REVISED DRYWELL BREAK
BASE CASE ANALYSIS

July, 1985

GULF STATES UTILITIES COMPANY
RIVER BEND STATION - UNIT 1

INTRODUCTION

Two base case analyses performed to determine the River Bend Station (RBS) containment pressure and temperature response to hydrogen release and subsequent deflagration burning have been previously submitted to the NRC (Ref. 1). These base cases were the stuck open relief valve case (SORV) and the drywell break case (DWB). As requested by the NRC Staff during the June 13, 1985 meeting with Gulf States Utilities (GSU), a revised DWB base case analysis to evaluate the effect of reducing the steam flow, revising the drywell/ADS sparger flow split, modifying the radiant heat transfer beam length, and reducing the drywell bypass leakage for the drywell break base case has been completed. In addition, GSU is providing additional justification for the temperature of hydrogen released. With the exception of these parametric variations, all other CLASIX-3 input was unchanged except as noted herein.

STEAM FLOW

The effect of using a reduced steam flow for the DWB base case has been evaluated. The previous DWB base case utilized an initial blowdown release rate and flow split between the drywell break and the wetwell as calculated by the MAAP computer code. This was followed by a non-mechanistic release rate which was continued until a 75% metal-water reaction was achieved. The non-mechanistic hydrogen release rate used was 0.1 lbm/sec and is consistent with the release rates developed by the Hydrogen Control Owners Group (HCOG) (Ref. 2).

The non-mechanistic model developed by the HCOG was based on assuring that the severely damaged core remained coolable and was completely quenched (i.e., all excess stored energy removed) at the end of the transient. Based on this model, the maximum heat which could be removed from the severely deformed core is 51 Mw, considering heat loses from the top, bottom and sides of the deformed core. The previous DWB analysis assumed that this heat was removed by producing steam at the existing RPV pressure. For this analysis, it was assumed that a portion of this steam is used in producing hydrogen. Based on the HCOG non-mechanistic model, the steam produced while removing the core decay heat and excess stored energy is equivalent to 44.2 Mw. Therefore, the steam flow associated with hydrogen production is 6.8 Mw. For this analysis approximately twice as much steam was assumed to be consumed by hydrogen production. The steam flow used in this analysis was conservatively assumed to be equivalent to 36.3 Mw. The steam temperature used in this analysis is the same as in the previous analysis and corresponds to the RPV pressure for this condition. Steam release rates are given in Table 1.

FLOW SPLIT

The effect of revising the flow split between the drywell break and the ADS valves has also been evaluated. Based on a recent MAAP analysis performed under the auspices of HCOG, the flow split was determined to be a function of the total steam flow. This relationship is illustrated in Figure 1. For the revised analysis, flow split during the initial blowdown and the period of high hydrogen release was the same as the previous analysis and was obtained from a MAAP analysis. Following this, a flow split based on Figure 1 and the assumed steam flow was used. This flow split (85% to ADS spargers) was then used for the duration of the hydrogen/steam release.

BEAM LENGTH

The NRC Staff suggested that the magnitude of the beam length used in radiant heat transfer be varied from that of our previous analysis. This concern has previously been addressed by Mississippi Power and Light (MP&L) (Ref. 3). MP&L performed a drywell sensitivity study in which the beam length was reduced from 48.67 feet in the drywell to 20 feet. The only significant effect of this major reduction in beam length was a slight increase (approximately 13%) in the drywell peak pressure created by the burn. Based on the MP&L study, it can be concluded that minor variations in beam length will have an insignificant effect on results.

Even though the magnitude of the beam length has been shown to have little effect on the overall results, GSU has modified the beam lengths used in our analysis. The beam lengths used in the revised DWB base case analysis are based on the Chemical Engineers' Handbook (Ref. 4) and were calculated from

$$BL = 3.5\ V/A$$

Where: BL = Beam Length

V = Compartment Volume

A = Area of Compartment

The revised values used for beam length are given in Table 2.

DRYWELL BYPASS LEAKAGE

The magnitude of drywell bypass leakage used in our previous DWB base case has also been revised. The drywell bypass leakage used previously was 10% of the allowable bypass leakage which is equivalent to an A/ K of 0.115 ft^2. For the present analysis, the tested drywell bypass leakage has been used. The measured bypass leakage is equivalent to an A/ K of 0.014 ft^2.

HYDROGEN TEMPERATURE

The NRC Staff requested that additional justification for the assumed hydrogen temperature be provided. A definitive assessment of the hydrogen temperature has not been performed; however, certain qualitative justification can be made for the temperature used in the RBS analysis. First, the relative quantity of steam and hydrogen produced during the constant release portion of the transient will tend to reduce the impact of assuming that the hydrogen and steam are at the same temperature. For this analysis the mass flow rate for steam exceeds the hydrogen mass flow by a ratio of approximately 363 to 1.

Secondly, during this portion of the transient, the RPV must be flooded above the degraded core. Therefore, while the hydrogen and steam are passing through this pool they will reach equilibrium. In addition, the hydrogen and steam will be thoroughly mixed while passing through the steam separator and steam dryer. Since the steam temperature for this portion of the transient was based on the prevailing RPV pressure, the same temperature (saturation temperature) was used for the hydrogen.

OTHER INPUT

For the revised analysis, drawdown of the suppression pool was assumed to occur at 2300 sec. into the transient which is consistent with the MAAP analysis. The Quantity of water removed was equal to 4,526 cubic feet and was removed at a rate of 5000 gpm. In addition, the containment flow areas were reviewed and verified as correct as given in the previous DWB base case.

RESULTS & CONCLUSIONS

The results for the revised DWB base case are given in Table 3. A complete set of plots of results for the revised DWB base case are given in Figures 2-29.

During the period of hydrogen release, the peak temperatures and pressures in all volumes were reduced. When the analysis was extended past the end of hydrogen release, the drywell temperature was less than the previous analysis while the temperatures in the other volumes increased slightly. The pressures resulting from the final forced burn were reduced significantly.

Although no dramatic changes were observed in the results, the most important change appears to be due to the reduction in the bypass leak rate. With the lower leak rate, the slow increase in base temperature has been decreased or essentially eliminated. Also, because of the reduced partial pressure of the water vapor, the conditions for ignition were reached with fewer pounds of hydrogen so that the peak pressures

and temperatures were reduced and the amount of hydrogen remaining at the end of hydrogen release was also reduced. The relative magnitude of the forced burn, after the completion of hydrogen release, was a little more severe because of the absence of the steam.

REFERENCES

1. RBG-21,218 dated June 7, 1985 from GSU (J.E. Booker) to NRC (H.R. Denton)

2. HGN-034 dated May 17, 1985 from HCOG (S.H. Hobbs) to NRC (Robert Bernero)

3. AECN-83/0479 dated August 23, 1983 from MP&L (L.F. Dale) to NRC (H.R. Denton)

4. Perry, R. H. and Chilton, C. H., Chemical Engineer' Handbook, 5th Edition, 1973 p. 10-56.

TABLE 1

River Bend CLASIX-3 Input

Revised DWB Base Case

Steam Release to the Suppression Pool

TIME (SECONDS)	FLOW RATE (LB/SEC)	ENERGY RATE (BTU/SEC)
0.	294.81	3.508E5
0.43	622.5	7.433E5
4.84	3457.44	4.124E6
9.72	3058.33	3.655E6
12.2	279.15	3.349E5
28.05	262.84	3.139E5
30.88	0.	1.0
1059.	0.	1.0
1096.	952.56	1.149E6
1169.	461.07	5.584E5
1223.	318.84	3.857E5
1295.	226.89	2.741E5
1405.	150.34	1.819E5
1608.	79.49	9.890E4
1798.	26.02	3.198E4
2007.	0.5	5.830E2
2032.	0.	10.
2386.	0.	10.
2422.	75.26	1.089E5
2477.	108.55	1.683E5
2531.	156.05	2.513E5
2549.	154.5	2.768E5
2567.	255.13	3.257E5
2604.	179.2	2.337E5
2762.	2.75	3.573E3
2819.	0.	10.
3644.999	0.	1.
3645.	30.855	39918.
21569.	30.855	39918.
21569.001	0.	1.

TABLE 1

River Bend CLASIX-3 Input

Revised DWB Base Case

Steam Release to the Drywell

Sheet 2 of 4

TIME (SECONDS)	FLOW RATE (LB/SEC)	ENERGY RATE (BTU/SEC)
0.	259.53	3.088E5
0.43	273.86	3.270E5
20.78	234.39	2.794E5
78.77	228.88	2.753E5
150.1	227.78	2.751E5
321.4	200.99	2.418E5
518.1	180.02	2.170E5
702.1	168.93	2.042E5
1059.	142.35	1.723E5
1096.	104.78	1.263E5
1187.	44.83	5.435E4
1295.	24.96	3.015E4
1405.	16.54	2.001E4
1534.	11.02	1.362E4
1798.	5.65	6.942E3
2032.	6.93	8.094E3
2366.	4.86	5.781E3
2404.	6.79	9.467E3
2567.	24.76	3.582E4
2659.	11.01	1.431E4
2672.	5.74	8.473E3
2992.	0.74	9.570E2
3649.999	0.0	3.000E1
3645.	5.445	6.339E3
21569.	5.445	6.339E3
21569.001	0.0	1.

TABLE 1

River Bend CLASIX-3 Input

Revised DWB Base Case

Hydrogen Releases to the Drywell

Sheet 3 of 4

TIME (SECONDS)	FLOW RATE (LB/SEC)	TEMPERATURE (F)
1295.	0.00	364.6
1871.	6.E-4	346.4
2032.	1.E-4	254.8
2386.	.0523	288.44
2404.	.16	722.2
2422.	.098	830.6
2440.	.104	873.6
2458.	.215	976.8
2477.	.323	1032.2
2495.	.264	1130.8
2513.	.138	1327.6
2531.	.076	1149.0
2549.	.012	1480.4
2567.	.004	835.6
2819.	0.000	503.9
3644.999	0.0	250.34
3645.	0.015	250.34
21569.	0.015	250.34
21569.001	0.0	250.34

TABLE 1

River Bend CLASIX-3 Input

Revised DWB Base Case

Hydrogen Flow to the Suppression Pool

Sheet 4 of 4

TIME (SECONDS)	FLOW RATE (LB/SEC)	TEMPERATURE (F)
1295.	0.0	364.6
1853.	.0012	372.7
2032.	0.0	243.6
2386.	0.0	288.4
2404.	1.224	722.2
2422.	.877	830.6
2440.	.969	873.6
2458.	1.954	976.8
2477.	3.012	1032.2
2495.	2.397	1130.8
2513.	1.221	1327.6
2531.	.6948	1149.0
2549.	.011	1480.4
2819.	0.0	503.9
3644.999	0.0	250.34
3645.	0.085	250.34
21569.	0.085	250.34
21569.001	0.0	250.34

TABLE 2

Radiant Heat Transfer Beam Length

COMPARTMENT	BEAM LENGTH
Drywell	11.5 ft.
Wetwell	21.6 ft.
Intermediate Volume	4.8 ft.
Upper Containment	27.4 ft.

TABLE 3

Summary of CLASIX-3 Results

RBS Drywell Break

		DWB BASE CASE	REVISED DWB
Number Burns	DW	0 (0)	0 (0)
	WW	28 (1)	35 (1)
	IN	0 (1)	0 (1)
	CT	0 (1)	0 (1)
Total Burned (lb)	DW	0 (0)	0 (0)
	WW	1416 (1466)	1504 (1569)
	IN	0 (175)	0 (156)
	CT	0 (339)	0 (292)
H2 Remaining (lb)	DW	33 (31)	36 (36)
	WW	73 (9)	68 (.4)
	IN	178 (24)	157 (1)
	CT	355 (10)	290 (1)
Peak Temp. (F)	DW	388 (341)	374 (338)
	WW	1893 (1137)	1863 (1358)
	IN	640 (1039)	416 (1125)
	CT	202 (1154)	165 (1190)
Peak Press. (psig)	DW	19.3 (32.3)	12.0 (22.4)
	WW	20.3 (45.3)	12.7 (34.7)
	IN	17.3 (44.3)	10.5 (34.7)
	CT	16.3 (45.3)	10.0 (34.6)

*Drywell, wetwell, intermediate volume, and containment are abbreviated as DW, WW, IN, and CT.

( ) - Values due to extension of transient past end of hydrogen release. These values result from a hydrogen burn which was forced to occur in multiple containment volumes simultaneously.

