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DRAINAGE ENHANCEMENTS

FOR

SUN VALLEY PARKWAY

OCTOBER 9, 1988

PREPARED BY

COLLAR, WILLIAMS & WHITE ENGINEERING
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PHOENIX, ARIZONA 85008
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October 9, 1988

Mr. D.C. Black
Special Assistant to the County Engineer
Maricopa County Highway Department
3325 West Durango
Phoenix, Arizona 85009

Re: Sun Valley Parkway
Summary Report, August Storms

Dear Mr. Black:

Transmitted herewith is our evaluation and conclusions regarding the impact of the August, 1988 storms on the Sun Valley Parkway, and our recommendations for drainage enhancements that you requested for the Maricopa County Highway Department.

We estimate the construction cost for enhancements to the interceptor channel and retention basins to range between $300,000 and $350,000. The construction costs for additional channel grading and miscellaneous enhancements in other areas of the project may range from between $50,000 to $80,000, depending on what work is constructed.

After inspecting the Sun Valley Parkway and the related drainage facilities, Collar, Williams & White Engineering believes that the magnitude of the damage to the Sun Valley Parkway as a result of the August storms has been substantially overstated in certain prior correspondence, and is perceived by some in a manner which is out of proportion with the true facts. For example, following the August 21 storm, correspondence was prepared by Greiner, Inc. and by the Flood Control District of Maricopa County ("Flood Control District") which was a very preliminary review of the storm damage. A non-technical person reading this correspondence could derive an entirely inaccurate conclusion that the situation was of a catastrophic nature. Greiner's "ball park" estimate that an additional expenditure of $2,000,000 was required was certainly premature. (We are interested to know exactly what work was contemplated by Greiner for this sum, and how Greiner calculated that figure).

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In addition, we believe that some of the results presented by Greiner and the Flood Control District were based on only a very preliminary analysis without full consideration of all of the features of the project and did not give appropriate weight to the cost/benefit analysis inherent in our design work.

The damage that occurred in the August storms is primarily found in several, random locations along: (1) a 2.8 mile area of the interceptor channel in Phase II-B and (2) a 1.4 mile area in the retention basins within the State Land area in Phase I-A. In addition, the capacity of two (2) culverts in Phase III was exceeded.

The Sun Valley Parkway contains approximately twenty-eight (28) miles of six (6) lane divided roadway, in excess of twenty-five (25) miles of drainage channels, and over 170 drainage culverts (both circular pipe and reinforced concrete box culverts). Accordingly, the drainage enhancements that you have now requested affect only a small part of the overall project. Collar, Williams & White Engineering was and is aware of the unique problems of constructing facilities within an alluvial fan; we discussed this aspect of our design effort in the Drainage Report for Sun Valley Parkway dated March, 1987.

Collar, Williams & White has now had an opportunity to complete a detailed analysis of the data from precipitation gauge number 1615, which is located 5 to 6 miles away from the affected area of the Sun Valley Parkway. While this distance is much greater than desired for definitive data about the actual magnitude of the storms at the affected area, and it is well known that Arizona storms are frequently composed of highly localized "cells" which can result in significant differences in the amount of rainfall in one area only a few hundred yards from another area, Rain Gauge Number 1615 is the closest gauge to the affected area.

We examined the data from Rain Gauge Number 1615, which had been recorded at 5 minute intervals, to determine the concentration of rainfall versus time. We do not believe it meaningful to simply look at total rainfall (3.11 inches versus 9 hours). Our detailed analysis reveals the particular storm to have been a 64 year frequency storm of 3.14 inches over an eight (8) hour duration.

The runoff generated from a 64 year frequency storm is approximately 90% of the runoff anticipated from a 100 year event of the same duration. In addition, rainfall had been recorded on August 19 and 20 immediately preceding this particular storm, which indicates that the soil was in a partially or fully saturated condition prior to the August 21 storm. If the soil was nearly saturated when the August 21 storm occurred, the peak runoff that was experienced might well have been equal to or greater than the flows we used in the design of the Sun Valley Parkway project (our design was based on the 100 year, 1 hour storm, which is in accord with your original criteria). This was not a "normal storm"; this was not a storm of 20 or 25 year frequency. This was a major storm event from a high intensity thunderstorm which may well have generated flows equivalent to or greater than the 100 year "design storm" used for this project.

The philosophy of Collar, Williams & White Engineering from the beginning of the Sun Valley Parkway project was to apply a rational, logical, cost effective design approach based on sound engineering judgement. We discussed this approach with the interested parties at length during our design effort. During this phase, the estimated construction cost for the Sun Valley Parkway was $42,000,000, or approximately $1,500,000 per mile. We performed value engineering on several aspects of the project in order to provide a cost effective design which met the Maricopa County and the Arizona State Land Department criteria. Our review of the soil test data provided to us by others and our determination of the anticipated velocities within the interceptor channel (5 to 6 feet per second) indicated that an earthen channel would meet all such criteria.

The plans prepared by Collar, Williams & White included substantial erosion control features for both the interceptor channel and the significant tributary flows entering the channel. Had the interceptor channel been completely concrete lined, as some now suggest should have been done, approximately $2,500,000 ($90,000 per mile) would have been added to the original estimated construction cost. We did not feel at that time, nor do we believe at this time, that the benefit derived from such concrete lining justifies the significant added costs. It is common knowledge in Arizona that earthen channels will have

certain maintenance associated with them; they are used routinely throughout Maricopa County and the State of Arizona in conjunction with roadway projects, and we firmly believe that earthen channels are the correct answer to the cost/benefit decision for this project. Limited maintenance in the event of major storms has been and is still the best solution.

Inasmuch as a major storm did occur, and certain unanticipated soil conditions were encountered (see our September 30, 1988 letter, Section 8), damage resulted in a localized area of the Sun Valley Parkway project. In response to the request by the Maricopa County Highway Department that we consider and present our recommendations for new, additional desired drainage enhancements that should further reduce maintenance costs over the anticipated life of the Sun Valley Parkway, we now present alternatives for the enhancements, which we have divided into the following categories:

Section 1 - Storm Frequency Analysis
Section 2 - Design Approach
Section 3 - Channel Bank Protection
Section 4 - Outlet Protection, Wagner Wash
Section 5 - Damage at Drop Structure, Station 859+20
Section 6 - Roadside Channel Enhancements
Section 7 - Interceptor Channel, Miscellaneous Damage
Section 8 - Interim Report, September 30, 1988

After your detailed review of this report we are anxious to finalize design details and proceed with construction.

Respectfully Submitted,

COLLAR, WILLIAMS & WHITE ENGINEERING

Robert R. Wagoner

Robert R. Wagoner, P.E., R.L.S.
Vice President

LFO/tw

xc: Thomas J. Phelan - Maricopa County Highway Department
Nicholas P. Karan - Maricopa County Flood Control District

L.C. Huang - Maricopa County Flood Control District
Robert M. Williams - Burns International
Robert S. Mitchell - Burns International
George Seldin - Sun Valley Improvement Corp.
Andrew S. Hendricks - Gaston & Snow
Ed Raubenheimer - Hansomb & Associates
Peter K. Kompaniez - Heron Financial Corporation
Dennis J. White - Heron Financial Corporation
Bruce Gulledge - Security Pacific Merchant Bank
Eugene R. Shulze - Greiner Engineering Sciences, Inc.
Phil Turner - Greiner Engineering Sciences, Inc.
Cliff Williams - Greiner Engineering Sciences, Inc.
Ron Pulice - Pulice Construction
Don Webb - Pulice Construction
Lyle Gabrielson - Rick Engineering
Dennis Stryker - Rick Engineering
Donald Collar - Collar, Williams & White Engineering
Les Olson - Collar, Williams & White Engineering
Fred Fleet - Collar, Williams & White Engineering
Collis Lovely - Collar, Williams & White Engineering
Arthur E. Romley - Romley & Romley

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SECTION 1

STORM FREQUENCY ANALYSIS
AUGUST 21, 1988 STORM

In the memoranda issued by The Flood Control District and by Greiner, Inc. regarding storm damage to the facilities at the Sun Valley Parkway, it was stated that the storm of August 21, 1988, was estimated to be between a 5 year and 25 year frequency "depending on what duration is used". This statement represents an incorrect analysis of the precipitation data recorded at Rain Gauge Number 1615, which is located 5 to 6 miles south of the interceptor channel at an elevation of 4031 feet. Mr. Huang's statement that "3.11 inches of precipitation was recorded in a 9 hour period" is not correct.

Collar, Williams & White has obtained the detailed precipitation data for Rain Gauge Number #1615, which records precipitation totals at 5 minute intervals. A careful analysis of this data reveals the following:

1. 3.14 inches of precipitation was recorded over an 8 hour period (between 5:00 a.m. and 1:00 p.m. on August 21).

2. The highest intensity of precipitation occurred between 8:30 a.m. and 9:30 a.m.; 2.02 inches of precipitation was recorded in 1 hour.

3. Of the above 2.02 inches, 1.54 inches occurred within a 30 minute interval (8:50 a.m. to 9:20 a.m.).

4. Of the total 3.14 inches of precipitation, 2.90 inches occurred within a 6 hour period (5:00 a.m. to 11:00 a.m.).

When comparing these precipitation values for the given duration to the precipitation table for Buckeye, Arizona, the storm of August 21 was actually a 23 year to 64 year frequency storm event for a 30 minute to 8 hour duration. Figures 1-1 and 1-2 show the comparison of actual precipitation versus the estimated frequency (or return period) storm. The estimated rainfall table is published by the U.S. Department of Commerce, Weather Bureau Technical Memorandum WR-44, Western Region.

When comparing the runoff anticipated from a 100 year storm to the runoff from storms of lesser frequency, it is a hyperbolic curve and not a straight line comparison (that is, runoff from a 25 year storm is significantly greater than 25% of the runoff

from a 100 year storm). The actual recorded storm at Rain Gauge Number 1615 was 3.14 inches of precipitation, which is 90% of the precipitation expected from the 100 year storm. The precipitation expected from a 25 year storm is approximately 75% of the precipitation expected from the 100 year storm.

In conclusion, we believe the storm and the resulting runoff that occurred on August 21, 1988 was clearly an unusual major storm event. Because the soil was prewetted by recorded precipitation that occurred on August 19 and 20, the soil may have been already saturated, or nearly so, and therefore it is quite conceivable that the runoff which took place on August 21, 1988 was very near or in excess of the expected runoff from a 100 year storm.

ESTIMATED RETURN PERIODS FOR SHORT-DURATION PRECIPITATION IN ARIZONA
(Inches)

Station: Buckeye

Latitude: 32° 22'

Longitude: 112° 35'

Elevation (feet): 870

(3.14) – Actual Recorded Precipitation Amount Storm on 08/21/88

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	25	50	100
5 min.	0.19	0.27	0.39	0.46	0.57	0.66	0.74
10 min.	0.29	0.41	0.60	0.72	0.89	1.02	1.15
15 min.	0.37	0.52	0.76	0.91	1.13	1.29	1.45
30 min.	0.51	0.73	1.05	1.26	1.56	1.79	2.01
1 hr.	0.65	0.92	1.33	1.59	1.98	2.27	2.55
2 hr.	0.68	0.97	1.41	1.69	2.11	2.42	2.72
3 hr.	0.71	1.02	1.49	1.79	2.23	2.56	2.89
6 hr.	0.79	1.14	1.69	2.04	2.54	2.92	3.30
8 hr. / 12 hr.	0.86	1.25	1.87	2.26	2.81	3.24	3.67
24 hr.	0.93	1.36	2.05	2.49	3.10	3.57	4.05

FREQUENCY OF EVENT

Actual Storm Duration → 8 hr. / 12 hr.

(1.54) – 23 Year

(2.02) – 28 Year

(2.34) – 44 Year

(2.38) – 36 Year

(2.90) – 49 Year

(3.14) – 64 Year

08/21/88 Precipitation at Sta. 1615
Frequency varies from 23 year to 64 year, for 30 minutes to 8 hour duration.

FIGURE 1-1

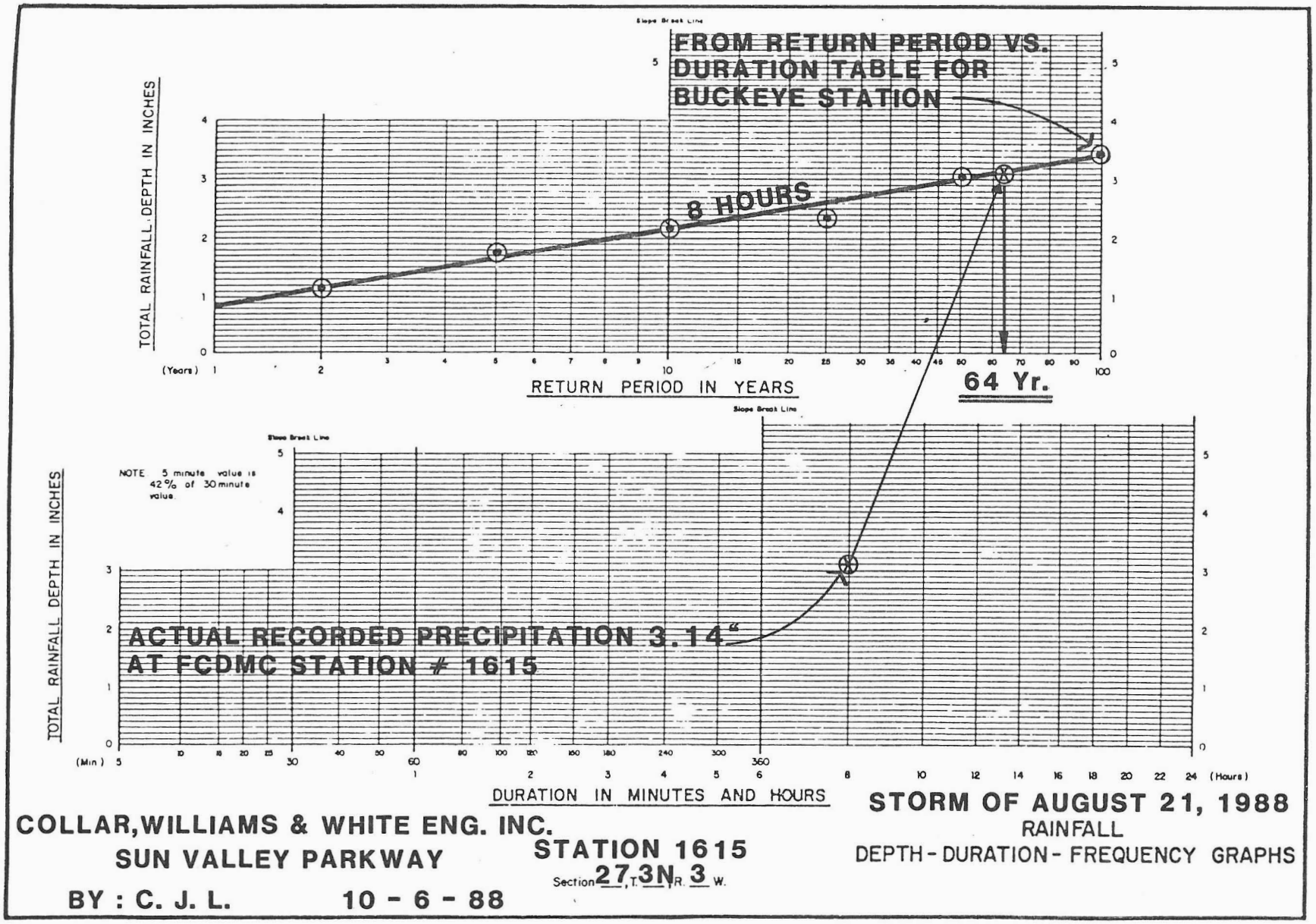

FROM RETURN PERIOD VS. DURATION TABLE FOR BUCKEYE STATION
8 HOURS
64 Yr.
TOTAL RAINFALL DEPTH IN INCHES
RETURN PERIOD IN YEARS
(Years)
Slope Break Line
NOTE 5 minute value is 42% of 30 minute value.
ACTUAL RECORDED PRECIPITATION 3.14"
AT FCDMC STATION # 1615
DURATION IN MINUTES AND HOURS
(Min)
(Hours)
COLLAR, WILLIAMS & WHITE ENG. INC.
SUN VALLEY PARKWAY
BY : C. J. L.
10 - 6 - 88
STATION 1615
Section 27, T. 3N, R. 3 W.
STORM OF AUGUST 21, 1988
RAINFALL
DEPTH - DURATION - FREQUENCY GRAPHS

FIGURE 1-2

SECTION 2

DESIGN APPROACH

ALLUVIAL FANS

Collar, Williams & White Engineering is experienced in the design of roadway and drainage facilities within an alluvial fan area of desert mountain foothills. We are aware of the difficulty of design within alluvial fans, as stated in Paragraph 1, Page 2 of the March, 1987 Drainage Report for Phases 1, 2 and 3. Further discussion of our design approach for handling these difficulties was discussed within the section entitled "Proposed Development and Drainage System".

