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ADDENDUM TO BEST MANAGEMENT PRACTICES PLAN: STORMWATER SAMPLING PROGRAM RESULTS
18 OCTOBER 1988

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ADDEMDUM TO BEST MANAGEMENT PRACTICES PLAN:

STORMWATER SAMPLING PROGRAM RESULTS

Prepared for the
Feed Materials Production Center
WESTINGHOUSE MATERIALS COMPANY OF OHIO

Prepared by
ROY F. WESTON, INC.
West Chester, Pennsylvania
and
Oak Ridge, Tennessee

18 October 1988

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Figure 2. Drainage Ditch Sampling Locations

Figure A-1. Nomograph for solution of Manning formula for circular pipes flowing full, n = 0.013. Using D = 24 inches and S = 0.008 Q, Q is found to be 21 cfs.

Figure A-2. Nomograph for solution of hydraulic elements of a circular pipe. A value of d/D of 0.125 for MH-30 gives $Q/Q_f = 0.03$.

ADDENDUM TO BEST MANAGEMENT PRACTICES PLAN - STORMWATER SAMPLING PROGRAM RESULTS

1.0 INTRODUCTION

The stormwater sampling program at the Feed Materials Production Center (FMPC) was performed under order from the Ohio EPA as a requirement for the facility's Best Management Practices (BMP) Plan. Two sampling events were performed as part of this sampling program: (1) a base flow sampling event on 27 April 1988 during which twelve manholes were sampled; and (2) a storm flow event on 20 and 21 July 1988 during which sixteen manholes and twelve drainage ditches were sampled. Base flow is defined as the amount of flow in the storm drainage system normally present during dry weather conditions. It consists primarily of cooling tower blowdown water and ground water infiltration/inflow. Storm flow is the flow in the storm drainage system during a rainfall event. All sampling locations were established by WMCO in response to the Ohio EPA directive.

Sampling was accomplished using standard techniques as described in "Sampling Plan for the Characterization of Stormwater Runoff at the Feed Materials Production Center", October 1987 and "Quality Assurance and Quality Control Plan for Preparation of Best Management Practices (BMP) Plan for the Feed Materials Production Center", 30 October 1987. Custom-designed, stainless steel, self-tipping bailers with teflon coated steel cables were

used to sample the manholes. Drainage ditch samples were collected using a dipper, or by immersion of the sample bottles, depending on the conditions at the sample station. Decontamination of samplers was by washing with a detergent solution, followed by rinsing with de-ionized water.

For the first sampling event, WESTON personnel mobilized in response to a forecasted rain event. The predicted rainfall did not occur; however, WESTON was prepared to collect samples suitable for documenting base flow conditions instead. During this sampling event, the sixteen manholes were essentially dry and could not be sampled.

As it happened, weather conditions were unusually dry following the base flow sampling and a storm event suitable for sampling did not occur until 20 July 1988. On that date, WESTON personnel were mobilized during a significant rainfall event that produced 3 to 5 inches of rain in the Cincinnati area. Although intermittent, rainfall was quite heavy at times and a total of 1.7 inches of rainfall was recorded at the FMPC weather station station during this storm. Sampling crews were able to resample all twelve of the manholes that were sampled during the base flow event and to sample four additional manholes (MH-05, MH-11, MH-14, and MH-35) that previously could not be sampled due to lack of flow. Due to the heavy continuous rainfall which developed late on 20 July, WESTON was also able to collect samples from twelve of the drainage ditches that evening and the following morning. The sampling locations of the storm sewer manholes and the drainage ditches are shown in FIGURE 1 and FIGURE 2, respectively.

The analytical results for the manhole samples are presented in Table 1. Altogether, thirty-four samples were collected: twelve

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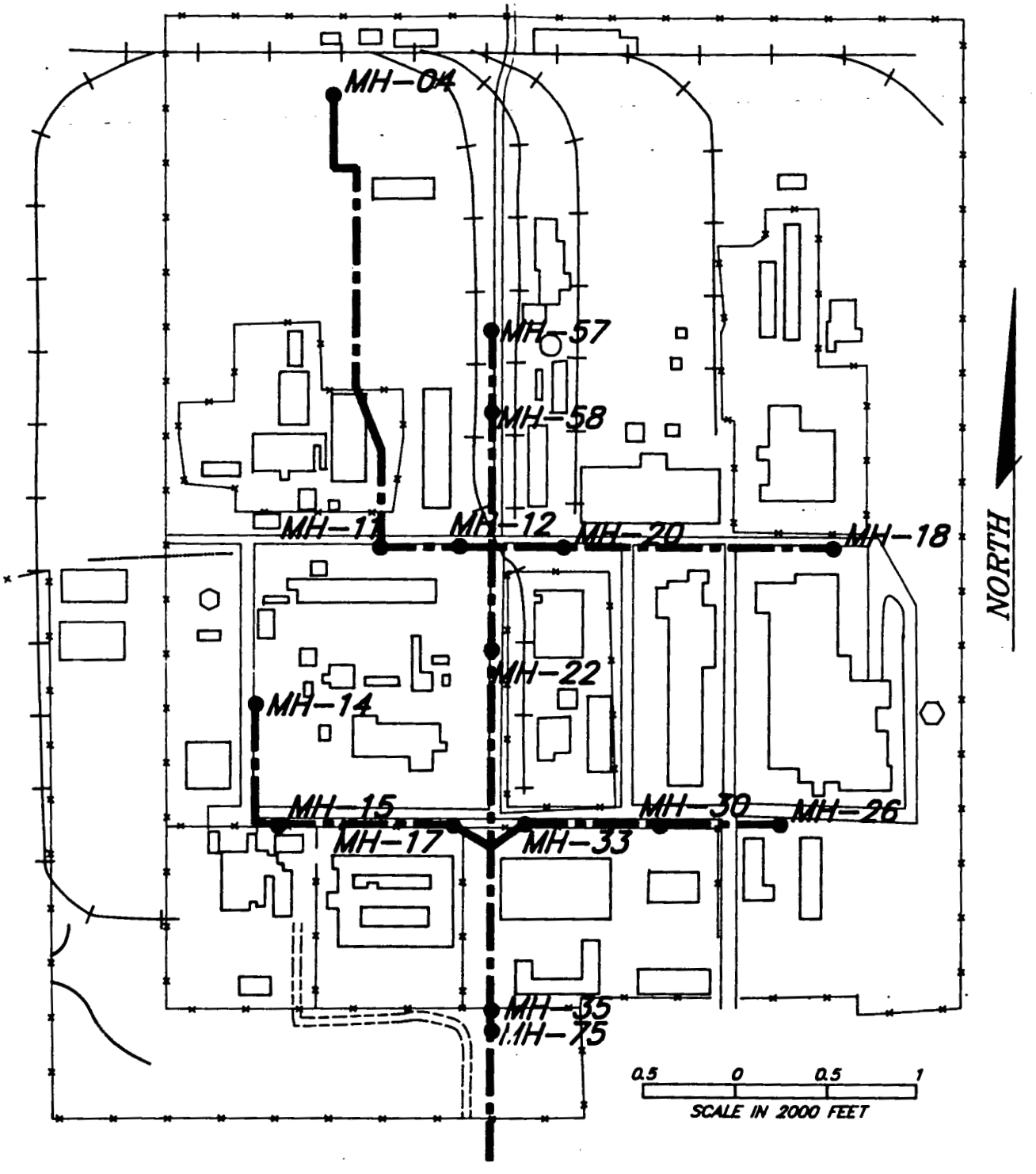

NOTE: ONLY THOSE LINES CONTAINING MANHOLES SAMPLED AS PART OF THE BMP STORM SEWER SAMPLING PROGRAM ARE SHOWN ON THIS MAP.

