The Water Resource Division of DMJM+HARRIS

September 24, 2001

Our File No.: 16-3352 B1.1 01./01
Subject: Del Mar Bluff Stabilization Project 1
Drainage Improvement and
Landslide Warning System

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Dear Duygu:

We very much enjoyed working with you on this interesting assignment. Attached is the Final Report and Hydrology and Hydraulics Calculations, together with the Quantities and Cost Estimate.

Sincerely,

R. Joe Bergquist /UK.

R. Joe Bergquist,
Project Manager

cc: Ulrich Kappus, P.E.,
President

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The Del Mar Bluffs Stabilization Project 1 Drainage Improvements and Landslide Warning System Report has been prepared by or under the supervision of the following Registered Civil Engineer. The Registered Civil Engineer attests to the technical information therein, and has judged the qualification of any technical specialist providing engineering data upon which recommendations, conclusions, and decisions are based.

Ulrich Kappus
REGISTERED CIVIL ENGINEER

9/24/01
DATE

REGISTERED PROFESSIONAL ENGINEER
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Del Mar Drainage Study Report

Del Mar Drainage Study for the
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Between Railroad Right of Way Mile Post 244.1 to 245.7

Introduction

This drainage report is focused on identifying the drainage improvements required to protect the railroad along the bluff West of the community of Del Mar. To accomplish this objective required new hydrologic and hydraulic analysis to updated a 1993 study of the Del Mar Drainage system and identified drainage improvements required. The worked performed is described herein with the presentation of the results. The focus was not on identification of the drainage issues or required improvements within the community, but on what is required to control the flows that reach the Railroad's (RR) right-of-way (ROW).

The report is divided into the following sections:

- Scope
- Background
- Analysis
- Results and Conclusions
- Recommendations
- Appendices

Scope

Perform the hydrologic and hydraulic calculations required to update the final drainage report titled "Del Mar Drainage Study, Railroad Right of Way Mile Post 244.1 to 245.7"[1] by Fraser Engineering, Inc., dated November 1993. Use the updated final report to:

- Document the condition of the of the existing drainage facilities within the RR's ROW.
- Present the hydrology and hydraulic calculations used in the analysis.
- Show the drainage boundary map's basins with the City's map (scale 1:200) or recent mapping.
- Document hydrologic parameters (time of concentrations, rainfall intensities, and runoff coefficients).
- List the revised design discharges for the 100-year flood.
- List the recommended surface drainage improvements,

Perform a hydraulic analysis of the existing and proposed drainage systems to determine the adequacy of existing facilities. This analysis will lead to proposed modifications or improvements recommendations within the project area. Transfer the recommendations to the team and assist with the final design, which will be divided between Project 1 [those that can be implemented without lengthy permit constraints] and Project 2 [those improvements that will require a lengthy permit process]. The design process will go through the following steps:

- Drainage improvements alternative screening to selected alternative (10% design level). Involves all team members, especially the geotechnical members.
- Analyze the alternatives selected by the initial screen process and develop 30% designs for review purposes.
- Develop a 60 % design package of the selected components of the selected alternative.
- Finalize the design package.

The design and screening process will use environmental inputs and other considerations like permitting processes and successes to eliminate the alternative that cannot be constructed or permitted.

Background

The 1993 report determined the 100-year storm runoff for nine drainage basins at nine existing culverts crossing the railroad between Coast Boulevard and North Torrey Pines Road. The nine drainage basins' tributary to these culverts cover an area of 440 acres in City of Del Mar. Eight of the existing culverts are pipes, either RCP or CIP, ranging in diameter from 24-inches to 48-inches. The most southerly culvert is a 6-feet by 6-feet reinforced concrete box. The basin discharges and culvert capacities of the nine culverts were estimated to be:

Table 1: Existing 1993 Culvert Capacities, cfs

Culvert No. & (BR #)	Size (inches)	Basin No.	Area (acres)	Q100 (cfs)	Culvert Capacity (cfs)	Storm Return Frequency
1 (244.1)	30 RCP	100	69.6	140	80	6
2 (244.3)	24 CIP	200	1.1	4	140	100
3 (244.4)	48 CIP	300	65.7	160	148	60
4 (244.5)	24 CMP	400	43.6	90	35	1
5 (244.7)	48 RCP	500	137.8	310	120	1
6 (244.9)	48 RCP	600	36.6	120	125	100
7 (244.16)	30 RCP	700	32.4	85	46	4
8 (245.21)	30 CIP	800	2.6	15	65	100
9 (245.4)	6X6 BOX	900	51.6	95	730	100

Drainage system improvements recommended in the report included immediate drainage maintenance and improvements and long term ones. The immediate one included the restoration of Culvert No. 5 (BR #244.7), clean all ditches and inlet structures. During the field trip inspection made in May 2001 the restoration of Culvert No.5 near 8th Street still had not been performed.

The long-term improvement recommendations made in 1993 included new culverts, refurbishing old one's inlets and outlets, and regarding and concrete lining of ditches. It also included recommendations for geologic mapping and bluff stability monitoring plan. The statuses of these recommendations are shown below in Table 2.

Table 2: Drainage System Improvements Recommended in 1993

Recommendation Priority and No.		Location	Recommendation	Status in 2001
1	a	Between #4(BR 244.5) &#5(BR 244.7)	New 66" culvert	Not yet planned
1	b	From #4 to new cul.	Line ditch	Not yet planned
1	c	From #5 to new cul.	Line ditch	Not yet planned
1	d	Culvert #1(BR 244.1)	Reconst. inlet str.	Not yet planned
1	e	Culvert #2(BR244.3)	Reconst. Inlet str.	Did
1	f	From 13st to #2	Regrade canal	Not yet
1	g	From #7(BR 245.16) to #8(BR 245.21)	Reconst. Inlet at #8 & ditch from #7 to #8	Closed off, N/A
2	a	Culvert #3(BR 244.4)	New inlet	Did
2	b	Culvert #8	New flume down hill	Closed off, N/A
2	c	Culvert #6(BR 244.9)	New outfall	Not yet planned
2	d	All along RR	Evaluate subdrains	In 2001 Study
2	e	Below Seagrove Park	Line ditch	Not yet planned
2	f	RR side ditches	Regrade	Some, more needed
3	a	Culvert #1	New headwall & dis. Structure	Not yet planned
3	b	Culvert #2	Refurbish structure	Not yet planned
3	c	Culvert #3	Increase headwall	Used CB
3	d	Entire site	Prepare detail mapping	In 2001 Study
3	e	Hill bluff sides	Establish monitoring	In 2001 Study

Note: Those "not yet planned" are being re-examined in the 2001 study.

