hanger 12" dia	150.00	LF	MPLUPLUM2	11.00	0.18 27	7.84 1,176	0.00 0	13.00 1,950	0.00 0	20.84 3,126	20.84
(15200 0000 Plumbing Fixtures)												
(15284 0000 Pumps)												
(15298 0010 Pumps, well)												
B USR AA <15298 2060 >	Submersible well pump, 240 HP	2.00	EA	MPLUQ	0.10	44.00 88	1568.70 3,137	191.60 383	18000.00 36,000	0.00 0	19760.30 39,521	19760.30
TOTAL New Water Well						1,414	36,457	50,356	91,538	0	178,352	

09.08. Grade Control Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08. Grade Control Structure											
09.08.001. Concrete											
(02501 0000 Walks, Roads, Parking, Paving)											
(02512 0010 Fine grade)											
(02512 1099 For slab on grade)											
MIL AA <02512 1100 > Fine grade, for slab on grade, machine	4290.00	SY	COFGB11L	130.00	0.02 66	0.40 1,735	0.27 1,165	0.00 0	0.00 0	0.68 2,900	0.68
(03110 0000 Structural CIP Formwork, Accessories & Joints)											
(03170 0010 Forms in place, slab on grade)											
(03170 1169 Keyed joint form)											
M MIL AA <03170 1170 > Forms in place, SOG, 4 uses, wood, keyed joint form, 7" to 12" high	21000	LF	ACARC1	50.00	0.08 1,680	2.24 47,061	0.00 0	0.51 10,710	0.00 0	2.75 57,771	2.75
(03210 0000 Reinforcing Steel)											
(03217 0010 Reinforcing in place, A615 Gr 60)											
(03217 0599 Slab on grade)											
M MIL AA <03217 0600 > Reinforcing in place, slab on grade, #3 to #7	3111100	LB	SIWRRODM4	575.00	0.01 21,778	0.28 884,797	0.00 0	0.29 902,219	0.00 0	0.57 1,787,016	0.57
(03300 0000 Cast-In-Place Concrete)											
(03301 0000 Structural Concrete)											
(03326 0009 Concrete ready mix, matl only, placing see 03372)											
M RSM AA <03326 0400 > Concrete ready mix, regular weight, 5000 psi	31111	CY	N/A	0.00	0.00 0	0.00 0	0.00 0	67.65 2104659	0.00 0	67.65 2,104,659	67.65
(03301 0000 Structural Concrete)											
(03334 0009 Curing)											
M MIL AA <03334 0300 > Curing, sprayed membrane curing compound	385.00	CSF	ALABCLAB2	11.88	0.17 65	3.48 1,340	0.00 0	3.26 1,255	0.00 0	6.74 2,595	6.74
(03301 0000 Structural Concrete)											
(03372 0010 Placing concrete, see 03326 for material costs)											
(03372 4299 Slab on grade)											
MIL AA <03372 4700 > Placing conc, slab on grade, over 6" thick, w/crane & bucket	31111	CY	ULABC7	18.13	0.44 13,732	10.41 323,990	5.66 176,014	0.00 0	0.00 0	16.07 500,004	16.07
TOTAL Concrete	31111	CY			37,321	1258923	177,179	3018843	0	4,454,945	143.20

09.08. Grade Control Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08.002. Excavation & Stockpile, U/S											
(02224 0010 Excavating, bulk, dozer) (02224 0999 Open site) (02224 5449 335 HP)											
L USR AA <02224 5455 > Stockpile material					0.02	0.62	1.08	0.00	0.00	1.70	
	58331	CY	CODTB15	150.00	1,359	36,206	62,910	0	0	99,116	1.70
(02232 0010 Excavate and load) (02232 0011 Hydraulic excavator) (02232 0114 1-1/2 CY)											
L MIL AA <02232 0120 > Excavate & load, hydr excavator, 1.5 CY, medium matl					0.02	0.66	0.65	0.00	0.00	1.31	
	58331	CY	CODEB12B	90.00	1,295	38,621	38,055	0	0	76,676	1.31
TOTAL Excavation & Stockpile, U/S	58331	CY			2,654	74,827	100,965	0	0	175,792	3.01

09.08. Grade Control Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08.003. Backfill & Compaction, U/S											
USR AA < > Processing of excess excav. matl					0.00	0.00	0.00	0.00	1.25	1.25	
	58331	CY		0.00	0	0	0	0	72,914	72,914	1.25
(02214 0000 Excavation/Backfill/Compaction)											
(02215 0009 Backfill)											
(02215 1199 Dozer or front end loader)											
USR AA <02215 2500 > Waste, backfill, excess					0.01	0.28	0.66	0.00	0.00	0.95	
excavated on-site material	58331	CY	CODTB10M	150.00	583	16,432	38,749	0	0	55,181	0.95
(02214 0000 Excavation/Backfill/Compaction)											
(02220 0010 Compaction)											
(02220 8719 Air tamper)											
L MIL AA <02220 8900 > Compaction, structural/trench,					0.13	2.61	0.30	0.00	0.00	2.90	
by hand w/air tamp, 6" lift	58331	CY	ULABB9	40.00	7,291	152,168	17,254	0	0	169,422	2.90
(02220 0010 Compaction)											
(02220 8999 Water)											
M MIL AA <02220 9030 > Compaction, water, wagon, 6000					0.00	0.10	0.22	0.20	0.00	0.53	
gal, 3 mile haul	58331	CY	COFWB59	250.00	233	5,932	13,078	11,666	0	30,676	0.53
TOTAL Backfill & Compaction, U/S	58331	CY			8,108	174,532	69,081	11,666	72,914	328,194	5.63

09.08. Grade Control Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08.005. Excavation & Stockpile, D/S											
(02224 0010 Excavating, bulk, dozer) (02224 0999 Open site) (02224 5449 335 HP)											
L USR AA <02224 5455 > Stockpile material					0.02	0.62	1.08	0.00	0.00	1.70	
	8332.00	CY	CODTB15	150.00	194	5,172	8,986	0	0	14,158	1.70
(02232 0010 Excavate and load) (02232 0011 Hydraulic excavator) (02232 0114 1-1/2 CY)											
L MIL AA <02232 0120 > Excavate & load, hydr excavator, 1.5 CY, medium matl					0.02	0.66	0.65	0.00	0.00	1.31	
	8332.00	CY	CODEB12B	90.00	185	5,517	5,436	0	0	10,952	1.31
TOTAL Excavation & Stockpile, D/S	8332.00	CY			379	10,688	14,422	0	0	25,110	3.01

09.08. Grade Control Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08.006. Backfill & Compaction, D/S											
USR AA < > Processing of excess excav. matl					0.00	0.00	0.00	0.00	1.25	1.25	
	3000.00	CY		0.00	0	0	0	0	3,750	3,750	1.25
(02214 0000 Excavation/Backfill/Compaction)											
(02215 0009 Backfill)											
(02215 1199 Dozer or front end loader)											
USR AA <02215 2500 > Waste, backfill, excess					0.01	0.28	0.66	0.00	0.00	0.95	
excavated on-site material	3000.00	CY	CODTB10M	150.00	30	845	1,993	0	0	2,838	0.95
(02214 0000 Excavation/Backfill/Compaction)											
(02220 0010 Compaction)											
(02220 8719 Air tamper)											
L MIL AA <02220 8900 > Compaction, structural/trench,					0.13	2.61	0.30	0.00	0.00	2.90	
by hand w/air tamp, 6" lift	3000.00	CY	ULABB9	40.00	375	7,826	887	0	0	8,714	2.90
(02220 0010 Compaction)											
(02220 8999 Water)											
M MIL AA <02220 9030 > Compaction, water, wagon, 6000					0.00	0.10	0.22	0.20	0.00	0.53	
gal, 3 mile haul	3000.00	CY	COFWB59	250.00	12	305	673	600	0	1,578	0.53
TOTAL Backfill & Compaction, D/S	3000.00	CY			417	8,976	3,553	600	3,750	16,879	5.63

09.08. Grade Control Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08.007. Spread Excess Mat'l on Site, D/S											
(02214 0000 Excavation/Backfill/Compaction)											
(02220 0010 Compaction)											
(02220 5799 Steel wheel tandem roller)											
AF AA <02220 5800 > Compaction, steel wheel tandem roller, 5 ton					0.01	0.20	0.22	0.00	0.00	0.42	
	5332.00	CY	COFCB10E	212.50	38	1,060	1,197	0	0	2,257	0.42
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L CIV AA <02224 5455 > Spread material					0.01	0.28	0.66	0.00	0.00	0.95	
	5332.00	CY	CODTB10M	150.00	53	1,502	3,542	0	0	5,044	0.95
TOTAL Spread Excess Mat'l on Site, D/S	5332.00	CY			91	2,562	4,739	0	0	7,301	1.37

09.08. Grade Control Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08.008. Riprap, 15' Drop											
(02262 0000 Slope/Erosion Control)											
(02270 0010 Rip-rap)											
(02270 0099 Machine placed for slope protection)											
					0.26	7.69	5.26	24.97	0.00	37.91	
M RSM AA <02270 0100 > Rip-rap, random, machine placed for slope protection. Placed with clamshell.	8888.00	CY	UOEHB12G	7.75	2,294	68,336	46,717	221,933	0	336,987	37.91
TOTAL Riprap, 15' Drop	8888.00	CY			2,294	68,336	46,717	221,933	0	336,987	37.91
TOTAL Grade Control Structure					51,264	1598845	416,656	3253043	76,664	5,345,208	

09.09. Water Distribution System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.09. Water Distribution System											
09.09.001. 12" PVC Pipe											
(02214 0000 Excavation/Backfill/Compaction)											
(02215 0009 Backfill)											
(02215 1199 Dozer or front end loader)											
MIL AA <02215 1200 > Backfill, trench, dozer, no compaction, 60 HP	3000.00	CY	CODTB10L	53.13	0.03 85	0.80 2,386	0.52 1,555	0.00 0	0.00 0	1.31 3,941	1.31
(02214 0000 Excavation/Backfill/Compaction)											
(02220 0010 Compaction)											
(02220 6999 Walk behind, vibrating plate)											
MIL AA <02220 7000 > Compaction, struct/trench, 6" lifts, 2 passes18" wide, vib plate	3000.00	CY	ULABA1	25.00	0.04 120	0.83 2,480	0.12 365	0.00 0	0.00 0	0.95 2,846	0.95
(02220 0010 Compaction)											
(02220 8999 Water)											
M MIL AA <02220 9000 > Compaction, water, truck, 3000 gal, 3 mile haul	3000.00	CY	COKBB45	236.00	0.01 26	0.24 729	0.24 735	0.20 600	0.00 0	0.69 2,064	0.69
(02228 0010 Excavating, trench or continuous footing (BCY))											
(02228 0300 Excavate with hydraulic excavator)											
(02228 0300 1/2 CY)											
MIL AA <02228 0302 > Excavate trench, mdm soil, 4'-6' D, 1/2 CY excavator	3000.00	CY	CODEB12E	91.50	0.02 66	0.65 1,954	0.26 795	0.00 0	0.00 0	0.92 2,748	0.92
(15153 0000 Plastic Pipe)											
(15155 0010 Pipe plastic, no couplings and hangers)											
(15155 1839 PVC schedule 40)											
B USR AA <15155 1990 > Pipe PVC sched 40 no coupling/hanger 12" dia	40617	LF	MPLUPLUM2	11.00	0.18 7,384	7.84 318,303	0.00 0	13.00 528,021	0.00 0	20.84 846,324	20.84
TOTAL 12" PVC Pipe	40617	LF			7,680	325,852	3,449	528,621	0	857,922	21.12