FIGURE 1 STORM SEWER SAMPLING LOCATIONS

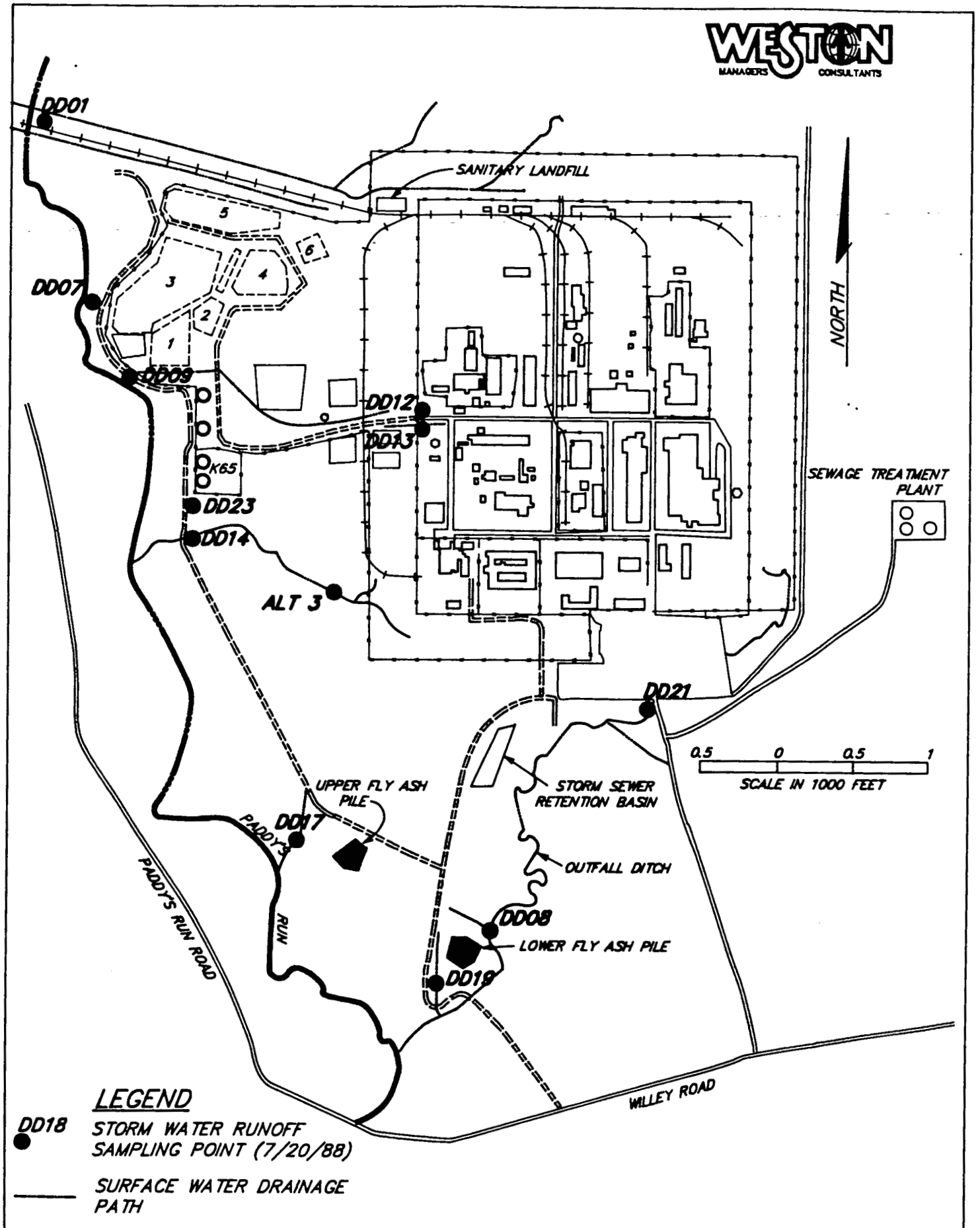

FIGURE 2 DRAINAGE DITCH SAMPLING LOCATIONS

TABLE 1
ANALYTICAL RESULTS FOR STORM SEWER SAMPLES COLLECTED ON APRIL 27, 1988, JULY 20, AND JULY 21, 1988 AT THE FEED MATERIALS PRODUCTION CENTER, FERNALD, OHIO