Because of the difficulties of collecting and routing runoff from construction of a roadway through an alluvial fan, Collar, Williams & White Engineering applied conservative design parameters to the design of the drainage facilities in order to compensate for the broad overland sheet flow. These parameters are described in Exhibit 2-1, which was written in April, 1987.

The idea of collecting overland sheet flow and concentrating the runoff via culverts under the roadway was dictated by the State Land Department in Phase I (which is the area of the retention basins). This was discussed in our drainage report in the section entitled "Proposed Development and Drainage System". This same concept was continued in Phase II-B because it was a cost effective approach to handling the runoff and would maximize development of the land north of the roadway. Of particular interest is the requirement of the State Land Department that concrete lined channels be minimized.

Based on all available data, an earthen channel design, coupled with drop structures and tributary erosion protection features (for the existing washes), was determined to be adequate. Maricopa County Highway Department was aware at that time that an earthen drainage channel would require maintenance. The Maricopa County was also aware that sediment transport and deposition would be inherent, as is evidenced by drainage facilities throughout Maricopa County in other desert alluvial fans. This is further evidenced by the fact that the Maricopa County Highway Department, during the final stages of plan review, required Collar, Williams & White Engineering to increase the height of all box culverts "for maintenance purposes", (reinforced concrete box culverts designed for 3' height were increased to 4' height, and so on).

C. LOVELY
April 1987

SUN VALLEY PARKWAY

CONSERVATIVE DESIGN ASSUMPTIONS

1. A runoff curve number of 86 for future developed conditions instead of 83 for existing conditions was used, and a runoff coefficient of .50 used instead of 0.35.
   County Retention Requirements, where pre must equal post runoff, was assumed to not have been enforced under future development conditions. (A worst case scenario.)

2. A more conservative precipitation value of 2.55 inches was used by the designer in Phase I & II (2.55 inches) instead of the lower acceptable value of 2.43 inches used by the designer in Phase III.

3. Pavement Drainage criteria of 100yr was used instead of the normal 10yr design criteria.

4. Where flows from one wash were split into several culverts the splits were rounded up to increase capacity slightly.

5. The HEC-1 hydrologic model was used instead of the "then" acceptable ADOT's modified SCS Type I procedure. In most cases HEC-1 gives higher peak discharge values.

6. The potential effect of the detention basins in Phase I in attenuating peak flows intercepted and routed through the basins was not taken into account in sizing culverts or the basin inlets and outlets.

7. In many channels the freeboard is greater than the minimum required design criteria of 0.5 feet.

EXHIBIT 2-1

BRUCE BABBITT
GOVERNOR

Arizona
State Land Department

1624 WEST ADAMS
PHOENIX, ARIZONA 85007

OFFICE OF
STATE LAND COMMISSIONER

M E M O R A N D U M

TO: Don Collar, Ken Dyer, Fred Fleet, Collis Lovely, George Tepley, Don Ferris, Bob Williams, Lillian Diaz, Art Cornelius, Lee Jaeger, Melinda Lewis, Bill O'Sullivan, Don Young

DATE: April 17, 1986

FROM: Barbara Burg

SUBJECT: Review of Right-of-Way Application No. 16-93165
The Adams Group, Inc.
April 14, 1986
1624 West Adams, Room 421
Phoenix, Arizona

APPLICATION STATUS

The above-subject application is for a 150-foot road right of way, including utilities, to be built to Maricopa County standards.

Notifications of this proposed easement have been sent to the Town of Surprise, the Department of Transportation, Maricopa County Highway Department, the Director of the Arizona State Museum for archaeological clearance and the Agriculture and Horticulture Department for a survey of the area for protected native plants, together with the grazing lessees.

PLEASE BE ADVISED THAT THE PRESENT APPLICATION IS A PRELIMINARY ONE AND CAN BE AMENDED TO INCLUDE ADDITIONAL DRAINAGE AND REALIGNMENT.

This proposed project will be built progressively:

Stage 1 - Issue a right of entry so that The Adams Group may blade a 12' patrol road within the proposed 150-foot easement. The requirements are as follows:

a. Clearance for archaeological and protected native plants.

b. All grazing lessees must be notified of the construction dates, as they will be moving livestock in the next three-week period.

EXHIBIT 2-2

c. 10% of the total price of acquisition.

CONCERN: The percentage above grade of the roadbed.

RANGE The Conditions agreed to by Robert Williams, The Adams Group, Inc. and Bill O'Sullivan, SLD, for the proposed 12-foot patrol roadway are as follows:

1. Cattleguards will be placed at all locations where roadway will intersect ranch boundaries. These will be at the following locations:
   T4N, R3W, Sec. 25, SE¼
   T4N, R3W, Sec. 29, west quarter corner
2. Cattleguards will be a minimum of 12' wide.
3. Fences will not be cut until cattleguards are ready to be installed.
4. Roadway will go around reservoir in Section 29, T4N, R3W on the downstream side, in order to prevent interference with natural waterflow into the reservoir.
5. Applicant should notify lessees as to dates they will be working.
6. These conditions will be applicable to the 12' road only. Other conditions will need to be met for the construction of the six-lane road.

Attached is a map showing the ranch names and boundaries, and following is a list of the contacts:

Ranch	Contact	Phone
Narramore	Hod Holdcraft	388-2223
Widow Snell	" "	" "
Shelley Bros.	Earl Shelley	988-2871
Hassayampa	Ted Hazen	772-8585

URBAN PLANNING The number of access points is a concern and even though the County wants one-mile access only from a future development viewpoint median breaks at the half-mile and intersection each mile would be more desirable.

It is important to future development to know the acreages left in the triangular parcels in Sections 25 and 30.

ENGINEERING A copy of the latest survey submitted by The Adams Group was returned with the problem areas noted in red.

Memo to: Attendees at April 14, 1986 Meeting

All written descriptions and surveys must be for each individual section.

MINERALS

Any dirt from the drainage easements could be sold "incidental permits for removal of natural products" for road construction.

We would need to know how much material is needed from each section.

HYDROLOGY

1. Massive sheet and channel flow problems associated with project.

2. Best solution appears to be capture and route through designated floodways.

   - o design for Q^{100}_{max} in all cases
   - o swale design collector on southside
   - o incorporate detention storage (recharge?) into design; stockwatering also a factor; water rights a concern
   - o keep Q's, V., sediment load same as under natural conditions at intersection with major channels; concern for concentration time necessary
   - o use drop structures as necessary
   - o incorporate natural vegetation and lithology into design; min use of concrete-lined structures

3. Consider maximum potential use of land in design.

There will be a meeting on Monday, April 28, 1986, at 9 o'clock A.M., Room 421, Arizona State Land Department, to continue discussion of this right-of-way project.

EXHIBIT 2-2

SECTION 3

CHANNEL BANK PROTECTION

This section will discuss the complexity of the current existing field conditions, factors influencing the solution, and recommendations by Collar, Williams & White for drainage enhancements.

PROJECT DISCUSSION

As discussed in the original drainage report prepared by Collar, Williams & White, this is a complex watershed and drainage facility,which is made more difficult by random variations in the soil characteristics found along the channel bank. As discussed in our September 30, 1988 Interim Report, non-distinct random pockets of highly erodible soil exist throughout the interceptor channel and the retention basins.

The erosion that occurred during the August storms consists of two types:

a. Flows from existing tributary washes were concentrated at a single location.
b. Overland sheet flow affecting the entire length of the interceptor channel and retention basins.

During the August storms, some of the significant washes undermined or were diverted around the erosion protection features which had been constructed. Once this process began, the riprap failed, or was non-effective, and the existing washes began "headcutting" upstream thereby contributing large amounts of sediment to the interceptor channel. The phenomenon of "headcutting" occurs where the elevation or level of the existing wash is being eroded downward (that is, lowered in elevation due to increasing velocity); and the deepening of the wash bed migrates upstream until an equilibrium is once again reached for the slope of the wash bed. This occurred along the channel when the flow from the existing washes encountered no resistance upon entering the interceptor channel (that is, when water flowed under or around the erosion protection). Photo 3-1 shows both the riprap failure and the headcutting condition of the tributary washes.

The overland sheet flow is the most difficult problem to solve. In the particular area affected, the overland sheet flow problem is compounded by innumerable localized depressions which consist of insignificant braided swales. When one of these localized depressions included a pocket of the highly erodible soil,

severe bank erosion took place. At several locations, the top 1 foot or so of soil eroded, exposing the calcareous material (light to moderately cemented soils) at which point the erosion ceased. Photo 3-2 shows an example of sheet flow erosion along the southbank of the interceptor channel. Notice that the major erosion is very localized, indicating a pocket of highly erodible soil or a localized depression that concentrated the flow, or both. No distinct "wash" is discernible upstream from this point. Also visible is the minor bank erosion on either side of the failure. This minor erosion is to be expected with an earthen channel and presents no significant maintenance problem. Please note that the minor erosion seen in Photo 3-2 represents by far, the majority of the condition of the channel banks after the August storm.

In our approach to finding a practical solution to the erosion problem, there are several factors to consider which are of a considerable magnitude and which have a drastic effect on the costs of any solution. They are as follows:

1. The south bank of the interceptor channel is 2.8 miles long (approximately 15,000 feet).
2. The total length of banks along the retention basins is 1.4 miles (7,400 feet).
3. There are 7 major tributary washes entering the interceptor channel.
4. The number of localized depressions is virtually indeterminate; a depression exists perhaps every 200 to 300 feet along the entire 4.2 miles of bank.
5. For any enhancement, the quantity involved (4.2 miles along the south bank only) make a solution with even a relatively small unit cost a significant expenditure when applied to the entire project.

ALTERNATIVE SOLUTIONS

During our analysis, Collar, Williams & White investigated a variety of possible enhancements to stabilize the south bank. These alternatives included:

a. lining the entire channel bank with various materials;
b. expanding the Greiner collector ditch and adding with appropriate erosion control;
c. adding a concrete collector ditch "uphill" from the south channel bank;
d. constructing a substantial berm at the top of the south channel bank with protected spillways into the interceptor channel;
e. constructing an erosion proof cap along the entire south bank to act as a continuous weir;
f. several combinations of the above.

We investigated the use of many different materials, or combinations thereof, to use as erosion control or lining:

a. Grouted Riprap
b. Pneumatically applied mortar with welded wire fabric (shotcrete).
c. Pneumatically applied mortar with fiberglass reinforcement (shotcrete).
d. Fabric
e. Soil Cement
f. Hydromulch
g. Asphalt Pavement
h. Emulsified Base Material
i. Non-grouted Riprap
j. Gabéons
k. Spray on Emulsions

Several of the alternatives explored were cost prohibitive and were ruled out. For example, to apply a "shotcrete" lining (pneumatically applied mortar) along the entire south bank with a 5 foot wide cap and cutoff wall at the top was estimated, at current bid prices, to cost $850,000. Therefore, after a thorough analysis of cost, availability and effectiveness, many of the lining materials under consideration were eliminated.

In an attempt to apply "normal standards or principles", which are the industry norm for projects of this magnitude, and in order to consider construction costs very closely, we began to focus on the concept of collecting the runoff above the channel and directing it into the channel through "spillways" (with the addition of appropriate erosion control features). A closer analysis of this concept presents a rather straightforward problem:

> To collect the runoff from a 100 year storm in a collector ditch, you would need a large ditch parallel to the interceptor channel and the same erosion problems would likely occur in the "collector ditch".

Therefore, our final recommendations address the overall bank erosion problem in this manner:

1. A berm and collector ditch system can be constructed to convey runoff from normal low intensity storms through protected spillways into the interceptor channel.
2. The top of the bank can be constructed to act as a continuous weir. When infrequent major storms occur, the capacity of the collector ditch will be exceeded and sheet flow will occur over the top of the berm down the sides of the channel.

This concept will provide very little maintenance during periods of "normal" rainfall, but will require additional maintenance after major storms. This situation is quite common and "normal" throughout roadway and drainage systems in Arizona.

Photos 3-3 and 3-4 exhibit the need to provide appropriate erosion protection at proposed spillway locations, and the need to stabilize the berm along the bank.

RECOMMENDATIONS

Factors that led us to the recommended solution is the existing condition of the north bank of the interceptor channel (on the roadway side). Even though the same soil exists on the north side of the channel, very little major bank erosion (or "headcutting" of the bank) occurred. In observing roadside channels throughout Sun Valley Parkway, very little "major erosion" occurred on the roadway side of the channel banks. Between the back of curb and top of bank exists an 8 foot shoulder consisting of compacted native soil with 4 inches of compacted gravel or ABC.

Two characteristics are present:

1. In most locations the only runoff affecting the channel bank is from the median curb to the top of bank (approximately 48 feet).
2. The top of the bank has been stabilized (the shoulder) by compaction of native soil and compacted gravel/ABC. This stabilization is preventing major erosion of the channel bank since no or little headcutting can begin at the top of bank.

For this reason we feel that stabilizing the top of bank (preventing headcutting of the channel bank) along the south side of the channel will stabilize the vast majority of erosion areas now existing. Likewise, we do not feel additional stabilization of the roadside channel bank (north bank) is cost beneficial.

Therefore, we propose the following enhancement to the south interceptor channel bank and along all retention basin banks in Phase I-A:

1. Reconstruction of the inlets from the significant tributary washes.
2. Construct a 2 feet high berm 8 feet wide and 1 foot high (above natural ground) along the top of the south bank.
3. Upstream from, and adjacent to the berm, construct a grader ditch to act as a "collector ditch" (depth of ditch from top of berm to be 2 feet).

4. The top of berm and north face (upstream) of the grader ditch will be constructed of 1 foot of compacted soil beneath an 8 inch cap of soil cement.

5. Construct numerous spillways along this length to direct low flows into the interceptor channels. Spillways will be constructed of fiberglass reinforced shotcrete (pneumatically applied mortar with fiberglass reinforcing fiber instead of welded wire fabric).

The existing tributary wash inlets will be reconstructed at their original invert elevations so as to prevent additional headcutting upstream. The detail for this reconstruction is shown in Figure 3-1. The details for construction of the berm, collector ditch, and spillways are shown in Figures 3-2, through 3-5. As mentioned earlier, this modification will convey normal runoff into the channel without erosion. The berm will be constructed parallel to the natural ground such that, during major storms, it will act as a continuous weir and sheet flow will occur down the channel bank. The top of the berm (composed of soil cement and compacted soil) will prevent widespread headcutting. Certain areas of the bank may experience more severe erosion (or "sloughing off" of the toe of the bank); however, these should be comparatively isolated and some maintenance will be necessary.

We estimate the construction cost for these improvement to be:

	LOW	HIGH
Interceptor Channel	$210,000	$240,000
Retention Basins (includes cost of 4.25 acres additional R.O.W.)	$ 90,000	$110,000
	$300,000	$350,000

These estimates are based on current bid prices for earthwork and grouted riprap. The fiber reinforced shotcrete was estimated at $9.00 per square yard in place. Approximately 4.25 acres of additional right of way is required from the State Land Department along the perimeter of the retention area, the cost of which was calculated at $2,000 per acre. Drainage easements could possibly be obtained in lieu of purchasing right of way. The following page is a quantity take off from the enhancements as presented herein.