Figure 1

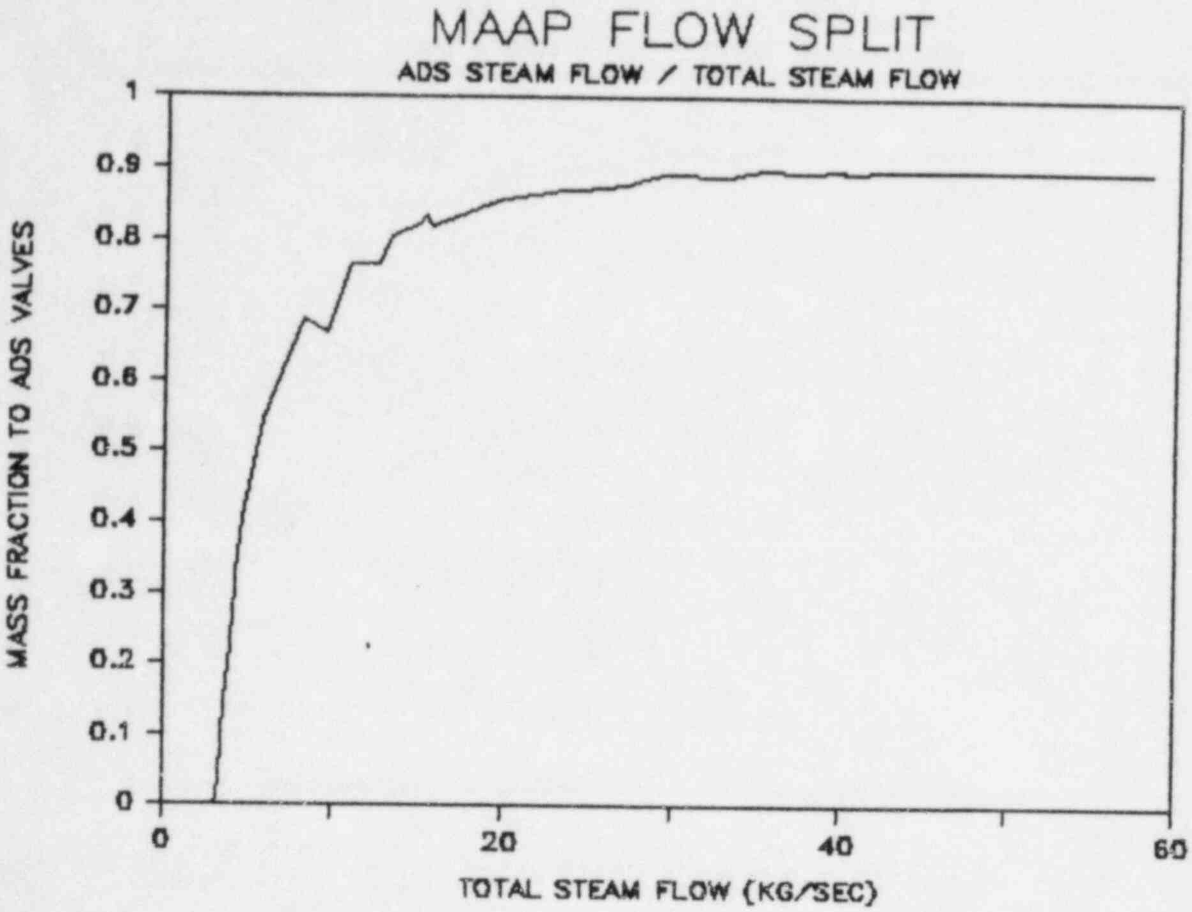
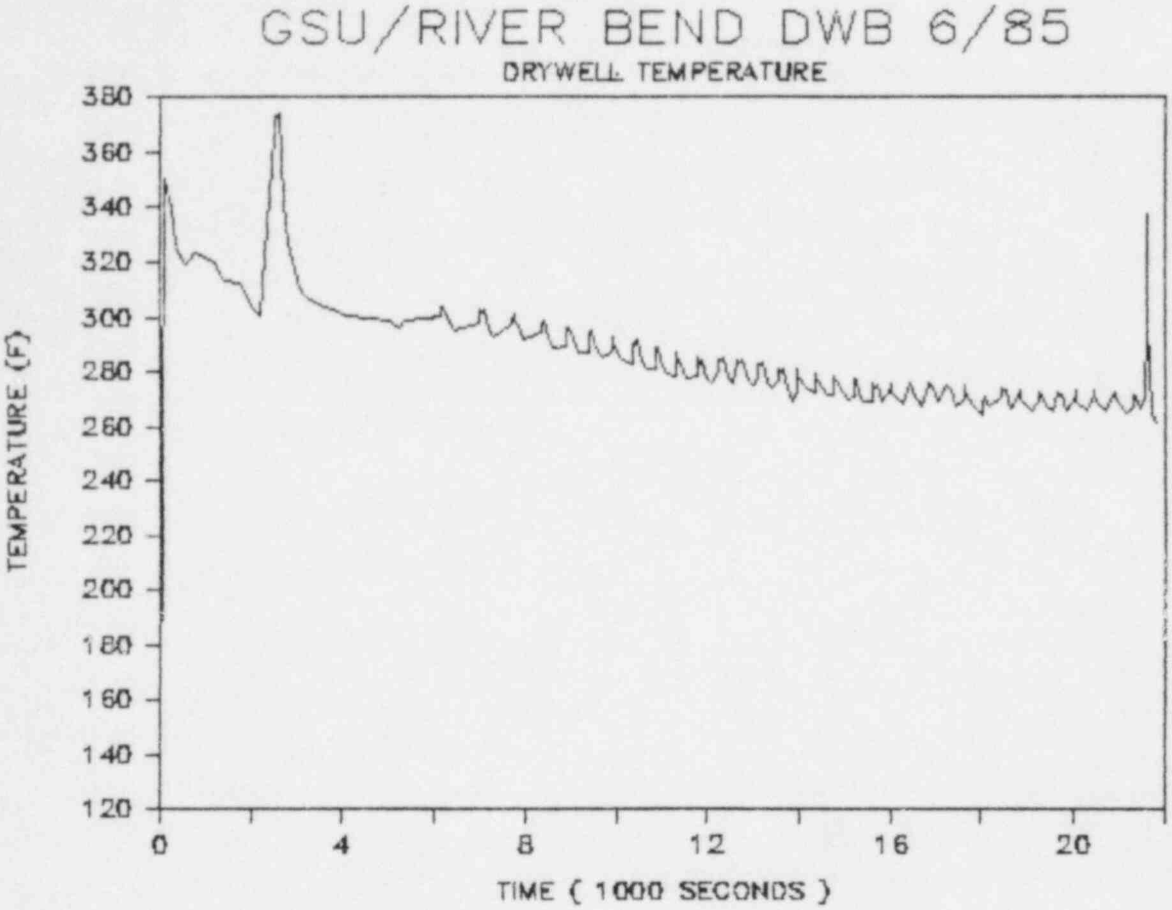
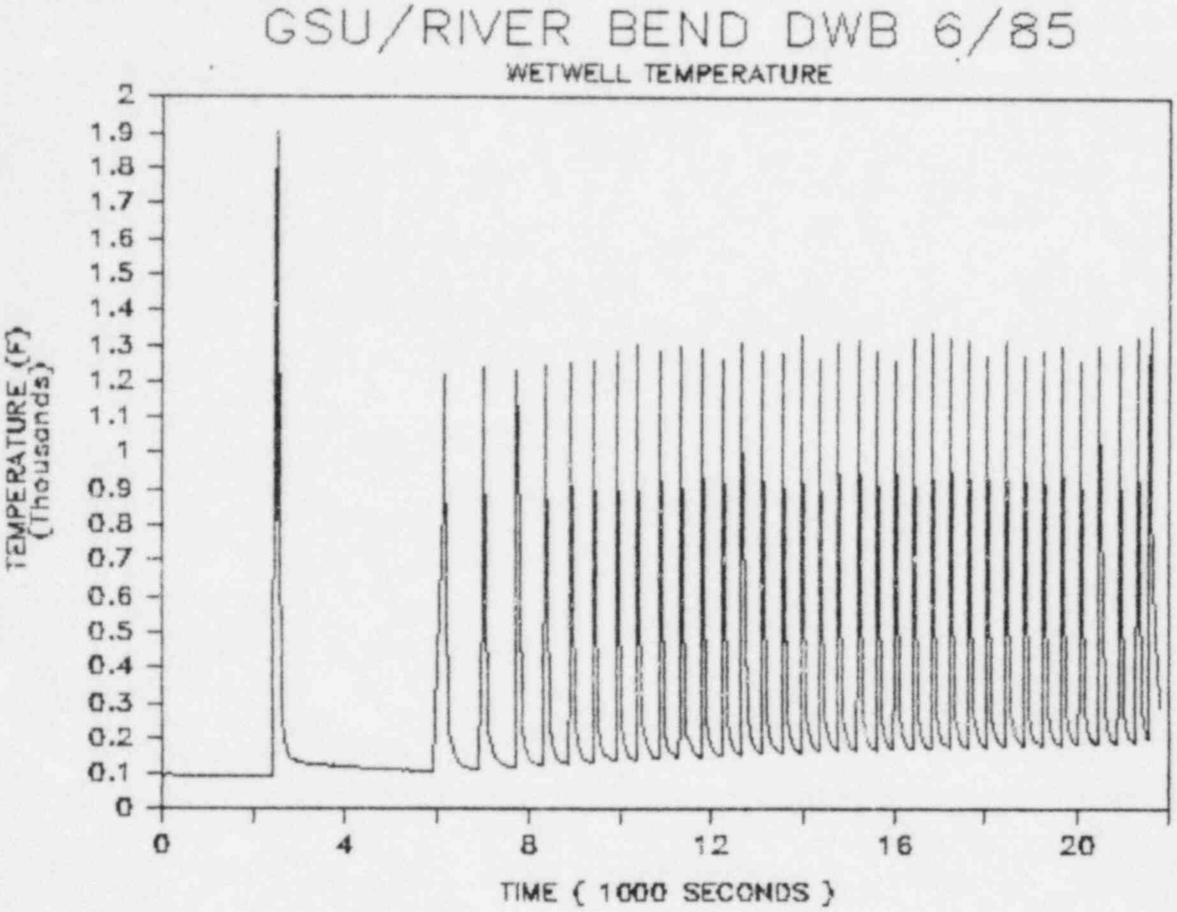

MAAP FLOW SPLIT
ADS STEAM FLOW / TOTAL STEAM FLOW
MASS FRACTION TO ADS VALVES
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
TOTAL STEAM FLOW (KG/SEC)

Figure 2



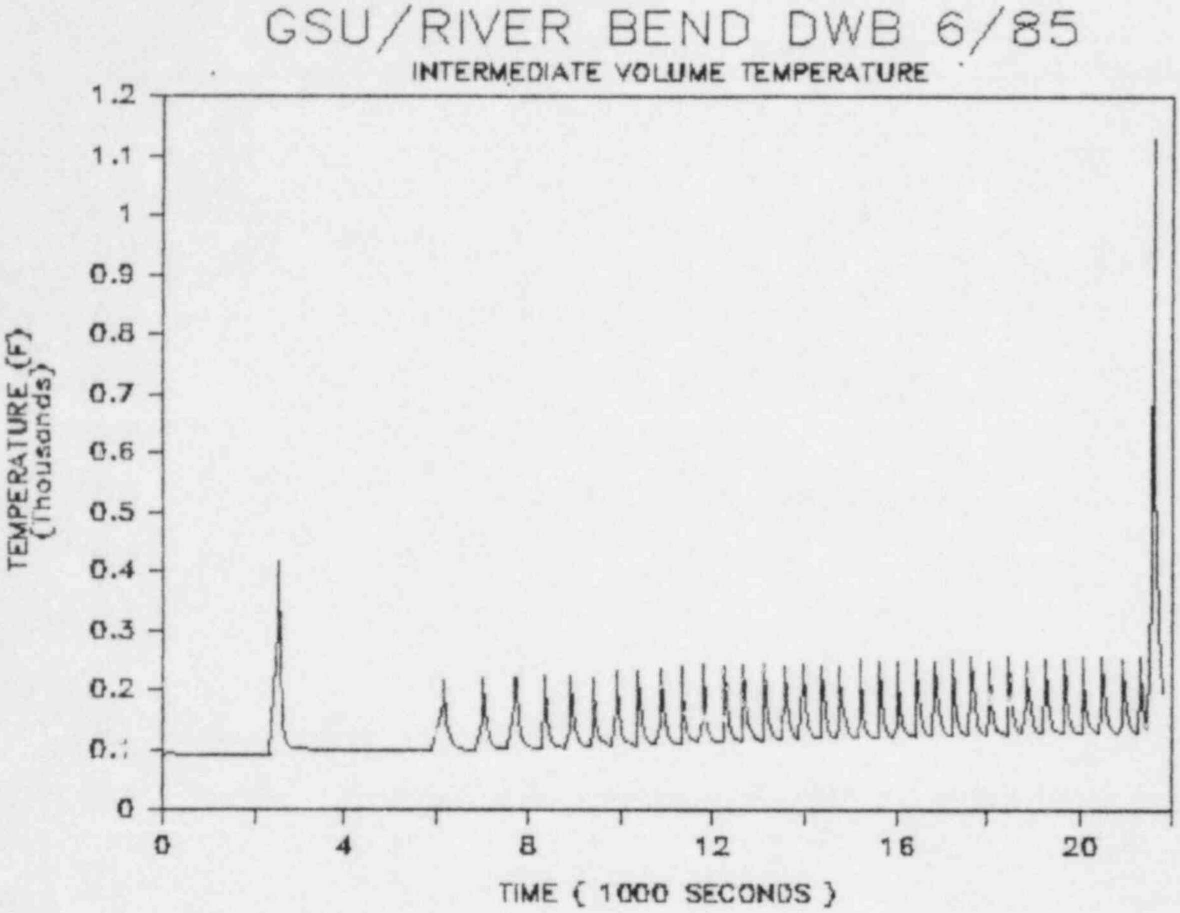
GSU/RIVER BEND DWB 6/85
DRYWELL TEMPERATURE
TEMPERATURE (F)
380
360
340
320
300
280
260
240
220
200
180
160
140
120
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 3



GSU/RIVER BEND DWB 6/85
WETWELL TEMPERATURE
TEMPERATURE (F) (Thousands)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 4



GSU/RIVER BEND DWB 6/85
INTERMEDIATE VOLUME TEMPERATURE
TEMPERATURE (F)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 5

