City of Albuquerque
P.O. BOX 1293 ALBUQUERQUE, NEW MEXICO 87103

August 13, 1998

John Provine
Molzen-Corbin & Associates
2701 Miles Road, SE
Albuquerque New Mexico 87119

RE: Drainage Report for Runway 12-30 Reconstruction ~~(N-16)~~ Received August 12, 1998
M-14/D024 F

Mr. Provine:

I have reviewed the referenced report dated August 10, 1998 and forward the following comments.

The report narrative was detailed, however, I was unable to follow the proposed improvements on your drainage maps. Please submit a drainage report that contains the proposed storm drain improvements. A grading plan will also need to be submitted. With this information I will be able to send you more detailed comments.

If you have any questions please call me at 924-3984.

Sincerely,

Carlos A. Montoya
Project Manager

c: Andrew Garcia
File

CITY OF ALBUQUERQUE
NEW MEXICO

DRAINAGE REPORT
FOR
RUNWAY 12-30 RECONSTRUCTION

October 1998

A.I.P. No.: 3-35-0003-21
City Project No.: 5677.01

Prepared
for
City of Albuquerque
Aviation Department

11/1/98

JOHN M. PROVINE
NEW MEXICO
10007
REGISTERED PROFESSIONAL ENGINEER

10/1/98

RECEIVED
OCT 02 1998
HYDROLOGY SECTION

MOLZEN-CORBIN & Associates

2701 Miles Road, SE
Albuquerque, New Mexico 87106
(505) 242-5700

BER81-20.R01

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1.0 AUTHORITY

On November 1997, the City of Albuquerque, New Mexico, signed an Agreement for Engineering Services authorizing Molzen-Corbin & Associates to proceed with the design of Runway 12-30 Improvements. The project includes the reconstruction and lengthening of Runway 12-30 and parallel Taxiway G . The project also includes the reconstruction of the southern portion of the perimeter road and South Gate Avenue.

2.0 RELATED STUDIES

The Albuquerque International Airport Drainage Master Plan, prepared by Molzen-Corbin & Associates in 1994, is used as the primary reference for the design of the improvements associated with the Runway 12-30 project.

The Design Analysis Report for the 1996 Runway 3-21 Reconstruction project, prepared by URS Greiner, is also used in this analysis, due to changes in some of the drainage systems from those outlined in the Drainage Master Plan.

3.0 PURPOSE

The purpose of this report is to provide a complete hydrologic and hydraulic analysis of the proposed airport improvements, to summarize the results obtained from this analysis, and to recommend drainage improvements associated with the reconstruction and lengthening of Runway 12-30 and Taxiway G. This report, combined with the construction drawings, is submitted for review.

4.0 HYDROLOGIC/HYDRAULIC ANALYSIS

4.1 Hydrologic Methodology and Criteria

In order to develop detailed discharge hydrographs from each watershed and subsequent routing, a hydrologic modeling computer program was used. The AHYMO computer model was utilized in the drainage analysis of the Runway 12-30 reconstruction project. All drainage analysis performed under this design meets the revised criteria for Section 22.2, Hydrology (January 1991), from the City of Albuquerque's Development Process Manual (DPM) with modeling prepared using AMAFCA'S AHYMO97 computer program.

AHYMO97 is the latest version of the AHYMO computer model released in August of 1997. The AHYMO97 computer model has the capability to develop detailed discharge hydrographs and route these hydrographs over time to account for flow attenuation. This recent revision to the computer model includes provisions required for the acceptance of the model by the Federal Emergency Management Agency (FEMA). AHYMO models developed under the Drainage Master Plan project were used as a basis for the modeling in this project. All existing models were updated using the current version of AHYMO.

Rainfall data is an important element of developing any AHYMO model. The principal design storms considered in this analysis are the 10-year/6-hour and 100-year/6-hour events. Rainfall depths were obtained from the NOAA Atlas 2, Precipitation Frequency Atlas of the Western United States, Volume IV. The 10-year/6-hour and 100-year/6-hour rainfall depths were computed at 1.57 inches and 2.35 inches, respectively. The 10-year and 100-year/6-hour rainfall depths have been distributed using NOAA Atlas procedures in conjunction with the Type I rainfall distribution command in AHYMO.

Other parameters that are required for input into the AHYMO97 computer model are:

- **Basin Area, A (Acres)** - The basin areas are delineated from available topographic mapping, field investigations, or proposed roadway geometry. These delineations correspond to the entire area contributing to a designated out-fall location or analysis point. Basin areas can be found in Appendix C and Plates 1 and 2 of this report

- **Time of Concentration, Tc (Hrs.)** – The time of concentration is the time it takes excess runoff to travel along the hydraulic length of the watershed. The hydraulic length, watershed slope, and ground cover are all factors in determining the time of concentration for a watershed. Due to the small basin areas anticipated on this project, all Tc values are considered to be a minimum value of 12 minutes.

- **Land Treatment, LT (%)** – The land treatment factors define the ground cover within a basin. Land treatment factors are defined in four categories: A, B, C, and D. A description of these land treatments can be found in Table 4-1.

By taking into account the above listed watershed variables, the AHYMO97 model computes hydrographs displaying the peak discharge (Q) and volumetric runoff (V) values for each basin. Summary's of these models can be found in Appendix A.

4.2 Hydraulic Design Criteria

The design criteria used for this project follow the same concept that has been used for other projects of this type at the Albuquerque International Sunport. All runway and taxiway safety areas will be graded to drain away from the pavements with storm drains and inlets extended to all areas that do not drain away freely on the surface. The storm drain systems will be sized to handle the 10-year/6-hour design storm, with temporary ponding occurring in the graded areas (islands) of the airfield sized to accommodate the 100-year/6-hour event. FAA Manual

TABLE 4-1

LAND TREATMENTS

Treatment	Land Condition
A	Soil uncompacted by human activity with 0 to 10 percent slopes. Native grasses, weeds, and shrubs in typical densities with minimal disturbance to grading, groundcover, and infiltration capacity. Croplands. Unlined arroyos.
B	Irrigated lawns, parks, and golf courses with 0 to 10 percent slopes. Native grasses, weeds, and shrubs, and soil uncompacted by human activity with slopes greater than 10 percent and less than 20 percent.
C	Soil compacted by human activity. Minimal vegetation. Unpaved parking, roads, trails. most vacant lots. Gravel or rock on plastic (desert landscaping). Irrigated lawns and parks with slopes greater than 10 percent. native grasses, weeds, and shrubs, and soil uncompacted by human activity with slopes at 20 percent or greater. Native grass, weeks, and shrub areas with clay or clay loam soils and other soils of very low permeability as classified by SCS Hydrologic Soil Group D.
D	Impervious areas, pavement, and roofs.
Most watersheds contain a mix of land treatments. To determine proportional treatments, measure respective sub-areas. In lieu of specific measurement for Treatment D, the areal percentages in Table A-5 may be employed.	

AC 150/5320-5b, "Airport Drainage", states that positive drainage should be provided for all pavements and safety areas to handle the runoff resulting from the 5-year design storm, but that on-site ponding may be allowed to temporarily store the excess runoff from larger recurrence interval storms in the interest of economical construction. The City of Albuquerque's Development Process Manual (DPM), Section 22.3, Hydraulics, was also followed in the analysis of Runway 12-30 project.

Roadway drainage for South Gate Avenue Relocation will be analyzed for the 100-year/6-hour event; culverts will be sized to pass the 100-year/6-hour event without over topping of the roadway. This meets the NMSH&TD drainage criteria for the design and analysis of culverts for rural highways, which requires the headwater depth at the inlet of the culvert be at the top of the structure for the 50-year/24-hour storm event. The culvert structure must also be analyzed for the 100-year/24-hour storm event with the headwater depth not to exceed the elevation of the edge of the roadway pavement.

The culverts were analyzed using Hydraulic Charts for the Selection of Highway Culverts, as shown in Appendix B. Drop inlets and lines were sized using the Quick HEC-12 computer program developed by "Haested Methods". All drop inlets are located in a sump condition, including a 50% clogging factor in infield areas and 20% in paved area, as specified in FAA AC 150/5320-5B, Figure 25.

5.0 SITE LOCATION

The Albuquerque International Sunport is located on the south end of Albuquerque, and can be accessed from I-25 off of Sunport Blvd. The project site can be found in the City of Albuquerque Zone Atlas Maps N, 16-17 (see Figure 1 and Sheet 1 of Appendix C) This project includes the reconstruction of Runway 12-30, as well as the southeast portion of Taxiway G and perimeter road, including pavement, storm sewer, drainage and electrical. The relocation of the South Gate Avenue will also include pavement, utility, and drainage improvements; this work will be done on the newly acquired land from Kirtland Airforce Base.

The improvements will be divided into three sections. Drainage issues with these three sections will be discussed in Sections 5 through 7.

1. Section 1 - The northwest portion of Runway 12-30 at the new Taxiway G - : E-3.

2. Section 2- Along the southeast portion of the existing Runway 12-30 in predominately in Basin 35SE.

3. Section 3 the southerly newly acquired portion form Kirtland AFB, and in the southern portion of Basin MB.

6.0 SECTION 1- RUNWAY 12-30 NORTHWEST

6.1 Existing Conditions and Drainage

The new system, which was put in as part of the Runway 3-21 Reconstruction Project, conveys flows from the southeast side of the Runway 12-30/ Taxiway E intersection into the Runway 3-21 Collection System. This system consists of a series of manholes and 36" trunk line, with 24" stub outs to drop inlet structures. This system drains the north side of Runway 12-30 and the south side of Taxiway J with the infield area included. Drainage from this area is now taken into the new Runway 3-21 system, including flows from Runway 12-30, Taxiway J, and the infield area.

6.2 Proposed Conditions

With the reconstruction of Runway 12-30, the extension of Taxiway E-3 across Taxiway E to Runway 12-30 will be added. This will meet the newly added Taxiway G-1 on the south side of Runway 12-30. The southern section of Taxiway E-3 will cover the area in which a manhole and drop inlet is located. The infield area, which will be established because of the new taxiway, will have to be provided with drainage. The existing system will be extended to drain this area. On the south side of Runway 12-30, the newly relocated Taxiway G-1 will have no impact on the storm sewer system with only a shift in the paved area.

6.3 Proposed Drainage Improvements

The manhole and drop inlet on the north side of the runway will have to be relocated and cleared of the new taxiway. A manhole will have to be relocated approximately 100 feet southeast of the present location. The drop inlet will be moved into the infield island to drain the area. The drop inlet and the 24" RCP connector will be located 300 feet from the newly positioned manhole. This may be seen on Sheet 2 (Appendix C: Storm Drain Line 1).

7.0 SECTION 2- RUNWAY 12-30 SOUTHEAST BASIN 35SE

7.1 Existing Conditions and Drainage

This section is located from the centerline of Runway 12-30 southwest to Runway 17-35 and south to the property line. This area incorporates the newly delineated basin 35SE as illustrated on Plate 2, with most of the existing northern section of Basin 35SE incorporated into the Runway 3-21 system. This area is mostly undeveloped and undisturbed by human activity with slope ranging from 0-10%. The only developed area is a portion of Runway 12-30 and the NMERI site just south of the airport property.

Drainage from this site is mostly overland south with most flows from the pavement being captured by drop inlets of a storm sewer system and conveyed through a 24" and 48" trunk lines with drop inlets. The inlets are located in the infield area between the Runway 12-30 and Taxiway G. Both trunk lines have an outlet at a sump area just north of the perimeter road. From here the system flows are conveyed under the road via 2-36" culverts.

7.2 Proposed Conditions

The extension of Runway 12-30, overrun area, and Taxiway G will consist of a paved runway width of 150 feet and 852 feet in length with an overrun length of 800 feet. Taxiway G will be moved approximately 55 feet south and parallel to Runway 12-30, with two new connector taxiways. The extension will develop new infield areas in which drainage will have to be provided. The overrun area extension will cause increased area and slopes in excess of 20%. The perimeter Road will also be reconstructed and extended from the southwest side of Runway 17-35, southeast around Runway 12-30. This will consist of a paved 24-foot section with a swale on the inside portion.

7.3 Proposed Drainage Improvements

An underground storm drain system will be installed to convey flows from basins 616, and 608. This system will consist of 4-drop inlets with a 36" feeder line connecting into the drop inlet just south of Taxiway G and east of Runway 17-35. A drainage swale will run along the newly reconstructed perimeter road that will pick up flows from basin 617 and the overrun area. This flow will discharge through a double "D" drop inlet into a 24" CMP down the overrun slope into the arroyo below the escarpment (as seen in Sheets 3-5 in Appendix C: Storm Drain Lines 2 and 3).

TABLE 7-1
BASIN S35

SUB-BASIN NO.	HISTORIC (FROM MASTER PLAN)					EXISTING					PROPOSED				
	AREA (sq mi)	Q10 (cfs)	V10 (ac-ft)	Q100 (cfs)	V100 (ac-ft)	AREA (sq mi)	Q10 (cfs)	V10 (ac-ft)	Q100 (cfs)	V100 (ac-ft)	AREA (sq mi)	Q10 (cfs)	V10 (ac-ft)	Q100 (cfs)	V100 (ac-ft)
616											0.0124	19.45	0.620	31.81	1.086
607	0.0075	11.63	0.368	19.10	0.649	0.0075	11.50	0.362	18.95	0.641	0.0088	13.72	0.436	22.50	0.266
608	0.0055	8.43	0.265	13.90	0.470	0.0055	8.43	0.265	13.90	0.470	0.0067	10.27	0.323	16.93	0.572
610	0.0263	9.40	0.684	20.05	1.502	0.0263	9.40	0.684	11.66	0.966	0.0249	8.90	0.648	18.99	1.423
609	0.0208	9.66	0.289	27.07	0.804	0.0208	9.66	0.289	27.07	0.804	0.0177	8.22	0.246	23.03	0.684
611	0.0112	7.99	0.252	17.83	0.561	0.0112	7.99	0.252	17.83	0.561	0.0233	16.61	0.524	37.07	1.167
612A						0.0852	60.63	1.918	136.29	4.266	0.0612	43.62	1.377	97.33	3.064
612B						0.0175	12.48	0.394	27.84	0.876	0.0175	12.48	0.394	27.84	0.826
617A											0.0285	24.78	0.742	51.05	1.589
617B											0.0032	1.17	0.030	3.80	0.106
PERIM FENCE @ CULVERT															
	0.2525	68.40	8.807	82.87	17.101	0.0713	33.42	1.852	65.69	3.441	0.0938	47.75	2.799	87.25	5.697
@ ASR						0.0175	12.48	0.394	27.84	0.876	0.0175	12.48	0.394	27.84	0.876
DROP INLET OVERRUN															
SOUTH											0.0152			32.18	1.020
NORTH											0.0230			41.89	1.355

8.0 SECTION 3- RUNWAY 12-30 NORTHEAST MIDDLE BASIN

8.1 Existing Conditions and Drainage

The Runway 12-30 NE Middle basin is one of the largest basins on the airport property. Flows from this Basin are detained in a detention pond on the south side of the airport, which discharges into a natural arroyo. The arroyo also captures flows from basin 1451, which incorporates the area north of Runway 12-30. West of Taxiway H, this basin is predominately natural ground cover with slopes under 10%. The only developed area in this basin is the pavement on the runway and taxiway. Most of the flows pass through a 24" culvert under South Gate Avenue.

Drainage from this basin is concentrated into the arroyo south of the pond, with a 100-year pond discharge of 119 cfs and a discharge of 130.3 cfs from basin 1451. The flows from basin 1451 are basically from infield areas north of Runway 12-30 and east of Runway 17-35 with some flows from Runway 12-30. The infield area is predominately natural ground cover with slopes under 10%.

8.2 Proposed Conditions

The proposed extension of Runway 12-30, overrun area, and perimeter road will consist of an 852-foot runway extension, and 800 ft overrun. This extension will be southeast over the existing South Gate Avenue. A perimeter road extension will consist of a 24-foot section around the overrun area, tying into Taxiway H. Due to the runway extension, the relocation of South Gate Avenue will take place, which will consist of a 24-foot road section with 4-foot shoulders. The road will match the existing road just west of the ASR site and continue east, and meet the existing road east of the pond.

8.3 Proposed Drainage Improvements

With the extension of the perimeter road, a drainage swale will be added to convey the flows from the area between the runway and perimeter road. These flows will discharge into a double "D" drop inlet on the north side of the overrun area (see Appendix B for Hydraulic analysis and Appendix C: Sheet 6 for Storm Drain Line 4 Plan and Profile). Once intercepted, these flows will be conveyed in a 24" CMP into an existing arroyo. The relocation of the South Gate Avenue will require a drainage structure to convey flows from the detention pond under the road, connecting the existing 36" outfall pipe to a 42" pipe, which will pass through the road. This will be done via a manhole located at the end of the outfall pipe. This manhole will also serve as a junction for the 24" RCP, conveying the flows from the new drop inlet at infield area just west of the South Gate Avenue match (see Appendix C: Sheet 8 Storm Drain Lines 9-11). The relocation of the South Gate Avenue will intercept some of the natural arroyos; these will have to be maintained by a culvert system. There will be a series of four culverts under the relocated road to convey these flows. These were sized using the Hydraulic Charts (see Appendix B and Appendix C: Sheet 7 – Storm Drain Lines 5-8).

TABLE 8-1
MIDDLE BASIN

SUB-BASIN NO.	HISTORIC (FROM MASTER PLAN)					EXISTING					PROPOSED				
	AREA (sq mi)	Q10 (cfs)	V10 (ac-ft)	Q100 (cfs)	V100 (ac-ft)	AREA (sq mi)	Q10 (cfs)	V10 (ac-ft)	Q100 (cfs)	V100 (ac-ft)	AREA (sq mi)	Q10 (cfs)	V10 (ac-ft)	Q100 (cfs)	V100 (ac-ft)
POND															
OUTLET	1.4688	97.57	64.485	119.09	121.238	1.4688	97.59	68.486	119.14	121.258	1.4688	97.59	68.486	119.14	121.26
1451B	1.546	98.32	68.03	130.30	119.70	0.0772	32.20	1.637	73.70	3.927	0.0120	3.56	0.194	17.74	0.513
1451A											0.0947	37.87	2.131	151.85	4.741
TOTAL						1.5460	98.36	68.031	130.30	119.723	1.5750	98.58	68.704	172.11	120.997

FIGURE 2
CULVERT SIZING CALCULATIONS

Storm Pipe No. 8
Sta 28+14.92

Headwater Depth = 3 ft
Q_{100} = 17.74 cfs
Q_{10} = 3.56 cfs
Slope = 0.09 ft/ft
Length = 100 ft

$L / 100\ S_o$ = 100 ft / (100 * 0.09 ft/ft)
= 11.1 ⇒ Use 20

From attached nomograph (see attached figure 3 & 4):

Q = 18 cfs ∴ Use 1 - 24" CMP

Storm Pipe No. 6
Sta 17+51.73

Headwater Depth = 3.5 ft
Q_{100} = 3.80 cfs
Q_{10} = 1.17 cfs
Slope = 0.015 ft/ft
Length = 70 ft

$L / 100\ S_o$ = 70 ft / (100 * 0.015 ft/ft)
= 46.7

From attached nomograph (see attached figure 3 & 4):

Q = 19 cfs ∴ Use 1 – 24" CMP

Storm Pipe No. 7
Sta 25+09.15

Headwater Depth = 7 ft
Q_{100} = 151.85 cfs
Q_{10} = 37.87 cfs
Slope = 0.03 ft/ft
Length = 135 ft

$L / 100\ S_o$ = 135 ft / (100 * 0.03 ft/ft)
= 45.0

From attached nomograph (see attached figure 3 & 4):

Q = 70 cfs ∴ Use 2 – 36" CMP's

Storm Pipe No. 5
Sta 12+83.57

Headwater Depth = 4 ft
Q_{100} = 51.05 cfs
Q_{10} = 24.78 cfs
Slope = 0.03 ft/ft
Length = 95 ft

$L / 100\ S_o$ = 95 ft / (100 * 0.03 ft/ft)
= 31.7

From attached nomograph (see attached figure 3 & 4):

Q = 33 cfs ∴ Use 2 – 30" CMP's

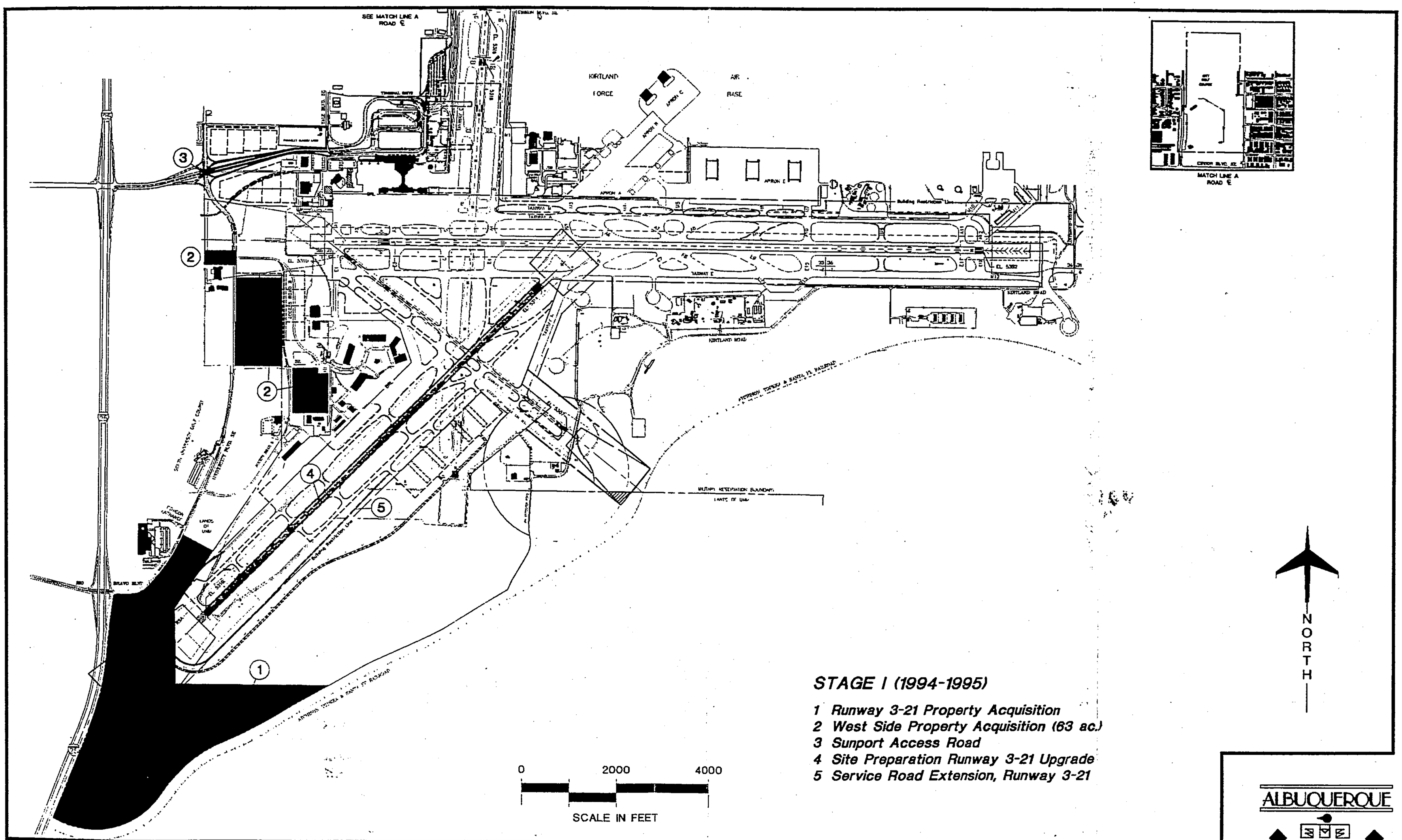

Exhibit 7A
STAGE I (1994-95) DEVELOPMENT

M-16/D024I

City of Albuquerque

P.O. BOX 1293 ALBUQUERQUE, NEW MEXICO 87103

RECEIVED
DEC 4 1990
HYDROLOGY DIVISION

November 28, 1990

PROJECT ACCEPTANCE LETTER

Mountain States Constructors, Inc.
P.O. Box 6098
Albuquerque, NM 87197

RE: RUNWAY 3-21 EXTENTION & OVERLAY TAXIWAYS, CURB & GUTTER CONSTRUCTION, AND NEW AIR FREIGHT APRON, PROJECT NO. 3372

Dear Sir:

The above referenced project has been completed according to the plans and specifications. The project consisted of earth grading, asphalt and concrete pavement with airfield lighting and marking, storm drains, water main relocation, security fencing, and mulching and seeding.

The City of Albuquerque accepts the referenced project as a whole and the contractual correction period began July 18, 1990. The correction period on this project is for one (1) year.

