11-29-93

STUDY OF FLOOD CONTROL MEASURES AT 40TH ST. AND DOUBLE TREE RANCH ROAD

PROJECT ST - 75235.00

CITY OF PHOENIX, ARIZONA

DASHNEY AND ASSOCIATES INC.
4323 N. 12TH ST., SUITE 100
PHOENIX, ARIZONA

Dashney and Associates, Inc.
engineers • planners • surveyors

December 23, 1976

Engineering Department
City of Phoenix
700 Municipal Building
251 West Washington
Phoenix, Arizona 85003

Attn: Mr. J.E. Attebery, City Engineer

Re: Project No. ST-75235.00

Gentlemen:

We submit herewith Volume I of the final report for the above project for review and approval, in accordance with Contract No. 16714, dated April 28, 1976.

The rather voluminous hydrologic and hydraulic computer computations for this project, contained in Volumes II, III, IV, and V have been previously submitted.

Respectively,
DASHNEY AND ASSOCIATES, INC.

Rolf Erikson

Rolf Erikson, P.E.
Project Engineer

RE:sd

Enc.

4323 NORTH 12th STREET / PHOENIX, ARIZONA 85014 / PHONE 264-3768

STUDY OF FLOOD CONTROL

MEASURES

AT 40TH STREET AND DOUBLE TREE RANCH ROAD

PROJECT: ST-75235.00

CITY OF PHOENIX

ARIZONA

DASHNEY AND ASSOCIATES, INC.

4323 North 12th Street, Suite 100

Phoenix, Arizona 85014

October 7, 1976

Registered Professional Engineer (Civil)
CERTIFICATE EXPIRES
ROLF ERIKSON
DEC. 31, 19
ARIZONA U.S.A.

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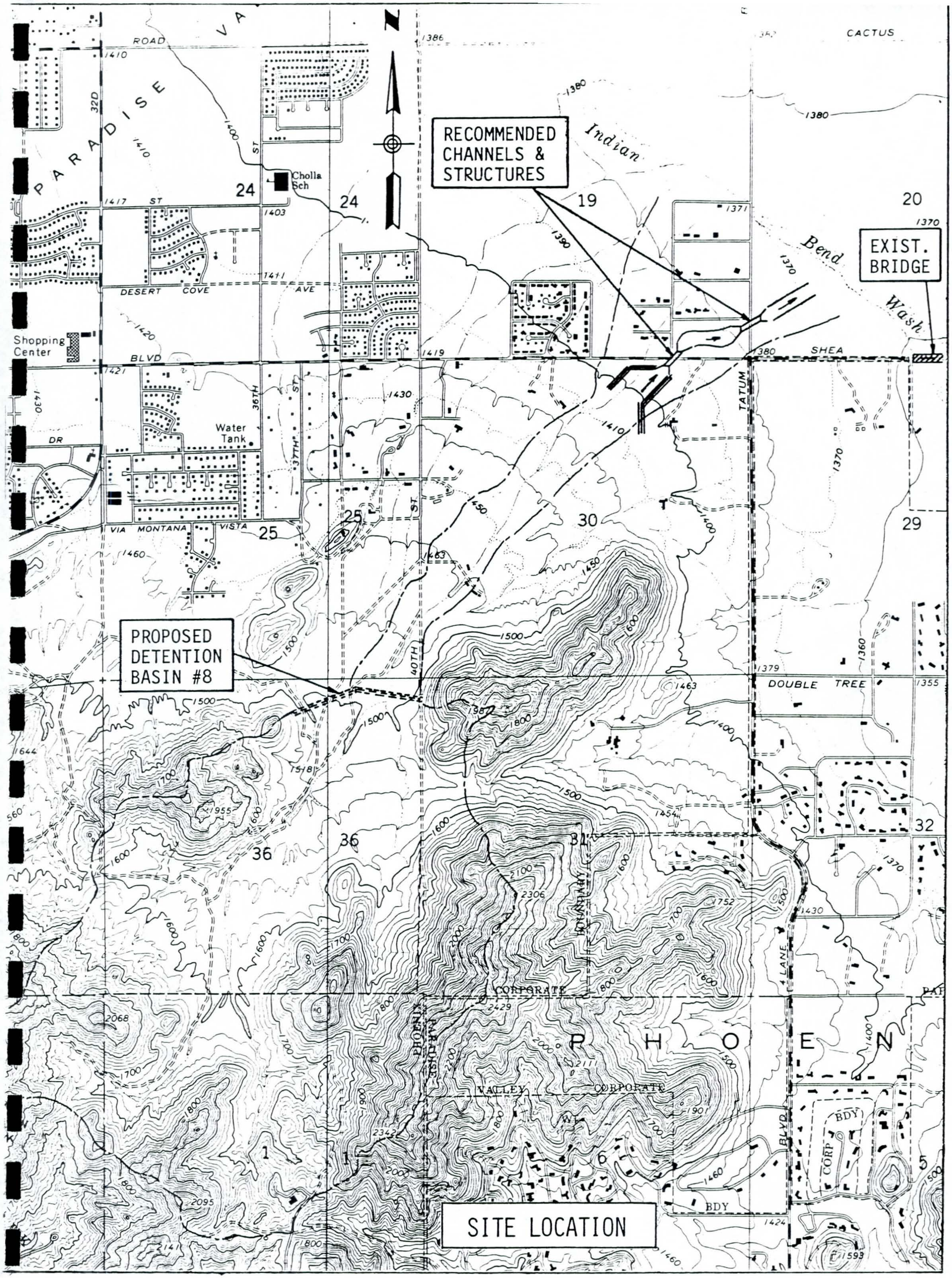
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ROAD
DESERT COVE AVE
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SUMMARY AND RECOMMENDATIONS

As the result of the following study and report concerning the desirability of a flood control structure to be located near 40th Street south of Double Tree Ranch Road, absolutely nothing could be found to justify its construction, either on the basis of pure economics or from an aesthetic standpoint. Besides examining in detail the effects and benefits of Detention Basin #8, located in an investigation of the North Phoenix Mountains by John Carollo Engineers (Project ST-71185.00), two similar structures - positioned somewhat upstream from the latter - were also studied. In either case, not a single item for the justification of its construction could be found. In all instances, the benefit-cost ratios were tremendously low - ranging from 0.10 to 0.40 (depending upon the downstream channel utilization and configuration). For a somewhat lesser amount of capital cost, a new downstream channel could be constructed to accommodate the 100-year runoff and also drainage structures, designed for the 25-year storm, added below both Shea and Tatum Boulevards. However, as in the case of the detention dams, none of the various downstream rechannelization, with associated structures, were found to have any true economic justification. Nevertheless, inasmuch as Shea Boulevard is being developed into a full arterial, and a bridge is being built on the roadway alignment easterly of this project to span Indian Bend Wash, logically some measures should be taken on Shea Boulevard also to accommodate the runoff from the North Phoenix Mountains. In addition, a storm drain is currently under design (Project P-74237) to provide for all watersheds to the south of Shea Boulevard from 32nd to 48th Street (Tatum Boulevard). The latter does not take into consideration the drainage area which is the subject of this study and report.

In view of the foregoing, and particularly since street drainage projects inside the City of Phoenix are undertaken more as a matter of simple "good housekeeping" rather than on the basis of pure economic justification, construction is recommended for the channels and drainage structures adjacent to both Shea and Tatum Boulevards, as depicted by PLAN 13 of this study and report.

LOCATION OF PROJECT

This project is located on the northerly slopes of the Phoenix Mountains (more popularly known as the "North Phoenix Mountains") approximately 9 miles north-northeasterly from the center of Phoenix, Arizona.

DESCRIPTION OF AREA AND PROBLEM

The watershed under study (totaling over 2 square miles) is "tear-drop" in shape, with the wider portion to the south being along the uppermost ridges of the Phoenix Mountains - while the narrow portion, representing various "braided" outflow channels, extends in a north-northeasterly direction to junction with Indian Bend Wash centered approximately at an intersection of Tatum Boulevard (48th Street) and Cholla Street (Elevation: 1371). The most southwesterly extremity of the watershed is marked by Squaw Peak (Elevation: 2608), and the easterly edge at various points lies within the corporate boundary of Paradise Valley. The "bulbous" portion of the drainage area lies within the rocky northern outcrops of the Phoenix Mountains, while the "neck" portion (which widens considerably in its lower extremity) is on the more gentle southerly slopes of Paradise Valley, and these slopes are composed of caliche cemented talus. Thus, the soils of the watershed have a very high runoff potential, with an infiltration rate of only about 0.05 to 0.15 inch per hour (rated "Group D" in Soil Conservation procedures), and therefore, have very high resistance to erosion. The natural vegetation is typical Sonoran desert type, with sparse mesquite, creosote bush, black bush, catclaw, palo verde and some cactus with about 15 to 20% density. The climate is likewise typical Sonoran, with hot summers, mild winters, and infrequent rainfalls. Most of the annual rainfall (7 inches) is accounted for by summer thunderstorms of high intensity but short duration. In the recent past, there have been three occasions (1951, 1968, and 1972) within the memory of the present residents of the area in which these storms have been of such intensity that the resultant runoff from the area has forced the closure of Shea Boulevard at a point about ½ mile westerly of its juncture with Tatum Boulevard. These closure periods have been relatively short because of the nature of the runoff, and have caused very little damage to property and homes since, until recently, the area has been very sparsely developed. However, inasmuch as the area has experienced considerable development in the last four years, and yet further homes, more subdivisions, and some commercial enterprises are currently being planned adjacent to Shea Boulevard, a need has obviously arisen to examine the desirability of undertaking flood control measures in the watershed. In particular, the possible Detention Basin #8, as described in the report by John Carollo Engineers (Contract No. 13580, Project ST-71185.00), has become the subject of much concern. The latter, which would be located just southerly of Double Tree Ranch Road (i.e., approximately at the north line of Section 36, T3N, R3E, and within the newly purchased Phoenix Mountain Preserve) could be (and apparently has been) considered variously as aesthetically unappealing, inconsistent and damaging to the environment, and also economically infeasible. Inasmuch as developing a cost-benefit ratio for the detention basin and dam was beyond the scope of Contract No. 13580 to John Carollo Engineers, this study and report was initiated to provide the latter and also to develop possible alternate flood control measures.

PROCEDURES

A hydrologic study of the upstream area from the presently proposed structure (hereafter referred to as the "Carollo Dam") and also the downstream portion of the watershed was made to determine the peak discharge at selected points for the 2, 5, 10, 25, 50, and 100-year frequency storms. This was accomplished through utilization of a TR-20 computer model and procedures developed by the Soil Conservation Service (more popularly known as the "SCS Method"). These computations, including a hydrologic map and other pertinent data, are contained in Volume II of this report. To establish the latter computer model, some 30 cross-sections were developed at selected points from the existing City of Phoenix 1" = 100' quarter-section topographic maps. In addition, water surface profiles and overflow areas were developed for the 2, 5, 10, 25, 50, and 100-year runoffs by use of the HEC-2 computer program. In conjunction with the foregoing, cross-sections were taken by means of a field survey at 22 selected stations, from a point near the juncture of the watershed with Indian Bend Wash to a point where the 100-year frequency discharge first overflowed the main channel (i.e., approximately 4,000 feet southerly of Shea Boulevard). The foregoing computations, with a key map, are contained in Volume III of this report. In addition, a two zone flood plain delineation of the present conditions was prepared on a 1" = 100' scale mylar reproducible made from City of Phoenix quarter section maps. This was reduced to a 1" = 400' scale mosaic on a sepia reproducible for submittal with this study and report. (See Plate XV.)

An estimate was also made of the present annual cost of the possible flood damages - including an estimate of the secondary effects. A composite probability of exceedence versus damage curve was developed for five separate reaches (Plates III through VII), and also, a composite probability of exceedence versus damage curve for the entire watershed was prepared, which reflects the probable future conditions and zoning. (See Plate VIII.) In the course of preparing the foregoing, several field reviews were performed in the area, inhabitants were interviewed about past damages and flooding, and the County Assessor Tax Rolls were examined to determine the real value (i.e., approxmately 60% of the market value) of the buildings and property within each reach of the flooding area.

Upon Completion of the foregoing, an investigation of alternatives to alleviate the damages as previously determined was undertaken. The various alternate plans considered are given in Plate XII. For each of these alternates, a probability of exceedence versus residual damage curve was developed and compared to a similar curve representing the possible future damages, in order to estimate the possible benefits. (See Plates VIII to XI.) An average annual cost, annual benefit, and benefit-cost ratio was computed for each of the alternate combinations studied. (See Plate XIII.)

ASSUMPTIONS

In the course of developing the various estimates of possible damages that could occur in the future under the existing conditions and zoning in the watershed, plus also the costs, residual damages, and benefits envisioned upon the adoption of any of the several flood control plans, it became necessary to make a considerable number of assumptions, as follows:

1. The water surface at residences lying directly within a principal channel of the watershed would be considered the same as the computed energy gradient, since the flow obstacle created by the building would tend to convert the velocity head of the watercourse into a static head.

2. The water surface adjacent to buildings lying at the periphery of the water course would be considered as the hydraulic gradient, inasmuch as there would be no tendency for the building to restrict the flow and convert the velocity head into a static head.

3. Residences which had been flooded in the past from storms of known frequency would continue to be, with a flood providing an equal discharge, even though the computed hydraulic or energy gradients indicated otherwise.

4. Since the level of residence flooding in the past has been limited to less than 3", any discharge resulting in a lowered water surface of 3" from that of the recorded flood would cease to cause damage to the individual structure and contents (excepting, of course, those cases in which the computed water surface would still indicate flooding).

5. Residences existing during the last severe runoff of record, which at that time were nearly flooded, would be flooded to a depth of 3" in any future storm of the same severity - due to the restrictions of the various water courses caused by the additional buildings and resultant landscaping.

6. Residences constructed since the last severe flood of record and located centrally within a water course (and also below the computed water surfaces) would likewise be flooded to a level of 3" inside the building. Likewise, these would be calculated to suffer no damage for any frequency runoff resulting in a 3" lower water surface profile.

7. Residences that would eventually be constructed in the presently subdivided areas and also in future subdivisions, because of the knowledge obtained in this study regarding flood elevations, would be at a sufficiently high elevation that they would not suffer any structural or content damage.

8. Landscaping damage in existing subdivided areas for the various frequency storms was determined through proportioning the total volume of the respective storms to the volume and known damage occurring with the last severe storm of record.

9. Landscaping damage in regions of future subdivisions was computed by assuming the areas flooded by the various frequency storms to be proportional to the total volume of the individual storms in relation to the area of flooding and

the total volume of the 100-year storm. The flooded areas, without adaption of Flood Plain Zoning were then considered to have 1.5 lots per acre, and the landscaping damage was considered as $350 per lot.

10. Structural damage to residences subjected to flooding was computed at 8% of the real value as listed in the County Assessor Tax Rolls,and damage to contents was calculated at 10% of their value (which, in turn, was figured at 50% of the structure's real value). Since the real values of the various homes, as given in the County Assessor Tax Rolls, are roughly 60% of their true market value, the above assumptions are roughly equivalent to the depth-damage curves developed by the U.S. Army Corps of Engineers from the 22 of June 1972 Phoenix flood. This showed the residential damages to be 5% for 0.0 to 0.25 feet submergence and the damage to contents for the same range to be 4 to 5%.

11. Damage to the landscaping of presently subdivided land was estimated at 5% of the property value as listed in the County Assessor Tax Rolls.

12. Indirect damages were assumed to be 10% of the direct damages (i.e., structure, contents, and landscaping). U.S. Army Corps of Engineers studies recommend that a figure between 10 and 15% be used. The lower figure was adopted, because the flooding depths are generally shallow, and therefore, the prolonged interruption of services (gas, electric, etc.), detouring of traffic and the need to evacuate residents are considered unlikely.

13. The total possible indirect damages for the watershed were were assumed to remain for any alternate plan which had no structural provision for conveying runoff across Shea and Tatum Boulevards, since these would be the main trouble spots from the standpoint of traffic and service interruption.

14. In those alternate plans, in which the storm drain would be connected to a structure at approximately 46th Street on Shea and/or at Tatum Boulevard, the added cost of the storm drain extension to Indian Bend Wash was computed as a benefit.

15. In order to provide ease of maintenance, in the preliminary design of the channelization for the various alternate plans, the minimum bottom width for any channel was established at 10 feet. In the design of those channels in which the maximum water depth would be less than 3 feet, 2:1 side slopes were provided. In those instances in which the depth could not be economically limited to 3 feet, 4:1 side slopes were adopted. Also, wherever the maximum channel velocity exceeded 10 f.p.s., mortared rock lining was provided up to the maximum design water depth.

16. Maintenance costs (clean up, repairs, etc.) on all channels and/or ford sections downstream were assumed to be roughly equal for all plans and therefore would not be an economic consideration.

17. In the determination of the R/W needed for the various alternate channel configurations, an excess 10-foot strip of land was provided on each side of the area needed for the channel, in order to provide for a maintenance road. In those cases in which the R/W for the channel required over one-half the area of a given parcel, the entire property was considered as a R/W purchase. R/W costs were assumed to be $12,000 per acre.

18. Unit prices used in developing the costs of the various plans envisioning downstream channels and culverts were based upon the publication "Construction Cost 1975 and Quantities and Cost of Materials," prepared in 1976 by the Contracts and Specifications Services of the Arizona Department of Transportation (Highways Division). The unit prices adopted for dam-related items were the same as those used in the report "Investigation of North Phoenix Mountains Flood Detention Basins", City of Phoenix, Arizona, 1973, by John Carollo Engineers.

19. Contingency items (engineering, field staking, inspection, etc.) were assumed to be 10% of construction costs (12% for those alternate plans utilizing detention basin and dams) with administration and legal costs being 8% (basin and dam alternates only).

20. A discount rate of 6% was used for computing all annual costs.

INVESTIGATION AND RESULTS

Analysis of the watershed runoff on the basis of the TR-20 computer program verified that the preliminary detention basin and dam, designed by John Carollo Engineers, is completely adequate to meet the requirements and conditions. The latter met all the criteria for a Class "C" flood control structure in regard to storage capacity for both the 6-hour, 100-year frequency storm, plus the multiple day storm. In addition, the size and elevation of the emergency spillway was found to be adequate, and the dam freeboard height was sufficient to meet the storage requirement of the possible maximum precipitation. The various computations, verifying all the above, are included in Volume IV of this report.

The peak discharges under the existing conditions at the proposed dam site were found to be the following:

2-year frequency = 650 c.f.s. (3-hour storm)
5-year frequency = 1175 c.f.s. (1-hour storm)
10-year frequency = 1685 c.f.s. (1-hour storm)
25-year frequency = 2210 c.f.s. (1-hour storm)
50-year frequency = 2750 c.f.s. (1-hour storm)
100-year frequency = 3300 c.f.s. (1-hour storm)

At a point approximately 3000 feet downstream (survey station 73+00), where the above peak discharges are only 2 to 2.5% greater, a portion of the larger quantity discharges overflow the right (easterly) side of the channel. While the majority of this flow simply continues in various braided channels onto Shea Boulevard, a portion is actually diverted easterly in a separate (overflow) channel and crosses Tatum Boulevard approximately 2300 feet southerly of its intersection with Shea Boulevard, and then continues on easterly within the corporate limits of the Town of Paradise Valley to an outflow in Indian Bend Wash. The discharge being naturally diverted into this overflow channel is estimated as follows:

2-year frequency = 0 c.f.s.

5-year frequency = 0 c.f.s.

10-year frequency = 60 c.f.s.

25-year frequency = 150 c.f.s.

100-year frequency = 300 c.f.s.

As the flow in the main channel continues north-northeasterly, the runoff is contained fairly well by the left (westerly) bank for about the next 2,500 feet (to survey station 48 + 00), at which point a "braiding" pattern also develops similar to that adjacent to, and just behind, the right (easterly) bank. Around 1,300 feet further downstream, the braided channels along the westerly edge of the rapidly widening flood plain begin overflowing the existing Shea Boulevard. At this point, because of the channel storage created by the greatly expanded outflow area (about 1000 feet wide during the 100-year runoff), the peak discharges are further reduced to the following:

2-year frequency = 500 c.f.s. (3-hour storm)

5-year frequency = 950 c.f.s. (1-hour storm)

10-year frequency = 1430 c.f.s. (1-hour storm)

25-year frequency = 1910 c.f.s. (1-hour storm)

50-year frequency = 2380 c.f.s. (1-hour storm)

100-year frequency = 2790 c.f.s. (1-hour storm)

At the point cited previously (i.e., survey station 35 + 00), the westerly-most braided channels discharge down 44th Court at approximately the following rates:

2-year frequency = 30 c.f.s.

5-year frequency = 75 c.f.s.

10-year frequency = 140 c.f.s.

25-year frequency = 240 c.f.s.

50-year frequency = 300 c.f.s.

100-year frequency = 365 c.f.s.

Some 600 feet southerly of Shea Boulevard, 44th Court curves to the left (westerly), and to the right (easterly) a cul-de-sac has been constructed as a part of the Desert Gardens subdivision. In this vicinity, the higher quantity discharges tend to continue more directly northerly with a portion (estimated at around 80 c.f.s. during the 100-year storm) completely overtopping the curb and then flowing northeasterly across Lots 21, 22, and 25 of the Desert Gardens subdivision. (See Plate I.)

A few hundred feet further downstream (approximately survey Station 32 + 00) from the preceding flow division, another portion of the flow is diverted in a southerly direction through Lot 5 (which is vacant) of the Gerald Estates subdivision, around the westerly side of a continuous wall encompassing three residences on Becker Lane (one block north of Shea Boulevard). (See Plate I.) This diversion is just westerly of what had once been a natural channel before the area was developed, and its discharge rate is estimated as follows:

2-year frequency = 45 c.f.s.

5-year frequency = 140 c.f.s.

10-year frequency = 260 c.f.s.

25-year frequency = 330 c.f.s.

50-year frequency = 435 c.f.s.

100-year frequency = 490 c.f.s.