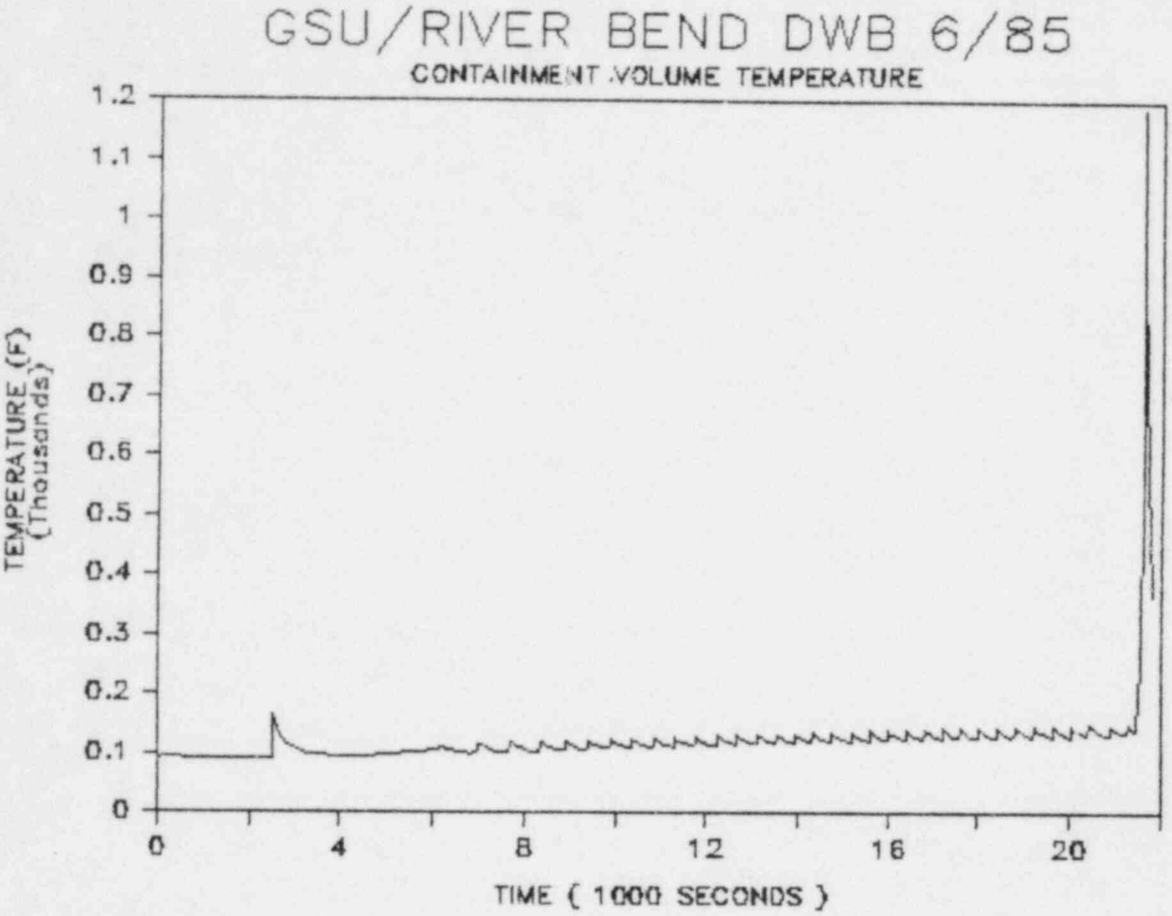
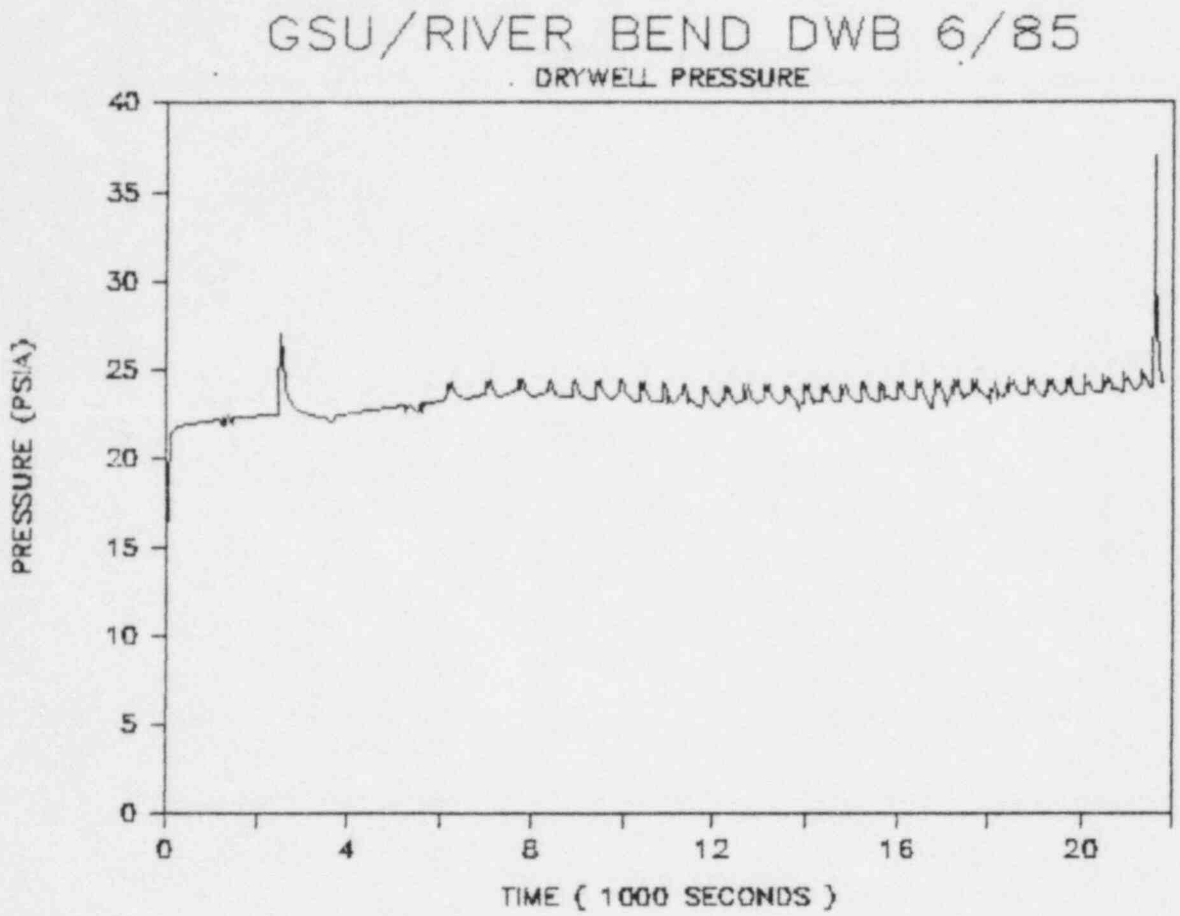

GSU/RIVER BEND DWB 6/85
CONTAINMENT VOLUME TEMPERATURE
TEMPERATURE (F)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 6



GSU/RIVER BEND DWB 6/85
DRYWELL PRESSURE
PRESSURE (PSIA)
40
35
30
25
20
15
10
5
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 7

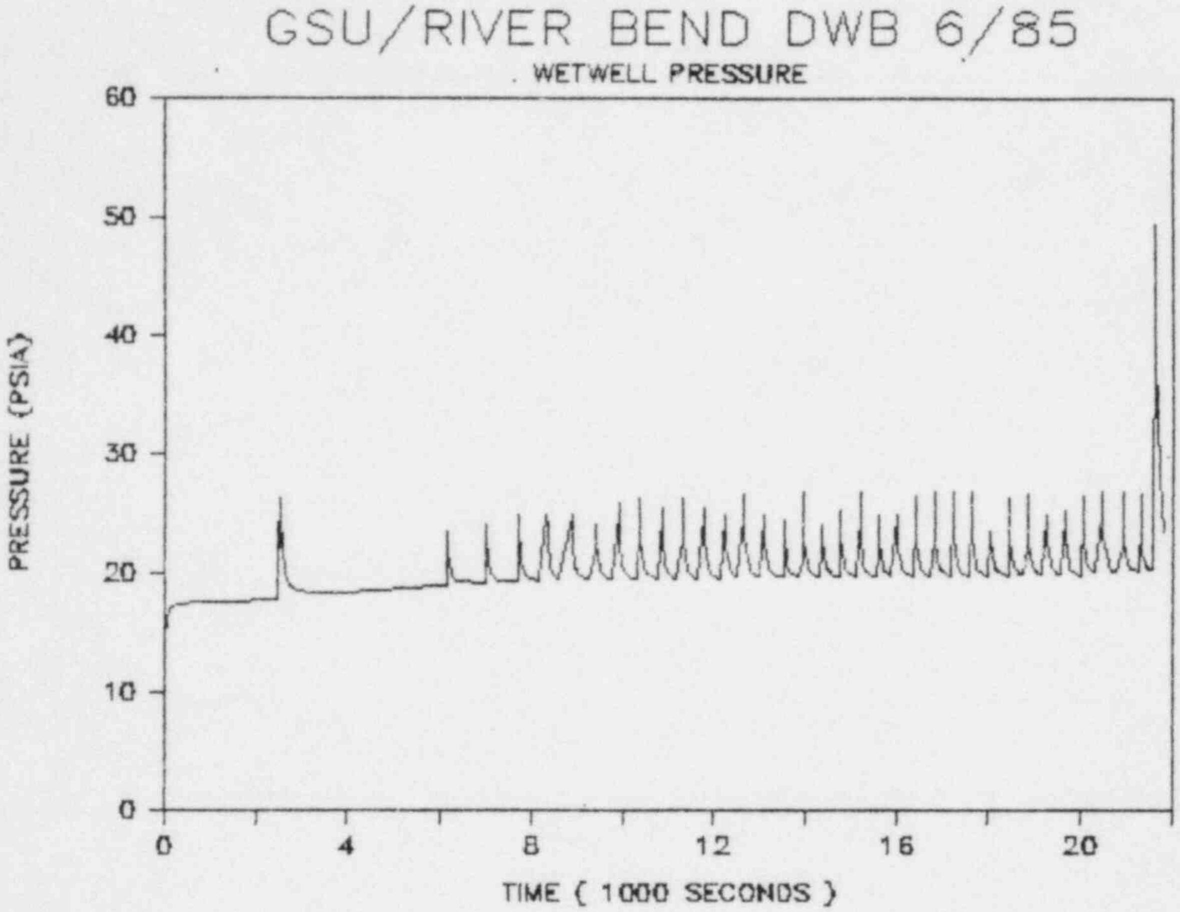
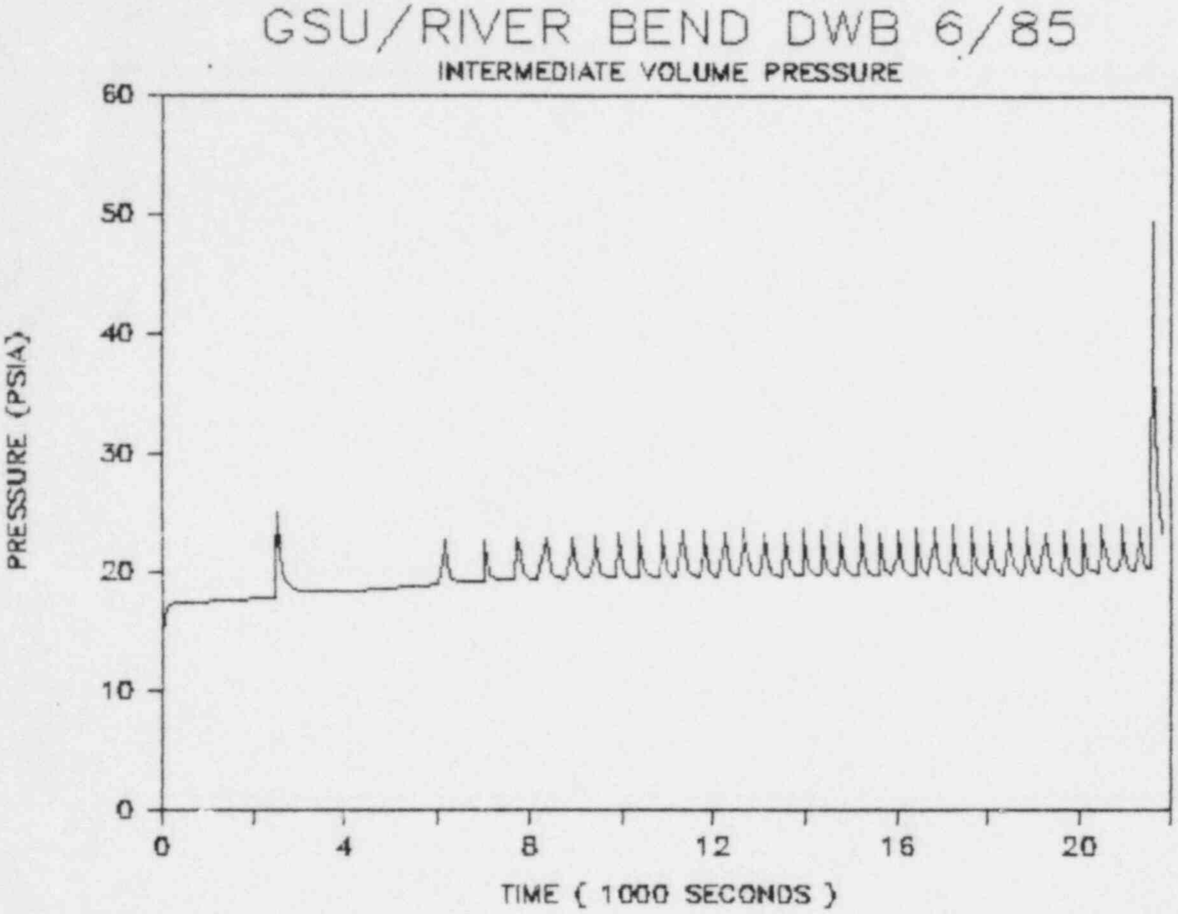

GSU/RIVER BEND DWB 6/85
WETWELL PRESSURE
PRESSURE (PSIA)
60
50
40
30
20
10
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 8



GSU/RIVER BEND DWB 6/85
INTERMEDIATE VOLUME PRESSURE
PRESSURE (PSIA)
TIME (1000 SECONDS)
0
10
20
30
40
50
60
0
4
8
12
16
20