Sincerely,

Brian L. Speicher, P.E.
Chief Construction Engineer
Design/Construction Division
Engineering Group
Public Works Department

BLS:tp

FILE COPY

City of Albuquerque

P.O. BOX 1293 ALBUQUERQUE, NEW MEXICO 87103

Ken Schultz
Mayor

UTILITY DEVELOPMENT DIVISION
HYDROLOGY SECTION
(505) 768-2650

November 5, 1987

Kenneth W. Crow, P.E.
Molzen-Corbin & Associates
2701 Miles Road, SE
Albuquerque, New Mexico 87106

RE: DRAINAGE REPORT SUBMITTAL OF RUNWAY 3-21 ALBUQUERQUE INTERNATIONAL AIRPORT, RECEIVED OCTOBER 23, 1987 FOR C.I.P. CONSTRUCTION PLANS APPROVAL ~~(N-167D8)~~ M-16/D024F

Dear Mr. Crow:

The above referenced submittal dated October 22, 1987, is approved. Hydrology Section can sign-off on construction drawings consistent with this Drainage Report.

One recommendation I have in regards to your use of the SCSHYDRO computer model for hydrology computations is to use the 24 hour duration rainfall in lieu of the 6 hour duration, since all the SCS distribution curves etc. are based on the historic 24 hour durations. The City's DPM methods use the 6 hour duration, but the methods are usually very conservative when compared to the SCS computer models.

If you have any further questions, call me at 768-2650.

Cordially,

Roger A. Green, PE

Roger A. Green, P.E.
C.E./Hydrology Section

cc: Bob Gill, Aviation Department

RAG/bsj

CALCULATED BY _____ DATE _____	CLIENT _____ PROJECT NO. _____
CHECKED BY _____ DATE _____	PROJECT _____
SHEET NO. _____ OF _____	SUBJECT _____

DRAINAGE REPORT

RUNWAY 3-21
ALBUQUERQUE INTERNATIONAL AIRPORT

AIP # 3-35-0003-08-88

APRIL 1989

RECEIVED
MAY 24 1989
HYDROLOGY SECTION

REGISTERED ENGINEER
STATE OF NEW MEXICO
No. 5258
HANS H. COUCHERON-AMIOT

MOLZEN-CORBIN
& Associates
505-242-5700 ALBUQUERQUE • NEW MEXICO • LAS CRUCES 505-525-2397

CALCULATED BY *ylc-a* DATE *4-17-89*	CLIENT _____ PROJECT NO. _____
CHECKED BY _____ DATE _____	PROJECT *R/W 3-21, ABQ*
SHEET NO. _____ OF _____	SUBJECT _____

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CALCULATED BY JLC-a DATE 4-12-89	CLIENT ____ PROJECT NO. ____
CHECKED BY ____ DATE ____	PROJECT R/W 3-21, ABQ
SHEET NO. ____ OF ____	SUBJECT ____

INTRODUCTION

A preliminary drainage report for this project was prepared and submitted for review with the Preliminary Engineering Report, dated August 1987.

The City Hydrology Section (Roger Green) approved the preliminary drainage report in principle by letter dated Nov. 5, 1987.

The project layout has changed considerably since the Preliminary Engineering Report was submitted — the runway was extended approximately 450 ft. to the southwest to accommodate the requested change of threshold location on R/W 21; Taxiway C was widened to meet Group IV criteria between the freight apron and Taxiway B, and numerous minor changes as the design process went forward.

The drainage system layout has then also been revised to accommodate the changes in project scope. The revised layout is schematically very similar to that of the preliminary report, and the principle of providing essentially "dry" pavement areas for a 10-year design storm while restricting the rate of discharge to the outlets to the Tijeras Arroyo by ponding the peak runoffs in the runway and taxiway safety areas, has been retained.

CALCULATED BY JLC-CC DATE 4-12-89	CLIENT ____ PROJECT NO. ____
CHECKED BY ____ DATE ____	PROJECT R/W 3-21, ABQ
SHEET NO. ____ OF ____	SUBJECT ____

PRELIMINARY DISCUSSION

The watershed of the project area southwest of "The Big I" runway intersection generally drains south across the Runway 3-21 alignment to the edge of the escarpment to Tijeras Arroyo. The grades are very flat and under existing conditions almost all of the rain that falls soaks into the surface soils. The proposed development of Runway 3-21 will cause a large increase in paved area and change the surface grades such as to cause concentrations of runoff that must be disposed of.

The soils at the Airport are quite varied both horizontally and vertically. Some soils with high clay content are subject to weakening and/or expansion when saturated. It is therefore essential to direct runoff away from the pavement edges and to avoid having it pond for long periods such that it can saturate the subgrade and migrate subsurface. Most pavement failures at the Airport have been associated with such ponding.

The upper end of the project watershed will not be developed with this project, but is likely to see extensive development in the future; the proposed new air freight building with parking areas, etc., will be built immediately following this project. Draining this area to the west will cause a lot of difficulties in crossing private lands and discharging to inadequate or non-existent existing drainage facilities. It is therefore best to provide for draining as much of the developable area within the airport boundaries as is reasonably

CALCULATED BY JCC DATE 4-12-89	CLIENT ____ PROJECT NO. ____
CHECKED BY ____ DATE ____	PROJECT R/W 3-21, ABQ.
SHEET NO. ____ OF ____	SUBJECT ____

feasible through the stormdrain system designed for this project, and the assumptions used should be fairly conservative since the nature and extent of the eventual full development is not known.

The Aviation Department has requested that the retention ponds currently serving the airport maintenance building and the FAA equipment yard be filled in and the drainage from these areas routed through the project system.

The freight apron should not be ponded except for the head necessary to push the runoff through the grates, but it is desirable to reduce the peak runoff to the outlets by temporarily ponding the runway and taxiway safety areas in a heavy downpour. The freight apron and other paved areas where excessive ponding would be a nuisance or potentially dangerous should therefore have fairly large free-flowing grate openings, and the outlet pipes down to the safety areas should be sized to minimize excessive head losses. The grates should also be designed for heavy duty since they will be exposed to large aircraft and heavy equipment. The Neenah R-3477 extra heavy duty airport inlet frame and grate (or approved equal) appear to be suitable for this use.

The grates in the grassed safety areas will be very much subject to clogging by cut grass and other debris and will not be as readily observable and accessible for the maintenance crews. It is therefore best to provide for ponding the safety areas by restricting the size of the outlet

CALCULATED BY MC-a DATE 4-12-89	CLIENT _____ PROJECT NO. _____
CHECKED BY _____ DATE _____	PROJECT R/W 3-21, ABQ
SHEET NO. _____ OF _____	SUBJECT _____

pipes, but to provide plenty of grate opening area. The Neenah R-3479 airport drainage frame and grate was used for the recent Runway 17-35 reconstruction project such that the Airport already has a number of them installed. This grate is not really an open, free-flowing type, but by making every required manhole location a drop inlet sufficient functioning waterway areas should be available somewhere along the safety area flow lines.

Concentrating the runoff from such large areas at the outlets of outlet lines "A" and "B" will cause erosion and changes in the existing channels below the escarpment. However, the airport property extends for more than half a mile down the hillside and the channels then merely cross under the AT&SF spur to KAFB and then on into the Tijeras Arroyo. Some additional channel work may eventually be necessary if the Tijeras bottom lands are ever developed, but it is probably better to wait and do such work along with the development if indeed it turns out to be necessary at all.

Drainage areas C-1, D-1, and E-1 are existing drainage areas that will be graded out and improved with the new construction. The discharges are to existing stormdrains that will not be materially affected. The areas already pond in heavy storms and will continue to do so.

CALCULATED BY Ps-a DATE 4-12-89	CLIENT ____ PROJECT NO. ____
CHECKED BY ____ DATE ____	PROJECT R/W 3-21, ABQ
SHEET NO. ____ OF ____	SUBJECT ____

The reconstruction of the pavements at the intersections of Taxiways E and G with Runway 3-21 will provide heavy duty access to the existing 20" concrete pavement on Taxiway G south of T/W E. The original construction in this area did not include any provisions for drainage. Water ponds after every rain and has thoroughly saturated and weakened the subgrade.

It is now necessary to protect the new construction by providing drainage facilities. It is reasonable to discharge to the existing outlet channel for the 60" RCP stormdrain from KAFB north of R/W 8-26. However, it is then necessary to intercept the twin 24" RCP stormdrain running along the west bank of the outlet channel and combine the discharge into the outlet channel. The existing drains and the outlet channel all belong to KAFB, and the new facilities should be designed such that KAFB will not incur additional costs for maintenance.

CALCULATED BY *fe-a* DATE 4-12-89	CLIENT _____ PROJECT NO. _____
CHECKED BY _____ DATE _____	PROJECT R/W 3-21, ABQ
SHEET NO. _____ OF _____	SUBJECT _____

STORMDRAIN DESIGN PROCEDURE

FAA AC 150/5320-5B "Airport Drainage" states that a 5-year design storm is generally considered sufficient for airport drainage design. A 10-year, 6hr design storm was selected for this project because the upper ends of the drainage area when fully developed will be more similar to an industrial park area than an airfield. The difference in cost is slight since only a few pipe sizes could be reduced, and the cost of stormdrain construction depends more on length of pipe and depth of cut than on size.

Rainfall depths for the 10- and 100-year, 6hr design storms were determined by following the procedures outlined in FHWA HEC-12 (1985 ed.). Rainfall intensities for the individual basin computations were computed by the City DPM ($I_{100} = (6hr.\ rain) \times 6.84 / T_c^{0.51}$, and $I_{10} = 0.657 \times I_{100}$) [The I/D curves were printed by the HEC-12 procedure, but are only included to show the general shape and relationship of the curves.)

Times of concentration, T_c, were calculated by the formula $T_c = 1.8(1.1-C)\sqrt{L}/\sqrt[3]{S}$ as recommended in AC 150/5320-5B, which allows for the influence of the "C factor" on overland flow times. The equation gives results comparable to the Kirpitch equation for paved surfaces.

Runoff rates were then calculated by the Rational Formula and routed through the system by following the general procedure outlined in the Denver COG Drainage Manual.

CALCULATED BY rfc-a DATE 4-12-89	CLIENT _____ PROJECT NO. _____
CHECKED BY _____ DATE _____	PROJECT R/W 3-21, ABQ.
SHEET NO. _____ OF _____	SUBJECT _____

Pipe sizes on the outlet stems were chosen by taking a reasonable guess at the reduced flowrates (90%) resulting from choking down the pipe sizes to induce minor ponding in the safety areas in a 10-year storm.

Hydraulic grade lines were then calculated using the reduced flowrates in the outlet pipes. The results checked out quite nicely with the HGL's just rising up into the areas intended to pond, but staying at or below the top of grate elevations in areas not desired to pond.

The amount of ponding was then checked by constructing triangular inflow-outflow hydrographs for the major areas of concern and comparing them to storage rating curves for the critical areas.

This again worked out nicely, showing minor ponding for the 10-year storm and confirming that the estimated outflow rates are reasonable.

Inflow-outflow hydrographs constructed for the 100-year, 6hr. storm indicate extensive ponding in the safety areas, but well within the available ponding capacities and without flooding the critical pavement areas of the runway and major taxiways.

(The estimated combined 100-year storage required for drainage sheds A and B is approximately 764,000 ft^3 and approximately 810,000 ft is available in the safety area along the southwest edge of R/W 3-21 by itself at a watersurface elevation of 5305 ft. MSL. Actually, the storage will of course be shared by all the ponding areas.)

CALCULATED BY JC-a DATE 4-12-88	CLIENT ____ PROJECT NO. ____
CHECKED BY ____ DATE ____	PROJECT R/W 3-21, ABQ.
SHEET NO. ____ OF ____	SUBJECT ____

No hydraulic gradeline or ponding calculations were carried out for drainage areas C-1, D-1, and E-1. These areas all discharge to existing storm-drains that appear to be functioning more or less as intended, and the effects, if any, of the proposed new construction on the existing systems down-stream should be negligible. These areas already pond under existing conditions and will continue to do so.

Some runoff will escape overland from drainage area F-4 in a 100-year event, but no damage is likely to occur. The excess water will just spread out to the southeast as it does now for 2 to 5-year storms.

The four 24" CMP culverts along the southwest access road are intended to prevent ponding behind the road embankment. The mesa is very flat and there are no defined drainageways. Flows should be minimal, but do need outlets.

CALCULATED BY JC-a DATE 4-12-89	CLIENT _____ PROJECT NO. _____
CHECKED BY _____ DATE _____	PROJECT R/W 3-21, ABQ
SHEET NO. _____ OF _____	SUBJECT _____

CONCLUSIONS

The drainage calculations carried out for this report are somewhat crude. They could be refined by going through a couple of iterations to make the numbers match up by successive closer approximations. However, doing so would serve little practical purpose. It is not important if the calculated 10-year peak pond levels should be 6" higher in this basin and 6" lower in that.

Such differences would not noticeably affect the functioning of the system, due to the dampening effects of the pond interconnections.

As they are, the calculations serve to show that the airfield pavements will be adequately drained, with provisions for future development in the upstream areas of watersheds A and B, the 100-year storm runoff will not breach the site, and the discharges to the Tijeras Arroyo are restricted to a reasonable level.

STORM DRAINAGE SYSTEM PRELIMINARY DESIGN DATA

RUNWAY 3-21, ABQ
OUTFALL LINE "A"
10-YEAR STORM

Location of Design Point INLET #	Basins	PIPE Length ft.	Inlet Time min.	Flow Time: Street min.	Flow Time: Pipe min.	Time of Concentration min.	Coefficient "C"	Intensity "I" in./hr.	Area "A" acre	Direct Runoff cfs	Other Runoff cfs	Summation Runoff cfs	Street: Slope %	Street: Allowable Capacity cfs	Pipe: Slope %	Pipe: Size in.	Pipe: Capacity cfs	Street: Design cfs	Street: Velocity fps	Pipe: Design cfs	Pipe: Velocity fps	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
18	A-1		5.7			10	0.95	3.26	4.13	12.8	—	12.8			0.30	30"	23.0			12.8	4.6	
		403			1.5																	
17	A-2					10	0.95	3.26	3.79	11.7	-	24.5			0.30	36"	37.5			24.5	5.2	
		400			1.3																	
16	A-3					10	0.80	3.26	6.20	16.2	—	40.7			0.40	36"	42.5			40.7	6.0	
		290			0.8																	
15	1/3(A-5)					10	0.6	3.26	8.90	1/3 5.8	—	46.5			0.30	42"	56.0			46.5	5.8	
		350			1.1																	
14	1/3(A-5)					10.4				1/3 5.8	—	52.3			0.30	42"	56.0			52.3	5.8	
		350			1.0																	
13	1/3(A-5) + A-4					11.4	0.65	3.05	9.41	18.7	1/3 5.8	76.8			0.30	48"	79.0	(76.8 x .9 =)		69.1	6.5	POND SAFETY AREA
		260			0.7																	
5	A-6,7,8					12.1	2.24" @	0.2%	+ #5	21	5	102			0.40	48"	92	(102 x 0.9 =)		91.8	7.3	— " —
		522			1.2																	
2	A-9					13.3	1.24" @	0.2%	+ #2	10.5	5	117.5			0.40	48"	92	(117.5 x 0.9 =)		105.8	8.3	— " —
		250			0.5																	
1	A-10					13.8			- #1		5	122.5			0.40	66"	109	(122.5 x 0.9)		110	4.6	— " —
		250			0.9																	
OUTLET						14.7																

Wright-McLaughlin Engineers

FIGURE 6-1. TYPICAL FORM FOR STORM DRAINAGE SYSTEM PRELIMINARY DESIGN DATA

MOLZEN-CORBIN & Associates
ALBUQUERQUE, N.M.

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: JC-a
DATE: 4-4-89
SHEET: ____ OF ____

PROJECT: RUNWAY 3-21, ABQ
LINE: A (MAIN STEM)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
STATION	STRUCT.	INV.	D	Q	A	V	K	S_F	L	Δ	LOSSES H_F	H_B	H_J	H_{MH}	H_T	$H_{MISC.}$	ΣH_L	E.G.	h_V	H.G.
OUTFALL	92.21																	98.04	0.33	97.71*
			66"	110	23.758	4.63	1679	.0043	250		1.07						1.07	99.11	0.33	98.78
DI #1	92.96													.06	.26		.32	99.43	1.10	98.33
			48"	105.8	12.566	8.42	1436	.0054	250		1.36						1.36	00.79	1.10	99.69
DI #2	93.96												.22	.06			.28	01.07	0.83	00.24
			48"	91.8	12.566	7.31	1436	.0041	522		2.13						2.13	03.20	0.83	02.37
DI #5	96.05												.36	.06			.42	03.62	0.47	03.15
			48"	69.1	12.566	5.50	1436	.0023	260		0.60						0.60	04.22	0.47	03.75
DI #13	96.83									90°		.09	.26	.03			0.38	04.60	0.46	04.14
			42"	52.3	9.621	5.44	1006	.0027	350		0.95						0.95	05.55	0.46	05.09
DI #14	98.38													.02			0.02	05.57	0.36	05.21
			42"	46.5	9.621	4.83	1006	.0021	350		0.75						0.75	06.32	0.36	05.96
DI #15	99.43									63.6°		.09		.03			0.12	06.44	0.51	05.93
			36"	40.7	7.069	5.76	666	.0037	290		1.08						1.08	07.52	0.51	07.01
DI #16	01.09												0.31	.03			0.34	07.86	0.19	07.67
			36"	24.5	7.069	3.47	666	.0014	400		0.54						0.54	08.40	0.19	08.21
DI #17	02.29													.01			.01	08.41	0.11	08.30
			30"	12.8	4.909	2.61	410.1	.0010	403		0.39						0.39	08.80	0.11	08.69
DI #18	04.00																			

REMARKS: * CONTROL (CROWN OF PIPE)

1/44

MOLZEN-CORBIN & Associates
ALBUQUERQUE, N.M.

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: JC-a
DATE: 4-5-89

PROJECT: RUNWAY 3-21 LINE: "A" (BRANCHES) SHEET: ____ OF ____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
STATION	STRUCT.	INV.	D	Q	A	V	K	S_F	L	Δ	LOSSES H_F	H_B	H_J	H_{MH}	H_T	$H_{MISC.}$	ΣH_L	E.G.	h_v	H.G.
D1 #5		00.00																		
																		03.54	0.39	03.15 (1)
			24"	15.7	3.142	5.01	226.2	.0048	401		1.94						1.94			
																		05.48	0.39	05.09
D1 #6		00.80												.02			0.02			
																		05.50	0.23	05.27
			24"	12.1	3.142	3.85	226.2	.0029	360		1.03						1.03			
																		06.53	0.23	06.30
D1 #7		01.52												.01			.01			
																		06.54	0.08	06.46 (2)
			24"	7.1	3.142	2.27	226.2	.0010	360		.36						.36			
																		06.90	0.08	06.82
D1 #8		03.32																		
																		OK		07.78 (2)
D1 #5		96.31																		
																				03.15 (1)
			24"		3.142		226.2		365											
D1 #9		97.02									THIS LINE WILL POND									
																				03.71 (2)
			24"		3.142		226.2		365		UNTIL MAINSTEM HGL									
D1 #10		97.77									DRAWS DOWN.									
																				02.96 (2)
			24"		3.142		226.2		364											
D1 #11		98.50																		
																		03.62	0.12	03.50 (3)
			24"	8.6	3.142	2.74	226.2	.0014	368		.53						.53			
D1 #12		02.90																04.15	0.12	04.03
																				07.00 (3)
D1 #2		97.50																		
																		00.56	0.32	00.24 (1)
			24"	14.2	3.142	4.53	226.2	.0040	375		1.49						1.49			
D1 #3		98.25												.02			.02	02.05	0.32	01.73
																		02.07	0.32	01.75
			24"	14.2	3.142	4.52	226.2	.0039	375		1.48						1.48			
D1 #4		99.00																03.55	0.32	03.23
																		OK		03.23 (2)

REMARKS: 1) CONTROL (FROM MAIN STEM HGL.)
2) — " — (TOP OF GRATE)
3 — " — (ASSUMED POND LEVEL)

18/24

STORM DRAINAGE SYSTEM PRELIMINARY DESIGN DATA

RUNWAY 3-21, ABQ.
OUTFALL LINE "B"
10-YEAR STORM

Location of Design Point INLET #	Basins	PIPE Length ft.	Inlet Time min.	Flow Time: Street min.	Flow Time: Pipe min.	Time of Concentration min.	Coefficient "C"	Intensity "I" in./hr.	Area "A" acre	Direct Runoff cfs	Other Runoff cfs	Summation Runoff cfs	Street: Slope %	Street: Allowable Capacity cfs	Pipe: Slope %	Pipe: Size in.	Pipe: Capacity cfs	Street: Design cfs	Street: Velocity fps	Pipe: Design cfs	Pipe: Velocity fps	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
41	B-1		10			10	0.80	3.26	13.0	33.9	—	33.9										PONDING REQ'D FOR FUT. DEV.
		340			0.9										0.20	30"	18.8			18.8	3.8	
40	B-2		15.2			15.2	0.80	2.64	13.5	28.5	—	62.4										
		518		—	1.3										0.40	42"	63			47.3	6.6	
38	—					12.2				—	—	62.4										—
		300			1.0										0.20	48"	65			62.4	5.1	
35	B-3		29			13.2	1-24" @ 0.2%	+ 2.35		10.5	5	77.9										
		429			1.1										0.30	42"	80			77.9	6.4	
29			—			14.3		2.72														
31	B-4		5.7			10	0.95	3.26	4.0	12.4	—	12.4										
		334			0.9										0.80	24"	20.5			12.4	6.4	
30	B-5					10	0.95	3.26	2.78	8.6	-	21.0										
		344			0.8										1.10	24"	24.0			21.0	7.4	
29						10		3.26														
29	B-6					12.9	1-24" @ 0.2%	+ 2.29		15.5	100.3	115.8										
		644			1.6										0.30	54"	108	(115.8	x 0.9=)	104.2	6.8	POND IN SAFETY AREAS
22	B-7					14.5	1-24" @ 0.2%	+ 2.22		17.5	5	131.3										
		300'			0.6										0.40	54"	127	(131.3	x 0.9=)	118.2	8.0	
21	B-8					15.1	0.3	2.64	4.0	3.2	—	134.5										
		400			0.8										0.40	54"	127	(134.5	x 0.9=)	121.1	8.0	
20						15.9																
	—	250			0.9										0.40	72"	138	(134.5	x 0.9=)	121.1	4.7	
OUTLET						16.8																
73	F-1		26			26	0.65	2.00	5.2	6.8		6.8										
		232'			3.0										0.20	24"	10.5			4	1.3	
72	F-2					10	0.95	3.26	3.7	9.9		16.7										F-2 IS MORE CRITICAL
		357			2.7										0.20	24"	10.5			7	2.2	
71	F-3					12.7	0.65	2.89	4.9	9.2		25.9										PONDING IN ALL SAFETY
		187			1.0										0.20	24"	10.5			10	3.2	AREAS
70	F-4					13.7	0.65	2.78	2.3	4.2		30.1										
		589			2.2										0.20	24"	10.5			14	4.5	
OUTLET						15.9																

Wright-McLaughlin Engineers

FIGURE 6-1. TYPICAL FORM FOR STORM DRAINAGE SYSTEM PRELIMINARY DESIGN DATA

MOLZEN-CORBIN & Associates

ALBUQUERQUE, N.M.

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: JC-a

DATE: 4-6-89

PROJECT: RUNWAY 3-21, ABQ

LINE: "B" (MAINSTEM)

SHEET: ____ OF ____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
											LOSSES									
STATION	STRUCT.	INV.	D	Q	A	V	K	S_F	L	Δ	H_F	H_B	H_J	H_{MH}	H_T	$H_{MISC.}$	ΣH_L	E.G.	h_v	H.G.
OUTLET		89.50																95.78	0.28	95.50
			72"	121.1	28.274	4.28	2039	.0035	250		0.88						.88	96.66	0.28	96.38
DI #20		90.25												.05	.15		.20	96.86	0.90	95.96
			54"	121.1	15.904	7.61	1967	.0038	400		1.52						1.52	98.38	0.90	97.48
DI #21		91.85												.05			.05	98.43	0.86	97.57
			54"	118.2	15.904	7.43	1967	.0036	300		1.08						1.08	99.51	0.86	98.65
DI #22		93.05											-.12	.05			.17	99.68	0.67	99.01
			54"	104.2	15.904	6.55	1967	.0028	644		1.81						1.81	01.49	0.67	00.82
DI #29		94.98											.31	.03	.05		0.39	01.88	0.60	01.28
			48"	77.9	12.566	6.20	1436	.0029	429		1.26						1.26	03.14	0.60	02.54
DI #35		96.77										.10	-.05	.03			.08	03.22	0.38	02.84
			48"	62.4	12.566	4.97	1436	.0019	300		0.57						.57	03.79	0.38	03.41
DI #38		97.37										.04		.02			.06	03.85	0.38	03.47
			42"	47.3	9.621	4.92	1006	.0022	3.18		0.70						.70	04.55	0.38	04.17
DI #39		99.14										.05		.02			.07	04.62	0.38	04.24
			42"	47.3	9.621	4.92	1006	.0022	200		0.44						.44	05.06	0.38	04.68
DI #40		99.94										.05	.12	.02			.19	05.25	0.23	05.02
			30"	18.8	4.909	3.83	410.1	.0021	340		0.71						.71	05.96	0.23	05.73
DI #41		01.62																		

REMARKS:

27/45

MOLZEN-CORBIN & Associates

ALBUQUERQUE, N.M.