In the past, as the above diversion continues northerly, it generally has followed its old natural wash through what is now Lots 11, 15, and 20 of the Gerald Estates subdivision.

Another 300 feet downstream (approximately survey Station 29 + 00), the main outflow channel is intersected by 46th Street, which causes yet another diversion in a northerly direction, estimated at the following rates:

2-year frequency = 5 c.f.s.

5-year frequency = 35 c.f.s.

10-year frequency = 60 c.f.s.

25-year frequency = 110 c.f.s.

50-year frequency = 145 c.f.s.

100-year frequency = 175 c.f.s.

As the above diverted flow continues northerly on 46th Street, since the roadway and its associated ditches have a capacity of only 100 c.f.s., portions of the higher runoff quantities overflow the easterly edge of the roadway section into various lots of the Morningside subdivision and also easterly down Desert Cove Avenue and Clinton Street. Just southerly of its intersection with Shangri La Road, in the past the flow on 46th Street has united with that flow diverted northerly around survey Station 32 + 00 and also with that portion which overtopped 44th Court at the aforementioned cul-de-sac. Just northerly of Shangri La Road, this runoff, estimated at over 600 c.f.s. during the 100-year frequency storm, mostly flows north-northwesterly across Lots 9 and 7, Block 1 of the Morningside subdivision before entering the periphery of the Indian Bend Wash flood plain.

The main body of the flow remaining after the above-mentioned three diversions continues in an easterly direction and is mostly contained within Block 4 of the Morningside subdivision, and at survey Station 15 + 00 discharges into and over Tatum Boulevard at the following estimated rates:

2-year frequency = 420 c.f.s.

5-year frequency = 700 c.f.s.

10-year frequency = 970 c.f.s.

25-year frequency = 1230 c.f.s.

50-year frequency = 1500 c.f.s.

100-year frequency = 1740 c.f.s.

In estimating the above splits and diversions in the runoff, and also in developing the water surface profiles for the downstream channels, some difficulties were encountered. Up through survey Station 35 + 00, the flow was found to be sub-critical, except for the very lower runoff quantity runoffs. Above Station 35 + 00 and up through 50 + 00, the flow for most discharge rates was found to be "tumbling", in that sub-critical flow was alternately encountered in one section and supercritical in the next, etc. Between Stations 55 + 00 and 72 + 75, the flow rate was determined to be supercritical, and for a short region between Stations 74 + 75 to 76 + 00, the subcritical flow again occurred, due to a brief restriction in the natural channel. Upstream from the latter, up through Station 84 + 13, a "tumbling" condition again occurred with supercritical and sub-critical flow alternating between the various selected cross sections. Beginning at Station 89 + 13, up through the final cross section, Station 105 + 18, the flow was found to be supercritical.

On the basis of the foregoing data, it was possible to obtain a rather reliable estimate of the large discharge which had occurred from the watershed on the morning of the 22 of June 1972, and also, in relation to the latter, to judge the costs that could result from future flooding in the watershed.

On the evening of the 21 of June 1972, and during the next morning, northeastern Phoenix was subjected to heavy thunderstorms, which were part of a series of moderate to heavy early summer thunderstorms affecting Arizona, Nevada, and Utah during the 20-23 of June 1972. The cause of these storms was a very deep flow of very moist unstable tropical air that had invaded the southwestern United States from the Gulf of California and the Pacific Ocean west of Baja, California. A majority of this storm's rainfall occurred between

6:00 and 12:00 a.m. on the 22nd of June in the northeastern part of Phoenix, with the greatest intensities recorded during a 1.5 to 2-hour period. According to the "Report on Flood of 22 June 1972, Phoenix Metropolitan Area, Arizona", October 1972 by the U.S. Army Corps of Engineers (Los Angeles District), this storm was centered about three miles south-southwesterly from the upper regions of the watershed under study. In addition, the foregoing report estimated that the 22 of June 1972 storm produced a flood in Indian Bend Wash (the outflow for this watershed) with a frequency of occurrence of one every 70 years.

As could be expected, the foregoing storm produced a rather substantial runoff in the downstream channel of the subject watershed. According to the statements of several residents immediately adjacent to the channel, in the region of Fanfol Drive, the flood sounded like "a freight train". This is not an unexpected phenomenon, since the velocities probably ranged between 13 and 21 f.p.s., which would result in the conveyance of rather large rocks and boulders along the bottom of the main channel. Attempts have been made to establish the discharge rate in the main channel from the water levels indicated by the residents adjacent to the wash. The uppermost indication (approximately survey Station 78 + 10) was an elevation 1455.06 provided at the rear of the residence at 4101 East Fanfol Drive (i.e., the floor elevation, which nearly flooded). However, upon analyzing the flow at various sections in this vicinity, it was found that no reliable estimate could be made because of the "tumbling" flow and the probable presence of a hydraulic jump. At approximately survey Station 72 + 75, within a reach of steady supercritical flow, an elevation of 1449.5 was indicated by Mrs. Jean Petrie on the channel bank to the east of her residence at 4115 East Mountain View Road on the basis of a series of horse "road apples" that had been swept away by the flood. On a stage-discharge basis, this would correspond to a rate of 3160 c.f.s., while the 100-year peak at this section is computed to be about 3330 c.f.s. Further downstream, at survey Station 66 + 00, Mr. Loren Dickenson of 4138 East Mountain View Road indicated a peak elevation of 1440.3 on the east patio of his home. On a stage-discharge basis, this would correspond to a rate of 2950 c.f.s., while the 100-year peak at this section is computed to be 3040 c.f.s. On the basis of the foregoing testimony, there is little doubt that the 22 of June 1972 flood was within 3 to 5% of being the 100-year frequency event for this watershed.

Attempts were made to verify the above runoff rate by applying rainfall data on the 22 of June 1972 storm by means of the TR-20 computer model. By using a 3.85", 1-hour storm, (indicated by rainfall gauge #13 at 18th Street and Turney), the discharge rate at Station 72 + 75 was computed to be 4266 c.f.s. (storm #8, section 140 in the Volume II computations). Through applying a 4.25", 6-hour rainfall (as given in the isohyetal map in the October 1972 U.S. Army Corps of Engineers report), the discharge at the same station was computed as 4173 c.f.s. (storm #7 in the Volume II computations). No attempt was made to apply the rate from the nearest recording rain gauge (no. 42 at Mummy Mountain) because the latter indicated the heaviest rate much later in the morning than the actual peak from the watershed.

The above two discharges, computed from indicated rainfall rates, are some 25 to 28% above what is actually indicated by the channel for the watershed. Upon considering this further, it is felt that the result from gauge no. 13 is not really applicable, because the latter was actually in the estimated center of the thunderstorm, some three miles from the watershed. In addition, it is suspected that the isohyetal map prepared by the U.S. Army Corps of Engineers is somewhat of a guess immediately northerly of the Phoenix Mountain crest because of the lack of recording rain gauges. The most accurate indication of the rainfall in the watershed was probably the non-recording gauge no. 30 at 32nd Street and Shea Boulevard, which indicated a total of 3.77 inches for the storm. Assuming this occurred during a 6-hour period with a normal distribution, the discharge at Station 72 + 75 would be computed to be about 3500 c.f.s., or again within 5% of the estimated 100-year peak.

As a consequence of the June 1972 flood, some negligible damage was suffered in the watershed south of Shea Boulevard. A small culvert which had been placed in the main channel by a property owner to the south of Fanfol Drive was completely washed out; and some erosion occurred on the channel bank to the rear of the residence of Mr. Stephen Gerst, also to the south of Fanfol Drive, while silt and debris was deposited on a basketball court adjacent to the Petrie residence.

Greater problems were created to the north of Shea Boulevard. The runoff down 44th Court, which overtopped the curb adjacent to the cul-de-sac some 600 feet north of Shea Boulevard, eroded a 3-foot hole behind the curb and sidewalk, then continued across Lot 22 of the Desert Gardens subdivision, and then was diverted to the east by a wall (which was nearly undercut by erosion) to the rear of the residence owned by Richard T. Dodson, 10805 North 45th Place, Lot 24 of the same subdivision. As this flow continued in a northeasterly direction it nearly entered the residence at 4502 East Mercer Drive (Lot 24 of Gerald Estates subdivision), belonging to George De Fabritis.

The only flooding of homes occurred in the region of the northerly diversion at approximately survey Station 32 + 00. The interior of the residence at 4532 East Shea Boulevard (Lot 2 of Gerald Estates), according to the testimony of several witnesses, suffered considerably from the flood waters and the resulting deposits of silt and debris. Another home suffering damage was at 4519 East Becker Lane (Lot 6 of Gerald Estates Subdivision), belonging to Mr. Robert T. Banks, who is the only remaining home owner of the three flooded during the 1972 event. During the flood peak shortly before 8:00 a.m. on the 22 of June 1972, the water level rose approximately 18" upon the wall (facing Shea Boulevard) to the rear of his residence and surged through a gate into the back yard. Unfortunately, inasmuch as the wall around the back yard was also connected to the sides of the residence, there was no outlet for the on-rushing waters, which soon achieved a depth of over one foot outside the house's arcadia doors leading to the back yard. Upon realizing that the water could soon flood the entire interior, Mr. Banks attempted to remove a portion of the block wall to the east of the building in order to provide a flood outlet. However, as soon as this was attempted, a portion of the wall collapsed from the water pressure, nearly submerging and burying Mr. Banks in a rush of Super-lite blocks and muddy water. While this did effectively lower the water surface adjacent to his home, sufficient water had entered the building to soil the carpeting and cause a total of about $3,000.00 in damage to his home and property. The two homes, located just easterly of the Banks' residence on the same block, fared much better, mainly because the flood waters were not entrapped by walls interconnected with the building itself. At the residence at 4531 East Becker Lane (Lot 7 of Gerald Estates), the flood apparently also entered the back yard through a gate in the walled southerly side of the property. However, this evidently escaped around both sides of the building below and through a wooden fence. At the residence further to the east, 4543 East Becker Lane (Lot 8 of Gerald Estates), owned by Mr. Michael Flax, the water also entered the back yard, damaging a portion of the wall, but was released around the easterly side of the building after Mrs. Flax simply opened the side gate.

The flood waters, which had gone through the Banks property and had flowed approximately 1-foot deep through the parcel to the west (Lot 5 of Gerald Estates), proceeded almost directly northerly and also entered the interior of the residence at 4520 East Becker Lane (Lot 11 of Gerald Estates). Continuing further, the waters crossed Lots 15 and 20 of Gerald Estates (the latter lot then being vacant). On the former of these, a residence (now 4525 East Mercer Drive) was under construction, and it could not be determined with any certainty from witnesses whether or not the waters actually overtopped the floor. As this runoff proceeded north-northeasterly from the Gerald Estates subdivision, it crossed a vacant field and was joined from the west by the runoff overtopping the curb on 44th Court before entering 46th Street just south of Shangri La Road.

The runoff which followed the third main diversion, 46th Street and just easterly, caused no substantial damage. While the water came very close to entering the homes at 4601, 4602, and 4614 East Clinton Street (Lot 8, Block 4, and Lots 9 and 10, Block 3, respectively, of the Morningside subdivision), only minor damage resulted to the landscaping. At 4602 East Desert Cove Ave. (Lot 9, Block 2, of the same subdivision), the owner, George A. Burton, and his family were away at the time, but upon returning, found that some water had apparently entered under the front door, as the adjacent carpeting was somewhat soiled.

After being joined from the west by the previously diverted runoff, the flow down 46th Street mainly crosed north-northeasterly across Lot 9 (then vacant), Block 1, of the Morningside subdivision and entered the southerly fringe of the flooding in the Indian Bend Wash in Lot 7, Block 1, of the subdivision. (See preceding discussion.)

The main body of the remaining undiverted runoff flowed in an east-northeasterly direction in Block 4 of the Morningside subdivision and entered no homes, but caused some minor damage to landscaping and the contents of some outbuildings. Easterly of Tatum Boulevard, absolutely no damage resulted from this watershed's runoff, since the area was (and still is) undeveloped.

In summary, at the very most, the total damages (structural, contents, landscaping, and indirect) suffered during the 22 of June 1972 flood in this watershed probably amounted to less than $15,000.00.

On the basis of the foregoing information it was possible to make an estimate of those damages that would result should such a similar flood (i.e., of 100-year frequency) occur in the future, plus also those arising from events of lower discharge rates and higher probability. To accomplish the foregoing, the region of possible damages was arbitrarily divided into five reaches, as follows. (See Plate II.)

SURVEY STATION 5 + 00 to 15 + 00

While this region, between Tatum Boulevard and Indian Bend Wash south of Shea Boulevard, is currently undeveloped, it is considered likely that the entire area would be eventually subdivided into ½ acre lots. Assuming no selected floodway is adopted, a total of 25 lots would be expected to be within the 100-year flood limit of this watershed, and a proportionately lesser number for the runoffs with lesser rates. Assuming further that all structures in the future developed area would be above the 100-year flood level, all possible direct damages were figured to be to landscaping ($350.00 per lot). The probability of exceedence versus damage curve for the above is shown on Plate III.

SURVEY STATION 15 + 00 to 31 + 45

Some additional damage is envisioned in this area for an equivalent to the 22 of June 1972 flood and also from lesser discharges, because of the restrictions in the floodway due to future buildings and adjacent landscaping. In addition to the homes at 4532 East Shea Boulevard, 4519 and 4520 East Becker Lane, it is probable that the residences on Lots 8 of Block 4, Lots 9, 10, and 14 of Block 3 of the Morningside subdivision (4601, 4602, and 4714 East Clinton Street, respectively) would be subjected to flooding in various frequency events. In addition, the residence on Lot 15 of the Gerald Estates subdivision (4525 East Mercer Lane, under construction during the June of 1972 flood), or either or both adjacent to the residence at 4520 East Becker Lane (Lot 15 of Gerald Estates) would also be damaged in the interior, depending upon the amount of diversion created by the wall that has been constructed around the back yard of the latter. The latter building is now particularly vulnerable to flooding, since the newly constructed wall has openings upstream, adjacent to the structure itself, but no openings downgrade to the rear of the property. This wall will therefore serve ideally as a catchment to retain water and insure that the building itself will flood, which previously occurred in the June of 1972 event (before the wall was constructed). The probability of exceedence versus damage curve for this reach is on Plate IV.

<u>46TH STREET</u>

Due to the additional water that would be diverted, even under the present conditions, into 46th Street by the various buildings, walls, and fences of the Gerald Estates subdivision, it is considered likely that the residence on Lot 9, Block 2, of the Morningside subdivision (4602 East Desert Cove Avenue) in the future could suffer considerably more flooding than during the June of 1972 storm. In addition, water could also enter the structure on Lot 9, Block 1, of the same subdivision (4602 East Shangri La Road) during the events with higher discharge rates. See Plate V for the probability of exceedence versus damage curves for this reach.

<u>44TH COURT</u>

In this region, the main area of probable damage would be the residences on Lots 21 and 22 of the Desert Gardens subdivision, as a result of the flow overtopping the curb in the region of the aforementioned cul-de-sac. The residence on Lot 21 of the subdivision (10653 North 44th Court) would be particularly susceptible to flooding, because it is located down grade from the cul-de-sac and, moreover, a block wall has been constructed on the east and south edges of the property (i.e., further downgrade), which will, in effect, serve as a dam to the further movement of flood waters. The probability of exceedence versus damage curves for the above area are shown on Plate VI.

SURVEY STATION 31 + 45 to 70 + 00

Although this region is currently undeveloped and not subdivided, it is considered probable that the entire reach could soon be developed into ½ acre lots. Should no selected floodway be adopted, a total of 45 lots were estimated to be within the 100-year flood limit of the subject watershed (and, of course, a proportionately lesser number for runoffs of lesser rates). As in the case of the reach between survey Station 5 + 00 and 15 + 00, all damages were figured to be to landscaping ($350.00 per lot), since all structures constructed in the future are expected to be above the 100-year flood level. The probability of exceedence versus damage curves for this area are on Plate VII.

In summation, the total annual damages to be expected in this watershed total is $8,500. (See the area under the curve on Plate VIII, which also represents the residual damages for the "do nothing" alternate PLAN #1.)

In conformance with the City of Phoenix present criteria, the inner zone of the flood plain for the watershed was established in accordance with the U.S. Army Corps of Engineers procedure. Because of the presence of "tumbling" and also supercritical flow in several regions, the normally used "Method 4", as specified by the latter agency, could not be adopted, and the more laborious "Method 1" had to be used. The establishment of the inner zone of a floodway, by definition, involves allowing the restriction of the waterway until the hydraulic gradient is raised 1 foot above that of the 100-year flood. Upon attempting to establish this between Station 15 + 00 and 35 + 00, a major problem was caused, inasmuch as the resultant water surface would be raised above the elevation of several building floors, which are presently only marginally above the 100-year flood elevation. (See Plate XIV, Floodway Profile.) In view of the foregoing, it was decided not to establish an inner zone in this region;

but to recommend AO-2 flood zoning instead. The latter would simply allow the construction of permanent structures anywhere on the presently subdivided lots, provided the floor elevations were above that established for the 100-year flood. Beginning at around Station 70 + 00, because the floodway was fairly well confined due to the natural configuration, it was decided to establish the edge of the restricted floodway at the existing limit of the 100-year flood. (See Plate XV.) Moreover, raising the water surface in this region could cause considerable problems through increasing the discharge into the overflow channel to the east (i.e., the one crossing Tatum to the south of Shea), and also further endangering the home at 4138 East Mountain View Road (to the right of survey Station 66 + 00).

As an alternate to the possible detention basin and dam, as designed by John Carollo Engineers (Plate XVII), two alternate structures were considered about ½ mile upstream (southerly in the watershed). (See Plate XVII.) Tentative designs for both of these were likewise made in accordance with current criteria in regard to storage capacity, size, and elevation of emergency spillway and dam freeboard height. (See computations in Volume IV of this report.)

Inasmuch as all the above detention basin plans involved standard spillways that would discharge drainage for a rather prolonged period (approximately 25 to 30 hours, with peak rates varying from 250 to 660 c.f.s. across Shea Boulevard), the addition of downstream channelization and roadway drainage structures were also considered in conjunction with both plans.

As alternate to construction any of the above-mentioned detention basins and dams, consideration was also given to rechannelization of the downstream watershed. In all, four possible schemes were examined, as follows:

1. Dyke and rechannel the main course at approximately survey Station 71 + 00, in order to divert the entire flow easterly

into the "overflow" channel which crosses Tatum Boulevard some 2300 feet southerly of its intersection with Shea Boulevard. This alternative was rejected after a cursory examination, because of the obvious need of reaching a complicated agreement with the Town of Paradise Valley, plus also providing extensive rechannelization within the corporate limits of the latter, in order to provide an adequate outflow system for the discharge into the Indian Bend Wash to the east.

2. Construct a manifold, or collector-type channel just southerly of Shea Boulevard which would connect easterly to a box culvert built diagonally across the intersection of Shea and Tatum Boulevards. At the outlet of the latter, another channel would be constructed in a northeasterly direction which would connect to the Indian Bend Wash. The latter solution was likewise rejected after a brief examination, because of the very expensive right of way purchases that would have to be made along the Shea Boulevard frontage from both C. Miracle Life Church and Smitty's Super Value, Inc. In addition, box culverts of rather large cross-sections would have to be constructed to provide access to both the above-mentioned and other properties.

3. Construct a collector-type channel and drop structure to the south of Shea Boulevard and conduct the drainage northeasterly in a box culvert built diagonally below the intersection of Shea Boulevard and 46th Street. This would also necessitate an outlet channel in an east-northeasterly direction through property which is presently undeveloped.

The latter channel would either "daylight" out just west of Tatum Boulevard, or in Indian Bend Wash (depending upon whether a box culvert would also be constructed across Tatum Boulevard). The foregoing alternate was considered to be the most economical and practical for further evaluation and study.

4. A further improvement of the foregoing was also considered, in that the drop structure south of Shea would be eliminated and rechannelization and dyking of the existing wash would be undertaken southerly to approximately survey Station 73 + 00. This solution was viewed as undesirable because of the added cost and because the benefits derived from it would be mostly to individuals developing land south of Shea, and not to the general public. Moreover, almost the same results could be achieved, at a much lesser cost, by flood plain zoning the channel southerly of Shea Boulevard.

In addition to the construction of various detention dams, channels and drainage structures, consideration was also given to purchasing property and flood easements, plus removing structures in the developed areas to alleviate the possible future damages.

During the course of this watershed study, an additional important factor was encountered which greatly influenced the final selection of the remedial plan. In conjunction with the design currently underway by the firm of Yost and Gardner Engineers for the re-paving of Shea Boulevard from 32nd to 48th Street (Project P-74237), a rather large storm drain is contemplated, extending some ½ mile easterly of the intersection of Shea with Tatum Boulevard (48th Street) to an outlet in Indian Bend Wash. While currently the design of the foregoing storm drain is still in its tentative stages, it is presumed that the latter must carry approximately 700 c.f.s. in only a 2-year frequency storm. Should the latter drain be given an outlet at a structure crossing diagonally below the intersection of Shea Boulevard and 46th Street, placing the following length of large pipe (between Stations 66 + 10 and 145 + 27 on Shea Boulevard) could be avoided:

7917 feet of 90" Pipe @ $135.00 per ft. = $1,068,795.00

However, assuming an allowable hydraulic grade of 1408.00 at Station 66 + 10 of Shea Boulevard, a somewhat larger pipe would be necessary between Stations 66 + 10 and 104 + 40 (the latter at 46th Street), as follows:

3830 feet of 98" Pipe @ $150.00 per ft. = $ 574,500.00

In addition, the following additional lengths of pipe would be necessary to accomodate the drainage developed easterly of 46th Street"

Station 107 + 38 to 110 + 68:		
330 feet of 24" Pipe @ $30.00 per ft.	=	$ 9,900.00
Station 110 + 68 to 117 + 27 (48th Street):		
659 feet of 30" Pipe @ $36.00 per ft.	=	$ 23,724.00
Station 117 + 27 to 145 + 27 (Indian Bend Wash):		
2,800 feet of 36" Pipe @ $42.00 per ft.	=	$ 117,600.00
Net Saving of outletting Storm Drain @ 46th St.	=	$ 343,071.00
Annual Net Saving (6% discount, 50 year capitalization period = 343,071(0.0634)	=	$ 21,765.00

Should a box culvert be constructed also at Tatum and also used as an outlet for a portion of the Shea Boulevard storm drain, the latter length of 36" pipe above (2800 feet) could be eliminated and replaced with the following:

Station 117 + 27 to the outlet side of the Tatum box culvert:

640 feet of 36" Pipe @ $42.00 per ft.	=	$	26,880.00

Station 120 + 57 to 145 + 27 (Indian Bend Wash):

2,470 feet of 24" Pipe @ $30.00 per ft.	=	$	74,100.00
		$	100,980.00

Therefore, a net saving of $343,071.00 + 117,600.00 - 100,980.00 = $359,691.00 would result should storm drain outlets be provided at both 46th Street at Shea and at Tatum Boulevard. (Annual net saving = $359,691 x 0.06344 = $22,820)

The various alternates, as cited in the previous discussion, plus all feasible combinations thereof, are listed on Plate XII. For these plans a probability of exceedence versus residual damage curve was developed (Plates VIII to XI), except for PLANS #6, 6a, 7, 7a, 9, and 10 (which had no residual damages). In addition to estimating the total cost of each plan, an annual cost, annual benefit, and benefit-cost ratio was computed for 25, 50 and 100-year periods of capitalization. Only the 50-year period of capitalization is included with this report (Plate XIII), since the estimates for the other two periods were not appreciable different in regard to net benefits, benefit-cost ratio, and the rate of return percent.