For further details refer to Appendix A

Recent geotechnical investigations performed by Leighton and Associates, Inc., (part of the project design team) in January 2001, and the early work of the team for the 10 percent report determined that some improvements have already been made to the drainage system. Some of the work reported completed includes the removal of storm drain outlets and construction of lined drainage ditches along the easterly side of the tracks in 1996. The RR performed much of this work around 1995 and 1996. An underground cable installed by MCI to parallel the railroad in the last year (2000) has also altered the sub drains. Some of the sub-drains have been removed.

The limits of the study were set by the scope of work to be from the at-grade crossing at 15th Street in Del Mar southerly to SR21 rail over crossing, approximately 1.5 miles in length as shown in Figure 1. The entire drainage area under study encompasses approximately 408 acres (0.64 sq. mi.).

The areas of particular concerns established in 2001 have been prioritized and divided into areas with needs for drainage upgrades, bluff toe protection, and bluff embankment support. Table 1 summarizes the risk prioritization in terms of drainage improvements. The medium and low criteria refers to areas that need drainage improvements right away (primary), in the near future (secondary), and within 5 to 10 years (tertiary).

Table 3 – Drainage priorities in 2001

Primary	**Start (MP)**	**Finish (MP)**	**Approximate Length (feet)**
Subdrainage Improvements			
South of CB to 11th Street	244.20	244.53	1742
South of Shippey Lane to end of ER Site	244.67	244.73	316
Surface Drainage Improvements			
CB to 11th Street	244.10	244.53	2,112
South of Shippey Lane to end of ER Site	244.67	244.73	316
New Culvert at MP 244.7	n/a	n/a	n/a
Secondary			
Subdrainage Improvements			
New Subdrain outlet at 5.5 Street	n/a	n/a	n/a
South of 11th to South of Shippey Lane	244.50	244.7	1,056
Surface Drainage Improvements			
10th to 11th Street East of Tracks	n/a	n/a	400
South of ER Site to 5.5 Street	244.73	244.90	900
Anderson Canyon to 101 Bridge	245.37	245.60	1,478
Tertiary			
Subdrainage Improvements			
5.5 Street to Anderson Canyon.	244.90	245.37	2,482
Anderson Canyon to 101 Bridge	245.37	245.60	1,478
Surface Drainage Improvements			
5.5 Street to Anderson Canyon.	244.90	245.37	2,482

For further detail on priorities refer to the Design Report's 10 percent submittal.

Analysis

The drainage study started with a collection of data and information including the following items:

- Measurements and photos of the drainage facilities along the bluff obtained during the May field trip performed by Mr. Joe Bergquist and Gary Sjelin.

- New surveys work being conducted in 2001 of bluff area by Melchior Land Surveying Inc, for DMJM + HARRIS.
- Existing City of Del Mar Storm Drain Map provided by Powell/PBS&J for City Engineer.
- San Diego Area Regional Standard Drawings, Department of Public Works, March 1995.
- Results of the hydrology study shown in Appendix B of the Drainage Report.
- AREMA design latest standards.
- USBR Research Report No. 24.

Hydrologic Analysis

The hydrological analysis performed for the drainage study was based on the San Diego County Storm Drainage Manual. Per the Manual's Procedures for Hydrologic Computations runoff determination methods depend on recorded data or established runoff computation methods. For basin under study of less than 0.5 square miles in area without recorded runoff the manual states the Rational Method could be used. Since the basins in Del Mar under study are less than 0.5 square miles the Rational Formula [Q discharge = CiA] and methodology was followed. This method required the following steps to be taken:

- Drainage Area Determination – using field investigations, City's mapping, and drainage construction information.

- Basin Characteristics Identification – again using available data – including:
  1. Area limits, land use, and soil information using topographic maps and City maps.
  2. Time of concentration using topographic maps and basin identification.
  3. Rainfall intensity – using manual rainfall data for Type B distribution.
  4. Runoff coefficient –using manual runoff curve numbers.

- Runoff Quantity Determination by inserting the area, rainfall intensity, and coefficient determined above.

The new work identified 21 basins instead of 9 per the 1993 study. Much of the new division was due to the improvements built by the City of Del Mar to route the flood flows through to the ocean. The discharges for the 25-year and 100-year floods from the 21 basins were collected at appropriate design points like existing culverts or ditches to facilitate the determination of the capacity of the existing facilities.

For further details refer to Appendix B.

Hydraulic Analysis

The hydraulic analysis required for the drainage study report included the following steps:

1. Determine the capacities of the existing surface drainage system including:
   - Curb inlets and catch basins at the ends of the streets and alleyways in Del Mar up gradient of the railroad.
   - Brow ditches above the tracks near the street ends.
   - Drainage ditches next to the tracks.
   - Culverts under the tracks.

2. Compare the existing system's capacity to the 25-year and 100-year flood discharges the system is required to carry at the design points identified in the hydrology study Appendix B.