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: JCa

DATE: 4-7-89

PROJECT: RUNWAY 3-21, ABQ

LINE: "B" (BRANCH DI #23-28)

SHEET: ____ OF ____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
STATION	STRUCT.	INV.	D	Q	A	V	K	S_F	L	Δ	LOSSES H_F	H_B	H_J	H_{MH}	H_T	$H_{MISC.}$	ΣH_L	E.G.	h_V	H.G.
DI #22		95.00																		
			24"	14.4	3.142	4.58	226.2	.0041	375		1.52						1.52	99.33	0.32	99.01 1
DI #23		95.75																00.85	0.32	00.83
			24"	5.5	3.142	1.74	226.2	.0006	375					.02			.02	00.87	.05	00.82 1
DI #24		96.50									.22						.22	01.09	.05	01.04
			24"	7.8	3.142	2.47	226.2	.0012	375					—			—	01.09	.05	01.04 1
DI #25		97.25									.44						.44	01.53	.09	01.44
			24"	9.1	3.142	2.88	226.2	.0016	375					—			—	01.53	.09	01.44 1
DI #26		98.00									.60						.60	02.13	.13	02.00
			24"	8.3	3.142	2.63	226.2	.0013	375					—			—	02.13	.13	02.00 2
DI #27		98.75									.50						.50	02.63	.11	02.52
			24"	9.6	3.142	3.07	226.2	.0018	375					—			—	02.63	.11	02.52 2
DI #28		99.50									.68						.68	03.31	.14	03.17
														—			—	03.31	.14	03.17 2

REMARKS: 1) CONTROL (FROM MAINSTEM HGL)
2) — " — (TOP OF GRATE)

NOTE: LOW POINT OF SAFETY AREA OCCURS APPROX. @ DI #23
PONDING WILL OCCUR IN THIS AREA UNTIL THE
MAINSTEM DRAINS OUT.

28/46

MOLZEN-CORBIN & Associates

ALBUQUERQUE, N.M.

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: JPC-a

DATE: 4-10-89

PROJECT: RUNWAY 3-21

LINE: "B" (BRANCHES)

SHEET: ____ OF ____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
STATION	STRUCT.	INV.	D	Q	A	V	K	S_F	L	Δ	LOSSES H_F	H_B	H_J	H_{MH}	H_T	$H_{MISC.}$	ΣH_L	E.G.	h_v	H.G.
D1 #29		96.00																		
			24"		3.142		226.2		375'		PONDING WILL OCCUR									01.28 (1)
D1 #32		96.65									IN THIS AREA UNTIL THE									
			24"		3.142		226.2		375'		MAINSTEM HGL DRAWS									01.03 (2)
D1 #33		97.40									DOWN.									
			24"		3.142		226.2		375'											01.42 (2)
D1 #34		98.15																		
																				01.97 (2)
D1 #29		98.04																		
			24"	12.4	3.142	3.95	226.2	.0030	344'		1.03						1.03	01.52	0.24	D1.28 (1)
D1 #30		01.83								63°		.04		.01			.05	02.55	0.24	02.31
			24"	21.0	3.142	6.68	226.2	.0086	334'		2.88						2.88	02.60	0.69	01.91
D1 #31		04.50									PIPE NOT FULL							05.48	0.69	04.79
					2/3 of 14.2 (Top of gates level)															
D1 #35		98.70																		
			24"	9.5	3.142	3.02	226.2	.0018	325'		0.57						0.57	02.98	0.14	02.84
D1 #36		99.35												—			—	03.55	0.14	03.41
			24"	4.7	3.142	1.50	226.2	.0004	325'		0.14						0.14	03.55	.03	03.52
D1 #37		00.00																03.69	.03	03.66
																		OK		04.00

REMARKS: 1/ CONTROL (FROM MAINSTEM HGL)

2/ CONTROL (TOP OF GRATE)

29/42

MOLZEN-CORBIN & Associates

ALBUQUERQUE, N.M.

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: JCa

DATE: 4-10-89

PROJECT: R/W 3-21, ABQ

LINE: "F"

SHEET: ____ OF ____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
STATION	STRUCT.	INV.	D	Q	A	V	K	S_F	L	Δ	LOSSES H_F	H_B	H_J	H_{MH}	H_T	$H_{MISC.}$	ΣH_L	E.G.	h_V	H.G.
OUTLET	END SECTION	05.44																09.13	.19	08.94 (1)
			42"	34	9.621	3.53	1006	.0011	28'		.03						.03	09.16	.19	08.97
J-BOX		05.50										.04	.28	.01	.01		.34	09.50	.31	09.19
			24"	14	3.142	4.46	226.2	.0038	590		2.26			.02			2.28	11.78	.31	11.47
DI #70		06.70								75°		.06		.01			.07	11.85	.16	11.69
			24"	10	3.142	3.18	226.2	.0020	187		.37						.37	12.22	.16	12.06
DI #71		07.17								90°		.03		-			.03	12.25	.08	12.17
			24"	7	3.142	2.22	226.2	.0010	357		.34						.34	12.59	.08	12.51
DI #72		07.99								60°		.01		—			.01	12.60	.03	12.57
			24"	4	3.142	1.27	226.2	.0003	232		.07						.07	12.67	.03	12.64
DI #73		08.55																		

REMARKS: (1) CONTROL

38/AC

City of Albuquerque
P.O. BOX 1293 ALBUQUERQUE, NEW MEXICO 87103

January 18, 1995

Mark Holstad
Greiner, Inc.
5971 Jefferson NE
Albuquerque, NM 87109

RE: AIA RUNWAY 3-21 RECONSTRUCTION ~~(N16-D9)~~ M-16/D024E ENGINEER'S STAMP DATED DECEMBER 22, 1994.

Dear Mr. Holstad:

The Design Analysis Report received Dec. 27, 1994 is approved. If you have any questions, please call me at 768-2654.

Sincerely,

Carlos Montoya, P.E.
PWD/Hydrology

CM/dl

c: Andrew Garcia
File

DESIGN ANALYSIS REPORT

CITY OF ALBUQUERQUE
AVIATION DEPARTMENT
RECONSTRUCT/LENGTHEN RUNWAY 3-21
CITY PROJECT NO. 4589

DECEMBER 1994

Prepared for:

CITY OF ALBUQUERQUE, AVIATION DEPARTMENT
ALBUQUERQUE, NEW MEXICO

Prepared by:

Greiner, Inc.
5971 Jefferson Boulevard, NE, Suite 101
Albuquerque, New Mexico 87109
(505) 345-3999

Mark S. Holstad, P.E.
Greiner, Drainage Engineer

MARK S. HOLSTAD
NEW MEXICO
No. 7288
REGISTERED PROFESSIONAL ENGINEER

12-22-94

Greiner Job. No. E028622
A.I.P No. 3-35-0003-LOI

RECEIVED
DEC 27 1994
DIVISION

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REPORT EXHIBITS/FIGURES

Exhibit I	Basin Map and Proposed Drainage Improvements - Ultimate Condition
Exhibit II	Basin Map and Proposed Drainage Improvements - Interim Condition
Exhibit III	Proposed Drainage System (Bound in Pocket)
Exhibit IV	AHYMO Flowchart (Bound in Pocket)
Figure 1	Typical Culvert Crossing

APPENDICES

A. Hydrology Calculations

B. Hydraulic Calculations

C. AHYMO Summaries

D. Outlet Baffle Chute by Richard Heggen

E. Plan and Profile Sheets

ENCLOSURES

- Disk of Input/Output Files (Bound in Pocket)

PLANS-BOUND SEPARATELY

Albuquerque International Airport
Reconstruct and Lengthen Runway 3-21 (half-size)

EXECUTIVE SUMMARY

A/E Job # 4589-01 between the City of Albuquerque and Greiner, Inc., provides for the design of the Reconstruction and Lengthening of Runway 3-21 at Albuquerque International Airport (ABQ). This study evaluates the necessary drainage improvements and proposes specific improvements. A system of pipes and inlets is proposed in the airfield area, which is collected and discharged to the Tijeras Arroyo.

RELATED STUDIES AND DESIGN GUIDANCE

A. DRAINAGE MASTER PLAN

Molzen-Corbin & Associates is currently preparing a Drainage Master Plan for ABQ. A draft Master Plan for review was submitted to the Aviation Department in June 1994. Greiner has received a copy of this Master Plan and has reviewed it. In June, 1993, Molzen-Corbin provided copies of the Master Plan hydrologic modeling to that date. Greiner used this model and modified it in accordance with the proposed design of Runway 3-21. We met with Molzen-Corbin staff and have received the following basic criteria specific to the Runway 3-21 project:

1. Due to problems in the existing drainage systems, diversions to the new system should be provided.

2. All flow from the new system should be collected and discharged via a single outlet to the Tijeras Arroyo.

The recommendations and procedures of the Master Plan have been generally followed. Significant variations have been verbally communicated to Molzen-Corbin. These variations are:

1. The internal Runway 3-21 drainage system was revised to delay construction of a costly line needed in the future.

2. Basins 507 and 706 (see Exhibit I) were routed into the Runway 3-21 system. This is accordance with the Master Plan goal stated above that the maximum flow possible be rerouted from the overloaded existing systems draining to the west.

3. The draft Master Plan still includes a detention pond which has been replaced by an outfall pipe and outlet structure to the Tijeras Arroyo.

B. TIJERAS ARROYO

The Tijeras Arroyo Drainage Management Plan, Phase II, August 1990 by Leedshill-Herkenhoff, Inc., provides design concepts as well as hydrologic data that were useful in the design of the outfall structure.

The proposed outfall is on land owned by Open Space. The Open Space Advisory Board approved this on May 24. The Environmental Planning Commission (EPC) reviewed this in July and site plan was approved by the Development and Review Board (DRB) on December 1, 1994 (DRB 94-409, case number SPR-94-8).

C. DESIGN CRITERIA

The requirements of FAA AC 150/5320-5B are met.

Hydrology and hydraulics are in accordance with City of Albuquerque criteria.

REROUTING OF FLOWS

Rerouting of some flows will be accomplished under this project. The two purposes of this rerouting are:

A. The existing systems that drain to the west across University Boulevard are overloaded. Rerouting of flows in and north of the General Aviation Area to the new system will reduce the flow to the west.

B. Three existing pipes outlet to the southeast of Runway 3-21 and are causing erosion. These flows will be collected into a single outlet pipe to the Tijeras Arroyo.

HYDROLOGY

A. GENERAL

Procedures and methods are in accordance with the January, 1993 update of Section 22.2 of the Development Process Manual.

B. COMPUTER MODEL

AHYMO is the computer model used for hydrologic analysis in the Albuquerque area. Substantial efforts were recently expended in developing this model to the acceptance of FEMA. It has received the endorsement of the local governments as well as FEMA. The January, 1994 version of the model was used in this analysis.

C. SEDIMENT BULKING

A 2% sediment bulking factor is used based on a Modified Universal Soil Loss Equation (MUSLE) (analysis attached in Appendix A).

D. HYDROLOGY RESULTS

The AHYMO Summary Tables for the 10 year and 100 year conditions are attached in Appendix C.

DRAINAGE SYSTEM AND HYDRAULICS

A. GENERAL

A system of inlets, pipes, ponds in infield areas and an outfall to the Tijeras Arroyo are proposed to drain the Runway 3-21 area. This system is sized for the 10 year storm and checked to confirm that the 100 year storm is contained.

B. AIRFIELD - 10 YEAR STORM

Inlets and pipes are sized to drain a 10 year storm at a minimum. The inlets are sized to require a minimal amount of ponding within the safety area. Ponding within the safety area was limited to a maximum depth of 0.5 to 1.0 foot. The pipes operate within a non-pressure to a slight surcharge condition. The HGL is below the inlet grates and therefore does not limit drainage from any basins under a 10 year storm.

Grate safety factors of 1.25 for paved areas and 2.0 for non-paved areas were utilized in accordance with Figure 25 of FAA AC 150/5320-5B.

A small area at the south end of Runway 3-21 drains off-site. This is addressed in Section F below.

C. AIRFIELD - 100 YEAR STORM

The greater runoff from the 100 year storm results in greater ponding depths and greater flow through the inlets. This increased flow rate raises the hydraulic grade line (HGL) along the pipe. Where the HGL is below the elevation of the inlet grate, the pipe capacity does not limit inlet drainage and the basin drains as quickly as the grates will permit. The robust ponding volume provided in the typical infield area easily contains the additional storage required under this circumstance.

In many basins, the HGL will rise above the grate elevation. The inlet capacity, at a given depth, is reduced within a specific basin when the HGL rises above the inlet grate. At the same time, the rising HGL increases the friction slope available and will cause more discharge through a given pipe.

The HGL analysis of a 100 year storm is quite complicated for a system sized for a 10 year storm. If it can be proven that the 100 year storm is contained within the limits of ABQ and flow does not discharge out of basin, than a precise HGL is not required. The following methods were used:

South Branch. This system consists of SD-13, SD-15, SD-16, and SD-23. The system will discharge no less than a 10 year storm. Therefore, an AHYMO run was made using the 100 year storm rainfall but conservatively limiting the inlet capacities to the outflow rates developed in AHYMO for the 10 year storm. This assured that the pipe flow rates were equal to that of the 10 year storm. AHYMO provides a storage volume under this analysis. We have defined this as $V_{100\text{-}10}$ since it is the storage volume for the 100 year storm while releasing inlet and pipe flows equal to those experienced under the 10 year storm.

The lowest overflow point in the South Branch is 5297.0 at Basin 1116 (except SD-23, see below). A conservative approach is to compare the storage volume within the South Branch below elevation 5297.0 to $V_{100\text{-}10}$ (see Table 1). The total $V_{100\text{-}10}$ (12.51) of the South Branch is less than the available volume (15.20) therefore the 100 year storm is contained.

Existing flows in Basin 1113 drain directly over the escarpment and are not controlled. Basin 1113 is proposed to drain through SD-23. The overflow from Basin 1113 is 5293.50. Therefore runoff would flow from SD-13 through SD-1113 and would spill out of basin if not controlled. A flap gate is provided at the junction box at Station 34+63.49, SD 23 to prevent

backflow during surcharge conditions in SD-13. A storage volume well in excess of the full 100 year runoff volume is provided in Basin 1113. The runoff will be stored in Basin 1113 until flow decreases in SD-13 and Basin 1113 will then quickly drain.

North Branch. The North Branch is considerably more difficult to analyze. This system consists of SD-2 and upstream contributing pipes. The lower portion is capable of draining flows well in excess of a full 100 year storm, without the HGL rising above the inlet grates. This portion of the system will therefore drain as quickly as the inlets permit and will not be constrained by pipe capacity. At some point, however, the HGL will rise above the inlet elevation and limit drainage from the basin. A similar analysis to that used for the South Basin, showed that adequate storage volume exists to contain the $V_{100\text{-}10}$ within the North Branch system.

However, the overflow elevation out of the North Branch is at the southwest corner of Basin 706 which is the future De-Icing area. Basin 706 is completely impervious with a small volume for ponding. Unlike other basins, the 100 year runoff from Basin 706 must be immediately removed from the basin by the pipe system. If not, the excess will flow out of the basin to the southwest. The minimal ponding available in Basin 706 attenuates the Q_{100} from 95 cfs to 88 cfs. The $V_{100\text{-}10}$ (storage volume required in a basin for a 100 year storm where the outflow is limited to the peak 10 year outflow) for Basin 706 is 0.72 AF while the V_{100} is 3.46 AF. At a minimum, the 88 cfs must drain as far as Basin 729 and the HGL must be 5303.65 or lower at Basin 729 (see Station 49+77.83 of the 100 year HGL for SD-4). The next downstream basin is 709. If the HGL is 5302.13 or lower, (see Station 43+70.80 of the 100 year HGL for SD-4), the Q_{10} from Basins 706 and 729 will flow to and through SD-3 and have free discharge. If, on the other hand, the HGL is greater than 5303.65, flow draining through the upper portion of SD-3 could actually backflow into Basin 729 and occupy the storage, preventing the required drainage from Basin 706. This would result in overflow to the southwest out of basin 706 under a 100 year storm and is not acceptable.

Downstream analysis showed that the HGL at the tie in of SD 4 to SD 3 in Basin 709 will be greater than 5302.13 but less than 5302.61 (for purposes of this analysis, we have assumed the HGL = 5302.61 shown at Station 90+36 of the 100 year HGL for SD-3). This means that the full Q_{100} from Basin 706 will drain to Basin 729 but less than the full Q_{100} will drain immediately to Basin 709. No flow will backflow from SD-3 to Basin 729. The total 100 year volume for basins 706 and 729 is 4.30 as shown in

TABLE 1 - SOUTH BRANCH BASINS
AVAILABLE STORAGE VOLUME (AF)

Elevation	Basin	1103	1104	1107	1108	1116	1102	1109	1110A	TOTAL EXCLUDING 1113 & 1114	1113	1114
	5293	-	-	-	-	-	***	***	-	-	5.5901	0.2686
	5294	-	-	-	.1174	0.0218	-	-	-	0.1392	****	0.4901
	5295	-	-	-	.6282	0.4838	-	-	0.0195	1.1315	-	****
	5296	-	-	-	2.0400	1.9196	-	-	0.1244	4.0840	-	-
	5297	-	0.2084	-	3.9100	4.3943	-	-	0.3691	8.8818	-	-
	5298	-	0.9752	-	****	****	-	-	****	0.9752	-	-
	5299	-	****	-	-	-	-	-	-	-	-	-
	5300	-	-	0.0612	-	-	-	-	-	0.0612	-	-
	5301	-	-	0.5835	-	-	-	-	-	0.5835	-	-
	5302	.1002	-	****	-	-	-	-	-	0.1002	-	-
	5303	.4619	-	-	-	-	-	-	-	0.4619	-	-
									Total	16.4185		
* 100 yr. Volume (AF)		1.605	1.743	2.118	1.452	0.739	3.024	0.799	0.318	11.798	2.76	2.085
** V_{100-10} (AF)		0.340	0.572	0.424	0.416	0.309	0.721	0.221	0.056	3.059	2.580	-

* Total 100 year volume generated within the basin.

** Volumes calculated by AHYMO where the 100 year storm was generated, then outflow from the basin was limited to the maximum outflow released in the 10 year AHYMO analysis.

*** Storage begins above elevation 5303

**** Ponding at this depth will be contained on the ABQ property but will flood a runway or taxiway, 100 year ponding is less than this depth.

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TABLE 2 - PORTION OF NORTH BRANCH BASINS AVAILABLE STORAGE VOLUME (AF)

Elevation	Basin	705	704	703	507	605	609	604	606	610	706	729	
	5298	-	-	-	-	-	-	-	-	-	-	.0941	
	5299	-	-	-	-	-	-	-	-	-	-	.5955	
	5300	-	-	-	-	-	-	-	-		-	1.4646	
	5301	-	-	-	-	-	-	.0154	-	-	-	2.5572	
	5302	-	-	-	-	-	-	.4097	-	-	-	3.7511	
	5303	-	-	-	-	-	-	1.3170	-	-	-	5.0470	
	5304	-	-	-	.0001	-	.0001	2.8173	-	-	-	6.4470	
	5305	-	-	.0773	.3772	-	.5109	5.0512	.0935	.0124	-	7.9585	
	5306	-	-	.9185	1.6978	.4913	2.7572	***	1.2564	.2041	.2997	9.5874	
	5307	.0109	.6993	***	***	3.0855	***	-	4.1706	.7826	***	***	
	5308	.8393	2.6805	-	-	***	-	-	9.3353	***	-	-	
													Total
* 100 yr. Volume (AF)		1.64	0.931	1.87	1.52	2.34	2.27	2.76	2.75	1.13	3.46	0.84	21.51
** V_{100-10} (AF)		0.718	0.391	0.830	0.568	0.985	0.465	1.016	1.0531	0.4693	0.4729	0.2613	7.23

* Total 100 year volume generated within the basin.

** Volumes calculated by AHYMO where the 100 year storm was generated, then outflow from the basin was limited to the maximum outflow released in the 10 year AHYMO analysis.

*** Ponding at this depth will be contained on the ABQ property but will flood a runway or taxiway, 100 year ponding is less than this depth.

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Table 2. Conservatively a volume greater than 4.3 AF was therefore provided below elevation 5303 at Basin 729. This will permit full drainage of the Q_{100} from Basin 706 to Basin 729, at which point adequate storage is provided for the full V_{100}. The peak flow in SD-3 occurs at approximately 1.67 hours into the 100 year storm, after which time Basin 729 will quickly drain.

A 100 year HGL is shown for the north branch and is based on a Q_{100} flow which was developed by iteration. The following criteria must be met:

1) The flow rates from a particular basin will be determined by the grate capacity, if the HGL is below the top of grate.
2) If the HGL is above the top of grate, the flow from basin will be reduced, possibly to zero. In some cases, backflow from an adjacent basin may occur.

The goal of this analysis is to come to a conservative approximation of the actual flows experienced under a 100 year storm and to prove that flows do not escape from ABQ but are contained and released in a controlled manner. Further iterations will more closely approximate the actual conditions but are unnecessary once this proof is made. The following are identified as conservative assumptions and/or approaches:

1) Higher flows in SD-2 and SD-3 will result in a higher HGL at the junction with SD-4. This is the linchpin of the analysis, as this could cause backflow into Basin 729 and cause out of basin flow from Basin 709. Therefore, assumptions resulting in higher flows in SD-2 and SD-3 are conservative. The highest possible flows from SD-6, SD-7, SD-22, SD-8, SD-10, SD-11, SD-9, and SD-3 upstream of the junction with SD-4 are assumed.
2) At peak flow, no run off from Basin 729 under Q_{100} drains to SD-3, therefore Basin 729 accepts full Q_{100} and V_{100} from Basin 706.

A minimum HGL of 5202.61 is determined for SD-3 at the junction of SD-4. The resultant upstream HGL at the end of SD-3 at the SD-10 junction is 5305.09, which restricts flow from Basins 604, 609, 605, 507, 703, 606, and 610.

As shown in Table 2, a $V_{100\text{-}10}$ of 6.50 AF in basins 705, 704, 703, 507, 605, 609, 604, 606 and 610 will provide the required storage to limit the discharge to that experienced in the 10 year storm. Further refinements are possible with additional analyses but are not necessary to prove that the system functions adequately.

See Appendix D for the calculations and Tables generated in the 100 year analysis.

D. OUTFALL FROM THE AIRFIELD TO THE TIJERAS ARROYO

Outfall to the Tijeras Arroyo is contained within a pipe due to serious erosion caused by overland flow from the existing facilities. The outfall pipe crosses an unused existing railroad spur.

The outfall is sequentially downsized to minimize pipe size and cost while taking advantage of slopes up to 5.3%. The hydraulic calculations for this downsizing are per the procedure in the DPM and are contained in the Appendix.

E. DISCHARGE TO THE TIJERAS

Discharge from the outfall pipe to the Tijeras Arroyo will involve an apron followed by a baffle block drop structure. Following the baffle block drop structure is a scour hole with a concrete bottom and Reno mattress sides. The outlet channel to the Tijeras Arroyo is then via a channel with an earth bottom and rip-rapped sides. Considerations in this selection are:

1. The baffle block structure is recommended by Leedshill-Herkenhoff in the Tijeras Arroyo Drainage Management Plan, Phase II.

2. The Tijeras Arroyo is an unlined natural channel, subject to changes in the elevation and location of the thalweg. The baffle block structure and scour hole allows significant variation in the Arroyo elevation.

3. Flow from the pipe is supercritical under design conditions, requiring energy dissipation to protect the outlet facilities.

4. The structure will be submerged by flow in the Tijeras Arroyo under flood conditions. This could result in scour conditions requiring protection.

5. The Tijeras Arroyo will move laterally if not constrained, threatening the structures.

The outfall is based on a physical model by the University of New Mexico. The report by the University of New Mexico is attached.

The flow from the outfall will contain relatively little sediment. Therefore, some scour in the Tijeras Arroyo is anticipated downstream of the outfall. This scour should not be significant because regular flood events in the Tijeras should periodically fill the scour hole.

The north side of the Arroyo is controlled by gabion structures at the outfall.

F. SOUTH END OF RUNWAY 3-21

The southern portion of the proposed Runway 3-21 extension will be lower than the existing ground in order to balance required earthwork. Because of this lower grade, a portion of the southern airfield between the runway/ taxiway extensions and the service road that loops around it cannot gravity drain to the remaining proposed airfield drainage system.

All of the runoff produced in this area is discharged through pipe culverts which cross underneath and perpendicular or slightly skewed to the service road. They are located at natural drainage ways and follow the existing drainage pattern as closely as possible. Basins 1110, 1112, and 1113 were sub-divided based on the culvert locations as shown in Exhibit I.