CONCLUSIONS:

Following is a summary of the assorted plans and a discussion of each in regard to respective benefits, disadvantages, etc.

PLAN 1 (See Plate VIII):

This envisions taking no further action. However, in doing this, the annual flood damages of \$8,500.00 would remain. In addition, since flooding would be allowed to continue across Shea Boulevard from the subject watershed, this alternate would be completely inconsistent with current plans of developing Shea Boulevard into a full arterial with a storm drain along its entire length and also a bridge at its crossing with Indian Bend Wash.

PLAN 2 (See Plates IX and XV):

This involves establishing flood-plain zoning in the undeveloped areas to the east of Tatum Boulevard (4.65 acres) and to the south of Shea Boulevard (9.30 acres). According to some authorities on flood control economics, such as L.D. James (See Bibliography), the regulation of flood-plain development has a cost just as real as that of structural measures. Part of the total cost is the legal and administrative cost of enacting and enforcing the regulation, but the major economic cost is the advantage lost by those kept from locating in the flood plain. The recommended equation for estimating the discounted annual cost per acre is the following:

$$c_L = F_1(M_o - F_2M_t) - I_a - I_p$$

Where F_1 = capital recovery factor based upon the project discount (i.e., 6%) and "t" years - the latter being the number of years the present zoing can be expected to be maintained (i.e., 50 assumed) = 0.063444.

M_o = current average market value in dollars per acre of flood plain land adjusted so as to not include effects of flood hazard ($12,000.00 per acre)

F_2 = single payment present worth factor based on a rate of return expected on real estate investment (10%) for "t" years (50) = 0.008519

M_t = projected market value of M after "t" years (5% annual increase in value assumed for 50 years) = 12,000 X 11.46740 = $137,609

I_a = average net farm income expected from farming flood plain land (none on this project)

I_p = average annual value non-owners in the community place on having open land rather than open space in the flood plain (assumed to be an original value of $7,000 capitalized at 6% over 50 years - or 7000 X 0.06344 = $444 per year).

The discounted annual cost of flood plain zoning on this project is therefore:

$$c_L = 0.063444\ (12{,}000 - 0.08519 \times 137{,}609) - 0 - 444 = \$243.00 \text{ per acre}$$

By adopting this plan, runoff would continue to cross Shea Boulevard from this watershed causing an estimated annual damage of $4,600.00 (composed of direct damages to the presently subdivided areas, plus indirect damages). As in the case of PLAN 1, this would be inconsistent with the development of Shea Boulevard into a major arterial with full drainage controls.

<u>PLAN 3 (See Plates X and XVI):</u>

This consists of [redacted] and [redacted], in order to allow for the runoff from future storms. However, even under this plan, some $4,600.00 annual residual damages would remain (composed of landscaping damage in future developments and indirect damages). In addition, the major disadvantage of runoff continuing across Shea Boulevard would remain. An important factor in considering this plan is the widespread sheet overland flow pattern in the lower watershed, which can result in the shifting of watercourses between the various flooding events. Hence, there is no guarantee that the properties and homes selected for purchase would actually constitute those subjected to future flooding.

PLAN 4 (See Plates X, XV, and XVI):

This plan is simply a combination of plans 2 and 3 above and, therefore, it has the same disadvantages. However, most of the possible future damages would be elimnated under this alternate, with the indirect annual damages of $1,200.00 remaining, due to the interruption of services from the continued flooding of roadways and underground utilities.

PLANS 5 & 5a (See Plates X and XVII):

This alternate consists entirely of [redacted] - or its alternate with the spillway retaining wall - and adopting no additional measures further downstream. As result of these plans, runoff would continue for a much longer period, but at a lower rate, across the roadways downstream; and only the estimated indirect damages ($1,200.00 annually) would possibly remain. Also, adoption of either of these alternates would necessitate the extension of the Shea Boulevard storm drain past 46th Street to an outlet in the Indian Bend Wash. While the maximum possible pool surface area of 47 acres behind the "Carollo" dam is relatively small in relation to the entire mountain preserve area, and the maximum period of water retention would be only about 25 hours, from an ecological standpoint, some damage to desert vegetation within the retention basin could be expected. Also, the addition onto the natural terrain of a low, 2,000-foot long fill area, with a deeply cut spillway into an adjacent hill, would be quite evident from almost any viewpoint downstream. Even with the downstream (4:1) slopes of the dam being landscaped with natural vegetation, those opposing the retention basin from an ecological or aesthetic standpoint would probably not be deterred from engaging in injunctive suits against its construction. Taking into consideration the various other alternates, the simple construction of the "Carollo" dam alone (with no other improvements) has no discernible merit from either the standpoint of cost, benefits, or aesthetic value.

PLANS 6 & 6a (See Plate XVII):

These two plans envision constructing the "Carollo" dam, or its alternate, respectively, and also building channel and drainage structures downstream in order to conduct the outflow beneath both Shea and Tatum Boulevards. Under either of these alternates, no provision would be made downstream to provide an outlet for the Shea Boulevard storm sewer, which, therefore, would have to be extended easterly to the Indian Bend Wash. While either of these plans would completely eliminate all foreseeable damages, the various other disadvantages - as cited above in the discussion of plans 5 and 5a - would remain.

PLANS 7 & 7a (See Plate XVII):

These two alternates are basically the same as Plans 6 & 6a, above, with the exception that the downstream channels and structures would be constructed on a somewhat enlarged basis in order to provide an outlet near the intersection of Shea Boulevard and 46th Street for the Shea storm drain. As in the case of plans 6 & 6a, residual damage should be entirely eliminated under either one of these plans. However, the same environmental and aesthetic disadvantages occurring with plans 5, 5a, 6, and 6a would continue to exist. Inasmuch as other less costly alternates are possible, there also seems to be no discernible reason for the adoption of either one of these plans.

PLAN 8 (See Plates X and XVIII):

Under this plan, two flood control dams (termed "Alternate II" in this report) would be constructed approximately ½ mile upstream in the watershed form the proposed "Carollo" dam, without any downstream channels or structures to provide for the outflow. As a result, as also in the case of plans 5 and 5a, runoff would continue across the roadways, and the estimated indirect damages of $1,200.00 yearly would probably remain. In addition, there would be the necessity of extending the Shea Boulevard storm drain easterly to Indian Bend Wash. While the maximum pool surface area behind these dams is somewhat smaller (33 acres) than with the "Carollo" dam (47 acres), from an ecological standpoint some damages could be expected to the desert vegetation behind both these dams. However, the presence of both these structures would be far more apparent from any downstream viewpoint than in the case of the "Carollo" dam. Thus, it is even more likely that great objections (and injunctive lawsuits) would be raised against both the detention basins envisioned in this plan. Therefore, as in the case of plans 5 and 5a, this plan has no discernible merit.

PLAN 9 (See Plate XVIII):

This plan is merely an [redacted]g, in that it includes channels [redacted] downstream in order to pass the outflow from the dams across both Shea and Tatum Boulevards. However, under this alternate, there would be no provision for an outlet for the Shea Boulevard storm sewer, which would have to be extended considerably easterly to an outfall in the Indian Bend Wash. Even though this plan would completely eliminate all foreseeable damages, the assorted disadvantages - as cited previously under Plan 8 - would remain.

PLAN 10 (See Plate XVIII):

This alternate consists of a further improvement of Plan 9, with the enlargement of the downstream channel and structures, in order to provide an outlet for the Shea Boulevard storm drain. Residual damages should also be entirely eliminated under this plan, but the assorted environmental and aesthetic disadvantages inherent in the preceding two plans would also remain. Even should the above considerations be overlooked because other less costly (and equally effective) alternates are available, there seems to be no particular merit in this plan.

PLAN 11 (See Plates XI and XIX):

This alternate envisions constructing no detention basins upstream in the watershed, but rather, building downstream channels and drainage structures at both Shea and Tatum Boulevards to accommodate the entire runoff. Under this plan, the channels would be designed for the 100-year frequency event, and the two roadway drainage structures for only a 25-year frequency storm (with an overflow spillway to allow for the 100-year frequency event). The residual damage ($3,900.00 yearly) which would probably result from this system (assuming no flood plain zoning) would consist of landscaping damage to the south of Shea Boulevard, which should be subdivided in the future. However, since this plan has no provision for an outlet and the discharge from the proposed Shea Boulevard storm drain, its benefit-cost ratio is the lowest (0.07) of the various structural alternates considered.

PLAN 12 (See Plates XI and XIX):

This plan is virtually identical to the preceding one, with the exception that flood plain zoning would be established upstream (i.e., south of Shea Boulevard). This additional measure would reduce the probable residual damages to almost zero. (Some negligible indirect damages would occur with storm discharges exceeding that of the 25-year frequency.) However, since this alternate has no provision for also being an outlet for the Shea storm drain, there are several other possible plans which would provide for the latter, and, therefore, also have a much higher benefit-cost ratio.

PLAN 13 (See Plates XI and XX):

This scheme represents a further improvement of the preceding plan. In it, the channel downstream from Shea Boulevard and the structure under Tatum Boulevard would be designed to include the discharge from the Shea Boulevard storm drain (which would outlet into the downstream wingwalls of the structure under Shea Boulevard). As in the case of Plan 12, the residual damages would be negligible. Its total cost is roughly equal or less than any of the preceding plans envisioning structural alternates (with the exception of Plans 5a and 8, neither of which completely solved the runoff problems across Shea and Tatum Boulevards). In addition, its benefit-cost ratio, while still low (0.46), is among the best of any of the plans previously described.

PLAN 13a (See Plates XI and XXI):

The above could be considered as the first-stage construction of Plan 13. In this plan, the channel downstream from the structure at Shea Boulevard would be "daylighted" just to the west of Tatum Boulevard. At the latter point, the runoff would overflow across Tatum Boulevard in the same manner as it does under the present conditions, and flood plain zoning would be established easterly of Tatum Boulevard. The proposed Shea Boulevard storm drain would discharge into the downstream channel from the outlet wings of the structure on Shea Boulevard. However, the small drainage that would collect on Shea Boulevard easterly of 46th Street would have to be conducted easterly in a small storm sewer to Indian Bend Wash, rather than be diverted southerly to an outlet in the downstream wingwall of a structure on Tatum (as in Plan 13). Under this alternate, a small amount of residual damages of an indirect nature would remain ($600.00/year), due to the possible interruption of services on Tatum Boulevard. In addition, adoption of this plan would entail some risk of a lawsuit, in that runoff would be somewhat more concentrated near the outlet of the system at Tatum Boulevard and upon the land just easterly than it is under the present conditions. However, upon the improvement of Tatum Boulevard into a full arterial, a structure could be added at Tatum, the channel lowered upstream to connect to the Shea box culvert, and an outlet channel constructed east-northeasterly into Indian Bend Wash. The latter, in effect, would create Plan 13, as described above. Therefore, the advantage of the lower first cost of this alternate ($498,000.00) and the improved benefit-cost ratio (0.83) would inevitably be considerably diminished upon future expansion of the system.

PLAN 13b (See Plates XI and XXI):

This plan represents a further development of the foregoing, in that the design of the culvert at the intersection of Shea Boulevard and 46th Street is optimized in relation to the benefits realized versus cost. The selection of this more economical structure was based upon a flood insurance standpoint. In using this approach, the cost of the drainage structure is divided by the years it should eliminate overflow across the roadway. In this particular installation, it is logical that the remaining usefulness of the road soon to be constructed is about 50 years (after which widening and realignment will be necessary). Therefore, with a structure providing for a 50-year flood, there would be a 90% probability that all overflows through the life expectancy of the present roadway would be eliminated, and the "flood-insurance" per annum cost would be the cost of the structure ($210,900.00) divided by 50, or $4,200.00. Similarly, a structure providing for a 5-year storm would probably eliminate nine flooding events (i.e., 10 intervals less one) and be expected to provide protection for a total of 41 (non-flooding) years, with the resulting cost per annum being $2,900.00 ($119,000.00 divided by 41). Utilizing this approach further, costs per annum were developed for structures providing for the 2, 10, and 25-year flooding events. A graph depicting the relative cost per annum versus design storm frequencies is included (Plate XXIII). From an examination of the latter, quite obviously the cost per year for any type of structure is very high on a short term basis (i.e., designed for the 1 or 2-year storm). In the design for a storm of average frequency (5 years), the costs per annum are lowest. However, the costs per year rise slowly at a uniform rate in designs for storms of lower frequency (10 to 50 years). By adopting a structure designed for a 5-year storm - rather than 25 years, as in Plan 13a, etc. - an additional $66,000.00 saving could be effected. The residual damages under this plan would be somewhat increased (to $800.00/annum) above that for Plan 13a, due to the possible added interruption of services (and maintenance clean-up) on Shea Boulevard, caused by somewhat more frequent overflows. However, this does not appreciably affect the annual benefits of Plan 13b which, due to the lower costs, has a somewhat better benefit cost ratio (0.93).

RECOMMENDATIONS

In selecting any one of the aforementioned 18 plans for implementation, one must consider the degree of accuracy with which the presented figures have been prepared. The costs have been estimated with a fair degree of confidence, but the practical difficulty lies in the evaluation of the benefits. By far, the greatest source of uncertainty is the date of future flood occurrences. In the analysis presented in this report, it is assumed that the future floods will occur in a statistically normal pattern. In fact, it is assumed that the annual value of the real future damage is equal to the value of the calculated average annual flood damage. To be completely honest, this assumption is, of course, a wild guess.

In addition, it must be emphasized that around 75% of the benefits for the more advantageous plans are composed of a cost reduction in the construction of a storm sewer on Shea Boulevard which, in itself, probably cannot be economically justified. In somewhat the same manner, the cost of flood plain zoning could be, from an economic standpoint, the subject of considerable debate. It can logically be argued that this cost would be upon the various land developers, and not upon the general public. Therefore, should this cost be deleted from those plans for which flood plain zoning is envisioned, the benefit-cost ratios would be somewhat improved. In the case of Plan 13b, an actual net benefit of $1,300.00 might occur, with a resulting benefit-cost ratio of 1.05.

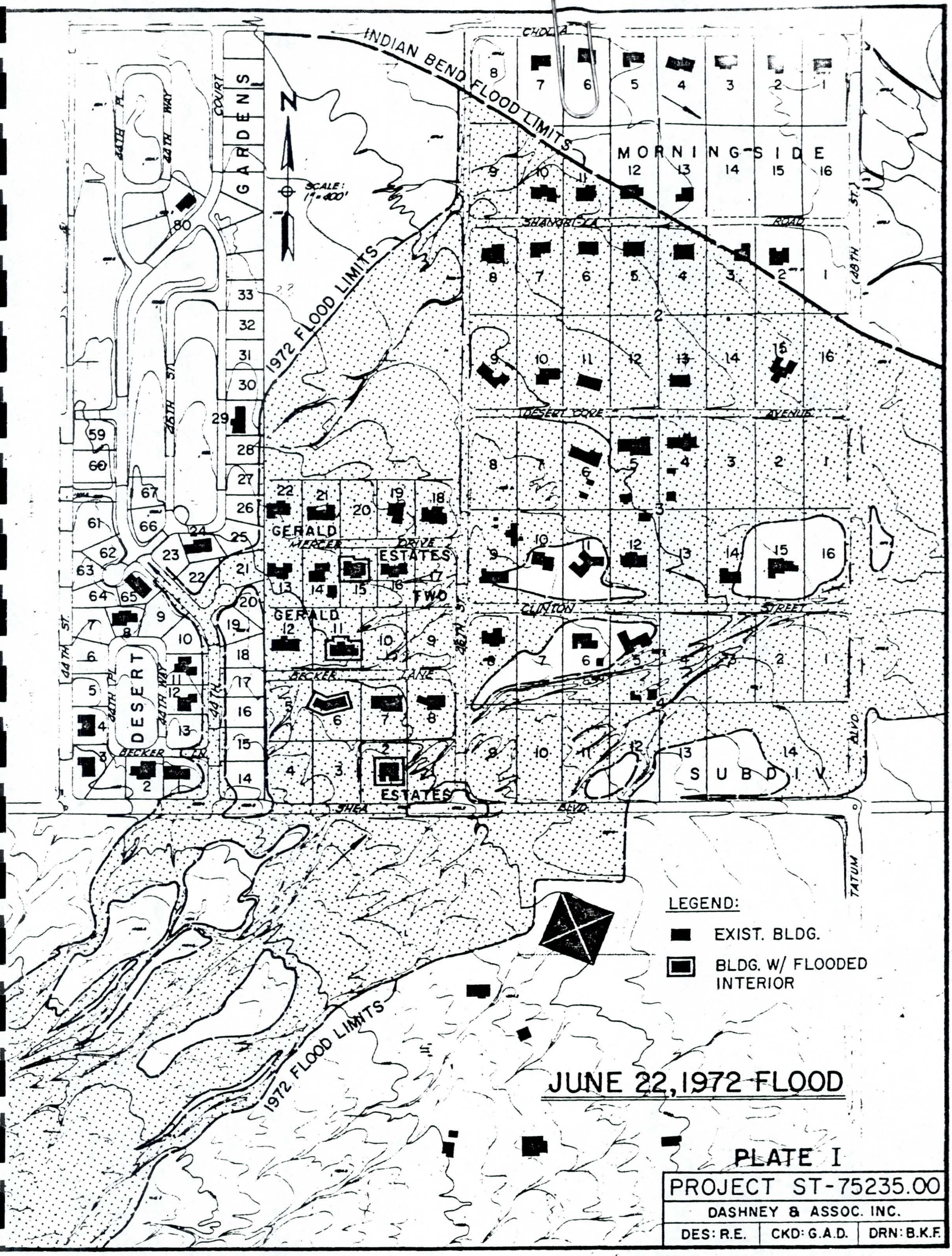
For the above reasons, it is recommended that a simple social-economic decision be made, and that the plan selected be the one which is most consistent with the developmental requirements of the area and which will also ultimately have the greatest benefit at the least possible total cost.

On first appraisal, one is tempted to select Plan 13b. However, since this envisions a structure designed for only a 5-year frequency storm across Shea

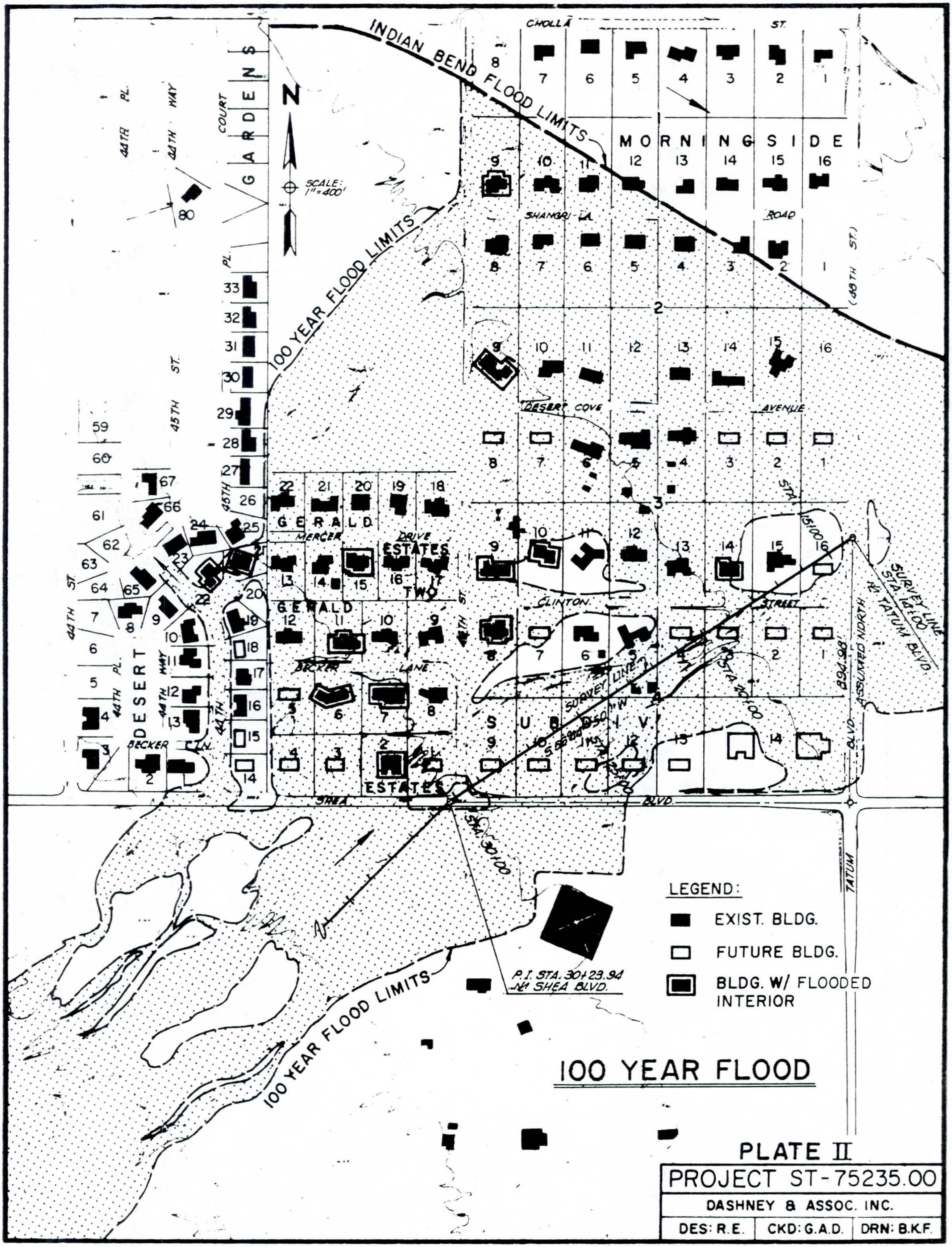
Boulevard and thus disqualifies its cost from federal participation, the ultimate cost to the City of Phoenix would probably be higher. Plan 13a, which would be eligible for federal participation because its envisioned structure is designed for the 25-year frequency event, is also a very logical choice. However, it should be noted that the latter (like Plan 13b) is only a temporary measure and, once Tatum Boulevard is developed into a full arterial, it would have to be modified into Plan 13. This would entail a somewhat greater cost than if Plan 13 were originally adopted, because the channel connecting the structures at Shea and Tatum Boulevards would have to be completely re-excavated, and some rather expensive lining removed and entirely replaced. In addition, Plan 13a or 13b would involve some degree of legal liability, since both would be vulnerable to pettifogging suits by the owners easterly of Tatum Boulevard, who would undoubtedly claim that runoff had been concentrated on their property. Moreover, any developer of property easterly of Tatum would be caused further unhappiness should they be subjected, under Plan 13a, to a 250-foot-wide flood-zoning restriction of which the City of Phoenix would later purchase only a 150-foot width in order to initiate Plan 13. In view of all of the above considerations, it can only be recommended that Plan 13 be adopted.