Analyte	Units	MH-04	MH-11	MH-12		MH-14	MH-15		MH-17		MH-18		MH-20	
		7-20-88	7-20-88	4-27-88	7-20-88	7-20-88	4-27-88	7-20-88	4-27-88	7-20-88	4-27-88	7-20-88	4-27-88	7-20-88
Aluminum	ug/L	3,110	1,020	200u	585	2,640	200u	1,100	200u	456	391	9,880	204	675
Barium	ug/L	200u	200u	200u	200u	200u	200u	200u	200u	200u	200u	200u	200u	200u
Calcium	ug/L	58,800	43,300	86,800	53,800	45,400	52,800	45,300	41,900	40,300	90,700	38,600	67,300	38,500
Chromium	ug/L	10.0u	10.0u	10.0u	10.0u	10.0u	10.0u	10.0u	10.0u	10.0u	10.0u	10.8	10.0u	10.0u
Copper	ug/L	25.0u	26.2	25.0u	25.0u	27.5	55.5	277	25.0u	25.0u	25.0u	43.7	25.0u	25.0u
Iron	ug/L	3,300	1,040	204	475	2,790	235	1,910	227	229	483	15,700	526	512
Lead	ug/L	13.0	5.0U	5.0u	5.0u	12.0	5.0u	13.6	5.0u	5.0u	5.0u	13.3	5.0u	5.6
Magnesium	ug/L	9,500	5,730	22,600	9,780	8,590	15,300	11,200	13,200	11,500	20,600	9,130	25,700	7,380
Manganese	ug/L	310	104	520	78.4	199	26.5	82.0	26.7	28.0	55.0	280	74.5	31.1
Sodium	ug/L	5,000u	25,500	30,800	31,400	7,800	18,700	19,600	14,800	20,000	25,500	13,700	17,700	20,900
Zinc	ug/L	53.4	70.2	23.0	42.2	68.7	39.9	120	30.2	31.6	126	179	43.8	48.5
TOC	mg/L	7.5	9.1	6.4	7.6	5.7	5.9	6.3	11.5	2.7	7.7	16.6	12.4	5.6
TOX	ug/L	42	22	62	64	99	50	34	62	56	49	110	26	40
TDS	mg/L	256	311	476	506	163	332	273	270	251	316	251	306	242
TSS	mg/L	182	89.0	4.0j	14	241	12	17	6	11	39	286	4	22.0
Oil and Grease	mg/L	1.5	2.8	1.0j	1.0u	1.9	1.0j	1.8	1.0j	1.0u	1.0j	1.0u	1.0j	1.0u
Chloride	mg/L	4.7	11.0	12.0	42.5	10.4	22.2	13.6	16.4	17	33.8	13.9	42.2	17.6
Fluoride	mg/L	4.1	1.4	0.4j	1.3	0.74	0.4j	1.4	0.4j	0.94	0.4j	0.75	0.4j	1.0
Sulfate	mg/L	42.7	28.7	52.7	72.0	36.3	40.9	52.9	71.2	34.8	46.4	22.9	71.4	44.2
Nitrate	mg/L	0.76	13.5	2.8	24.5	1.3	859	9	4.4	5.4	1.8	2.1	1.6	2.6
1,1,1-TCA	ug/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.50u	1u
TCE	ug/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.50u	1u
PERC	ug/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.50u	1u
Gross Alpha	pCi/L	160±20	1200±100	2400±00	2500±200	640±30	2000±100	2400±100	580±100	1100±100	2600±100	820±40	990±40	1100±100
Gross Beta	pCi/L	99±6	640±10	680±20	1400±100	350±10	780±22	1200±100	410±10	560±10	1800±100	630±10	490±10	590±10
Thorium-228	pCi/L	NR	NR	NR	NR	NR	NR	NR	1.0±0.2	-0.1±0.3	0.1±0.2	1.4±0.5	0.0±0.1	0.1±0.1
Thorium-230	pCi/L	NR	NR	NR	NR	NR	NR	NR	0.2±0.2	1.5±0.5	0.9±0.3	5.4±0.8	0.8±0.2	0.6±0.2
Thorium-232	pCi/L	NR	NR	NR	NR	NR	NR	NR	0.0±0.1	0.1±0.2	0.0±0.1	1.2±0.4	0.0±0.1	0.1±0.1
Uranium-234	pCi/L	66±9	700±70	690±130	1300±100	260±20	810±160	1000±100	370±40	640±20	440±110	390±40	310±40	480±60
Uranium-235	pCi/L	1.4±1.7	31±16	-0.2±2.4	74±27	24±7	74±48	28±20	20±10	27±3	-0.2±2.4	17±10	11±7	21±15
Uranium-238	pCi/L	76±9	520±60	500±110	1300±100	240±20	850±160	990±100	300±40	560±10	1300±200	520±50	360±40	630±70
Radium-226	pCi/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Radium-228	pCi/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Flow	gpm	40	500	1	500	30	1	200	10	300	1	200	10	200
pH	std.	7.8	8.4	7.2	7.6	8.6	7.8	7.0	7.6	7.4	7.4	8.2	8.2	6.9
Conductivity	umhos	290	180	480	690	150	380	380	380	400	440	200	335	282
Temperature	°C	25	24	13	25	24	26	26	28	29	12	24	14	24

NOTES:
1. An "u" indicates the parameter was analyzed for but not detected. The minimum detection limit for the sample, not the method detection limit, is reported preceding the "u".
2. A "j" indicates the parameter was detected, but was not quantifiable. The detection limit for the sample is reported preceding the "j".
3. NR = Not requested.
4. TOC = total organic carbon.
5. TOX = total organic halogen.
6. TDS = total dissolved solids.
7. TSS = total suspended solids.
8. 1,1,1-TCA = 1,1,1-trichloroethane.
9. TCE = trichloroethylene.
10. PERC = perchchloroethylene (or tetrachloroethylene).
11. P = ponded water (not measurably flowing).

TABLE 1 (Cont'd.)

Analyte	Units	MH-22		MH-26		MH-30		MH-33		MH-35	MH-57		MH-58	
		4-27-88	7-20-88	4-27-88	7-20-88	4-27-88	7-20-88	4-27-88	7-20-88	7-20-88	4-27-88	7-20-88	4-27-88	7-20-88
Aluminum	ug/L	200u	520	227	627	2,390	726	259	977	1,280	200u	566	635	1,030
Barium	ug/L	200u	200u	200u	200u	200u	200u	200u	200u	200u	200u	200u	200u	200u
Calcium	ug/L	77,500	62,300	116,000	34,800	72,700	30,600	45,400	29,300	34,200	11,800	60,000	106,000	31,800
Chromium	ug/L	10.0u	10.0u	10.0u	10.0u	10.2	10.0u	205	10.0u	10.0u	10.0u	10.0u	10.0u	10.0u
Copper	ug/L	25.0u	26.7	25.0u	25.0u	25.0u	25.0u	31.6	25.0u	31.7	25.0u	25.0u	25.0u	25.0u
Iron	ug/L	451	504	1,050	578	4,140	607	1,630	1,720	2,010	229	336	1,310	2,900
Lead	ug/L	5.0u	5.0u	5.0u	5.8	28.8	9.3	6.7	8.6	7.3	5.0u	7.5	5.0u	13.5
Magnesium	ug/L	22,600	11,400	29,200	6,750	20,600	5,930	11,600	5,240	6,670	26,500	12,000	25,100	6,330
Manganese	ug/L	229	71.0	101	39.8	221	45.8	67.5	81.0	67.6	30.6	60.5	47.6	62.7
Sodium	ug/L	31,200	37,000	278,000	16,800	47,000	14,100	42,800	12,600	18,700	30,100	41,600	29,000	25,900
Zinc	ug/L	27.1	64.0	44.1	69.6	180	57.8	206	174	104	26.8	130	95.4	2,060
TOC	mg/L	9.2	5.4	17.1	92	11.2	6.3	4.0	9.4	12.0	5.1	4.6	46.0	6.0
TOX	ug/L	130	43	46	22	74	28	190	900	200	50	10	140	38
TDS	mg/L	473	309	1,190	180	373	198	391	149	208	631	386	490	248
TSS	mg/L	4.0j	19	22	14	137	79	4	85.0	74.0	13	21	21	44.0
Oil & Grea	mg/L	1.0j	1.0u	7.0	1.1	1.8	1.0u	1.0j	1.0u	1.0u	1.0j	1.0u	1.7	1.0u
Cloride	mg/L	46.3	22.1	242	15.8	77.2	16.4	91.4	12.0	10.7	42.2	50.2	24.6	6.3
Fluoride	mg/L	3.2	1.4	0.4j	0.38	0.4j	0.83	2.8	1.4	0.97	0.4j	0.83	0.4j	0.61
Sulfate	mg/L	90.2	62.6	95.9	36.4	37.4	32.5	48.7	25.5	38.2	171	64.2	152	47.6
Nitrate	mg/L	2.7	9.1	5.2	1.8	1.3	2.1	0.99	1.0u	4.6	0.35	6.1	1.0	1.8
1,1,1-TCA	ug/L	NR	NR	NR	NR	NR	NR	0.50u	4.6	NR	NR	NR	0.50u	1u
TCE	ug/L	NR	NR	NR	NR	NR	NR	0.50u	1u	NR	NR	NR	0.50u	1u
PERC	ug/L	NR	NR	NR	NR	NR	NR	0.50u	1u	NR	NR	NR	0.50u	1u
Gross Alpha	pCi/L	1100±100	1500±100	5400±200	1000±100	1700±100	1100±100	640±40	520±20	820±20	440±40	430±20	210±20	170±20
Gross Beta	pCi/L	690±20	780±10	2000±100	560±10	370±10	600±10	490±10	380±10	460±10	180±10	230±10	89±6	100±10
Thorium-228	pCi/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Thorium-230	pCi/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Thorium-232	pCi/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Uranium-234	pCi/L	460±110	690±80	1200±200	350±80	470±50	240±60	230±40	160±10	410±40	150±20	180±20	97±8	71±8
Uranium-235	pCi/L	26±27	29±18	98±47	16±22	12±8	4±17	13±10	5.7±1.9	16±10	1.9±2.7	7.8±4.5	3.2±1.4	2.7±1.8
Uranium-238	pCi/L	410±110	680±80	1700±40	920±100	740±60	760±80	380±50	320±10	510±50	150±20	220±20	100±10	110±10
Radium-226	pCi/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Radium-228	pCi/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Flow	gpm	p	500	p	p	<1	300	10	500	800	1	40	1	40
pH	std.	7.6	8.4	7.7	6.8	8.8	7.0	8.2	8.5	8.1	8.2	8.1	8.8	8.3
Conductivity	mhos	430	390	1500	270	435	280	370	190	245	600	525	470	465
Temperature	°c	12	25	24	26	16	26	11	26	26	9	23	11	22