3. Design new facilities where the existing drainage components are inadequate or not existing.

The existing capacity analysis was based on standard drainage and hydraulic principles and the dimensions and configuration of each feature studied. Where possible local design standards were used to avoid repeating hydraulic calculations. This was especially true with known capacities given for a curb inlet or catch basin feature. The ensuing design that followed the check of existing to required capacities utilizes the same principles and manuals

The flows from the hydrology analysis were used to size the facilities required. The sized facility is then used for the 30 percent design submittal with the input from the team and the client.

For further details refer to Appendix C.

Results and Conclusions

Hydrologic Analysis Results

Hydrology results presented in Tables 4 through 8 are based on the analysis documented in Appendix B. Table 4 gives the 25-yr and Table 5 the 100-yr peak discharge for each of the 21 basins used to determine runoff. Table 6 gives the 25-yr and Table 7 the 100-yr peak discharge at the selected design points along the ROW. The basins and design points used are shown in Figures 1. Design Points were selected to obtained discharges for hydraulic design purposes and to be used in the comparison of past drainage design study results. Drainage features hydraulically designed with these discharges included inlets, ditches, culverts, and training walls. Table 8 summarizes the 25-year and the 100-year flood discharges being generated during at the ends of each street or alley.

Table 4 - Basin 25-yr Discharge Summary

Basin	C	I	A	Q_{25}
		(in/hr)	(acre)	(cfs)
1	0.55	1.49	0.64	0.53
2	0.55	1.49	1.94	1.60
3	0.55	1.49	2.55	2.10
4	0.55	1.49	2.86	2.36
10	0.55	1.49	9.56	7.89
20	0.55	1.49	16.00	13.20
30	0.55	1.49	12.90	10.64
40	0.55	1.49	8.50	7.01
50	0.55	1.49	4.16	3.43
60	0.55	1.49	26.60	21.95
70	0.55	1.49	1.20	0.99
80	0.55	1.49	5.69	4.70
90	0.55	1.49	16.80	13.86
100	0.55	1.49	5.00	4.13
110	0.55	1.49	18.10	14.94
120	0.55	1.49	3.70	3.05
130	0.55	1.49	22.10	18.24
140	0.55	1.49	49.40	40.76
150	0.55	1.49	133.70	110.33
160	0.55	1.49	23.90	19.72
170	0.55	1.49	42.60	35.15

Table 5 - Basin 100-yr Discharge Summary

Basin	C	I	A	Q_{100}
		(in/hr)	(acre)	(cfs)
1	0.55	3.00	0.64	1.1
2	0.55	3.00	1.94	3.2
3	0.55	3.00	2.55	4.2
4	0.55	3.00	2.86	4.7
10	0.55	3.00	9.56	15.8
20	0.55	3.00	16.00	26.4
30	0.55	3.00	12.90	21.3
40	0.55	3.00	8.50	14.0
50	0.55	3.00	4.16	6.9
60	0.55	3.00	26.60	43.9
70	0.55	3.00	1.20	2.0
80	0.55	3.00	5.69	9.4
90	0.55	3.00	16.80	27.7
100	0.55	3.00	5.00	8.3
110	0.55	3.00	18.10	29.9
120	0.55	3.00	3.70	6.1
130	0.55	3.00	22.10	36.5
140	0.55	3.00	49.40	81.5
150	0.55	3.00	133.70	220.6
160	0.55	3.00	23.90	39.4
170	0.55	3.00	42.60	70.3

Table 6 - 25-yr Peak Discharge Summary at Selected Design Points

Design Point	Q100	DA	Contributing Basin(s)	Remarks	
1	62.7	59.39	1, 2, 10, 20, 30, 40, & 50	Existing 30" RCP; Incl. DP2	Br 244.1
2	2.7	1.94	2	Flows to DP1	
3	13.0	5.41	3, 4, & 80	Existing 24" CIP	Br 244.3
4	36.8	44.60	60, 70, & 90	Existing 48" CIP; 12th St.	Br 244.4 Schute
5	4.9	5.00	100	Sea Orbit Lane	
6	40.4	48.9	100, 110, 120, & 130	DP5+DP7+DP8 +DP9; Existing 48in CIP	Br 244.5
7	17.7	18.10	110	11th St.	
8	3.1	3.70	120	St Midway 10th/11th Streets	
9	18.9	22.10	130	10th St.	
10	43.0	49.40	140	8th St. - North Side	
11	124.6	133.70	150	8th St. - South Side	
12	151.1	183.10	140, & 150	DP10 + DP11; 8th St.; Existing 48"RCP	Br 244.7
13	24.7	23.90	160	Existing 30" RCP	
14	44.2	42.60	170	Existing 6' X 6' RCB	Anderson Canyon Br 245.4

Table 7 - 100-yr Peak Discharge Summary at Selected Design Points

Design Point	Q100	DA	Contributing Basin(s)	Remarks	
1	92.9	59.39	1, 2, 10, 20, 30, 40, & 50	Existing 30" RCP; Incl. DP2	Br 244.1
2	3.2	1.94	2	Flows to DP1	
3	18.3	5.41	3, 4, & 80	Existing 24" CIP	Br 244.3
4	73.6	44.60	60, 70, & 90	Existing 48" CIP; 12th St.	Br 244.4 Schute
5	8.3	5.00	100	Sea Orbit Lane	
6	80.3	48.9	100, 110, 120, & 130	DP5+DP7+DP8 +DP9; Existing 48in (type?)	Br 244.5
7	29.9	18.10	110	11th St.	
8	6.1	3.70	120	St Midway 10th/11th Streets	
9	36.5	22.10	130	10th St.	
10	81.5	49.40	140	8th St. - North Side	
11	220.6	133.70	150	8th St. - South Side	
12	302	183.10	140, & 150	DP10 + DP11; 8th St.; Existing 48"RCP	Br 244.7
13	43.1	23.90	160	Existing 30" RCP	
14	74.4	42.60	170	Existing 6' X 6' RCB	Anderson Canyon Br 245.4

Taking these summaries the 25 and 100-year discharges at the ends of streets follow:

Table 8 – 25-yr & 100-yr Peak Discharge Summary at Street Ends

Street Name	Contributing Basins	Q25 (cfs)	Q100 (cfs)	Comments
15th St. & Coast Blvd.	10, 20, 30, 40, & 50	59.0	88.6	Carried in City storm drain to outlet by park
13th Street	3 & 80	12.3	22.5	Curb Inlet to ditch
Lois Lane	4	4.6	4.7	Outlet is BR 244.4
12th Street	60, 70, & 90	47.7	73.6	Outlet is BR 244.4
Orbit Lane	100	4.9	8.3	Outlet is BR 244.5
11th Street	110	17.6	30.0	Outlet is ditch to BR 244.5
No Name Ln	120	3.1	6.1	Outlet is ditch to BR 244.5
10th Street	130	18.8	36.5	Outlet is ditch to BR 244.5
9th Street	95%*140	40.6	77.5	Outlet is ditch to BR 244.7
Shippey Ln.	5%*140	2.1	4.1	Outlet is ditch to BR 244.7
8th Street	10%*150	12.4	22.1	Outlet is ditch to BR 244.7
Lt Orphan A	10%*150	12.4	22.1	Outlet is ditch to BR 244.7
7th Street	10%*150	12.4	22.1	Outlet is ditch to BR 244.7
Sherrie Ln	10%*150	12.4	22.1	Outlet is ditch to BR 244.7
6th Street	10%*150	12.4	22.1	Outlet is ditch to BR 244.7
5th St or Ln	10%*150	12.4	22.1	Outlet is ditch to BR 245.4
4th Street	40%*150	49.6	88.2	Outlet is ditch to BR 245.4

The comparison of the 1993 and 2001 hydrology analysis results is contained in Appendix A

Hydraulic Analysis Results

Results of the hydraulic analyses are presented below by structure: inlets, ditches, and culverts. These were the existing features and those analyzed.

- **Inlet Structures**

Using the methods outlined in Appendix C, the inlet structure capacities were determined and then compared to the flows each are expected to carry. The results are listed below:

Table 9: Inlet structures characteristics and capacities.

Location	Inlet type	Existing Structure Dimensions	Avail. Head	Out Pipe Dia.	Capacity of inlet (cfs)	Capacity of pipe (cfs)	Capacity of structure (cfs)
13th St.	Curb inlet	7' X 6"	4 inches	24"	10.6	114.0	10.6
Lois lane:	Grated inlet basin	3'4" X 2'	2 feet	12"	49.9	18.0	18.0
12th St.	Two curb inlets	10'X6"	2 feet	24"	76.0	114.0	76.0
Orbit Ln.	Curb inlet & a grated Inlet basin	3'X6" 4'X2'	2 feet 1 foot	18"	11.4 35.2	46.7	46.7
11th St.	Curb inlet	3'X6"	4 inches	12"	4.5	18.0	4.5

Check Inlet

For 13th and 11th street inlets, the capacity was less than the100-year flood, which were 12.3 and 30.0 cfs respectively. At 11th street the 30.0 cfs flow could not be carried with existing facilities. The remaining existing inlets have sufficient capacity. The other ends of streets from 10th street to 4th street do not have inlets and have reported to have considerable flood damage when the flow jumps the end of the curb and the brow ditch.

- **Drainage Ditches**

Ditch capacities were calculated and then compared to the flows each are expected to carry. The sections compared and listed below are described in Appendix C and shown on Figure 2.

Table 10: Discharge capacities of selected ditch cross-sections.

No.	Bed Slope Ft/ft	Discharge capacity using 6-inch freeboard (cfs)	Discharge capacity using 2-feet freeboard (cfs)	Cross section lining material type	Required capacity (cfs)	Remarks
10	0.0042	130.5	25.0	Earth	4.3	Okay
20	0.0127	277.0	63.8	Earth	4.0	Okay
30	0.0055	59.1	0.2	Earth	3.2	Redesigned – 2ft fb limit exceeded
40	0.0091	63.6	4.3	Earth	22.9	Redesigned – 2ft fb limit exceeded
50	0.0189	36.9	0.0	Earth	4.7	Redesigned – 2ft fb limit exceeded
60	0.0470	701.2	0.0	Concrete	72.5	Okay with 6-inch fb
70	0.0313	54.5	0.0	Concrete	42.6	Okay with 6-inch fb
80	0.0311	229.9	0.0	Concrete	146.0	Okay with 6-inch fb
90	0.0250	125.8	0.0	Concrete	99.3	Redesigned
100	0.0059	10.1	0.0	Concrete	100.0	Redesigned
110	0.0250	39.0	0.0	Earth	110.3	Redesigned
120	0.0319	13.7	0.0	Earth	88.2	Redesigned
130	0.0052	160.8	20.8	Concrete	55.2	Okay with 6-inch fb
140	0.0019	162.0	45.7	Concrete	83.5	Okay with 6-inch fb
150	0.0089	467.9	164.1	Concrete	94.6	Okay with 6-inch fb
160	0.0163	89.6	15.8	Earth	81.5	Okay with 6-inch fb

Per the design criteria all ditches should carry the 100-year flood flow. With that goal calculations indicated that the ditch between 4th street and 7th street needed to be redesigned, see capacities for designated ditch stations 150 through 90. Capacities determined for designated sections 30 and 50 [between 13th and 15th Street] because of the freeboard requirement are not adequate so different modification had to be considered to provide the required capacity. Ditches throughout the rest of the reach are considered adequate.

- **Culverts**

Culvert capacities were calculated and then compared to the flows each are expected to carry. The ones compared and listed below are documented in Appendix C.

REV.	DATE	DESCRIPTION	BY	APP

INFORMATION CONFIDENTIAL: All plans, drawings, specifications, and or information furnished herewith shall remain the property of the North San Diego County Transit Development Board; shall be held confidential; and shall not be used for any purpose not provided for in agreements with the North San Diego County Transit Development Board.