09.09. Water Distribution System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.09.002. Pump Station at Alma School Rd											
USR AA < > Electrical work					0.00	0.00	0.00	0.00	500.00	500.00	
	1.00	LS		0.00	0	0	0	0	500	500	500.00
USR AA < > Housing					0.00	0.00	0.00	0.00	1000.00	1000.00	
	1.00	LS		0.00	0	0	0	0	1,000	1,000	1000.00
(15288 0010 Pumps, general utility) (15288 4000 Centrifugal, end suction, horizontal base mount,) (15288 4200 Horizontal split case, single stage)											
M MIL AA <15288 4210 > Pump, cntfgl,1.5"D, horiz mtd, horiz splt, sgl stg,2.5HP, 1500 GPM	1.00	EA	MPLUQ1	0.21	9.41	373.33	0.00	2192.39	0.00	2565.72	
					9	373	0	2,192	0	2,566	2565.72
TOTAL Pump Station at Alma School Rd	1.00	EA			9	373	0	2,192	1,500	4,066	4065.72

09.09. Water Distribution System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.09.003. Bridge Crossing											
(15153 0000 Plastic Pipe)											
(15155 0010 Pipe plastic, no couplings and hangers)											
(15155 1839 PVC schedule 40)											
B USR AA <15155 1990 > Pipe PVC sched 40 no					0.18	7.84	0.00	13.00	0.00	20.84	
coupling/hanger 12" dia	1700.00	LF	MPLUPLUM2	11.00	309	13,322	0	22,100	0	35,422	20.84
TOTAL Bridge Crossing	1700.00	LF			309	13,322	0	22,100	0	35,422	20.84

09.09. Water Distribution System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.09.004. Pump Station at Country Club Rd											
USR AA < > Electrical work					0.00	0.00	0.00	0.00	500.00	500.00	
	1.00	LS		0.00	0	0	0	0	500	500	500.00
USR AA < > Housing					0.00	0.00	0.00	0.00	700.00	700.00	
	1.00	LS		0.00	0	0	0	0	700	700	700.00
(15155 0010 Pipe plastic, no couplings and hangers) (15155 1839 PVC schedule 40) (15288 4200 Horizontal split case, single stage)											
B MIL AA <15288 4210 > Pump, cntfgl,1.5"D, horiz mtd, horiz splt, sgl stg,2HP, 700 GPM	1.00	EA	MPLUQ1	0.22	9.09	360.60	0.00	1005.00	0.00	1365.60	
					9	361	0	1,005	0	1,366	1365.60
TOTAL Pump Station at Country Club Rd	1.00	EA			9	361	0	1,005	1,200	2,566	2565.60

09.09. Water Distribution System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.09.005. Bridge Crossing											
(15153 0000 Plastic Pipe)											
(15155 0010 Pipe plastic, no couplings and hangers)											
(15155 1839 PVC schedule 40)											
B USR AA <15155 1990 > Pipe PVC sched 40 no coupling/hanger 12" dia	1700.00	LF	MPLUPLUM2	11.00	0.18 309	7.84 13,322	0.00 0	13.00 22,100	0.00 0	20.84 35,422	20.84
TOTAL Bridge Crossing	1700.00	LF			309	13,322	0	22,100	0	35,422	20.84
TOTAL Water Distribution System					8,317	353,231	3,449	576,018	2,700	935,398	

09.10. Road Crossing for Pipeline Syst	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.10. Road Crossing for Pipeline Syst											
09.10.001. Excavation											
(02054 0000 Selective Demolition)											
(02069 0009 Saw cutting)											
(02069 0009 Asphalt)											
M RSM AA <02069 0010 > Saw cutting, asphalt, up to 3" deep	620.00	LF	COELB89	131.25	0.02 9	0.41 253	0.18 111	0.25 155	0.00 0	0.84 519	0.84
(02228 0010 Excavating, trench or continuous footing (BCY))											
(02228 1599 Excavate by hand)											
(02228 1624 To 2' deep, piled only)											
MIL AA <02228 1625 > Excavate trench, normal soil, by hand, piled only, to 2' deep	89.00	CY	ULABB2	7.00	0.71 64	14.91 1,327	0.00 0	0.00 0	0.00 0	14.91 1,327	14.91
TOTAL Excavation	89.00	CY			73	1,580	111	155	0	1,846	20.74

09.10. Road Crossing for Pipeline Syst	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.10.002. Asphalt, 3"											
(02501 0000 Walks, Roads, Parking, Paving)											
(02505 0010 Asphaltic concrete pavement)											
(02505 0809 Binder course)											
					0.10	2.47	1.33	26.94	0.00	30.73	
M MIL AA <02505 0813 > Asphaltic conc pavement, highway, binder course, 4" thick	12.00	TON	COKCB25	106.25	1	30	16	323	0	369	30.73
TOTAL Asphalt, 3"	12.00	TON			1	30	16	323	0	369	30.73

09.10. Road Crossing for Pipeline Syst	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.10.003. ABC, 6"											
(02200 0000 Earthwork)											
(02242 0000 Pavement Base)											
(Material cost accounts for purchasing and delivery (20 miles one-way haul))											
(02244 0010 Base course, large areas)											
M AF AA <02244 1530 > Base course, gravel, bank run, compacted, 6" D, large areas	16.00	CY	COFGB36C	104.38	0.05	1.37	1.97	11.64	0.00	14.98	
					1	22	31	186	0	240	14.98
TOTAL ABC, 6"	25.00	TON			1	22	31	186	0	240	9.58

09.10. Road Crossing for Pipeline Syst	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.10.004. Backfill & Compaction											
USR AA < > Processing of excess excav. matl	55.00	CY		0.00	0.00 0	0.00 0	0.00 0	0.00 0	1.25 69	1.25 69	1.25
(02214 0000 Excavation/Backfill/Compaction) (02216 0010 Backfill, structural, dozer or front end loader) (02216 5499 Backfill around foundation)											
MIL AA <02216 5500 > Backfill, strl, 6" lifts, by hand, no compaction, around foundation	55.00	CY	ULABB2	7.00	0.71 39	14.91 820	0.00 0	0.00 0	0.00 0	14.91 820	14.91
(02214 0000 Excavation/Backfill/Compaction) (02220 0010 Compaction) (02220 8719 Air tamper)											
L MIL AA <02220 8900 > Compaction, structural/trench, by hand w/air tamp, 6" lift	55.00	CY	ULABB9	40.00	0.13 7	2.61 143	0.30 16	0.00 0	0.00 0	2.90 160	2.90
(02220 0010 Compaction) (02220 8999 Water)											
M MIL AA <02220 9030 > Compaction, water, wagon, 6000 gal, 3 mile haul	55.00	CY	COFWB59	250.00	0.00 0	0.10 6	0.22 12	0.20 11	0.00 0	0.53 29	0.53
TOTAL Backfill & Compaction	55.00	CY			46	969	29	11	69	1,077	19.59
TOTAL Road Crossing for Pipeline Syst					121	2,600	187	676	69	3,532	

09.11. Planting Irrigation System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.11. Planting Irrigation System											
Braided irrigation system with 50% efficiency											
TOTAL Reach 1 (949 acr-ft)	66.00	ACR			0	0	0	0	204,600	204,600	3100.00

09.11. Planting Irrigation System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Reach 2 (3,130 acr-ft)	226.00	ACR			0	0	0	0	700,600	700,600	3100.00

09.11. Planting Irrigation System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Reach 3 (362 acr-ft)	29.00	ACR			0	0	0	0	89,900	89,900	3100.00

09.11. Planting Irrigation System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Reach 4 (2,113 acr-ft)	152.00	ACR			0	0	0	0	471,200	471,200	3100.00

09.11. Planting Irrigation System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Reach 5 (4,449 acr-ft)	434.00	ACR			0	0	0	0	1345400	1,345,400	3100.00

09.11. Planting Irrigation System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Reach 6 (6,097 acr-ft)	580.00	ACR			0	0	0	0	1798000	1,798,000	3100.00
TOTAL Planting Irrigation System					0	0	0	0	4609700	4,609,700	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12. SRPMIC Irrigation Channel T-Junc											
09.12.001. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.002. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.003. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D	0				0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.004. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.005. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.006. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.007. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.008. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.009. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	
TOTAL SRPMIC Irrigation Channel T-Junc					0	0	0	0	31,500	31,500	

09.15. Debris Removal	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.15. Debris Removal											
USR AA < > Disposal fee					0.00	0.00	0.00	0.00	30.00	30.00	
	177000	TON		0.00	0	0	0	0	5310000	5,310,000	30.00
(02045 0000 Site Demolition)											
(02046 0009 Site demolition, no hauling)											
(02046 1899 Concrete to 6" thick)											
L USR AA <02046 1900 > Site dml, conc reinforced					0.08	1.74	0.33	0.00	0.00	2.07	
	118000	CY	CLADB	60.00	9,829	205,214	38,456	0	0	243,670	2.07
(02053 0010 Rubbish handling, add to demolition prices)											
(02053 2999 Loading & trucking, including 2 mile haul)											
(02053 3079 Machine loading truck)											
L MIL AA <02053 3080 > Rubbish handling,2 mile haul, loading & trucking,machine loading truck					0.27	6.49	4.17	0.00	0.00	10.66	
	118000	CY	COEIB17	15.00	31,471	765,454	492,025	0	0	1,257,479	10.66
TOTAL Debris Removal	118000	CY			41,300	970,668	530,481	0	5310000	6,811,149	57.72

09.16. Cultural Mitigation	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Cultural Mitigation					0	0	0	0	300,000	300,000	
TOTAL Construction					613,976	16757540	16465922	1108382511270386		55,577,673	

14.01. Trail	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14. Recreation											
14.01. Trail											
Trail is 5.13-mi long and 12-ft wide											
14.01.001. Clear & Grub											
(02108 0000 Site Clearing)											
(02110 0009 Clearing)											
(02110 0499 With dozer and brush rake)											
L AF AA <02110 0550 > Clearing, brush w/dozer & brush rake, medium brush	7.46	ACR	CODTB11A	0.50	4.00 30	105.17 785	131.85 984	0.00 0	0.00 0	237.03 1,768	237.03
(02234 0010 Hauling, loose cubic yards)											
(02234 0239 Highway haulers, no loading included)											
(02234 0239 8 CY)											
MIL AA <02234 0260 > Haul & dispose	223.80	CY	COEIB34A	19.38	0.05 12	1.31 294	2.45 548	0.00 0	10.00 2,238	13.76 3,080	13.76
TOTAL Clear & Grub	7.46	ACR			41	1,078	1,531	0	2,238	4,848	649.83

14.01. Trail		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.01.002. Grading												
EP AA <	> GRADER,MOTOR, ARTIC, CAT 16-H					0.00	0.00	81.57	0.00	0.00	81.57	
		844.19	HR	G15CA006	1.00	0	0	68,857	0	0	68,857	81.57
GEN AA <	> SCRAPER, SP,ELEV, 22CY (16.8M3) 25.0T (22.7MT), PS					0.00	0.00	122.40	0.00	0.00	122.40	
		281.40	HR	S10Z5930	1.00	0	0	34,443	0	0	34,443	122.40
MAP AA <	> ROLLER,VIB,DD,S/P, 6.6T, 56"W, SMOOTH DRUMS					0.00	0.00	36.46	0.00	0.00	36.46	
		281.40	HR	R45CA005	1.00	0	0	10,260	0	0	10,260	36.46
GEN AA <	> TRUCK, OFF-HWY, WATER, 6000GAL (22,712L) (W/ 330HP TRACTOR)					0.00	0.00	73.85	0.00	0.00	73.85	
		281.40	HR	T60Z7920	1.00	0	0	20,780	0	0	20,780	73.85
MIL AA <	> Outside Equip. Operator, Heavy HR 32.3300					1.00	33.23	0.00	0.00	0.00	33.23	
		844.19	HR	X-EQOPRHVY	1.00	844	28,054	0	0	0	28,054	33.23
MIL AA <	> Grade checker					1.00	20.67	0.00	0.00	0.00	20.67	
		281.40	HR	X-LABORER	1.00	281	5,816	0	0	0	5,816	20.67
MIL AA <	> Outside Truck Driver, Heavy					1.00	28.68	0.00	0.00	0.00	28.68	
		281.40	HR	X-TRKDVRHV	1.00	281	8,071	0	0	0	8,071	28.68
MIL AA <	> Laborer (foreman)					1.00	20.67	0.00	0.00	0.00	20.67	
		140.70	HR	X-LABORER	1.00	141	2,908	0	0	0	2,908	20.67
TOTAL Grading		12100	CY			1,548	44,850	134,340	0	0	179,190	14.81
TOTAL Trail		36115	SY			1,589	45,928	135,872	0	2,238	184,038	5.10