Complete water-surface computations for the foregoing Plan 13 have been made, in order to verify its practicality. (See Volume V.) A detailed listing of its cost is shown on Plate XXIX. In estimating the foregoing, no allowance has been made for the purchase of drainage easements from the 60-acre parcel fronting on Shea Boulevard from 660 to 1980 feet westerly of its intersection with 46th Street. This foregoing land is very soon to be developed by Tom Cavanagh Realty of Scottsdale, Arizona. Representatives of this company have unofficially expressed a willingness to grant temporary construction easements for the necessary dyking, since these would also be of advantage to them. Moreover, an approval of the final subdivision plans could stipulate that the necessary dykes be constructed.

The recommended box culverts in Plan 13 are standard sizes, as developed by the Structures Section of the Division of Highways, State of Arizona Department of Transportation. In connection with these, it should be noted that the box culvert proposed at Tatum Boulevard would flow under outlet control, and the one envisioned at Shea Boulevard would be under inlet control. Therefore, while it has not been such a design practice in Arizona, the latter could be designed with tapered barrels, in order to induce outlet control and also afford some cost savings. However, upon cursory examination, it appears that the height of the barrels could be decreased less than 1.5 feet, and the actual monetary savings would be marginal. It must be emphasized that the computed costs of Plan 13 envision rather expensive channel lining in those reaches where the water velocities could exceed 10 f.p.s. Upon actual analysis of the natural channel material, the latter may be found to be sufficiently cohesive to permit somewhat higher velocities without causing erosion.



INDIAN BEND FLOOD LIMITS
CHOLLA
MORNING SIDE
SHANGRI-LA
ROAD
DESERT COVE
AVENUE
CLINTON
STREET
SHEA
BLVD.
TATUM
BLVD
SUBDIV
GARDENS
COURT
DESERT
44TH ST.
44TH PL.
44TH WAY
44TH
46TH ST.
48TH ST.
BECKER
LANE
BECKER LN
MERCER
DRIVE
GERALD ESTATES
GERALD ESTATES TWO
ESTATES
1972 FLOOD LIMITS
1972 FLOOD LIMITS
SCALE: 1" = 400'
N
LEGEND:
EXIST. BLDG.
BLDG. W/ FLOODED INTERIOR
JUNE 22, 1972 FLOOD
PLATE I
PROJECT ST-75235.00
DASHNEY & ASSOC. INC.
DES: R.E.
CKD: G.A.D.
DRN: B.K.F.


INDIAN BEND FLOOD LIMITS
100 YEAR FLOOD LIMITS
100 YEAR FLOOD LIMITS
N
SCALE: 1" = 400'
CHOLLA ST.
MORNINGSIDE
SHANGRI-LA ROAD
DESERT COVE AVENUE
CLINTON STREET
GERALD ESTATES
MERCER DRIVE
GERALD ESTATES TWO
BECKER LANE
DESERT
BECKER LN.
GARDENS
SUB. IV.
SHEA BLVD.
TATUMA BLVD.
(68TH ST.)
44TH PL.
44TH WAY
45TH ST.
44TH ST.
45TH PL.
COURT
SURVEY LINE
SURVEY LINE STA. 14+00 ℄ TATUM BLVD.
ASSUMED NORTH 894.98'
STA. 15+00
STA. 20+00
STA. 30+00
P.I. STA. 30+23.94 ℄ SHEA BLVD.
LEGEND:
EXIST. BLDG.
FUTURE BLDG.
BLDG. W/ FLOODED INTERIOR
100 YEAR FLOOD
PLATE II
PROJECT ST-75235.00
DASHNEY & ASSOC. INC.
DES: R.E.
CKD: G.A.D.
DRN: B.K.F.

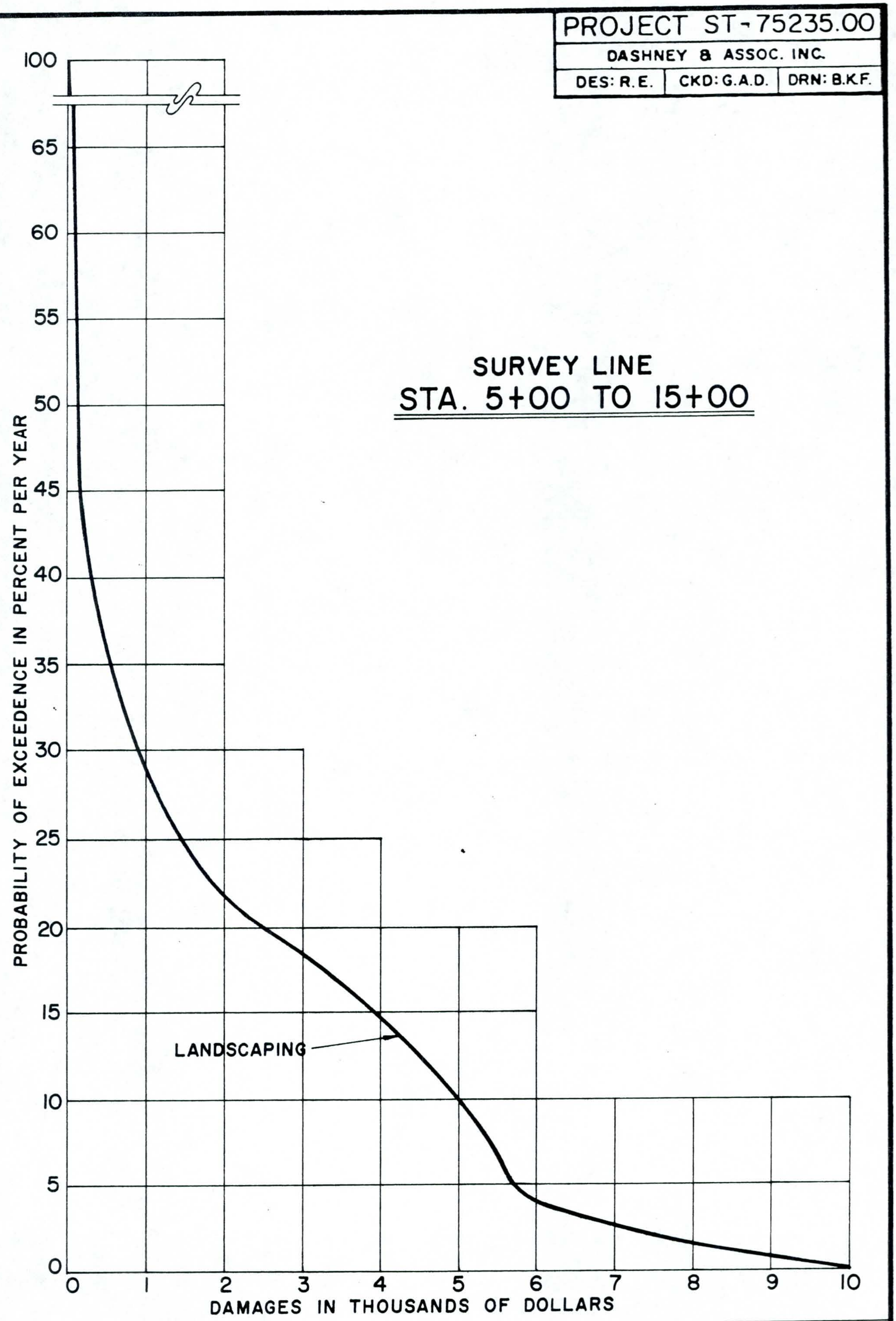

PROJECT ST-75235.00
DASHNEY & ASSOC. INC.
DES: R.E.
CKD: G.A.D.
DRN: B.K.F.
SURVEY LINE
STA. 5+00 TO 15+00
PROBABILITY OF EXCEEDENCE IN PERCENT PER YEAR
DAMAGES IN THOUSANDS OF DOLLARS
LANDSCAPING
100
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10

PLATE III

PROJECT ST-75235.00		
DASHNEY & ASSOC. INC.		
DES: R.E.	CKD: G.A.D.	DRN: B.K.F.

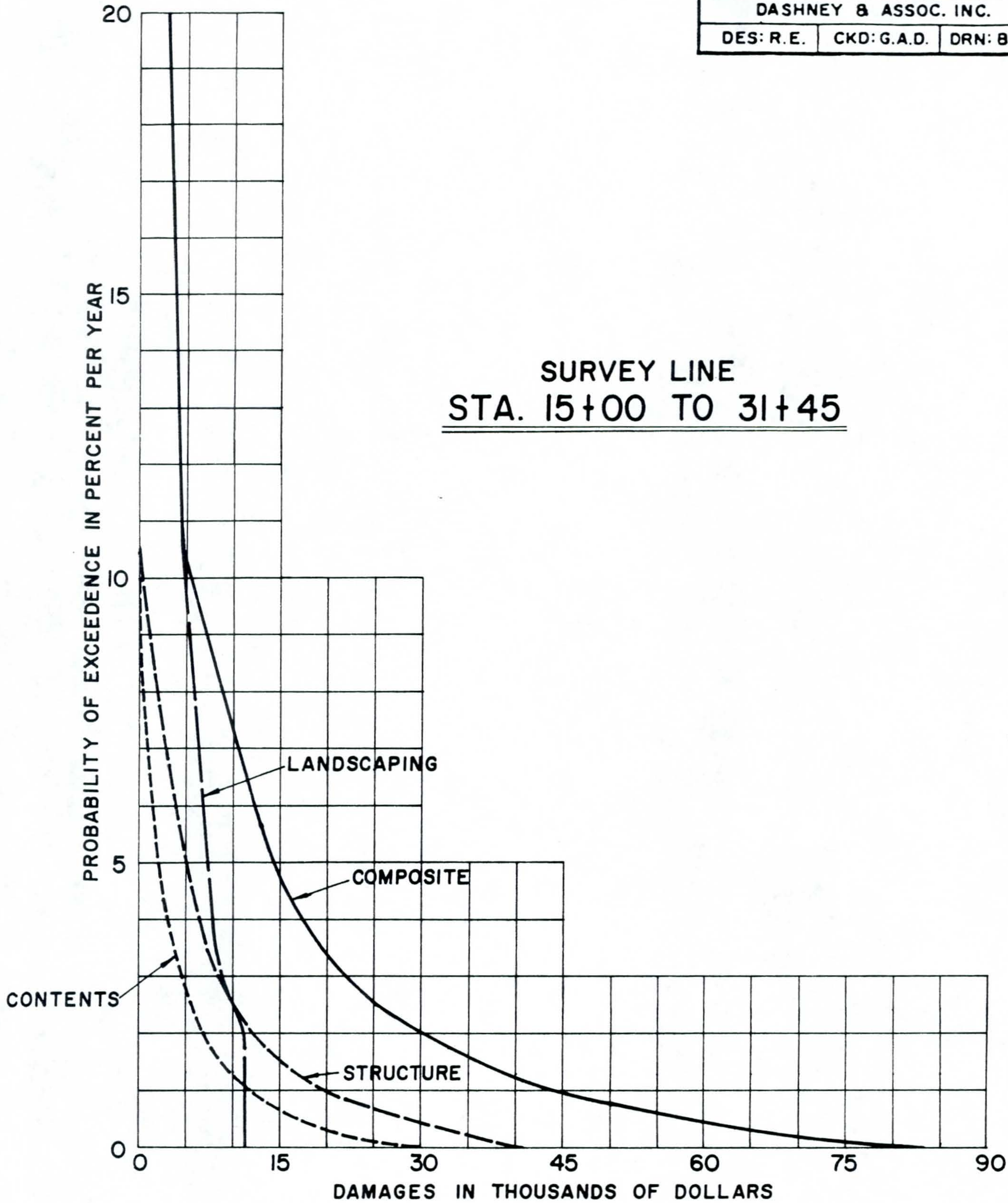


PLATE IV

PROJECT ST-75235.00		
DASHNEY & ASSOC. INC.		
DES: R.E.	CKD: G.A.D.	DRN: B.K.F.

46TH STREET

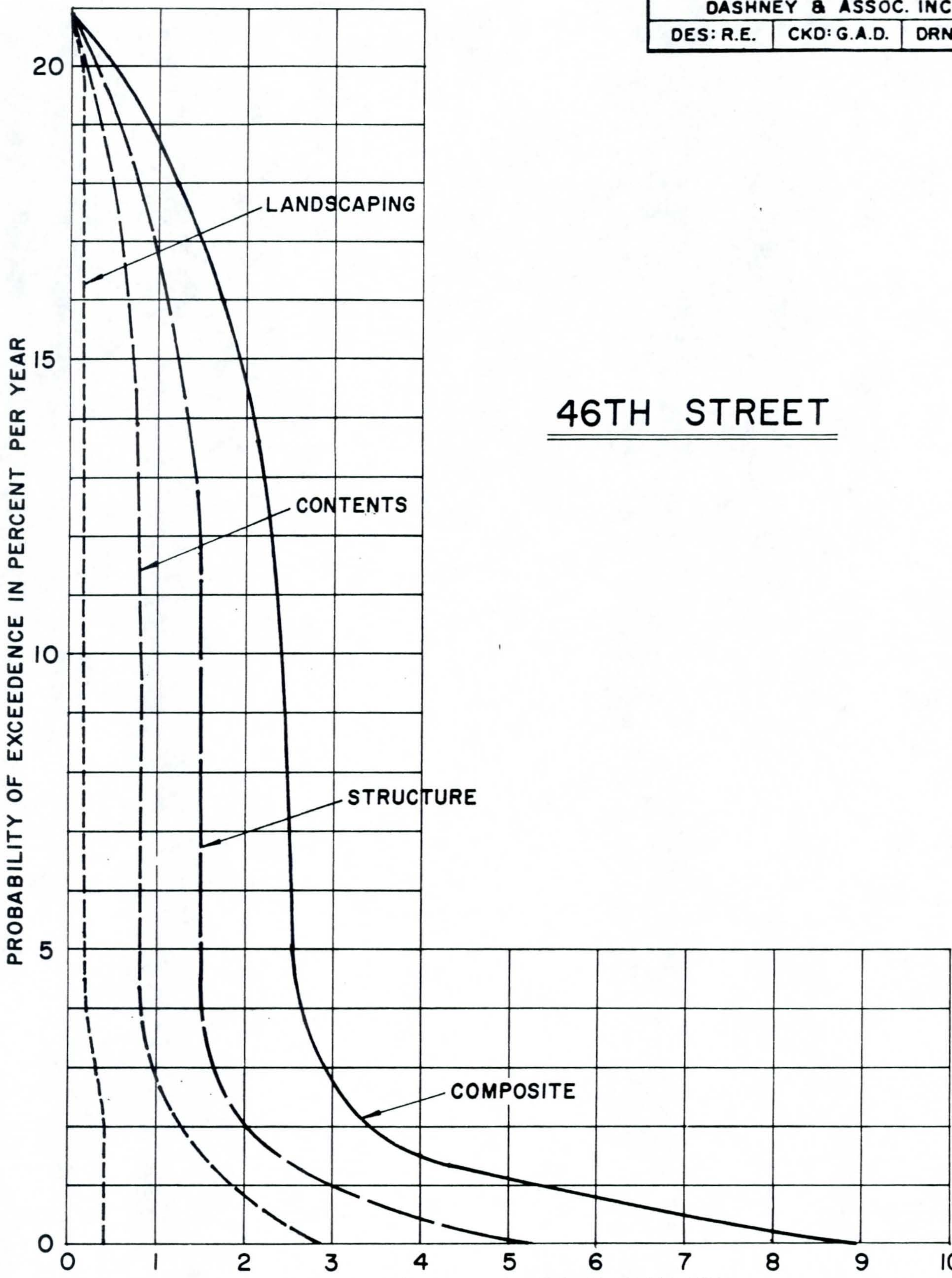


PLATE V

PROJECT ST-75235.00		
DASHNEY & ASSOC. INC.		
DES: R.E.	CKD: G.A.D.	DRN: B.K.F.

44TH COURT

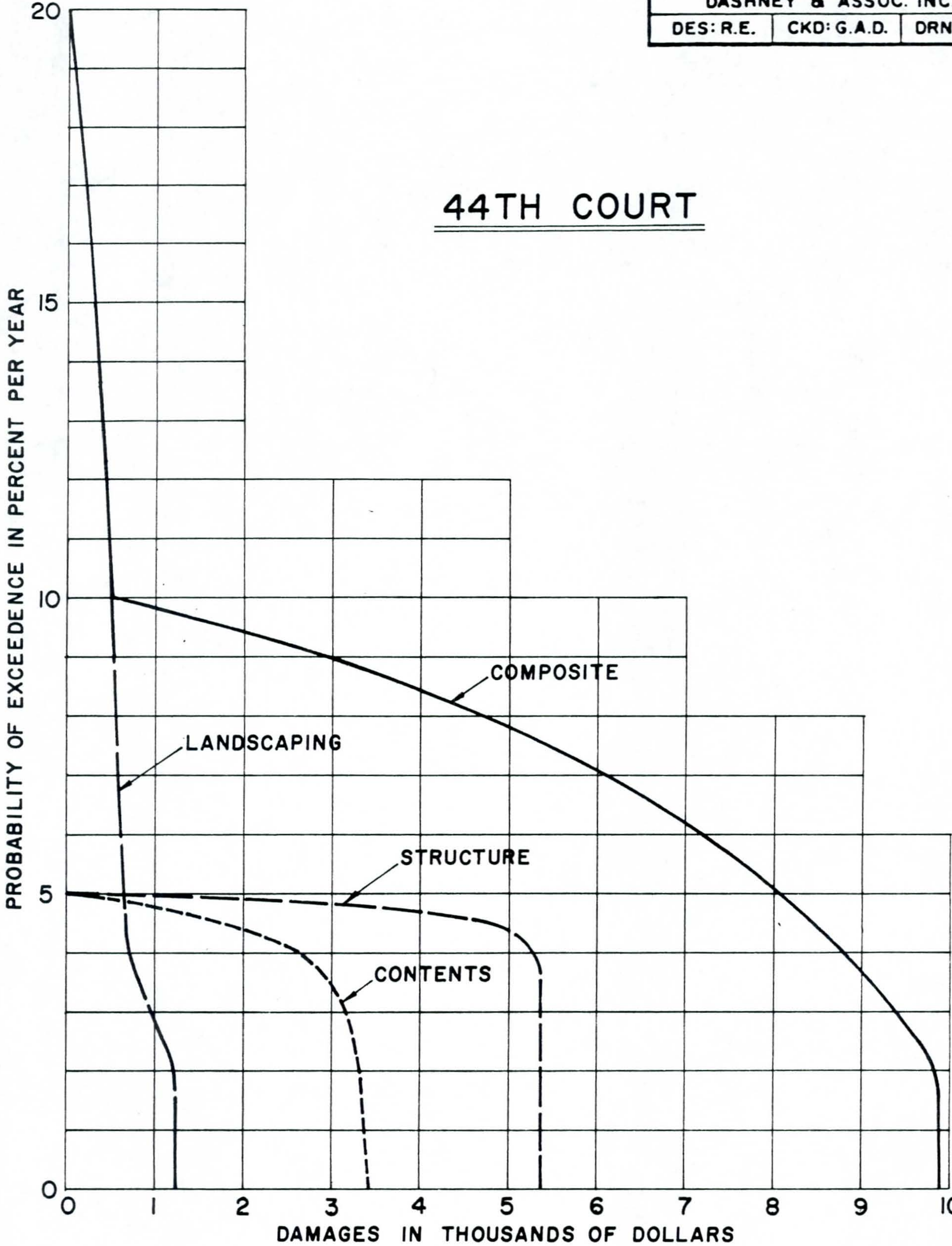


PLATE VI

PROJECT ST-75235.00		
DASHNEY & ASSOC. INC.		
DES: R.E.	CKD: G.A.D.	DRN: B.K.F.