DESIGNED BY
DRAWN BY
CHECKED BY
APPROVED BY
DATE JULY 2001

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Table 11: Culvert characteristics and capacities at different design points.

Design point	BR Number	Culvert existing size	Allowable HW elevation (ft)	Maximum capacity (cfs)	Required capacity (cfs)	Remarks
DP 1	244.1	30-inch	38.3	75.6	92.9	Undersized
DP 3	244.3	30-inch	52.3	27.6	18.3	Adequate
DP 4	244.4	48-inch	52.2	160.0	73.6	Adequate
DP 6	244.5	42-inch	56.4	118.2	80.8	Adequate
DP 12	244.7	48-inch	61.5	129.7	302.0	Undersized
DP 14	245.4	6'X5.5' arch	50.5	881.9	74.4	Adequate

For Design Point 12, BR 244.7, the required carrying capacity was 302 cfs while the current culvert has a maximum capacity of 129.7 cfs. The 30-inch culvert at Design Point 1 is also undersize without considering the effect of a surcharge on the manhole.

> **Training walls:**

Training walls of different sizes were determined to be a possible solution to controlling the discharges at the end of 9th and 4th street. An alternative to curb inlets and training walls is the use of a crossing trench with a grate near the end of the street.

Recommendations

Based on the results of the hydraulic analysis and the documentation of the condition of the facilities there are a number of inlets, ditches, and culverts that require rehabilitation or replacement. Documentation of existing features is contained in photos and field inspection notes contained in Appendix D.

Recommendations about the improvements that should be designed include the following items listed under the same titles of inlet, ditch, culvert, and training wall. Recommendations will guide the 30 percent design work and alternative analysis required with that submittal.

> **Inlet Structures**

At 13th street a new 7-foot curb inlet is the recommended design alternative. This new inlet should be connected to a new 12-inch pipe that runs to the culvert at BR 244.3.

At 11th street for the 30.0 cfs flow, two curb inlets are recommended. Each curb inlet will need to convey 15 cfs of flow. The dimension required of such inlets were found to be 7 feet wide and 6-inches high when a depression of 11-inches was assumed.

The other ends of streets from 10th street to 4th street do not have inlets and have reported to have considerable flood damage when the flow jumps the end of the curb and the brow ditch. At these locations, new curb inlets, or a stepped outfall are recommended.

> **Drainage Ditches**

Hydraulic calculations indicate that the ditch's cross-section needs to be redesigned between stations 150 and 90. For this reach, minor modifications to the channel bed are suggested and the sections to be designed for best hydraulic conditions (most efficient and economical design).

For sections 30 and 50, a freeboard of 2-feet was required and the design effort for these should consider different modification to provide the required capacity. Minor excavating of the ditch is possible but not final solutions unless there is constant maintenance of the sediment build-up expected. Other solutions could include a retaining wall on either side and a wider bottom width. Another solution is to reduce the flows into the ditch to reduce the amount of ditch upgrade required. The reduction could occur from capturing the street flows at the end of 13th street and carrying them in a new pipeline to BR 244.3.

It is also recommended that a 6-inch freeboard be considered if the situation existed where a ditch was next to the tracks is lined with gunite, concrete, or shotcrete. The lined occurs for section 130.

> **Culverts**

For Design Point 12, the required capacity was 302 cfs while the current culvert has a maximum capacity of 129.7 cfs. Different design alternatives were studied on a reconnaissance level. It was found that using a single pipe would require significantly larger diameter and energy dissipation impact basin. Therefore, two parallel pipes were considered for the grouted bores. The bores could be either inclined or horizontal connecting to a vertical shaft. The results indicate that two parallel 36-inch lined bores would convey the 100-year flood flows for the horizontal bores and 42-inch lined bores for the vertical bores. The vertical case would also require a larger impact basin. It is expected that the outlet for the storm drain would have an invert elevation of 8.2 feet above sea level. The concepts are shown on Figure C5 in Appendix C.

> **Training walls:**

Due to the large width of 9th street (120 feet wide), it was found that the 100-year flood would not flood the entire road. Flooded width was estimated at 47 feet assuming a longitudinal slope of 4 percent (from topographic maps) and side slopes of 2 percent for this street. Maximum depth of water was estimated at 5.6 inch in the street. Average velocity of flow was estimated at 7.5 ft/sec from Manning equation. Total head was estimated at 1.34 feet or 17 inches. Therefore, maximum height of training wall for this street was estimated at 23 inch or about 2 feet.

For 4th street, the maximum width of flow (100-year flood of 88.2 cfs) over the street was found to be 30 feet. Maximum depth of flow is estimated at 0.5 feet. Velocity of flow was estimated at 9.22 ft/sec. Therefore, total energy head was estimated at 1.8 feet or 22 inches. Adding to that 6-inches of freeboard, results in a required height of 28 inches at the middle of the road. The sides are 0.3 feet higher than the middle; therefore, heights at the sides will be 2 feet or 24 inches.

Appendices

Four appendixes are used to document the work presented in this report. The four include the following:

1. Appendix A: Fraser's Report Updated

   This appendix updates the status of recommendations made in the Fraser's report and compares the results of this new hydrology with the past work.

2. Appendix B: Hydrology

   This appendix presents the hydrologic analysis and results.

3. Appendix C: Hydraulics

   This appendix presents the hydraulic analysis and results based on the hydrology work contained in Appendix B.

4. Appendix D: Documentation of the Condition of Existing Features

   This appendix contains photos taken during field trips and inspection reports by the NCTD inspection engineers.

APPENDIX A

FRASER'S REPORT UPDATED

Del Mar Drainage Study Report
Appendix A – Fraser's Report Updated

Del Mar Drainage Study for the
Del Mar Bluff Drainage Improvement and Landslide Warning System Project

Between Railroad Right of Way Mile Post 244.1 to 245.7

Introduction

Per our scope the following is the Fraser's Report updated and compared to the new work performed in 2001 for the drainage design project.