14.02. Concrete Curb	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.02. Concrete Curb											
(02520 0000 Curbs)											
(02525 0009 Curbs)											
(02525 0249 Curb, cast in place)											
B AF AA <02525 0270 > Curb, CIP, 6" x 18"					0.20	5.80	0.00	4.46	0.00	10.26	
	27086	LF	ACARC2	30.00	5,417	157,069	0	120,804	0	277,873	10.26
TOTAL Concrete Curb	27086	LF			5,417	157,069	0	120,804	0	277,873	10.26

14.03. Trail Head Signs	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.03. Trail Head Signs											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02842 0009 Signs)											
(02842 0589 Guide and directional signs)											
M USR AA <02842 0590 > Signs, reflectorized w/post, 12"					1.33	27.56	0.00	81.60	0.00	109.16	
x 18", guide & directional signs	4.00	EA	ALABCLAB2	1.50	5	110	0	326	0	437	109.16
TOTAL Trail Head Signs	4.00	EA			5	110	0	326	0	437	109.16

14.04. Parking Lot	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.04. Parking Lot											
(02200 0000 Earthwork)											
(02242 0000 Pavement Base)											
(Material cost accounts for purchasing and delivery (20 miles one-way haul))											
(02243 0009 Sub-base, prepare & roll)											
L MIL AA <02243 0010 > Base, prepare & roll sub-base, small areas to 2500 SY	550.00	SY	COFGB32A	100.00	0.03 17	0.85 465	0.84 465	0.00 0	0.00 0	1.69 929	1.69
(02242 0000 Pavement Base)											
(Material cost accounts for purchasing and delivery (20 miles one-way haul))											
(02244 0010 Base course, large areas)											
B MIL AA <02244 0100 > Base course, crushed 3/4" stone, compacted, 6"D, large areas	550.00	SY	COFGB36C	300.00	0.02 9	0.48 262	0.68 376	2.66 1,463	0.00 0	3.82 2,101	3.82
(02501 0000 Walks, Roads, Parking, Paving)											
(02505 0010 Asphaltic concrete pavement)											
(02505 0849 Wearing course)											
M RSM AA <02505 0850 > Asphaltic conc pavement, highway, wearing course, 2" thick	150.00	TON	COKCB25B	71.88	0.17 25	4.09 614	2.61 391	60.69 9,104	0.00 0	67.39 10,108	67.39
(02501 0000 Walks, Roads, Parking, Paving)											
(02512 0010 Fine grade)											
(02512 0010 For highways)											
L MIL AA <02512 0020 > Fine grade, for roadway, base or leveling course	1.00	MSY	COFGB11L	0.12	16.67 17	438.21 438	294.25 294	0.00 0	0.00 0	732.46 732	732.46
(02579 0000 Pavement Marking)											
(02580 0009 Lines on pavement)											
(02580 0799 Parking stall)											
M MIL AA <02580 0802 > Lines on pvmt, parking stall, paint, 6" wide	300.00	LF	APTRPORD2	350.00	0.01 2	0.13 39	0.00 0	0.25 75	0.00 0	0.38 114	0.38
(02839 0000 Walk/Road/Parking Appurtenances)											
(02841 0010 Parking barriers)											
(02841 0999 Wheel stops, precast concrete)											
B CIV AA <02841 1000 > Parking barriers, 6" x 10" x 6'-0", wheel stops, precast conc w/dowels	12.00	EA	ULABB2	10.00	0.50 6	10.43 125	0.00 0	27.53 330	0.00 0	37.96 456	37.96
(02842 0009 Signs)											
(02842 0009 Reflectorized)											
(02842 0539 Exit)											

14.04. Parking Lot	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
M MIL AA <02842 0540 > Signs, reflectorized, UTMCD std, exit, 12" x 18" w/post	2.00	EA	ALABCLAB2	2.00	1.00 2	20.67 41	0.00 0	18.56 37	0.00 0	39.22 78	39.22
(02842 0009 Reflectorized) (02842 0549 Entry)											
M MIL AA <02842 0550 > Signs, reflectorized, UTMCD std, entry, 12" x 18" w/post	2.00	EA	ALABCLAB2	2.00	1.00 2	20.67 41	0.00 0	18.55 37	0.00 0	39.22 78	39.22
TOTAL Parking Lot	2.00	EA			79	2,025	1,526	11,046	0	14,598	7298.85

14.05. Mileage Marker	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.05. Mileage Marker											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02842 0009 Signs)											
(02842 0589 Guide and directional signs)											
M USR AA <02842 0590 > Signs, reflectorized w/post, 12"					1.33	27.56	0.00	60.33	0.00	87.89	
x 18", guide & directional signs	22.00	EA	ALABCLAB2	1.50	29	606	0	1,327	0	1,934	87.89
TOTAL Mileage Marker	22.00	EA			29	606	0	1,327	0	1,934	87.89

14.06. Educational Plaque	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.06. Educational Plaque											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02842 0009 Signs)											
(02842 0589 Guide and directional signs)											
M USR AA <02842 0590 > Signs, reflectorized w/post, 12"					1.33	27.56	0.00	60.33	0.00	87.89	
x 18", guide & directional signs	11.00	EA	ALABCLAB2	1.50	15	303	0	664	0	967	87.89
TOTAL Educational Plaque	11.00	EA			15	303	0	664	0	967	87.89

14.07. Concrete Bench	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.07. Concrete Bench											
(02870 0000 Site/Street Furnishings)											
(02871 0009 Benches)											
(02871 0009 Precast concrete, w/backs, wood rails)											
M MIL AA <02871 0010 > Benches, park, precast conc, w/backs, wood rails, 4' long	22.00	EA	ALABCLAB2	0.63	3.20 70	66.14 1,455	0.00 0	376.29 8,278	0.00 0	442.43 9,734	442.43
TOTAL Concrete Bench	22.00	EA			70	1,455	0	8,278	0	9,734	442.43

14.08. Rest Stop	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.08. Rest Stop											
Each rest stop includes:											
- 12'x12' shade structure on concrete pad											
- pinic table											
- trash receptacle 2' dia 18" high (2ea)											
- bike stand											
- plaque											
- masonry wall 4' high 60' long											
14.08.001. Shade Structure											
USR AA < > Shade structure on concrete pad					0.00	0.00	0.00	0.00	11000	11000.00	
	6.00	EA		0.00	0	0	0	0	66,000	66,000	11000.00
TOTAL Shade Structure	6.00	EA			0	0	0	0	66,000	66,000	11000.00

14.08. Rest Stop	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.08.002. Picnic Table											
(02870 0000 Site/Street Furnishings)											
(02871 0009 Benches)											
(02871 1839 Permanent steel)											
B USR AA <02871 1840 > Picnic Table					12.00	248.04	0.00	1199.00	0.00	1447.04	
	6.00	EA	ALABCLAB3	0.25	72	1,488	0	7,194	0	8,682	1447.04
TOTAL Picnic Table	6.00	EA			72	1,488	0	7,194	0	8,682	1447.04

14.08. Rest Stop	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.08.003. Trash Receptacle											
(02870 0000 Site/Street Furnishings)											
(02876 0009 Trash receptacle)											
(02876 0009 Fiberglass, square)											
B RSM AA <02876 0010 > Trash receptacle, fiberglass, 2' square, 18" high	12.00	EA	ALABCLAB2	4.50	0.44 5	9.19 110	0.00 0	108.63 1,304	0.00 0	117.82 1,414	117.82
TOTAL Trash Receptacle	12.00	EA			5	110	0	1,304	0	1,414	117.82

14.08. Rest Stop	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.08.004. Bike Stand											
(02860 0000 Playfield Equipment)											
(02864 0010 Playground equipment)											
(02864 0199 Bike rack)											
B MIL AA <02864 0200 > Playground eqpt, bike rack, 10' long, permanent	6.00	EA	ULABB1	2.00	1.50 9	31.50 189	0.00 0	335.18 2,011	0.00 0	366.68 2,200	366.68
TOTAL Bike Stand	6.00	EA			9	189	0	2,011	0	2,200	366.68

14.08. Rest Stop	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.08.005. Plaque											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02842 0009 Signs)											
(02842 0589 Guide and directional signs)											
M USR AA <02842 0590 > Signs, reflectorized w/post, 12" x 18", guide & directional signs	6.00	EA	ALABCLAB2	1.50	1.33 8	27.56 165	0.00 0	60.33 362	0.00 0	87.89 527	87.89
TOTAL Plaque	6.00	EA			8	165	0	362	0	527	87.89

14.08. Rest Stop	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.08.006. Masonry Wall											
(04200 0000 Unit Masonry)											
(04232 0000 Concrete Unit Masonry (CMU))											
(04234 0010 Concrete block, back-up, no scaffolding)											
					0.13	4.00	0.00	2.15	0.00	6.15	
B MIL AA <04234 0350 > CMU, back-up, 8" x 8" x 16", no scaf/reinf, 2000 psi	1440.00	SF	AMABD8	40.00	180	5,761	0	3,096	0	8,857	6.15
TOTAL Masonry Wall	1440.00	SF			180	5,761	0	3,096	0	8,857	6.15
TOTAL Rest Stop	6.00	EA			274	7,714	0	13,967	66,000	87,680	14613.41

14.09. Gate, Double Swing, 6' High	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.09. Gate, Double Swing, 6' High											
(02835 0010 Fence, CL, gates & posts, posts 1/3 in grnd)											
(02835 6984 Gates, swing)											
(02835 7109 Without barbed wire)											
M MIL AA <02835 7275 > Fence, CL, 6' high, dbl, 20'W, indl, gates, swing, galv, w/o barb wire	6.00	EA	CLABB80B	1.25	3.20 19	74.04 444	45.81 275	464.08 2,784	0.00 0	583.93 3,504	583.93
TOTAL Gate, Double Swing, 6' High	6.00	EA			19	444	275	2,784	0	3,504	583.93

14.10. Guard Post, 6" dia. 8' high	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.10. Guard Post, 6" dia. 8' high											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02841 0010 Parking barriers)											
(02841 1999 Bollard, concrete filled steel pipe)											
B MIL AA <02841 2000 > Parking barriers, 8' L, 6" dia, bollard, ptd, conc filled stl pipe	11.00	EA	CLADB55	2.00	1.50 17	32.19 354	21.89 241	55.64 612	0.00 0	109.72 1,207	109.72
TOTAL Guard Post, 6" dia. 8' high	11.00	EA			17	354	241	612	0	1,207	109.72

14.11. Street Crossing Signs	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.11. Street Crossing Signs											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02842 0009 Signs)											
(02842 0589 Guide and directional signs)											
M USR AA <02842 0590 > Signs, reflectorized w/post, 12"					1.33	27.56	0.00	60.33	0.00	87.89	
x 18", guide & directional signs	11.00	EA	ALABCLAB2	1.50	15	303	0	664	0	967	87.89
TOTAL Street Crossing Signs	11.00	EA			15	303	0	664	0	967	87.89
TOTAL Recreation					7,530	216,313	137,914	160,472	68,238	582,936	