QUANTITIES

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	8" THICK SOIL CEMENT CAP W/ONE FOOT OF COMPACTED SUBGRADE (8% CEMENT COMPACTED TO 95%) (2.8 MILES + 1.4 MILES)	34,500	S.Y.		
2.	3" THICK PNEUMATICALLY APPLIED MORTAR W/FIBERMESH REINFORCING AT SPILLWAYS (160 S.Y. PER SPILLWAY, 58 SPILLWAYS)	9,280	S.Y.		
3.	6" GROUTED RIPRAP TRIBUTARY INLET STRUCTURES W/GROUTED RIPRAP CUTOFF WALLS (500 S.Y. EACH, 7 SPILLWAYS)	3,500	S.Y.		
4.	10 FOOT WIDE, 1' DEEP COMPACTED EARTH DITCH BANK	4.2	MILES		
5.	ONE FOOT HIGH EARTH BERM WITH 4:1 SIDE SLOPES AND 8 FOOT WIDE TOP PARALLEL TO INTERCEPTOR CHANNEL AND DETENTION BASINS	4.2	MILES		
6.	EARTHWORK REQUIRED TO RESTORE EXISTING TRIBUTARY INLETS TO ORIGINAL FLOW LINE ELEVATIONS FOR A DISTANCE OF 20' UPSTREAM FROM PROPOSED TRIBUTARY INLET STRUCTURES	7	EACH		
7.	EARTHWORK REQUIRED TO RESTORE SOUTH CHANNEL OF INTERCEPTOR CHANNEL BANK TO ORIGINAL CONDITION	2.8	MILES		
8.	EARTHWORK REQUIRED TO RESTORE BANKS OF DETENTION BASINS TO ORIGINAL CONDITION	1.4	MILES		
9.	EARTHWORK REQUIRED TO ENLARGE AND RECONSTRUCT EXISTING ROADSIDE DITCHES	3,000	L.F.		
10.	EARTHWORK REQUIRED TO CONSTRUCT EARTH BERM AND DITCH PARALLEL TO INTERCEPTOR CHANNEL.	2.8	MILES		

Photo 3-1, Station 890+00, looking south. Example of failure of grouted riprap and headcutting by tributary wash.

Photo 3-2, looking south, example of bank erosion due to sheet flow. No tributary wash exists.

Photo 3-3, looking west, example of erosion due to Greiner ditch. Note the swale continuing along the bank.

Photo 3-4, looking south. This is a view of the erosion and headcutting from the Greiner ditch in Photo 3-3 above. Headcutting stopped when it reached the level of the grouted riprap.

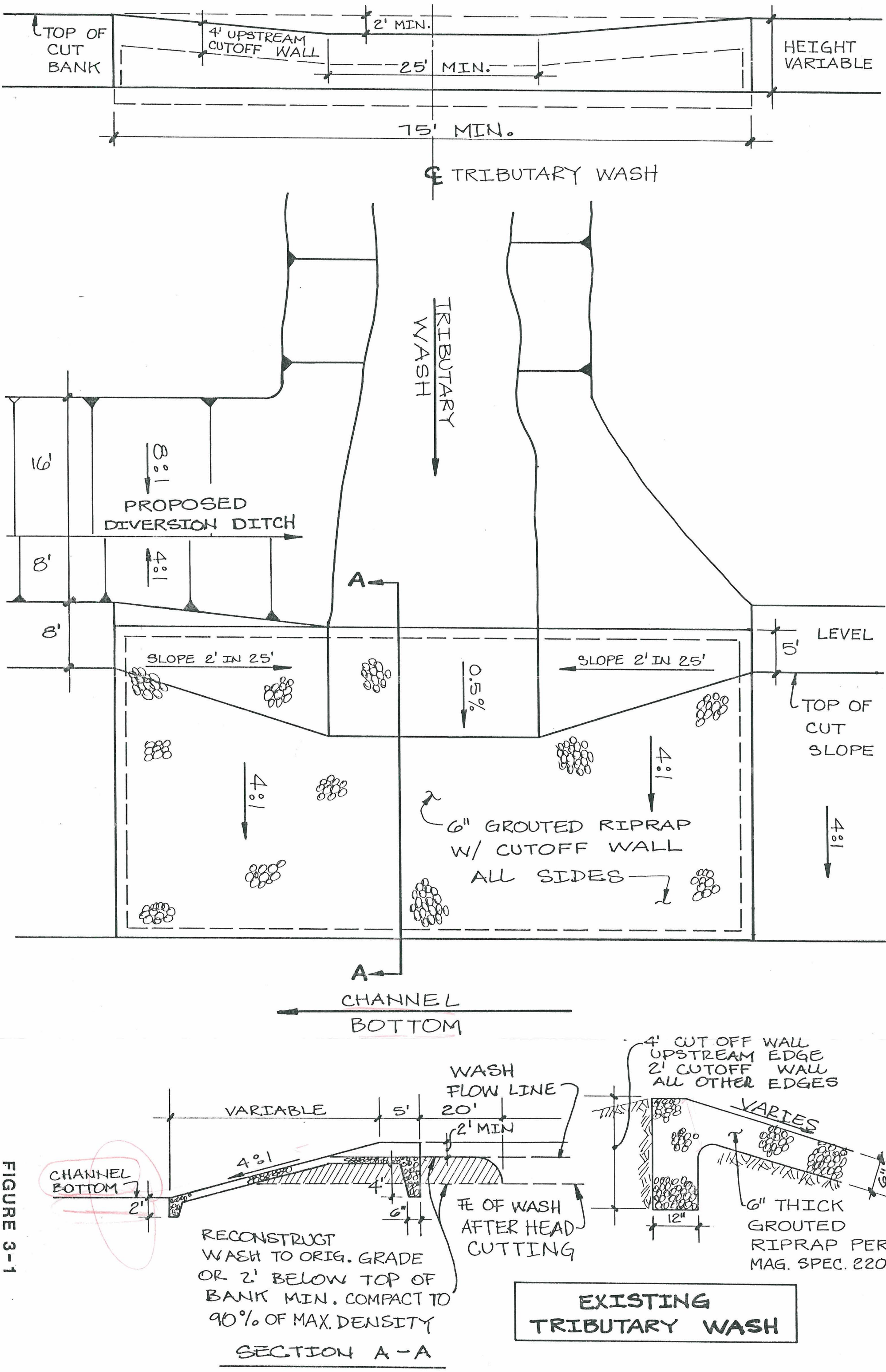
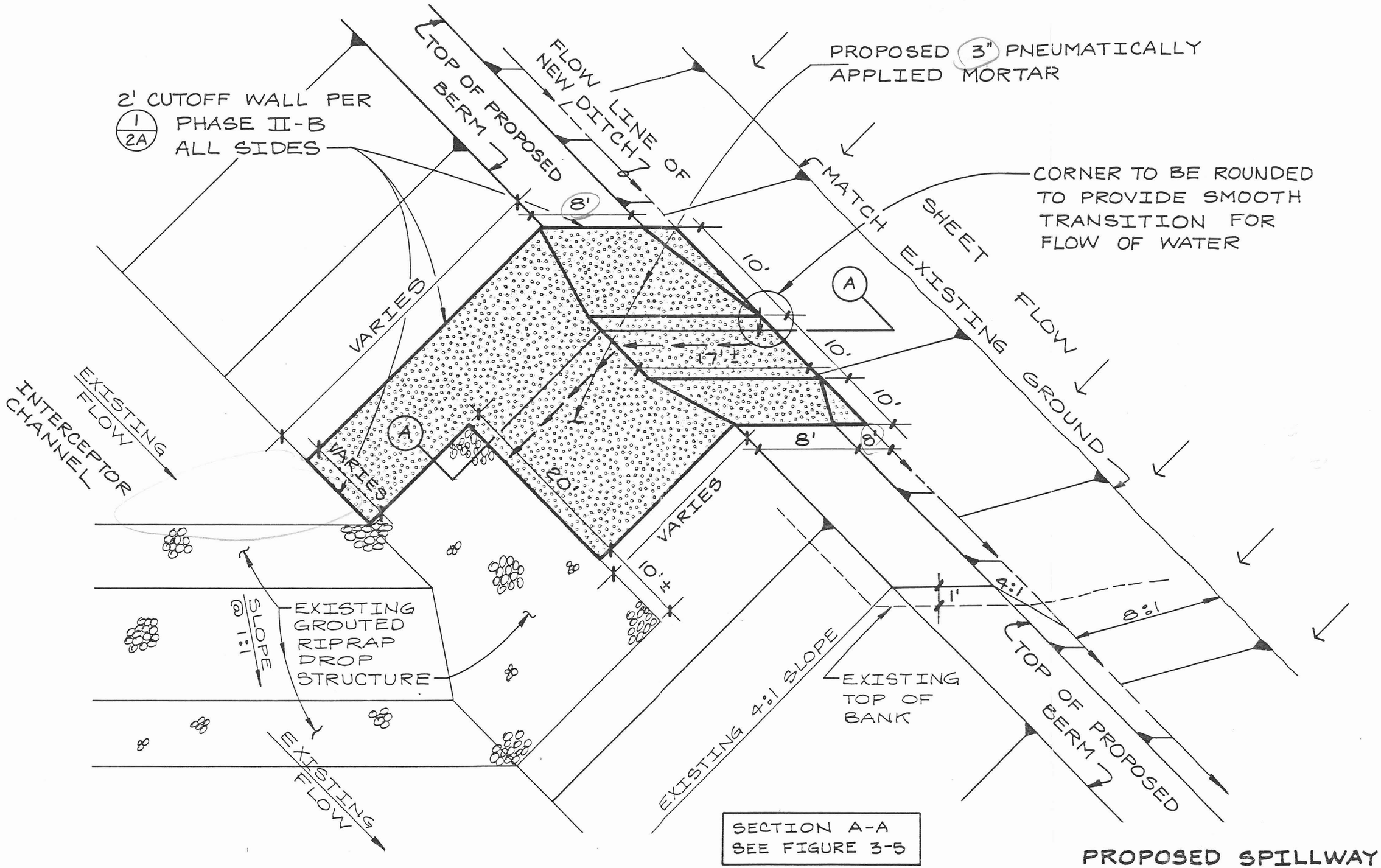

TOP OF CUT BANK
4' UPSTREAM CUTOFF WALL
2' MIN.
25' MIN.
HEIGHT VARIABLE
75' MIN.
℄ TRIBUTARY WASH
TRIBUTARY WASH
16'
8'
8'
PROPOSED DIVERSION DITCH
4:1
A
SLOPE 2' IN 25'
0.5%
SLOPE 2' IN 25'
5'
LEVEL
TOP OF CUT SLOPE
4:1
4:1
4:1
6" GROUTED RIPRAP W/ CUTOFF WALL ALL SIDES
A
CHANNEL BOTTOM
VARIABLE
5'
20'
WASH FLOW LINE
2' MIN
4:1
CHANNEL BOTTOM
2'
4'
6"
℄ OF WASH AFTER HEAD CUTTING
RECONSTRUCT WASH TO ORIG. GRADE OR 2' BELOW TOP OF BANK MIN. COMPACT TO 90% OF MAX. DENSITY
SECTION A-A
4' CUT OFF WALL UPSTREAM EDGE
2' CUTOFF WALL ALL OTHER EDGES
VARIES
6"
12"
6" THICK GROUTED RIPRAP PER MAG. SPEC. 220
EXISTING TRIBUTARY WASH

FIGURE 3-1

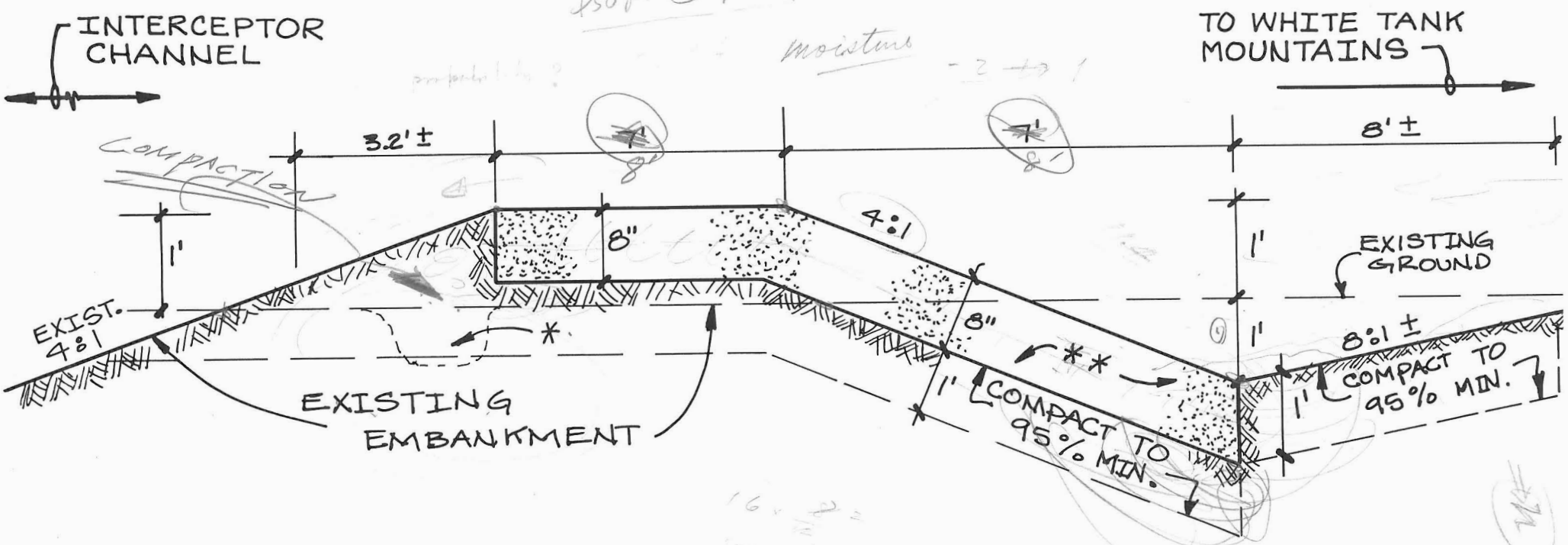


PROPOSED SPILLWAY INLET

FIGURE 3-2

* EXISTING GRADER DITCH TO BE BACKFILLED & COMPACTED.

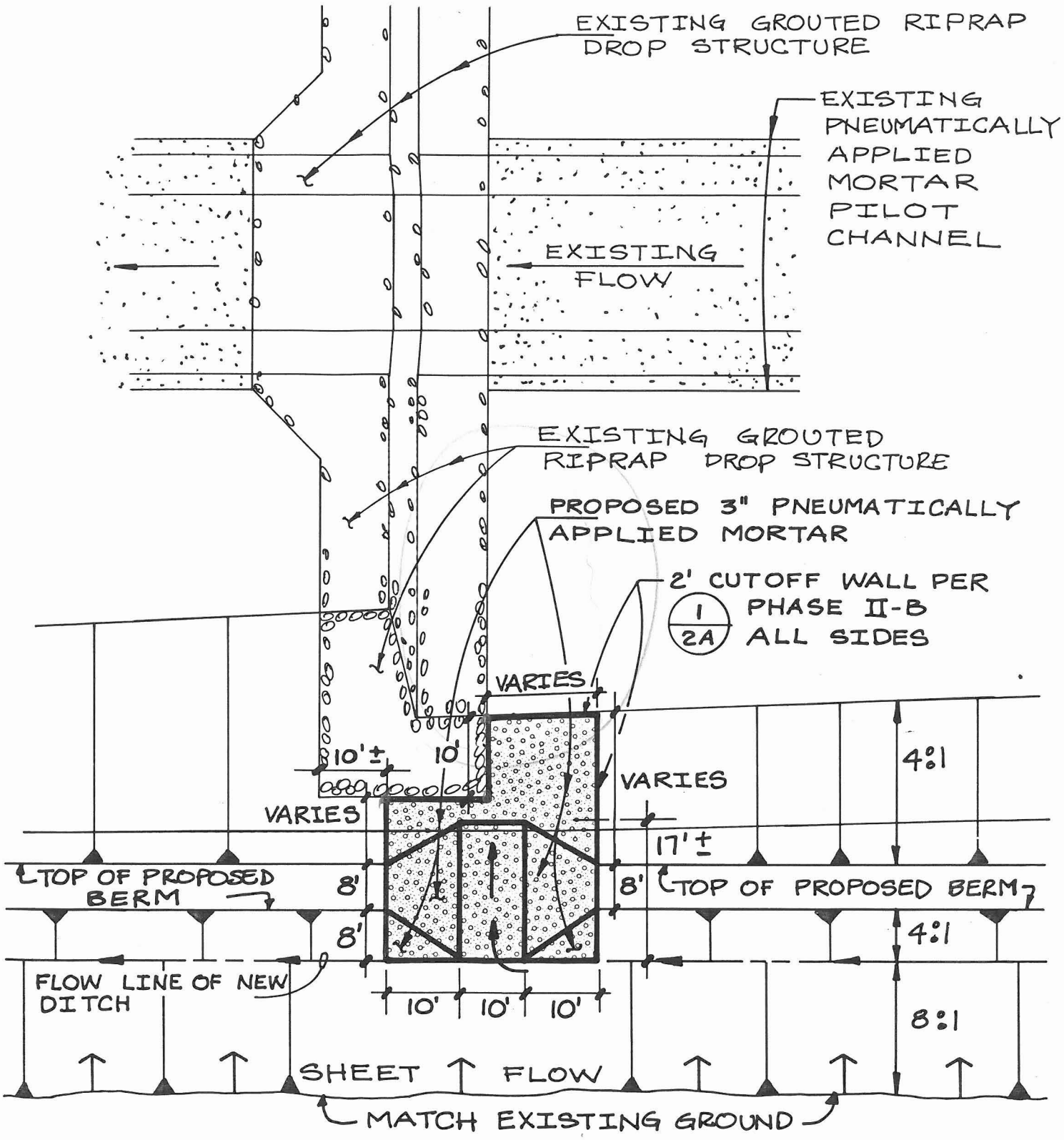
** 8" LIFT OF 8% SOIL CEMENT.