Drainage flows away from the extended runway and collects into a drainage swale running along the interior of the roadway alignment. Culverts are inlet controlled, with inlet collection points spaced along the flow line of the swale. If the inlet is not in a low point, a berm is placed at the downstream end of the culvert to collect runoff and maximize the flow entering each pipe. A typical culvert crossing section is illustrated in Figure 1. This shows the typical swale and inlet and outlet treatments.

Because of the tremendous fill required for the road, there are significant vertical drops between the inlet and outlet elevations. Slopes of the culverts at these crossings are on the order of 10%, and generate high velocities. In order to diminish the impacts of erosion, a standard stilling basin with gabion mattress is required at the outlet of each culvert as shown in the typical crossing detail.

Culverts are sized to match as closely as possible the existing 100 year flow. The culvert will restrict the outflow and water will pond either behind a berm or in a sump area. Culverts consist of 12" or 18" pipes.

The 100-year flow will be handled by the culverts with infield ponding. This ponding will be clear of the runway extension and roadway surfaces.

G. INTERIM CONDITION

Analysis was done for fully developed conditions. Sometime in the future the Airport plans to build an air freight area and taxiway within Basins 611 to 616, 901 and 907 (See Exhibit I). A future SD is planned to tie in to SD2.

In the interim, flow will be picked up as shown on Exhibit II in basins 608E and 901E. Runoff is delivered to an existing 24" storm drain also tying into SD2. The existing 24" line will be removed ultimately.

CONCLUSION

The "Reconstruct And Lengthen Runway 3-21" project will be a significant improvement to the Albuquerque International Airport (ABQ). Drainage improvements will be constructed to support this facility. Improvements to existing drainage conditions will be noted by off-site property owners as a result of this project. Flow from the existing overloaded systems draining to the west will be diverted to the new Runway 3-21 system. Multiple outlet pipes which drain south from Runway 3-21 will be collected to a single outfall to the Tijeras Arroyo. An energy dissipation structure will limit impact to the Tijeras Arroyo.

The proposed system meets City of Albuquerque and FAA criteria. A 10 year storm will be controlled with minimal ponding in the safety and paved areas. The collection and outfall system is designed for the 10 year storm. The increase in flow for a 100 year storm can be contained within the infield ponding areas without spilling over adjacent runways or taxiways.

Greiner

Job E028622 Computed By MSH Date 6-8-94
Description Ruy 3/21 Checked By BMD Date 6-8-94
Sediment Yield Sheet 1 of 4

Problem
Evaluate sediment bulking factor applicable to the Ruy 3/21 system.

Assumptions
MUSLE equation.

Procedures per the "Sedimentation and Erosion Design Guide", 3/94, RCE/AMAFCA.

10 year storm
- this is the critical storm for which inlets & pipes are sized.
- 100 year storm will pond in the large infield areas.

Greiner

Job E0028622 Computed By MSH Date 6-8-94
Description Checked By BMO Date 6-8-94
Sediment Yield Sheet 2 of 4

Analysis

$Y_s = \alpha (V q_p)^{\beta} K L S C P$ eqn (2.1)

where

Y_s = sediment yield for storm in tons
K = soil erodibility factor
LS = topographic factor representing combination of slope length and slope gradient
C = cover and management factor
P = erosion control practice factor
V = runoff volume for storm in Ac-ft
q_p = peak discharge in cfs
α = calibration factor
β = " "

Use eqn (2.2)

$\Rightarrow Y_s = 2.5 (V q_p)^{0.56} K L S C P$

several test holes were taken along Ray 3/21. Typically listed as Clayey-sand and sand by the Unified method. From Fig. B.1 and Table B.1

$\Rightarrow K = 0.17$ FINE SAND TABLE B.1

$C = 0.20$ from Table B.2.
20% Ground Cover / Grassy

Greiner

Job E028622 Computed By MSH Date 6-8-94
Description Sediment Yield Checked By PDMW Date 6-8-94
Sheet 3 of 4

$$LS = \left(\frac{\lambda}{72.6}\right)^{n} (0.065 + 0.0454 s + 0.0065 s^2)$$

(equation B.3)

Use $n = 0.3$
$\lambda = 190'$
$s = 3\%$

$$\Rightarrow LS = \left(\frac{190}{72.6}\right)^{0.3} \left[0.065 + 0.0454(3.0) + 0.0065(3.0)^2\right]$$

$$= 1.335 \times 0.2597 = 0.345$$

$P = 1.0$

Use Basin 107 as typical with maximum unpaved %.

From AHYMO
$V = 1{,}210$ AcFt
$q_p = 3402$ cfs

$$Y_s = 285[(1{,}210)3402]^{0.56}(0.17)(0.345)(0.20)1.0$$

$$= 26.8 \text{ tons} \times \frac{1\,CF}{110\#} \times \frac{2000\#}{ton} \times \frac{1\,CY}{27\,CF} = 18.1\,CY$$

$$BF = \frac{18.1\ CY}{1{,}210\ AcFt} \times \frac{1\ AcFt}{43{,}560\ CF} \times \frac{27\ CF}{1\ CY} = 0.0092$$

$= 0.92\%$

Greiner

Job E078622 Computed By MSH Date 6-8-94
Description Ray 3/21 Checked By BMMD Date 6-8-94
Sediment Yield Sheet 4 of 4

This analysis ignores the steeper sections of up to 4:1 (25%). On the other hand, typical slopes are 2% for the safety areas, rather than the 3% assumed. Also, the longitudinal slope in the non-safety areas is 0.5% to 1.0% typ.

⇒ Assume 2% Bulking Factor ✓

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 10-YEAR

LINE: SD 2 - 270 building

BY: [illegible]

DATE: 29 June 94

SHEET: 1 OF:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_i	h_{misc}	Σ	E.G.	h_v	H.G.
59+70.01 48+92.42	J-Box																				
		96"	608					370.0													
52+62.42	MH																				
		96"	608	50.266	12.10	9120	.0014	371.74													
56+34.60	J-Box		269											1.71				1.71	88.58	2.27	86.29
		90"	338	44.179	7.65	7677	.0019	299.84				0.57						.57	90.27	0.91	89.36
59+34.00	MH Junction									24"	45°				.06	.29		.35	90.84	0.91	89.93
		84	338	38.485	8.78	6399	.0023	600.03				1.69						1.68	91.19	1.20	89.99
65+34.63	J-Box		40.0								45°			.33				.33	92.87	1.20	91.67
		84"	311	"	8.08	"	.0024	57.71				.14						.14	93.20	1.01	92.19
65+92.34	BEND								48°				.15					.15	93.34	1.01	92.33
		84"	311	"	8.08	"	.0024												93.49	1.01	92.48
																				1.01	

NORMAL DEPTH TO J-BX AT STA 56+34

ASSUME SEALED INV = 78.79

REMARKS:

1699.92

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 10 YEAR

LINE: SD 3 - 2% bulking

BY: S Johnson

DATE: 23 Jun 94

SHEET: 2 OF:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
65+92.34	Bend								48°												
		84"	311	38.485	8.08	6388	.0024	32.66				.08						.08	93.49	1.21	92.48
66+25.00	Junction		5							24"	45°			.06				.06	93.57	1.21	92.56
		84"	306	"	7.95	6388	.0023	248.03				.57						.57	93.63	.98	92.65
68+73.63	MH																	0	94.20	.98	93.22
			306	"	7.95		.0023	34.37										.08	94.20	.98	93.22
69+08.00	Junction		5							24"	45°			.06				.06	94.28	.98	93.30
			301	"	7.82		.0022	283.00				.62						.62	94.34	.95	93.39
71+91.00	Junction									24"	45°			.06				.06	94.96	.95	94.01
			296	"	7.69		.0021	21.63										.05	95.02	.92	94.10
72+12.63	MH																	0	95.07	.92	94.15
			296		7.69		.0021	262.37										.55	95.07	.92	94.15
74+75.00	Junction		"							24"	45°							.06	95.62	.92	94.70
			290		7.54		.0021	76.95										.16	95.68	0.88	94.80
75+51.95	MH																	0	95.84	0.88	94.96
			290		7.54		.0021	4.00										.01	"	0.88	"
75+55.95	SD 18 Junction		21							36"	45°			.21				.21	95.85	.88	94.97
			269		6.99		.0018	850.76										1.53	96.06	.76	95.30
84+06.71	MH																	0	97.59	.76	96.83
			269		6.99			8.00										.01	"	.76	"
84+14.71	SD 12 Junction									30"								0	97.60	.76	96.84
			269		6.99		.0018	243.29										.44	"	.76	96.84
86+58.00	Junction									24"	45°							.06	98.04	.76	97.28
																			~~98.10~~	~~.76~~	~~97.34~~

REMARKS:

2085.66

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 10-year

LINE: SD 3 - 270 building

BY: [illegible]

DATE: 29 June 94

SHEET: 3 OF:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mb}	h_l	h_{misc}	Σ	E.G.	h_v	H.G.
86+58.00	Junction									24"	45°										
		84"	263	38.485	6.83	6388	.0017	65.00											98.10	.72	97.38
87+23.00	MH																	.11	98.21	.72	97.49
		84"	263		6.83		"	37.00										0	98.21	.72	97.49
87+60.00	Junction									24"	45°			.06				.06	98.27	.72	97.55
		84"	257		6.68		.0016	102.00										.06	98.33	0.69	97.64
88+62.00	Junction									24"	45°			.06				.16	98.49	0.69	97.80
		84"	251	38.485	6.52		.0015	174.00										.06	98.55	0.66	97.89
43+70.80 90+36.00	90° J-Box										45°			.37				.06	98.81	.66	98.15
		84"	203	38.485	5.27	6388	.0010	543.83				.54						.37	99.18	.43	98.75
95+79.83	Junction													.08				.54	99.72	.43	99.29
		84"	189	"	4.91	"	.0009	39.17				.04						.08	99.80	.37	99.43
96+19.00	MH																	.04	99.84	"	99.47
		84"	189	"	4.91	"	.0009	329.58				.31						0	"	"	99.47
97+15.86 99+68.58	90° c/s J-Box													.16				.31	100.15	.37	99.78
		54"	88	15.904	5.53	1.967	.002	470.42				.94						.16	100.31	.47	99.84
104+39.00	MH														.02			.94	101.25	.47	100.78
		54"	88	"	"	"	.002	211.00				.42						.02	101.27	.47	100.80
106+50.00	Bend								45°				.07					.42	101.69	.47	101.22
			88															.07	101.76	.47	101.29

REMARKS:

1992.0

MANNING'S n: _____

G-
J- O/A

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 10 year

LINE: SD 4 - 2% building

BY: Bew O

DATE: 30 June 94

SHEET: 4 OF:

Checked - SKG 30 June 94

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION		LOSSES							E.G.	h_v	H.G.
										D	θ	h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ			
90+36.00 43+70.80	SD 3 J-Box																		99.3		
		54"	68	15.9	4.28	1967	.0012	430'				.514						.514	99.18	.284	98.89
49+00.80	MH														.014			.014	98.66	.284	98.38
		54"	68	15.9	4.28	1967	.0012	27'				.03						.03	98.67	.284	98.39
48+27.83	Junction									24"	45°			.059				.059	98.70	.284	98.42
		54"	63	15.9	3.96	1967	.0010	150'				0.15						.015	98.76	.244	98.52
49+77.83	Junction									24"	45°			.073				.073	98.78	.244	98.54
		54"	57	15.9	3.58	1967	.0008	250'				0.20						.20	98.85	.199	98.65
52+27.74	MH														.010			.01	99.05	.199	98.85
		54"	57	15.9	3.58	1967	.0008	8'				.01						.01	99.06	.199	98.86
52+35.74	BEND								45°				.028					.028	99.07	.199	98.87
		54"	57	15.9	3.58	1967	.0008	430'				.34						.34	99.10	.199	98.90
56+65.74	MH														.010			.01	99.44	.199	99.24
		54"	57	15.9	3.58	1967	.0008	435.1				.35						.35	99.45	.199	99.25
13+29.01 61+01.45	SD5 MH														.010			.01	99.80	.199	99.60
																			99.81	.199	99.61

REMARKS:

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: RW3-21 10 year

LINE: SD5 2% walking

BY: [illegible]

DATE: 8 Jul 94

SHEET: ____ OF: ____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
13+29.61	SD5 MH																				
36+01.4	SD4																				
		54"	63	15.904	3.96	1967	.0010	90.52				.09						.09	99.81	.24	99.57
12+39.09	Junction																		99.90	.24	99.66
		54"	50.4	15.904	3.17	1967	.0007	239.09						.11				.11	100.01	.16	99.85
10+00	MH											.17						.17	100.18	.16	100.02
															.08			.01	100.19	.16	100.03
		54"	50.4	"	"	"	"	90.91				.06						.06	100.25	.16	100.09
9+09.09	Junction																				
			22.3																		
6+00	MH								45°												
			37.8																		
5+89.23																					

REMARKS:

MANNING'S n: _____

Normal Depth
54"
S = .0028

Q = 63 D = 2.53
V = 6.85

Q = 50.4 D = 2.21
V = 6.49

Q = 37.8 D = 1.88
V = 6.02

all below top of pipe however not at normal Depth

In this length goes to Normal Depth

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 10 year

LINE: SD 6 - 270 bulking

BY: MSH/SKJ

DATE: 29 June 94

SHEET: 6 OF:

Checked SKJ 29 June 94

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
99+68.55 45+03.12	J-Box																				
		54	78	15.904	4.90	1967	.00157	25.62				.04						0.04	100.33	0.34	99.96
45+88.74	BEND								45°				0.05					0.05	100.37	0.37	100.00
		54	78	"	"	"	"	25.62				.04						.04	100.42	"	100.05
45+14.31	JUNCTION									24"	45°			0.13				0.13	100.46	"	100.09
		54	69	"	4.34	"	.00123	66.96				.03						.03	100.59	0.29	100.30
46+81.32	J-BOX SD 8													0.33				0.33	100.67	0.29	100.38
		48	51	12.566	4.06	1436	.00126	365.31	0.46									0.46	100.94	0.26	100.48
50+48.69	Jct/MH													0.17				.17	101.20	0.26	100.94
		36	21	2.068	2.98	1669.9	.0010	174.21				.17						.17	101.37	0.14	101.23
52+20.90	JUNCTION									24"	45°			.08				.08	101.54	0.14	101.40
		36	17	"	2.41	"	.00065	275.80				.18						.18	101.62	.09	101.53
54+96.70	MH														.005			.01	101.80	.09	101.71
		36	17	"	2.41	"	.00065	203.30				.13						.13	101.81	.09	101.72
57+00.00	JUNCTION									24"	45°			.02				.02	101.94	.09	101.85
		30	13	4.909	2.65	410.1	.0010	246.70				.25						.25	101.96	.11	101.85
59+46.70	MH														.005			.01	102.21	.11	102.10
		30	13	"	"	"	"	53.30				.05						.05	102.22	.11	102.11
60+00.00	JUNCTION									24"	45°			.09				.09	102.27	.11	102.16
		30	9	"	1.83	"	.0005	390.72				.20						.20	102.36	.05	102.31
63+96.70	MH														.003			.003	102.56	.05	102.51
		30	9	"	"	"	"	53.30													
64+50.00	JUNCTION									24"	45°										

Normal Depth

REMARKS:

MANNING'S n: _____

1.04

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: _____

DATE: _____

SHEET: ____ OF: ____

PROJECT: R/W 3-21 10 year

LINE: SD 6 2% bulking

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION		LOSSES							E.G.	h_v	H.G.
										D	θ	h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ			
64+50.00	Junction																				
		24	4	3.142																	Normal Depth
69+00.00	MH/END																				

REMARKS:

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 10 year

LINE: SD 7 2% bulking

BY: MSH / SKJ

DATE: 29 June 94

SHEET: ___ OF: ___

Checked 29 June 94 SKJ

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
~~30+46.68~~ 24+20.75	MH																				
		36"	30	7.068	4.24	66.9	.0020	337.68				.68						.68	101.33	0.28	101.05
27+58.43	MH Junction													0.23				0.23	102.01	0.28	101.73
		30	13	4.909	2.65	410.1	.00100	175.57	0.18									0.18	102.24	0.11	102.13
29+34.00	Junction									24"	45°			0.08				0.08	102.42	0.11	102.31
		30	10	"	2.04	"	.00059	203.00	0.12									0.12	102.50	0.06	102.44
31+37.00	MH																	0	102.62	0.06	102.56
		30	10	"	"	"	"	134.00	0.08									0.08	102.62	"	102.56
32+71.00	Junction									24"	45°			0.08				0.08	102.70	"	102.64
		30	7	"	1.43	"	.00029	266.00	0.08									0.08	102.78	0.03	102.75
35+37.00	MH																	0	102.80	0.03	102.83
		24	7	3.142	2.23	226.2	.00096	603.00	0.06									0.06	102.86	0.03	102.83
36+00.00	Junction									24"	45°			0.08				0.08	102.92	0.08	102.84
		24	4	"	1.27	"	.00031	537.00	0.11									0.11	103.00	0.03	102.97
39+37.00	MH Junction									24"	45°			0.08				0.08	103.11	0.03	103.08
																			103.19	0.03	103.16

— goes to normal depth D = 0.73

REMARKS:

1516.25

MANNING'S n: _____

3,42

$Q = VA$
$V = Q/A$

$h_f = S_f L$

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 10 year

LINE: SD 8 2% bulking

BY: BNO
DATE: 6-29-94 checked SKJ 29 June 94
SHEET: ___ OF: ___

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A SF	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_l	h_{misc}	Σ	E.G.	h_v	H.G.
416+81.32 416+90.64	J-BOX																				
		30"	18	4.909	3.667	410.1	.0019	450.00	—			.8550	--	—				.86	100.74	0.21	100.53
421+40.64	MH											[illegible]			.0104			.01	101.60	0.21	101.39
		30"	18	4.909	3.667	410.1	.0019	123.36				.2344			[illegible]			.23	101.61	0.21	101.40
423+64.00	Junction									24"	45°	[illegible]		.0932	[illegible]			.09	101.84	0.21	101.63
		24"	12	3.142	3.819	226.2	.0028	326.64				.9146						.91	101.93	.23	101.70
425+90.64	MH								—			[illegible]			.0113			.01	102.84	.23	102.61
		24"	12	3.142	3.819	226.2	.0028	43.36				.1214		.26	[illegible]			.12	102.85	.23	102.62
426+34.00	Junction									24"	45°	.1314		.1965				.26	102.97	.23	102.74
		24"	6	3.142	1.910	226.2	.0007	360.00				.2520						.25	103.23	.06	103.17
429+94.00	MH Junction									24"	45°	[illegible]		Φ	.0008			[illegible]	103.48	.06	103.42

REMARKS:

1303.36

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 10 year

LINE: SD 9 - 2nd building

BY: [illegible] / SKJ

DATE: 6-29-94

SHEET: ___ OF: ___

Checked SKJ - 29 June 94

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
99+68.58 97+15.86	JBox													.03				.03	100.33	.12	100.21
		42"	27	9.621	2.81	1006	.0007	600.00				.42						.42	100.75	.12	100.63
103+15.86	MH														.01			.01	100.76	.12	100.64
		42"	27	"	2.81	"	.0007	260.14				.18						.18	100.94	.12	100.82
105+76.00	Bend								45°				.02					.02	100.96	.12	100.84
		42"	27	"	2.81	"	.0007	8.00				.01						.01	100.97	.12	100.85
105+84.00	MH Junction									24"	45°			~~.05~~	.05			.05	101.02	.09	100.93
		36	17	7.068	2.41	666.9	.00065	496.00 ~~414.00~~				~~.32~~						.32			
~~106+98.00~~	~~MH~~																				
															.00			Ø			
		36"	17	7.068	2.41	666.9	.0007	252.00				.27						.27			
110+80.00	MH Junction									24"	45°			.03				.03	101.34	.09	101.25
		30"	12	4.909	2.44	410.1	.0009	252.00				.23						.23	101.37	.09	101.28
113+32.00	Junction									24"	45°			.07 ~~.04~~				.07	101.60	.09	101.51
		24"	6	3.142	1.91	226.2	.0007	252.00				.18						.18	101.67	.06	101.61
115+84.00	MH Junction									24"	45°				Ø			Ø	101.85	.06	101.79

COMBINE MH & JUNCTION

NORMAL DEPTH D = 1.43'

D = 0.92

REMARKS:

1868.14

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 10 year

LINE: SD 10 2% building

BY: _____

DATE: 29 June 94

SHEET: ____ OF: ____

checked by CF 6/29/94

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
106+50.00 602+44.43	SD3 BEND								45°												
		54	88	15.904	5.53	1967	.00200	93.91	0.19									0.19	01.78	0.48	01.30
107+20.25 603+38.34	MH Junction																		01.97	0.48	01.49
														0.25				0.25	02.22	0.37	01.85
		48	61	12.566	4.85	1436	.00480	161.66	0.29									0.29	02.51	0.37	02.14
605+00.00	Junction									24"	45°			0.16				0.16	02.67	0.26	02.41
		48	51	"	4.06	"	.00426	300.00	0.38									0.38	03.05	0.26	02.79
608+00.00	MH Junction									24"	45°			0.03				0.03	03.08	0.28	02.80
		42	41	9.621	4.26	1006	.00466	262.00	0.43									0.43	03.51	0.28	02.80
610+62.00	Junction									24"	45°			0.08				0.08	03.59	0.28	03.31
		36"	30	7.068	4.24	666.9	.0020	154.08	0.31									0.31			
612+16.08	Junction																				

REMARKS:

817.57

MANNING'S n: _____

1.73 ✓

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 10 YEAR

LINE: SD 11 2nd building

BY: [illegible] / SKJ

DATE: 6-29-94

SHEET: ___ OF: ___

— Checked 27 June 94 SKJ

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_s	h_{misc}	Σ	E.G.	h_v	H.G.
603+38.34 107+20.25	MH Junction													0.24				0.24			
		36"	27	7.068	3.82	6660.9	.0016	450.00				0.72						0.72	302.22	.23	301.99
111+70.25	MH														.01			0.01	302.94	.23	302.71
		36"	27	"	3.82	"	.0016	100.00 ~~124.75~~				0.16						0.16	302.95	.23	302.72
112+~~95~~ 70.00	Junction									24"	45°			0.28 ~~0.28~~				0.28 ~~0.28~~	303.11	.23	302.88
		36"	14	"	1.98	"	.0004	175.00 ~~150.00~~				0.06						0.06	303.27	.06	303.21
114+45.00	MH Junction									24"	45°				Ø			Ø	303.33	.06	303.27

— NOTE Top of grate in this basin is 5300.79 — HOWEVER PONDING IS AVAILABLE UP TO ELEV 5305.3

REMARKS: 724.75

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: RW3-21 10 year

LINE: SD 12 2% bulking

BY: [signature]

DATE: 9 July 94

SHEET: ____ OF: ____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
SD3+12 84+14.71	wye																				
		36"	37	7.068	5.23	666.9	.0031	578.23				1.78						1.78	97.60	"	96.84 - from SD3
89+93	MH														.02			.02	99.38	0.42	98.96
		36"	37	7.068	5.23	666.9	.0031	320.32				0.99						0.99	99.40	0.42	98.98
93+13.32	JUNCTION MH													0.59				0.59	100.38	0.42	99.97
		30"	19	4.909	3.87	410.1	.0021	42.43				.09						.09	100.98	0.23	100.75
93+55.75	BEND								45°				.03					.03	101.07	0.23	100.84
		30"	19	"	3.87	"	.0021	305.				.64						.64	101.10	0.23	100.87
96+60.75	JUNCTION MH													.22				.22	101.74	0.23	101.51
		30"	11	"	2.24	"	.0007	336.				.24						.24	101.96	0.08	101.88
99+96.75	JUNCTION MH														.05			.05	102.20	0.08	102.12
		30"	3	"	0.61	"	.0001	327.37				.03						.03	102.25	.01	102.24
103+24.12	inlet																		102.28	.01	102.27

REMARKS:

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: RW 321 - 10 years

LINE: SD 13 - 2% bolking

BY: S Johnson

DATE: 18 Jun 84

SHEET: 1 OF: 8

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_f	h_{misc}	Σ	E.G.	h_v	H.G.	
59+72.01	J-BOX																					assumed sealed inv = 76.46
		72"	206	28.274	7.29	4236	.0024	60'				.14						.14	83.29	0.83	82.46	
59+10.01	JUNCTION		44						45	36"	45°			.23				.23	83.43	0.83	82.60	
		66"	163	23.758	6.86	3358	.0024	313.92				.75						.75	83.66	0.73	82.93	
55+96.04	MH											0						0	84.41	0.73	83.68	
		66"	163	"	"	"	.0024	262.23				.63						.63	84.41	0.73	83.68	
53+33.81	JUNCTION		2							24"	45°			.03				.03	85.04	0.73	84.31	
		66"	161	"	6.78	"	.0023	200.79				0.46						.46	85.07	0.71	84.36	
51+33.81	MH											0						0	85.54	0.71	84.83	
		66"	161	"	"	"	.0023	564.72				1.30						1.30	85.54	0.71	84.83	
45+69	JUNCTION		1							24"	45°			.03				.03	86.84	0.71	86.13	
		66"	160	"	6.73	"	.0023	549.0				1.26						1.26	86.87	0.70	86.17	
42+20	"									24"	45°			.03				.03	88.13	0.70	87.43	
		66"	158	"	6.65	"	.0022	578.88				1.27						1.27	88.16	0.69	87.47	
34+41.12	J-BOX									36"	45°	1.46		.18				0.11	89.43	0.69	88.74	
		60"	139	19.635	7.08	2604	.0028	328.62				0.92						.92	89.54	0.78	88.76	inv 82.74 87.74 top
31+12.50	MH																	0	90.46	.78	89.68	
		60"	139	"	"	"	"	400.0				1.12						1.12	90.46	.78	89.68	
27+12.50	J BOX												.12	.27				0.39	91.58	.78	90.80	inv = 84.28 top = 89.28
																			91.97	.78	91.19	

REMARKS:

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: S Johnson
DATE: 8 Jul 94
SHEET: ____ OF: ____

PROJECT: RW 321 10 year
LINE: SD 14 - 2% bulking

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
STA. 34+41.14 = STA. 35+10.8	SD13 BOX SD14																				
		36"	30	7.068	4.24	666.9	.0020	70.7				.14						.14	89.39		88.61
35+80.76	BEND								45°				.04					.04	89.53	0.28	89.25
		36"	30	"	"	"	"	269.94 / 195.01				.39						.39	89.57	0.28	89.29
37+75.77	J BOX													.12				.12	89.96	.28	89.57
		36	26	7.068	3.68	666.9	.0015	74.93				.11						.11	90.08	.21	89.87
38+50.70																			90.19	.21	89.98

INV = 85.95

REMARKS:

MANNING'S n: _____

2% building

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: RW 321 10 year

LINE: SD 15

BY: S Johnson

DATE: 21 June 94

SHEET: 3 OF: 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_f	h_{misc}	Σ	E.G.	h_v	H.G.
27+12.50 = 32+42.43	J-BOX	SEE	SD	13																	
		42"	48.5	9.621	5.04	1006	.0023	42.43				.10						.10	91.92	.39	91.53
32+05	Bend								45°				.06					.06	92.02	.39	91.63
		42"	48.5	"	"	"	"	8				.02						.02	92.08	.39	91.69
31+97	Junction									24"	45°			.18				.18	92.10	.39	91.71
		42"	41.5	"	4.31	"	.0017	202				.34						.34	92.28	.29	91.99
29+95	Junction													.11				.11	92.62	.29	92.33
		36"	24.5	7.068	3.47	666.9	.0013	165				.22						.22	92.73	.19	92.54
28+30	m H														.01			.01	92.95	.19	92.76
		36"	24.5	"	"	"	"	235				.31						.31	92.96	.19	92.77
25+95	Junction													.13				.13	93.27	.19	93.08
		36"	18.5	7.068	2.62	666.9	.0008	540				.43						.43	93.40	.11	93.29
20+55	Junction													.02				.02	93.83	.11	93.72
		30"	12.5	4.909	2.55	410.1	.0009	250				.23						.23	93.85	.10	93.75
18+05	Junction													.06				.06	94.08	.10	93.98
		30"	6.5	4.909	1.32	"	.0002	250				.05						.05	94.14	.03	94.11
15+55	END																		94.19	.03	94.16

REMARKS:

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

27 buildings

PROJECT: RW 321 10 year

LINE: SD 16

BY: [illegible]

DATE: 19 June 94

SHEET: 2 OF: 8

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
27+12.50 = 32+22.57	JBOX																				
		48"	93	12.56	7.40	1436	.0042	4243				.18						.18	91.9	.85	91.07
32+65	BEND								45°				.12					.12	92.10	.85	91.25
		48"	93	"	"	"	"	342				1.44						1.44	92.22	"	91.37
36+07	MH														.04			.04	93.66	"	92.81
		48"	93	"	"	"	"	168				0.71						0.71	93.70	"	92.85
37+75	JUNCTION									24"	45°			.27				.27	94.41	"	93.56
Add		48"	84"	"	6.68	"	.0034	400				1.36						1.36	94.68	0.69	93.99
41+75	JUNCTION									24"	45°			.24				.24	96.04	.69	95.35
		48"	75	"	5.97	"	.0027	193.25				0.53						.53	96.28	.55	95.73
43+73.25	JUNCT + MH									42	45°			0.43				.43	96.81	.55	96.26
		30"	29	4.929	5.91	412.1	.0050	201.75				1.01						1.01	97.24	.54	96.70
45+75	JUNCTION									24"	45°			.45				.45	98.25	.54	97.71
		30"	20	4.929	4.07	"	.0024	240				.58						.58	98.70	.26	98.44
43+15	MH														.01			.01	99.28	.26	99.02
		30"	20	4.929	"	"	"	440				1.06						1.06	99.29	.26	99.03
52+55	JUNCTION									24	45°			.19				.19	100.35	.26	100.09
		30	15	"	3.06	"	.0013	260.2				.34						.34	100.54	.15	100.39
55+15.20	JUNCTION									24	45°			.12				.12	100.88	.15	100.73
		24"	5	3.142	1.59	276.2	.0005	379.8				.19						.19	101.00	.04	100.96
58+95	JUNCTION end									24	45°								101.19	.04	101.15
39+91	MH																				

REMARKS:

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: RD 3-21 10 year

LINE: SD 17

BY: [illegible]

DATE: 3 Jul 94

SHEET: ____ OF: ____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION		LOSSES							E.G.	h_v	H.G.	
										D	θ	h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ				
29+93.25 SD5	wye																					
		24"	17	3.142	5.41	22.62	.0056	35.35											93.83		93.72	becomes unsealed - assume
29+70.00 SD17												.20						.20	94.03	.45	93.57	seals again at inlet
														.35				.35	94.38	.19	94.19	
		24"	11	"	3.50	"	.0024	308				.73						.73	95.11	.19	94.92	
32+78																						

S = .0110

Q = 11

D = 0.96'

V = 7.41

REMARKS:

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R.3321

LINE: SD 18 2% bulking

BY: [illegible]

DATE: 8 Jul 94

SHEET: ___ OF: ___

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
SD3+5 / 75+55.95	SD18 JUNCTION																				
		36	24	7.263	3.40	666.9	.0013	372.43				.48						.48	96.06	.18	
																			96.54	.18	96.36
29+28.43	JUNCTION													.11				.11	96.65	.11	96.54
		36"	19	7.263	2.69	666.9	.0003	171.06				.14						.14	96.79	.11	96.68
30+99.49	C.B.																				

goes to Normal Depth D=2.38'

@ S = 2.3%
Q=24" D= 0.99
V = 11.72

Q = 19 D = 0.88
V = 10.98

?

REMARKS:

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: RW3-21 10 years

LINE: SD19 2% culking

BY: [illegible]

DATE: 8 July 94

SHEET: ____ OF: ____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.	
74+75 SD3	WYE																					
		24"	12	3.142	3.82	226.2	.0028	35.35				.10						N/A	97.84	0.23	97.61	Becomes uncoaled D=
75+00 SD3 + SD19	C.B								28°	thru	top		.03	.19				.22	98.06	0.08	97.98	Seals A inlet inv = 95.61 top = 97.61
		24"	7	3.142	2.23	226.2	.0010	351.16				.35						.35	98.41	0.08	98.33	
78+51.16	C.B.		4							thru	top			.07				.07	98.48	.01	98.47	
	-	24"	3	3.142	0.95	226.2	.0002	56.82				.01						.01	98.49	.01	98.48	
79+07.93	C.B																					

Q = 12 D = pressure
S = .0038

Q = 7 D = 1.00
V = 4.44

Q = 3 D = 0.63
V = 3.54

REMARKS:

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: S Q[illegible]
DATE: 3 Jul 74
SHEET: ___ OF: ___

PROJECT: RW 3-21 10 year + LINE: SD 21 2% bulking

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
27+58.43 SD7 = 422+47.78 SD 21																					
		30"	17	4.909	3.46	410.1	.0017	539.87				.92						.92	102.24	.17	102.07
427+87.65	INLET													.13				.13	103.16	.17	102.99
		24"	8.5	3.142	2.71	226.2	.0014	100.00				.14						.14	103.03	.11	102.92
428+87.65																			103.17	.11	103.06

REMARKS:

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: _____

LINE: SD23 2 % bulking

BY: S. Johnson

DATE: 29 Jul 94

SHEET: ____ OF: ____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
34+-3.45 ~~39+75.77~~	JBOX																				
		24"	5	3.142	1.59	226.2	.0005	313.49				.15						.15	90.08	.04	90.04
31+50	MH														.002			.01	90.23	.04	90.19
		24"	5	"	"	"	"	450				.22						.22	90.24	.04	90.20
27+50	MH																	.01	90.46	"	90.42
		24"	5	"	"	"	"	450										.22	90.47	"	90.43
22+50	MH																	.01	90.69	"	90.61
		24"	5	"	"	"	"	450										.22	90.70	"	90.66
18+00	MH																	.01	90.92	"	90.89
		24"	5	"	"	"	"	403				.20						.20	90.93	"	90.89
13+97	BEND								45°						.005			.01	91.13	.04	91.09
[illegible]								47				.02						.02	91.14	.04	91.10
13+50	END																		91.16	.04	91.12

REMARKS:

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: RW3-21 100 yr

LINE: SD2 +2% bulking per upstream analysis

BY: [illegible]

DATE: 8 Sept 94

SHEET: 1 OF:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
		120"																			
49+92.42	JBox									72"	45°								285.98	3.54	232.44
		96	84/759	50.266	15.10	9120	.0069	370.0				2.56						2.56	288.54	3.54	85.00
52+62.42	mH														.19			.19	88.72	3.54	85.18
		96	759	50.266	15.10	9120	.0069	371.74				2.57						2.57	91.29	3.54	87.75
51+34.16	J Box	66"	396	23.758	16.67									2.51				2.51	93.80	1.05	92.75
		90	458/362.5	44.179	8.21	7677	.0022	289.31				0.67						0.67	94.47	1.05	93.42
59+34.00	mH/Junc		—													.07		.07	94.54	1.38	93.16
		84	362.5	38.485	9.42	6388	.0032	600.63				1.93						1.93	96.47	1.38	95.09
65+34.63	JBox	48"	42	12.566	3.34									.52				.52	96.99	1.08	95.91
		84	417/320.5	38.485	8.33	"	.0025	57.71				.14						.14	97.13	1.08	96.05
65+92.34	Bend												.15					.15	97.28		
		84	320.5	"		"															

REMARKS: Q_{100} from Atlas; Q_{100} +2% for adjustments

1699.92

MANNING'S n: _____ losses except 5% 2.7%

8.68

2 = 11-0 + 6" = 11.69

− 7.0

10.93

3.0" − 8' 5=.00537 > no normal depth

Assume pipe seals at J-B.
INV = 5274.44 + 8' = 82.4

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT +2% bolkins

BY: _____

DATE: _____

PROJECT: 100yr

LINE: SD3 per upstream analysis SHEET: 2 OF: ____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
65+92.34	Bal																				
		84"	320.5	38.485	8.33	6388	.0025	32.66				.08						.08	297.28	1.08	296.20
66+25.00	Junc.	24"	6	3.142	1.91									.07				.07	97.36	1.08	96.28
		84	314.5	"	8.17	"	.0024	243.03				.60						.60	97.43	1.04	96.39
68+73.03	MH														.05			.05	98.03	1.04	96.99
		84	314.5	"	8.17	"	.0024	34.97				.03						.03	98.03	1.04	97.04
69+08.00	Junc.	24	5.5	3.142	1.75									.07				.07	98.16	1.04	97.12
		84	309	"	8.03	"	.0023	283.00				.66						.66	98.09	1.00	97.09
71+91.00	Junc.	24"	5.5		1.75									.06				.06	98.75	1.00	97.75
		84	303.5	"	7.89	"	.0023	21.03				.05						.05	98.81	0.96	97.85
72+12.03	MH														.05			.05	98.36	0.96	97.90
		84	303.5	"	7.89	"	.0023	262.30				.59						.59	98.91	.96	97.95
74+75.00	JUNC	24"	14.5		4.62									.14				.14	99.50	.96	98.54
		84	289	"	7.51	"	.0020	76.75				.16						.16	99.64	.88	98.76
75+51.95	MH														.04			.04	99.80	.88	98.92
		84	289	"	7.51	"	.0020	4.00				.008						.01	99.84	.88	98.96
75+55.95	SD18 JUNC	36"	27	7.063	3.82									.25				.25	99.85	.88	98.97
		84	262	"	6.81	"	.0017	850.76				1.43						1.43	300.10	.72	99.38
34+06.71	MH														.04			.04	301.53	.72	300.81
		84"	262	"	6.81	"	.0017	3.00				.01						.01	301.57	.72	300.85
34+14.71	SD12 JUNC	—												—				0	301.58	.72	300.86
		84	262	"	6.81	"	.0017	243.29				.41						.41	301.58	.72	00.86
36+58.00	JUNC.	24"	95		3.02									.09				.09	01.99	.72	01.27
		84"	252.5	"	6.56	"													02.08		

REMARKS:

2065.66

MANNING'S n: _____

losses except S_f .61

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 100 ~~50~~ year

LINE: SD 3 - 270 bulking per upstream analysis

BY: _____

DATE: 8 Sep 94

SHEET: 3 OF: _____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
86+58.00	Junction									24"	45°										
		84"	252.5	38.485	6.56	6393	.0016	65.00				.10						.10	53+2.08	.67	01.41
87+23.00	MH														.03			.03	02.18	.67	01.51
		84"	252.5	"	6.56	"	.0016	37.00				.06						.06	02.21	.67	01.54
87+60.00	Junction		9		2.86					24"	45°			.03				.03	02.27	.67	01.60
		84"	243.5	"	6.33	"	.0015	102.00				.15						.15	02.35	.62	01.73
88+62.00	Junction		9.5		3.02					24"	45°			.03				.03	02.50	.62	01.38
		84"	234	"	6.03	"	.0013	174.00				.23						.23	02.53	.57	02.01
43+70.50 90+36.00	SD 4 J-Box		30		1.89					54"	45°			.24				.24	02.31	.57	02.24
		84"	234	"	5.30	"	.0010	543.83				.55						.55	03.25	.44	02.61
95+79.33	Junction		19		6.05					24"	45°			.09				.09	03.60	.44	03.16
		84"	185	33.235	4.31	"	.0003	39.17				.03						.03	03.39	.36	03.33
96+19.00	MH														.02			.02	03.72	.36	03.36
		84"	135	"	4.31	"	.0008	349.58				.28						.28	03.74	.36	03.38
97+19.86 99+68.58	SD 6/9 J-Box	54" 42"	91 20	15.904 9.621	5.72 2.09									.24				.24	04.02	.36	03.66
		54"	74	15.904	4.65	19.7	.0014	470.42				.67						.67	04.26	.34	3.92
104+39.00	MH														.02			.02	04.93	.34	4.59
		54"	74	"	4.65	"	.0014	211.00				.30						.30	04.95	"	4.61
106+50.00	BEND								45°				.05					.05	05.25	"	4.91
		54"	74	"	4.65	"	.0014												05.30	.34	04.96

REMARKS:

1992.0

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: CD 4+5 100yr

LINE: includes 2% bulking

BY:

DATE:

SHEET: OF:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
43+70.30	JBox																				
		54	"	"	"	"	.0023	430				.99						.99	2.66	.55	5302.13
48+00.80	MH														.03			.03	3.67	.55	
		54	95	15.904	5.97	1967	.0023	172.03				.41						.41	3.70	.55	
49+77.83	JUNCTION													.04				.04	4.11	.55	3.56
		54"	90	15.904	5.66	1967	.0021	249.91				.52						.52	4.15	.50	3.65
52+27.74	MH														.03			.03	4.67	.50	4.17
		54"	90	"	"	"	"	8				.02						.02	4.70	.50	4.20
52+35.74	BEND												.07					.07	4.72	.50	
		54"	90	"	"	"	"	430				.90						.90	4.79	.50	
56+65.74	MH														.03			.03	5.68	.50	
		54"	90	"	"	"	"	427.71				.90						.90	5.72	.50	5.22
60+93.45	MH														.03			.03	6.62	.50	6.12
		54"	90	"	"	"	"	8				.02						.02	6.65	.50	
+ 01.45 13+29.61	BEND								45°				.07					.07	6.67	.50	
		54"	90	15.904	5.66	1967	.0021	92.52				.19						.19	6.74	.50	
12+39.09	JUNCTION									54"	45°			.07				.07	6.93	.50	
		54	68	15.904	4.28	1967	.0012	11.77				.01						.01	7.00	.23	6.72
12+30.30	BEND TRANS								45°				.13			.09		.22	7.01	0.28	6.73
		2.58 x 4.33	68	8.77	7.73														7.23	0.93	5306.3

REMARKS:

MANNING'S n:

Rout 756 - 88.73

+27 = 90

@ Q = 90
d = 4.33
V = 8.05
A = 11.18

d = 7.4
Q = 67.80
V = 7.73
A = 8.77

trial

trend w/ elev @ 6.30

transition from U to O
trend inv = 5302.90
use elev at 6.30 use
trend 2 ordinate d = 3.4'

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 100 year

LINE: SD 6 - 270 building

BY: S Johnson

DATE: 7 Sept 1984

SHEET: OF:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.	
97+15.80 99+68.58 45+63.12	J-Box																					
		54	91	15.904	5.72	1967	.0021	25.62				.05						.05	04.76	.51	03.75	
45+88.74	BEND								45°						.07			.07	4.31	.51	3.80	
		54	91	"	5.72	"	.0021	25.42				.05						.05	4.38	.51	3.87	
41+14.16	SD8 Junction		13		4.14					24"	45°			.20				.20	4.43	.51	3.92	
		54	78	"	4.90	"	.0016	66.96				.11						.11	4.63	.37	4.26	
46+81.32	J-BOX		21	4.909	4.28					30"								.13	4.74	.37	4.37	
		48"	57	12.566	4.54	1436	.0016	365.37				.57						.57	4.87	.32	4.55	
SD7 50+46.69	JUNCTION		28		3.96					36"	45°			.19				.19	5.44	.32	5.12	
		36"	29	7.068	4.10	666.9	.0019	174.21				.33						.33	5.63	.26	5.37	
52+20.90	JUNCTION		5		1.59					24"	45°			.14				.14	5.96	.26	5.70	GRATE 5.46
		36"	24	"	3.40	"	.0013	275.80				.36						.36	6.10	.18	5.92	
54+96.70	MH														.09			.01	6.46	.18	6.28	
		36"	24	"	3.40	"	.0013	203.3				.26						.26	6.47	.18	6.29	
57+00.00	+ Reduce Junction	24"	5											.03		.05		.08	6.73	.18	6.55	GRATE EL: 6.27 PONDING IN BOTH 705 + 704
		30"	19	4.909	3.87	410.1	.0021	246.7				.52						.52	6.81	.23	6.58	
59+46.70	MH														.01			.01	7.33	.23	7.10	
		30"	19	4.909	3.87	410.1	.0021	53.3				.11						.11		.23		
60+00.00	JUNCTION		6																	.23		GRATE 6.66
		30"	13																			
63+96.70	MH																					
		30"	13																			
64+50.00	JUNCTION		6																			
		24"	7	3.142		2262																GRATE 7.32

69+22 JUNCTION END

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 100year

LINE: SD 7 + 8 2% bulking

BY: S Johnson

DATE: 8 Sept 94

SHEET: ___ OF ___

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_i	h_{misc}	Σ	E.G.	h_v	H.G.	
~~30+46.68~~ 24+20.75	MH																					
		36"	28	7.068	3.96	666.9	.0018	337.68				.60						.60	5.63	.24		
27+58.43	MH Junction		18																6.23	.24	5.99	PONDING
		30"	10	4.909		410.1		175.57														
29+34.00	Junction									24"	45°											
								203.00														
31+37.00	MH																					
								134.00														
32+71.00	Junction									24"	45°											
								266.00														
35+37.00	MH																					
								63.00														
36+00.00	Junction									24"	45°											
								337.00														
39+37.00	MH Junction									24"	45°											
416+90.64	Junction																					
		30"	13	4.909	2.65	410.1	.001	450'				.45						.45	4.63	.11		
421+40.64	MH														.006			.01	5.08	.11	4.97	
		30"	13	"	2.65	"	.001	123.36				.12						.12	5.09	.11		
422+64.00	Junction	24"	4											.04				.04	5.21	.11	5.10	
		30"	9	"	1.83	"	.0005	8'				.004						.0	5.25	.05	5.20	
422+72	Reducer															.08		.08	5.25	.05		
		24"	9	3.142	2.86														5.33	.13	5.20	
								1516.25														

REMARKS:

MANNING'S n: _____

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

PROJECT: R/W 3-21 100yr

LINE: SD10 - SD9

BY:

DATE: 6 Sept 94

SHEET: OF:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
STATION	STRUCT	D	Q	A	V	K	S_f	L	Δ	JUNCTION D	JUNCTION θ	LOSSES h_f	h_b	h_j	h_{mh}	h_t	h_{misc}	Σ	E.G.	h_v	H.G.
SD 10																					
602+44.43	Bend																		5305.30	.34	
		54"	74	15.904	4.65	1967	.0014	93.91				.13						.13	05.43	.34	05.09
603+38.39	SD 11 Junction	36"	27	3.068	3.82									.21				.21	5.64	.22	5.42
		48"	47	12.566	3.74	1436	.0011	161.26				.18						.18		.22	
605+00	Junction																				
SD 7																					
97+45.86	J-Box																				
		42	20	9.621	2.08	1006	.0004	600										.24	4.26	.07	
103+15.86	MH														.005			∅		.07	
		42	20	"	2.03	"	"	260.14										.10		.07	
105+76	BEND								45°				.01					.01	4.60	.07	4.53
		42	20	"	2.08	"	"	8				.003						∅	4.61	.07	4.54
105+84	Junction	24"	8									-.02						∅	4.61	.07	
		36	12	7.068	1.70	6669	.0003	496				.16						.16	4.61	.04	
110+80	Junction																		4.77	.04	4.73
		36																			

@ Q=78
.85
.01
.36

REMARKS:

MANNING'S n:

University of New Mexico

Department of Civil Engineering

Outlet Baffle Chute
Runway 3-21
Albuquerque International Airport

Richard J. Heggen

August 10, 1994

A Report Prepared for
Greiner, Inc.

Outlet Baffle Chute
Runway 3-21
Albuquerque International Airport

Richard J. Heggen
Department of Civil Engineering
University of New Mexico

August 10, 1994

Introduction

Runway 3-21, Albuquerque International Airport, will generate a 1290 cfs 100-year discharge and a 873 cfs 10-year discharge. Greiner, Inc. has proposed drainage improvements including catch basins, underground conveyance, approximately 4700 feet of outfall pipe, terminal diameter 9 feet, a 20 foot x 20 foot horizontal apron, a 14.75-foot drop by baffle chute, 20 feet wide with 8 rows of staggered teeth, and a trapezoidal confluence channel into the Tijeras Arroyo.

High pipe velocities complicate the baffle chute hydraulics. A conventional Type 9 baffle chute (*Hydraulic Design of Stilling Basins and Energy Dissipaters*, EM 25, Bureau of Reclamation, 1978) presumes critical depth at the drop brink. To bring the supercritical pipe outflow through a hydraulic jump and then drop it to critical would require a prohibitively long apron.

The UNM Civil Engineering/AMAFCA Open Channel Test Facility investigated a related problem in *Primrose Point Supercritical Baffle Chute* for Community Sciences Corp., March 1993. Freeboard precluded supercritical Primrose channel flow from jumping before entering a baffle chute. The solution was a reduction of initial baffle tooth height. With smaller teeth where the oncoming velocity is high, energy dissipation is evenly distributed down the chute.

The Greiner design is similar. The lower 4 rows of baffle teeth are of standard Type 9 dimensions, 3 foot height, 6 foot spacing. The upper 4 rows have decreasing dimension toward the top, placing less projected area against the supercritical inflow.

T or C Baffled Apron Spillway, GR-79-2, Bureau of Reclamation, 1979 provides scour guidance for Type 9 designs. The design accordingly has the bottom 2 rows completely buried and the next row partially buried.

Fig. 1 illustrates the profile.