15.01. Museum Restroom	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15. Cost Sharing											
15.01. Museum Restroom											
USR AA < > Restroom					0.00	0.00	0.00	0.00	76.00	76.00	
	615.00	SF		0.00	0	0	0	0	46,740	46,740	76.00
TOTAL Museum Restroom	1.00	EA			0	0	0	0	46,740	46,740	46740.00

15.02. Habitat Interpretive Center	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.02. Habitat Interpretive Center											
USR AA < > Outdoor Demonstration Area					0.00	0.00	0.00	0.00	12.00	12.00	
	1050.00	SF		0.00	0	0	0	0	12,600	12,600	12.00
TOTAL Habitat Interpretive Center	1.00	EA			0	0	0	0	12,600	12,600	12600.00

15.03. Shade Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.03. Shade Structure											
USR AA < > Shade structure on concrete pad					0.00	0.00	0.00	0.00	11000	11000.00	
	1.00	EA		0.00	0	0	0	0	11,000	11,000	11000.00
TOTAL Shade Structure	1.00	EA			0	0	0	0	11,000	11,000	11000.00

15.04. Parking Lot	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.04. Parking Lot											
(02200 0000 Earthwork)											
(02242 0000 Pavement Base)											
(Material cost accounts for purchasing and delivery (20 miles one-way haul))											
(02243 0009 Sub-base, prepare & roll)											
L MIL AA <02243 0010 > Base, prepare & roll sub-base, small areas to 2500 SY	275.00	SY	COFGB32A	100.00	0.03 8	0.85 232	0.84 232	0.00 0	0.00 0	1.69 465	1.69
(02242 0000 Pavement Base)											
(Material cost accounts for purchasing and delivery (20 miles one-way haul))											
(02244 0010 Base course, large areas)											
B MIL AA <02244 0100 > Base course, crushed 3/4" stone, compacted, 6"D, large areas	275.00	SY	COFGB36C	300.00	0.02 5	0.48 131	0.68 188	2.66 732	0.00 0	3.82 1,051	3.82
(02501 0000 Walks, Roads, Parking, Paving)											
(02505 0010 Asphaltic concrete pavement)											
(02505 0849 Wearing course)											
M RSM AA <02505 0850 > Asphaltic conc pavement, highway, wearing course, 2" thick	75.00	TON	COKCB25B	71.88	0.17 13	4.09 307	2.61 196	60.69 4,552	0.00 0	67.39 5,054	67.39
(02501 0000 Walks, Roads, Parking, Paving)											
(02512 0010 Fine grade)											
(02512 0010 For highways)											
L MIL AA <02512 0020 > Fine grade, for roadway, base or leveling course	0.50	MSY	COFGB11L	0.12	16.67 8	438.21 219	294.25 147	0.00 0	0.00 0	732.46 366	732.46
(02579 0000 Pavement Marking)											
(02580 0009 Lines on pavement)											
(02580 0799 Parking stall)											
M MIL AA <02580 0802 > Lines on pvmt, parking stall, paint, 6" wide	150.00	LF	APTRPORD2	350.00	0.01 1	0.13 19	0.00 0	0.25 38	0.00 0	0.38 57	0.38
(02839 0000 Walk/Road/Parking Appurtenances)											
(02841 0010 Parking barriers)											
(02841 0999 Wheel stops, precast concrete)											
B CIV AA <02841 1000 > Parking barriers, 6" x 10" x 6'-0", wheel stops, precast conc w/dowels	6.00	EA	ULABB2	10.00	0.50 3	10.43 63	0.00 0	27.53 165	0.00 0	37.96 228	37.96
(02842 0009 Signs)											
(02842 0009 Reflectorized)											
(02842 0539 Exit)											

15.04. Parking Lot	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
M MIL AA <02842 0540 > Signs, reflectorized, UTMCD std, exit, 12" x 18" w/post	1.00	EA	ALABCLAB2	2.00	1.00 1	20.67 21	0.00 0	18.56 19	0.00 0	39.22 39	39.22
(02842 0009 Reflectorized) (02842 0549 Entry)											
M MIL AA <02842 0550 > Signs, reflectorized, UTMCD std, entry, 12" x 18" w/post	1.00	EA	ALABCLAB2	2.00	1.00 1	20.67 21	0.00 0	18.55 19	0.00 0	39.22 39	39.22
TOTAL Parking Lot	1.00	EA			40	1,013	763	5,523	0	7,299	7298.85

15.05. Utilities for Restroom	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Utilities for Restroom					0	0	0	0	15,000	15,000	

15.06. Picnic Table	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.06. Picnic Table											
(02870 0000 Site/Street Furnishings)											
(02871 0009 Benches)											
(02871 1839 Permanent steel)											
B USR AA <02871 1840 > Picnic Table					12.00	248.04	0.00	1199.00	0.00	1447.04	
	4.00	EA	ALABCLAB3	0.25	48	992	0	4,796	0	5,788	1447.04
TOTAL Picnic Table	4.00	EA			48	992	0	4,796	0	5,788	1447.04

15.07. Trash Receptacle	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.07. Trash Receptacle											
(02870 0000 Site/Street Furnishings)											
(02876 0009 Trash receptacle)											
(02876 0009 Fiberglass, square)											
B RSM AA <02876 0010 > Trash receptacle, fiberglass, 2' square, 18" high	8.00	EA	ALABCLAB2	4.50	0.44 4	9.19 73	0.00 0	108.63 869	0.00 0	117.82 943	117.82
TOTAL Trash Receptacle	8.00	EA			4	73	0	869	0	943	117.82

15.08. Concrete Bench	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.08. Concrete Bench											
(02870 0000 Site/Street Furnishings)											
(02871 0009 Benches)											
(02871 0009 Precast concrete, w/backs, wood rails)											
M MIL AA <02871 0010 > Benches, park, precast conc,					3.20	66.14	0.00	376.29	0.00	442.43	
w/backs, wood rails, 4' long	5.00	EA	ALABCLAB2	0.63	16	331	0	1,881	0	2,212	442.43
TOTAL Concrete Bench	5.00	EA			16	331	0	1,881	0	2,212	442.43

15.09. Signs	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.09. Signs											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02842 0009 Signs)											
(02842 0589 Guide and directional signs)											
M USR AA <02842 0590 > Signs, reflectorized w/post, 12"					1.33	27.56	0.00	60.33	0.00	87.89	
x 18", guide & directional signs	10.00	EA	ALABCLAB2	1.50	13	276	0	603	0	879	87.89
TOTAL Signs	10.00	EA			13	276	0	603	0	879	87.89
TOTAL Cost Sharing					120	2,685	763	13,673	85,340	102,461	
TOTAL Va Shly' Akimel	1.00	EA			621,626	16976538	16604599	1125796911423964		56,263,070	56263070

		QUANTITY	UOM	CONTRACT	CONTINGN	PE&D	EDC	S&A	TOTAL COST	UNIT COST
09	Construction			76,033,027	19008257	7,603,303	760,330	4,942,147	108,347,064	
14	Recreation			798,650	199,663	79,865	7,987	51,912	1,138,077	
15	Cost Sharing			140,376	35,094	14,038	1,404	9,124	200,036	
TOTAL	Va Shly' Akimel	1.00	EA	76,972,054	19243013	7,697,205	769,721	5,003,183	109,685,177	109685177

		QUANTITY	UOM	CONTRACT	CONTINGN	PE&D	EDC	S&A	TOTAL COST	UNIT COST
09	Construction									
09.01	Low Flow Channel			1,401,113	350,278	140,111	14,011	91,072	1,996,587	
09.02	Reshaping Salt River Riverbed			20,713,528	5,178,382	2,071,353	207,135	1,346,379	29,516,778	
09.04	Wetland Features			24,910,757	6,227,689	2,491,076	249,108	1,619,199	35,497,828	
09.05	Planting			4,163,453	1,040,863	416,345	41,635	270,624	5,932,921	
09.07	New Water Well			244,350	61,088	24,435	2,444	15,883	348,199	
09.08	Grade Control Structure			7,323,187	1,830,797	732,319	73,232	476,007	10,435,542	
09.09	Water Distribution System			1,281,540	320,385	128,154	12,815	83,300	1,826,194	
09.10	Road Crossing for Pipeline Syst			4,839	1,210	484	48	315	6,895	
09.11	Planting Irrigation System			6,315,507	1,578,877	631,551	63,155	410,508	8,999,598	
09.12	SRPMIC Irrigation Channel T-Junc			43,156	10,789	4,316	432	2,805	61,498	
09.15	Debris Removal	118000.00	CY	9,331,596	2,332,899	933,160	93,316	606,554	13,297,524	112.69
09.16	Cultural Mitigation			300,000	75,000	30,000	3,000	19,500	427,500	
TOTAL	Construction			76,033,027	19008257	7,603,303	760,330	4,942,147	108,347,064	
14	Recreation									
14.01	Trail	36115.00	SY	252,141	63,035	25,214	2,521	16,389	359,300	9.95
14.02	Concrete Curb	27086.00	LF	380,699	95,175	38,070	3,807	24,745	542,495	20.03
14.03	Trail Head Signs	4.00	EA	598	150	60	6	39	852	213.11
14.04	Parking Lot	2.00	EA	20,000	5,000	2,000	200	1,300	28,499	14249.67
14.05	Mileage Marker	22.00	EA	2,649	662	265	26	172	3,775	171.59
14.06	Educational Plaque	11.00	EA	1,325	331	132	13	86	1,887	171.59
14.07	Concrete Bench	22.00	EA	13,335	3,334	1,334	133	867	19,003	863.77
14.08	Rest Stop	6.00	EA	120,126	30,032	12,013	1,201	7,808	171,180	28530.01
14.09	Gate, Double Swing, 6' High	6.00	EA	4,800	1,200	480	48	312	6,840	1140.01
14.10	Guard Post, 6" dia. 8' high	11.00	EA	1,654	413	165	17	107	2,356	214.21
14.11	Street Crossing Signs	11.00	EA	1,325	331	132	13	86	1,887	171.59
TOTAL	Recreation			798,650	199,663	79,865	7,987	51,912	1,138,077	
15	Cost Sharing									
15.01	Museum Restroom	1.00	EA	64,036	16,009	6,404	640	4,162	91,251	91251.32
15.02	Habitat Interpretive Center	1.00	EA	17,263	4,316	1,726	173	1,122	24,599	24599.20
15.03	Shade Structure	1.00	EA	15,071	3,768	1,507	151	980	21,475	21475.49
15.04	Parking Lot	1.00	EA	10,000	2,500	1,000	100	650	14,250	14249.67
15.05	Utilities for Restroom			20,551	5,138	2,055	206	1,336	29,285	
15.06	Picnic Table	4.00	EA	7,930	1,983	793	79	515	11,300	2825.07
15.07	Trash Receptacle	8.00	EA	1,291	323	129	13	84	1,840	230.02
15.08	Concrete Bench	5.00	EA	3,031	758	303	30	197	4,319	863.77
15.09	Signs	10.00	EA	1,204	301	120	12	78	1,716	171.59
TOTAL	Cost Sharing			140,376	35,094	14,038	1,404	9,124	200,036	
TOTAL	Va Shly' Akimel	1.00	EA	76,972,054	19243013	7,697,205	769,721	5,003,183	109,685,177	109685177

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	AZ PRIV	TOTAL COST	UNIT COST
09 Construction		55,577,673	5,527,767	3,040,272	6,384,571	343,779	5,158,964	76,033,027	
14 Recreation		582,936	58,294	32,062	67,329	3,625	54,404	798,650	
15 Cost Sharing		102,461	10,246	5,635	11,834	637	9,562	140,376	
TOTAL Va Shly' Akimel	1.00 EA	56,263,070	5,596,307	3,077,969	6,463,735	348,042	5,222,931	76,972,054	76972054
CONTINGENCY								19,243,013	
SUBTOTAL								96,215,067	
PE&D								7,697,205	
SUBTOTAL								103,912,273	
EDC								769,721	
SUBTOTAL								104,681,993	
S&A								5,003,183	
TOTAL INCL OWNER COSTS								109,685,177	

		QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	AZ PRIV	TOTAL COST	UNIT COST
09	Construction										
09.01	Low Flow Channel			1,022,675	102,268	56,247	118,119	6,360	95,444	1,401,113	
09.02	Reshaping Salt River Riverbed			15,118,842	1,511,884	831,536	1,746,226	94,026	1,411,014	20,713,528	
09.04	Wetland Features			18,182,406	1,818,241	1,000,032	2,100,068	113,079	1,696,931	24,910,757	
09.05	Planting			3,038,912	303,891	167,140	350,994	18,899	283,616	4,163,453	
09.07	New Water Well			178,352	17,835	9,809	20,600	1,109	16,645	244,350	
09.08	Grade Control Structure			5,345,208	534,521	293,986	617,371	33,243	498,858	7,323,187	
09.09	Water Distribution System			935,398	93,540	51,447	108,039	5,817	87,299	1,281,540	
09.10	Road Crossing for Pipeline Syst			3,532	353	194	408	22	330	4,839	
09.11	Planting Irrigation System			4,609,700	460,970	253,534	532,420	28,668	430,215	6,315,507	
09.12	SRPMIC Irrigation Channel T-Junc			31,500	3,150	1,733	3,638	196	2,940	43,156	
09.15	Debris Removal	118000.00	CY	6,811,149	681,115	374,613	786,688	42,359	635,672	9,331,596	79.08
09.16	Cultural Mitigation			300,000	0	0	0	0	0	300,000	
TOTAL	Construction			55,577,673	5,527,767	3,040,272	6,384,571	343,779	5,158,964	76,033,027	
14	Recreation										
14.01	Trail	36115.00	SY	184,038	18,404	10,122	21,256	1,145	17,176	252,141	6.98
14.02	Concrete Curb	27086.00	LF	277,873	27,787	15,283	32,094	1,728	25,933	380,699	14.06
14.03	Trail Head Signs	4.00	EA	437	44	24	50	3	41	598	149.55
14.04	Parking Lot	2.00	EA	14,598	1,460	803	1,686	91	1,362	20,000	9999.77
14.05	Mileage Marker	22.00	EA	1,934	193	106	223	12	180	2,649	120.41
14.06	Educational Plaque	11.00	EA	967	97	53	112	6	90	1,325	120.41
14.07	Concrete Bench	22.00	EA	9,734	973	535	1,124	61	908	13,335	606.15
14.08	Rest Stop	6.00	EA	87,680	8,768	4,822	10,127	545	8,183	120,126	20021.06
14.09	Gate, Double Swing, 6' High	6.00	EA	3,504	350	193	405	22	327	4,800	800.01
14.10	Guard Post, 6" dia. 8' high	11.00	EA	1,207	121	66	139	8	113	1,654	150.32
14.11	Street Crossing Signs	11.00	EA	967	97	53	112	6	90	1,325	120.41
TOTAL	Recreation			582,936	58,294	32,062	67,329	3,625	54,404	798,650	
15	Cost Sharing										
15.01	Museum Restroom	1.00	EA	46,740	4,674	2,571	5,398	291	4,362	64,036	64036.01
15.02	Habitat Interpretive Center	1.00	EA	12,600	1,260	693	1,455	78	1,176	17,263	17262.60
15.03	Shade Structure	1.00	EA	11,000	1,100	605	1,271	68	1,027	15,071	15070.52
15.04	Parking Lot	1.00	EA	7,299	730	401	843	45	681	10,000	9999.77
15.05	Utilities for Restroom			15,000	1,500	825	1,733	93	1,400	20,551	
15.06	Picnic Table	4.00	EA	5,788	579	318	669	36	540	7,930	1982.51
15.07	Trash Receptacle	8.00	EA	943	94	52	109	6	88	1,291	161.41
15.08	Concrete Bench	5.00	EA	2,212	221	122	256	14	206	3,031	606.15
15.09	Signs	10.00	EA	879	88	48	102	5	82	1,204	120.41
TOTAL	Cost Sharing			102,461	10,246	5,635	11,834	637	9,562	140,376	
TOTAL	Va Shly' Akimel	1.00	EA	56,263,070	5,596,307	3,077,969	6,463,735	348,042	5,222,931	76,972,054	76972054

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	AZ PRIV	TOTAL COST	UNIT COST
CONTINGENCY									19,243,013	
SUBTOTAL									96,215,067	
PE&D									7,697,205	
SUBTOTAL									103,912,273	
EDC									769,721	
SUBTOTAL									104,681,993	
S&A									5,003,183	
TOTAL INCL OWNER COSTS									109,685,177	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09 Construction			613,976	16757540	16465922	1108382511270386		55,577,673	
14 Recreation			7,530	216,313	137,914	160,472	68,238	582,936	
15 Cost Sharing			120	2,685	763	13,673	85,340	102,461	
TOTAL Va Shly' Akimel	1.00	EA	621,626	16976538	16604599	1125796911423964		56,263,070	56263070
OVERHEAD								5,596,307	
SUBTOTAL								61,859,378	
HOME OFC								3,077,969	
SUBTOTAL								64,937,346	
PROFIT								6,463,735	
SUBTOTAL								71,401,081	
BOND								348,042	
SUBTOTAL								71,749,123	
ARIZONA PRIV								5,222,931	
TOTAL INCL INDIRECTS								76,972,054	
CONTINGENCY								19,243,013	
SUBTOTAL								96,215,067	
PE&D								7,697,205	
SUBTOTAL								103,912,273	
EDC								769,721	
SUBTOTAL								104,681,993	
S&A								5,003,183	
TOTAL INCL OWNER COSTS								109,685,177	

		QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09	Construction									
09.01	Low Flow Channel			14,607	411,436	611,239	0	0	1,022,675	
09.02	Reshaping Salt River Riverbed			197,117	5598677	7992657	587,754	939,754	15,118,842	
09.04	Wetland Features			240,988	6557129	6766642	4858635	0	18,182,406	
09.05	Planting			58,848	1228496	94,256	1716160	0	3,038,912	
09.07	New Water Well			1,414	36,457	50,356	91,538	0	178,352	
09.08	Grade Control Structure			51,264	1598845	416,656	3253043	76,664	5,345,208	
09.09	Water Distribution System			8,317	353,231	3,449	576,018	2,700	935,398	
09.10	Road Crossing for Pipeline Syst			121	2,600	187	676	69	3,532	
09.11	Planting Irrigation System			0	0	0	0	4609700	4,609,700	
09.12	SRPMIC Irrigation Channel T-Junc			0	0	0	0	31,500	31,500	
09.15	Debris Removal	118000.00	CY	41,300	970,668	530,481	0	5310000	6,811,149	57.72
09.16	Cultural Mitigation			0	0	0	0	300,000	300,000	
TOTAL	Construction			613,976	16757540	16465922	1108382	511270386	55,577,673	
14	Recreation									
14.01	Trail	36115.00	SY	1,589	45,928	135,872	0	2,238	184,038	5.10
14.02	Concrete Curb	27086.00	LF	5,417	157,069	0	120,804	0	277,873	10.26
14.03	Trail Head Signs	4.00	EA	5	110	0	326	0	437	109.16
14.04	Parking Lot	2.00	EA	79	2,025	1,526	11,046	0	14,598	7298.85
14.05	Mileage Marker	22.00	EA	29	606	0	1,327	0	1,934	87.89
14.06	Educational Plaque	11.00	EA	15	303	0	664	0	967	87.89
14.07	Concrete Bench	22.00	EA	70	1,455	0	8,278	0	9,734	442.43
14.08	Rest Stop	6.00	EA	274	7,714	0	13,967	66,000	87,680	14613.41
14.09	Gate, Double Swing, 6' High	6.00	EA	19	444	275	2,784	0	3,504	583.93
14.10	Guard Post, 6" dia. 8' high	11.00	EA	17	354	241	612	0	1,207	109.72
14.11	Street Crossing Signs	11.00	EA	15	303	0	664	0	967	87.89
TOTAL	Recreation			7,530	216,313	137,914	160,472	68,238	582,936	
15	Cost Sharing									
15.01	Museum Restroom	1.00	EA	0	0	0	0	46,740	46,740	46740.00
15.02	Habitat Interpretive Center	1.00	EA	0	0	0	0	12,600	12,600	12600.00
15.03	Shade Structure	1.00	EA	0	0	0	0	11,000	11,000	11000.00
15.04	Parking Lot	1.00	EA	40	1,013	763	5,523	0	7,299	7298.85
15.05	Utilities for Restroom			0	0	0	0	15,000	15,000	
15.06	Picnic Table	4.00	EA	48	992	0	4,796	0	5,788	1447.04
15.07	Trash Receptacle	8.00	EA	4	73	0	869	0	943	117.82
15.08	Concrete Bench	5.00	EA	16	331	0	1,881	0	2,212	442.43
15.09	Signs	10.00	EA	13	276	0	603	0	879	87.89
TOTAL	Cost Sharing			120	2,685	763	13,673	85,340	102,461	
TOTAL	Va Shly' Akimel	1.00	EA	621,626	16976538	16604599	1125796	911423964	56,263,070	56263070

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
OVERHEAD								5,596,307	
SUBTOTAL								61,859,378	
HOME OFC								3,077,969	
SUBTOTAL								64,937,346	
PROFIT								6,463,735	
SUBTOTAL								71,401,081	
BOND								348,042	
SUBTOTAL								71,749,123	
ARIZONA PRIV								5,222,931	
TOTAL INCL INDIRECTS								76,972,054	
CONTINGENCY								19,243,013	
SUBTOTAL								96,215,067	
PE&D								7,697,205	
SUBTOTAL								103,912,273	
EDC								769,721	
SUBTOTAL								104,681,993	
S&A								5,003,183	
TOTAL INCL OWNER COSTS								109,685,177	

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	ACARC1	3 carpnters			PROD = 100%				CREW HOURS = 420	
MIL	B-CARPNTERL	Carpenters	3.00	HR	30.46	3.00	91.38			91.38
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
	TOTAL					4.00	112.05	0.00	0.00	112.05
	ACARC2	5 carpnters			PROD = 100%				CREW HOURS = 903	
MIL	B-CARPNTERF	Carpenters	1.00	HR	31.46	1.00	31.46			31.46
MIL	B-CARPNTERL	Carpenters	4.00	HR	30.46	4.00	121.84			121.84
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
	TOTAL					6.00	173.97	0.00	0.00	173.97
	ALABCLAB2	2 laborers			PROD = 100%				CREW HOURS = 21906	
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	20.67	2.00	41.34			41.34
	TOTAL					2.00	41.34	0.00	0.00	41.34
	ALABCLAB3	3 laborers			PROD = 100%				CREW HOURS = 40	
MIL	B-LABORER L	Laborers, (Semi-Skilled)	3.00	HR	20.67	3.00	62.01			62.01
	TOTAL					3.00	62.01	0.00	0.00	62.01
	AMABD8	3 brklayrs			PROD = 100%				CREW HOURS = 36	
MIL	B-BRKLAYR L	Bricklayers	3.00	HR	32.54	3.00	97.63			97.63
MIL	B-BRKLAYRHL	Bricklayers, (Semi-Skilled)	2.00	HR	31.20	2.00	62.39			62.39
	TOTAL					5.00	160.03	0.00	0.00	160.03
	APTRPORD2	2 paintords			PROD = 100%				CREW HOURS = 1	
MIL	B-PAINTORDL	Painters, Ordinary	2.00	HR	22.74	2.00	45.48			45.48
	TOTAL					2.00	45.48	0.00	0.00	45.48
	CLABB80B	3 laborers + 1 crane, hydr, trk mtd, 14 ton			PROD = 100%				CREW HOURS = 5	
MIL	B-LABORER L	Laborers, (Semi-Skilled)	3.00	HR	20.67	3.00	62.01			62.01
MIL	B-EQOPRLT L	Equip. Operators, Light	1.00	HR	30.53	1.00	30.53			30.53
GEN	C80Z2240 E	CRANE, HYD, TRUCK MTD, 14T	1.00	HR	57.27			1.00	57.27	57.27
	TOTAL					4.00	92.54	1.00	57.27	149.81
*	CLADB	5 laborer + 2 89# Pavement Breaker			PROD = 100%				CREW HOURS = 1967	
MIL	A15Z0150 E	AIR COMPRESSOR, 375CFM, 100 PS	1.00	HR	17.09			1.00	17.09	17.09
GEN	A20Z0400 E	PAVING BREAKER, 66LB (30KG)	2.00	HR	0.90			2.00	1.79	1.79
MIL	B-LABORER L	Laborers, (Semi-Skilled)	4.00	HR	20.67	4.00	82.68			82.68
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	A20Z0475 E	AIR HOSE,1.0"X 100'L (25MMX 31M	2.00	HR	0.34			2.00	0.68	0.68
	TOTAL					5.00	104.35	5.00	19.55	123.90