NOTES:
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11. P = ponded water (not measurably flowing).

TABLE 1 (Cont'd.)

Analyte	Units	MH-75		MH-22DUP	MH-33DUP	RB-01	RB-02	RB-03	RB-04
		4-27-88	7-20-88	4-27-88	7-20-88	4-27-88	4-27-88	7-20-88	7-20-88
Aluminum	ug/L	200u	780	200u	1,190	200u	200u	546	200u
Barium	ug/L	200u	200u	200u	200u	200u	200u	200u	200u
Calcium	ug/L	51,000	31,300	76,100	27,300	5,000u	5,000u	34,800	5,000u
Chromium	ug/L	10.0u	10.0u	10.0u	10.0u	10.0u	100u	10.0u	10.0u
Copper	ug/L	25.0u	25.0	25.0u	28.0u	25.0u	25.0u	25.0u	25.0u
Iron	ug/L	188	723	441	1,160	125	10.0u	412	100u
Lead	ug/L	5.0u	8.3	5.0u	11.8	5.0u	5.0u	5.0u	5.0u
Magnesium	ug/L	12,400	6,650	22,600	5,220	5,000	5,000u	5,350	5,000u
Manganese	ug/L	15.0u	54.5	238	85.3	15.0u	15.0u	33.6	15.0u
Sodium	ug/L	24,200	17,200	32,400	14,100	5,000u	5,000u	12,000	5,000u
Zinc	ug/L	90.4	90.8	39.7	146	34.4	15.0u	27.4	20.0u
TOC	mg/L	5.6	5.2	5.2	13.3	10.8	10.5	0.66	0.66
TOX	ug/L	74	150	54	270	220	270	30	17
TDS	mg/L	418	170	492	158	10.0j	10.0j	9.0	11.0
TSS	mg/L	37	52	4.0j	125	4.0j	4.0j	6.0	4.0
Oil & Grease	mg/L	1.0j	1.0u	1.0j	1.0u	1.0j	1.0j	1.5	1.5
Cloride	mg/L	47.0	13.2	73.2	6.3	0.5	0.5j	11.0	7.2
Fluoride	mg/L	0.4j	0.83	3.2	0.78	0.4j	0.4j	0.10u	0.10u
Sulfate	mg/L	55.7	33.3	89.8	24.9	10.0j	10.0uj	5.0u	5.0u
Nitrate	mg/L	0.56	2.4	2.6	1.6	0.10u	0.10u	0.10u	0.10u
1,1,1-TCA	ug/L	NR	NR	NR	NR	NR	NR	NR	NR
TCE	ug/L	NR	NR	NR	NR	NR	NR	NR	NR
PERC	ug/L	NR	NR	NR	NR	NR	NR	NR	NR
Gross Alpha	pCi/L	27±9	700±20	920±50	610±20	0±1	1±1	1±1	1±1
Gross Beta	pCi/L	14±4	380±10	510±50	480±10	0±2	0±2	1±2	0±2
Thorium-228	pCi/L	NR	NR	NR	NR	0.0±0.1	0.0±<0.1	NR	NR
Thorium-230	pCi/L	NR	NR	NR	NR	0.0±0.1	0.0+<0.1	NR	NR
Thorium-232	pCi/L	NR	NR	NR	NR	0.0±0.1	0.1±<0.1	NR	NR
Uranium-234	pCi/L	17±3	310±20	440±50	170±40	0.0±0.1	0.0±<0.1	0.0±0.1	0.0±0.1
Uranium-235	pCi/L	0.5±0.5	11±4	3.7±4.2	6.8±9.6	0.0±0.1	0.0±<0.1	0.0±0.1	0.0±0.1
Uranium-238	pCi/L	18.3±3	370±20	430±50	420±20	0.0±0.1	0.0±<0.1	0.0±0.1	0.0±0.1
Radium-226	pCi/L	NR	NR	NR	NR	NR	NR	NR	NR
Radium-228	pCi/L	NR	NR	NR	NR	NR	NR	NR	NR
Flow	gpm	200	1,000	p	500	NA	NA	NA	NA
pH	std.	8.0	7.0	7.6	8.5	NA	NA	NA	NA
Conductivity	umhos	430	260	430	190	NA	NA	NA	NA
Temperature	°C	14	25	12	26	NA	NA	NA	NA

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10. PERC = perchchloroethylene (or tetrachloroethylene).
11. P = ponded water (not measurably flowing).

manhole samples from the base flow event; sixteen samples from the storm flow event; and one duplicate and two bailer rinse blank samples from each event collected in the field for QA/QC purposes. Table 2 presents the analytical results for the twelve drainage ditch samples, which were collected on 20 July and 21 July 1988. A compilation of available and relevant regulatory limits is provided for comparison purposes in Table 3. The mapping coordinates for all of the sampling stations are given in Table 4. The point coordinates are given in feet of northing and easting based on the Ohio Coordinate System, South Zone, City of Cincinnati datum.