Figure 9

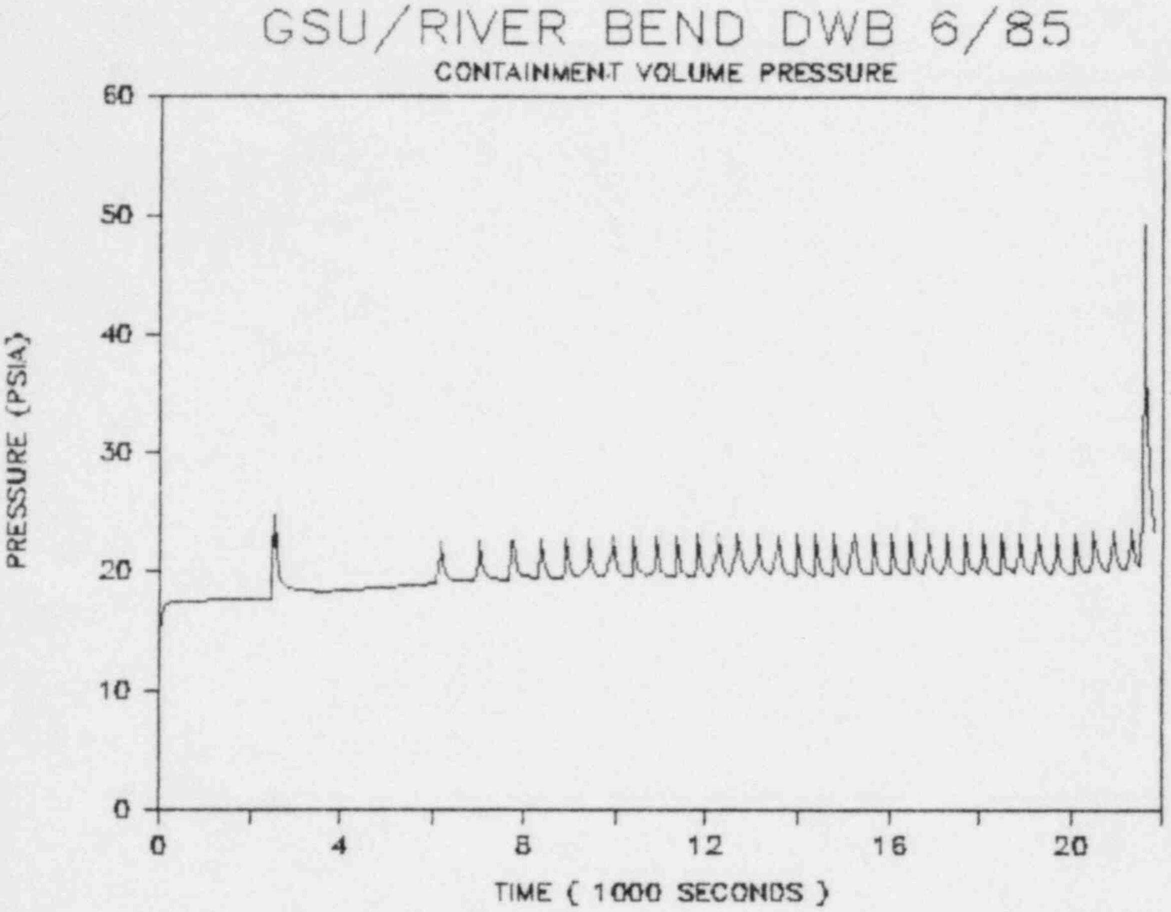
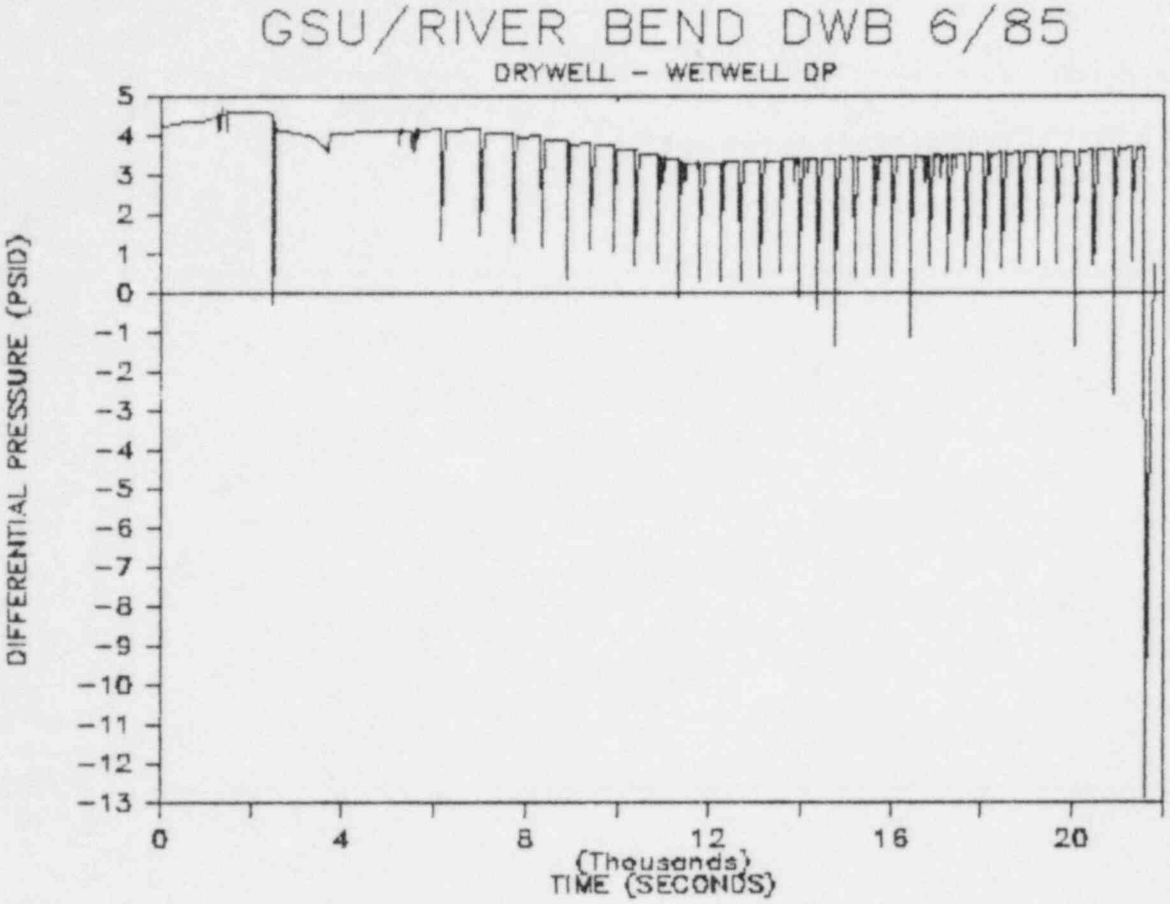

GSU/RIVER BEND DWB 6/85
CONTAINMENT VOLUME PRESSURE
PRESSURE (PSIA)
60
50
40
30
20
10
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 10



GSU/RIVER BEND DWB 6/85
DRYWELL - WETWELL DP
DIFFERENTIAL PRESSURE (PSID)
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
0
4
8
12
16
20
(Thousands)
TIME (SECONDS)

Figure 11

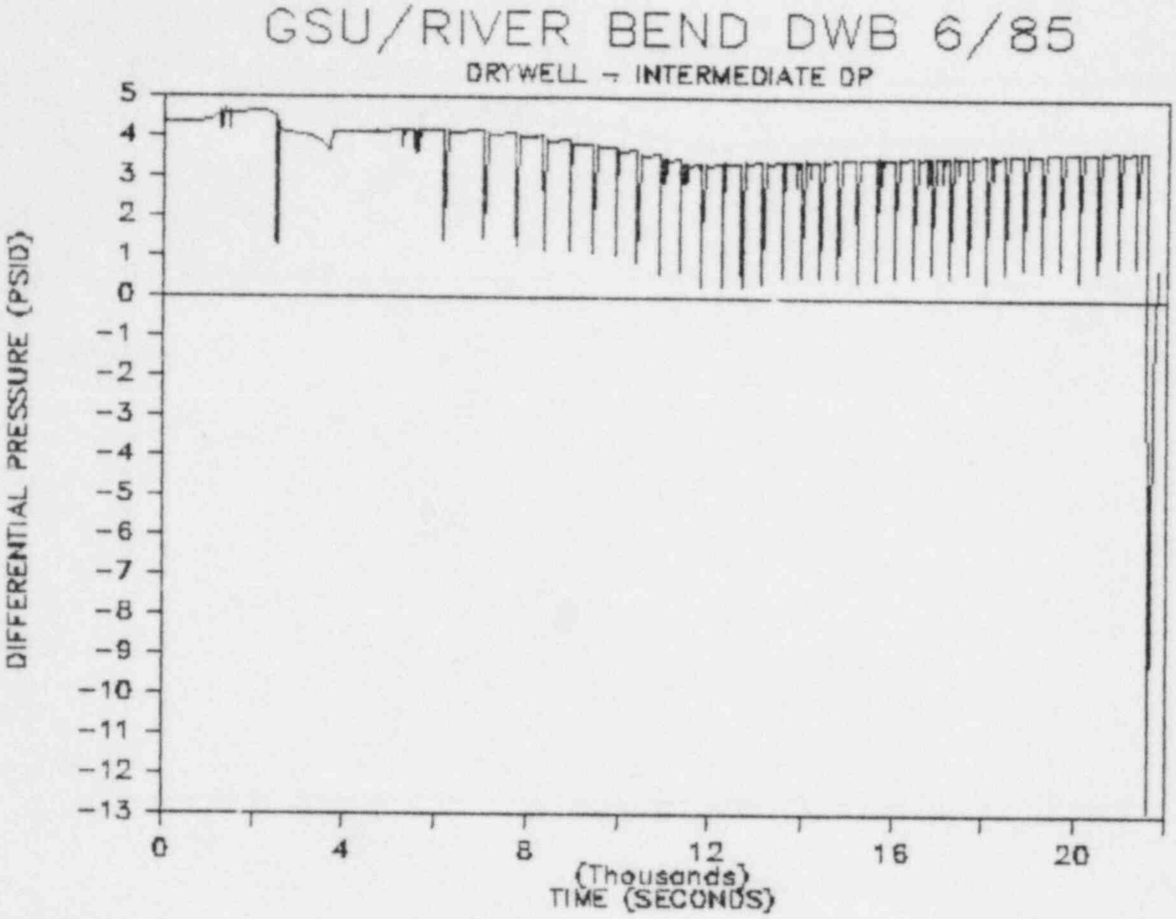

GSU/RIVER BEND DWB 6/85
DRYWELL - INTERMEDIATE DP
DIFFERENTIAL PRESSURE (PSID)
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
0
4
8
12
16
20
(Thousands)
TIME (SECONDS)

Figure 12

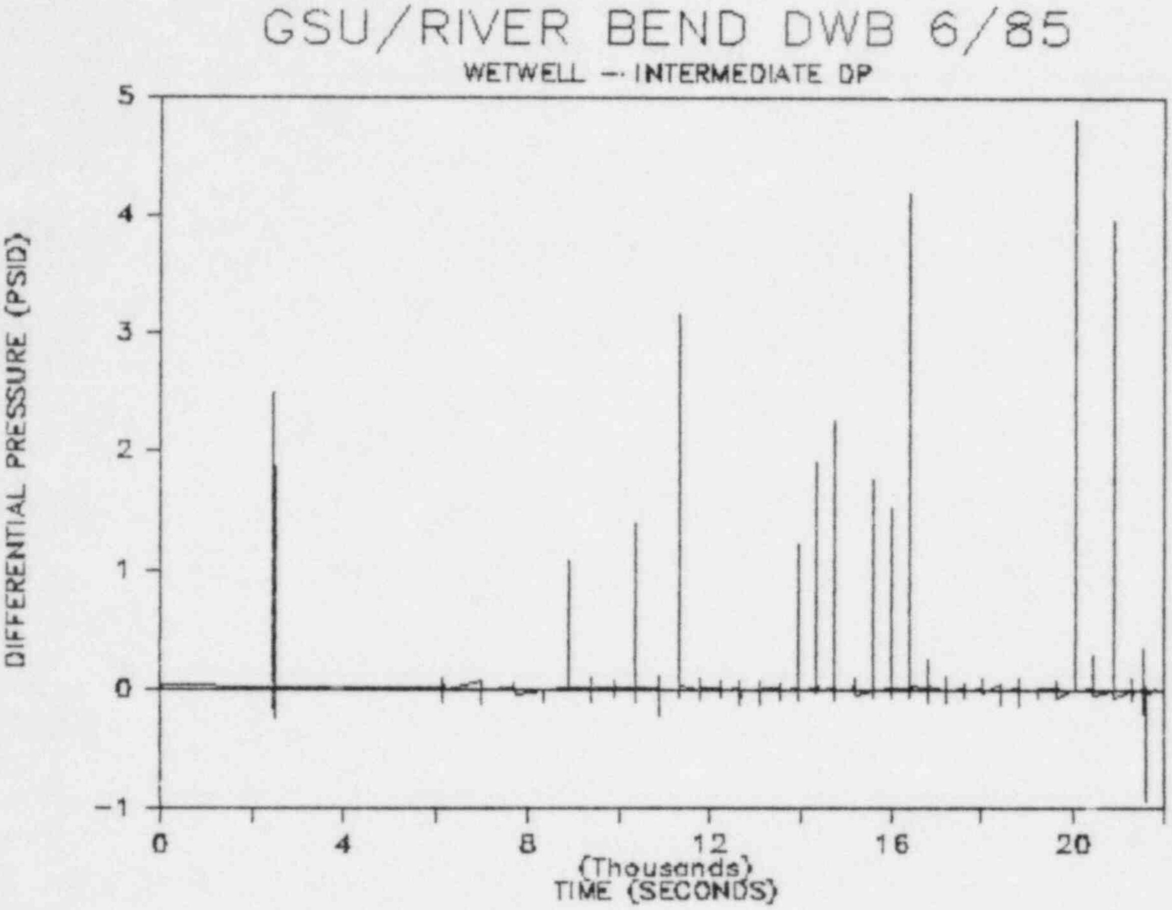

GSU/RIVER BEND DWB 6/85
WETWELL -- INTERMEDIATE DP
DIFFERENTIAL PRESSURE (PSID)
5
4
3
2
1
0
-1
0
4
8
12
16
20
(Thousands)
TIME (SECONDS)