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	CLADB55	2 laborers + 1 drill, auger, 14" dia, 30' depth	PROD = 100%						CREW HOURS =	6
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	20.67	2.00	41.34			41.34
MIL	B-TRKDVRLTL	Truck Drivers, Light	1.00	HR	23.05	1.00	23.05			23.05
GEN	D30Z2840 E	DRILL, AUGER, 14" DIA, 30' DEE	1.00	HR	24.95			1.00	24.95	24.95
GEN	T50Z7400 E	TRUCK, HWY 25,000 (11,340KG)GVW	1.00	HR	17.77			1.00	17.77	17.77
GEN	T40Z7000 E	TRK FLATBED, 8'X 20'(2.4MX 6.1M	1.00	HR	1.04			1.00	1.04	1.04
	TOTAL					3.00	64.39	3.00	43.77	108.16
	CODEB12B	1 eqoprcrn + 1 hydr excavator, crawler, 1.50 CY	PROD = 100%						CREW HOURS =	61082
MIL	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	1.00	HR	33.23	1.00	33.23			33.23
MIL	B-EQOPROILL	Equip. Operators, Oilers	1.00	HR	26.35	1.00	26.35			26.35
GEN	H25Z3185 E	HYD EXCV, CRAWLER, 55,000LBS,	1.00	HR	58.72			1.00	58.72	58.72
	TOTAL					2.00	59.59	1.00	58.72	118.31
	CODEB12E	1 eqoprcrn + 1 hydr excavator, crawler, 0.50 CY	PROD = 100%						CREW HOURS =	33
MIL	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	1.00	HR	33.23	1.00	33.23			33.23
MIL	B-EQOPROILL	Equip. Operators, Oilers	1.00	HR	26.35	1.00	26.35			26.35
GEN	H25Z3160 E	HYD EXCV, CRAWLER, 24,000LBS,	1.00	HR	24.24			1.00	24.24	24.24
	TOTAL					2.00	59.59	1.00	24.24	83.82
	CODTB10L	1 eqoprmed + 1 dozer, crawler, 76-100 HP	PROD = 100%						CREW HOURS =	56
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	20.67	0.50	10.33			10.33
GEN	T15Z6440 E	DOZER, CRAWLER, 76-100HP	1.00	HR	27.53			1.00	27.53	27.53
	TOTAL					1.50	42.25	1.00	27.53	69.78
	CODTB10M	1 eqoprmed + 1 dozer, crawler, 341-440 HP	PROD = 100%						CREW HOURS =	36649
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	20.67	0.50	10.33			10.33
GEN	T15Z6600 E	DOZER, CRAWLER, 341-440HP	1.00	HR	99.64			1.00	99.64	99.64
	TOTAL					1.50	42.25	1.00	99.64	141.89
	CODTB11A	1 eqoprmed + 1 dozer, crawler, 181-250 HP	PROD = 100%						CREW HOURS =	15
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
GEN	T15Z6520 E	DOZER, CRAWLER, 181-250HP	1.00	HR	65.93			1.00	65.93	65.93
	TOTAL					2.00	52.59	1.00	65.93	118.51
	CODTB15	1 eqoprmed + 1 dozer, crawler, 181-250 HP	PROD = 100%						CREW HOURS =	22070
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	20.67	0.50	10.33			10.33
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	2.00	HR	25.43	2.00	50.86			50.86
GEN	T50Z7420 E	TRUCK, HWY 45,000 (20,412KG)GVW	2.00	HR	45.79			2.00	91.57	91.57
GEN	T40Z6860 E	REAR DUMP BODY, 16-23.5CY (12.2	2.00	HR	2.14			2.00	4.28	4.28
GEN	T15Z6520 E	DOZER, CRAWLER, 181-250HP	1.00	HR	65.93			1.00	65.93	65.93
	TOTAL					3.50	93.11	5.00	161.78	254.89

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	COEIB17	1 trkdvrhv + 1 truck, dump, 12 CY			PROD = 100%				CREW HOURS = 7867	
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	20.67	2.00	41.34			41.34
MIL	B-EQOPRLT L	Equip. Operators, Light	1.00	HR	30.53	1.00	30.53			30.53
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	25.43	1.00	25.43			25.43
GEN	L50Z4640 E	LOADER/BCK-HOE,WH, 0.80CY(0.6M3	1.00	HR	15.12			1.00	15.12	15.12
GEN	T50Z7420 E	TRUCK, HWY 45,000 (20,412KG)GVW	1.00	HR	45.79			1.00	45.79	45.79
GEN	T40Z7090 E	REAR DUMP BODY, 12CY (9.2M3)	1.00	HR	1.64			1.00	1.64	1.64
	TOTAL					4.00	97.30	3.00	62.55	159.85
	COEIB34A	1 trkdvrhv + 1 truck, dump, 12 CY			PROD = 100%				CREW HOURS = 12	
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	25.43	1.00	25.43			25.43
GEN	T50Z7420 E	TRUCK, HWY 45,000 (20,412KG)GVW	1.00	HR	45.79			1.00	45.79	45.79
GEN	T40Z7090 E	REAR DUMP BODY, 12CY (9.2M3)	1.00	HR	1.64			1.00	1.64	1.64
	TOTAL					1.00	25.43	2.00	47.42	72.85
	COELB89	1 eqoprlt + 1 truck, flatbed, 8' x 20'			PROD = 100%				CREW HOURS = 5	
MIL	B-EQOPRLT L	Equip. Operators, Light	1.00	HR	30.53	1.00	30.53			30.53
MIL	B-TRKDVRLTL	Truck Drivers, Light	1.00	HR	23.05	1.00	23.05			23.05
GEN	XMEZ9560 E	WATER TANK, 500 GAL (1,893L)	1.00	HR	1.70			1.00	1.70	1.70
GEN	C60Z1970 E	CONC SLAB SAW, 7" (178MM) DEPT	1.00	HR	3.04			1.00	3.04	3.04
GEN	T50Z7400 E	TRUCK, HWY 25,000 (11,340KG)GVW	1.00	HR	17.77			1.00	17.77	17.77
GEN	T40Z7000 E	TRK FLATBED, 8'X 20'(2.4MX 6.1M	1.00	HR	1.04			1.00	1.04	1.04
	TOTAL					2.00	53.58	4.00	23.56	77.14
	COFCB10E	1 eqoprmed + 1 roller, vib, tandem, S/P, 6 ton			PROD = 100%				CREW HOURS = 11752	
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	20.67	0.50	10.33			10.33
GEN	R45Z5680 E	ROLLER, VIB, DD, SP 6.0T	1.00	HR	47.68			1.00	47.68	47.68
	TOTAL					1.50	42.25	1.00	47.68	89.94
	COFCB10F	1 eqoprmed + 1 roller, vib, tandem, S/P, 12 ton			PROD = 100%				CREW HOURS = 25011	
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	20.67	0.50	10.33			10.33
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	1.00	HR	46.53			1.00	46.53	46.53
	TOTAL					1.50	42.25	1.00	46.53	88.78
	COFCB70A	3 eqoprmed + 1 roller,vib,sd,S/P,22 ton,84" wide			PROD = 100%				CREW HOURS = 22533	
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	20.67	2.00	41.34			41.34
MIL	B-EQOPRMEDL	Equip. Operators, Medium	3.00	HR	31.92	3.00	95.75			95.75
GEN	G15Z3080 E	GRADER, MOTOR, 135 HP (101KW)	1.00	HR	35.31			1.00	35.31	35.31
GEN	R30Z5642 E	ROLLER, STATIC, 3W, SP, 12.0T	1.00	HR	25.38			1.00	25.38	25.38
GEN	R50Z5820 E	ROLLER, VIB, SD, SP 22.0T	1.00	HR	43.15			1.00	43.15	43.15
	TOTAL					6.00	158.76	3.00	103.83	262.59

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	COFGB11L	1 eqoprmed + 1 grader, motor, artic, 28,770 lbs	PROD = 100%						CREW HOURS =	46
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
GEN	G15Z3080 E	GRADER, MOTOR, 135 HP (101KW)	1.00	HR	35.31			1.00	35.31	35.31
	TOTAL					2.00	52.59	1.00	35.31	87.90
	COFGB32A	2 eqoprmed + 1 roller,vib,sd,S/P,12 ton,84"x60"	PROD = 100%						CREW HOURS =	8
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
MIL	B-EQOPRMEDL	Equip. Operators, Medium	2.00	HR	31.92	2.00	63.83			63.83
GEN	G15Z3080 E	GRADER, MOTOR, 135 HP (101KW)	1.00	HR	35.31			1.00	35.31	35.31
GEN	R50Z5810 E	ROLLER, VIB, SD, SP 12.0T	1.00	HR	49.17			1.00	49.17	49.17
	TOTAL					3.00	84.50	2.00	84.48	168.98
	COFGB36C	3 eqoprmed + 1 dozer, crawler, 251-340 HP	PROD = 100%						CREW HOURS =	3
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-EQOPRMEDL	Equip. Operators, Medium	3.00	HR	31.92	3.00	95.75			95.75
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	25.43	1.00	25.43			25.43
GEN	G15Z3080 E	GRADER, MOTOR, 135 HP (101KW)	1.00	HR	35.31			1.00	35.31	35.31
GEN	T15Z6570 E	DOZER, CRAWLER, 300-340HP	1.00	HR	83.26			1.00	83.26	83.26
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	1.00	HR	46.53			1.00	46.53	46.53
GEN	T60Z7910 E	TRUCK, OFF-HWY, WATER, 5000GAL	1.00	HR	40.14			1.00	40.14	40.14
	TOTAL					5.00	142.85	4.00	205.24	348.09
	COFWB59	1 trkdvrhv + 1 water tanker, 5,000 gal	PROD = 100%						CREW HOURS =	12001
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	25.43	1.00	25.43			25.43
GEN	T50Z7520 E	TRUCK, HWY 55,000 (24,948KG)GVW	1.00	HR	44.22			1.00	44.22	44.22
GEN	T45Z7280 E	TRAILER, WATER TANKER, 5000GAL	1.00	HR	11.83			1.00	11.83	11.83
	TOTAL					1.00	25.43	2.00	56.04	81.47
	COKBB45	1 eqoprmed + 1 asphalt distributor, 3,000 gal	PROD = 100%						CREW HOURS =	13
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	25.43	1.00	25.43			25.43
GEN	A25Z0580 E	ASPHALT DISTR, 3,000GAL (11355L	1.00	HR	16.10			1.00	16.10	16.10
GEN	T50Z7580 E	TRUCK, HWY 45,000 (20,412KG)GVW	1.00	HR	41.71			1.00	41.71	41.71
	TOTAL					2.00	57.34	2.00	57.81	115.15
	COKCB25	8 laborers + 1 asph finisher, w/screed, 10' wide	PROD = 100%						CREW HOURS =	0
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	7.00	HR	20.67	7.00	144.69			144.69
MIL	B-EQOPRMEDL	Equip. Operators, Medium	3.00	HR	31.92	3.00	95.75			95.75
GEN	A30Z0640 E	ASPHALT PAVER, 10.0' (3.1M)W,SP	1.00	HR	74.74			1.00	74.74	74.74
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	1.00	HR	46.53			1.00	46.53	46.53
GEN	R30Z5645 E	ROLLER, STATIC, 9 TIRES, SP,14T	1.00	HR	19.65			1.00	19.65	19.65
	TOTAL					11.00	262.10	3.00	140.92	403.02