Fraser's Report:

The following is the Fraser's report in outline form and the notation if the section had to be updated or not with the present work for the drainage design project.

- Introduction – no change.
- Authorization – no change.
- Scope of Services – no change.
  1. Locate points of runoff along RR, estimate flow, and discuss accuracy.
  2. Locate sources of irrigation water and assess their impact.
  3. Map the present drainage system [sizes, capacities, and locations].
  4. Prepare a condition report.
  5. Recommend immediate drainage M&O and improvement plans.
  6. Discuss long-term improvement and maintenance plans.
  7. List approvals and the approval process.
  8. Prepare final report and presentation of findings.

- Report Organization – no change.

Geological – see the new work contained in the geological reports by Leighton and Associates.

- Geologic Setting – study area consists of minor surficial fill soils and slope wash overlaying the quaternary Bay Point formation which overlies the Torrey Sandstone from MP 244.15 to MP 245.0 and the Del Mar formation from MP 245.0 to MP 245.7. Fill soils and slope wash consist of relatively sandy soils. The Bay Point formation massive silty sands typically fails by block falls that form a nearly vertical face. The Torrey sandstone typically fine-grained sandstone, weathers to form nearly vertical faces. The Del Mar formation typically a siltsone to claystone weathers to form a clayey, blocky material with closely spaced joints and fractures that stand with a 1:1 to 2:1 slope. This formation more than the others acts as a vertical barrier to ground water movement and causes seepage to occur at the top of this formation.

- Bluff Stability Issues – It appears that the stability of the east bluff is most affected by erosion from water running over the bluff top. Therefore, long-term stability is dependent on controlling this water. The same over-topping water influences the western bluff's stability, but the bluff is also affected by wave action at the toe of the bluff. At least 7 areas of slope instability were observed on the west bluff in 1993. Stability techniques for these areas may not be long-term. Factors that tend to reduce bluff stability include wave action, seepage water, rodent activity and wind action.
    - Opinion – All water observed seeping form the bluff faces emanates form surface irrigation water. The exact source of the excess irrigation water is difficult to accurately locate except for a short reach between MP 244.15 and 244.3 (North of 13th Street).
    - New opinion is that ground water seepage is as important to control as is the surface water discharges to protect and stabilize the bluff.

Immediate Drainage Maintenance and Improvement Plans – This section needs to be changed. For details see the 10 percent design report and the summary of priorities listed in the section below on changes.

- Immediate Items – Three items identified including restoring culvert #5 [refer to the table below to collate culvert numbers used in Fraser's report to BR numbers used by NCTD for their culverts], cleaning all ditches and culverts, and removal of tree at MP 244.7.

Long Term Drainage Improvements and Maintenance Plan – same situation as above with immediate drainage improvement plans, see the section below on changes.

- Plan divided between the City of Del Mar and NCTD and needs the cooperation of both as all water entering the RR ROW emanates from the City.

- RR uses 100-year flood discharges for design while the City uses a 50-year flood discharge for design purposes.

- NCTD Issues – Priority 1:
    1. New culvert to replace culvert #4 and #5.
    2. Concrete line side ditch from culvert #4 to 10th Street.
    3. Concrete line side ditch from 8th to 10th Street.
    4. Reconstruct the inlet structure for culvert #1.
    5. Construct a new inlet structure 10 feet west of existing cleanout structure for culvert #2 near end of 13th Street.
    6. Concrete line side ditch from 13th Street to culvert #2.
    7. Reconstruct the inlet structure for culvert #8, regrade and install a concrete side ditch from culvert #7 to #8.

- NCTD Issues – Priority 2:
    1. Construct a new inlet structure for culvert #3
    2. Replace existing flume down bluff for culvert #8 outfall.
    3. Construct a new outfall for culvert #6
    4. Evaluate existing subdrains.

5. Concrete line RR side ditch below Seagrove Park.
6. Regrade unlined roadbed side ditches.

- NCTD Issues – Priority 3:
  1. Construct a new headwall and energy dissipation structure for culvert #1 at beach bluff.
  2. Refurbish outfall for culvert #2.
  3. Increase headwall height and outlet channel walls then refurbish the outfall flume structure for culvert #3.
  4. Prepare a detailed geological map of area.
  5. Start a bluff monitoring plan with measurements taken after each major storm and at least every 2 months.

- City's Issues: [Interestingly most of the City's issues are the same in 2001]
  1. Restrict pedestrian traffic.
  2. Reduce park irrigation amounts.
  3. Educate the community on irrigation impacts and how to reduce irrigation volumes.
  4. Check curb inlet capacity and water flow lines around and near culvert #1.
  5. Intercept surface water overtopping cut in basin 100.
  6. Construct a collection system to collect all design flows at end of 13th Street.
  7. Construct a collection system to collect all design flows at end of 10th Street.
  8. Improve ditch capacity of concrete ditch from 4th to 10th Street.
  9. Improve ditch capacity of concrete ditch form 9th to 10th Street.
  10. Improve ditch capacity of ditches in basin 500 from 9th Street to culvert #6.
  11. Improve ditch capacity of ditch north of 4th Street to culvert #6.
  12. Construct an effective drainage collection system at the end of 4th Street.
  13. Construct a ditch from 4th Street south 250 feet.
  14. Control drainage off Spinnaker Court.

Outside Agencies Approval and Processes – no change, if anything the permitting is becoming more difficult to obtain.

- Assumptions with biological impacts need to be settled with a survey.
- Assumptions with the California Coastal Commission (CCC), COE's 404 permit, USF&W section 10, Regional Water Control Board, California Environmental Quality Act (CEQA), and NEPA's rules or the FTA's guidelines, California Department of Fish and Game (DFG), and City's permits.
- Permits and regulatory requirements by type of action.

Appendix A: Hydrology and Hydraulic Study The appendix had to be revised for new conditions found in Del Mar like new City stormwater drainage system improvements. See attached Appendix B for hydrology and Appendix C for hydraulic study. Changes are shown below.