During the two sampling events, the concentrations of eleven metals and nine other general water quality parameters (e.g. total suspended solids (TSS) and nitrate) were analyzed from all drainage ditch and storm sewer samples. The volatile organic solvents 1,1,1-trichloroethane (1,1,1-TCA), trichloroethylene (TCE), and perchloroethylene (PERC) were analyzed from the manholes (MH-20, MH-33, and MH-58) located near specific use areas. Three uranium isotopes (U-234, U-235, and U-238), gross alpha radiation, and gross beta radiation were analyzed for all samples. The thorium isotopes Th-228, Th-230, and Th-232 were analyzed from three manholes (MH-17, MH-18, and MH-20) located near areas where thorium containing materials are stored. Radium isotope analyses were performed at four drainage ditch locations (DD-08, DD-14, DD-17, and DD-19) in areas near the fly ash piles and K-65 silos as requested by the Ohio EPA. Measurements of pH and conductivity and estimates of flow rates were made at all sampling locations.

TABLE 2
ANALYTICAL RESULTS FOR DRAINAGE DITCH SAMPLES COLLECTED JULY 20 AND 21, 1988,
AT THE FEED MATERIALS PRODUCTION CENTER, FERNALD, OHIO

Analyte	Units	DD-01 7-20-88	DD-07 7-21-88	DD-08 7-21-88	DD-09 7-21-88	DD-12 7-20-88	DD-13 7-20-88	DD-14 7-20-88	DD-17 7-20-88	DD-19 7-20-88	DD-21 7-20-88	DD-23 7-20-88	DD-ALT3 7-20-88
Aluminum	ug/L	869	456	1,470	964	345	200u	14,400	47,000	15,200	200u	11,700	404
Barium	ug/L	217	320	200u	209	200u	200u	387	366	300	200u	226	200u
Calcium	ug/L	153,000	157,000	31,400	80,100	33,700	5,000u	255,000	372,000	47,900	5,000u	85,900	70,700
Chromium	ug/L	10.0u	10.0u	10.0u	10.0u	10.0u	10.0u	12.8	66.3	19.1	10.0u	18.5	10.0u
Copper	ug/L	25.0u	28.8	25.0u	25.0u	25.0u	25.0u	50.4	106	57.5	25.0u	37.8	25.0u
Iron	ug/L	1,080	601	1,730	889	382	100u	19,300	95,600	17,900	170	22,200	369
Lead	ug/L	5.0u	5.0u	17.3	5.0u	5.0u	5.0	38.2	34.5	44.5	5.0	14.0	5.0u
Magnesium	ug/L	31,500	38,300	7,230	19,200	5,000	5,000u	43,600	93,000	9,860	5,000u	18,400	15,300
Manganese	ug/L	143	494	494	96.2	19.0	15.0u	2,080	2,270	725	20.0	713	102
Sodium	ug/L	10,100	16,800	5,980	25,300	26,100	5,000u	10,400	5,000u	5,000u	5,000u	5,000U	15,500
Zinc	ug/L	84.4	20.0u	426	26.0	53.3	20.0u	136	331	107	20.0u	106	108
TOC	mg/L	14.4	118	10.1	7.6	10.1	5.0	16.6	13.2	4.5	2.8	9.4	5.6
TOX	ug/L	41	260	64	37	14	10u	39	22	28	35	43	10u
TDS	mg/L	692	1,190	87.0	414	237	169	358	370	156	42.0	155	370
TSS	mg/L	266	20.0	472	148	10.0	23.0	2,150	7670	405	21.0	385	11.0
Oil & Grease	mg/L	1.0u	1.0u	1.4	1.8	1.0u	1.6	1.0u	1.2	1.0u	1.1	1.0u	1.0u
Cloride	mg/L	11.3	28.1	14.8	39.3	14.8	5.7	227	2.5u	2.5u	2.5	2.5u	12.6
Fluoride	mg/L	0.24	1.2	0.10u	1.3	1.5	0.69	0.68	0.31	0.26	0.10u	0.32	1.3
Sulfate	mg/L	317	38.3	6.8	89.9	48.1	25.7	48.4	121	25.5	6.2	14.3	102
Nitrate	mg/L	1.0u	0.20u	1.0u	2.6	6.3	3.1	1.8	6.4	1.4	6.1	0.20u	0.10u
1,1,1-TCA	ug/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TCE	ug/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
PERC	ug/L	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Gross Alpha	pCi/L	8±5	850±50	49±9	420±30	390±20	180±100	450±60	120±50	290±90	3±1	100±20	520±40
Gross Beta	pCi/L	13±3	560±20	39±4	380±10	330±10	140±10	370±30	270±40	260±60	4±2	110±10	190±20
Thorium-228	pCi/L	NR	NR	NR	0.1±0.3	NR	NR	NR	NR	NR	NR	NR	NR
Thorium-230	pCi/L	NR	NR	NR	1.4±0.5	NR	NR	NR	NR	NR	NR	NR	NR
Thorium-232	pCi/L	NR	NR	NR	0.1±0.2	NR	NR	NR	NR	NR	NR	NR	NR
Uranium-234	pCi/L	0.6±0.5	160±30	7.0±0.6	57±30	150±20	45±11	120±10	42±4	69±9	0.6±0.2	14±4	270±30
Uranium-235	pCi/L	0.3±0.2	5±10	0.3±0.1	1.0±8.6	8.7±4.4	6.1±3.7	21±5	2.6±1.2	7.4±3.0	0.1±0.1	2.0±1.3	12±8
Uranium-238	pCi/L	2.4±0.5	740±60	9.4±0.7	310±40	230±20	100±14	220±20	42±4	100±10	1.0±0.3	64±6	310±30
Radium-226	pCi/L	NR	NR	1.4±0.4	NR	NR	NR	7.0±0.6	11±1	14±1	NR	NR	NR
Radium-228	pCi/L	NR	NR	3.1±2.2	NR	NR	NR	4.5±1.8	5.3±1.7	7.8±2.7	NR	NR	NR
Flow	gpm	p	1	p	30	P	2	10	6	10	40	30	p
pH	std.	7.6	7.5	7.7	7.9	6.3	5.7	7.9	8.1	8.8	7.3	7.9	7.8
Conductivity	umhos	700	900	7.5	420	280	210	238	300	120	38	132	490
Temperature	oC	25	22	25	20	25	29	23	25	25	25	25	26

NOTES:
1. An "u" indicates the parameter was analyzed for but not detected. The minimum detection limit for the sample, not the method detection limit, is reported preceding the "u".
2. A "j" indicates the parameter was detected, but was not quantifiable. The detection limit for the sample is reported preceding the "j".
3. NR = Not requested.
4. TOC = total organic carbon.
5. TOX = total organic halogen.
6. TDS = total dissolved solids.
7. TSS = total suspended solids.
8. 1,1,1-TCA = 1,1,1-trichloroethane.
9. TCE = trichloroethylene.
10. PERC = perchchloroethylene (or tetrachloroethylene).
11. P = ponded water (not measurably flowing).