Figure 13

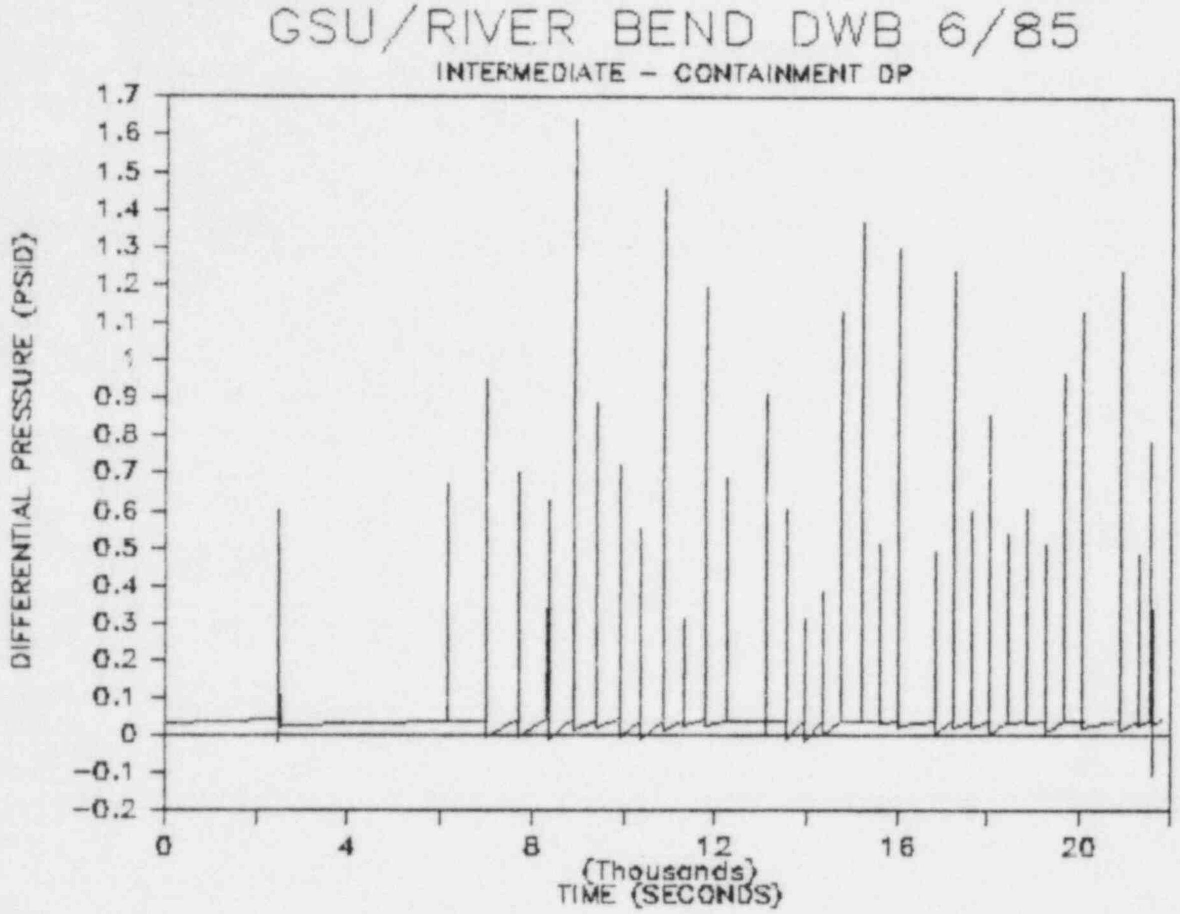
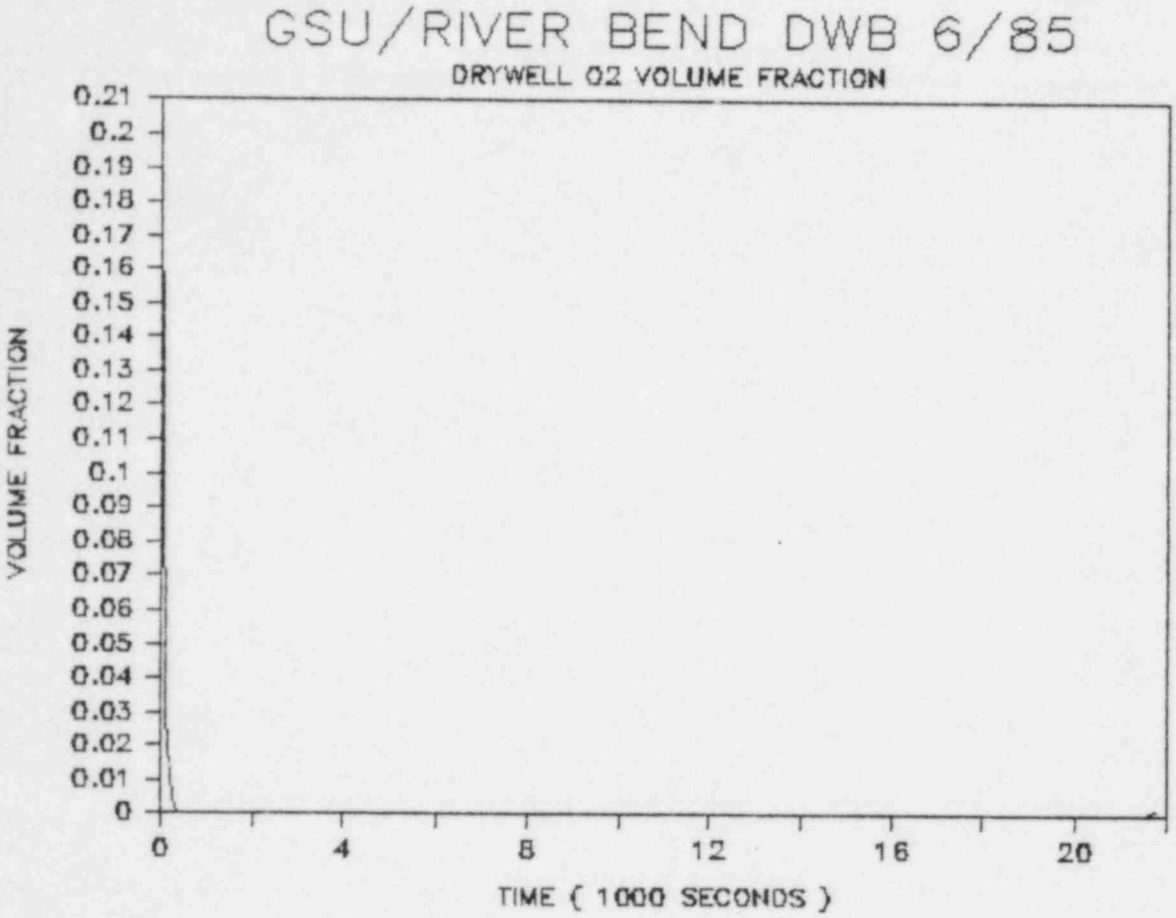

GSU/RIVER BEND DWB 6/85
INTERMEDIATE - CONTAINMENT DP
DIFFERENTIAL PRESSURE (PSID)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0
4
8
12
16
20
(Thousands)
TIME (SECONDS)

Figure 14



GSU/RIVER BEND DWB 6/85
DRYWELL O2 VOLUME FRACTION
VOLUME FRACTION
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 15

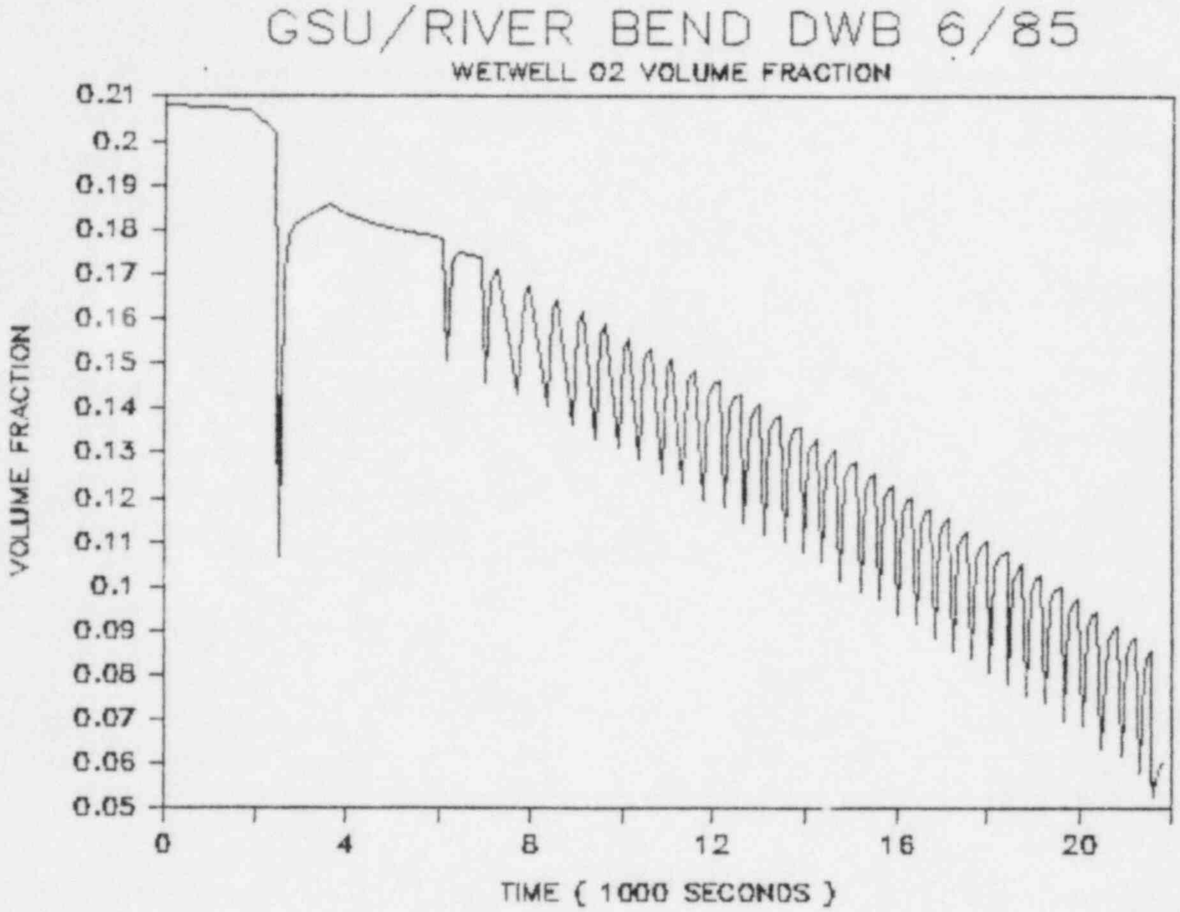

GSU/RIVER BEND DWB 6/85
WETWELL O2 VOLUME FRACTION
VOLUME FRACTION
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 16

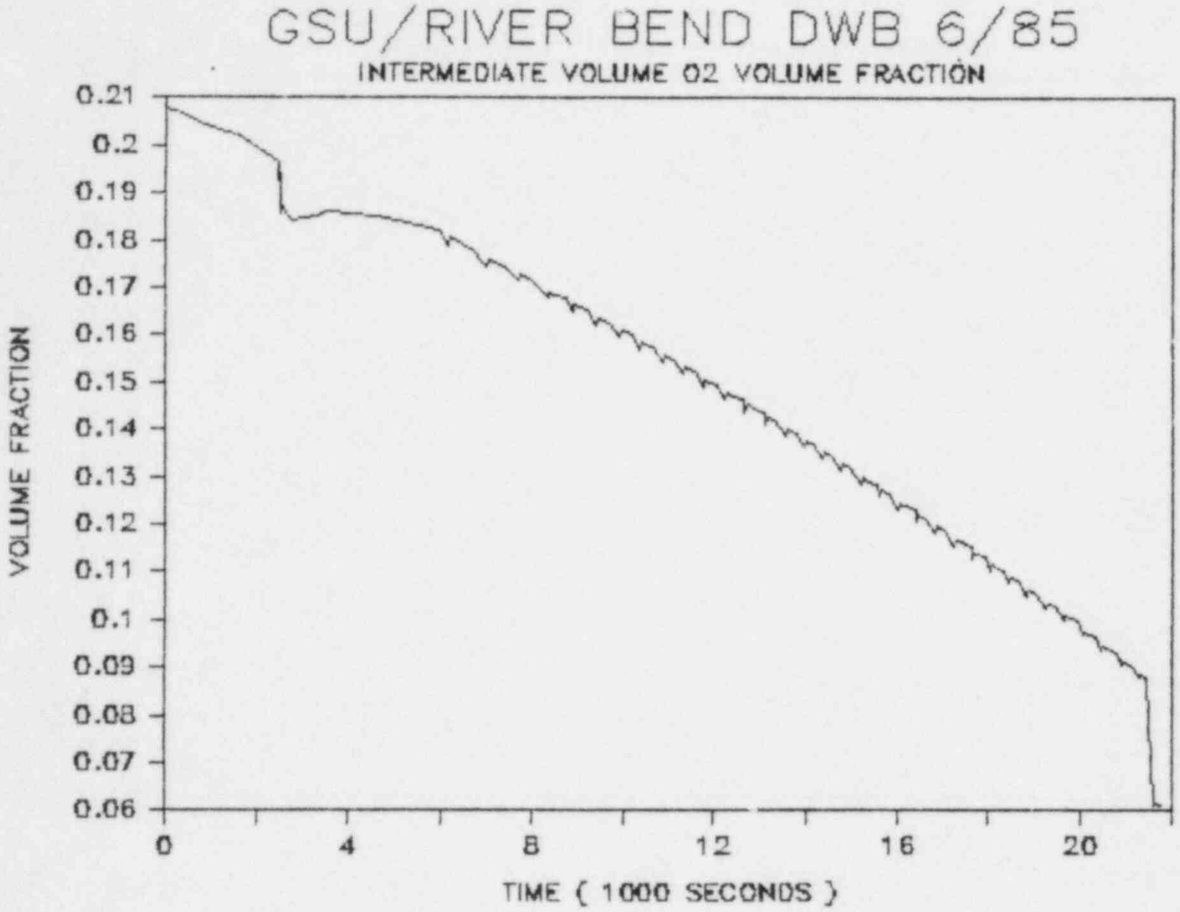

GSU/RIVER BEND DWB 6/85
INTERMEDIATE VOLUME O2 VOLUME FRACTION
VOLUME FRACTION
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 17