PROPOSED SOIL CEMENT BANK STABILIZATION

(SECTION LOOKING UPSTREAM)

FIGURE 3-3



PROPOSED SPILLWAY INLET AT EXISTING DROP STRUCTURE

FIGURE 3-4

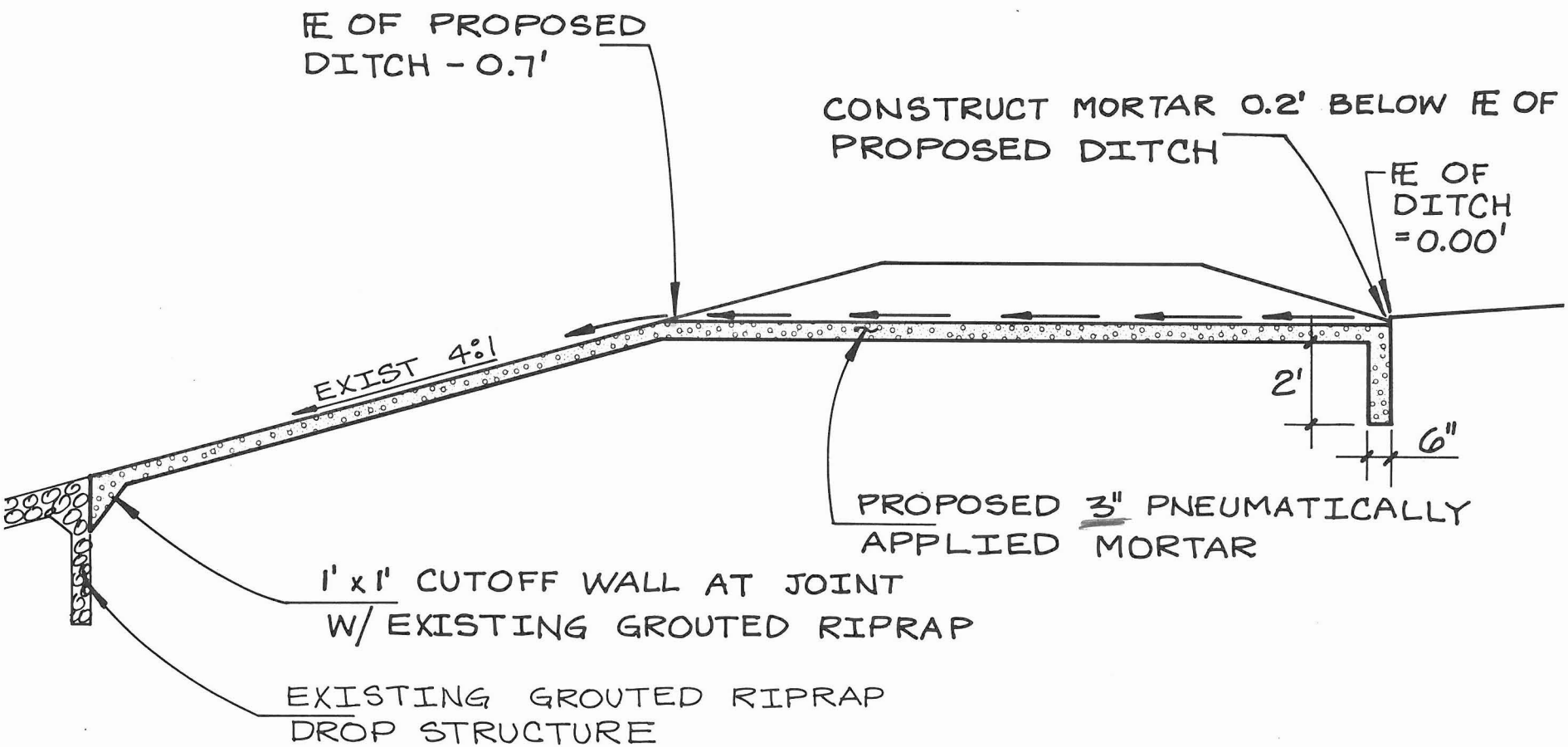


FIGURE 3-5

SECTION A-A

SPILLWAY DETAIL AT EXISTING DROP STRUCTURE SHOWING TIE TO EXISTING GROUTED RIPRAP

SECTION 4

OUTLET PROTECTION
WAGNER WASH

Collar, Williams & White's letter of September 30, 1988 (which is reproduced in Section 8) explains the constriction that has occurred at the confluence of Wagner Wash and the interceptor channel. Figure 4-1 shows how the outlet work was constructed in comparison to the intended geometry shown on the plans. Figure 4-2 shows our recommendation for reconstruction of the outlet protection. Photos 4-1 and 4-2 show the constriction and lack of a grouted riprap cutoff wall.

Additional concerns have been voiced about the ponded water in the dissipator basin. Maricopa County has requested that a means be provided for it to drain. On Figure 4-2 we have detailed how this can be accomplished during reconstruction. It should be noted that prior to the August storms, the flow line ("riverbed elevation") of Wagner Wash was at elevation 1491.30. The bottom of the dissipator basin is at elevation 1488.90, thereby making it nearly impossible to have drained. After the August storms, the flow line of Wagner Wash at the end of the outlet protection is at elevation 1488.0.

The loose riprap to be placed downstream from the outlet should be placed so as not to block the pilot channel. The riprap should be shaped to form a swale to allow water to easily drain from the pilot channel.

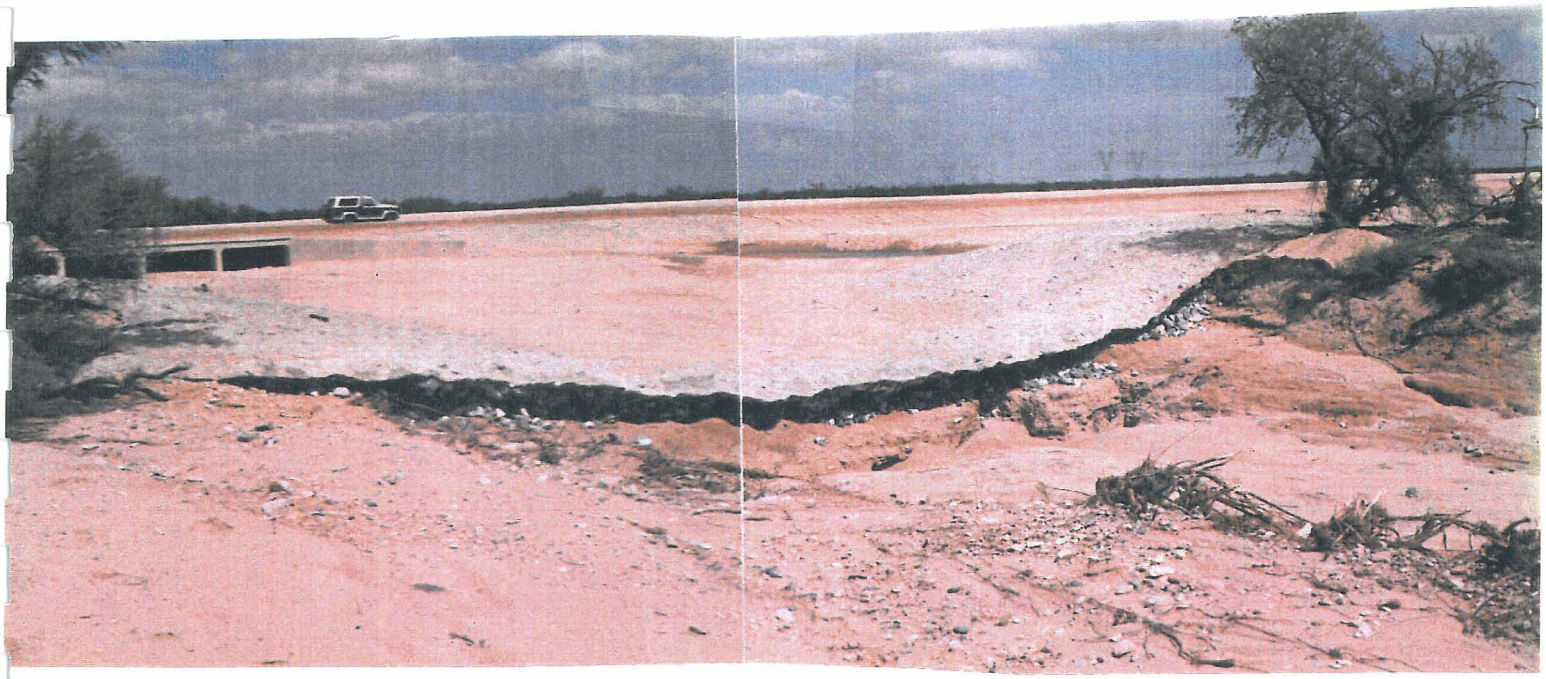


Photo 4-1, Wagner Wash outlet protection looking north. The cutoff wall can be seen with no grout. This photo also shows the constriction along the left side.

Photo 4-2, Wagner Wash outlet protection. The depth of scour was 3' to 5'.

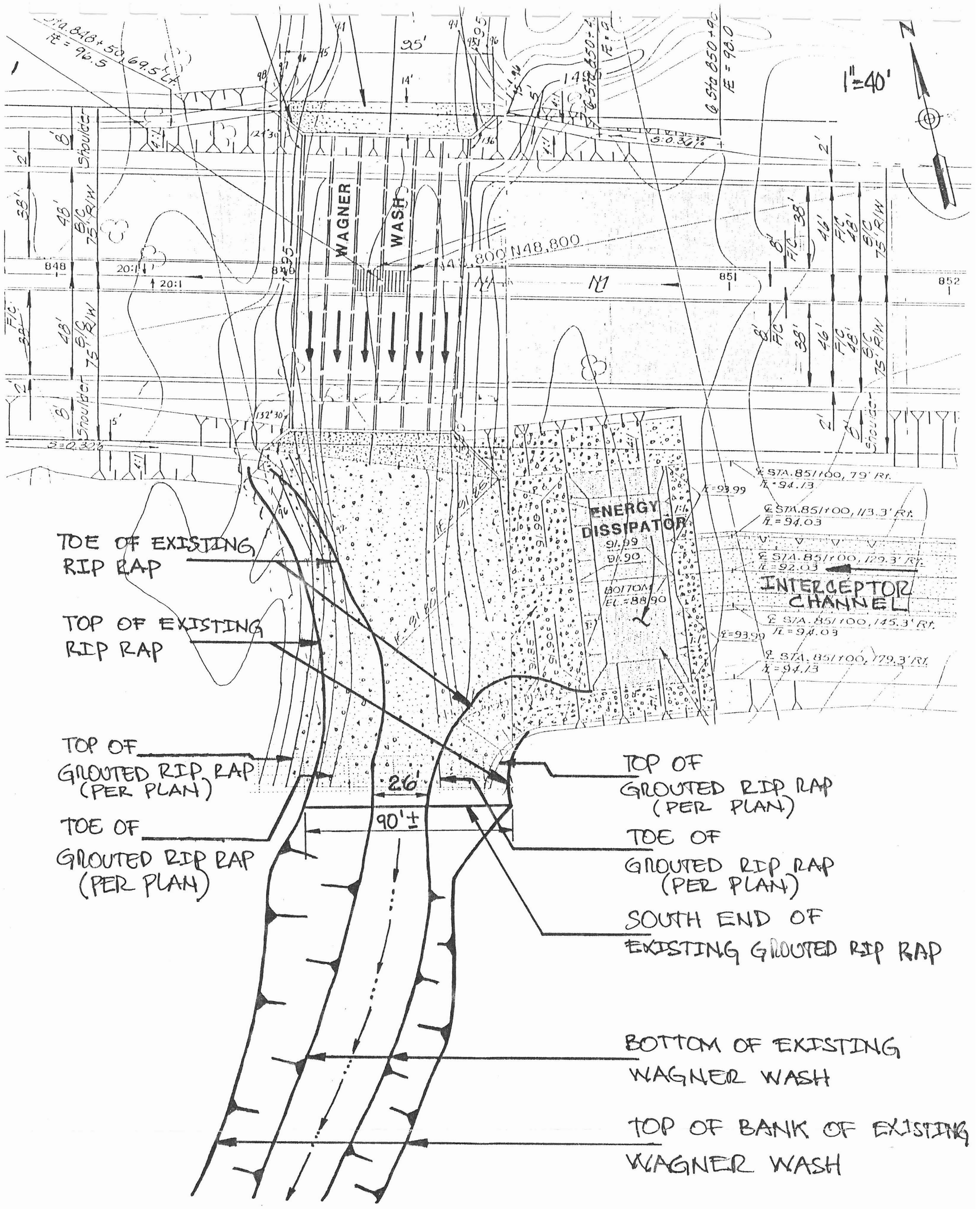
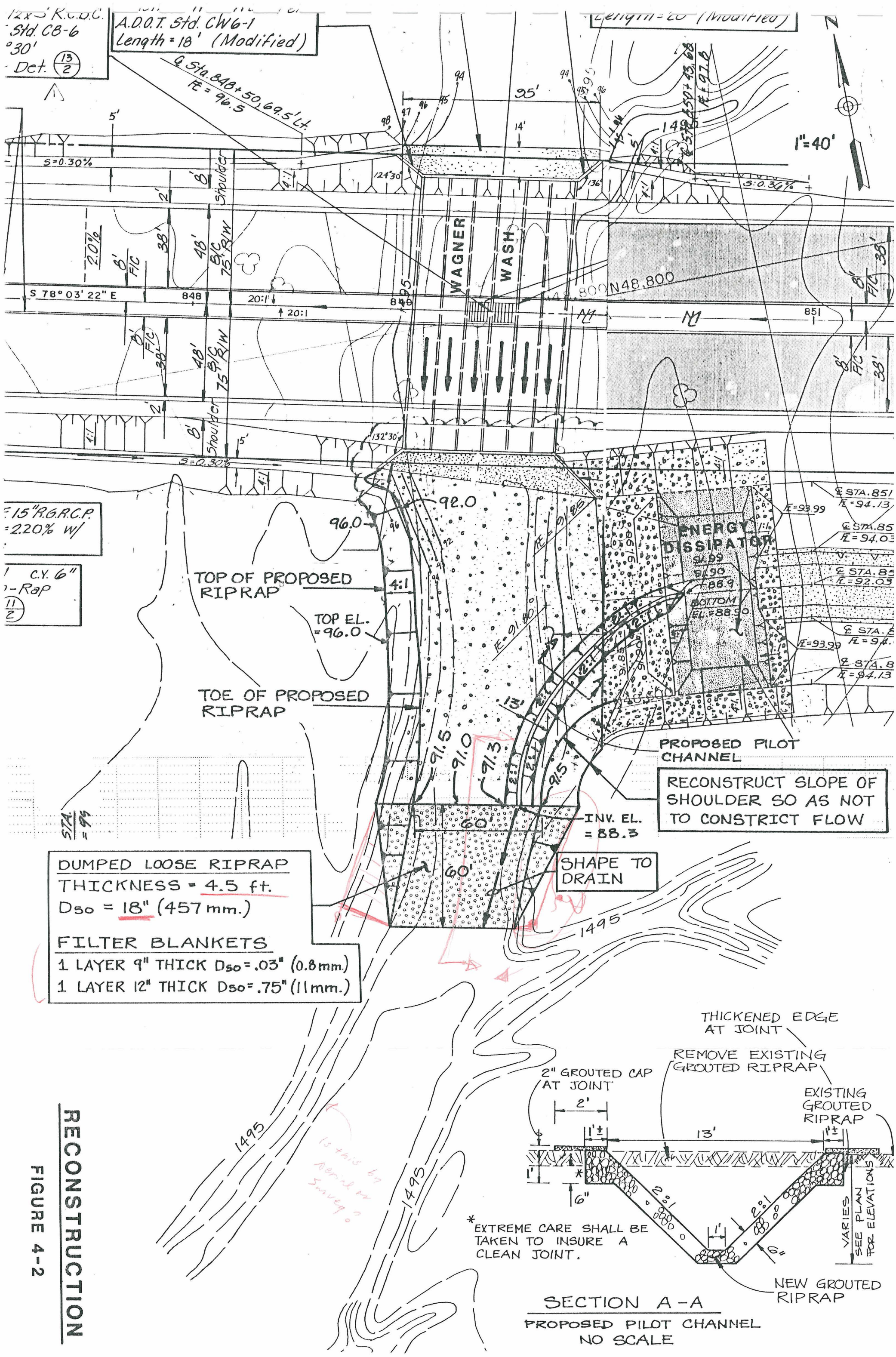


FIGURE 4-1

EXISTING CONSTRICTION AT CONFLUENCE OF INTERCEPTOR CHANNEL & WAGNER WASH



RECONSTRUCTION

FIGURE 4-2

SECTION 5

DAMAGE AT DROP STRUCTURE STATION 859+20

The damage that occurred at this drop structure was extensive and is somewhat perplexing. Photos 5-1 and 5-2 show the damage that occurred at the downstream end of the drop structure where it joins the pneumatically applied mortar (hereinafter referred to as "shotcrete"). Also shown is the buckled shotcrete channel between Stations 859+20 and 857+20.