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	COKCB25B	8 laborers + 1 roller,vib,tandem,S/P,12Ton,84"w	PROD = 100%						CREW HOURS =	3
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	7.00	HR	20.67	7.00	144.69			144.69
MIL	B-EQOPRMEDL	Equip. Operators, Medium	4.00	HR	31.92	4.00	127.66			127.66
GEN	A30Z0640 E	ASPHALT PAVER, 10.0' (3.1M)W,SP	1.00	HR	74.74			1.00	74.74	74.74
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	2.00	HR	46.53			2.00	93.07	93.07
GEN	R30Z5645 E	ROLLER, STATIC, 9 TIRES, SP,14T	1.00	HR	19.65			1.00	19.65	19.65
	TOTAL					12.00	294.02	4.00	187.45	481.47
	MPLUPLUM2	2 plumbers	PROD = 100%						CREW HOURS =	4015
MIL	B-PLUMBER L	Plumbers	2.00	HR	43.10	2.00	86.20			86.20
	TOTAL					2.00	86.20	0.00	0.00	86.20
	MPLUQ	3 plumber + 1 20 Ton Crane, Hydraulic+Welder	PROD = 100%						CREW HOURS =	20
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
MIL	B-EQOPRMEDL	Equip. Operators, Medium	0.40	HR	31.92	0.40	12.77			12.77
MIL	B-PLUMBER A	Plumbers	1.00	HR	36.23	1.00	36.23			36.23
MIL	B-PLUMBER L	Plumbers	1.00	HR	43.10	1.00	43.10			43.10
MIL	B-PLUMBER F	Plumbers	1.00	HR	44.10	1.00	44.10			44.10
MIL	C75Z2160 E	CRANE, HYD, R/T, 20T, 70' BOOM	0.40	HR	44.29			0.40	17.71	17.71
MIL	W35Z8680 E	WELDER, 300AMP, SKID MTD	1.00	HR	1.45			1.00	1.45	1.45
	TOTAL					4.40	156.87	1.40	19.16	176.03
	MPLUQ1	2 plumbers	PROD = 100%						CREW HOURS =	9
MIL	B-PLUMBER L	Plumbers	1.00	HR	43.10	1.00	43.10			43.10
MIL	B-PLUMBER A	Plumbers	1.00	HR	36.23	1.00	36.23			36.23
	TOTAL					2.00	79.33	0.00	0.00	79.33
	SIWRRODM4	4 rodmen	PROD = 100%						CREW HOURS =	5411
MIL	B-RODMAN L	Rodmen, (Reinforcing)	4.00	HR	40.88	4.00	163.51			163.51
	TOTAL					4.00	163.51	0.00	0.00	163.51
	ULABA1	1 laborer + 1 concrete saw, 6.63" depth	PROD = 100%						CREW HOURS =	120
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
GEN	C60Z1970 E	CONC SLAB SAW, 7" (178MM) DEPT	1.00	HR	3.04			1.00	3.04	3.04
	TOTAL					1.00	20.67	1.00	3.04	23.71
	ULABA2	2 laborers + 1 truck, flatbed, 20,000-25,000 GVW	PROD = 100%						CREW HOURS =	5096
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	20.67	2.00	41.34			41.34
MIL	B-TRKDVRLTL	Truck Drivers, Light	1.00	HR	23.05	1.00	23.05			23.05
GEN	T40Z6960 E	TRK FLATBED, 8'X 12'(2.4MX 3.7M	1.00	HR	0.72			1.00	0.72	0.72
GEN	T50Z7400 E	TRUCK, HWY 25,000 (11,340KG)GVW	1.00	HR	17.77			1.00	17.77	17.77
	TOTAL					3.00	64.39	2.00	18.50	82.88

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	ULABB1	3 laborers				PROD = 100%			CREW HOURS =	3
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	20.67	2.00	41.34			41.34
	TOTAL					3.00	63.01	0.00	0.00	63.01
	ULABB2	5 laborers				PROD = 100%			CREW HOURS =	22
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	4.00	HR	20.67	4.00	82.68			82.68
	TOTAL					5.00	104.35	0.00	0.00	104.35
	ULABB23A	2 laborers + 1 drill, rotary, 16" water well				PROD = 100%			CREW HOURS =	366
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
GEN	D35Z2900 E	DRILL, ROTARY,16"(406MM)WTR WEL	1.00	HR	102.46			1.00	102.46	102.46
GEN	T50Z7320 E	TRUCK, HWY 8,800 (3,992KG)GVW	1.00	HR	9.53			1.00	9.53	9.53
	TOTAL					3.00	74.25	2.00	111.98	186.24
	ULABB23B	2 laborers + 1 drill, rotary, 16" water well				PROD = 100%			CREW HOURS =	67
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
GEN	D35Z2900 E	DRILL, ROTARY,16"(406MM)WTR WEL	1.00	HR	102.46			1.00	102.46	102.46
GEN	T50Z7320 E	TRUCK, HWY 8,800 (3,992KG)GVW	1.00	HR	9.53			1.00	9.53	9.53
GEN	P60Z5410 E	PUMP, CENTRF, DEWATER, 6" DIA	1.00	HR	22.42			1.00	22.42	22.42
	TOTAL					3.00	74.25	3.00	134.40	208.66
	ULABB9	5 laborers + 1 air compressor, 100 CFM				PROD = 100%			CREW HOURS =	1535
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	4.00	HR	20.67	4.00	82.68			82.68
GEN	A15Z0120 E	AIR COMPRESSOR, 100CFM, 100PSI	1.00	HR	11.30			1.00	11.30	11.30
GEN	A20Z0480 E	AIR HOSE,1.5"X 100'L (38MMX 31M	1.00	HR	0.53			1.00	0.53	0.53
	TOTAL					5.00	104.35	2.00	11.83	116.18
	ULABC7	6 laborers + 1 crane, hydr, trk mtd, 60 ton				PROD = 100%			CREW HOURS =	1716
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	5.00	HR	20.67	5.00	103.35			103.35
MIL	B-CEMTFINRL	Cement Finishers	1.00	HR	31.82	1.00	31.82			31.82
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
GEN	XMEZ9520 E	CONC VIBRATOR, 2.5" (63.5MM) DI	2.00	HR	3.70			2.00	7.40	7.40
GEN	B30Z1050 E	BUCKET, CONCRETE, 1.0CY (0.8M3)	1.00	HR	0.47			1.00	0.47	0.47
GEN	C80Z2280 E	CRANE, HYD, TRUCK MTD, 65T	1.00	HR	94.68			1.00	94.68	94.68
	TOTAL					8.00	188.75	4.00	102.54	291.30

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	UOEHB12G	1 eqoprcrn + 1 crane, crawler, drag/clam, 17 ton	PROD = 100%						CREW HOURS = 1147	
MIL	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	1.00	HR	33.23	1.00	33.23			33.23
MIL	B-EQOPROILL	Equip. Operators, Oilers	1.00	HR	26.35	1.00	26.35			26.35
GEN	C85Z2370 E	DRAGLINE/CLAMSHELL,CRWLR, 0.50C	1.00	HR	38.25			1.00	38.25	38.25
GEN	B25Z1040 E	BUCKET, CLAMSHELL, 0.6CY(0.5M3)	1.00	HR	2.48			1.00	2.48	2.48
	TOTAL					2.00	59.59	2.00	40.74	100.32

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
MIL	B-BRKLAYR	Bricklayer	21.25	0.0%	34.8%	3.91	0.00	32.54	HR	02/26/03	32.22	108
MIL	B-BRKLAYRH	Bricklayer (Semi-Skilled)	20.25	0.0%	34.8%	3.91	0.00	31.20	HR	02/26/03	25.32	72
MIL	B-CARPNTER	Carpenter	19.33	0.0%	38.8%	3.62	0.00	30.46	HR	02/26/03	31.68	5774
MIL	B-CEMTFINR	Cement Finisher	20.00	0.0%	29.1%	6.01	0.00	31.82	HR	02/26/03	28.47	1716
MIL	B-EQOPRCRN	Equip. Operator, Crane/Shovel	22.02	0.0%	27.9%	5.08	0.00	33.23	HR	02/26/03	32.62	62262
MIL	B-EQOPRLT	Equip. Operator, Light	19.91	0.0%	27.8%	5.08	0.00	30.53	HR	02/26/03	28.51	7876
MIL	B-EQOPRMED	Equip. Operator, Medium	20.99	0.0%	27.8%	5.08	0.00	31.92	HR	02/26/03	30.27	165405
MIL	B-EQOPROIL	Equip. Operator, Oiler	16.64	0.0%	27.8%	5.08	0.00	26.35	HR	02/26/03	24.69	62262
MIL	B-LABORER	Laborer (Semi-Skilled)	12.37	0.0%	38.8%	3.50	0.00	20.67	HR	02/26/03	23.81	215602
MIL	B-PAINTORD	Painter, Ordinary	15.45	0.0%	33.0%	2.20	0.00	22.74	HR	02/26/03	27.66	3
MIL	B-PLUMBER	Plumber	27.35	0.0%	25.6%	8.75	0.00	43.10	HR	02/26/03	34.82	8109
MIL	B-RODMAN	Rodman (Reinforcing)	20.91	0.0%	46.0%	10.35	0.00	40.88	HR	02/26/03	36.56	21642
MIL	B-TRKDVRHV	Truck Driver, Heavy	15.92	0.0%	33.8%	4.12	0.00	25.43	HR	02/26/03	24.66	64034
MIL	B-TRKDVRLT	Truck Driver, Light	14.14	0.0%	33.9%	4.12	0.00	23.05	HR	02/26/03	23.25	5106
MIL	X-EQOPRHVY	Outside Equip. Operator, Heavy	22.02	0.0%	27.9%	5.08	0.00	33.23	HR	02/26/03	31.93	844
MIL	X-LABORER	Outside Laborer	12.37	0.0%	38.8%	3.50	0.00	20.67	HR	02/26/03	24.50	422
MIL	X-TRKDVRHV	Outside Truck Driver, Heavy	18.35	0.0%	33.9%	4.12	0.00	28.68	HR	02/26/03	24.81	281