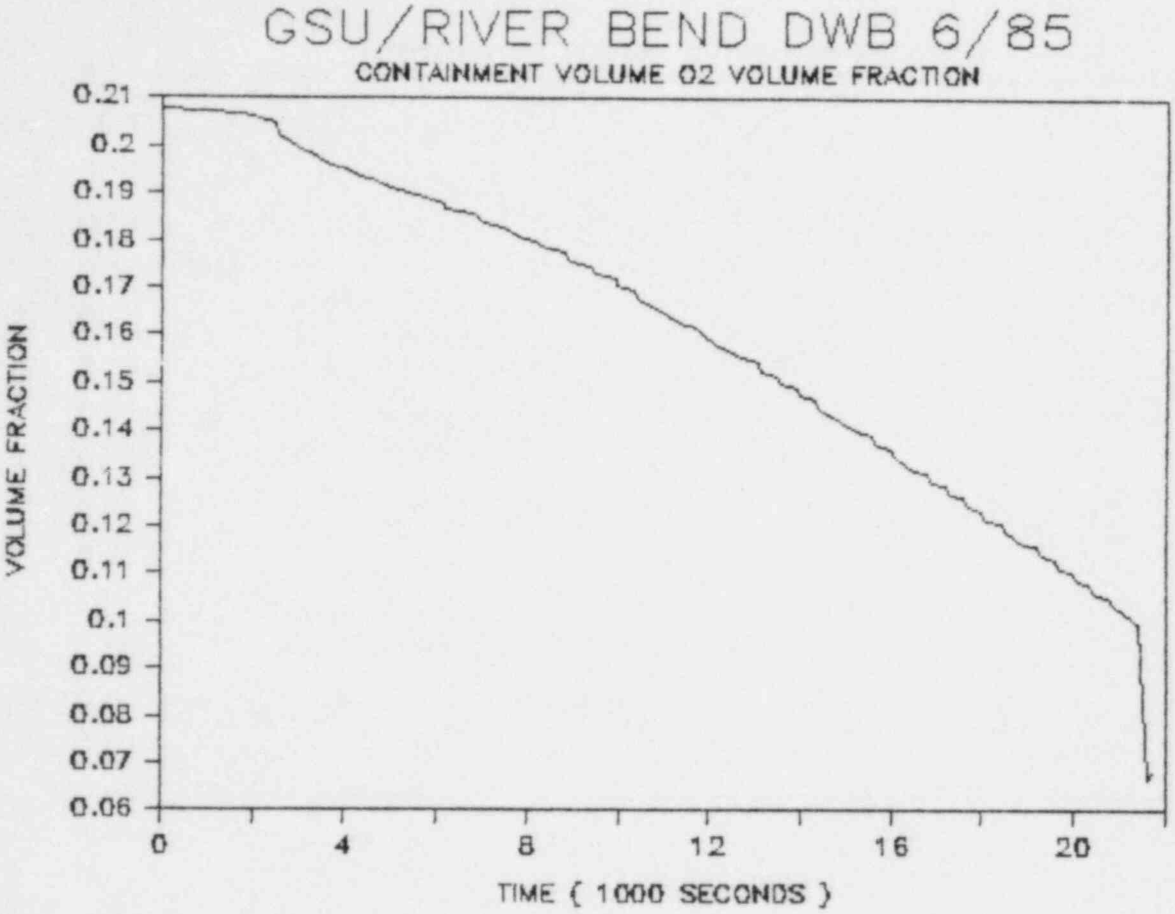
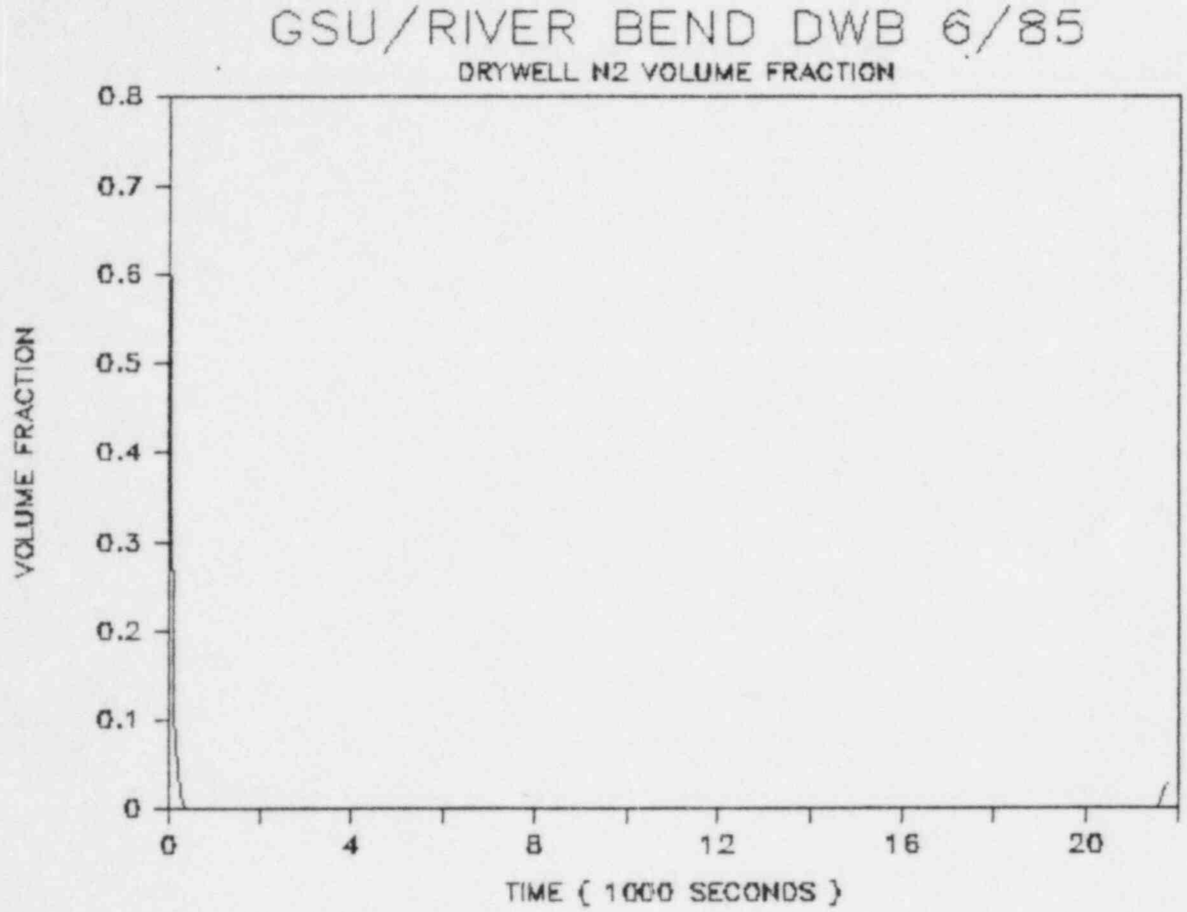

GSU/RIVER BEND DWB 6/85
CONTAINMENT VOLUME O2 VOLUME FRACTION
VOLUME FRACTION
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 18



GSU/RIVER BEND DWB 6/85
DRYWELL N2 VOLUME FRACTION
VOLUME FRACTION
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 19

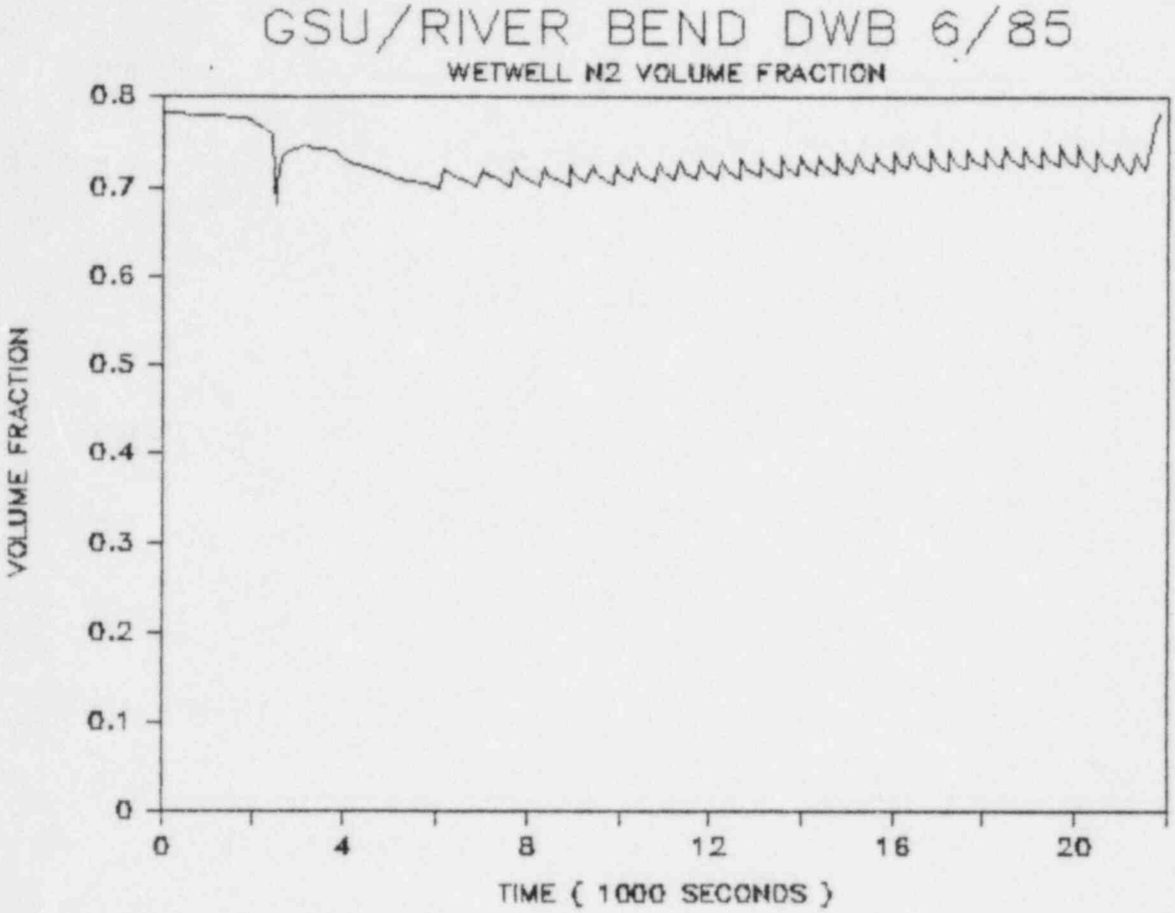

GSU/RIVER BEND DWB 6/85
WETWELL N2 VOLUME FRACTION
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
VOLUME FRACTION
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 20

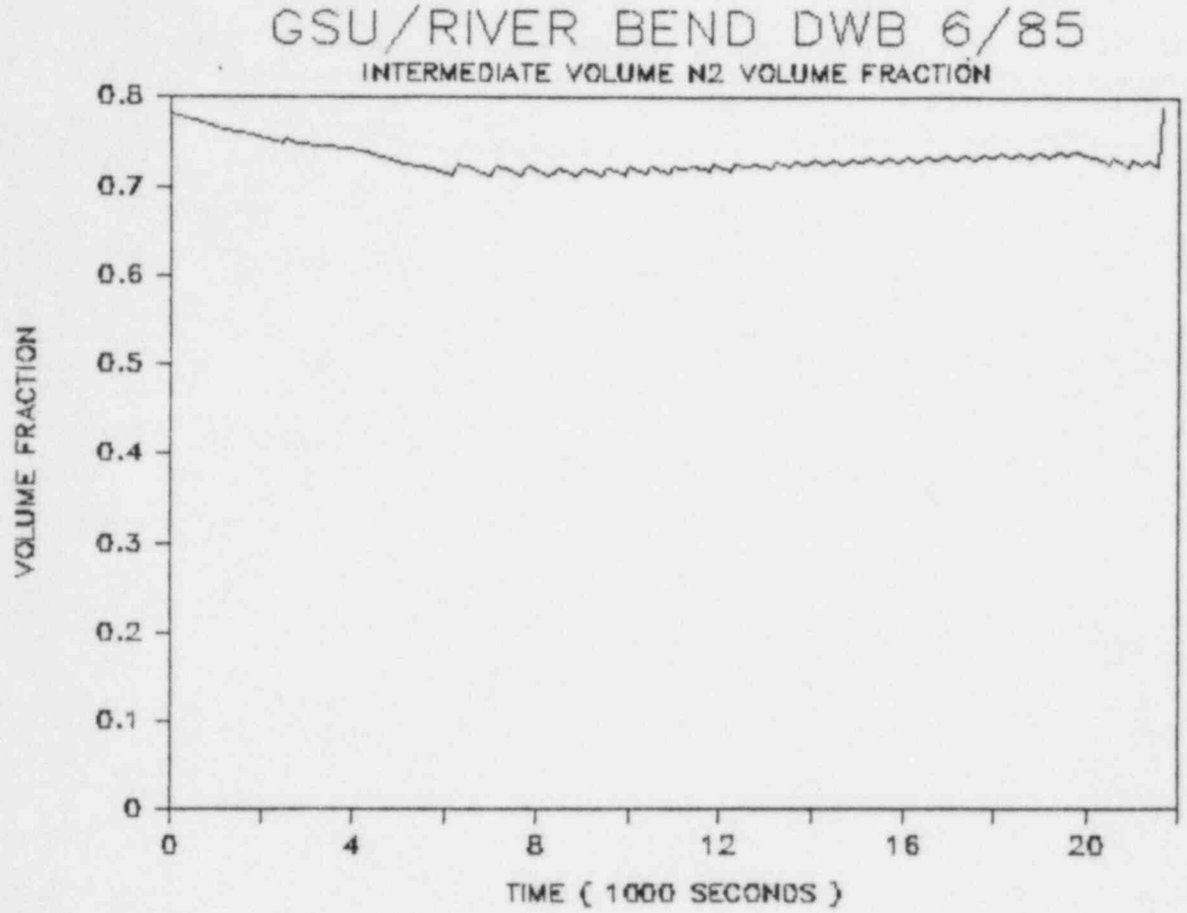
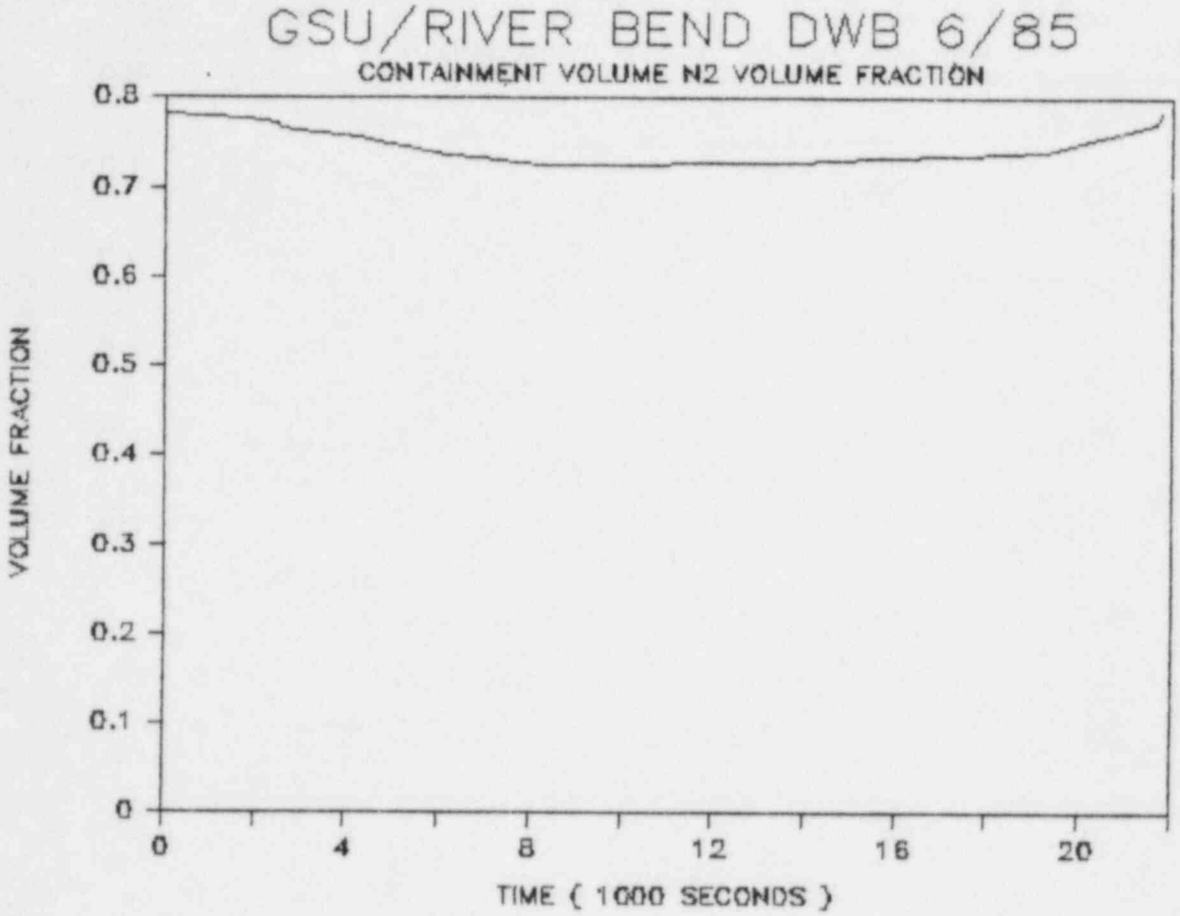
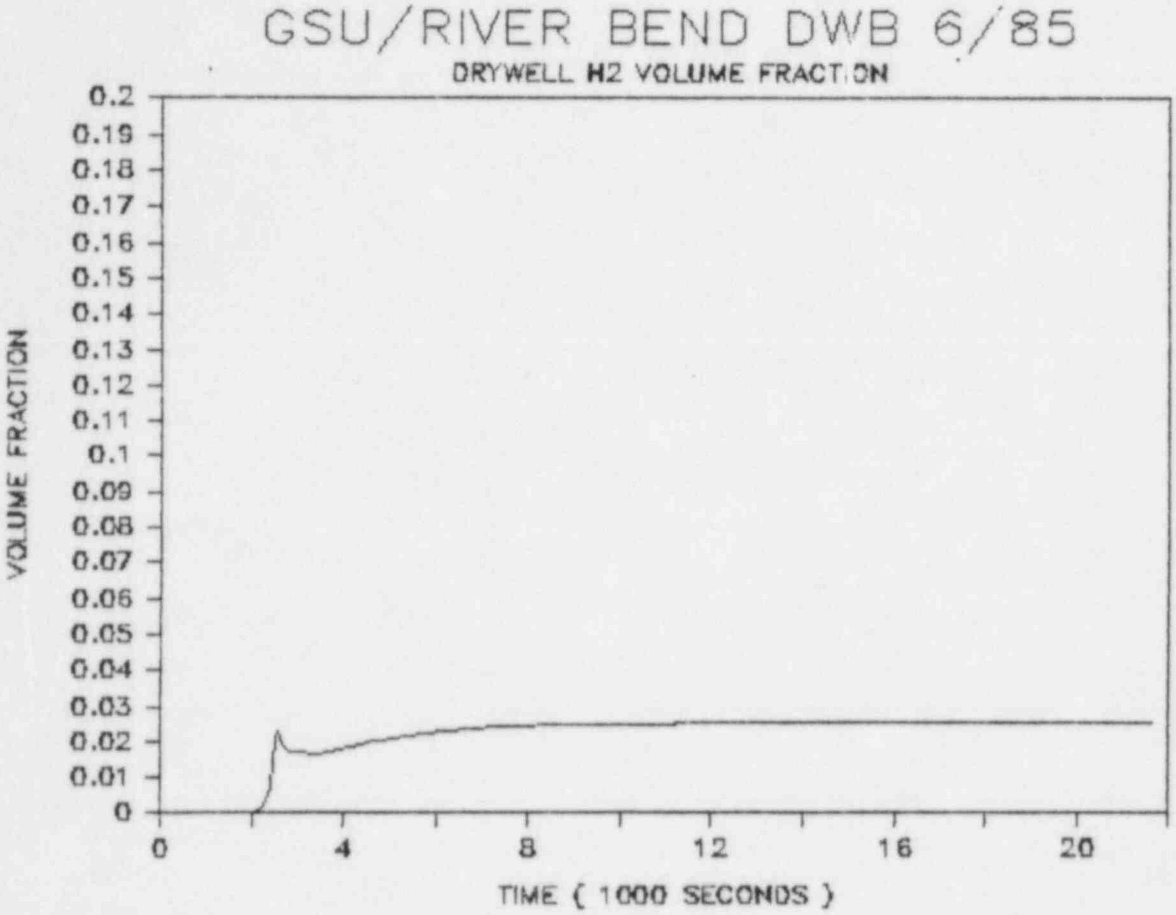