New Priorities

Recent erosion and drainage problems followed by a series of studies resulted in a new listing of priorities as follows in Table A1.

Table A1 – Drainage priorities in 2001

Primary	**Start (MP)**	**Finish (MP)**	**Approximate Length (feet)**
Subdrainage Improvements			
South of CB to 11th Street	244.20	244.53	1742
South of Shippey Lane to end of ER Site	244.67	244.73	316
Surface Drainage Improvements			
CB to 11th Street	244.10	244.53	2,112
South of Shippey Lane to end of ER Site	244.67	244.73	316
New Culvert at MP 244.7	n/a	n/a	n/a
Secondary			
Subdrainage Improvements			
New Subdrain outlet at 5.5 Street	n/a	n/a	n/a
South of 11th to South of Shippey Lane	244.50	244.7	1,056
Surface Drainage Improvements			
10th to 11th Street East of Tracks	n/a	n/a	400
South of ER Site to 5.5 Street	244.73	244.90	900
Anderson Canyon to 101 Bridge	245.37	245.60	1,478
Tertiary			
Subdrainage Improvements			
5.5 Street to Anderson Canyon.	244.90	245.37	2,482
Anderson Canyon to 101 Bridge	245.37	245.60	1,478
Surface Drainage Improvements			
5.5 Street to Anderson Canyon.	244.90	245.37	2,482

This can be compared to the work carried out on the last listing of priorities in Table A2.

Table A2: Drainage system improvements recommended in 1993

Recommendation Priority and No.		Location	Recommendation	Status in 2001
1	a	Between #4(BR 244.5) &#5(BR 244.7)	New 66" culvert	Not yet planned
1	b	From #4 to new cul.	Line ditch	Not yet planned
1	c	From #5 to new cul.	Line ditch	Not yet planned
1	d	Culvert #1(BR 244.1)	Reconst. inlet str.	Not yet planned
1	e	Culvert #2(BR244.3)	Reconst. Inlet str.	Did
1	f	From 13st to #2	Regrade canal	Not yet
1	g	From #7(BR 245.16) to #8(BR 245.21)	Reconst. Inlet at #8 & ditch from #7 to #8	Closed off, N/A
2	a	Culvert #3(BR 244.4)	New inlet	Did
2	b	Culvert #8	New flume down hill	Closed off, N/A
2	c	Culvert #6(BR 244.9)	New outfall	Not yet planned
2	d	All along RR	Evaluate subdrains	In 2001 Study
2	e	Below Seagrove Park	Line ditch	Not yet planned
2	f	RR side ditches	Regrade	Some, more needed
3	a	Culvert #1	New headwall & dis. Structure	Not yet planned
3	b	Culvert #2	Refurbish structure	Not yet planned
3	c	Culvert #3	Increase headwall	Used CB
3	d	Entire site	Prepare detail mapping	In 2001 Study
3	e	Hill bluff sides	Establish monitoring	In 2001 Study

Note: Those "not yet planned" are being re-examined in the 2001 study.

Comparisons

The results of the hydrology study performed in 1993 developed runoff from nine basins and looked at the capacity of the existing nine culverts in this reach of track. The present study used 22 basins due to changes in the basin drainage system to do the same thing. The results of both studies are compared below.

Table A3: Existing 1993 culvert capacities

Culvert No. & (BR #)	Size (inches)	Basin No.	Area (acres)	Q100 (cfs)	Culvert Capacity (cfs)	Storm Return Frequency
1 (244.1)	30 RCP	100	69.6	140	80	6
2 (244.3)	24 CIP	200	1.1	4	140	100
3 (244.4)	48 CIP	300	65.7	160	148	60
4 (244.5)	24 CMP	400	43.6	90	35	1
5 (244.7)	48 RCP	500	137.8	310	120	1
6 (244.9)	48 RCP	600	36.6	120	125	100
7 (244.16)	30 RCP	700	32.4	85	46	4
8 (245.21)	30 CIP	800	2.6	15	65	100
9 (245.4)	6X6 BOX	900	51.6	95	730	100

Table A4: 2001 study culvert characteristics and capacities.

Design point	BR Number	Culvert existing size	Allowable HW elevation (ft)	Maximum capacity (cfs)	Capacity required for Q100 (cfs)	Remarks
DP 1	244.1	30-inch	38.3	75.6	92.9	Undersized
DP 3	244.3	30-inch	52.3	27.6	18.3	Adequate
DP 4	244.4	48-inch	52.2	160.0	73.6	Adequate
DP 6	244.5	42-inch	56.4	118.2	80.3	Adequate
DP 12	244.7	48-inch	61.5	129.7	302.0	Undersized
DP 14	245.4	6'X5.5' arch	50.5	881.9	74.4	Adequate

The comparison then is in Table A5.

Table A5: 1993 vs. 2001 Runoff Peaks at 1993 Culverts

Culvert No. & (BR #)	1993 Size (inches)	1993 Culvert Capacity (cfs)	1993 Q100 (cfs)	2001 Culvert Capacity (cfs)	2001 Q100 (cfs)	Comment
1 (244.1)	30 RCP	80	140	76	92.9	To be upgraded
2 (244.3)	24 CIP	140	4	28	18.3	Was upgraded to a 30-inch dia.
3 (244.4)	48 CIP	148	160	160	73.6	Adequate
4 (244.5)	24 CMP	35	90	118	80.3	Was upgraded to a 48-inch dia.
5 (244.7)	48 RCP	120	310	130	302.0	To be upgraded
6 (244.9)	48 RCP	125	120	closed		
7 (244.16)	30 RCP	46	85	closed		
8 (245.21)	30 CIP	65	15	closed		
9 (245.4)	6X6 BOX	730	95	880	74.4	Adequate