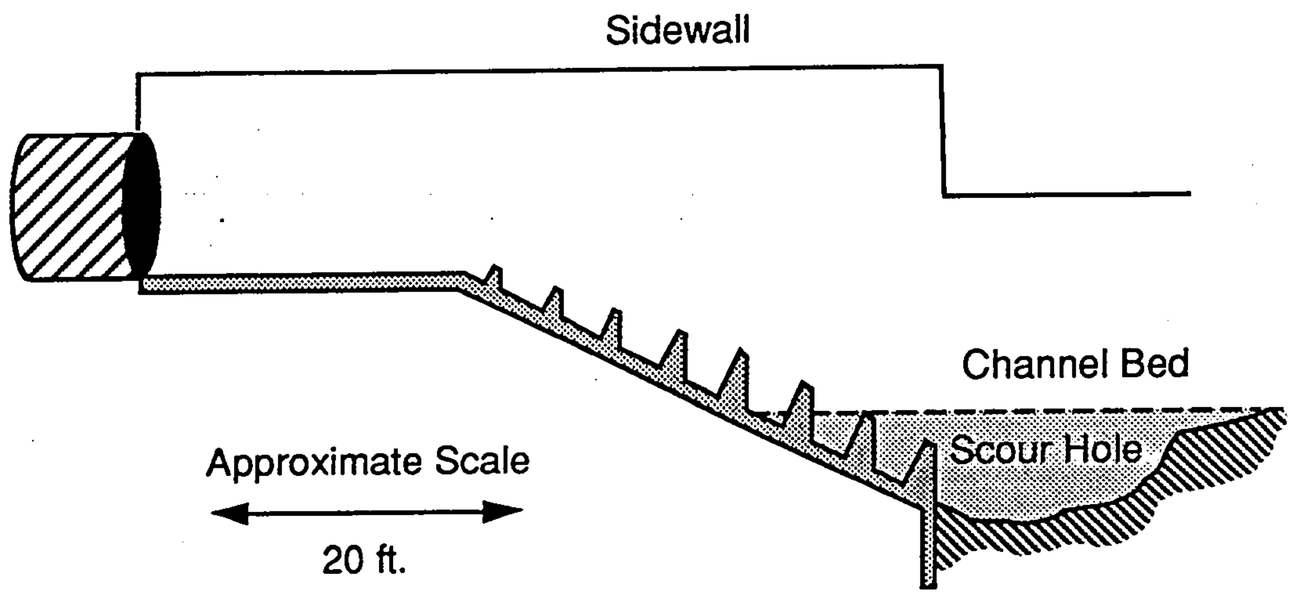

Figure 1. Generalized profile of baffle chute.

Problem Statement

Greiner engaged UNM to model the baffle chute to:

1) Determine the hydraulic profile,

2) Estimate immediate scour at the baffle chute toe, and

3) Evaluate design modification as indicated.

The Models

The study employed the UNM Civil Engineering/AMAFCA Open Channel Test Facility. The 50 foot articulated table served as a platform for a three-dimensional channel and baffle chute model constructed of pipe, wood and sheet metal.

Discharge measurement was by a pressure differential Annubar Flow Sensor, model GCR25 in the model water supply.

Geometric similitude was 1:13.5, scaled to model the 9-foot prototype pipe with an 8-inch model. The inertial-gravity force ratio was the same for both model and prototype, making Froude numbers equal.

The downstream model bed was covered with 4.75 inches of loose gravel for scour observation. The gravel particles need not dimensionally correspond to the prototype bed material. Were this a study of sediment transport through the scour zone, selected model sediment would be required. In this case, however, only the general shape of the final scour hole is of interest. This shape conforms to the hydraulic roller at the chute bottom which, once formed, is not substantially influenced by the particle size.

Experiments

Experiments were run for the 100-year discharge and 10-year discharge, the latter flow more likely to determine the general state of the channel.

Two baffle block alternatives were tested. Alternative 1 is the initial design, Figure 1. As subsequently noted, the upper row of baffle teeth creates a vertical splash at low flows. Alternative 2 eliminates the lower row of teeth and shifts the remaining rows down the slope 6 feet, moving the first baffle impact from the brink of the incline to 6 feet down the incline. Figure 2 illustrates Alternative 2.

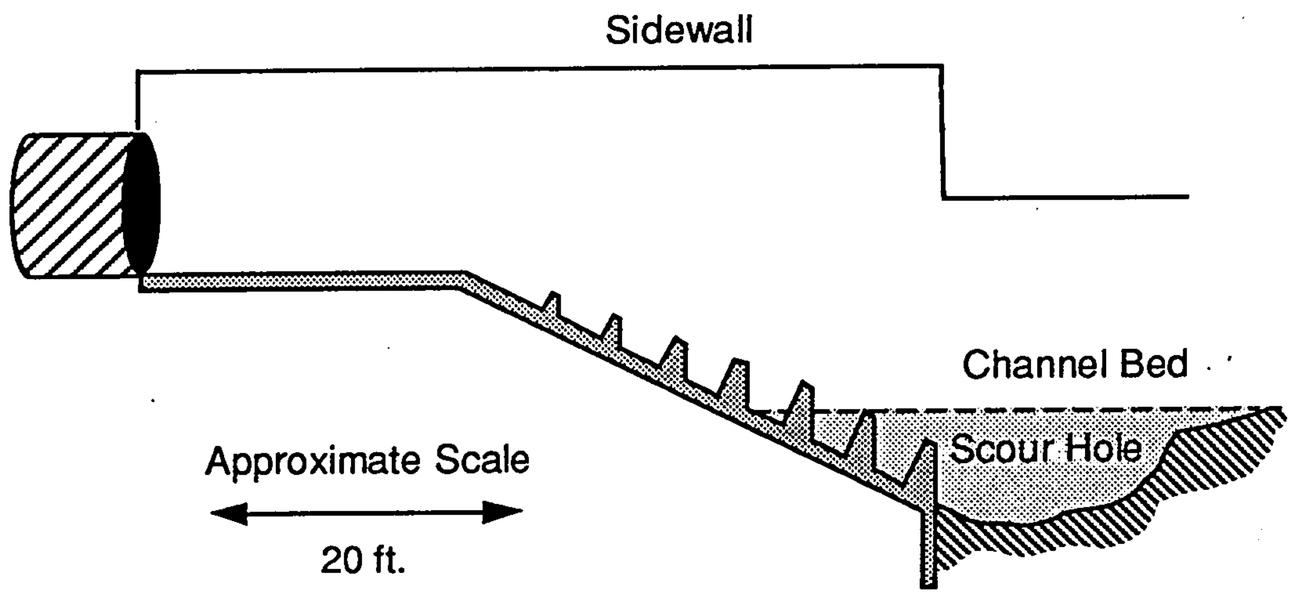

Figure 2. Alternative 2 Baffle Chute.

In the course of modeling, AMAFCA indicated interest in extending the inlet upstream, in effect inserting a prismatic rectangular transition between the pipe and the horizontal apron. A 13.5-foot extension (1.5 pipe diameters) was tested. Fig. 3 illustrates the extension.

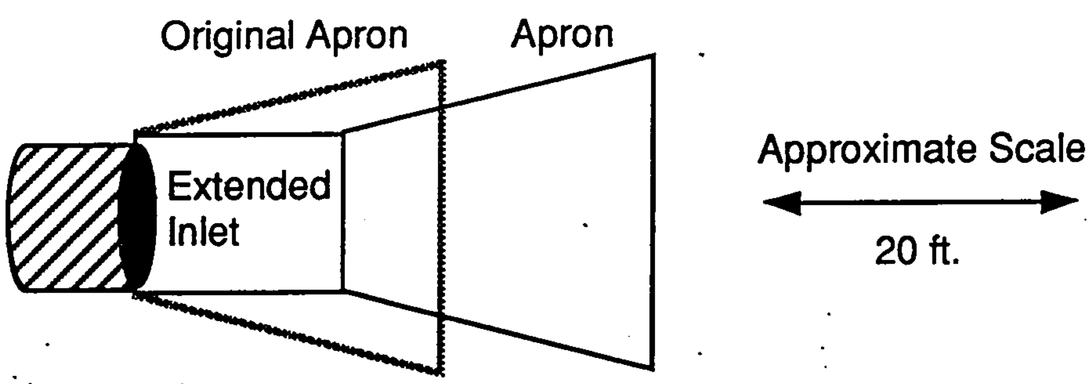

Figure 3. Extended Inlet, Plan view.

Table 1 describes the experiments.

Table 1. Experiments

Alternative	Discharge	
1	10-year	100-year
2	10-year	100-year
2, Extended Inlet	10-year	100-year

Flow and scour depths were measured at channel center and along both banks. Fig. 4 illustrates the depth measurements at a cross-section. The legend indicates:

Bed	Bed surface, model hard lining
wr	Water surface, right bank
wc	Water surface, channel center
wl	Water surface, left bank
br	Bed surface, erodible material, right bank
bc	Bed surface, erodible material, center
bl	Bed surface, erodible material, left bank

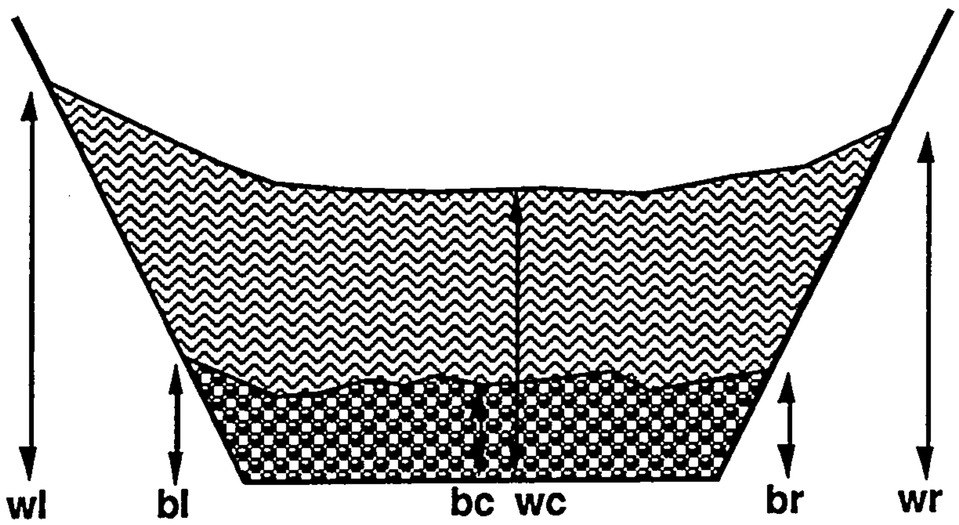

Figure 4. Measured depths.

Results

Fig. 5 illustrates the circumferencial flowlines emerging from the pipe. The lower flowlines spread outward, impacting the apron sidewalls. The resulting splash tends to be higher than the depth of flow at channel center. This behavior is seen in the subsequent data.

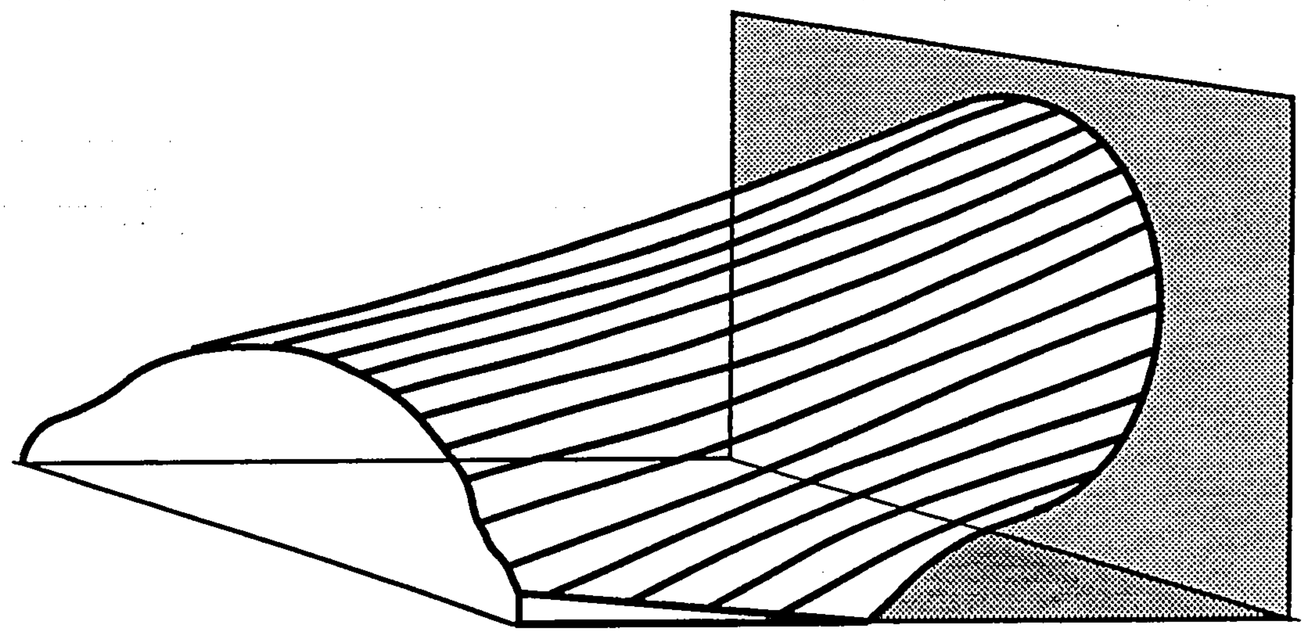

Figure 5. Flowlines.

Figs. 6-11 illustrate prototype flow depths at steady state after scour. The horizontal dashed line indicates the erodible bed elevation before flow. Model data is in the Appendix. Station 0.00 is the pipe outlet without an extended inlet. Negative stationing indicates the extended inlet.

As ground surface elevation is approximately 5085, all experiments contain the flow.

Alternative 1 vs. Alternative 2

Vertical splash from the Alternative 1 upper baffle row is significantly greater than splash in Alternative 2. Reducing the initial impact reduces the propensity of upward-deflected flow to shoot over the subsequent teeth.

10-Year vs. 100-Year

There is only small difference between the 10 and 100-year profiles. The greater discharge splashes vertically less at certain locations because momentum carries it downstream. Low flow splash is dramatically apparent when the Alternative 1 model 1s started and stopped. At very small discharges, nearly the entire flow sharply bounces upward at the first baffle, as kinetic energy converts to elevation.

Center vs. Wall Profiles

Flow emerging from the pipe is piled at the channel center, as illustrated in Fig. 5. As flow enters the chute, the horizontal spreading reverses this pattern and high water rides up on the sidewalls. By the time flow reaches the bottom of the chute, depths are consistent.

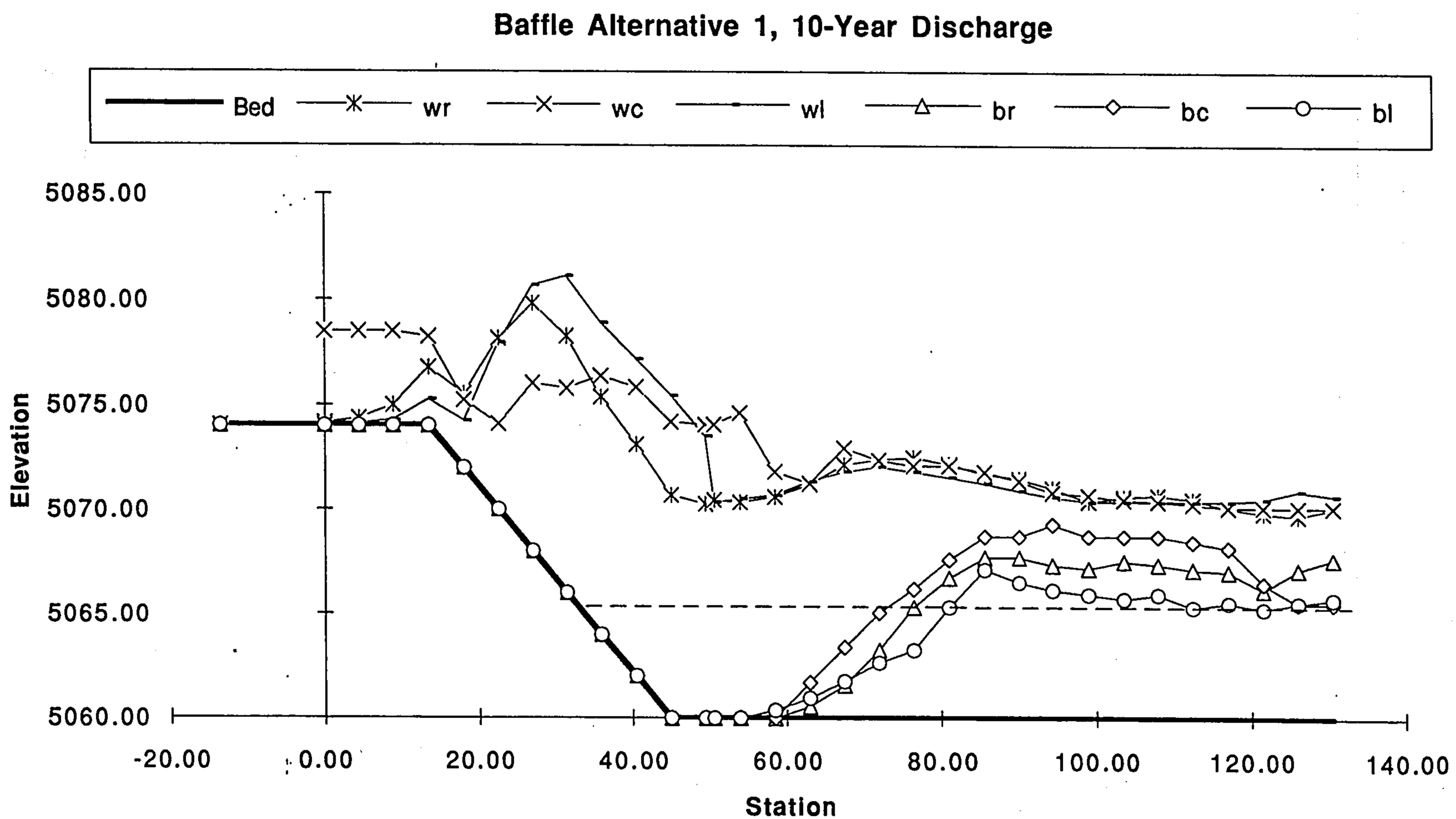

Figure 6. Alternative 1 (Top Baffle at Chute Brink), 10-Year Flow, 873 cfs.

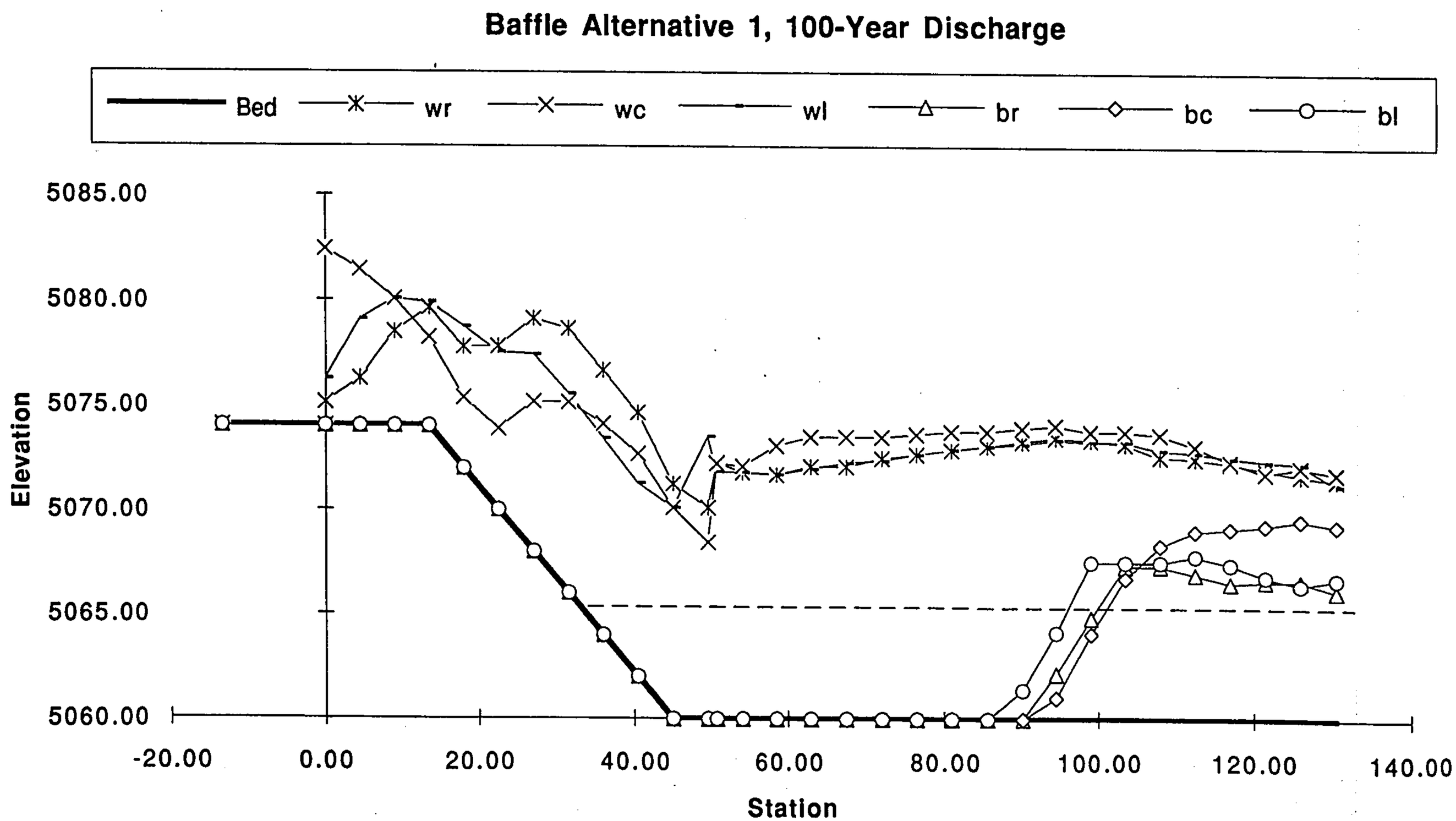

Figure 7. Alternative 1 (Top Baffle at Chute Brink), 100-Year Flow, 1290 cfs.

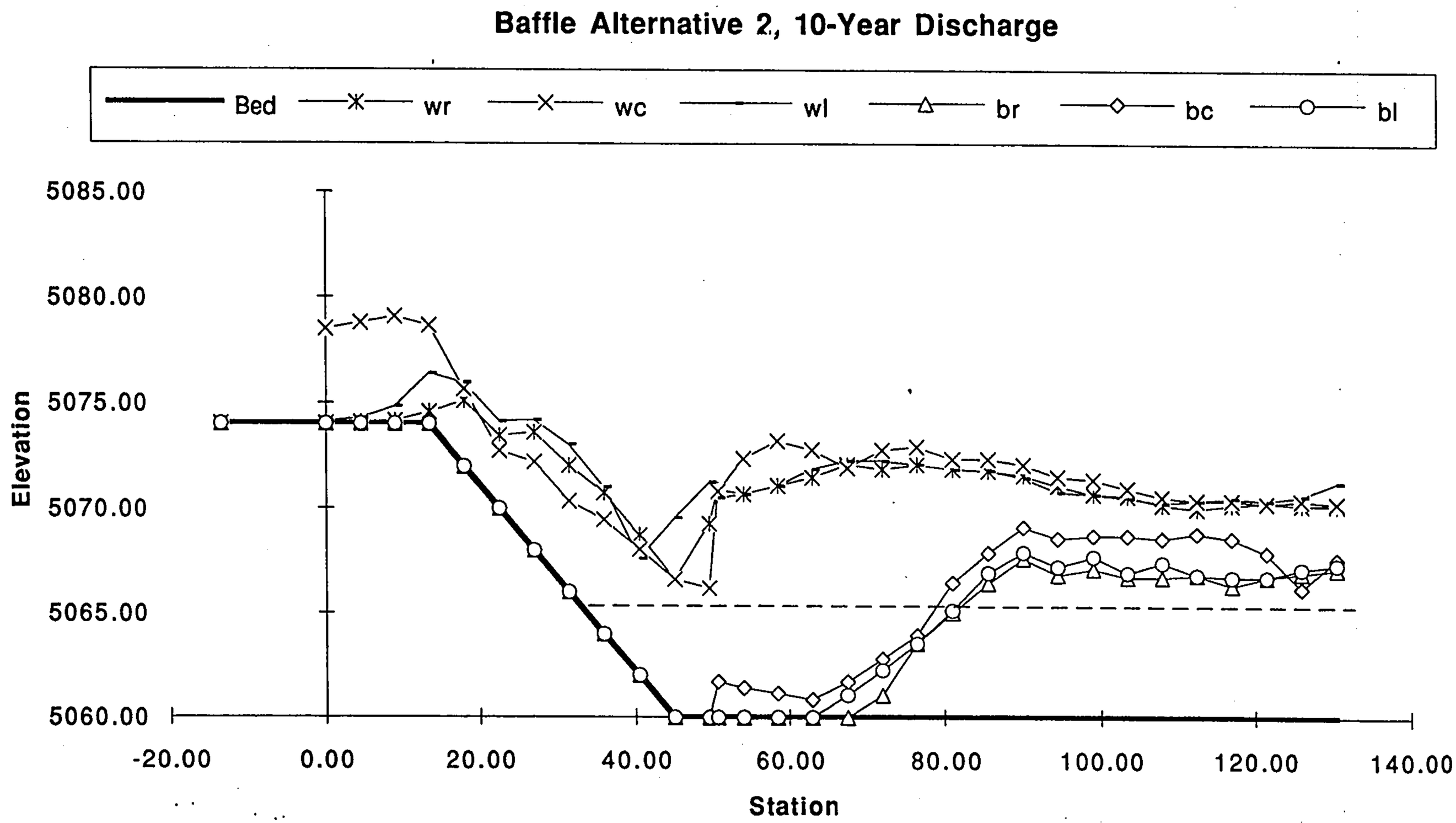

Figure 8. Alternative 2 (Top Baffle below Chute Brink),
10-Year Flow, 873 cfs.