GSU/RIVER BEND DWB 6/85
INTERMEDIATE VOLUME N2 VOLUME FRACTION
VOLUME FRACTION
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 21



GSU/RIVER BEND DWB 6/85
CONTAINMENT VOLUME N2 VOLUME FRACTION
VOLUME FRACTION
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 22



GSU/RIVER BEND DWB 6/85
DRYWELL H2 VOLUME FRACTION
VOLUME FRACTION
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 23

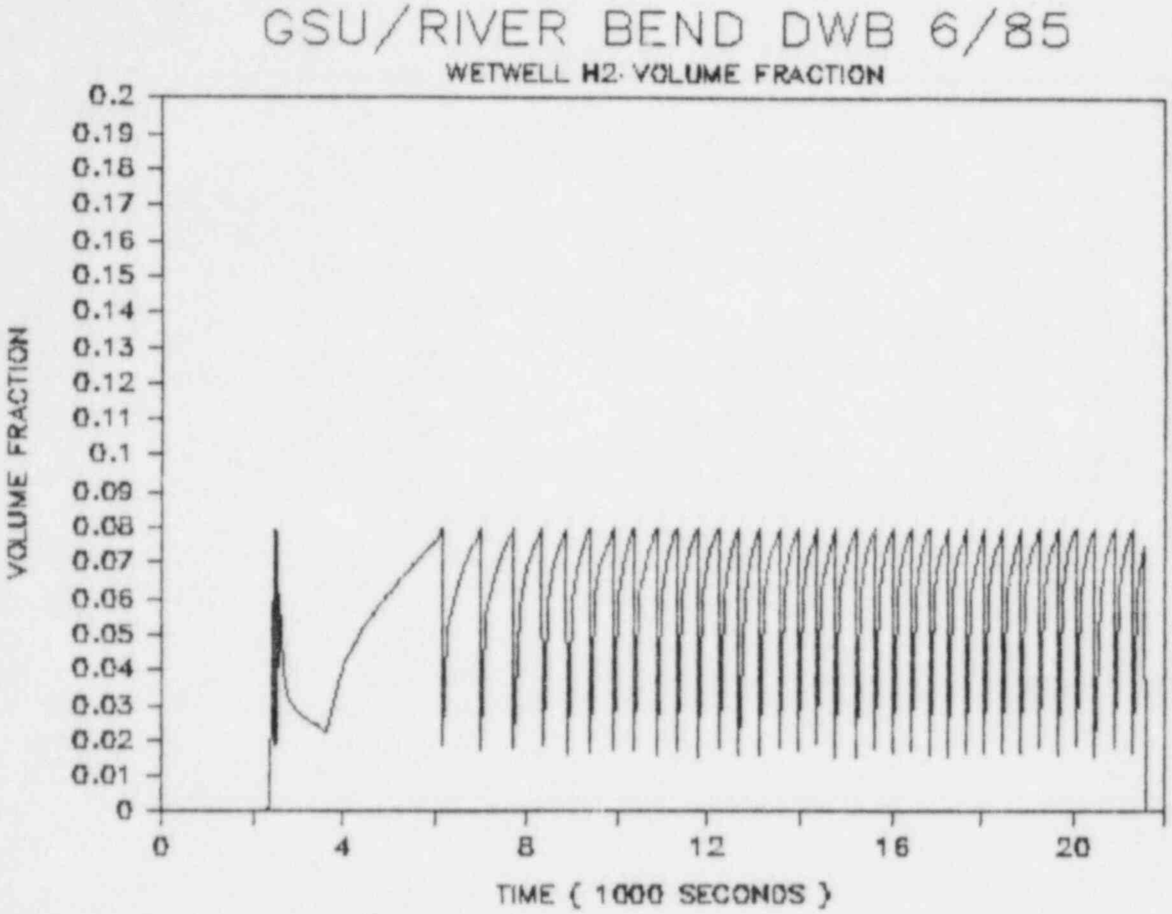

GSU/RIVER BEND DWB 6/85
WETWELL H2 VOLUME FRACTION
VOLUME FRACTION
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 24

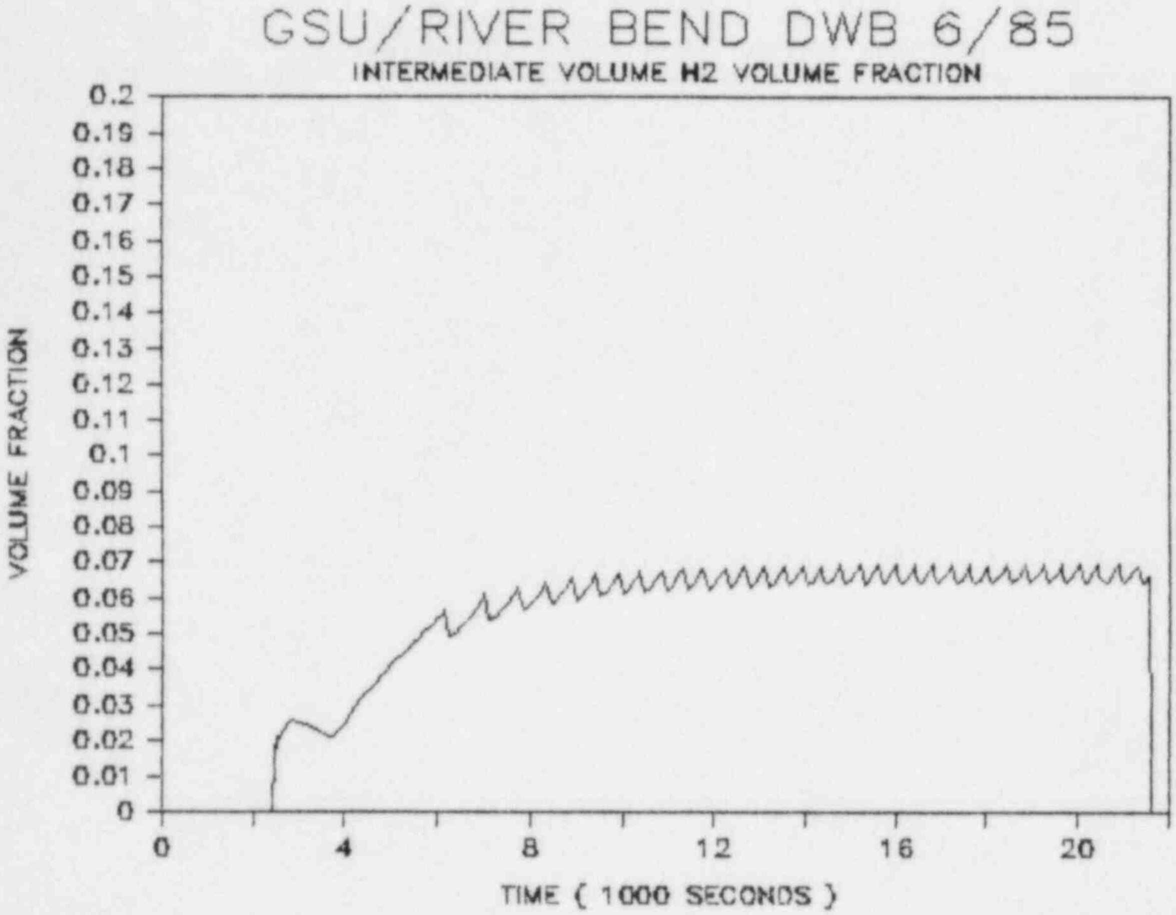

GSU/RIVER BEND DWB 6/85
INTERMEDIATE VOLUME H2 VOLUME FRACTION
VOLUME FRACTION
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 25

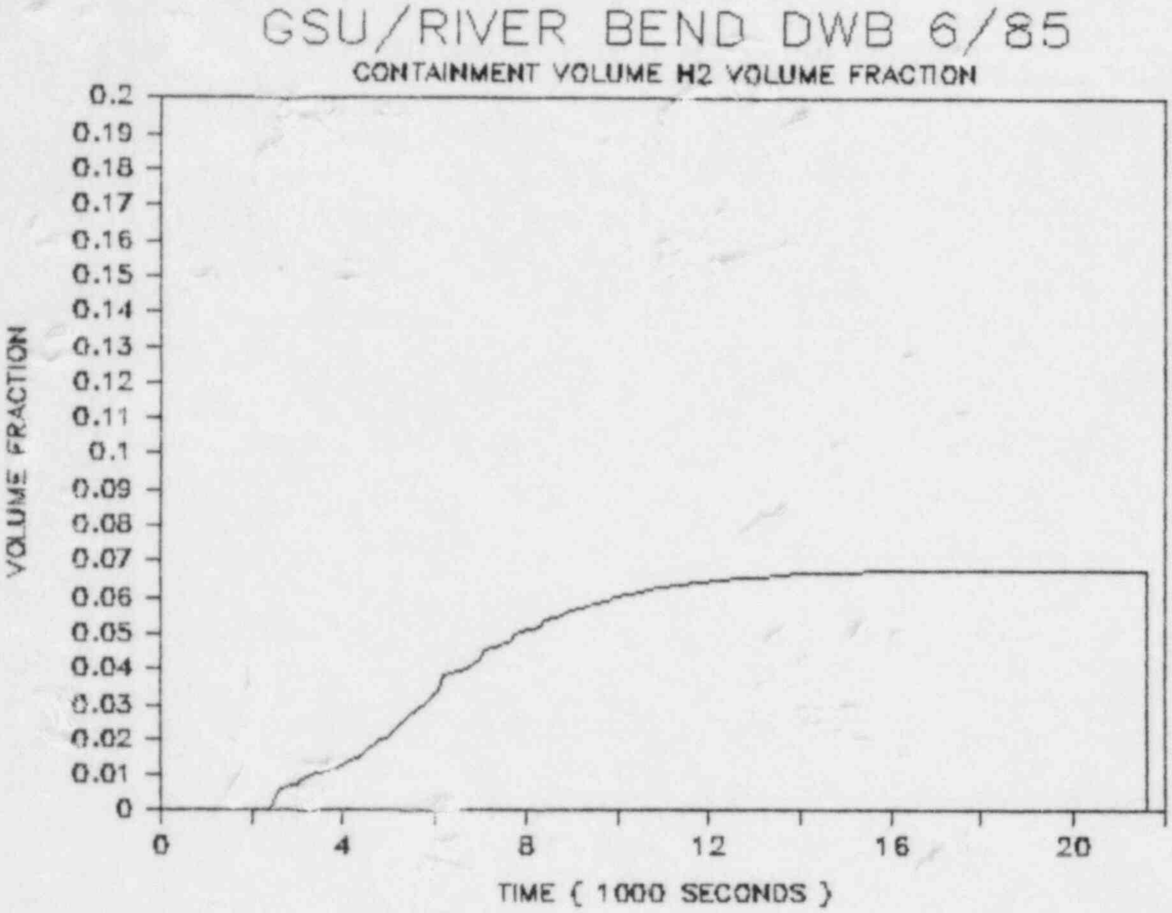

GSU/RIVER BEND DWB 6/85
CONTAINMENT VOLUME H2 VOLUME FRACTION
VOLUME FRACTION
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 26