As discussed in our September 30, 1988 interim report, a contributing factor for much of the damage throughout the interceptor channel was due to construction not being complete and/or not being performed according to the plans prepared by Collar, Williams & White. We believe the cause of the damage at this drop structure to be an extension of the same factors.

Personnel at the Maricopa County Highway Department and Greiner are aware that a complex drainage facility such as the interceptor channel is only as sound as the weakest link within the facility; similar to the strength of a chain (the "weakest link" theory). It was our intention that the drop structure be constructed of 6 inch grouted riprap with a 4 feet deep grouted cutoff wall at the downstream edge to provide a solid base to absorb the energy caused by the water dropping a vertical distance of 5 feet. The details in Figure 5-1 and 5-2 (which are a reproduction of the plans) assumed that a smooth clean joint would be constructed between the grouted riprap and the shotcrete channel, thereby providing an unobstructed flow line. The shotcrete channel was "tied" into the earth channel bottom, to prevent movement, by constructing a 2' deep cutoff wall along the longitudinal edges of the shotcrete channel. This vertical cutoff wall also provides protection from scour (erosion) along the edges of the shotcrete channel and prevents water from undermining the channel. This concept was employed throughout the interceptor channel from Wagner Wash upstream, to Station 964+20. It was imperative, for our design to function properly, that reasonable care be exercised during construction to insure that the intent of the design was met.

It is our belief that either reasonable care was not exercised or field conditions prevented construction of a smooth, clean joint; the result is a poor joint. Specifically, the following items appear to have contributed to the failure.

1. The grouted riprap at the joint with the shotcrete appears not to have been 6" thick. This can be seen in Photo 5-3.

2. The 4' deep grouted cutoff wall was not grouted. The trench was dug, and filled with loose, uncompacted rock. This can be seen in Photo 5-4.

3. There may not have been a clean joint between the shotcrete and grouted riprap. Several other joints along this reach were observed which may have been contaminated with dirt or debris prior to application of shotcrete (See Photos 5-5, 5-7 and 5-8). During the storm, this dirt was washed away leaving a gap between the shotcrete and grouted riprap. Photo 5-6 shows a questionable joint at the failed drop structure; however since the shotcrete channel had been buckled and uplifted throughout this reach, we cannot positively state that the joint problem existed at this location.

We theorize that the effects of any or all of the above items could have allowed damage in this manner:

> Grouted riprap has no structural characteristics unless it is on a solid foundation. The apron of the drop structure was to have been a solid foundation. However, because the grouted riprap was placed on loose uncompacted rock in the cutoff wall, the impact of the falling water could easily have loosened the riprap at the top of the joint (which is directly over the cutoff wall).
>
> This effect would have been compounded if the grouted riprap was thin at this joint or if there was a gap or obstruction at the joint with the shotcrete. The force of the water at this drop structure is significant. Once a gap was formed or the loose riprap settled, the damage would increase to such an extent that the entire area would experience failure. Figure 5-3 graphically depicts the situation at the time of the storm.

It is our understanding that this damage has now been repaired and reconstructed in the field. We do not know if a grouted cutoff wall was constructed. Should Maricopa County desire additional insurance against future failure, Collar, Williams & White proposes an appropriate "patch" over the area to strengthen the riprap and the shotcrete channel.

Photo 5-1, Station 859+20. Looking West.

Photo 5-2, Station 859+20. Looking Southwest. The scour hole occurred at the toe of the grouted riprap.

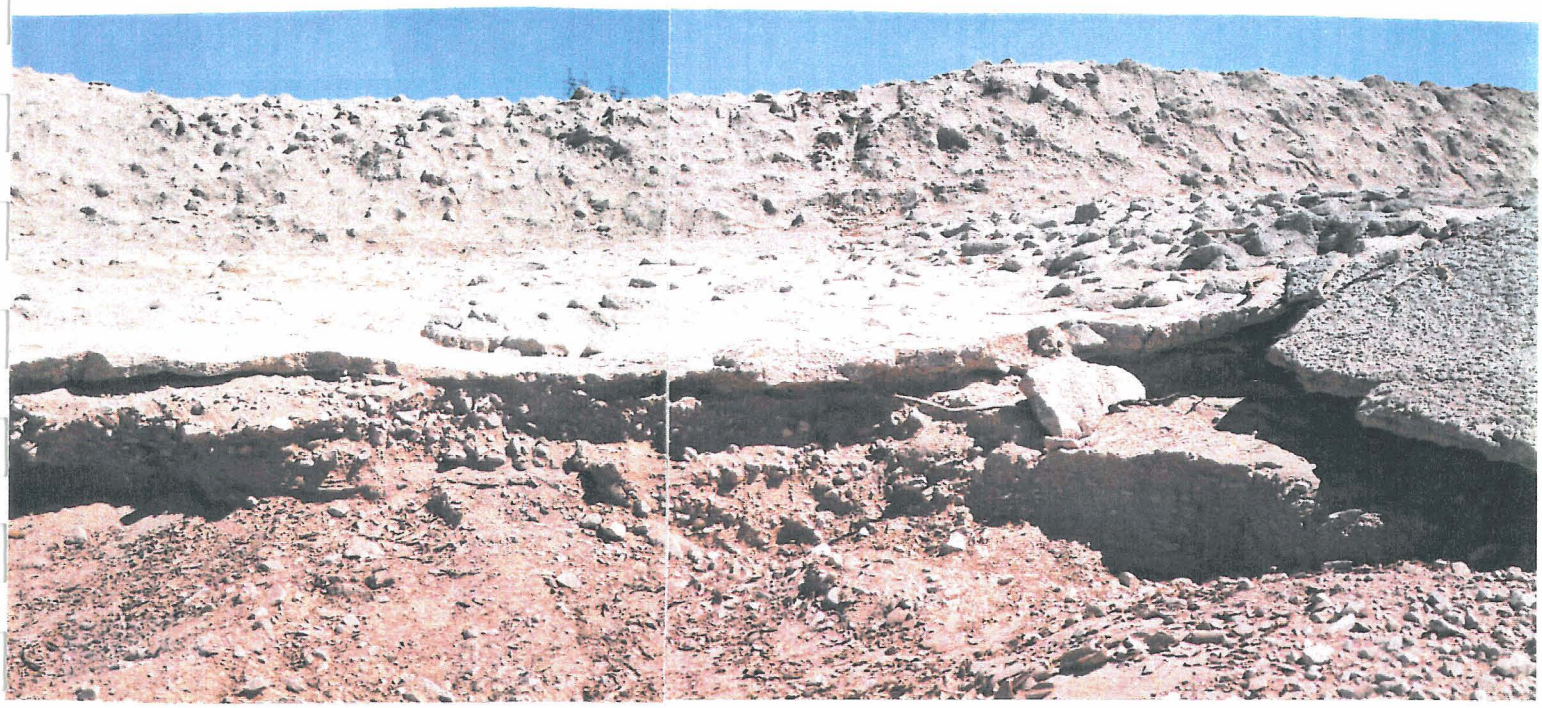


Photo 5-3, Station 859+20. Drop structure failure. Edge of grouted riprap is not 6" thick.

Photo 5-4, Station 859+20. No grout exists in the cutoff wall.

Photo 5-5. Indicates dirt or debris existed when shotcrete was applied. A possible gap exists between the shotcrete and grouted riprap.

Photo 5-6, Station 859+20. Joint between shotcrete and grouted riprap.

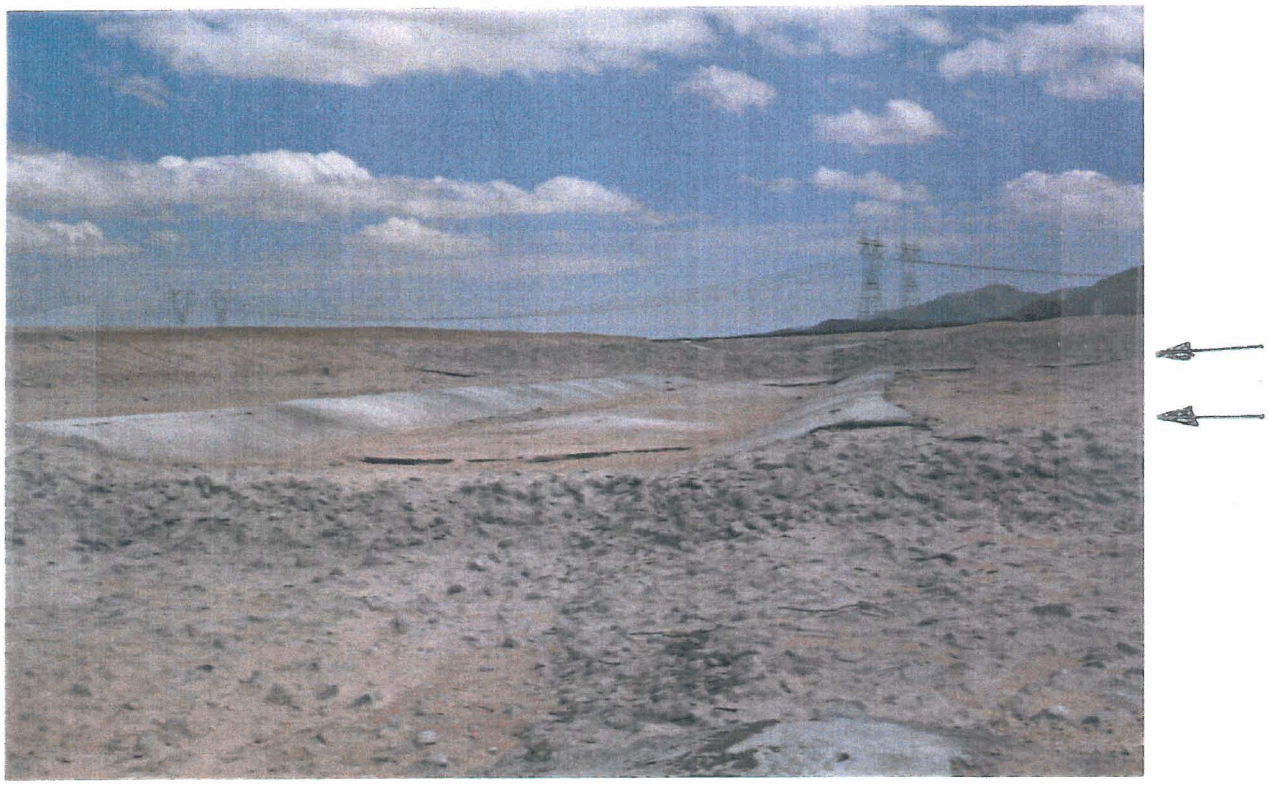
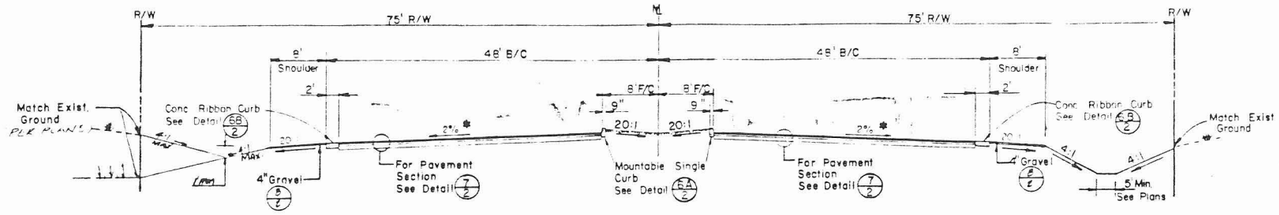


Photo 5-7, looking upstream. Note obstructed flowlines and uneven joints.

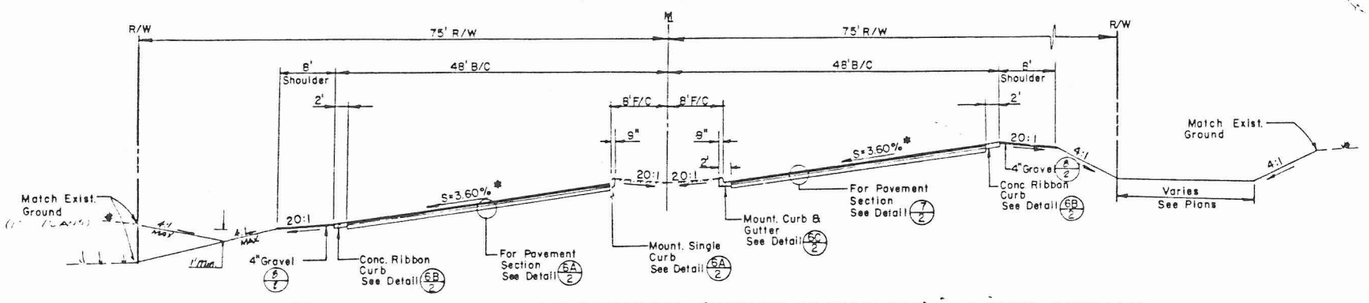
Photo 5-8, looking downstream. Note obstructed flowline and uneven joint.

* MAXIMUM CROSS-SLOPE VARIES AT INTERSECTIONS AND/OR SUPER ELEVATION TRANSITIONS. SEE PLANS FOR SPECIFIC CROSS SLOPES AND ELEVATIONS.