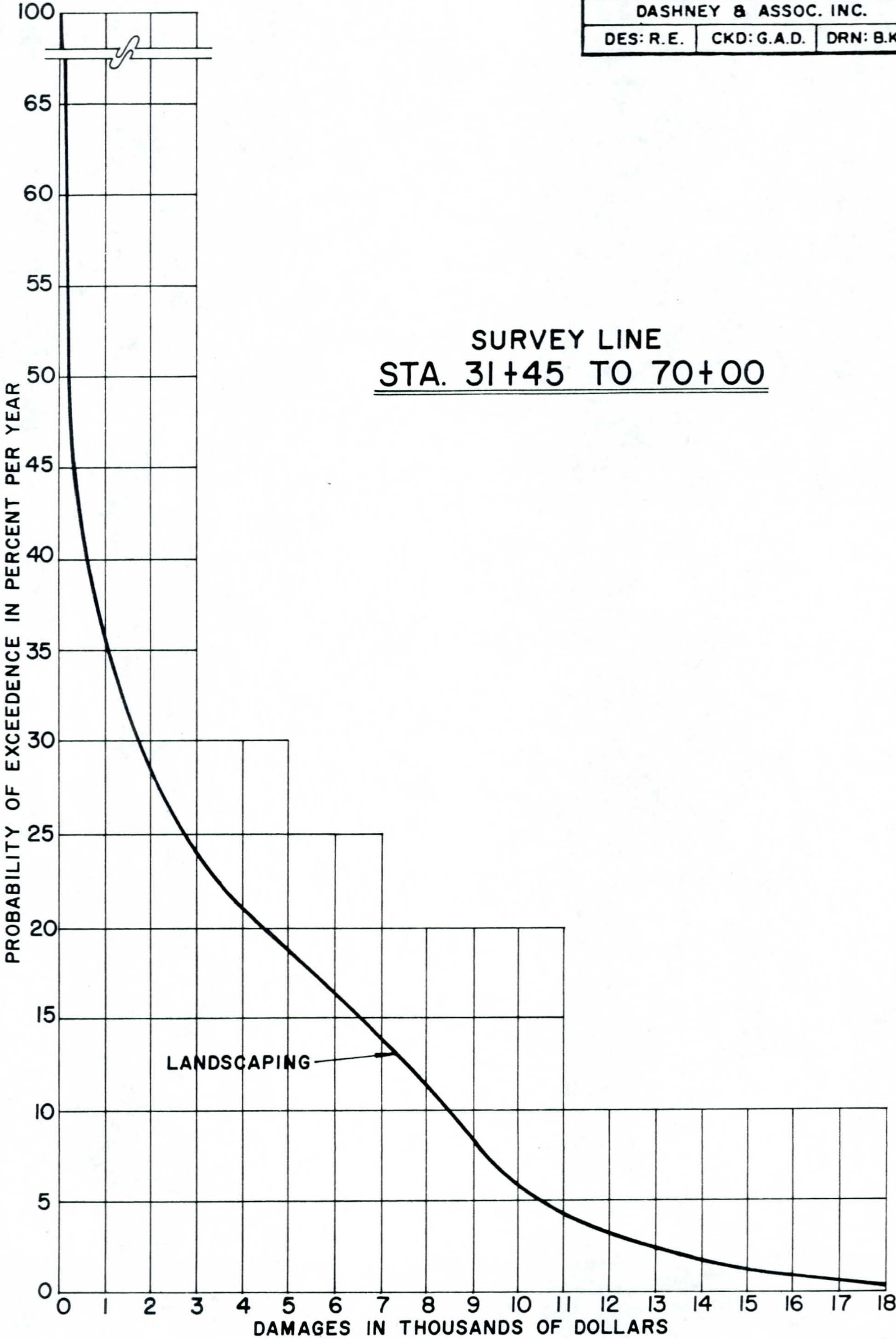
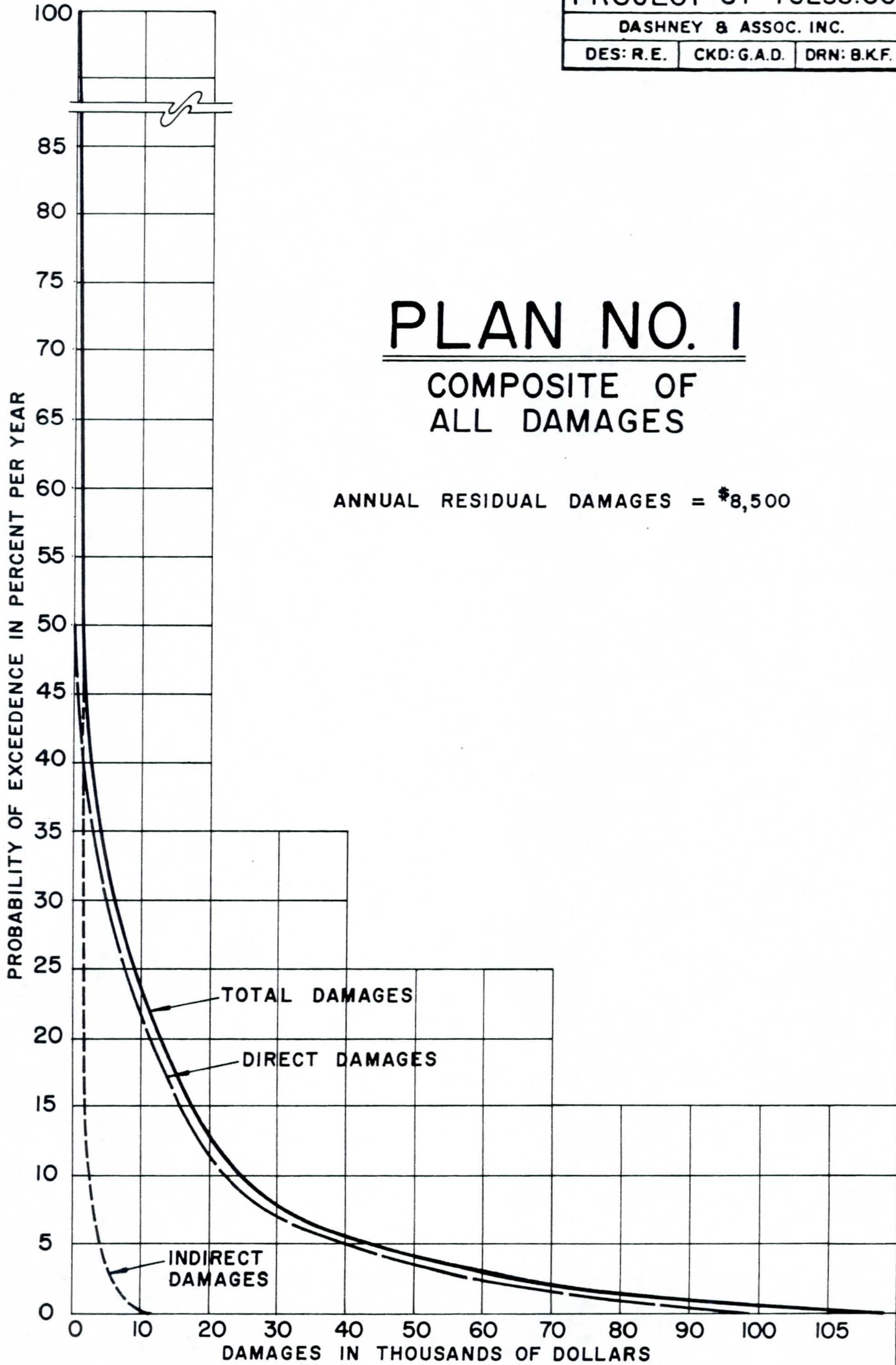


PLATE VII

PLAN NO. 1

COMPOSITE OF ALL DAMAGES

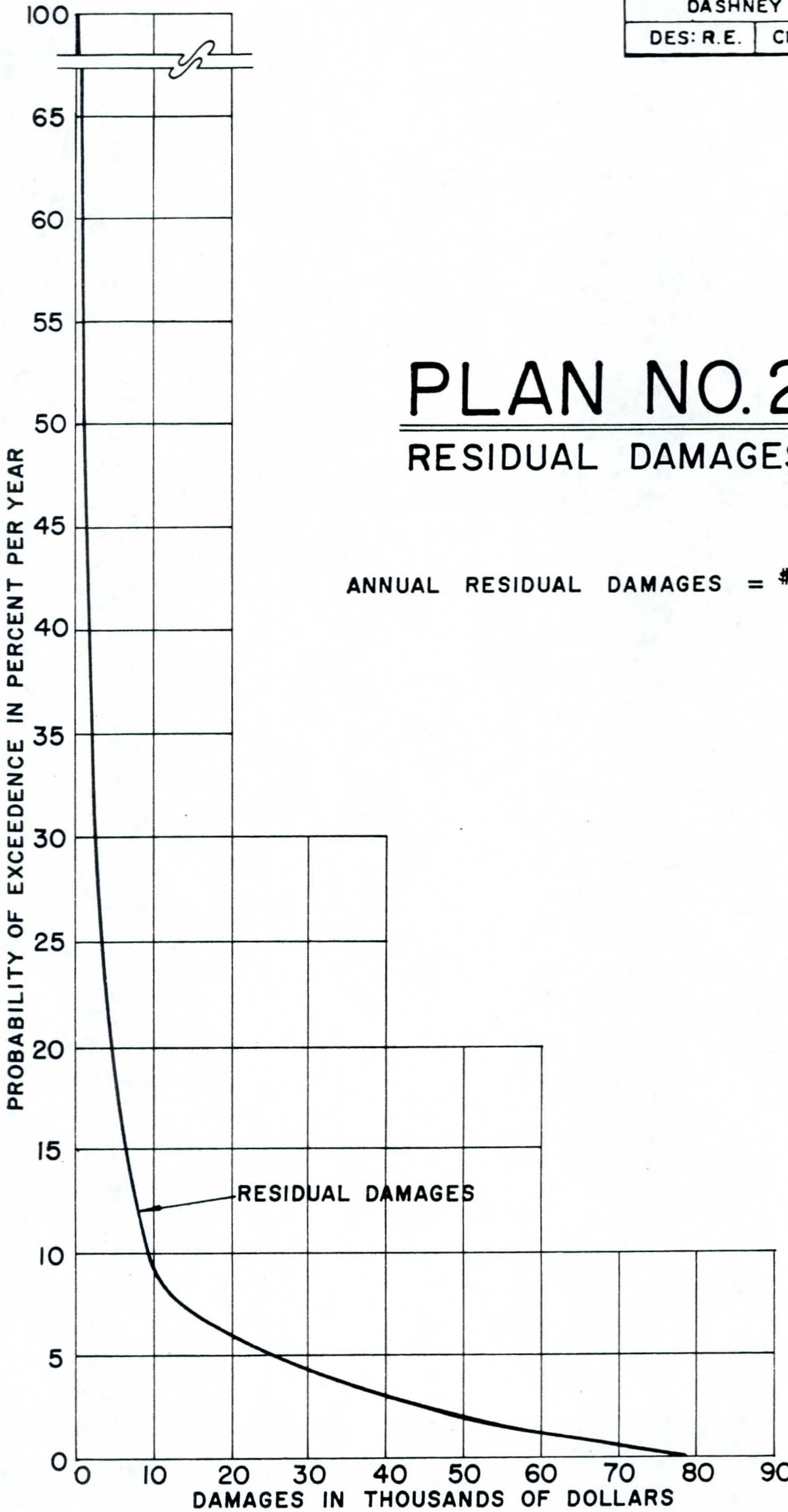
ANNUAL RESIDUAL DAMAGES = $8,500



PLAN NO. 2

RESIDUAL DAMAGES

ANNUAL RESIDUAL DAMAGES = $4,600



PROJECT ST-75235.00		
DASHNEY & ASSOC. INC.		
DES: R.E.	CKD: G.A.D.	DRN: B.K.F.

PLAN NOS. 3,4,5,5A & 8

RESIDUAL DAMAGES

PLAN NO. 3 -
ANNUAL RESIDUAL DAMAGES = $4,600

PLAN NOS. 4, 5, 5A & 8 -
ANNUAL RESIDUAL DAMAGES = $1,200

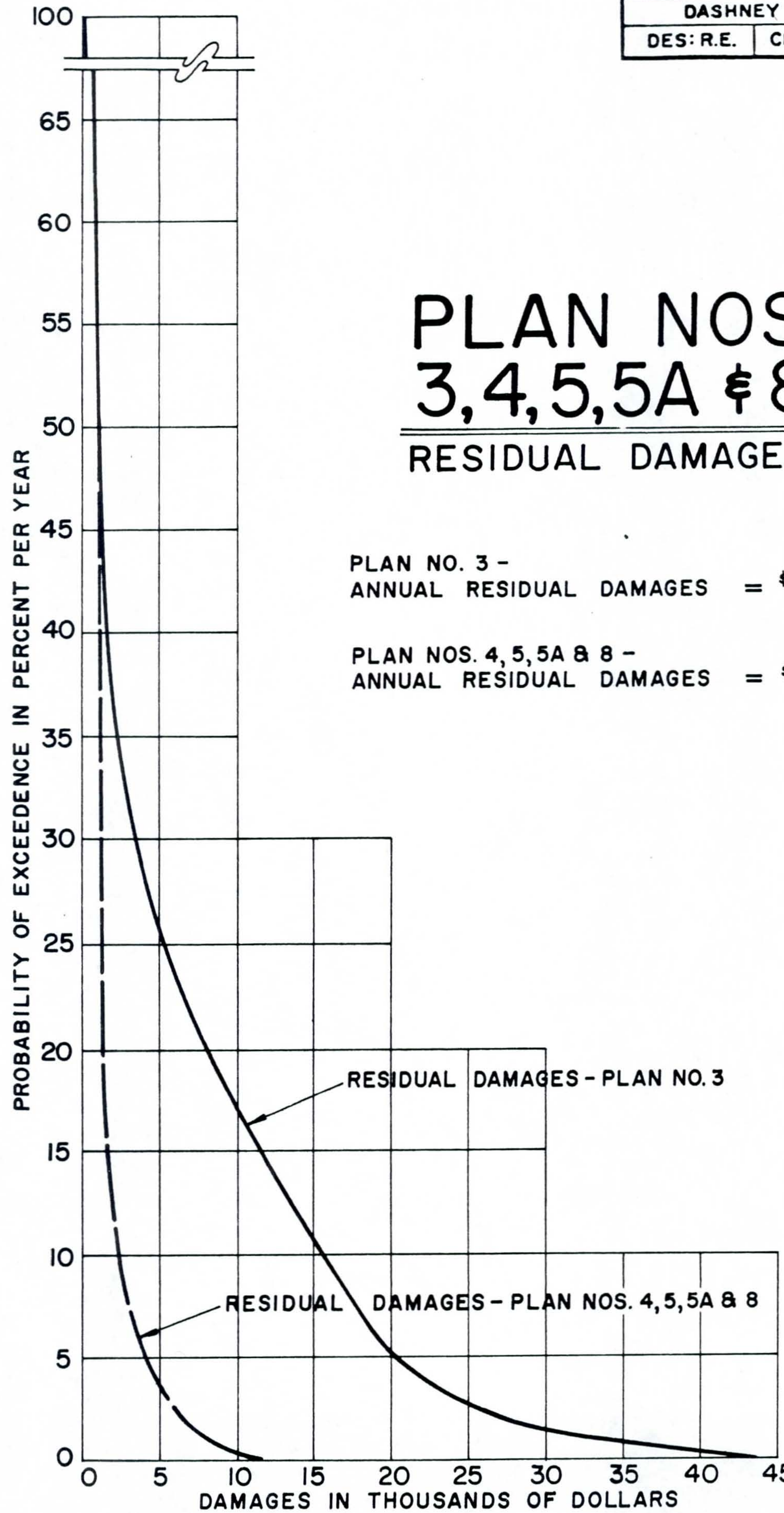


PLATE X

PROJECT ST-75235.00		
DASHNEY & ASSOC. INC.		
DES: R.E.	CKD: G.A.D.	DRN: B.K.F.

PLAN NOS. 11, 12, 13, 13A & 13B

RESIDUAL DAMAGES

PLAN NO. 11 –
ANNUAL RESIDUAL DAMAGES = $3,900

PLAN NOS. 12 & 13 –
ANNUAL RESIDUAL DAMAGES = NEGLIGIBLE

PLAN NO. 13A –
ANNUAL RESIDUAL DAMAGES = $600

PLAN NO. 13B –
ANNUAL RESIDUAL DAMAGES = $800

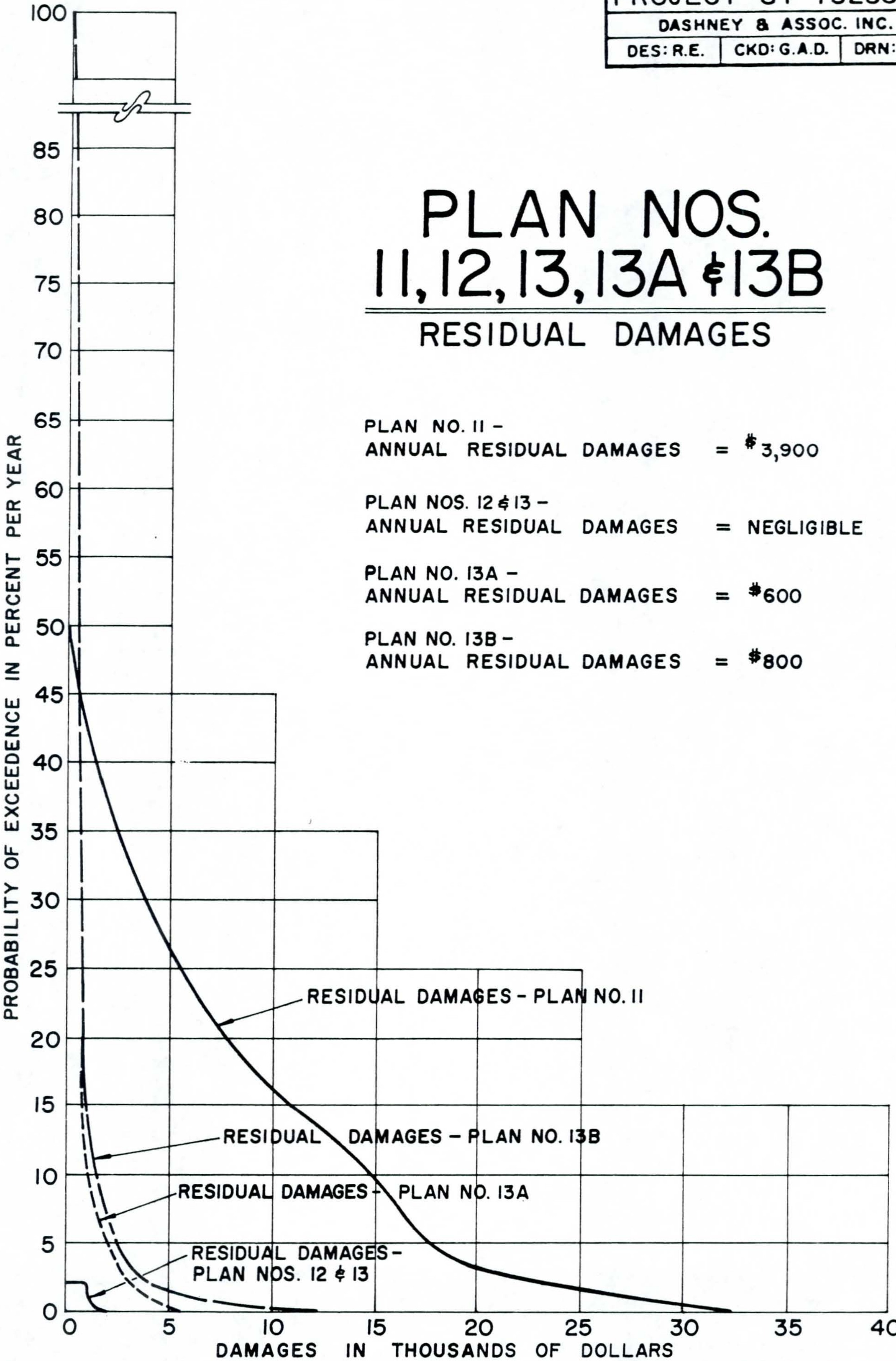


PLATE XI

ALTERNATE PLANS

PLAN # 1 - Take no further action

PLAN # 2 - Establish Flood Plain Zoning in undeveloped areas

PLAN # 3 - Purchase property, flood plain easements and/or remove structures in developed areas to allow for the runoff from future storms

PLAN # 4 - Purchase property, flood plain easements and/or remove structures in developed areas to allow for the runoff from future storms + Establish Flood Plain Zoning in undeveloped areas

PLAN # 5 - Construct "CAROLLO" Dam

PLAN # 5a - Construct Alternate "CAROLLO" Dam

PLAN # 6 - Construct "CAROLLO" Dam + Downstream Channel and Structures

PLAN # 6a - Construct Alternate "CAROLLO" Dam + Downstream Channel and Structures

PLAN # 7 - Construct "CAROLLO" Dam + Downstream Channel and Structures + Shea and Tatum Boulevard Storm Drain Connection

PLAN # 7a - Construct Alternate "CAROLLO" Dam + Downstream Channel and Structures + Shea and Tatum Boulevard Storm Drain Connections

PLAN # 8 - Construct Alternate #2 Detention Dams

PLAN # 9 - Construct Alternate #2 Detention Dams + Downstream Channel and Structures

PLAN #10 - Construct Alternate #2 Detention Dams + Downstream Channel and Structures + Shea and Tatum Boulevard Storm Drain Connections

PLAN #11 - Construct Downstream Channel (100-year frequency) and Structures (25-year frequency)

PLAN #12 - Construct Downstream Channel (100-year frequency) and Structures (25-year frequency) + Establish Flood Plain Zoning in undeveloped areas

PLAN #13 - Construct Downstream Channel (100-year frequency) and Structures (25-year frequency) + Shea and Tatum Boulevard Storm Drain Connections + Establish Flood Plain Zoning in undeveloped areas