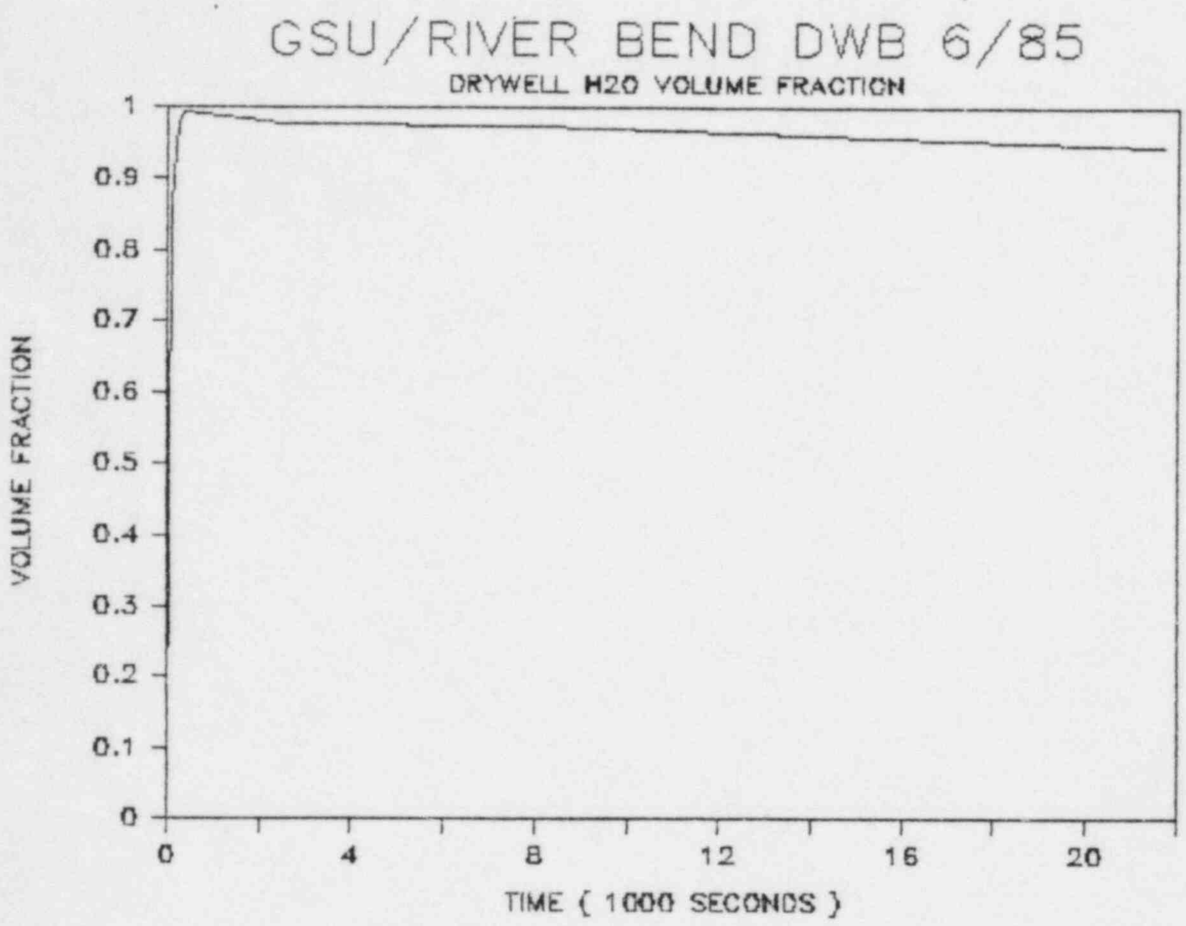

GSU/RIVER BEND DWB 6/85
DRYWELL H2O VOLUME FRACTION
VOLUME FRACTION
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 27

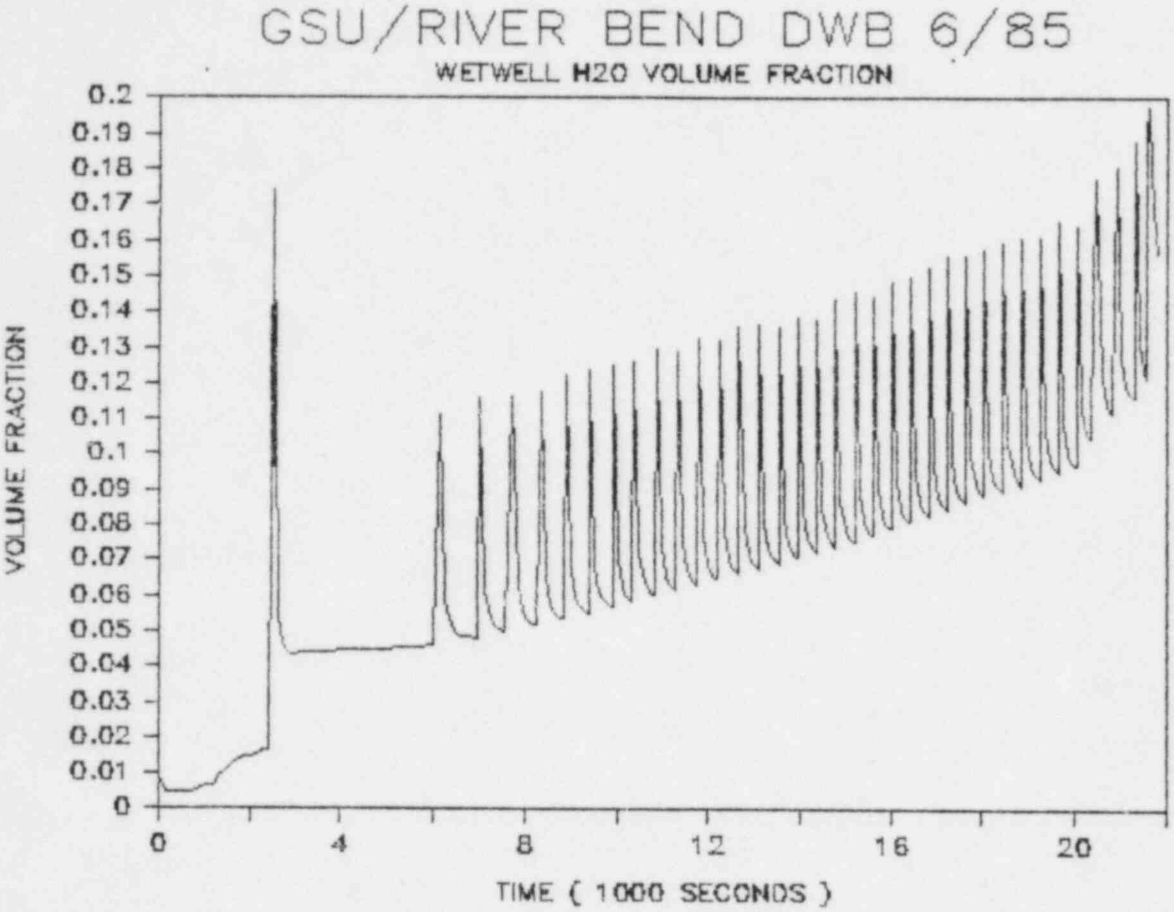
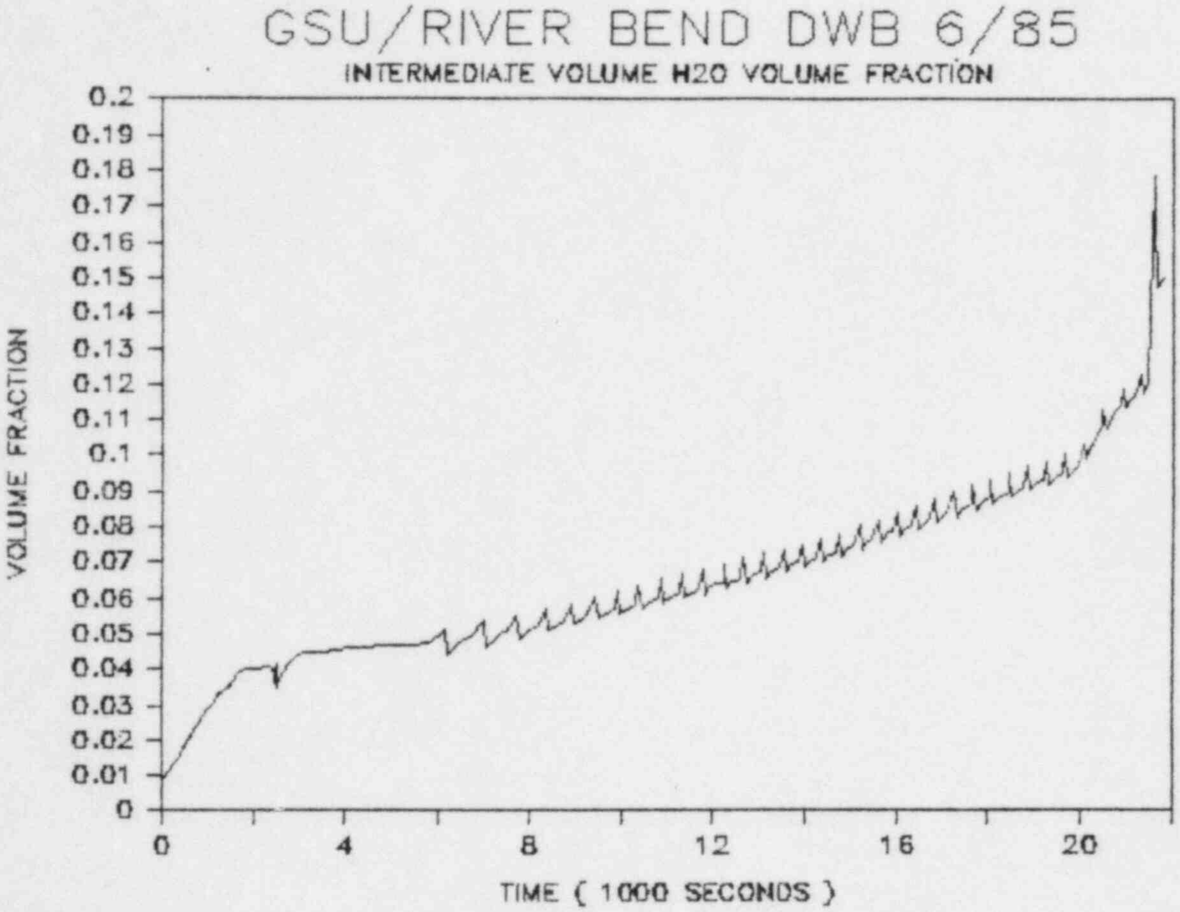
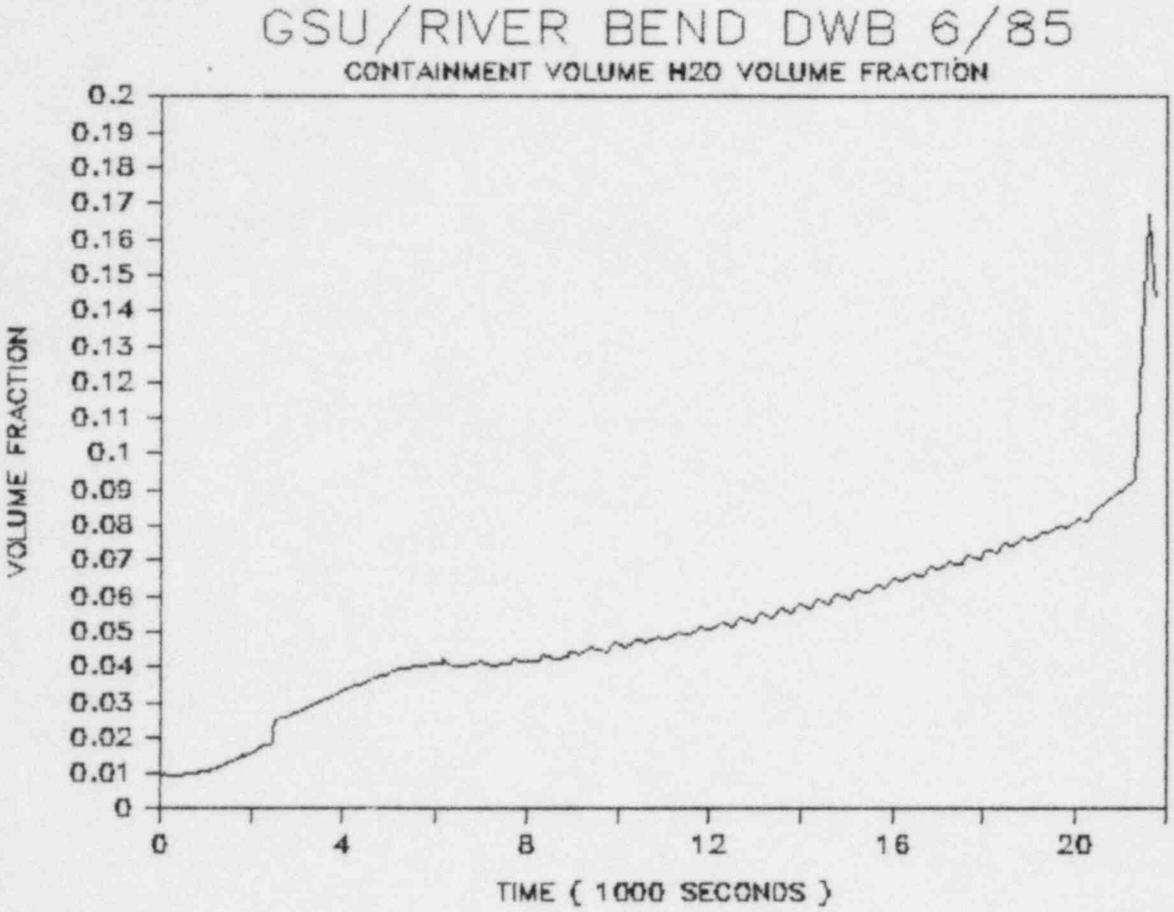

GSU/RIVER BEND DWB 6/85
WETWELL H2O VOLUME FRACTION
VOLUME FRACTION
TIME (1000 SECONDS)
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
4
8
12
16
20

Figure 28



GSU/RIVER BEND DWB 6/85
INTERMEDIATE VOLUME H2O VOLUME FRACTION
VOLUME FRACTION
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
4
8
12
16
20
TIME (1000 SECONDS)

Figure 29



GSU/RIVER BEND DWB 6/85
CONTAINMENT VOLUME H2O VOLUME FRACTION
VOLUME FRACTION
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
4
8
12
16
20
TIME (1000 SECONDS)