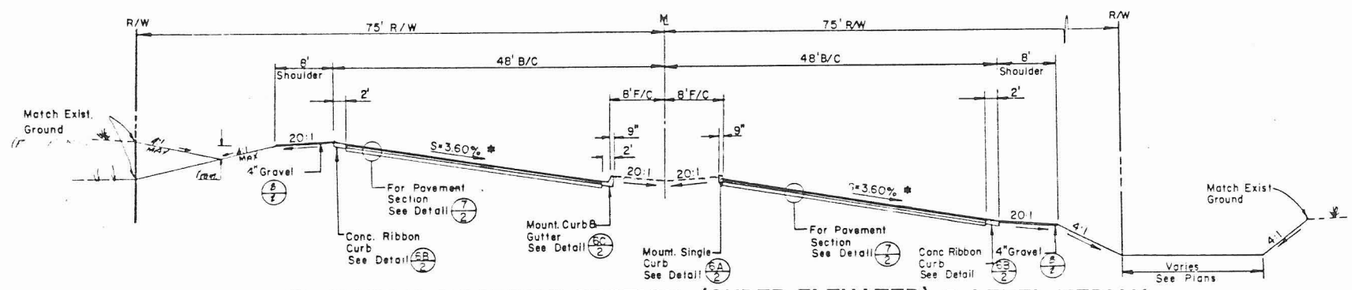
1/2 TYPICAL ROADWAY SECTION (NORMAL CROWN)

N.T.S



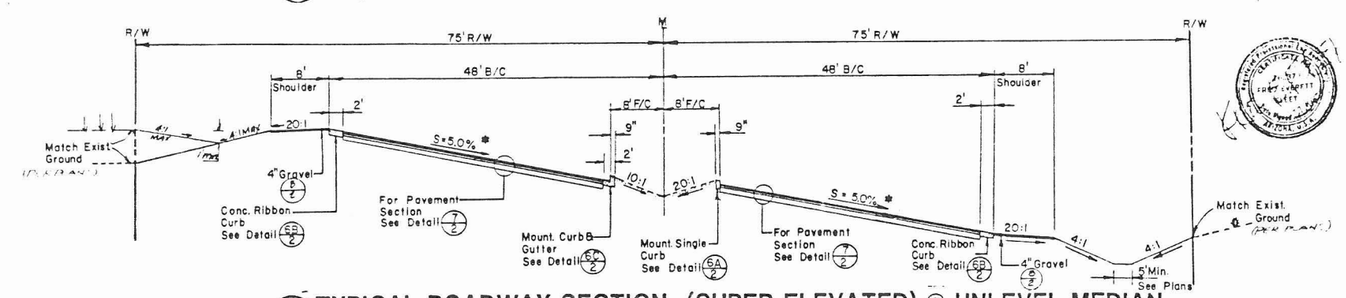
2/2 TYPICAL ROADWAY SECTION (SUPER ELEVATED) @ LEVEL MEDIAN

N.T.S



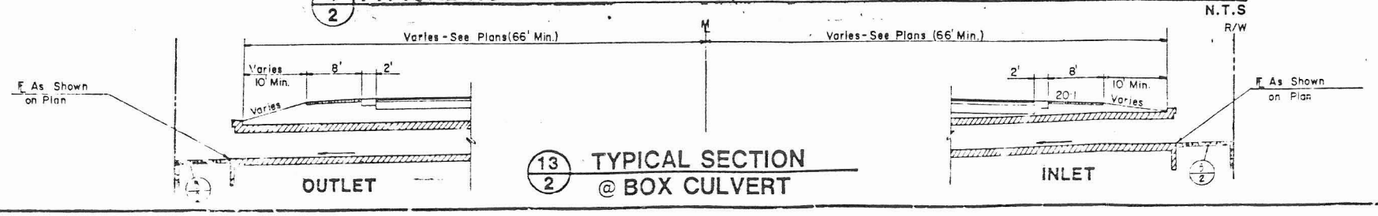
3/2 TYPICAL ROADWAY SECTION (SUPER ELEVATED) @ LEVEL MEDIAN

N.T.S

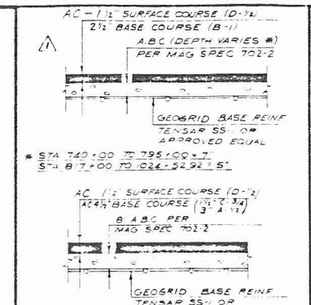


4/2 TYPICAL ROADWAY SECTION (SUPER ELEVATED) @ UNLEVEL MEDIAN

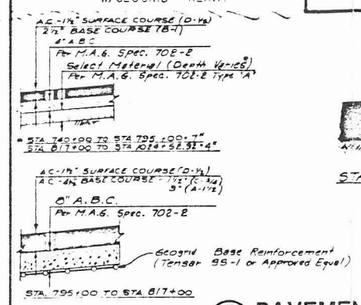
N.T.S



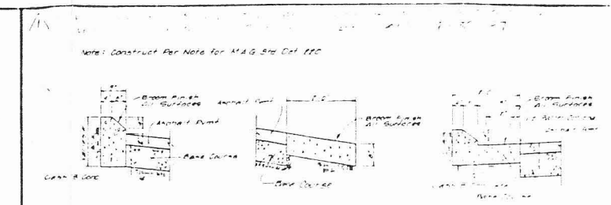
13/2 TYPICAL SECTION @ BOX CULVERT



ALTERNATE "C"
A.C. OVER GRANULAR BASE W/GEOGRID REINF.

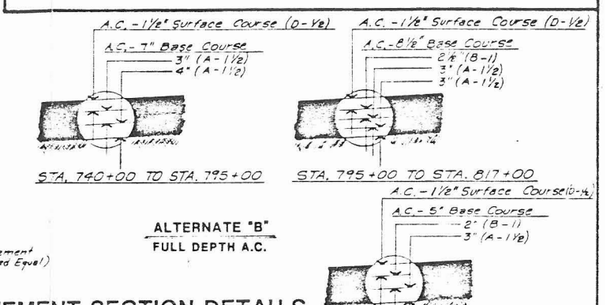


ALTERNATE "A"
A.C. OVER GRANULAR BASE



6/2 CONCRETE CURB DETAILS

N.T.S.



ALTERNATE "B"
FULL DEPTH A.C.

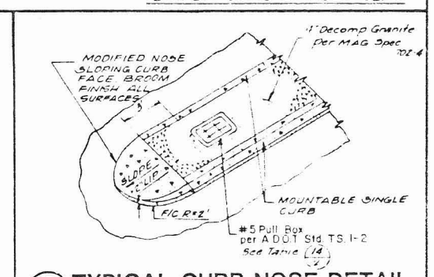
7/2 PAVEMENT SECTION DETAILS

N.T.S

STATION	OFFSET	STATION	OFFSET
784+58.49	55.37'LL.	892+46.95	55.37'LL.
784+58.49	6.00'LL.	892+46.95	6.00'RL.
784+58.49	55.37'RL.	892+46.95	55.37'RL.
785+88.49	55.37'LL.	944+26.26	55.37'LL.
785+88.49	6.00'RL.	944+26.26	6.00'LL.
785+88.49	55.37'RL.	944+26.26	55.37'RL.
837+83.33	55.37'LL.	945+56.26	55.37'LL.
837+83.33	6.00'LL.	945+56.26	6.00'RL.
837+83.33	55.37'RL.	945+56.26	55.37'RL.
839+13.33	55.37'LL.	998+97.54	55.37'LL.
839+13.33	6.00'RL.	998+97.54	6.00'LL.
839+13.33	55.37'RL.	998+97.54	55.37'RL.
891+16.95	55.37'LL.	1000+27.54	55.37'LL.
891+16.94	6.00'LL.	1000+27.54	6.00'RL.
891+16.95	55.37'RL.	1000+27.54	55.37'RL.

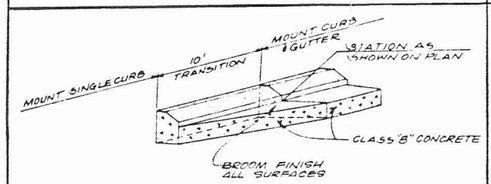
14/2 #5 PULLBOX TABLE

N.T.S.



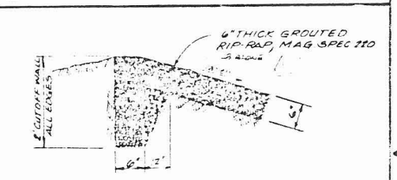
9/2 TYPICAL CURB NOSE DETAIL

N.T.S



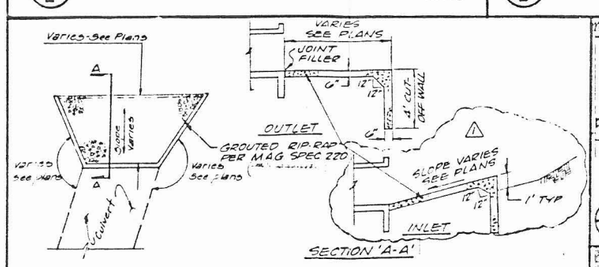
10/2 CONCRETE GUTTER TRANSITION

N.T.S



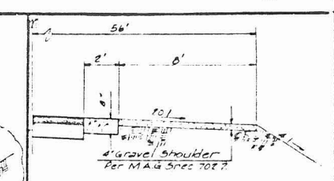
11/2 GROUTED RIP-RAP DETAIL

N.T.S



5/2 RIP-RAP TERM. AT CULVERT (INLET- OUTLET)

N.T.S.



8/2 GRAVEL SHOULDER DETAIL

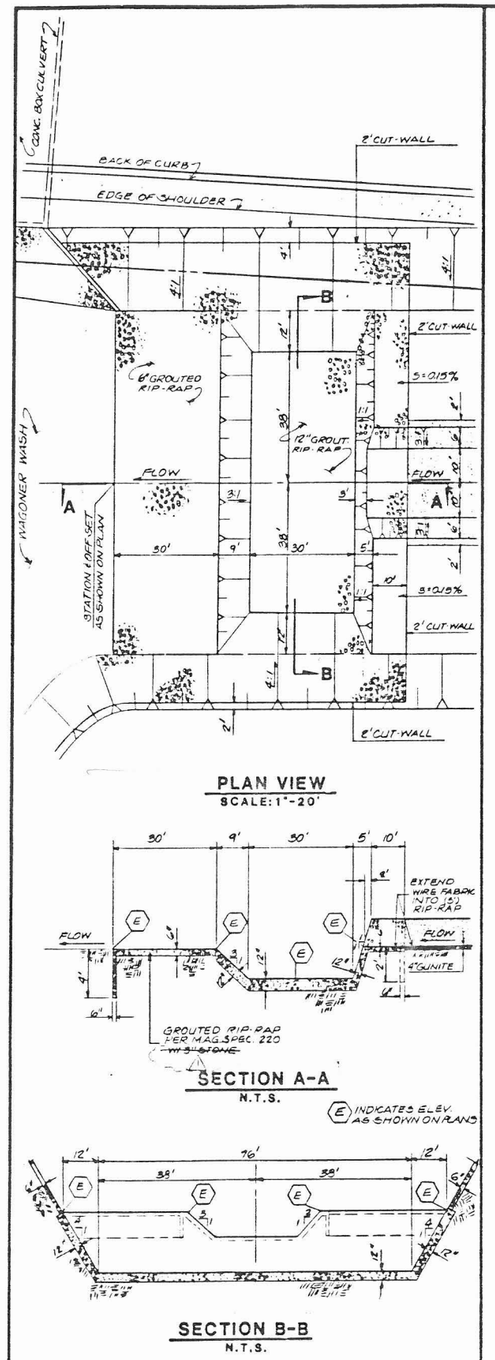
N.T.S.

Dolan, Williams & White Engineering Inc.