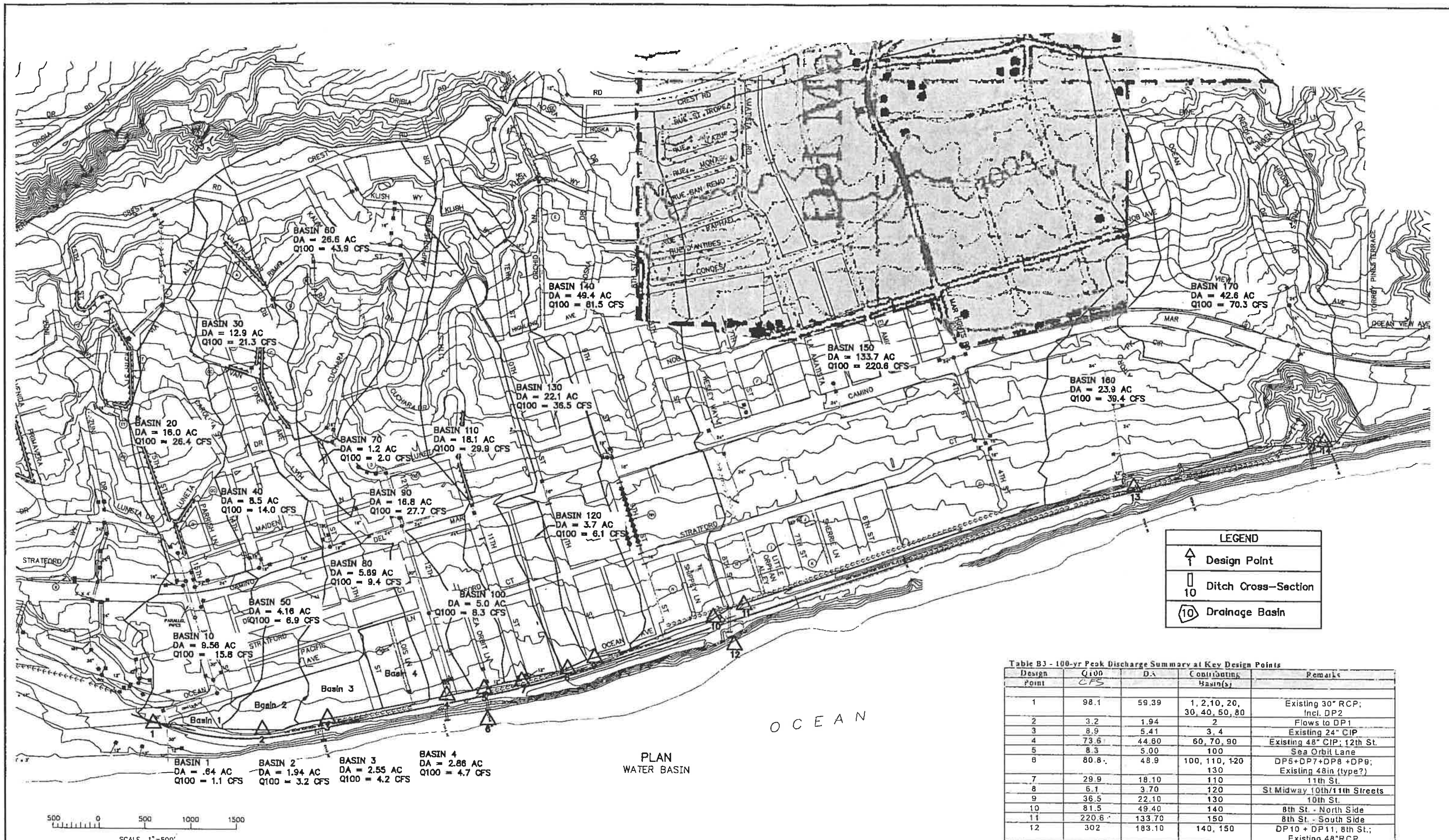

Table B3 - 100-yr Peak Discharge Summary at Key Design Points

Design Point	Q100 CFS	DA	Contributing Basin(s)	Remarks
1	98.1	59.39	1, 2,10, 20, 30, 40, 50, 80	Existing 30" RCP; Incl. DP2
2	3.2	1.94	2	Flows to DP1
3	8.9	5.41	3, 4	Existing 24" CIP
4	73.6	44.60	60, 70, 90	Existing 48" CIP; 12th St.
5	8.3	5.00	100	Sea Orbit Lane
6	80.8	48.9	100, 110, 120 130	DP5+DP7+DP8 +DP9; Existing 48in (type?)
7	29.9	18.10	110	11th St.
8	6.1	3.70	120	St Midway 10th/11th Streets
9	36.5	22.10	130	10th St.
10	81.5	49.40	140	8th St. - North Side
11	220.6	133.70	150	8th St. - South Side
12	302	183.10	140, 150	DP10 + DP11, 8th St.; Existing 48"RCP
13	43.1	23.90	160	Existing 30" RCP
14	74.4	42.60	170	Existing 6' X 6' RCB

REV.	DATE	DESCRIPTION	APP

INFORMATION CONFIDENTIAL
All plans, drawings, specifications, and or information furnished herewith shall remain the property of the North San Diego County Transit Development Board; shall be held confidential; and shall not be used for any purpose not provided for in agreements with the North San Diego County Transit Development Board.

DESIGNED BY
DRAWN BY
CHECKED BY
APPROVED BY
DATE JULY 2001

NCTD NORTH SAN DIEGO COUNTY TRANSIT DEVELOPMENT BOARD

DMJM HARRIS
3800 Kilroy Airport Way, Suite 350
Long Beach, California 90806

SUBMITTED: ____ APPROVED: ____

DEL MAR BLUFF DRAINAGE IMPROVEMENT PROJECT
DRAINAGE BASINS

SCALE: 1"=500'
CONTRACT NO.
DRAWING NO. FIGURE 1
REV
SHEET NO. 1 OF 2

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