SRC	ID.NO.	EQUIPMENT DESCRIPTION	DEPR	FCCM	FUEL	FOG	TR WR	TR REP	EQ REP	TOTAL RATE	** TOTAL ** HOURS
GEN	A15Z0120	AIR COMPRESSOR, 100CFM, 100PSI	0.97	0.28	6.34	2.52	0.03	0.00	1.16	11.30 HR	1535
GEN	A15Z0150	AIR COMPRESSOR, 375CFM, 100 PSI	2.95	0.87	7.09	2.49	0.15	0.03	3.51	17.09 HR	1967
GEN	A20Z0400	PAVING BREAKER, 66LB (30KG)	0.27	0.03					0.59	0.90 HR	3933
GEN	A20Z0475	AIR HOSE,1.0"X 100'L (25MMX 31M)	0.11	0.01					0.22	0.34 HR	3933
GEN	A20Z0480	AIR HOSE,1.5"X 100'L (38MMX 31M)	0.17	0.02					0.34	0.53 HR	1535
GEN	A25Z0580	ASPHALT DISTR, 3,000GAL (11355L)	5.59	1.19		1.80			7.52	16.10 HR	13
GEN	A30Z0640	ASPHALT PAVER, 10.0' (3.1M)W,SP	21.05	5.68	8.08	4.34	1.69	0.30	33.60	74.74 HR	3
GEN	B25Z1040	BUCKET, CLAMSHELL, 0.6CY(0.5M3)	1.11	0.26					1.11	2.48 HR	1147
GEN	B30Z1050	BUCKET, CONCRETE, 1.0CY (0.8M3)	0.20	0.05					0.21	0.47 HR	1716
GEN	C60Z1970	CONC SLAB SAW, 7" (178MM) DEPTH	0.26	0.04	1.67	0.67			0.40	3.04 HR	125
GEN	C75Z2160	CRANE, HYD, R/T, 20T, 70' BOOM	13.56	4.48	6.47	2.42	1.17	0.20	15.98	44.29 HR	8
GEN	C80Z2240	CRANE, HYD, TRUCK MTD, 14T	18.70	6.11	10.43	4.64	0.76	0.13	16.50	57.27 HR	5
GEN	C80Z2280	CRANE, HYD, TRUCK MTD, 65T	28.95	10.65	18.25	5.98	0.92	0.16	29.77	94.68 HR	1716
GEN	C85Z2370	DRAGLINE/CLAMSHELL,CRWLR, 0.50CY	12.06	3.37	6.19	2.46			14.16	38.25 HR	1147
GEN	D30Z2840	DRILL, AUGER, 14" DIA, 30' DEEP	2.47	0.65	12.84	5.11	0.06	0.01	3.81	24.95 HR	6
GEN	D35Z2900	DRILL, ROTARY,16"(406MM)WTR WELL	19.57	8.82	30.77	12.24	0.72	0.13	30.22	102.46 HR	433
EP	G15CA006	GRADER,MOTOR, ARTIC, CAT 16-H	23.15	9.33	13.47	5.67	2.22	0.39	27.33	81.57 HR	844
GEN	G15Z3080	GRADER, MOTOR, 135 HP (101KW)	9.86	3.91	6.61	2.79	0.47	0.08	11.59	35.31 HR	22589
GEN	H25Z3160	HYD EXCV, CRAWLER, 24,000LBS,	7.42	2.12	4.12	1.93			8.64	24.24 HR	33
GEN	H25Z3185	HYD EXCV, CRAWLER, 55,000LBS,	17.96	5.51	8.76	4.10			22.39	58.72 HR	61082
GEN	L50Z4640	LOADER/BCK-HOE,WH, 0.80CY(0.6M3)	3.76	1.14	3.13	1.24	0.72	0.13	5.00	15.12 HR	7867
GEN	P60Z5410	PUMP, CENTRF, DEWATER, 6" DIA	1.60	0.37	12.93	5.14			2.37	22.42 HR	67
GEN	R30Z5642	ROLLER, STATIC, 3W, SP, 12.0T	8.46	2.20	3.39	0.99			10.33	25.38 HR	22533
GEN	R30Z5645	ROLLER, STATIC, 9 TIRES, SP,14T	6.05	1.32	4.17	1.22	0.34	0.06	6.49	19.65 HR	3
MAP	R45CA005	ROLLER,VIB,DD,S/P, 6.6T, 56"W,	10.04	2.14	5.31	2.11			16.86	36.46 HR	281
GEN	R45Z5680	ROLLER, VIB, DD, SP 6.0T	12.59	2.68	8.07	3.21			21.14	47.68 HR	11752
GEN	R45Z5690	ROLLER, VIB, DD, SP 12.0T	12.58	2.68	7.27	2.89			21.12	46.53 HR	25020
GEN	R50Z5810	ROLLER, VIB, SD, SP 12.0T	12.32	2.68	10.54	4.19	0.48	0.08	18.88	49.17 HR	8
GEN	R50Z5820	ROLLER, VIB, SD, SP 22.0T	9.90	2.16	10.97	4.37	0.48	0.08	15.18	43.15 HR	22533
GEN	S10Z5930	SCRAPER, SP,ELEV, 22CY (16.8M3)	40.39	9.93	19.03	7.57	5.53	0.97	38.97	122.40 HR	281
GEN	T15Z6440	DOZER, CRAWLER, 76-100HP	6.42	1.84	4.55	2.02			12.69	27.53 HR	56
GEN	T15Z6520	DOZER, CRAWLER, 181-250HP	15.87	7.11	13.65	4.79			24.50	65.93 HR	22085
GEN	T15Z6570	DOZER, CRAWLER, 300-340HP	19.61	8.78	18.20	6.39			30.28	83.26 HR	3
GEN	T15Z6600	DOZER, CRAWLER, 341-440HP	22.90	10.26	23.04	8.09			35.36	99.64 HR	36649
GEN	T40Z6860	REAR DUMP BODY, 16-23.5CY (12.2-	0.93	0.20					1.01	2.14 HR	44139
GEN	T40Z6960	TRK FLATBED, 8'X 12'(2.4MX 3.7M)	0.34	0.07					0.31	0.72 HR	5096
GEN	T40Z7000	TRK FLATBED, 8'X 20'(2.4MX 6.1M)	0.49	0.10					0.45	1.04 HR	10
GEN	T40Z7090	REAR DUMP BODY, 12CY (9.2M3)	0.71	0.15					0.77	1.64 HR	7878
GEN	T45Z7280	TRAILER, WATER TANKER, 5000GAL	2.92	0.98	3.28	0.96	0.45	0.08	3.15	11.83 HR	12001
GEN	T50Z7320	TRUCK, HWY 8,800 (3,992KG)GVW	1.94	0.42	3.47	1.22	0.34	0.06	2.08	9.53 HR	433
GEN	T50Z7400	TRUCK, HWY 25,000 (11,340KG)GVW	3.48	0.87	6.88	2.25	0.70	0.12	3.47	17.77 HR	5106
GEN	T50Z7420	TRUCK, HWY 45,000 (20,412KG)GVW	10.97	2.40	15.62	5.48	0.97	0.17	10.16	45.79 HR	52017
GEN	T50Z7520	TRUCK, HWY 55,000 (24,948KG)GVW	10.24	2.25	15.62	5.48	0.97	0.17	9.49	44.22 HR	12001
GEN	T50Z7580	TRUCK, HWY 45,000 (20,412KG)GVW	10.88	2.42	12.30	4.32	1.43	0.25	10.10	41.71 HR	13
GEN	T60Z7910	TRUCK, OFF-HWY, WATER, 5000GAL	10.38	3.38	9.12	3.63	1.82	0.32	11.48	40.14 HR	3
GEN	T60Z7920	TRUCK, OFF-HWY, WATER, 6000GAL	18.80	6.13	17.21	6.84	3.45	0.61	20.80	73.85 HR	281
GEN	W35Z8680	WELDER, 300AMP, SKID MTD	0.34	0.06	0.52	0.25			0.28	1.45 HR	20
GEN	XMEZ9520	CONC VIBRATOR, 2.5" (63.5MM) DIA	1.04	0.16	0.69	0.48			1.33	3.70 HR	3433
GEN	XMEZ9560	WATER TANK, 500 GAL (1,893L)	0.26	0.14		1.00	0.09	0.01	0.20	1.70 HR	5

No errors detected...

* * * END OF ERROR REPORT * * *

SUMMARY REPORTS SUMMARY PAGE

PROJECT OWNER SUMMARY - Scope....1
PROJECT OWNER SUMMARY - Facility....2
PROJECT INDIRECT SUMMARY - Scope....3
PROJECT INDIRECT SUMMARY - Facility....4
PROJECT DIRECT SUMMARY - Scope....6
PROJECT DIRECT SUMMARY - Facility....7

DETAILED ESTIMATE DETAIL PAGE

09. Construction
01. Low Flow Channel
001. Excavation & Stockpile....1
002. Spread Excess Mat'l on Site....2
02. Reshaping Salt River Riverbed
001. Cut & Stockpile....3
002. Fill....4
003. Spread Excess Mat'l on Site....5
004. Vegetation Grading....6
04. Wetland Features
001. Excavation & Stockpile, 7' Layer....7
002. 2' Lining of Wetland Clay Mat'l....8
003. 2' Layer of Coarser Mat'l on Top....9
004. Spread Excess Mat'l on Site....10
05. Planting
001. Cottonwood/Willow....11
002. Mesquite....12
003. Sonoran Desert....13
004. Wetland Vegetation....14
07. New Water Well....15
08. Grade Control Structure
001. Concrete....16
002. Excavation & Stockpile, U/S....17
003. Backfill & Compaction, U/S....18
005. Excavation & Stockpile, D/S....19
006. Backfill & Compaction, D/S....20
007. Spread Excess Mat'l on Site, D/S....21
008. Riprap, 15' Drop....22
09. Water Distribution System
001. 12" PVC Pipe....23
002. Pump Station at Alma School Rd....24
003. Bridge Crossing....25
004. Pump Station at Country Club Rd....26
005. Bridge Crossing....27
10. Road Crossing for Pipeline Syst
001. Excavation....28
002. Asphalt, 3"....29
003. ABC, 6"....30
004. Backfill & Compaction....31
11. Planting Irrigation System
001. Reach 1 (949 acr-ft)....32

DETAILED ESTIMATE DETAIL PAGE

002. Reach 2 (3,130 acr-ft).....33
003. Reach 3 (362 acr-ft).....34
004. Reach 4 (2,113 acr-ft).....35
005. Reach 5 (4,449 acr-ft).....36
006. Reach 6 (6,097 acr-ft).....37
12. SRPMIC Irrigation Channel T-Junc
001. Triangular IC 4'TW by 2"D.....38
002. Triangular IC 4'TW by 2"D.....39
003. Triangular IC 4'TW by 2"D.....40
004. Triangular IC 4'TW by 2"D.....41
005. Triangular IC 4'TW by 2"D.....42
006. Triangular IC 4'TW by 2"D.....43
007. Triangular IC 4'TW by 2"D.....44
008. Triangular IC 4'TW by 2"D.....45
009. Triangular IC 4'TW by 2"D.....46
15. Debris Removal.....47
16. Cultural Mitigation.....48
14. Recreation
01. Trail
001. Clear & Grub.....49
002. Grading.....50
02. Concrete Curb.....51
03. Trail Head Signs.....52
04. Parking Lot.....53
05. Mileage Marker.....55
06. Educational Plaque.....56
07. Concrete Bench.....57
08. Rest Stop
001. Shade Structure.....58
002. Picnic Table.....59
003. Trash Receptacle.....60
004. Bike Stand.....61
005. Plaque.....62
006. Masonry Wall.....63
09. Gate, Double Swing, 6' High.....64
10. Guard Post, 6" dia. 8' high.....65
11. Street Crossing Signs.....66
15. Cost Sharing
01. Museum Restroom.....67
02. Habitat Interpretive Center.....68
03. Shade Structure.....69
04. Parking Lot.....70
05. Utilities for Restroom.....72
06. Picnic Table.....73
07. Trash Receptacle.....74
08. Concrete Bench.....75
09. Signs.....76

BACKUP REPORTS BACKUP PAGE

CREW BACKUP.....1
LABOR BACKUP.....8
EQUIPMENT BACKUP.....9

* * * END TABLE OF CONTENTS * * *