TABLE 3

Relevant Regulatory Limits

Metals (ppm)

	MCL	Ohio EPA ORC
Al	-	-
Ba	1.0	1.0
Ca	-	-
Cr	0.05	-
Cu	1.0	0.012 to 0.043[1]
Fe	0.3	-
Pb	0.05	0.05
Mg	-	-
Mn	0.05	-
Na	-	-
Zn	5.0	0.040 to 0.115[1]

Other General Water Quality Parameters (mg/l)

	MCL	Ohio EPA ORC	NPDES 1988 Permit	
			MH-175	Storm Sewer Retention Basin
TOC	-	-	-	-
TOX	-	-	-	-
TDS	-	750 (trans.) 500 (month avg.)	-	-
TSS	-	-	40 Daily Max. 20 Daily Avg.	100 Daily Max. 30 Daily Avg.
O&G	-	-	15	15 Daily Max.
Cl^-	-	-	0.10	-
Fl^-	-	1.0	-	-
SO_4	-	250	-	-
NO_X	10	10	-	-

Volatile Organics (ppm)

	MCL
1,1,1-TCA	0.200
TCE	0.005
PERC	

Table 3 (continued)

Radionuclides (pCi/l)	DOE Guidelines (MH-175)
Gross Alpha	-
Gross Beta	-
Thorium-228	400
Thorium-230	300
Thorium-232	50
Uranium-234	500
Uranium-235	600
Uranium-238	600
Radium-226	30
Radium-228	30

Physical Parameters	Ohio EPA ORC	NPDES 1988 Permit (MH-175)
pH	6.0 to 9.0	6.5 to 9.0
Conductivity (umhos)	1200 trans 800 month avg.	-

NOTE:
1) Variable depending on water hardness.

TABLE 4. Map Coordinate Locations of Sampling Stations for FMPC Stormwater Sampling Events of April 27, 1988, July 20, and July 21, 1988.

Drainage Ditches	Northing	Easting	Manholes	Northing	Easting
DD-01	482,622	1,377,511	MH-04	481,958	1,380,325
DD-07	481,498	1,377,778	MH-11	480,738	1,380,413
DD-08	477,377	1,380,207	MH-12	480,730	1,380,617
DD-09	481,042	1,378,081	MH-14	480,321	1,380,037
DD-12	480,794	1,379,866	MH-15	479,997	1,380,079
DD-13	480,707	1,379,846	MH-17	479,980	1,380,583
DD-14	479,976	1,378,288	MH-18	480,699	1,381,648
DD-17	478,015	1,378,828	MH-20	480,722	1,380,904
DD-19	477,262	1,379,701	MH-22	480,449	1,380,699
DD-21	478,857	1,381,315	MH-26	479,947	1,381,622
DD-23	480,143	1,378,307	MH-30	479,974	1,380,757
DD-ALT3	479,759	1,378,252	MH-33	479,477	1,380,667
			MH-35	481,349	1,380,729
			MH-57	481,086	1,380,719
			MH-58	479,449	1,380,663
			MH-75	479,963	1,381,153

Units are in feet and tied in with Ohio coordinate system, south zone, City of Cincinnati datum.

2.0 ANALYTICAL RESULTS

2.1 Metals

The highest level for aluminum was 47 parts per million (ppm) from sample DD-17 with three additional drainage ditch samples (DD-14, DD-19, and DD-21) exceeding 10 ppm. None of the manhole samples exceeded 10 ppm with the highest levels being 9.88 ppm from the storm flow event at MH-18 and 2.39 ppm from the base flow event at MH-30. The manhole samples showed a general increase in aluminum content between the base flow and storm flow events. There are no regulatory limits set for aluminum. The general increase in aluminum content may be accounted for by higher clay content in the storm flow samples. The samples were not filtered and the higher flow veolcity of the storm flow run-off may have caused suspension of greater amounts of aluminum-rich clay.

Barium has an established primary maximum contaminant level (MCL) of 1.0 ppm. This limit is also set by the Ohio EPA Ohio River Criteria (ORC). The limit was not exceeded by any of the samples. The highest detected barium concentration was 0.387 ppm from DD-14. None of the manhole samples from either the base or storm flow event had barium levels above the detection limit of 0.2 ppm.

The highest calcium levels were found in sample DD-17 which had 372 ppm. For the manholes, samples from the base flow event generally had higher concentrations than samples from the storm flow event. The base flow maximum was 116.9 ppm at MH-26 while the storm flow maximum was 62.3 ppm at MH-22 (the MH-22 duplicate value was 76.1 ppm). No MCL or other applicable standard for calcium exists.

For chromium, the primary MCL is 0.05 ppm and the laboratory detection limit was 0.01 ppm. Four of the drainage ditch samples had detectable levels of chromium with DD-17 at 0.0663 ppm being the only one above the MCL. Only two of the manhole samples contained detectable levels of chromium: MH-33, at 0.205 ppm, which exceeded the MCL during the base flow event; and, MH-18, at 0.0108 ppm during the storm flow event.

The secondary maximum concentration level (SMCL) for copper is 1 ppm and this value was not exceeded in any of the samples tested. The highest levels found were 0.106 ppm for DD-17, 0.277 ppm for MH-15 from the storm flow event, and 0.0555 for MH-15 from the base flow event. In the manholes where copper was detected, copper concentrations tended to be higher in the storm flow sampling event.

Iron and manganese have SMCLs of 0.3 ppm and 0.05 ppm, respectively. Both of these elements, however, occur naturally in the groundwater in the area of the FMPC at levels exceeding these SMCLs. In the drainage ditch samples, ten of twelve exceeded the SMCL for iron with four having values greater than 10 ppm and the highest being DD-17 at 95.6 ppm. Nine of twelve drainage ditch samples exceeded the SMCL for manganese but the maximum concentration was only 2.27 ppm. In the manhole samples, most exceeded the SMCL for iron with the highest levels occurring at MH-30 during the base flow event with 4.14 ppm and at MH-18 during the storm flow event with 15.7 ppm. There were no concentrations of manganese over 1 ppm in the manhole samples although most of them exceeded the SMCL. The highest manganese levels were 0.520 ppm at MH-12 for the base flow event and 0.310 ppm at MH-4 for the storm flow event. The general tendency was for iron concentrations to increase from the base flow event to the storm flow event while manganese concentrations showed no clear trend.