850840-5

Figure 5-1

ADDENDUM NO. 4



3/2A ENERGY DISSIPATOR BASIN DETAIL

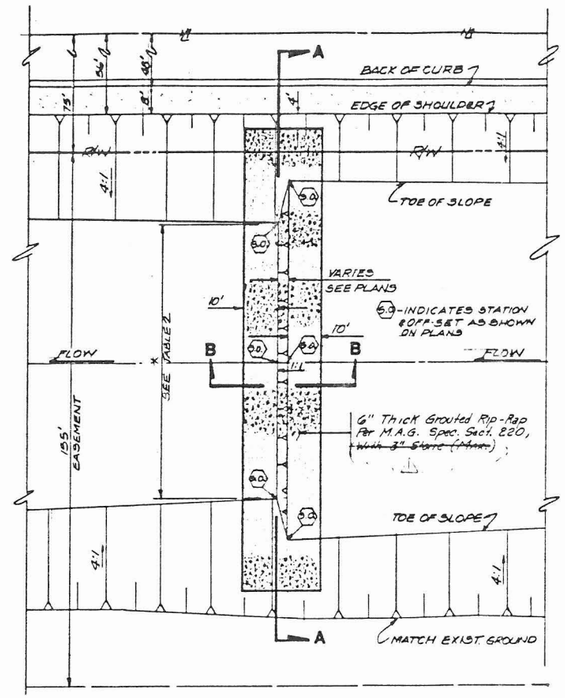


TABLE 2	
W 60'	STA. 987+16.70 to STA. 988+10.43
W 50'	STA. 990+11.03 to STA. 998+34.33

2/2A DROP STRUCTURE DETAIL

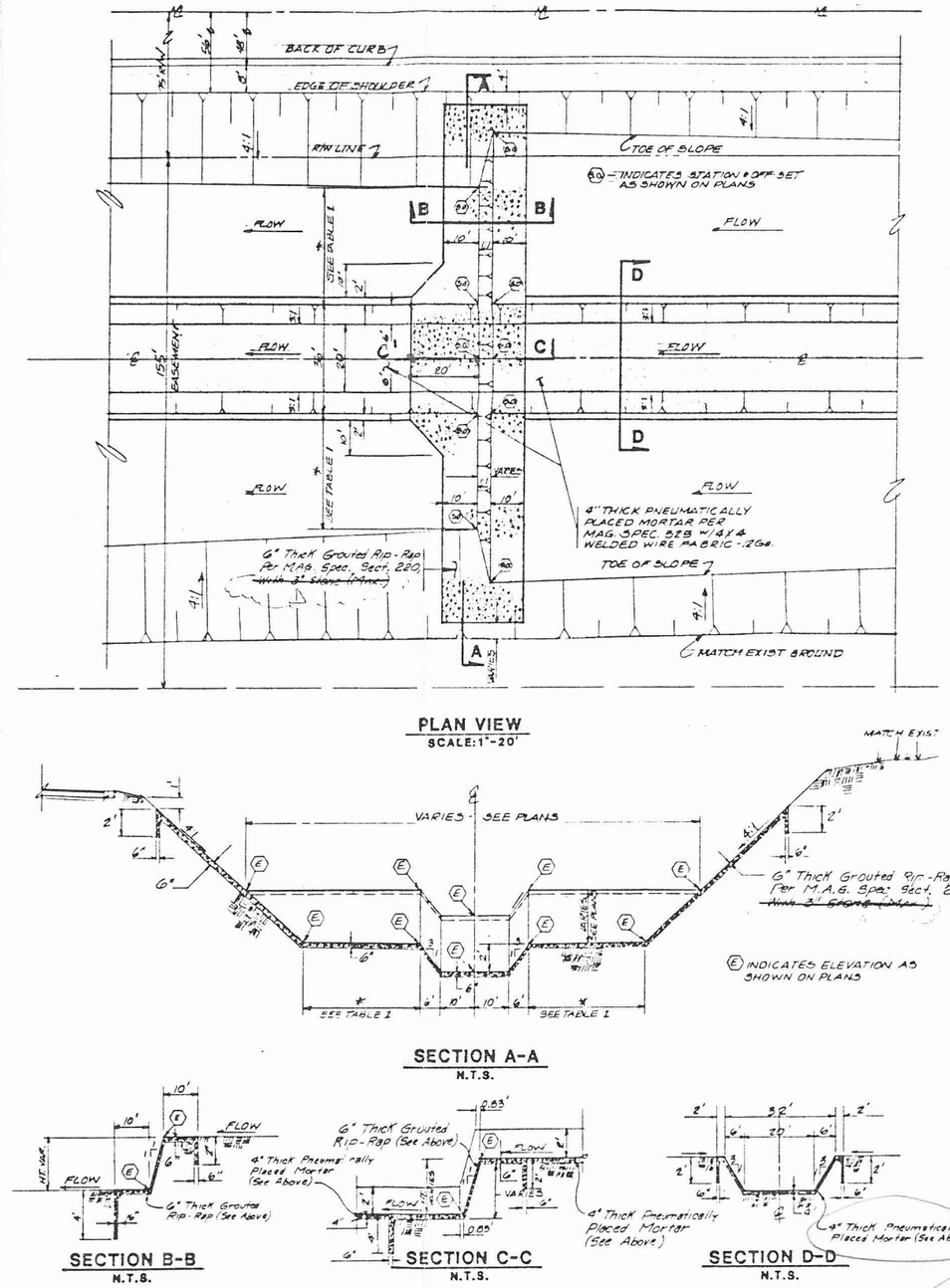


TABLE 1	
W 34'	STA. 884+77.7 to STA. 889+95.65
W 24'	STA. 893+69.99 to STA. 894+16.35

1/2A DROP STRUCTURE DETAIL W/LOW FLOW CHANNEL

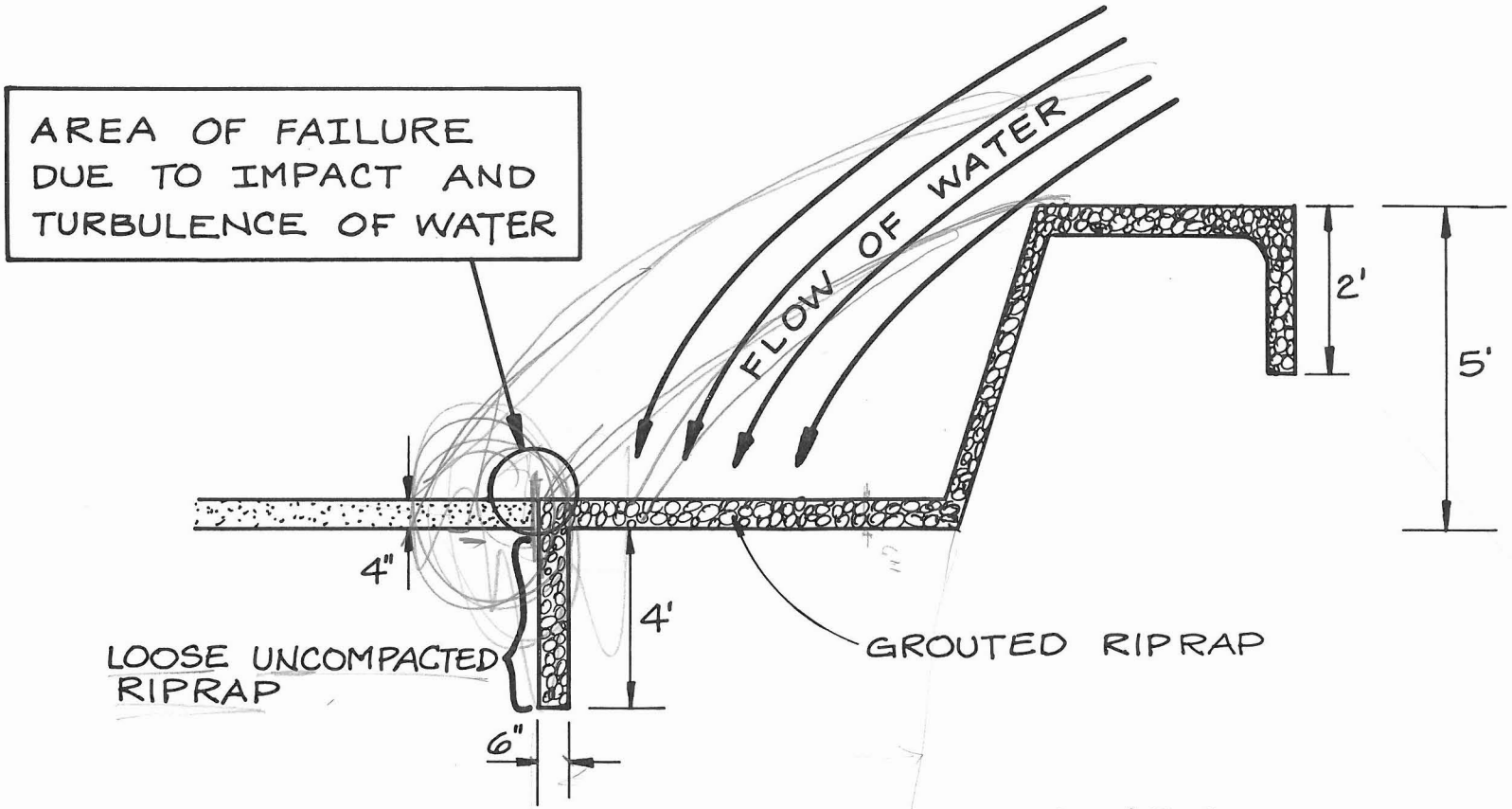
Figure 5-2

Collar, Williams & White Engineering, Inc.

ADDENDUM NO. 1

1 4/30/97 REVISE DIMENSIONS

1 4/29/97 DELETE 3" STONE FROM RIP-RAP



DROP STRUCTURE
STATION 859+20

FIGURE 5-3

SECTION 6

ROADSIDE CHANNEL ENHANCEMENTS

During our field observations after the August 21 storm, we have determined several locations which require additional riprap or minor roadside channel work in Phases I and II. Some of these locations were referenced by Mr. Huang; Collar, Williams & White has discovered additional areas that need minor work.

The roadway channel work consists of regrading the channel, rerouting existing minor washes to a culvert, or deepening the roadway channel. Some of the work has already been completed by the contractor, apparently at the direction of Greiner without our knowledge. We have commented as to whether we believe the work to be satisfactory.

STATION	WORK NEEDED
Phase I	
A. 0+00	The contractor has already installed a channel to divert flow to the culvert at Sta. 5+00. Collar, Williams & White agrees.
B. 12+80	The contractor has already installed a channel to divert flow to the culvert at Sta. 16+00. Collar, Williams & White agrees.
C. 497+22 to 500+12	Deepen and widen channel to divert flow from existing washes north to the culvert at Sta. 500+12.
Phase II	
D. 473+68 to 480+00	This is the area where capacity of the two reinforced concrete box culverts was exceeded. As previously discussed in Collar, Williams & White's letter dated September 30, 1988, the channel will be deepened and re-graded to connect the culverts at Sta. 473+68 and 476+88 to the major culvert at Sta. 480+00.
E. 497+20 to 500+05	Deepen existing roadway channel to allow flows in tributary channels to turn and flow north to culvert at Sta. 500+12.

F.	518+75 to 523+00	Widen the east channel bank between Station 519+00 and 522+00 to provide a smooth diversion of the flows from the east to reach the culvert at Station 518+50.
G.	643+00	The contractor has already installed a channel to divert flow to the culvert at Sta. 645+73. Collar, Williams & White agrees.
H.	658+70	Reconstruct inlet to culvert. The inlet lip is too high.
I.	661+80	The contractor has already installed a channel to divert flow to the culvert at Sta. 658+94. Collar, Williams & White's preference would have been to re-route this wash to the larger culvert at Sta. 665+00.

Some concern has been expressed over minor erosion or wash out of soil behind some of the headwalls or wingwalls at culvert locations. We propose that Maricopa County personnel identify these locations in the field. For most situations, a minor amount of dumped riprap, with or without grout, will probably halt the erosion. Prior to placing the riprap, soil should be excavated such that the finished surface of the riprap does not protrude above existing grade causing runoff to be diverted around the riprap.

SECTION 7

INTERCEPTOR CHANNEL, MISCELLANEOUS DAMAGE

The erosion damage along the south bank of the interceptor channel was extensive at most of the drop structures. Photos 7-1 and 7-2 show an example of the erosion which caused the damage. Exhibit 7-1 is a tabulation of the damage to each drop structure. The tabulation reveals that damage was caused either by the Greiner ditch, by an existing tributary, or both. A review of Exhibit 7-1 shows that the Greiner ditch caused a majority of the damage from erosion along the south channel bank.

The major storm that occurred caused excessive siltation of the interceptor channel. The sediment came from erosion at the tributary washes, erosion at the drop structures, and erosion of the bank from sheet flow. How much sediment came from which source is difficult to define. It should be noted however, that erosion from upstream (washes and sheet flow) and sediment transport is a normally anticipated event in alluvial fans and in the desert environment. After all facilities are constructed, there will still be some sedimentation in the channel following major storms; however, this phenomenon does not indicate an error or omission of the Engineer or Contractor.

After the storm, localized scour was observed along the shotcrete low flow channel at the trailing edges of the drop structures. This scour was isolated to only a few of the structures and does not appear to be a widespread problem.

Photos 7-3 and 7-4 show this localized scour. These photos further show that the longitudinal edges of the low flow channel were not constructed according to the plans. The edge detail (in the plans) for the low flow channel was to have a 2' cutoff wall at the outside edge of the shotcrete channel, forming a vertical face to prevent undermining by turbulent flow. Exhibit 5-2 (Section 5), Detail 1-2A, Section D-D illustrates the intended construction.

The overhang that was constructed (shown in Photo 7-4), probably aided turbulence in this area (under the overhang) and probably aggravated or increased the scour depth.

SUMMARY OF DROP STRUCTURE DAMAGE

LEGEND

ND - No Damage
OS - Overland Sheet Flow
NW - Natural Wash
GD - Greiner Ditch
DR - Damage Repaired

DROP STRUCTURE STATION	CAUSE	DISCUSSION
854+80	ND	
857+20	ND	
861+20	DR	
859+20	DR, GD	LOCATION OF DROP STRUCTURE/CHANNEL FAILURE.
864+20	ND	
867+20	GD	
870+00	GD	EXCESSIVE EROSION.
873+00	ND	
877+00	ND	
880+00	DR, GD	
882+87	DR	
887+00	DR	
890+00	NW	
893+73	NW	
897+06	DR, GD	
900+00	DR, GD	
903+00	GD	
907+00	GD	
910+00	GD	
913+00	GD	
916+00	GD, NW	WASH AT 917+00 WAS PROBABLY INTERCEPTED BY GD.
923+00	GD	
919+00	GD	HARDPAN WAS PRESENT TO CONTROL HEADCUT.
926+60	GD	
930+06	GD	
933+53	GD	
937+00	NW	GROUTED RIPRAP AT INLET OF NATURAL WASH AT 937+20 NOT INSTALLED.
939+00	GD	
941+00	NW	
943+00	ND	GROUTED RIPRAP APRON FOR INLET CHANNEL WORKED.

EXHIBIT 7-1

DROP STRUCTURE STATION	CAUSE	DISCUSSION
945+80	NW	LARGE NATURAL WASH.
950+00	DR, GD	
953+00	ND	UPSTREAM GROUTED INLET WORKED AT 953+20.
955+00	NW	
958+00	GD	
961+20	GD, DR	
964+20	GD	
966+00	NW	
967+20	NW, GD	
970+20	NW	
972+90	GD	
976+13	GD, NW	
980+13	GD	
983+13	GD	
986+13	NW	
990+13	GD	
994+13	NW	
998+38	DR	PARTIALLY REPAIRED.

EXHIBIT 7-1

Photo 7-1, looking east. Concentrated flows from the Greiner ditch badly undermined the grouted riprap.

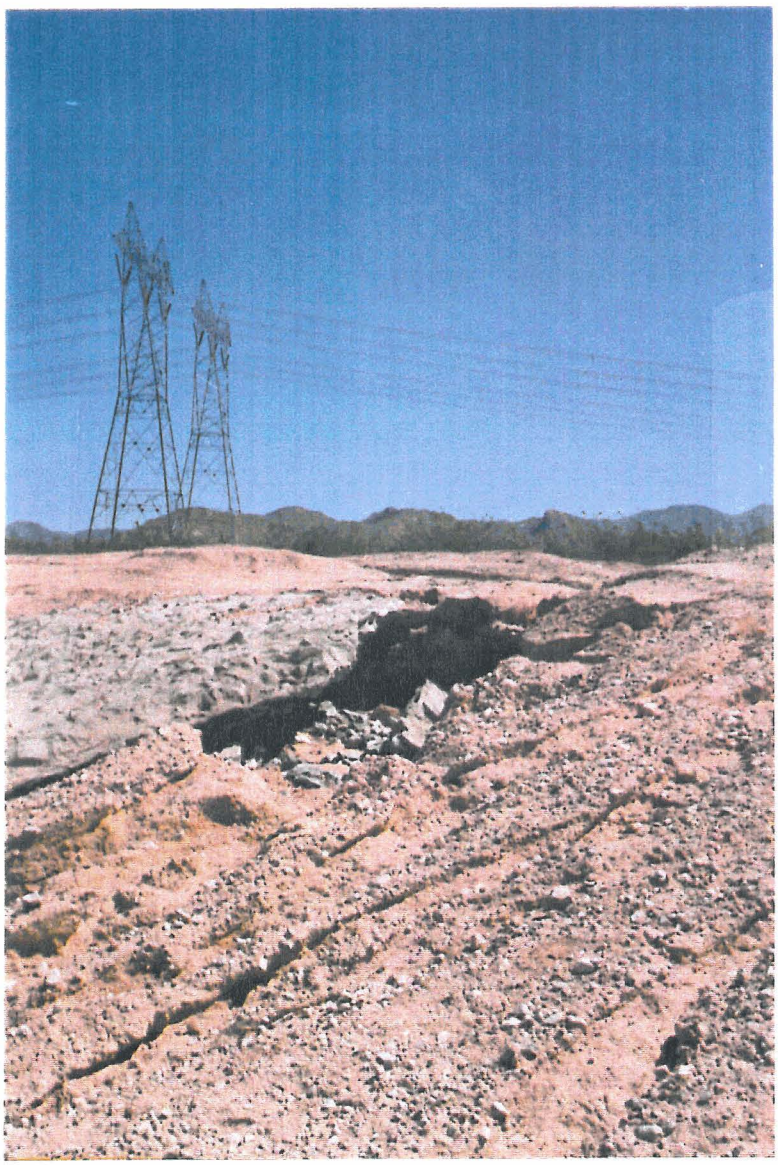


Photo 7-2, looking south. This is the same location as Photo 7-1, no grout exists in the cutoff wall.

Photo 7-3, looking southwest towards downstream. Note undermining of shotcrete channel and poor joints. Also note the overhanging lip of the shotcrete channel.

Photo 7-4, looking southwest towards downstream. Note the approximate 1' overhang beyond the 2' cutoff wall. This overhang allows scour under the "lip" of the shotcrete channel.

where is this

COLLAR, WILLIAMS & WHITE ENGINEERING

2702 NORTH 44th STREET, SUITE 100A, PHOENIX, ARIZONA 85008 (602) 957-3350

September 30, 1988

Mr. D.C. Black
Special Assistant to the County Engineer
Maricopa County Highway Department
3325 West Durango
Phoenix, Arizona 85009

Re: Sun Valley Parkway
Drainage Enhancements

Dear Mr. Black:

Pursuant to the meeting in your office on September 14, 1988, this letter represents our initial interim evaluation and preliminary findings relating to the August, 1988 storm damage. This interim evaluation, and the recommendations contained herein, have been expedited in order to allow construction to continue so as to avoid delay in the schedule and increased costs due to delay. We propose to follow up this letter within two weeks with a more definitive report.

Our investigation into the excessive erosion of the channel banks in the area of Station 840+00 to 1024+00, Phase II-B and Station 0+00 to 260+00, Phase I-A and the resulting siltation of the channel after the storms of August 19, 20, 21 and 23, has revealed these preliminary results:

Item 1 - The erosion protection structures designed by Collar, Williams & White Engineering were not constructed according to the plans.

<u>All</u> grouted riprap areas included a 2' deep grouted cutoff wall along all edges specified in the plans. These details were specified on Sheet 2, Detail 4/2, Phase I-A; Sheet 2, Detail 10/2, Phase I-B; Sheet 2, Detail 11/2, Phase II-A; and Sheet 2, Detail 11/2, Phase II-B. This cutoff wall was imperative to our design in order to prevent surface water from undercutting the erosion protection structure; such undercutting allows water to erode the soil beneath the grouted riprap, thereby leading to the eventual failure of the erosion protection structure.

As evidenced from visual observation along the entire reach of the interceptor channel where erosion and/or scour have occurred, there is no grout in these cutoff walls. While we cannot categorically state at this time that no cutoff walls were grouted, the evidence indicates that the grout called for in the design by Collar, Williams & White Engineering was non-existent in a majority of the cutoff walls along the interceptor channel. Therefore, the erosion protection structures as designed, were exposed to undercutting and failed in many areas.

As you know, Collar, Williams & White Engineering designed the erosion protection structures (and it provided construction staking services for the Contractor, as and when requested by the Contractor); however, Collar, Williams & White Engineering was not employed to provide construction observation services for Sun Valley Parkway to assure that the construction proceeded in accordance with our design and our plans. The construction observation services were awarded to Greiner, Inc. in order to have an independent firm verify that the Contractor performed its work in accordance with the Design Engineer's plans, presumably to avoid the potential for any conflict of interest between the designer and the observer.

Item 2 - Apparent lack of inspection of the construction of the erosion protection structures.

As specified in the plan details itemized above, the grouted riprap is to conform to MAG Standard Specification 220. An excerpt from Section 220.5, GROUTED RIPRAP, referring to the grout mix, states:

> "The amount of water shall be such as to permit gravity flow into the interstices with limited spading and brooming. The consistency of the grout shall be as approved by the Engineer."