PLAN #13a - Construct Downstream Channel (100-year frequency) and Structure at Shea Boulevard only (25-year frequency) + Shea Boulevard Storm Drain Connection only + Establish Flood Plain Zoning in undeveloped areas

PLAN #13b - Construct Downstream Channel (100-year frequency) and Structure at Shea Boulevard only (5-year frequency) + Shea Boulevard Storm Drain Connection only + Establish Flood Plain Zoning in undeveloped areas

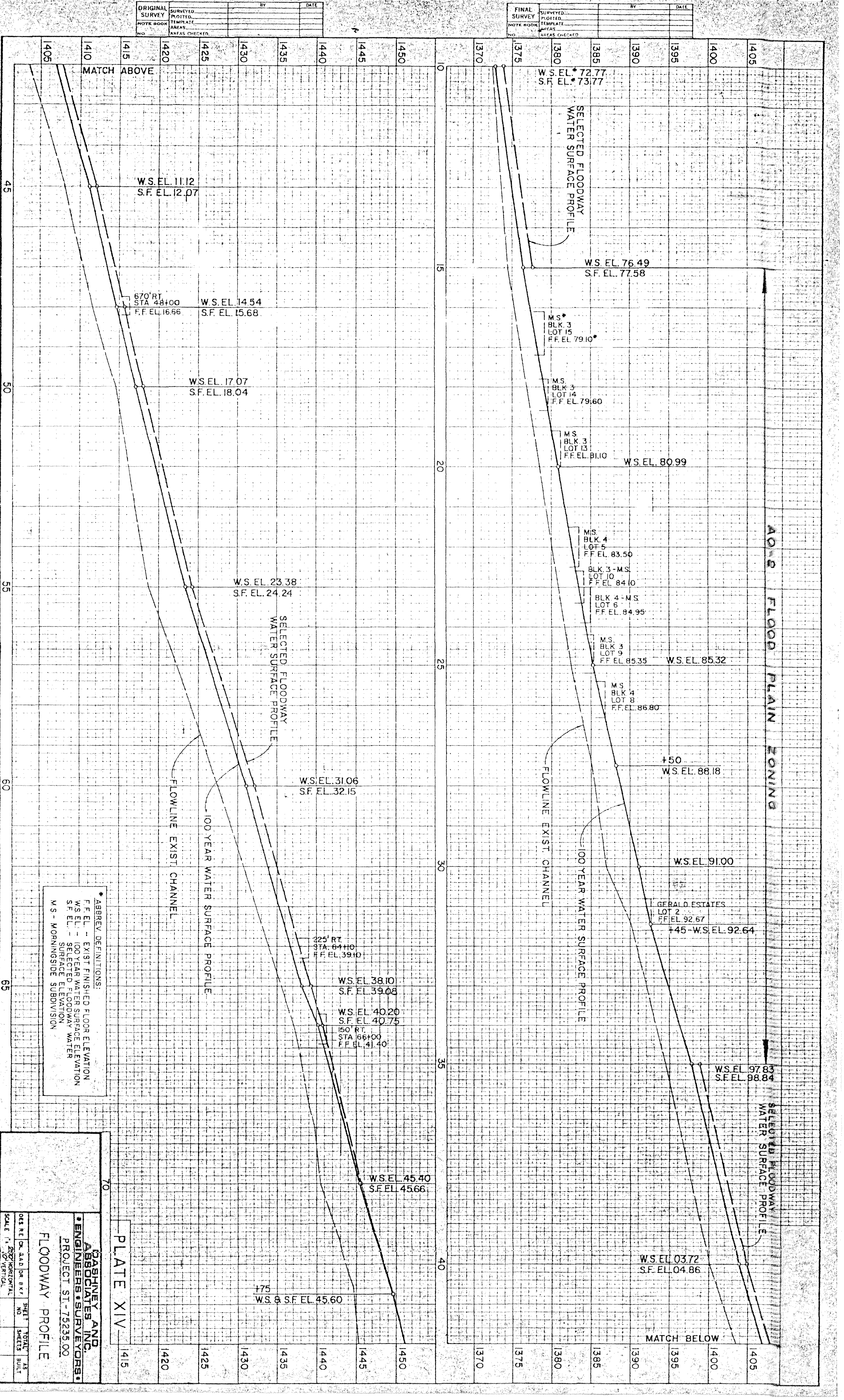
COST & BENEFITS OF FLOOD CONTROL PLANS

Period of Capitalization - 50 Years

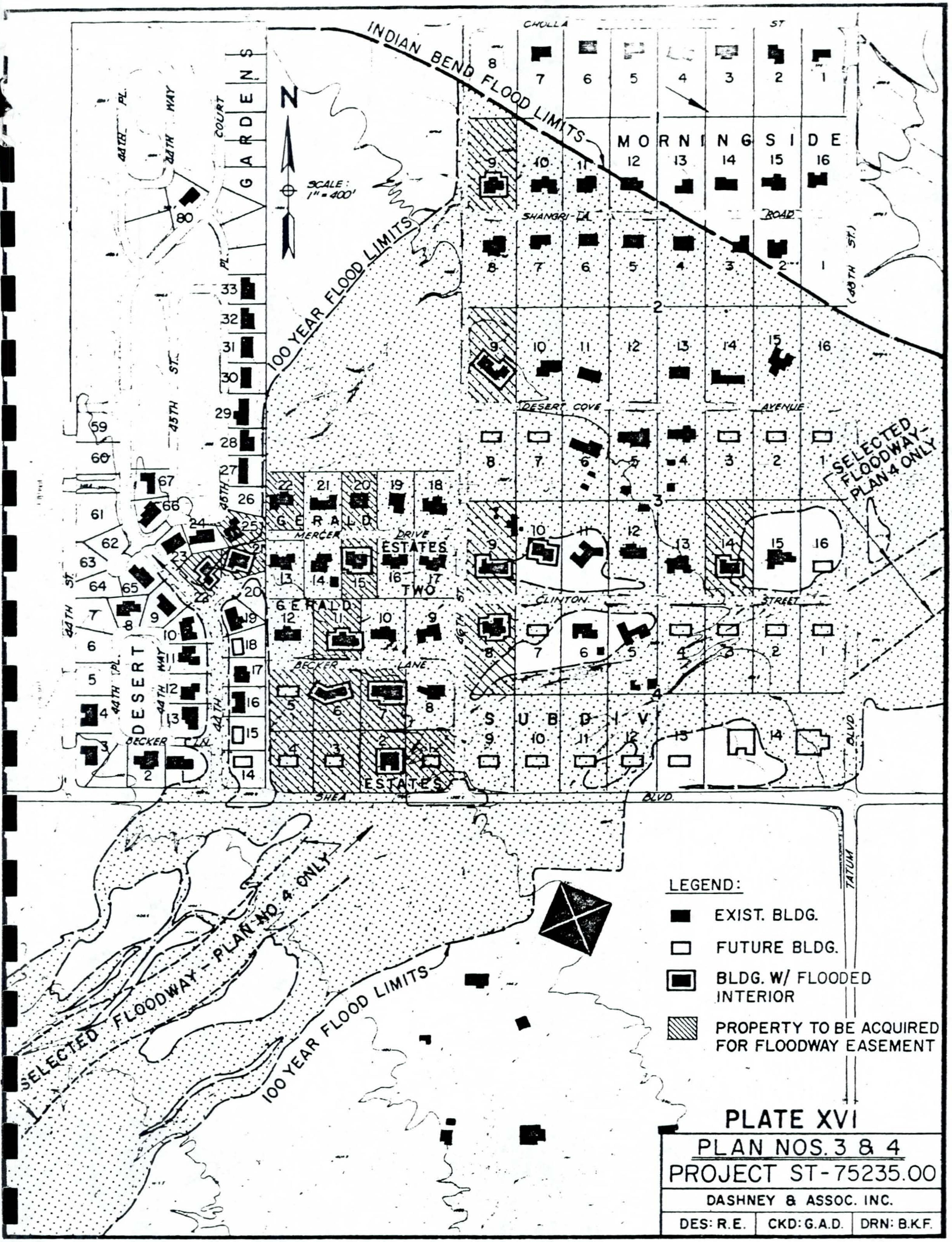
No. of Plan	Capital Cost	Capital Recovery Cost	Cost Flood Plain Zoning	Other Annual Costs	Average Annual Damage	Total Annual Costs	Annual Benefits	Other Benefits	Total Benefits	B/C Ratio
1	0	0	0	0	8,500	8,500	0	0	0	0
2	0	0	3,400	0	4,600	8,000	3,800	0	3,800	0.48
3	1,017,000	64,500	0	0	4,600	69,100	3,900	0	3,900	0.06
4	1,017,000	64,500	3,400	0	1,200	69,100	7,300	0	7,300	0.11
5	993,000	63,000	0	2,500*	1,200	66,700	7,300	0	7,300	0.11
5a	582,000	36,900	0	2,500*	1,200	40,600	7,300	0	7,300	0.18
6	1,299,000	82,400	0	2,500*	0	84,900	8,500	0	8,500	0.10
6a	888,000	56,300	0	2,500*	0	58,800	8,500	0	8,500	0.14
7	1,611,000	102,200	0	2,500*	0	104,700	8,500	22,800	31,300	0.30
7a	1,201,000	76,200	0	2,500*	0	78,700	8,500	22,800	31,300	0.40
8	651,000	41,300	0	2,500*	1,200	43,800	7,300	0	7,300	0.17
9	1,091,000	69,200	0	2,500*	0	71,700	8,500	0	8,500	0.12
10	1,373,000	87,100	0	2,500*	0	89,600	8,500	22,800	31,300	0.35
11	936,000	59,400	0	0	3,900	63,300	4,600	0	4,600	0.07
12	936,000	59,400	2,300	0	0	61,700	8,500	0	8,500	0.14
13	1,047,000	66,400	2,300	0	0	68,700	8,500	22,800	31,300	0.46
13a	498,000	31,600	3,400	0	600	35,600	7,900	21,800	29,700	0.83
13b	432,000	27,400	3,400	0	800	31,600	7,700	21,800	29,500	0.93

*Includes Dam Operation, Inspection & Maintenance Costs

PLATE XIII



MATCH ABOVE
W.S. EL. 11.12
S.F. EL. 12.07
670' RT.
STA. 48+00
F.F. EL. 16.66
W.S. EL. 14.54
S.F. EL. 15.68
W.S. EL. 17.07
S.F. EL. 18.04
W.S. EL. 23.38
S.F. EL. 24.24
SELECTED FLOODWAY WATER SURFACE PROFILE
FLOWLINE EXIST. CHANNEL
100 YEAR WATER SURFACE PROFILE
W.S. EL. 31.06
S.F. EL. 32.15
225' RT.
STA. 64+10
F.F. EL. 39.10
W.S. EL. 38.10
S.F. EL. 39.08
W.S. EL. 40.20
S.F. EL. 40.75
150' RT.
STA. 66+00
F.F. EL. 41.40
W.S. EL. 45.40
S.F. EL. 45.66
+75
W.S. & S.F. EL. 45.60
* ABBREV. DEFINITIONS:
F.F. EL. - EXIST FINISHED FLOOR ELEVATION
W.S. EL. - 100 YEAR WATER SURFACE ELEVATION
S.F. EL. - SELECTED FLOODWAY WATER SURFACE ELEVATION
M.S. - MORNINGSIDE SUBDIVISION
W.S. EL.* 72.77
S.F. EL.* 73.77
W.S. EL. 76.49
S.F. EL. 77.58
M.S.* BLK. 3 LOT 15 F.F. EL. 79.10*
M.S. BLK. 3 LOT 14 F.F. EL. 79.60
M.S. BLK. 3 LOT 13 F.F. EL. 81.10
W.S. EL. 80.99
M.S. BLK. 4 LOT 5 F.F. EL. 83.50
BLK. 3 - M.S. LOT 10 F.F. EL. 84.10
BLK. 4 - M.S. LOT 6 F.F. EL. 84.95
M.S. BLK. 3 LOT 9 F.F. EL. 85.35
W.S. EL. 85.32
M.S. BLK. 4 LOT 8 F.F. EL. 86.80
+50
W.S. EL. 88.18
W.S. EL. 91.00
GERALD ESTATES LOT 2 F.F. EL. 92.67
+45 - W.S. EL. 92.64
W.S. EL. 97.83
S.F. EL. 98.84
W.S. EL. 03.72
S.F. EL. 04.86
MATCH BELOW
AO-2 FLOOD PLAIN ZONING
PLATE XIV
CASHNEY AND ASSOCIATES INC.
• ENGINEERS • SURVEYORS •
PROJECT ST-7523.00
FLOODWAY PROFILE
ORIGINAL SURVEY
FINAL SURVEY


CHOLLA ST
INDIAN BEND FLOOD LIMITS
MORNINGSIDE
SHANGRI-LA ROAD
(48TH ST.)
DESERT COVE AVENUE
CLINTON STREET
SELECTED FLOODWAY-PLAN 4 ONLY
GARDENS
44TH PL.
44TH WAY
COURT
SCALE: 1" = 400'
N
100 YEAR FLOOD LIMITS
45TH ST.
45TH PL.
GERALD
MERCER DRIVE
ESTATES
TWO
GERALD
BECKER LANE
46TH ST.
DESERT
44TH PL.
44TH WAY
44TH ST.
BECKER LN.
ESTATES
SUBDIV
TATUM BLVD.
SHEA BLVD.
SELECTED FLOODWAY-PLAN NO 4 ONLY
100 YEAR FLOOD LIMITS
LEGEND:
EXIST. BLDG.
FUTURE BLDG.
BLDG. W/ FLOODED INTERIOR
PROPERTY TO BE ACQUIRED FOR FLOODWAY EASEMENT
PLATE XVI
PLAN NOS. 3 & 4
PROJECT ST-75235.00
DASHNEY & ASSOC. INC.
DES: R.E.
CKD: G.A.D.
DRN: B.K.F.

11-23-78

STUDY OF FLOOD CONTROL MEASURES AT 40TH ST. AND DOUBLE TREE RANCH ROAD

PROJECT ST - 75235.00

CITY OF PHOENIX,
ARIZONA

DASHNEY AND ASSOCIATES INC.
4323 N. 12TH ST., SUITE 100
PHOENIX, ARIZONA

LOCATION OF PROJECT

This project is located on the northerly slopes of the Phoenix Mountains (more popularly known as the "North Phoenix Mountains") approximately 9 miles north-northeasterly from the center of Phoenix, Arizona.

DESCRIPTION OF AREA AND PROBLEM

The watershed under study (totaling over 2 square miles) is "tear-drop" in shape, with the wider portion to the south being along the uppermost ridges of the Phoenix Mountains - while the narrow portion, representing various "braided" outflow channels, extends in a north-northeasterly direction to junction with Indian Bend Wash centered approximately at an intersection of Tatum Boulevard (48th Street) and Cholla Street (Elevation: 1371). The most southwesterly extremity of the watershed is marked by Squaw Peak (Elevation: 2608), and the easterly edge at various points lies within the corporate boundary of Paradise Valley. The "bulbous" portion of the drainage area lies within the rocky northern outcrops of the Phoenix Mountains, while the "neck" portion (which widens considerably in its lower extremity) is on the more gentle southerly slopes of Paradise Valley, and these slopes are composed of caliche cemented talus. Thus, the soils of the watershed have a very high runoff potential, with an infiltration rate of only about 0.05 to 0.15 inch per hour (rated "Group D" in Soil Conservation procedures), and therefore, have very high resistance to erosion. The natural vegetation is typical Sonoran desert type, with sparse mesquite, creosote bush, black bush, catclaw, palo verde and some cactus with about 15 to 20% density. The climate is likewise typical Sonoran, with hot summers, mild winters, and infrequent rainfalls. Most of the annual rainfall (7 inches) is accounted for by summer thunderstorms of high intensity but short duration. In the recent past, there have been three occasions (1951, 1968, and 1972) within the memory of the present residents of the area in which these storms have been of such intensity that the resultant runoff from the area has forced the closure of Shea Boulevard at a point about ½ mile westerly of its juncture with Tatum Boulevard. These closure periods have been relatively short because of the nature of the runoff, and have caused very little damage to property and homes since, until recently, the area has been very sparsely developed. However, inasmuch as the area has experienced considerable development in the last four years, and yet further homes, more subdivisions, and some commercial enterprises are currently being planned adjacent to Shea Boulevard, a need has obviously arisen to examine the desirability of undertaking flood control measures in the watershed. In particular, the possible Detention Basin #8, as described in the report by John Carollo Engineers (Contract No. 13580, Project ST-71185.00), has become the subject of much concern. The latter, which would be located just southerly of Double Tree Ranch Road (i.e., approximately at the north line of Section 36, T3N, R3E, and within the newly purchased Phoenix Mountain Preserve) could be (and apparently has been) considered variously as aesthetically unappealing, inconsistent and damaging to the environment, and also economically infeasible. Inasmuch as developing a cost-benefit ratio for the detention basin and dam was beyond the scope of Contract No. 13580 to John Carollo Engineers, this study and report was initiated to provide the latter and also to develop possible alternate flood control measures.

PROCEDURES

A hydrologic study of the upstream area from the presently proposed structure (hereafter referred to as the "Carollo Dam") and also the downstream portion of the watershed was made to determine the peak discharge at selected points for the 2, 5, 10, 25, 50, and 100-year frequency storms. This was accomplished through utilization of a TR-20 computer model and procedures developed by the Soil Conservation Service (more popularly known as the "SCS Method"). These computations, including a hydrologic map and other pertinent data, are contained in Volume II of this report. To establish the latter computer model, some 30 cross-sections were developed at selected points from the existing City of Phoenix 1" = 100'

5. Hydrologic Studies for the Village of Paradise Valley, prepared for Daycor Associates by Val-Tec, Inc., January 1976.

This report was done for the initial planning of "The Villages of Paradise Valley", a 1,200 acre planned community extending from 40th Street to 52nd Street from Thunderbird to Cholla including Paradise Valley Mall and a portion of the Indian Bend Wash. Contributing flow rates were estimated for a 100-year storm based on the old ADOT SCS method for existing watershed conditions. The report mentions that Indian Bend Wash channelization improvements were being designed by Water Resources Associates. This report identifies Parcel LD15 at the northeast corner of Shea and Tatum as one of several parcels not requiring onsite stormwater detention because of "suitable drainage outfall". This report estimated a 100-year discharge of 1,340 cfs from a contributing area of about 2 square miles to the southwest of the subject site with outfall to Tatum between Shea and the Indian Bend Wash.

6. Shea Boulevard Drainage Study, prepared for the City of Phoenix (Project # ST-75091.00), by Yost and Gardner Engineers, May 1976.

This report was done in conjunction with the design of a major storm drain in Shea Boulevard. It includes the area contributing runoff to Shea from 32nd Street to Tatum. This report uses a 2-year design frequency for the storm drain and assumes that the proposed detention basin/dam flood control projects in the contributing area to the south are constructed. These proposed flood control projects were the subject of a concurrent study by Dashney and Associates for the City of Phoenix.


N
CHOLLA ST.
SHEA BLVD.
TATUM BLVD.
40TH ST.
44TH ST.
46TH ST.
(48TH ST.)
DUNLAP AVE.
N BOUNDARY-CITY OF PHOENIX MOUNTAIN PRESERVE
INDIAN BEND 100 YEAR FLOODWAY FRINGE
SURVEY LINE
S45°23'35"W
S 56°44'50"W
P.I. STA 64+56.25
P.I. STA 30+21.94 ⌀ SHEA BLVD.
END SURVEY LINE
SURVEY LINE STA. 14+00 ⌀ TATUM BLVD.
ASSUMED NORTH
FD. REBAR IN H.H. ⌀ SHEA & TATUM BLVDS.
STA. 102+68 W.S. EL. 1485.65
STA. 55+00
STA. 50+00
STA. 45+00
STA. 40+00
STA. 35+00
STA. 25+00
STA. 20+00
STA. 15+00
STA. 10+00
LEGEND:
FLOODWAY FRINGE
100 YEAR FLOOD
FLOODWAY FRINGE
SELECTED FLOODWAY
FLOODWAY FRINGE
100 YEAR FLOOD
* W.S. EL. (100 YEAR WATER SURFACE ELEVATION)
EXIST. CHANNEL SECTION OF COMPUTED WATER SURFACE
PLATE XV
DASHNEY AND ASSOCIATES INC.
• ENGINEERS • SURVEYORS •
PROJECT ST-75235.00
FLOODPLAIN DELINEATION MAP
DES. R.E.
CK. G.A.D.
DR. B.K.F.
SHEET NO.
TOTAL SHEETS
AS BUILT
SCALE 1" = 400' HORIZONTAL

HYDROLOGY - STR. NO. 1	
DRAINAGE AREA	1.2 SQ. MI.
PEAK FLOW - 100 YR. 6 HR. STORM	2172 CFS
RUNOFF QUANTITY	140 AC. FT.
STORAGE TO EMERGENCY SPILLWAY	109 AC. FT.
PEAK DISCHARGE PRINCIPAL SPILLWAY	77 CFS
TIME TO DRAIN	31 HRS.

HYDROLOGY - STR. NO. 2	
DRAINAGE AREA	0.3 SQ. MI.
PEAK FLOW - 100 YR. 6 HR. STORM	478.8 CFS
RUNOFF QUANTITY	31 AC. FT.
STORAGE TO EMERGENCY SPILLWAY	22 AC. FT.
PEAK DISCHARGE PRINCIPAL SPILLWAY	18.7 CFS
TIME TO DRAIN	32 HRS.