The primary MCL for lead is 0.05 ppm and none of the samples tested contained lead concentrations in excess of this limit. The highest levels found were 0.0445 ppm in DD-19, 0.0288 ppm in MH-30 during the base flow event, and 0.0136 ppm in MH-15 during the storm flow event. The general tendency was for lead concentrations to increase from the base flow event sampling to the storm flow event sampling.

Magnesium concentrations in the manhole samples from the base flow event exceeded 10 ppm at every location with the high being 29.2 ppm at MH-26. During the storm flow event, six of the twelve drainage ditch samples had magnesium levels greater than 10 ppm with the high being 93.0 ppm. For the manholes, the storm flow event high was 12.0 ppm at MH-57. The base flow event concentrations were generally greater than the storm flow event concentrations. There are no applicable regulatory data or MCLs for magnesium to which these concentrations can be compared.

The highest concentration of sodium found was during the base flow event at MH-26 which had 278 ppm. This value was five times greater than any other manhole sample from either the base or storm flow sampling events. The highest sodium concentrations from the storm flow event were 41.6 ppm at MH-57 and 26.1 ppm at DD-12. There was no clear trend of increasing or decreasing concentration between base and storm flow events. No standards or MCLs apply to sodium.

Zinc has a SMCL of 5.0 ppm and no values found during either sampling event exceeded this limit. The highest zinc concentrations were 0.426 ppm in DD-08, 0.206 ppm in MH-33 from the base flow event, and 2.06 ppm in MH-58 from the storm flow event. There was no clear trend for increases or decreases in concentrations between the base and storm flow events.

2.2 Other Water Quality Parameters

Total organic carbon (TOC) was reported for all drainage ditch and manhole samples. The maximum values reported were from DD-07 at 118 mg/L, MH-58 at 46 mg/L during the base flow event, and MH-33 at 9.4 mg/L during the storm flow event. The storm flow duplicate of MH-33 had 13.3 mg/L of TOC. There was no well-defined trend between the base and storm flow events for TOC; as equal numbers of manhole samples increased and decreased in concentration. No MCL or other standard for comparison of TOC levels exists.

Total organic halogen (TOX) was analyzed for all samples. The highest concentrations for both the base and storm flow event manhole samples were from MH-33. This sample was 190 ug/L during base flow and 900 ug/L during storm flow. The duplicate of MH-33 (storm flow) was 270 ug/L. The discrepancy in the TOX values for MH-33 and MH-33 duplicate may in part be due to a twenty minute time span between collection of the sample and the duplicate. This time was due to the number of bottles that were filled to complete the sample and duplicate. The highest value from the drainage ditches was DD-07 at 260 ug/L. Seven manhole samples increased in concentration while five samples decreased between the base and storm flow manhole sampling events. There are no standards or MCLs available for comparison to the TOX levels that were found.

Although the holding times for TOX and TOC were exceeded for all of the base flow manhole samples, the results of the TOX and TOC analysis for those samples are included in this report for purposes of comparison with the storm flow and drainage ditch

samples. Storm flow samples MH-20, MH-33, DD-01, DD-19, and DD-23 were analyzed one day over holding time for TOC due to a power outage at the laboratory caused by an electrical storm. Again, these samples are included for comparison purposes.

Anomalously high values for TOX and TOC were obtained from two rinse blank samples (RB-01 and RB-02) collected during the base flow event. Reagent-grade water was used for RB-01 and RB-02 and standard decontamination procedures were followed; however, the source of this apparent contamination may be due to the quality of the reagent water used for the base flow rinse blanks. Alternatively, the high TOC and TOX values in RB-01 and RB-02 may be due to excessive detergents in the rinse water for these rinse blanks. Note that the storm flow rinse blanks were decontaminated with deionized-water from a different source. Anomalous levels of the metals aluminum, calcium, iron, manganese, sodium, and zinc in RB-03 may have been due to contaminated DI water or ineffecient decontamination of the sampling apparatus. All decontamination of samplers was performed with deionized water from a different source than that used for the rinse blanks.

Results of total dissolved solids (TDS) analysis can be compared to the SMCL, set at 500 mg/L, and to the Ohio EPA ORC standard for TDS, which is set at 500 mg/L (monthly average) and 700 mg/L (transient). Two samples, DD-07, and MH-26 (base flow), exceeded the SMCL and the Ohio EPA ORC transient maximum; both values were 1,190 mg/L. Three other samples exceeded the SMCL and the Ohio EPA ORC monthly average: 1) MH-57 (base flow) at 631 mg/L; 2) MH-12 (storm flow) at 506 mg/L; and, 3) DD-01 at 692 mg/L. There is a well-defined trend between the base and storm flow manhole samples, with nine samples decreasing in concentration during storm flow while only three increased.

The NPDES limits for total suspended solids (TSS) are set for MH-175 at 20 mg/L (daily average) and 40 mg/L (daily maximum) and for the storm water retention basin (SWRB) discharge at 30 mg/L (daily average) and 100 mg/L (daily maximum). There is no MCL for TSS. The analytical results for TSS shows that ten out of twelve of the drainage ditch samples exceeded the MH-175 daily average limit of 20 mg/L. Seven out of the twelve exceeded the H-175 daily maximum for TSS. The maximum value obtained from the drainage ditch samples was from DD-17 at 7,670 mg/L. The high TSS at DD-17 and DD-14 may possibly be related to clear-cutting and fence building activities in their water sheds. Of the base flow manhole samples, five exceeded the MH-175 daily average of 20 mg/L; the highest was MH-30 at 137 mg/L. Of the storm flow manhole samples ten exceeded the MH-175 daily average and eight exceeded the MH-175 daily maximum. The highest storm flow values were: MH-11 at 241 mg/L; 2) MH-14 at 2,150 mg/L; and, 3) MH-33 (duplicate) at 125 mg/L. As might be expected, the concentration of TSS tended to increase from the base flow manhole samples to the storm flow samples. Only three manholes had TSS values that fell from base to storm flow sampling.

Oil and grease (O&G) limits are set by the FMPC's NPDES permit at 15 mg/L for MH-175 and 15 mg/L (daily maximum) for the SWRB. None of the drainage ditch or manhole samples exceeded this limit. There is no MCL set for O&G. The highest value reported was 7.0 mg/L from MH-26 (base flow). The highest storm flow event value was 1.9 mg/L from MH-11, this sample was observed to have a very light oil sheen when collected. The highest drainage ditch was DD-09 at 1.8 mg/L.

The highest chloride concentration analyzed was 242 mg/L from MH-26 during the base flow event. The value is below the SMCL

for chloride set at 250 mg/L. The highest storm flow concentration was at MH-57 (50.2 mg/L) and the highest drainage ditch value was at DD-14, at 227 mg/L. Chloride concentrations were mostly lower during the storm flow event than during the base flow event.