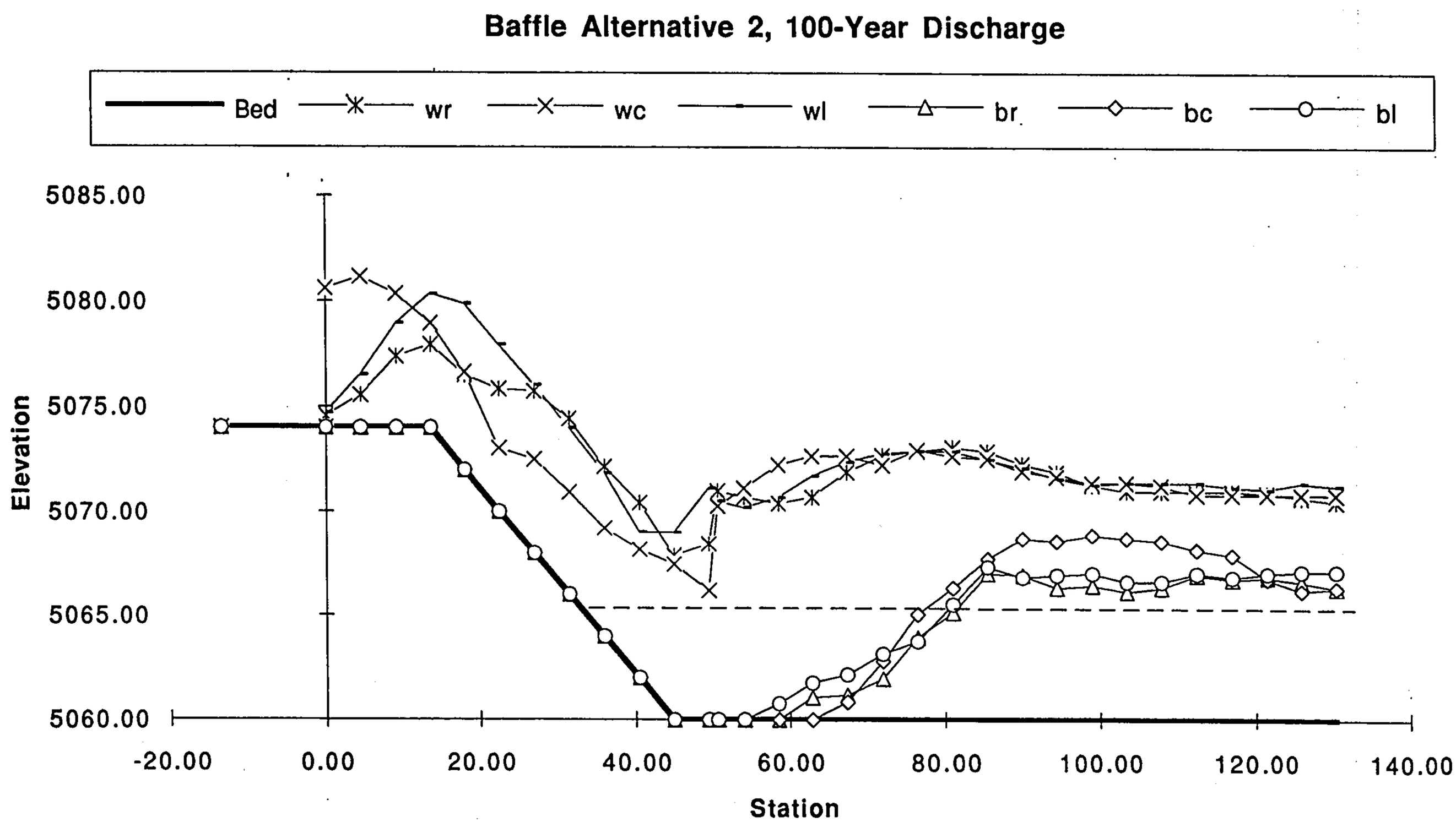

Figure 9. Alternative 2 (Top Baffle below Chute Brink),
100-Year Flow, 1290 cfs.

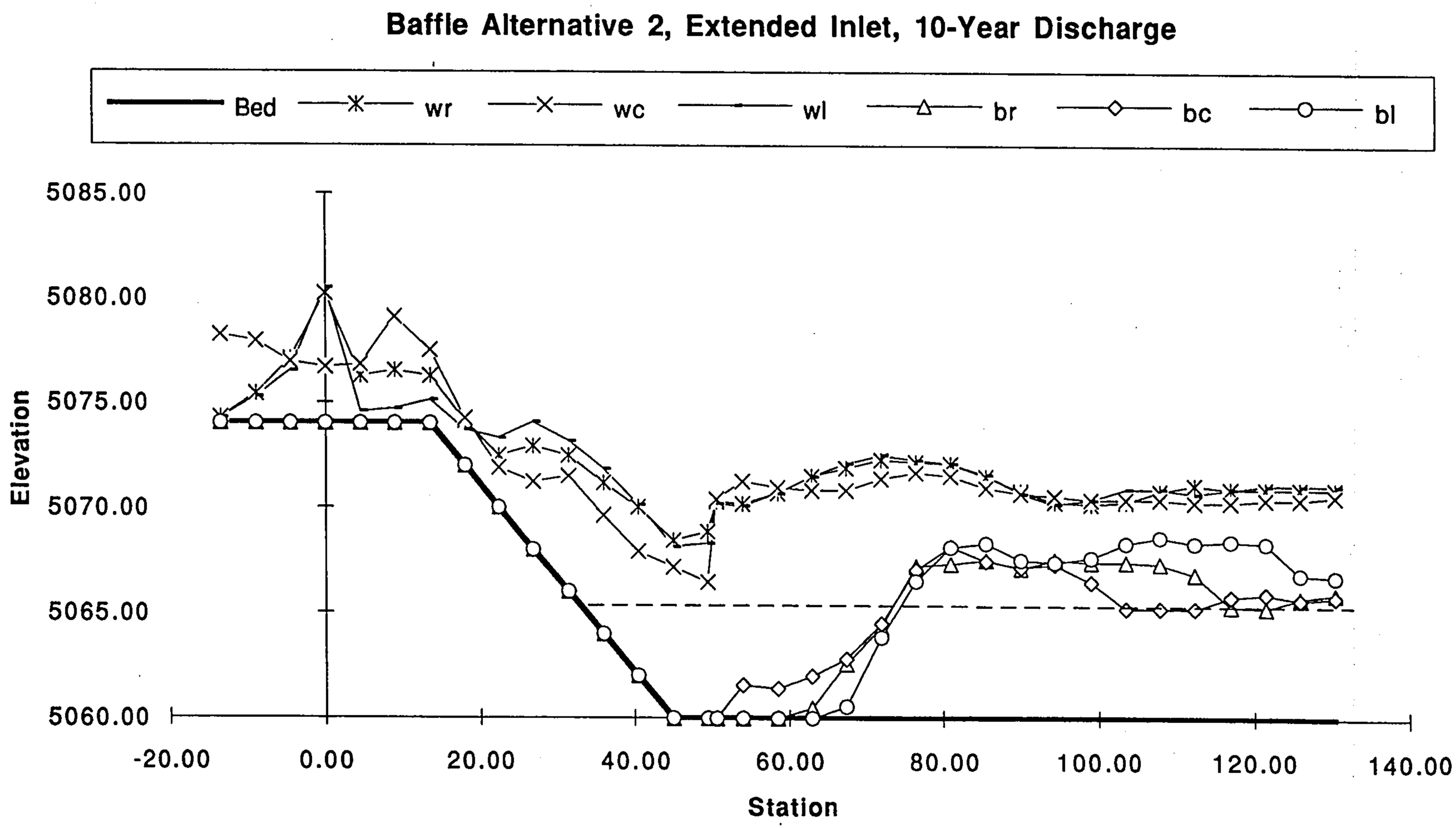

Figure 10. Extended Inlet,
Alternative 2 (Top Baffle below Chute Brink),
10-Year Flow, 873 cfs.

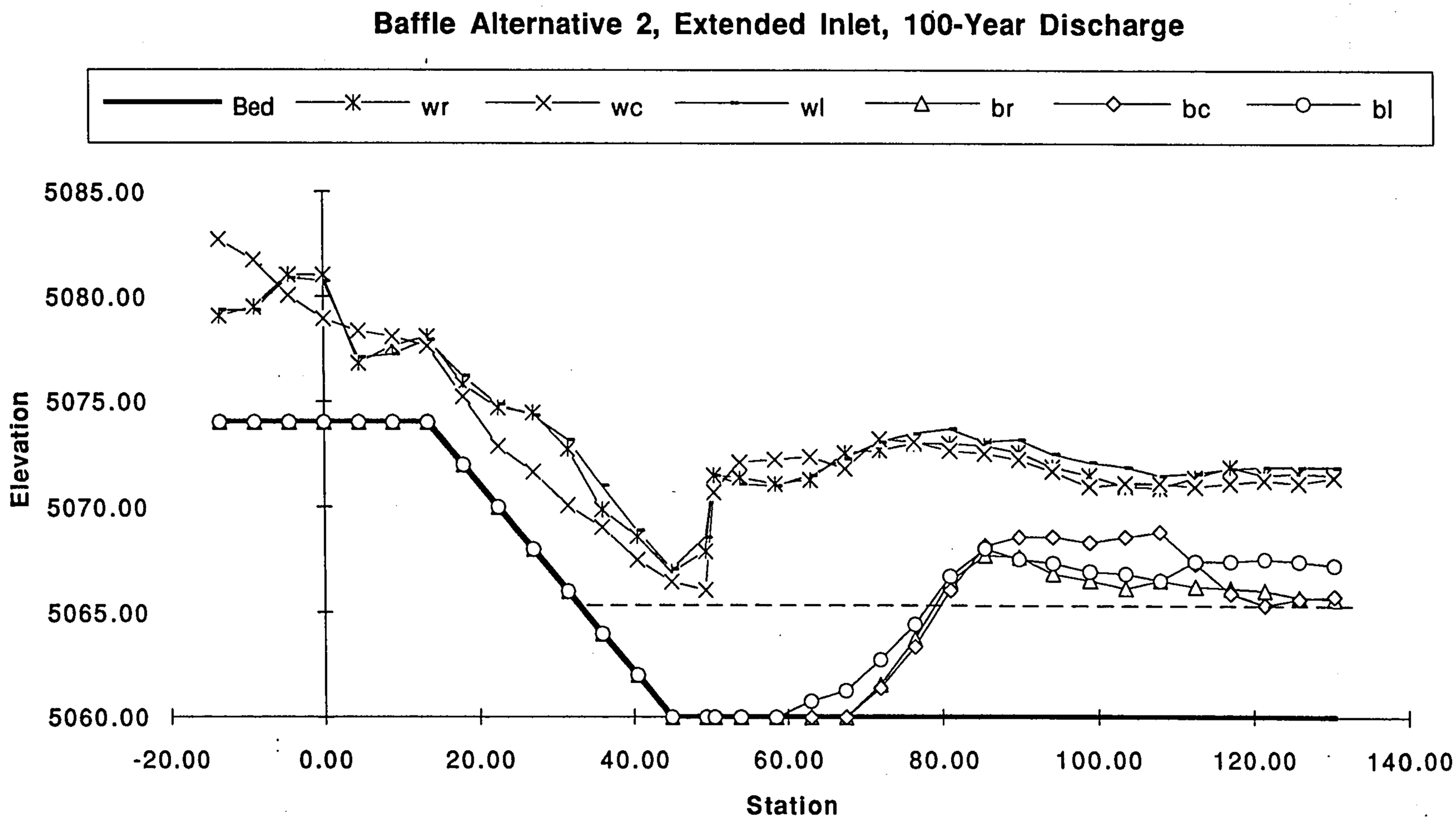

Figure 11. Extended Inlet,
Alternative 2 (Top Baffle below Chute Brink),
100-Year Flow, 1290 cfs.

Scour Hole

The 10-year Alternative 1 scour length below the chute toe is approximately 15 feet long. The 100-year length is approximately 45 feet. The 10 and 100-year Alternative 2 scour lengths are approximately 20 feet.

Velocities

The 100-year Alternative 2 mean cross-sectional velocities are given below. Values shown represent the range of measurements, as particular measurements are subject to error.

On Apron - 24.54, 17.18, 13.22, 12.73 fps. Velocity slows as flow spreads.

Down Chute - 11.37, 11.51, 9.55, 9.05, 9.11, 8.94, 7.95, 7.52 fps. Velocity appears to slow as splash depth increases. As velocities are not uniform, however, local velocities (such as between baffle teeth) are significantly higher.

Across Sour Hole - 3.98, 3.94, 3.85, 3.82, 4.34 fps. These velocities are low because depth is great. Local velocities, particularly at the bottom of the roller, are several fold higher.

Downstream - 5.20, 6.57, 9.67, 11.33, 11.89, 13.87, 13.03, 13.30, 14.67, 13.96, 13.13, 12.24, 12.46 fps. Velocity changes as flow draws toward normal depth.

Extended Inlet

In the model, the extended inlet was a vertical-walled channel, but it could as well be a square conduit, as the water surface is drawing down. The extended inlet allows the flow cross-section to approach the horizontal before lateral expansion over the apron. Such evening of the water surface allows the full width of baffles to operate more uniformly. The net effect is less center splash

Discussion

The results support Alternative 2 baffle teeth. Alternative 2 uses less concrete, reduces the initial splash and better dissipates the energy.

All experiments show the cross-sectional depth disparity due to the circular inflow. A channel extension between the pipe and the apron reduces the maximum flow depth down the drop structure. In the Airport case, however, the expense of an additional pipe-to-box transition seems unwarranted, as the sidewall height is sufficient in all cases.

A scour resistant apron prevents undercutting of the drop structure toe, serving the role of the model floor below the gravel. Presuming Alternative 2,

this apron should extend at least 40 feet downstream at elevation 5060 and be backfilled to elevation 5065.

HEC-2 indicates 31 fps at the end of the apron, but HEC-2 presumes one-dimensional hydraulics. Experimentally, head loss is greater than HEC-2 indicates and velocity is thus less.

For Q=1290, b=20, Z=1, n=0.03, V_n is 11.23 fps. This report does not evaluate the downstream profile, but the measured velocities are in approximate agreement with a Manning's estimate. Backwater from Tijeras will decrease the velocities, but can not be presumed to occur.

The downstream channel is subject to flow velocities sufficient to scour sandy material. As long as the Tijeras provides the current downstream boundary condition, the zone of degradation will stabilize below the baffle chute, as illustrated in Figs. 1, 2, 6-11. If the Tijeras bed drops, however, the unlined channel tributary channel will headcut.

Conclusions

1) Use the Alternative 2 baffle teeth, allowing flow to begin the drop before impacting the first row.

2) Protect the tow of the baffle chute by a scour-resistant apron at least 40 feet long.

3) The extended inlet diminishes flow depth at the crest of the baffle. While such improvement in not needed for the Airport structure, an extension may be warranted where freeboard is limited.

Appendix

Notes:

1. Multiply model distances by 13.5 to get prototype distances.
2. Multiply model discharges by 1.49 in gpm to get prototype discharges in cfs.

	model							prototype										
Sta	Dist.	wr	wc	wl	br	bc	bl	Sta	wr	wc	wl	br	bc	bl	mean y	Z	Area	Vel
	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(sf)	(fps)
Alt 1		10-Year																
1	0	0.13	4.00	0.13	0.00	0.00	0.00	0.00	0.15	4.50	0.15	0.00	0.00	0.00	1.60	0	31.95	27.32
2	4	0.31	4.00	0.13	0.00	0.00	0.00	4.50	0.35	4.50	0.15	0.00	0.00	0.00	1.67	0	33.30	26.22
3	8	0.88	4.00	0.25	0.00	0.00	0.00	9.00	0.99	4.50	0.28	0.00	0.00	0.00	1.92	0	38.48	22.69
4	12	2.47	3.75	1.13	0.00	0.00	0.00	13.50	2.78	4.22	1.27	0.00	0.00	0.00	2.76	0	55.13	15.84
5	16	3.13	2.88	2.00	0.00	0.00	0.00	18.00	3.52	3.24	2.25	0.00	0.00	0.00	3.00	0	60.08	14.53
6	20	7.25	3.63	7.06	0.00	0.00	0.00	22.50	8.16	4.08	7.94	0.00	0.00	0.00	6.73	0	134.55	6.49
7	24	10.50	7.13	11.25	0.00	0.00	0.00	27.00	11.81	8.02	12.66	0.00	0.00	0.00	10.83	0	216.60	4.03
8	28	10.88	8.69	13.44	0.00	0.00	0.00	31.50	12.24	9.78	15.12	0.00	0.00	0.00	12.38	0	247.57	3.53
9	32	10.13	11.00	13.25	0.00	0.00	0.00	36.00	11.40	12.38	14.91	0.00	0.00	0.00	12.89	0	257.85	3.39
10	36	9.88	12.31	13.50	0.00	0.00	0.00	40.50	11.12	13.85	15.19	0.00	0.00	0.00	13.38	0	267.68	3.26
11	40	9.50	12.63	13.75	0.00	0.00	0.00	45.00	10.69	14.21	15.47	0.00	0.00	0.00	13.46	0	269.10	3.24
12	44	9.13	12.50	12.00	0.00	0.00	0.00	49.50	10.27	14.06	13.50	0.00	0.00	0.00	12.61	0	252.23	3.46
13	45	9.29	12.50	9.21	0.00	0.00	0.00	50.63	10.45	14.06	10.36	0.00	0.00	0.00	11.63	1	367.64	2.37
14	48	9.21	13.00	9.34	0.00	0.00	0.00	54.00	10.36	14.63	10.51	0.00	0.00	0.00	11.83	1	376.60	2.32
15	52	9.43	10.50	9.51	0.00	0.00	0.32	58.50	10.61	11.81	10.70	0.00	0.00	0.36	10.92	1	337.65	2.59
16	56	9.96	10.00	10.09	0.50	1.50	0.85	63.00	11.21	11.25	11.35	0.56	1.69	0.96	10.20	1	308.04	2.83
17	60	10.80	11.50	10.49	1.38	3.00	1.56	67.50	12.15	12.94	11.80	1.55	3.38	1.76	10.07	1	302.75	2.88
18	64	11.02	11.00	10.71	2.88	4.50	2.35	72.00	12.40	12.38	12.05	3.24	5.06	2.64	8.63	1	246.89	3.54
19	68	11.11	10.75	10.49	4.74	5.50	2.88	76.50	12.50	12.09	11.80	5.33	6.19	3.24	7.21	1	196.23	4.45
20	72	10.84	10.75	10.27	5.98	6.75	4.74	81.00	12.20	12.09	11.55	6.73	7.59	5.33	5.40	1	137.04	6.37
21	76	10.40	10.50	10.00	6.86	7.75	6.33	85.50	11.70	11.81	11.25	7.72	8.72	7.12	3.74	1	88.65	9.85
22	80	10.22	10.13	9.69	6.84	7.75	5.80	90.00	11.50	11.40	10.90	7.70	8.72	6.53	3.62	1	85.47	10.21
23	84	9.82	9.63	9.43	6.51	8.25	5.45	94.50	11.05	10.83	10.61	7.32	9.28	6.13	3.25	1	75.60	11.55
24	88	9.25	9.50	9.25	6.38	7.75	5.27	99.00	10.41	10.69	10.41	7.18	8.72	5.93	3.23	1	74.90	11.66
25	92	9.43	9.31	9.25	6.69	7.75	5.09	103.50	10.61	10.47	10.41	7.53	8.72	5.73	3.17	1	73.51	11.88
26	96	9.51	9.25	9.25	6.55	7.75	5.27	108.00	10.70	10.41	10.41	7.37	8.72	5.93	3.17	1	73.32	11.91
27	100	9.34	9.13	9.25	6.33	7.50	4.74	112.50	10.51	10.27	10.41	7.12	8.44	5.33	3.43	1	80.40	10.86
28	104	8.98	9.00	9.25	6.24	7.25	4.92	117.00	10.10	10.13	10.41	7.02	8.16	5.54	3.31	1	77.09	11.32
29	108	8.76	9.00	9.34	5.45	5.75	4.65	121.50	9.86	10.13	10.51	6.13	6.47	5.23	4.22	1	102.17	8.54
30	112	8.63	9.00	9.69	6.33	4.88	4.92	126.00	9.71	10.13	10.90	7.12	5.49	5.54	4.20	1	101.53	8.60
31	116	8.98	9.00	9.51	6.77	4.88	5.09	130.50	10.10	10.13	10.70	7.62	5.49	5.73	4.03	1	96.88	9.01

	model							prototype										
Sta	Dist.	wr	wc	wl	br	bc	bl	Sta	wr	wc	wl	br	bc	bl	mean y	Z	Area	Vel
	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(sf)	(fps)
Alt 1	100-Year																	
1	0	1.00	7.50	2.00	0.00	0.00	0.00	0.00	1.13	8.44	2.25	0.00	0.00	0.00	3.94	0	78.75	16.38
2	4	2.00	6.63	4.50	0.00	0.00	0.00	4.50	2.25	7.46	5.06	0.00	0.00	0.00	4.92	0	98.47	13.10
3	8	4.00	5.38	5.38	0.00	0.00	0.00	9.00	4.50	6.05	6.05	0.00	0.00	0.00	5.54	0	110.70	11.65
4	12	5.00	3.75	5.25	0.00	0.00	0.00	13.50	5.63	4.22	5.91	0.00	0.00	0.00	5.25	0	105.00	12.29
5	16	5.13	3.00	6.00	0.00	0.00	0.00	18.00	5.77	3.38	6.75	0.00	0.00	0.00	5.30	0	105.97	12.17
6	20	6.94	3.44	6.69	0.00	0.00	0.00	22.50	7.81	3.87	7.53	0.00	0.00	0.00	6.40	0	128.03	10.08
7	24	9.88	6.38	8.38	0.00	0.00	0.00	27.00	11.12	7.18	9.43	0.00	0.00	0.00	9.24	0	184.80	6.98
8	28	11.25	8.13	8.50	0.00	0.00	0.00	31.50	12.66	9.15	9.56	0.00	0.00	0.00	10.46	0	209.10	6.17
9	32	11.25	9.00	8.38	0.00	0.00	0.00	36.00	12.66	10.13	9.43	0.00	0.00	0.00	10.74	0	214.73	6.01
10	36	11.25	9.50	8.25	0.00	0.00	0.00	40.50	12.66	10.69	9.28	0.00	0.00	0.00	10.88	0	217.50	5.93
11	40	10.00	9.00	9.00	0.00	0.00	0.00	45.00	11.25	10.13	10.13	0.00	0.00	0.00	10.50	0	210.00	6.14
12	44	9.00	7.50	12.00	0.00	0.00	0.00	49.50	10.13	8.44	13.50	0.00	0.00	0.00	10.69	0	213.75	6.04
13	45	10.93	10.88	10.52	0.00	0.00	0.00	50.63	12.30	12.24	11.84	0.00	0.00	0.00	12.12	1	389.46	3.31
14	48	10.49	10.75	10.49	0.00	0.00	0.00	54.00	11.80	12.09	11.80	0.00	0.00	0.00	11.90	1	379.56	3.40
15	52	10.40	11.63	10.40	0.00	0.00	0.00	58.50	11.70	13.08	11.70	0.00	0.00	0.00	12.16	1	391.12	3.30
16	56	10.75	12.00	10.66	0.00	0.00	0.00	63.00	12.09	13.50	11.99	0.00	0.00	0.00	12.53	1	407.54	3.17
17	60	10.75	12.00	10.93	0.00	0.00	0.00	67.50	12.09	13.50	12.30	0.00	0.00	0.00	12.63	1	412.12	3.13
18	64	11.11	12.00	11.02	0.00	0.00	0.00	72.00	12.50	13.50	12.40	0.00	0.00	0.00	12.80	1	419.78	3.07
19	68	11.28	12.13	11.28	0.00	0.00	0.00	76.50	12.69	13.65	12.69	0.00	0.00	0.00	13.01	1	429.40	3.00
20	72	11.46	12.25	11.46	0.00	0.00	0.00	81.00	12.89	13.78	12.89	0.00	0.00	0.00	13.19	1	437.72	2.95
21	76	11.64	12.25	11.64	0.00	0.00	0.00	85.50	13.10	13.78	13.10	0.00	0.00	0.00	13.32	1	444.00	2.91
22	80	11.81	12.38	11.72	0.00	0.00	1.21	90.00	13.29	13.93	13.19	0.00	0.00	1.36	13.01	1	429.58	3.00
23	84	11.99	12.50	11.90	1.91	0.88	3.68	94.50	13.49	14.06	13.39	2.15	0.99	4.14	11.22	1	350.29	3.68
24	88	11.90	12.25	11.81	4.30	3.63	6.69	99.00	13.39	13.78	13.29	4.84	4.08	7.53	8.00	1	224.09	5.76
25	92	11.72	12.25	11.81	6.51	6.00	6.69	103.50	13.19	13.78	13.29	7.32	6.75	7.53	6.22	1	163.01	7.91
26	96	11.19	12.13	11.46	6.51	7.38	6.69	108.00	12.59	13.65	12.89	7.32	8.30	7.53	5.33	1	134.86	9.57
27	100	11.11	11.63	11.37	6.16	8.00	6.95	112.50	12.50	13.08	12.79	6.93	9.00	7.82	4.88	1	121.27	10.64
28	104	10.93	11.00	11.16	5.80	8.13	6.60	117.00	12.30	12.38	12.56	6.53	9.15	7.43	4.71	1	116.38	11.08
29	108	10.66	10.50	11.02	5.89	8.25	6.07	121.50	11.99	11.81	12.40	6.63	9.28	6.83	4.49	1	109.92	11.74
30	112	10.40	10.75	10.93	5.89	8.50	5.71	126.00	11.70	12.09	12.30	6.63	9.56	6.42	4.49	1	110.03	11.72
31	116	10.22	10.50	10.00	5.45	8.25	5.98	130.50	11.50	11.81	11.25	6.13	9.28	6.73	4.14	1	99.94	12.91