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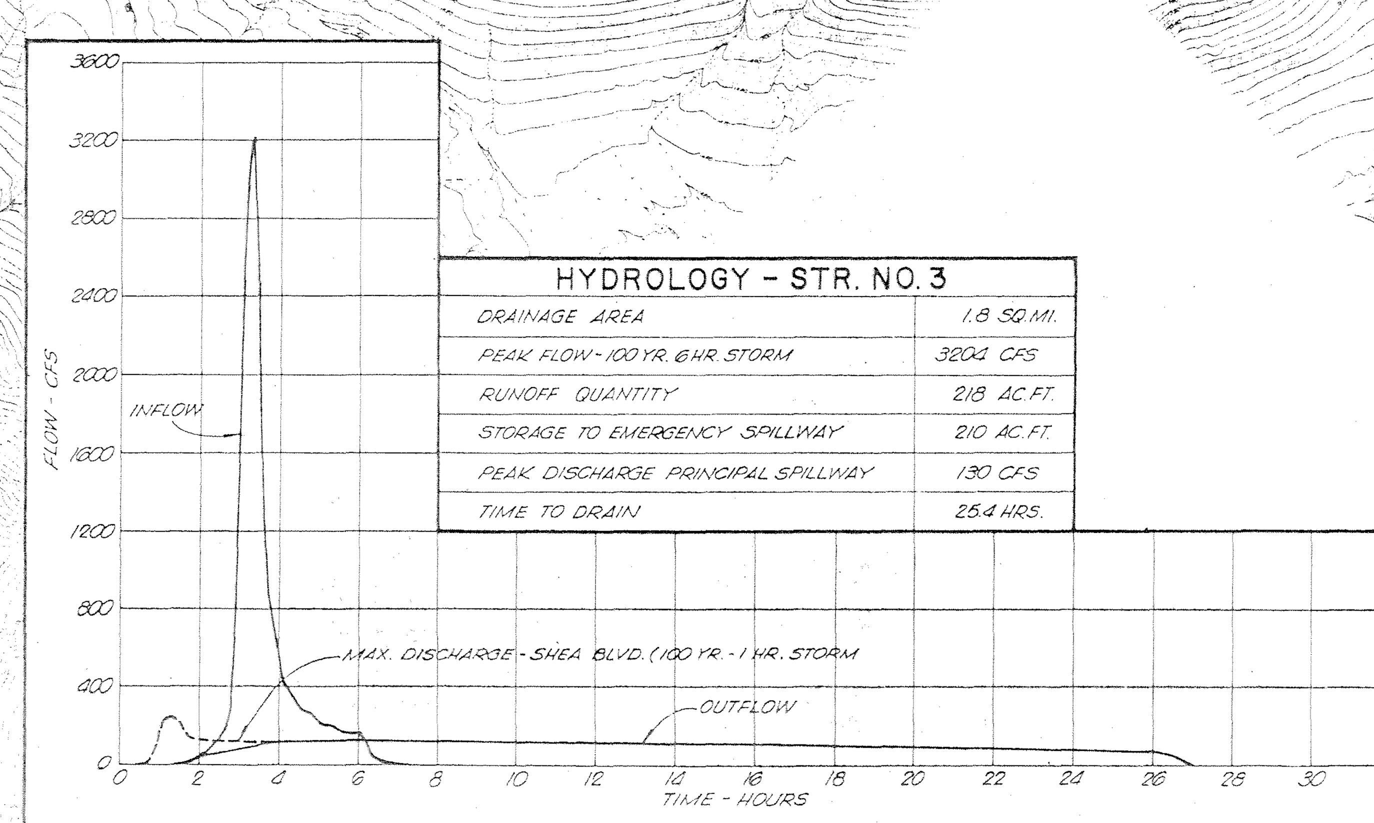
PROJECT ST-75235.00

PLAN NOS. 8, 9 & 10

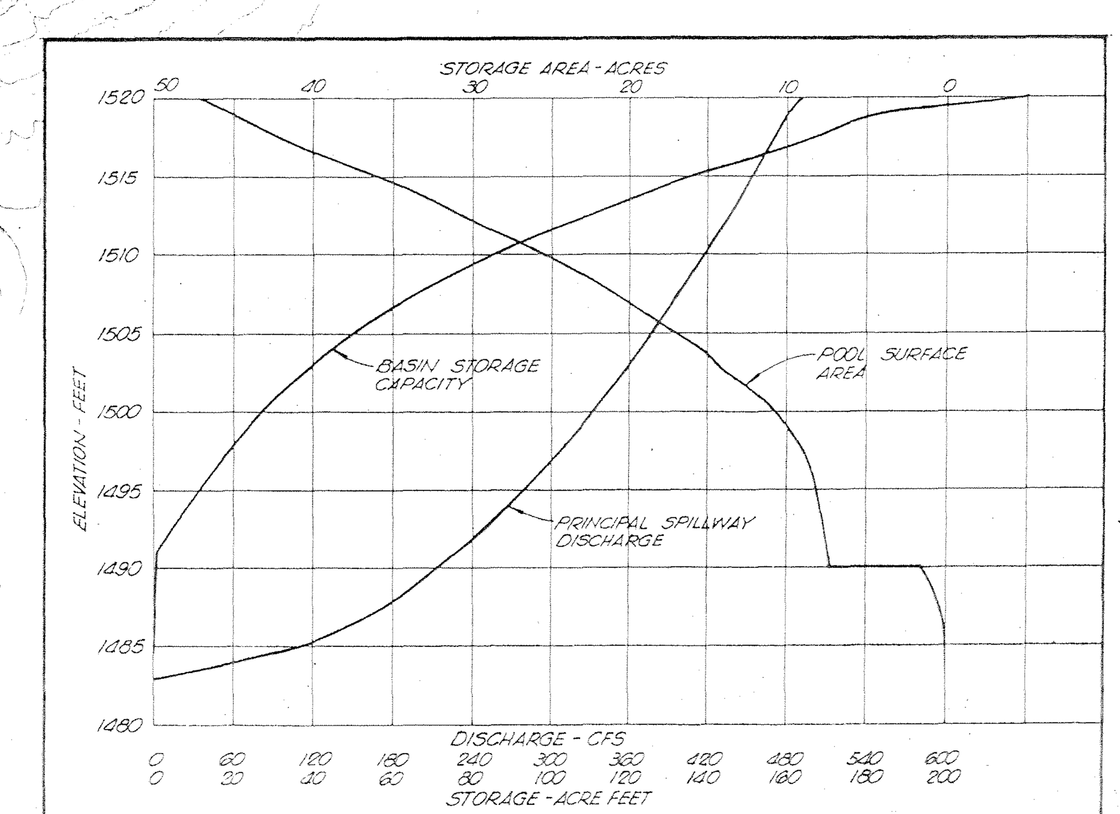
PLATE XVIII

DES. R.E.	CK. G.A.D.	DR. B.K.F.	SHEET NO.	TOTAL SHEETS	AS BUILT
SCALE 1" = 400' HORIZONTAL					

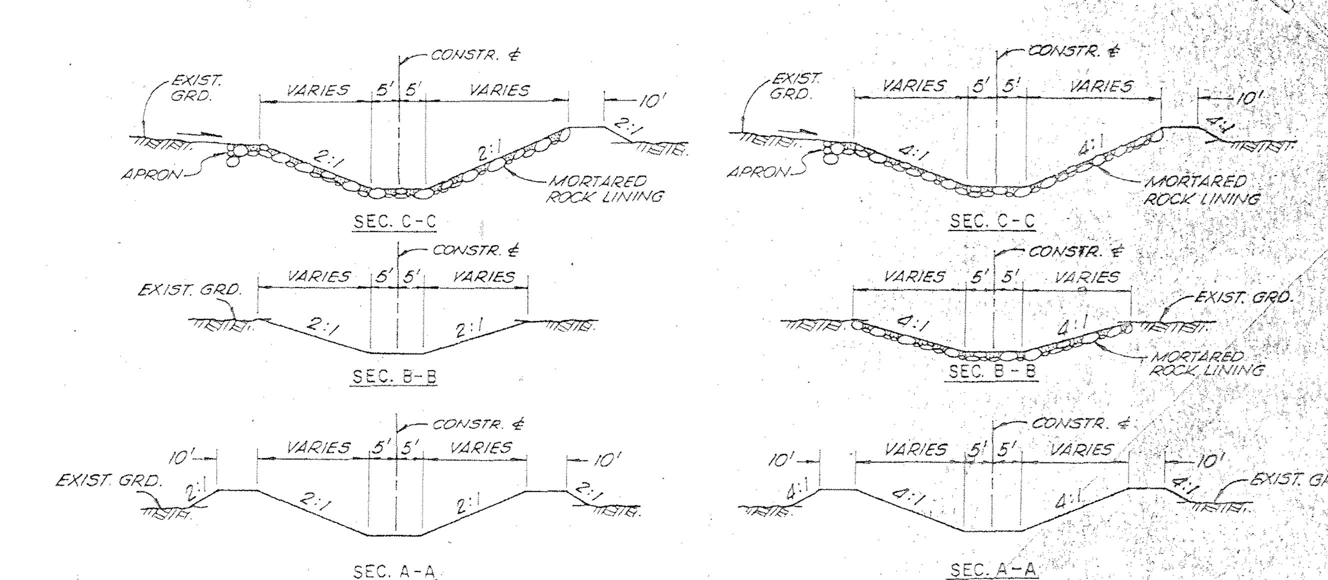


HYDROLOGY - STR. NO. 3	
DRAINAGE AREA	1.8 SQ. MI.
PEAK FLOW - 100 YR. 6 HR. STORM	3204 CFS
RUNOFF QUANTITY	218 AC. FT.
STORAGE TO EMERGENCY SPILLWAY	210 AC. FT.
PEAK DISCHARGE PRINCIPAL SPILLWAY	130 CFS
TIME TO DRAIN	25.4 HRS.

HYDROGRAPH - STRUCTURE NO. 3



FLOOD ROUTING DATA - STRUCT. NO. 3



TYPICAL SECTIONS
PLAN NO. 6 CHANNEL

TYPICAL SECTIONS
PLAN NO. 7 CHANNEL

* NOTE:
PLAN NOS. 5A, 6A, & 7A ARE IDENTICAL TO PLAN NOS. 5, 6, AND 7 RESPECTIVELY EXCEPT THEY INCLUDE A CONCRETE RETAINING WALL ADJACENT TO SPILLWAY CUT.

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PLAN NOS. 5, 6 & 7*

PLATE XVII

DES. R.E.	CK. G.A.D.	DR. B.K.F.	SHEET NO.	TOTAL SHEETS	AS BUILT
SCALE 1" = 400' HORIZONTAL					


PLAN
SELECTED FLOODWAY - PLAN NO. 12 ONLY
INDIAN BEND WASH
Sta 0+50 Begin Channel Constr.
Sta 4+90 to 10+00 New Earth Dykes Rt & Lt.
Sta 7+00 to 15+00 Earth Outlet Channel
Sta 0+50 to 7+00 Mortared Rock Outlet Channel
New Earth Dyke
Selected Floodway
100 Yr. Floodway Fringe
TATUM BLVD.
CLINTON ST.
SHEA BLVD.
Sta 15+94 to 29+64 New Mortared Rock Channel
Overflow Spillways Rt & Lt.
Sta 15+00 to 15+94 New 5-6'x6'x94' Box Culv. Skew 30° Lt.
Proposed Roadway Shea Blvd.
Chan. & Sta 30+45 = Shea Blvd Mon Line Sta 1031+90 (P-1423T)
Sta 29+64 to 31+60 New 4-6'x7'x194' Box Culv. Skew 45° Rt.
New Earth Dyke
New Conc. Lined Drop Structure
New Overflow Spillway
New Earth Dykes
PROFILE
Sta 0+50 - Begin Permanent Channel
Top Permanent Earth Dyke Rt & Lt.
Exist. Ground Line
S = 0.177%
S = 0.97%
℄ Earth Channel
℄ Masonry Channel
Approx. 25 Year Runoff Water Surface Profile
Approx. 100 Year Runoff Water Surface Profile
Proposed Shea Blvd Rdwy.
Top Headwall & Dyke El. 1394.86
Sta 35+45 Top Dyke El. 1399.62
Sta 39+65 Top Dyke El. 1405.05
Regraded Flowline
Special Conc. Lined Drop Structure
Exist. 15" San. Sewer
Sta 15+00 to 15+94 5-6'x6'x94' Box Culvert, 30° Skew Lt.
Sta 29+64 to 31+60 4-6'x7'x196' Box Culvert, 45° Skew Rt.
1360
1370
1380
1390
1400
SEC. C-C
SEC. B-B
SEC. A-A
Mortared Rock
CHANNEL TYPICAL SECTIONS
PLATE XIX
DASHNEY AND ASSOCIATES INC.
• ENGINEERS • SURVEYORS •
PROJECT ST - 75235.00
PLAN NOS. 11 & 12
DES. R.E. | CK. G.A.D. | DR. G.K.F. | SHEET NO. 1 | TOTAL SHEETS 1 | AS BUILT
SCALE 1" = 200' HORIZONTAL, 20' VERTICAL


INDIAN BEND WASH
Sta 0+50 Begin Channel Constr.
Sta 4+90 to 10+00 New Earth Dykes Rt & Lt
Sta 7+00 to 15+00 Earth Outlet Channel
Sta 0+50 to 7+00 Mortared Rock Outlet Channel
Chan R/W
Constr. ℄
New Earth Dyke
Selected Floodway
100 Yr. Floodway Fringe
TATUM BLVD (48TH ST)
Proposed 36" Storm Drain (Proj. P-7423100)
Overflow Spillways Rt & Lt
Sta 15+94 to 29+64 New Mortared Rock Channel
Sta 15+00 to 15+94 New 5-6'x6'x94' Box Culv. Skew 30° Lt.
CLINTON ST
SHEA BLVD
Proposed R/W
Proposed Roadway Shea Blvd (Proj. P-7423100)
Chan ℄ Sta 30+45 = Shea Blvd Mon Line Sta 103+90 (P-7423)
Sta 29+64 to 31+60 New 4-6'x7'x194' Box Culv. Skew 45° Rt.
New Conc Lined Drop Structure
New Overflow Spillway
Proposed 90" Storm Drain (Proj. P-7423100)
New Dyke
Selected Floodway
Selected Roadway
New Earth Dyke
N
Sta 0+50 - Begin Permanent Channel
25 Year Runoff Water Surface Profile
100 Year Runoff Water Surface Profile
Exist Ground Line
Top Permanent Earth Dyke Rt & Lt
S=0.177%
S=0.97%
℄ Earth Channel
℄ Masonry Channel
℄ El. 1357.56
℄ El. 1367.73
℄ El. 1380.56
℄ El. 1382.66
Sta 15+00 to 15+32 5-6'x6'x32' Box Culvert 30° Skew Lt.
Proposed Shea Blvd R/W
Top Headwall & Dyke El. 1394.66
25 Year Runoff Water Surface Profile
Sta 35+85 Top Dyke El. 1399.82
100 Year Runoff Water Surface Profile
Sta 39+65 Top Dyke El. 1405.05
Regraded Flowline
Special Conc. Lined Drop Structure
Exist 15" San. Sewer ℄ El. 1376.48
Sta 29+64 to 31+60 4-6'x7'x196' Box Culvert 45° Skew Rt.
1360
1370
1380
1390
1400
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
SEC. C-C
SEC. B-B
SEC. A-A
Mortared Rock
Varies
Constr. ℄
CHANNEL TYPICAL SECTIONS
PLATE XX
GASHNEY AND ASSOCIATES INC.
ENGINEERS SURVEYORS
PROJECT ST - 75235.00
PLAN 13
PLAN
PROFILE

SELECTED FLOODWAY-
PLAN NO. 12 ONLY
INDIAN BEND WASH
Sta 0+50 Begin Channel Constr.
Sta 4+90 to 10+00 New Earth Dykes Rt & Lt.
Sta 7+00 to 15+00 Earth Outlet Channel
Sta 0+50 to 7+00 Mortared Rock Outlet Channel
Sta 15+94 to 29+64 New Mortared Rock Channel
Sta 15+00 to 15+94 New 5-6'x6'x94' Box Culv. Skew 30° Lt.
Sta 29+64 to 31+60 New 4-6'x7'x 190' Box Culv. Skew 45° Rt.
Chan ℄ Sta 30+45 = Shea Blvd. Mon. Line Sta 103+90 (P-14237)
Proposed Roadway Shea Blvd (Proj. P-1423700)
Selected Floodway
100 Yr. Floodway Fringe
New Earth Dyke
New Earth Dykes
New Conc. Lined Drop Structure
New Overflow Spillway
Over Flow Spillways
TATUM BLVD (48TH ST)
CLINTON ST
SHEA BLVD
Chan R/W
Constr. ℄
Approx. 25 Year Runoff Water Surface Profile
Approx. 100 Year Runoff Water Surface Profile
Sta 0+50 - Begin Permanent Channel
Exist. Ground Line
Top Permanent Earth Dyke Rt & Lt.
S = 0.177%
S = 0.97%
℄ Earth Channel
℄ Masonry Channel
℄ El. 1361.56
℄ El. 1367.73
℄ El. 1380.56
℄ El. 1392.06
Sta 15+00 to 15+94 5-6'x6'x94' Box Culvert, 30° Skew Lt.
Sta 29+64 to 31+60 4-6'x7'x196' Box Culvert, 45° Skew Rt.
Exist. 15" San. Sewer ℄ El. 1376.45
Proposed Shea Blvd. Rdwy.
Top Headwall & Dyke El. 1394.86
Sta 35+45 Top Dyke El. 1399.69
Sta 39+05 Top Dyke El. 1405.05
Regraded Flowline
Special Conc. Lined Drop Structure
SEC. C-C
SEC. B-B
SEC. A-A
Mortared Rock
CHANNEL TYPICAL SECTIONS
PLATE XIX
DASHNEY AND ASSOCIATES INC.
ENGINEERS • SURVEYORS
PROJECT ST-75235.00
PLAN NOS. 11 & 12
DES. R.E. | CK. G.A.O. | DR. G.K.F. | SHEET NO. 1 | TOTAL SHEETS 1 | AS BUILT
SCALE 1" = 200' HORIZONTAL 20' VERTICAL

PLANS 5 & 6 - SUMMARY OF QUANTITIES

Dam(PLAN 5 & 6)		
Embankment: 126,100 C.Y. @ $2.00	= $	252,200
Spillway Excavation: 67,000 C.Y. @ $5.00	=	335,000
Basin Excavation: 109,000 C.Y. @ $1.50	=	163,500
Outlet Works: 2 @ $8,000	=	16,000
Fencing: 900 L.F. @ $4.00	=	3,600
Desert Landscaping: 3.1 acres @ $1,000	=	3,100
Landscape Fill: 36,000 C.Y. @ $1.50	=	54,000
Engineering Design & Inspection(12% of Construction Cost)	=	99,300
Administration, Legal, etc.(8% of Construction Cost)	=	66,200
(PLAN 5)	$	992,900
Channel Quantities(PLAN 6)		
Pipe Culvert at Shea		
66" Pipe Culvert: 196 L.F. @ $100	=	19,600
Hdwl. Conc.: 64.35 C.Y. @ $145	=	9,331
Hdwl. Reinf. Steel: 3935# @ $0.35	=	1,377
Struct. Excavation: 660 C.Y. @ $5.50	=	3,630
Special Comp.: 691 C.Y. @ $7.50	=	5,183
Pavement Cut & Replacement: 150 S.Y. @ $35	=	5,250
Handrail: 45 L.F. @ $25	=	1,125
	$	45,496
Pipe Culvert at Tatum		
66" Pipe Culvert: 94 L.F. @ $100	= $	9,400
Hdwl. Conc.: 51.06 @ $145	=	7,404
Hdwl. Reinf. Steel: 2668# @ $35	=	907
Struct. Excavation: 317 C.Y. @ $5.50	=	1,744
Special Comp.: 338 @ $7.50	=	2,535
Pavement Cut & Replacement: 114 S.Y. @ $35	=	3,990
Handrail: 24 L.F. @ $25	=	600
	$	26,580
Channels		
Mortared Rock Lining: 2780 C.Y. @ $15	= $	41,700
Structural Excavation(Lined Channel): 2420 C.Y. @ $5.50	=	13,310
Drainage Excavation(Unlined Channel): 19,398 @ $1.50	=	29,067
Embankment(Dykes): 455 C.Y. @ $2.00	=	910
	$	84,987
Miscellaneous		
R/W: 8.13 acres @ $12,000	= $	97,560
Adjust Water Lines: 5 Sites @ $2,500	=	12,500
Traffic Control: 2 Sites @ $10,000	=	20,000
Contingencies(Engineer, Staking, Insp., etc.)	=	19,000
	$	306,123
(PLAN 6)	$	1,299,023

PLANS 5a & 6a - SUMMARY OF QUANTITIES

Dam(PLAN 5a & 6a)		
Embankment: 97,300 C.Y. @ $2.00	= $	194,600
Spillway Excavation: 16,500 C.Y. @ $3.00	=	49,500
Basin Excavation: 109,000 C.Y. @ $1.50	=	163,500
Concrete Wall: 150 L.F. @ $100	=	15,000
Outlet Works: 2 @ $8,000	=	16,000
Fencing: 850 L.F. @ $4.00	=	3,400
Landscape Fill: 27,000 C.Y. @ $1.50	=	40,500
Desert Landscaping: 3.1 acres @$1,000	=	3,100
Engr. Design & Inspection (12% of Construction Cost)	=	58,300
Administration, Legal (8% of Construction Cost)	=	38,400
(Plan 5a)	$	582,300
Channel Quantities(PLAN 6a)		
Pipe Culvert at Shea		
66" Pipe Culvert: 196 L.F. @ $100	=	19,600
Hdwl. Conc.: 64.35 C.Y. @ $145	=	9,331
Hdwl. Reinf. Steel: 3935# @ $0.35	=	1,377
Struct. Excav.: 660 C.Y. @ $5.50	=	3,630
Special Comp.: 691 C.Y. @ $7.50	=	5,183
Pavement Cut & Replacement: 150 S.Y. @ $35	=	5,250
Handrail: 45 L.F. @ $25	=	1,125
	$	45,496
Pipe Culvert at Tatum		
66" Pipe Culvert: 94 L.F. @ $100	=	9,400
Hdwl. Conc.: 51.06 @ $145	=	7,404
Hdwl. Reinf. Steel: 2668# @ $35	=	907
Struct. Excav.: 317 C.Y. @ $5.50	=	1,744
Special Comp.: 538 @ $7.50	=	2,535
Pavement Cut & Replacement: 114 S.Y. @ $35	=	3,990
Handrail: 24 L.F. @ $25	=	600
	$	26,580
Channels		
Mortared Rock Lining: 2780 C.Y. @ $15	= $	41,700
Structural Excavation(Lined Channel): 2420 C.Y. @ $5.50	=	13,310
Drainage Excavation(Unlined Channel): 19,358 @ $1.50	=	29,067
Embankment(Dykes): 455 C.Y. @ $2	=	910
	$	84,987
Miscellaneous		
R/W: 8.13 acres @ $12,000	= $	97,560
Adjust Water Lines: 5 Sites @ $2,500	=	12,500
Traffic Control: 2 Sites @ $10,000	=	20,000
Contingencies(Engineer, Staking, Insp., etc.)	=	19,000
	$	306,123
(PLAN 6a)	$	888,423