Because we have observed the complete lack of any grout in many of the cutoff walls (no grout), we believe the above MAG Standard Specification has not been met by the Contractor; and since Greiner was to approve the consistency of the grout (which is not there) and insure compliance with the plans, we assume that Greiner has not fullfilled its observation service responsibilities with respect to these cutoff walls.

Item 3 - Pockets of unanticipated highly erodible soil and construction of an unauthorized parallel collector ditch.

Throughout the interceptor channel and the retention basins (Station 840+00 to 1024+00, Phase II-B, and Station 0+00 to Station 260+00, Phase I-A), we have observed numerous pockets of highly erodible soil. These pockets are non-distinct, random, and were not discernable from the information in the soil tests performed along this reach. The type and frequency of the soil tests were as specified by Maricopa County Highway Department. The cost of unlimited, pre-design soil tests along this entire reach was prohibitive, and certainly not something called for or performed in the custom and practice of design engineers in this community. Ordinarily, if such highly erodible soil is discovered at all during a project, it occurs as a result of field observation by the Contractor or the Engineer that has the responsibility for construction observation.

The channel bank has eroded and fallen into the channel in areas where this highly erodible soil has been found. This has occurred at random locations of overbank sheet flow, existing wash entrances, and concentrated flows into the channel from the unauthorized parallel collector ditch constructed adjacent to the interceptor channel designed by Collar, Williams & White Engineering. Cliff Williams of Greiner, Inc. has acknowledged Greiner's responsibility for unilaterally directing the Contractor to install this parallel collector ditch (the "Greiner Ditch"); we were not consulted.

The Greiner Ditch was not a part of our plans, and we believe the Greiner Ditch caused concentrated flows of stormwater to enter the channel at unprotected locations or at the drop structures which were not designed to accept such concentrated flows from the south. The effects of the Greiner Ditch, when coupled with the lack of grout in the cutoff walls, allowed undercutting and considerable erosion of the bank at these locations.

Because of the storm damage, Maricopa County has now requested that certain drainage enhancements be considered by Collar, Williams & White Engineering to further minimize future maintenance of the roadway and the related drainage facilities. Presented below are some of the most pressing issues and our recommendations concerning the same.

1. Adequacy of the retention dikes and the low flow pipes (Phase I-A).

   Some concern has been raised about the low flow pipes through the retention dikes. One statement was made that the low flow pipes are undersized and therefore water overtopped the dikes and washed them out. This statement is incorrect and evidences a misconception or misunderstanding of the intent of our design of the dikes and low flow pipes.

   Design of the retention dike system works in this manor: The retention basins will receive runoff and the water level will rise near the top of the dikes. Collar, Williams & White Engineering intended that the water will flow over the top of the dike into the next retention basin, or into a channel and through the culvert under the road. The low flow pipes, installed at the bottom of the retention basin, are merely to "bleed off" the water level in the basin at a controlled rate when the runoff ceases filling the basin. The low flow pipes were intentionally not sized to convey all direct run off from one retention basin to the next.

Three (3) of the uncompleted retention dikes were washed out during the storms. Loose riprap had been placed on the dikes but it had not yet been grouted. The soil composition of these dikes was virtually all sand. Therefore, when the water overflowed these uncompleted dikes, as fully anticipated in our design for the completed dikes, erosion occurred and the dikes failed.

Had the grouted riprap been in place on these dikes, the failure would not have occurred. This is evidenced by the fact that all other dikes that were completed and grouted did not fail.

2. Adequacy of the grouted riprap at the retention dikes.

Based on our observation of the highly erodible soil after the storms, we propose additional riprap protection be constructed at the retention dikes to minimize your concern about future maintenance. Because of the excessive instability of the soil, we propose adding grouted riprap at several locations that have a potential for future erosion. Had the soil with which these dikes were constructed been of more stable composition, we feel that our original design would have been adequate.

Attached are copies of the plan view along Phase I-A of the project highlighting those additional areas to receive grouted riprap, which is to be installed in the same manor as specified in the plans.

Please particularly note that cutoff walls <u>are required</u> at the locations indicated by an asterisk (*). All other locations do not require installation of these cutoff walls.

The cutoff walls should be constructed according to our original plan specifications, or as directed by Greiner through its change order.

3. Storm water on the roadway at Stations 473+68 and at Station 476+88, Phase II-A.

   There is no question that the storm water runoff concentrating at these RCBC's (reinforced concrete box culverts) exceeded their capacity. In Mr. Huang's memo to D.C. Black dated September 8, 1988, he explained in detail the likelihood that "breakout" occurred in the upstream watershed. This is quite common in alluvial fans where, during a storm, existing washes may "breakout" of their normal course and cross over and discharge into an adjacent watershed.

   We recommend a very simple and inexpensive solution to prevent re-occurrence of exceeding the culvert's capacity in the future: Lower the invert of the existing roadway channel along the east side of the Parkway to connect the RCBC's at Stations 473+68, 476+88, and 480+00. This concept was incorporated into our plans at several locations along the Sun Valley Parkway with success. The three existing culverts contain adequate capacity for the watersheds above them and the larger channel will allow the flows to equalize between the three culverts.

   We are revising the plans accordingly and we will forward prints very shortly.

4. Excessive scour at the downstream face of the grouted outlet protection on Wagner Wash at Station 849+00, Phase II-B.

   Scour holes 3 to 5 feet deep have occurred at the downstream face. Our plans called for a grouted riprap cutoff wall, as previously discussed. No grout exists in the exposed face and the riprap has deteriorated.

In addition, the outlet was not constructed geometrically according to the plans of Collar, Williams & White Engineering. Our plan detail shows a trapezoidal section with a 50' bottom width and a 90' top width. Survey cross sections performed on September 26, 1988 show that the outlet was constructed with a 26' bottom width, and 90' top width, thereby reducing the cross-sectional area through which the water must flow. In addition, the throat of the outlet is narrowed along the west side and further impedes the flow of water.

These two factors have caused a severe constriction at the outlet, possibly increasing velocities and causing excessive scour. We recommend the following action:

a. Remove the west riprap bank and regrade both the throat and outlet cross section to match the existing downstream channel.

b. Reconstruct the cutoff wall with proper grouting.

c. Place medium to large diameter riprap from the face of the cutoff wall to a point downstream.

We are currently preparing details and calculations to determine the geometrics of the work now required in this area.

We are proceeding to assess the remainder of the drainage issues and will formally respond as agreed. It should be noted that we are exploring solutions for channel bank stabilization that we believe will cost only a fraction of the $2,000,000 mentioned on Page 1 of the Greiner memo dated August 31, 1988.

I believe another matter needs your attention. During the construction process, we have not been included in the distribution of matters concerning this project, nor have we been consulted with prior to issuance of change orders which directly affect our plans. Since the meeting at your office where we discussed this matter, additional correspondence regarding the storm damage has been distributed by Greiner, Inc. and once again we were not copied directly.

I respectfully request that you direct the Engineer and other involved parties to copy us directly in future correspondence. That correspondence should be sent to the attention of Les Olson, Operations Manager.

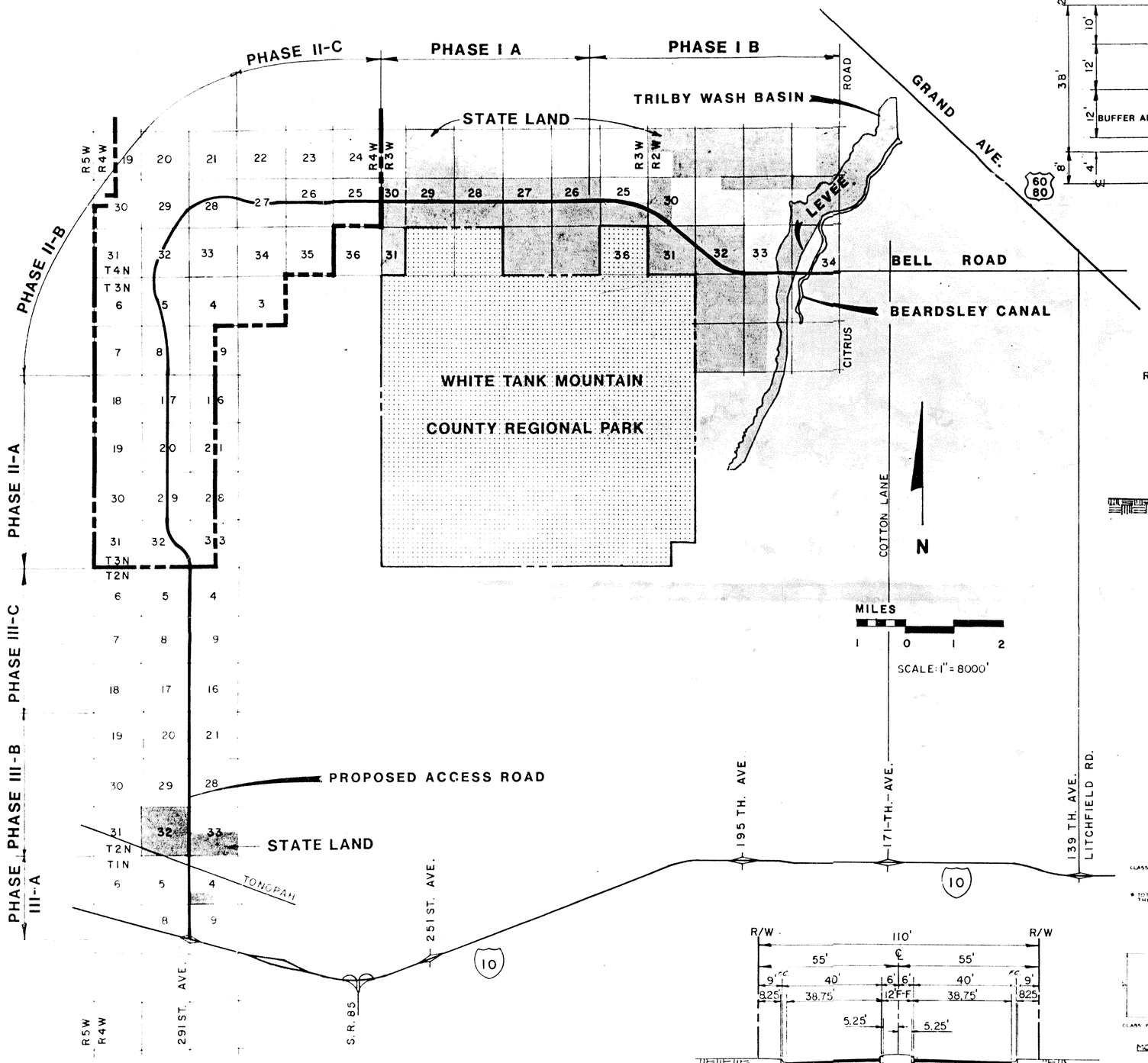
Sincerely,

Donald H. Collar, P.E., R.L.S.
President

LFO/tw

Enclosure

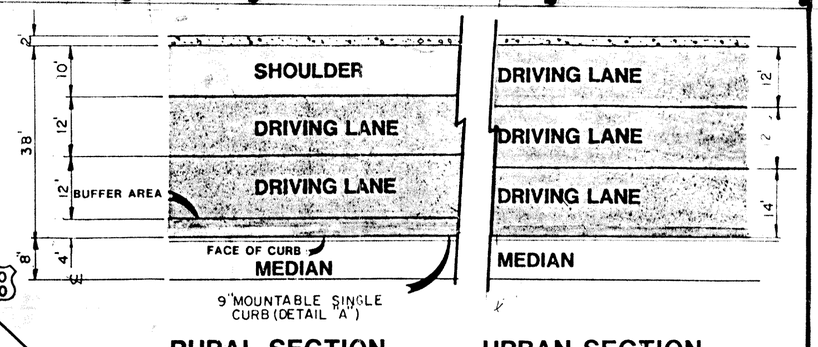
xc: Thomas J. Phelan, Maricopa County Highway Department
Nicholas P. Karan - Maricopa County Flood Control District
L.C. Huang - Maricopa County Flood Control District
Robert M. Williams - Burns International
Robert Mitchell - Burns International
George Seldin - Sun Valley Public Improvement Corp., no encl.
Andrew S. Hendricks - Gaston & Snow, no encl.
Ed Raubenheimer - Hansomb & Associates
Peter K. Kompaniez - Heron Financial Corporation, no encl.
Dennis J. White - Heron Financial Corporation, no encl.
Bruce Gulledge - Security Pacific Merchant Bank, no encl.
Eugene R. Shulze - Greiner Engineering Sciences, Inc.
Phil Turner - Greiner Engineering Sciences, Inc.
Cliff Williams - Greiner Engineering Sciences, Inc.
Ron Pulice - Pulice Construction
Don Webb - Pulice Construction
Arthur E. Romley - Romley & Romley
Lyle Gabrielson - Rick Engineering, no encl.
Dennis Stryker - Rick Engineering, no encl.



PROPOSED PARKWAY

FOR

WHITE TANK MOUNTAIN DEVELOPMENT AREA

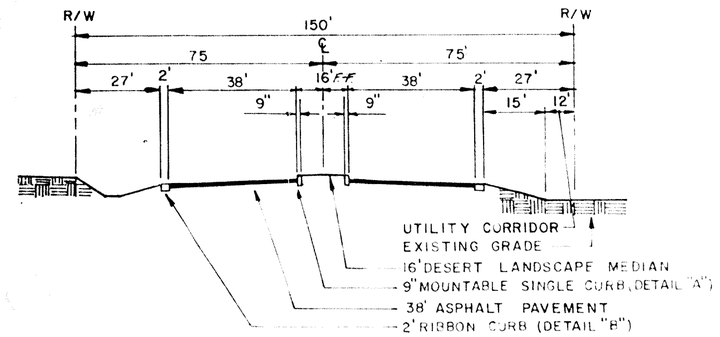


RURAL SECTION

URBAN SECTION

STRIPING DETAIL

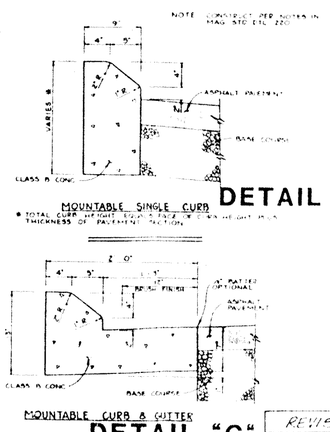
1" = 20'



TYPICAL SECTION

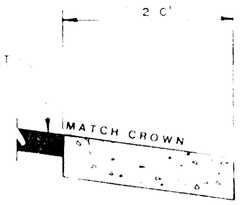
PHASES I-A & B, II & III-B

N.T.S.



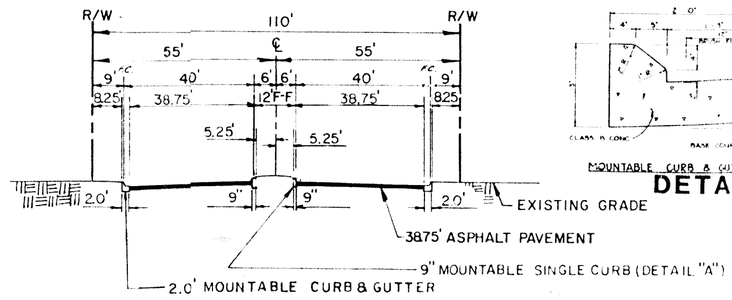
DETAIL "A"

DETAIL "C"



DETAIL "B"

MAG STD 220 (TYPE "B")



TYPICAL SECTION

PHASE III-A

REVISED	BY BR	DATE JUNE 20, 86	
REVISED	BY BR	DATE MAY 30, 86	
REVISED	BY BR	DATE MAY 5, 86	
REVISED	BY URR	DATE APRIL 25, 1986	
REVISED	BY JWT	DATE APRIL 8, 1986	
REVISED	BY CEF	DATE JAN 21, 1986	
REVISED	BY CEF	DATE JAN 9, 1986	

Dollar Williams & White Engineering Inc.

PHASING PLAN

Phoenix Locations

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(602) 957-3350

RECON (Regional Environmental Consultants)
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Scottsdale, Arizona 85251
(602) 947-8042

San Diego Locations

Rick Engineering Company (Main Office)
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5353 Mission Center Road, Suite 316
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(619) 729-4987

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San Marcos, California 92069
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Riverside, California 92507
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Mission Aerial Photos, Inc.
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COLLAR, WILLIAMS & WHITE ENGINEERING