	model							prototype										
Sta	Dist.	wr	wc	wl	br	bc	bl	Sta	wr	wc	wl	br	bc	bl	mean y	Z	Area	Vel
	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(sf)	(fps)
Alt 2	10-Year																	
1	0	0.00	4.00	0.13	0.00	0.00	0.00	0.00	0.00	4.50	0.15	0.00	0.00	0.00	1.55	0	30.98	28.18
2	4	0.06	4.25	0.25	0.00	0.00	0.00	4.50	0.07	4.78	0.28	0.00	0.00	0.00	1.71	0	34.20	25.53
3	8	0.13	4.50	0.75	0.00	0.00	0.00	9.00	0.15	5.06	0.84	0.00	0.00	0.00	2.02	0	40.35	21.64
4	12	0.50	4.13	2.13	0.00	0.00	0.00	13.50	0.56	4.65	2.40	0.00	0.00	0.00	2.54	0	50.70	17.22
5	16	2.75	3.25	3.50	0.00	0.00	0.00	18.00	3.09	3.66	3.94	0.00	0.00	0.00	3.56	0	71.25	12.25
6	20	3.06	2.44	3.69	0.00	0.00	0.00	22.50	3.44	2.75	4.15	0.00	0.00	0.00	3.45	0	68.93	12.67
7	24	5.00	3.75	5.50	0.00	0.00	0.00	27.00	5.63	4.22	6.19	0.00	0.00	0.00	5.34	0	106.88	8.17
8	28	5.38	3.88	6.25	0.00	0.00	0.00	31.50	6.05	4.37	7.03	0.00	0.00	0.00	5.82	0	116.33	7.50
9	32	6.00	4.88	6.25	0.00	0.00	0.00	36.00	6.75	5.49	7.03	0.00	0.00	0.00	6.42	0	128.48	6.80
10	36	6.00	5.38	5.00	0.00	0.00	0.00	40.50	6.75	6.05	5.63	0.00	0.00	0.00	6.14	0	122.85	7.11
11	40	5.88	5.88	8.50	0.00	0.00	0.00	45.00	6.62	6.62	9.56	0.00	0.00	0.00	7.60	0	151.95	5.75
12	44	8.25	5.50	10.00	0.00	0.00	0.00	49.50	9.28	6.19	11.25	0.00	0.00	0.00	8.91	0	178.13	4.90
13	45	9.69	9.63	9.34	0.00	1.50	0.00	50.63	10.90	10.83	10.51	0.00	1.69	0.00	10.19	1	307.43	2.84
14	48	9.51	11.00	9.51	0.00	1.25	0.00	54.00	10.70	12.38	10.70	0.00	1.41	0.00	10.79	1	332.17	2.63
15	52	9.87	11.75	9.87	0.00	1.00	0.00	58.50	11.10	13.22	11.10	0.00	1.13	0.00	11.43	1	359.41	2.43
16	56	10.22	11.38	10.57	0.00	0.75	0.00	63.00	11.50	12.80	11.89	0.00	0.84	0.00	11.78	1	374.48	2.33
17	60	10.75	10.63	10.93	0.00	1.50	0.94	67.50	12.09	11.96	12.30	0.00	1.69	1.06	11.20	1	349.49	2.50
18	64	10.57	11.38	10.93	0.94	2.50	2.00	72.00	11.89	12.80	12.30	1.06	2.81	2.25	10.29	1	311.68	2.80
19	68	10.75	11.50	10.75	3.15	3.50	3.15	76.50	12.09	12.94	12.09	3.54	3.94	3.54	8.70	1	249.69	3.50
20	72	10.57	11.00	10.57	4.48	5.75	4.56	81.00	11.89	12.38	11.89	5.04	6.47	5.13	6.51	1	172.46	5.06
21	76	10.49	11.00	10.49	5.71	7.00	6.16	85.50	11.80	12.38	11.80	6.42	7.88	6.93	4.92	1	122.49	7.13
22	80	10.31	10.75	10.22	6.77	8.13	7.04	90.00	11.60	12.09	11.50	7.62	9.15	7.92	3.50	1	82.32	10.61
23	84	9.87	10.25	9.60	6.07	7.63	6.42	94.50	11.10	11.53	10.80	6.83	8.58	7.22	3.60	1	84.96	10.28
24	88	9.51	10.13	9.51	6.33	7.75	6.86	99.00	10.70	11.40	10.70	7.12	8.72	7.72	3.08	1	71.05	12.29
25	92	9.43	9.75	9.34	5.98	7.75	6.16	103.50	10.61	10.97	10.51	6.73	8.72	6.93	3.24	1	75.20	11.61
26	96	9.07	9.38	9.16	5.98	7.63	6.60	108.00	10.20	10.55	10.31	6.73	8.58	7.43	2.78	1	63.20	13.81
27	100	8.90	9.25	9.25	6.07	7.83	6.07	112.50	10.01	10.41	10.41	6.83	8.81	6.83	2.79	1	63.49	13.75
28	104	9.07	9.25	9.34	5.63	7.63	5.98	117.00	10.20	10.41	10.51	6.33	8.58	6.73	3.16	1	73.12	11.94
29	108	9.16	9.13	9.25	5.98	7.00	5.98	121.50	10.31	10.27	10.41	6.73	7.88	6.73	3.22	1	74.70	11.69
30	112	9.07	9.25	9.43	6.16	5.50	6.33	126.00	10.20	10.41	10.61	6.93	6.19	7.12	3.66	1	86.60	10.08
31	116	9.07	9.13	10.00	6.33	6.75	6.51	130.50	10.20	10.27	11.25	7.12	7.59	7.32	3.23	1	75.00	11.64

	model							prototype										
Sta	Dist.	wr	wc	wl	br	bc	bl	Sta	wr	wc	wl	br	bc	bl	mean y	Z	Area	Vel
	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(sf)	(fps)
Alt 2	100-Year																	
1	0	0.50	5.88	0.63	0.00	0.00	0.00	0.00	0.56	6.62	0.71	0.00	0.00	0.00	2.63	0	52.58	24.54
2	4	1.38	6.38	2.25	0.00	0.00	0.00	4.50	1.55	7.18	2.53	0.00	0.00	0.00	3.75	0	75.08	17.18
3	8	3.00	5.63	4.38	0.00	0.00	0.00	9.00	3.38	6.33	4.93	0.00	0.00	0.00	4.88	0	97.58	13.22
4	12	3.50	4.38	5.63	0.00	0.00	0.00	13.50	3.94	4.93	6.33	0.00	0.00	0.00	5.07	0	101.33	12.73
5	16	4.00	4.13	7.00	0.00	0.00	0.00	18.00	4.50	4.65	7.88	0.00	0.00	0.00	5.67	0	113.47	11.37
6	20	5.19	2.69	7.06	0.00	0.00	0.00	22.50	5.84	3.03	7.94	0.00	0.00	0.00	5.60	0	112.05	11.51
7	24	6.88	4.00	7.13	0.00	0.00	0.00	27.00	7.74	4.50	8.02	0.00	0.00	0.00	6.75	0	135.08	9.55
8	28	7.50	4.38	7.13	0.00	0.00	0.00	31.50	8.44	4.93	8.02	0.00	0.00	0.00	7.13	0	142.58	9.05
9	32	7.25	4.63	7.00	0.00	0.00	0.00	36.00	8.16	5.21	7.88	0.00	0.00	0.00	7.08	0	141.60	9.11
10	36	7.50	5.50	6.25	0.00	0.00	0.00	40.50	8.44	6.19	7.03	0.00	0.00	0.00	7.22	0	144.38	8.94
11	40	7.00	6.63	8.00	0.00	0.00	0.00	45.00	7.88	7.46	9.00	0.00	0.00	0.00	8.11	0	162.23	7.95
12	44	7.50	5.50	9.88	0.00	0.00	0.00	49.50	8.44	6.19	11.12	0.00	0.00	0.00	8.58	0	171.60	7.52
13	45	9.78	9.13	9.34	0.00	0.00	0.00	50.63	11.00	10.27	10.51	0.00	0.00	0.00	10.59	1	324.10	3.98
14	48	9.51	9.88	9.07	0.00	0.00	0.00	54.00	10.70	11.12	10.20	0.00	0.00	0.00	10.67	1	327.35	3.94
15	52	9.25	10.88	9.51	0.00	0.00	0.68	58.50	10.41	12.24	10.70	0.00	0.00	0.77	10.86	1	335.14	3.85
16	56	9.51	11.25	10.40	0.94	0.00	1.56	63.00	10.70	12.66	11.70	1.06	0.00	1.76	10.75	1	330.46	3.90
17	60	10.57	11.25	11.02	1.03	0.75	1.91	67.50	11.89	12.66	12.40	1.16	0.84	2.15	10.93	1	338.12	3.82
18	64	11.28	10.88	11.37	1.74	2.50	2.80	72.00	12.69	12.24	12.79	1.96	2.81	3.15	9.93	1	297.35	4.34
19	68	11.46	11.50	11.46	3.50	4.50	3.33	76.50	12.89	12.94	12.89	3.94	5.06	3.75	8.66	1	248.15	5.20
20	72	11.64	11.25	11.46	4.56	5.63	4.92	81.00	13.10	12.66	12.89	5.13	6.33	5.54	7.22	1	196.36	6.57
21	76	11.46	11.13	11.11	6.24	6.88	6.51	85.50	12.89	12.52	12.50	7.02	7.74	7.32	5.28	1	133.36	9.67
22	80	10.93	10.63	10.75	6.16	7.75	6.07	90.00	12.30	11.96	12.09	6.93	8.72	6.83	4.62	1	113.85	11.33
23	84	10.57	10.38	10.31	5.63	7.63	6.16	94.50	11.89	11.68	11.60	6.33	8.58	6.93	4.44	1	108.51	11.89
24	88	10.04	10.13	10.04	5.71	7.88	6.24	99.00	11.30	11.40	11.30	6.42	8.87	7.02	3.89	1	93.00	13.87
25	92	9.78	10.13	10.13	5.45	7.75	5.89	103.50	11.00	11.40	11.40	6.13	8.72	6.63	4.11	1	98.99	13.03
26	96	9.78	10.00	10.13	5.63	7.63	5.89	108.00	11.00	11.25	11.40	6.33	8.58	6.63	4.04	1	96.98	13.30
27	100	9.78	9.63	10.13	6.16	7.25	6.24	112.50	11.00	10.83	11.40	6.93	8.16	7.02	3.71	1	87.93	14.67
28	104	9.78	9.63	9.96	5.98	7.00	6.07	117.00	11.00	10.83	11.21	6.73	7.88	6.83	3.87	1	92.38	13.96
29	108	9.69	9.63	9.87	6.07	6.00	6.24	121.50	10.90	10.83	11.10	6.83	6.75	7.02	4.08	1	98.25	13.13
30	112	9.51	9.63	10.13	5.89	5.50	6.33	126.00	10.70	10.83	11.40	6.63	6.19	7.12	4.33	1	105.38	12.24
31	116	9.34	9.63	10.00	5.63	5.63	6.33	130.50	10.51	10.83	11.25	6.33	6.33	7.12	4.27	1	103.56	12.46

	model							prototype										
Sta	Dist.	wr	wc	wl	br	bc	bl	Sta	wr	wc	wl	br	bc	bl	mean y	Z	Area	Vel
	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(sf)	(fps)
Alt 2, Extended Inlet				10-Year														
-2	-12	0.25	3.75	0.25	0.00	0.00	0.00	-13.50	0.28	4.22	0.28	0.00	0.00	0.00	1.59	0	31.88	27.39
-1	-8	1.25	3.50	1.13	0.00	0.00	0.00	-9.00	1.41	3.94	1.27	0.00	0.00	0.00	2.21	0	44.10	19.80
0	-4	2.75	2.63	2.25	0.00	0.00	0.00	-4.50	3.09	2.96	2.53	0.00	0.00	0.00	2.86	0	57.23	15.26
1	0	5.50	2.38	5.75	0.00	0.00	0.00	0.00	6.19	2.68	6.47	0.00	0.00	0.00	5.11	0	102.23	8.54
2	4	2.00	2.50	0.50	0.00	0.00	0.00	4.50	2.25	2.81	0.56	0.00	0.00	0.00	1.88	0	37.50	23.28
3	8	2.25	4.50	0.63	0.00	0.00	0.00	9.00	2.53	5.06	0.71	0.00	0.00	0.00	2.77	0	55.35	15.77
4	12	2.00	3.13	1.00	0.00	0.00	0.00	13.50	2.25	3.52	1.13	0.00	0.00	0.00	2.30	0	45.98	18.99
5	16	1.88	2.00	1.50	0.00	0.00	0.00	18.00	2.12	2.25	1.69	0.00	0.00	0.00	2.02	0	40.35	21.64
6	20	2.19	1.69	2.94	0.00	0.00	0.00	22.50	2.46	1.90	3.31	0.00	0.00	0.00	2.56	0	51.15	17.07
7	24	4.38	2.88	5.38	0.00	0.00	0.00	27.00	4.93	3.24	6.05	0.00	0.00	0.00	4.74	0	94.80	9.21
8	28	5.75	4.88	6.38	0.00	0.00	0.00	31.50	6.47	5.49	7.18	0.00	0.00	0.00	6.38	0	127.58	6.84
9	32	6.38	5.00	7.00	0.00	0.00	0.00	36.00	7.18	5.63	7.88	0.00	0.00	0.00	6.89	0	137.85	6.33
10	36	7.13	5.25	7.25	0.00	0.00	0.00	40.50	8.02	5.91	8.16	0.00	0.00	0.00	7.36	0	147.23	5.93
11	40	7.50	6.38	7.25	0.00	0.00	0.00	45.00	8.44	7.18	8.16	0.00	0.00	0.00	7.92	0	158.48	5.51
12	44	7.88	5.75	7.38	0.00	0.00	0.00	49.50	8.87	6.47	8.30	0.00	0.00	0.00	7.88	0	157.58	5.54
13	45	9.16	9.25	9.07	0.00	0.00	0.00	50.63	10.31	10.41	10.20	0.00	0.00	0.00	10.31	1	312.29	2.80
14	48	9.07	10.00	8.98	0.00	1.38	0.00	54.00	10.20	11.25	10.10	0.00	1.55	0.00	10.00	1	300.05	2.91
15	52	9.51	9.75	9.51	0.00	1.25	0.00	58.50	10.70	10.97	10.70	0.00	1.41	0.00	10.32	1	312.90	2.79
16	56	10.22	9.63	10.22	0.41	1.75	0.00	63.00	11.50	10.83	11.50	0.46	1.97	0.00	10.47	1	318.87	2.74
17	60	10.57	9.63	10.75	2.27	2.50	0.50	67.50	11.89	10.83	12.09	2.55	2.81	0.56	9.63	1	285.34	3.06
18	64	10.93	10.13	11.11	3.86	4.00	3.42	72.00	12.30	11.40	12.50	4.34	4.50	3.85	7.83	1	218.04	4.00
19	68	10.84	10.38	10.93	6.42	6.25	5.80	76.50	12.20	11.68	12.30	7.22	7.03	6.53	5.13	1	128.92	6.77
20	72	10.75	10.25	10.75	6.51	7.25	7.22	81.00	12.09	11.53	12.09	7.32	8.16	8.12	4.04	1	97.09	8.99
21	76	10.22	9.75	10.31	6.69	6.63	7.39	85.50	11.50	10.97	11.60	7.53	7.46	8.31	3.59	1	84.65	10.31
22	80	9.60	9.50	9.51	6.33	6.38	6.69	90.00	10.80	10.69	10.70	7.12	7.18	7.53	3.45	1	81.00	10.78
23	84	9.16	9.38	9.07	6.69	6.50	6.60	94.50	10.31	10.55	10.20	7.53	7.31	7.43	2.93	1	67.25	12.98
24	88	9.07	9.25	9.25	6.60	5.75	6.77	99.00	10.20	10.41	10.41	7.43	6.47	7.62	3.17	1	73.42	11.89
25	92	9.16	9.25	9.69	6.60	4.63	7.39	103.50	10.31	10.41	10.90	7.43	5.21	8.31	3.56	1	83.74	10.43
26	96	9.60	9.25	9.69	6.51	4.63	7.66	108.00	10.80	10.41	10.90	7.32	5.21	8.62	3.65	1	86.39	10.11
27	100	9.87	9.13	9.51	6.07	4.63	7.39	112.50	11.10	10.27	10.70	6.83	5.21	8.31	3.91	1	93.42	9.35
28	104	9.69	9.13	9.69	4.74	5.13	7.48	117.00	10.90	10.27	10.90	5.33	5.77	8.42	4.19	1	101.21	8.63
29	108	9.69	9.25	9.87	4.65	5.25	7.39	121.50	10.90	10.41	11.10	5.23	5.91	8.31	4.32	1	105.06	8.31
30	112	9.69	9.25	9.87	5.09	5.00	6.07	126.00	10.90	10.41	11.10	5.73	5.63	6.83	4.74	1	117.38	7.44
31	116	9.69	9.38	9.87	5.27	5.13	5.98	130.50	10.90	10.55	11.10	5.93	5.77	6.73	4.71	1	116.38	7.50

	model							prototype										
Sta	Dist.	wr	wc	wl	br	bc	bl	Sta	wr	wc	wl	br	bc	bl	mean y	Z	Area	Vel
	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(sf)	(fps)
Alt 2, Extended Inlet 100-Year																		
-2	-12	4.50	7.75	4.75	0.00	0.00	0.00	-13.50	5.06	8.72	5.34	0.00	0.00	0.00	6.38	0	127.50	10.12
-1	-8	4.88	6.88	4.75	0.00	0.00	0.00	-9.00	5.49	7.74	5.34	0.00	0.00	0.00	6.19	0	123.83	10.42
0	-4	6.25	5.38	6.13	0.00	0.00	0.00	-4.50	7.03	6.05	6.90	0.00	0.00	0.00	6.66	0	133.20	9.68
1	0	6.25	4.38	6.00	0.00	0.00	0.00	0.00	7.03	4.93	6.75	0.00	0.00	0.00	6.24	0	124.72	10.34
2	4	2.50	3.88	2.75	0.00	0.00	0.00	4.50	2.81	4.37	3.09	0.00	0.00	0.00	3.42	0	68.48	18.84
3	8	3.25	3.63	2.88	0.00	0.00	0.00	9.00	3.66	4.08	3.24	0.00	0.00	0.00	3.66	0	73.20	17.62
4	12	3.63	3.25	3.50	0.00	0.00	0.00	13.50	4.08	3.66	3.94	0.00	0.00	0.00	3.89	0	77.85	16.57
5	16	3.38	2.88	3.75	0.00	0.00	0.00	18.00	3.80	3.24	4.22	0.00	0.00	0.00	3.75	0	75.08	17.18
6	20	4.19	2.56	4.31	0.00	0.00	0.00	22.50	4.71	2.88	4.85	0.00	0.00	0.00	4.15	0	82.95	15.55
7	24	5.75	3.25	5.63	0.00	0.00	0.00	27.00	6.47	3.66	6.33	0.00	0.00	0.00	5.49	0	109.72	11.76
8	28	6.00	3.63	6.38	0.00	0.00	0.00	31.50	6.75	4.08	7.18	0.00	0.00	0.00	6.00	0	120.08	10.74
9	32	5.25	4.50	6.25	0.00	0.00	0.00	36.00	5.91	5.06	7.03	0.00	0.00	0.00	6.00	0	120.00	10.75
10	36	5.88	4.88	6.13	0.00	0.00	0.00	40.50	6.62	5.49	6.90	0.00	0.00	0.00	6.33	0	126.68	10.18
11	40	6.13	5.75	6.25	0.00	0.00	0.00	45.00	6.90	6.47	7.03	0.00	0.00	0.00	6.80	0	135.98	9.49
12	44	7.00	5.38	7.63	0.00	0.00	0.00	49.50	7.88	6.05	8.58	0.00	0.00	0.00	7.50	0	150.08	8.60
13	45	10.22	9.50	10.22	0.00	0.00	0.00	50.63	11.50	10.69	11.50	0.00	0.00	0.00	11.23	1	350.61	3.68
14	48	10.13	10.75	9.87	0.00	0.00	0.00	54.00	11.40	12.09	11.10	0.00	0.00	0.00	11.53	1	363.59	3.55
15	52	9.87	10.88	9.78	0.00	0.00	0.00	58.50	11.10	12.24	11.00	0.00	0.00	0.00	11.45	1	360.05	3.58
16	56	10.04	11.00	10.22	0.00	0.00	0.68	63.00	11.30	12.38	11.50	0.00	0.00	0.77	11.47	1	360.85	3.57
17	60	11.16	10.50	10.93	0.00	0.00	1.12	67.50	12.56	11.81	12.30	0.00	0.00	1.26	11.80	1	375.29	3.44
18	64	11.28	11.75	11.64	1.38	1.25	2.44	72.00	12.69	13.22	13.10	1.55	1.41	2.75	11.10	1	345.21	3.74
19	68	11.55	11.63	11.99	3.33	3.00	3.95	76.50	12.99	13.08	13.49	3.75	3.38	4.44	9.33	1	273.79	4.71
20	72	11.55	11.25	12.17	5.80	5.38	5.98	81.00	12.99	12.66	13.69	6.53	6.05	6.73	6.68	1	178.18	7.24
21	76	11.46	11.13	11.64	6.86	7.25	7.13	85.50	12.89	12.52	13.10	7.72	8.16	8.02	4.87	1	121.15	10.65
22	80	11.19	10.88	11.72	6.77	7.63	6.69	90.00	12.59	12.24	13.19	7.62	8.58	7.53	4.76	1	117.93	10.94
23	84	10.57	10.38	11.11	6.07	7.63	6.51	94.50	11.89	11.68	12.50	6.83	8.58	7.32	4.44	1	108.62	11.88
24	88	10.22	9.75	10.75	5.80	7.38	6.16	99.00	11.50	10.97	12.09	6.53	8.30	6.93	4.27	1	103.56	12.46
25	92	9.78	9.88	10.57	5.45	7.63	6.07	103.50	11.00	11.12	11.89	6.13	8.58	6.83	4.16	1	100.36	12.85
26	96	9.69	9.88	10.22	5.80	7.83	5.80	108.00	10.90	11.12	11.50	6.53	8.81	6.53	3.89	1	92.79	13.90
27	100	10.13	9.75	10.31	5.54	6.50	6.60	112.50	11.40	10.97	11.60	6.23	7.31	7.43	4.33	1	105.38	12.24
28	104	10.57	9.88	10.49	5.45	5.25	6.60	117.00	11.89	11.12	11.80	6.13	5.91	7.43	5.12	1	128.46	10.04
29	108	10.22	10.00	10.57	5.36	4.75	6.69	121.50	11.50	11.25	11.89	6.03	5.34	7.53	5.25	1	132.45	9.74
30	112	10.31	9.88	10.57	5.09	5.00	6.60	126.00	11.60	11.12	11.89	5.73	5.63	7.43	5.28	1	133.36	9.67
31	116	10.22	10.13	10.57	5.01	5.13	6.42	130.50	11.50	11.40	11.89	5.64	5.77	7.22	5.39	1	136.70	9.44