PLAN 7 - SUMMARY OF QUNATITIES

Dam		
Embankment: 126,100 C.Y. @ $2.00	= $	252,200
Spillway Excavation: 67,000 C.Y. @ $5.00	=	335,000
Basin Excavation: 109,000 C.Y. @ $1.50	=	163,500
Outlet Works: 2 @ $8,000	=	16,000
Fencing: 900 L.F. @ $4.00	=	3,600
Desert Landscaping: 3.1 acres @ $1,000	=	3,100
Landscape Fill: 36,000 C.Y. @ $1.50	=	54,000
Engineering Design & Inspection(12% of Construction Cost)	=	99,300
Administration, Legal, etc.(8% of Construction Cost)	=	66,200
	$	992,900
Pipe Culvert at Shea		
78" Pipe Culvert: 196 L.F. @ $100	= $	19,600
Hdwl. Conc.: 64.35 C.Y. @ $145	=	9,331
Hdwl. Steel: 3935# @ $0.35	=	1,377
Struct. Excavation: 752 C.Y. @ $5.50	=	4,140
Special Comp.: 910 C.Y. @ $7.50	=	6,830
Pavement Cut & Replacement: 178 S.Y. @ $35	=	6,230
Handrail: 45 L.F. @ $25	=	1,125
	$	48,633
Box Culvert at Tatum		
Conc.: 183.34 C.Y. @ $145	= $	26,657
Steel: 26,020# @ $0.35	=	9,107
Struct. Excavation: 982 C.Y. @ $5.50	=	5,401
Special Comp: 532 C.Y. @ $7.50	=	3,990
Pavement Cut & Replacement: 190 S.Y. @ $35	=	6,650
Handrail: 45 L.F. @ $25	=	1,125
	$	52,930
Channels		
Mortared Rock Lining: 11,651 S.Y. @ $15	= $	174,765
Structural Excavation(Lined Channel): 23,284 C.Y. @ $5.50	=	128,062
Drainage Excavation(Unlined Channel): 8750 C.Y. @ $1.50	=	13,125
Embankment(Dykes): 869 C.Y. @ $2.00	=	1,738
	$	317,690
Miscellaneous		
R/W: 10.15 acres @ $12,000	= $	121,800
Adjust Water Lines: 5 Sites @ $2800	=	12,500
Traffic Control: 2 Sites @ $10,000	=	20,000
Contingencies(Engr., Staking, Insp., etc.)	=	45,000
	$	199,300
	$	1,611,453

PLAN 7a - SUMMARY OF QUANTITIES

Dam		
Embankment: 97,300 C.Y. @ $2.00	=	$ 194,600
Spillway Excavation: 16,500 C.Y. @ $3.00	=	49,500
Basin Excavation: 109,000 C.Y. @ $1.50	=	163,500
Concrete Wall: 150 L.F. @ $100	=	15,000
Outlet Works: 2 @ $8,000	=	16,000
Fencing: 850 L.F. @ $4.00	=	3,400
Landscape Fill: 27,000 C.Y. @ $1.50	=	40,500
Desert Landscaping: 3.1 acres @ $1,000	=	3,100
Engr. Design & Inspection(12% of Construction Cost)	=	58,300
Administration, Legal, etc.(8% of Construction Cost)	=	38,400
		$ 582,300
Pipe Culvert at Shea		
78" Pipe Culvert: 196 L.F. @ $100	=	$ 19,600
Hdwl. Conc.: 64.35 C.Y. @ $145	=	9,331
Hdwl. Steel: 3935# @ $0.35	=	1,377
Structural Excavation: 752 C.Y. @ 5.50	=	4,140
Special Comp.: 910 C.Y. @ $7.50	=	6,830
Pavement Cut & Replacement: 178 S.Y. @ $35	=	6,230
Handrail: 45 L.F. @ $25	=	1,125
		$ 48,633
Box Culvert at Tatum		
Conc.: 183.34 C.Y. @ $145	=	$ 26,657
Steel: 26,020# @ $0.35	=	9,107
Structural Excavation: 982 C.Y. @ $5.50	=	5,401
Special Comp.: 532 C.Y. @ $7.50	=	3,990
Pavement Cut & Replacement: 190 S.Y. @ $35	=	6,650
Handrail: 45 L.F. @ $25	=	1,125
		$ 52,930
Channels		
Mortared Rock Lining: 11,651 S.Y. @ $15	=	$ 174,765
Structural Excavation(Lined Channel): 23,284 C.Y. @ $5.50	=	128,062
Drainage Excavation(Unlined Channel): 8750 C.Y. @ $1.50	=	13,125
Embankment(Dykes): 869 C.Y. @ $2.00	=	1,738
		$ 317,690
Miscellaneous		
R/W: 10.15 acres @ $12,000	=	$ 121,800
Adjust Water Lines: 5 Sites @ $2800	=	12,500
Traffic Control: 2 Sites @ $10,000	=	20,000
Contingencies(Engr., Staking, Insp., etc.)	=	45,000
		$ 199,300
		$ 1,200,853

PLANS 8 & 9 - SUMMARY OF QUANTITIES

Large Dam(Structure #1)		
Embankment: 58,360 C.Y. @ $2.00	= $	116,720
Spillway Excavation: 48,290 C.Y. @ $5.00	=	241,450
Basin Excavation: 20,368 C.Y. @ $1.50	=	30,552
Outlet Works: 1 @ $11,300	=	11,300
Fencing: 1000 L.F. @ $4.50	=	4,500
Desert Landscaping: 7.6 acres @ $1,000	=	7,600
Engr. Design & Inspection (12% of Construction Cost)	=	48,500
Administration, Legal, etc. (8% of Construction Cost)	=	32,362
	$	492,984
Small Dam(Structure #2)		
Embankment: 25,056 C.Y. @ $2.00	= $	50,112
Spillway Excavation: 7492 C.Y. @ $5.00	=	37,460
Basin Excavation: 21986 C.Y. @ $1.50	=	32,979
Outlet Works: 1 @ $4750	=	4,750
Fencing: 600 L.F. @ $4.50	=	2,700
Desert Landscaping: 4.5 acres @ $1000	=	4,500
Engr. Design & Inspection (12% of Construction Cost)	=	15,600
Administration, Legal, etc. (8% of Construction Cost)	=	10,400
	$	158,501
(PLAN 8)	$	651,485
Structure at Shea		
Conc.: 255.16 C.Y. @ $145	= $	36,978
Reinf. Steel: 36549# @ $0.35	=	12,792
Structural Excavation: 1596 C.Y. @ $5.50	=	8,778
Special Comp: 776 C.Y. @ $7.50	=	5,820
Pavement Cut & Replacement: 200 S.Y. @ $35	=	7,000
Handrail: 34 L.F. @ $25	=	850
	$	72,238
Structure at Tatum		
Conc.: 139.15 C.Y. @ $145	= $	20,177
Steel: 20,650# @ $0.35	=	7,228
Structural Excavation: 710 C.Y. @ $5.50	=	3,905
Special Compaction: 574 C.Y. @ $7.50	=	4,305
Pavement Cut & Replacement: 163 S.Y. @ $35	=	5,705
Handrail: 28 L.F. @ $25	=	700
	$	42,020
Channels		
Mortared Rock Lining: 4,170 S.Y. @ $15	= $	62,550
Structural Excavation (Lined Channel): 5440 C.Y. @ $5.50	=	29,920
Drainage Excavation (Unlined Channel): 31,244 C.Y. @ $1.50	=	46,866
Embankment(Dykes): 605 C.Y. @ $2.00	=	1,210
	$	140,546

Miscellaneous

R/W: 10.30 acres @ $12,000	=	$ 123,600
Adjust Water Lines: 5 Sites @ $2500	=	12,500
Traffic Control: 2 Sites @ $10,000	=	20,000
Contingencies(Engr., Staking, Insp., etc.)	=	29,000
		$ 185,100
(PLAN 9)		$ 1,091,389

PLAN 10 - SUMMARY OF QUANTITIES

Large Dam (Structure #1)		
Embankment: 58,360 C.Y. @ $2.00	= $	116,720
Spillway Excavation: 48290 C.Y. @ $5.00	=	241,480
Basin Excavation: 20,368 C.Y. @ $1.50	=	30,552
Outlet Works: 1 @ $11,300	=	11,300
Fencing: 1000 L.F. @ $4.50	=	4,500
Desert Landscaping: 7.6 acres @ $1,000	=	7,600
Engr. Design & Inspection (12% of Construction Cost)	=	48,500
Administration, Legal, etc. (8% of Construction Cost)	=	32,362
	$	492,984
Small Dam (Structure 2)		
Embankment: 25,056 C.Y. @ $2.00	= $	50,112
Spillway Excavation: 7492 C.Y. @ $5.00	=	37,460
Basin Excavation: 21986 C.Y. @ $1.50	=	32,979
Outlet Works: 1 @ $4750	=	4,750
Fencing: 600 L.F. @ $4.50	=	2,700
Desert Landscaping: 4.5 acres @ $1000	=	4,500
Engr. Design & Inspection (12% of Construction Cost)	=	15,600
Administration, Legal, etc. (8% of Construction Cost)	=	10,400
	$	158,501
Structure at Shea		
Conc.: 255.16 C.Y. @ $145	= $	36,998
Reinf. Steel: 36,549# @ $0.35	=	12,792
Structural Excavation: 1596 C.Y. @ $5.50	=	8,778
Special Comp.: 776 C.Y. @ $7.50	=	5,820
Pavement Cut & Replacement: 200 S.Y. @ $35	=	7,000
Handrail: 34 L.F. @ $25	=	850
	$	72,238
Structure at Tatum		
Conc.: 240.08 C.Y. @ $145	= $	34,812
Reinforcing Steel: 33,301# @ $0.35	=	11,655
Structural Excavation: 1215 C.Y. @ $5.50	=	6,683
Special Comp.: 585 C.Y. @ $7.50	=	4,388
Pavement Cut & Replacement: 210 S.Y. @ $35	=	7,350
Handrail: 52 L.F. @ $25	=	1,300
	$	66,188
Channels		
Mortared Rock Lining: 14,044 S.Y. @ $1.50	= $	210,660
Structural Excavation (Lined Channel): 26,653 C.Y. @ $5.50	=	146,592
Drainage Excavation (Unlined Channel): 10,102 C.Y. @ $1.50	=	15,153
Embankment (Dykes): 1877 C.Y. @ $2.00	=	3,754
	$	376,159

Miscellaneous

R/W: 998 acres @ $12,000	=	$ 119,760
Adjust Water Lines: 5 Sites @ $2,500	=	12,500
Traffic Control: 2 Sites @ $10,000	=	20,000
Contingencies (Engr., Staking, Insp., etc.)	=	55,000
		$ 207,260
		$ 1,373,330

PLAN 11 & 12 - SUMMARY OF QUANTITIES

Box Culvert at Shea		
Conc.: 510.87 C.Y. @ $145	= $	74,076
Reinf. Steel: 74,224# @ $0.35	=	25,978
Structural Excavation: 2901 C.Y. @ $5.50	=	15,956
Special Comp.: 1237 C.Y. @ $7.50	=	9,278
Pavement Cut & Replacement: 315 S.Y. @ $35	=	10,955
Handrail: 63 L.F. @ $25	=	1,575
Spillway $ Drop Inlet Lining: 1980 S.Y. @ $15	=	29,700
Drainage Excavation: 3152 @ $5.50	=	17,336
	$	184,854
Box Culvert at Tatum		
Conc.: 303.10 C.Y. @ $145	= $	43,950
Steel: 43,384# @ $0.35	=	15,184
Structural Excavation: 1946 C.Y. @ $5.50	=	10,703
Special Comp.: 532 C.Y. @ $7.50	=	3,990
Pavement Cut & Replacement: 241 S.Y. @ $35.00	=	8,435
Handrail: 79 L.F. @ $25.00	=	1,975
	$	84,237
Channel		
Mortared Rock Lining: 14,613 S.Y. @ $15.00	= $	219,195
Structural Excavation(Lined Channel): 22,255 C.Y. @ $5.50	=	122,403
Drainage Excavation(Unlined Channel): 16,896 C.Y. @ $1.50	=	25,344
Embankment(Dykes): 4,792 C.Y. @ $2.00	=	9,584
	$	376,526
Miscellaneous		
R/W: 15.91 acres @ $12,000	= $	190,920
Adjust Water Lines: 5 Sites @ $2,500	=	12,500
Traffic Control: 2 Sites @ $10,000	=	20,000
Contingencies (Engr., Staking, Insp., etc.)	=	66,800
	$	289,920
	$	935,537

PLAN 13 - SUMMARY OF QUANTITIES

Box Culvert at Shea

Conc: 511 C.Y. @ $145	=	$ 74,095
Steel: 74,224 Lbs. @ $0.35	=	25,979
Structural Excav: 2900 C.Y. @ $5.50	=	15,950
Special Comp: 1240 C.Y. @ $7.50	=	9,300
Pavement Cut & Replacement: 315 C.Y. @ $35	=	11,025
Handrail: 63 L.F. @ $25	=	1,575
Spillway, Drop Inlet & Entrance Channel Concrete: 1980 S.Y. @ $15	=	29,700
Drainage Excavation for Spillway, Inlet & Entrance Channel: 3150 C.Y. @ $5.50	=	17,325
		$ 184,949

Box Culvert at Tatum

Conc: 399 C.Y. @ $145	=	$ 57,855
Steel: 61,790 Lbs. @ $0.35	=	21,627
Structural Excav: 2160 C.Y. @ $5.50	=	11,880
Special Compaction: 555 C.Y. @ $7.50	=	4,163
Pavement Cut & Replacement: 290 C.Y. @ $35	=	10,150
Handrail: 103 L.F. @ $25	=	2,575
		$ 108,250

Channels

Mortared Rock Lining: 16,865 S.Y. @ $15	=	$ 252,975
Structural Excav. (Lined Channel): 27,460 C.Y. @ $5.50	=	151,036
Drainage Excav. (Unlined Channel): 19,375 C.Y. @ $1.50	=	29,066
Embankment (Dykes): 4,795 C.Y. @ $2	=	9,590
		$ 442,667

Miscellaneous

Adjust Water Lines: 5 Sites @ $2,500	=	$ 12,500
Traffic Control: 2 Sites @ $10,000	=	20,000
Contingencies (Engineering, Inspection, Staking, Etc.)	=	77,000
R/W: 16.77 Acres @ $12,000	=	201,240
		$ 310,740
	Total =	$1,046,606

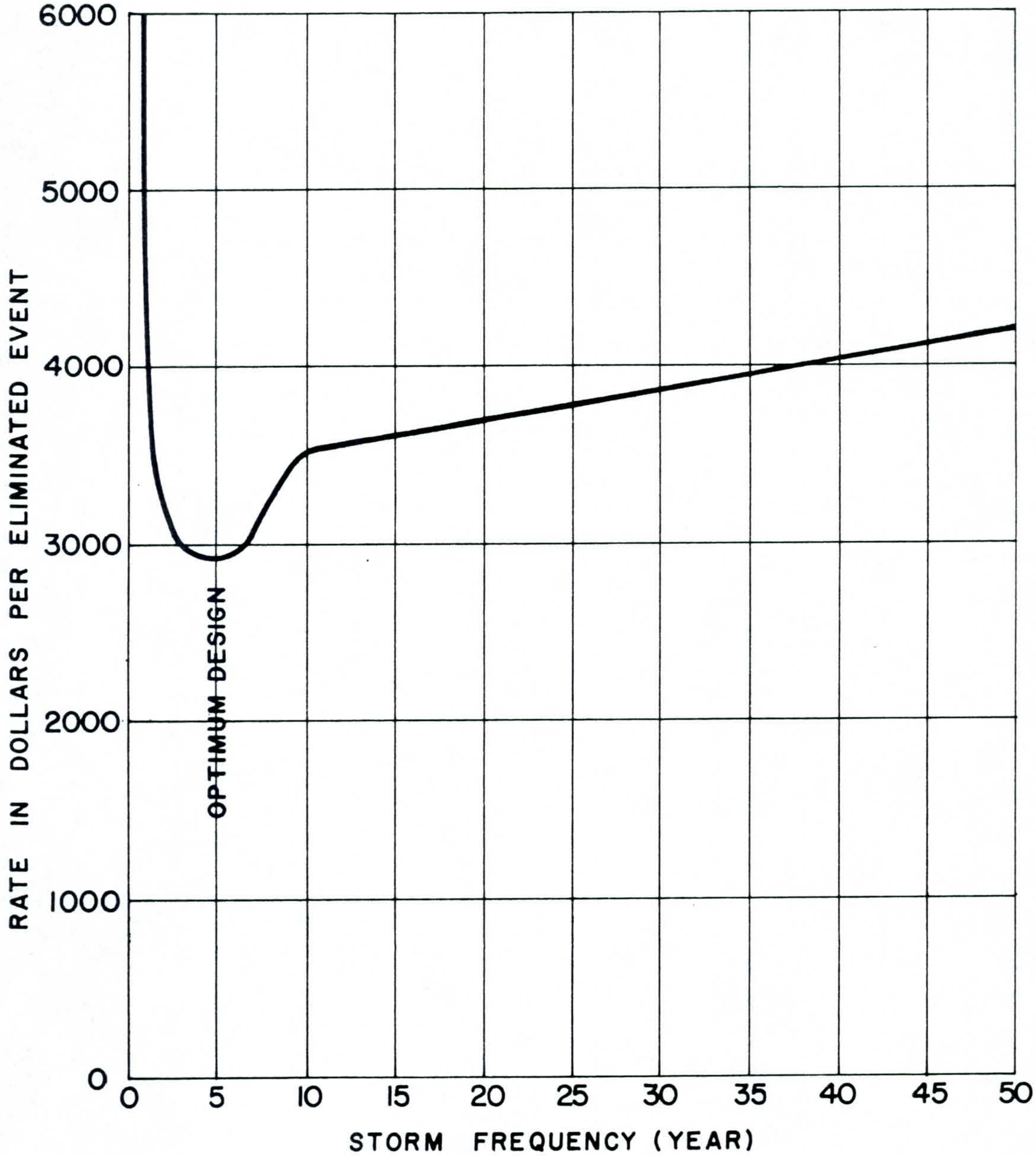
PLAN 13a - SUMMARY OF QUANTITIES

Box Culvert @ Shea		
Conc.: 510,87 C.Y. @ $145	= $	74,076
Reinf. Steel: 74,224# @ $0.35	=	25,978
Structural Excavation: 2901 C.Y. @ $5.50	=	15,956
Special Comp.: 1237 C.Y. @ $7.50	=	9,278
Pavement Cut & Replacement: 315 S.Y. @ $35.00	=	10,955
Handrail: 63 L.F. @ $25.00	=	1,575
Spillway & Drop Inlet Lining: 1980 S.Y. @ $15.00	=	29,700
Drainage Excavation: 3152 @ $5.50	=	17,336
	$	184,854
Channel		
Mortared Rock Lining: 4,666 S.Y. @ $15.00	= $	69,990
Structural Excavation (Lined Channel): 1954 C.Y. @ $5.50	=	10,747
Drainage Excavation (Unlined Channel): 13,845 C.Y. @ $1.50	=	20,768
Embankment(Dykes): 6460 C.Y. @ $2.00	=	12,920
	$	114,425
Miscellaneous		
R/W: 12.19 acres @ $12,000	= $	146,280
Adjust Water Lines: 4 Sites @ $2,500	=	10,000
Traffic Control: 1 Site @ $10,000	=	10,000
Contingencies (Engr., Staking, Insp., etc.)	=	32,000
	$	198,280
	$	497,559

PLAN 13b - SUMMARY OF QUANTITIES

Box Culvert at Shea		
Conc.: 294.74 C.Y. @ $145	=	$ 42,737
Steel: 41,415# @ $0.35	=	14,495
Structural Excavation: 1653 C.Y. @ $5.50	=	9,092
Special Comp.: 1237 C.Y. @ $7.50	=	9,278
Pavement Cut & Replacement: 239 S.Y. @ $35.00	=	8,365
Handrail: 34 L.F. @ $25.00	=	850
Spillway & Drop Inlet Lining: 1765 S.Y. @ $15.00	=	26,475
Drainage Excavation: 1430 C.Y. @ $5.50	=	7,865
		$ 119,157
Channel		
Mortared Rock Lining: 4,666 S.Y. @ $15.00	=	$ 69,990
Structural Excavation (Lined Channel): 1954 C.Y. @ $5.50	=	10,747
Drainage Excavation (Unlined Channel): 13,845 C.Y. @ $1.50	=	20,768
Embankment (Dykes): 6460 C.Y. @ $2.00	=	12,920
		$ 114,425
Miscellaneous		
R/W: 12.19 acres @ $12,000	=	$ 146,280
Adjust Water Lines: 4 Sites @ $2,500	=	10,000
Traffic Control: 1 Site @ $10,000	=	10,000
Contingencies (Engr., Staking, Insp., etc.)	=	32,000
		$ 198.280
		$ 431,862

PROJECT ST-75235.00		
DASHNEY & ASSOC. INC.		
DES: R.E.	CKD: G.A.D.	DRN: B.K.F.



SHEA BLVD. BOX CULVERT OPTIMIZATION CURVE

PLATE XXXII

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