The primary MCL for fluoride is 1.4 mg/L at temperatures above 79.3^{o}F, while the Ohio EPA ORC standard for fluoride is 1.0 mg/L. During the storm flow event seven manholes were at or above 1.0 mg/L. The highest fluoride concentration was from MH-04 during the storm flow event at 4.1 mg/L. The next highest concentration was 1.4 mg/L, at MH-15, MH-22, and MH-33. The duplicate (storm flow) MH-33 had 0.78 mg/L. One manhole (MH-33) was over 1.0 mg/L during the base flow event. Four of the drainage ditch samples were over 1.0 mg/L fluoride, the highest being DD-12 at 1.5 mg/L. Nearly all of the manholes sampled showed an increase in the concentration of fluoride from the base flow to the storm flow sampling events.

Only three samples exceeded the Ohio EPA ORC standard for sulfate (SO_4) of 250 mg/L. These were DD-01 at 317 mg/L, MH-20 at 442 mg/L, and MH-17 at 348 mg/L, all of which were sampled during the storm flow event. The highest SO_4 concentration in the manhole samples from the base flow event was 152 mg/L from MH-58. Concentrations of SO_4 were found to mostly decrease from the base flow to the storm flow sampling events.

The primary MCL and the Ohio EPA ORC standard for nitrate are 10 mg/L, which was exceeded by only two samples. These were MH-12 at 24.5 mg/L and MH-18 at 18.0 mg/L, both of which were collected during the storm flow event. The highest base flow event sample was MH-26 at 5.2 mg/L and the highest drainage ditch was DD-17 at

6.4 mg/L. There was a clear trend for nitrate concentrations to increase from the base flow event to the storm flow event in the manhole samples.

2.3 Volatile Organics

Three volatile organic solvents (1,1,1-TCA, TCE, and PERC were analyzed from three manhole locations (MH-20, MH-33, and MH-58) during both sampling events. The only sample which contained any of these compounds at a concentration greater than the detection limit was MH-33 from the base flow event at 4.6 ppb of 1,1,1-TCA. This value, however, is well below the primary MCL of 200 ppb.

2.4 Radioactive Isotopes and Gross Radiation

DOE Order 5480.xx sets guidelines now in effect for the FMPC for the discharge of radionuclides including Thorium-228, -230, and -232 and Uranium-234, -235, and -238. The DOE Order 5480.xx limit for U-234 is 500 pCi/L, which was exceeded by eight manhole samples. Four more manhole samples would exceed 500 pCi/L if the positive counting errors are added to the base values. Observed concentrations of U-235 were within the DOE Order 5480.xx limit of 600 pCi/L for all samples, ranging from 0.1 to 98 pCi/L. Concentrations of U-238 in excess of DOE Order 5480.xx limits (600 pCi/L) were observed in twelve samples; the base flow event sample from MH-26 was by far the highest value observed, at 1700 pCi/L, whereas other samples from MH-22 (storm flow), MH-26 (storm flow), and MH-30 (base and storm flow) ranged from 680 to 920 pCi/L. One drainage ditch sample, DD-07, with a value of 740 pCi/L exceeded the U-238 limit. High gross alpha (5400 pCi/L) and gross beta (2000 pCi/L) concentrations were also observed in the base flow event sample from MH-26; gross alpha measurements in other samples ranged from 170 to 2600 pCi/L, while gross beta

measurements ranged from 89 to 780 pCi/L. The maximum gross alpha and gross beta concentrations for drainage ditches were from DD-07 and were 850 pCi/L and 560 pCi/L, respectively. Where sampled, radium-226 and -228 were well within the 30 pCi/L discharge limits. Thorium values were also well within DOE Order 5480.xx limits at the locations where it was sampled.

2.5 Physical Parameters

The flow rate was estimated at all manhole and drainage ditch sampling locations in order to evaluate the total contaminant load carried by the water passing a sampling location. Flows in the storm sewer system were estimated using Manning's formula, based on elevations and slopes from the storm sewer plans, and measurements of the depth of flow at manholes. Flows in the drainage ditches were estimated by measuring the cross-sectional area of the ditch at the sampling location and estimating the velocity with a float. For small flows in the drainage ditches, the flow was caught in a graduated bucket and timed for measurement. The estimation methods are described in greater detail in the Appendix.

The acceptable pH range at the FMPC is 6.5 to 9.0 at MH-175. All of the manhole samples were within this range. Two drainage ditch samples, DD-12 and DD-13, had pH readings of 6.3 and 5.7, respectively, which are below the limit set for MH-175. Field pH meters were calibrated using buffer solutions of 4.0, 7.0, and 10.0 standard units.

The transient conductivity limit established by the Ohio EPA ORC is 1200 umhos. The only sample to exceed this limit was the MH-26 base flow event sample at 1500 umhos. The highest storm

flow event sample was 690 umhos at MH-12. The highest value from the drainage ditch samples was 900 umhos at DD-07. Conductivity was measured using calibrated field conductivity meters.

Temperature was measured for each sample station using standard centigrade-scale thermometers. This data was used to set the pH and conductivity meters to their proper temperature settings. In general, the temperatures recorded tended to reflect the ambient temperatures at the times of collection. Both seasonal and diurnal variations appear to have affected the temperature readings. The base flow event water temperatures ranged from 9°C at MH-57 to 28°C at MH-17 with the average 15.8°C. Three base flow samples were found to have anomolusly high temperatures at this time; these were MH-17 at 28°C, MH-15 at 26°C, and MH-26 at 24°C. Heat or heated water may be entering the storm sewer system at or near these manholes to result in these high temperatures. The storm flow event water temperatures ranged from 22°C at MH-58 to 29°C at MH-17. The average temperature was 25.0°C. MH-17 seems to have had a temperature slightly elevated above the normal range, indicating that a source of heat and/or heated water may exist at or near this manhole. The temperatures measured at the drainage ditch sample stations ranged from 20°C DD-09 to 29°C at DD-13, with the average 24.6°C. The temperature at DD-13 would seem to be anomalously high. There does not appear to be an explanation for this anomaly.

3.0 SUMMARY

The analytical data for MH-26 show that when sampled under base flow conditions, this was the most heavily contaminated of all the manholes. It had the highest concentrations of uranium-238, at 5,400 pCi/L (±200), and of TDS, at 1,190 mg/L, both of which

exceeded applicable limits. The sample also had the highest levels of the unregulated analytes sodium (278 mg/L), calcium (116.9 mg/L), magnesium (29.2 mg/L) and chloride (0.242 mg/L). The sample's high ionic burden is reflected by its having the highest measured conductivity of all samples, 1500 umhos, which also exceeded the Ohio EPA ORC. Additionally, nitrates and oil and grease were found to be high in comparison to the other samples, but well below applicable limits. The area drained by MH-26, which includes the area around Plant 6, is recommended for further study.

Analytical data showed MH-33 to also contain generally higher than average levels of contaminants. When sampled during the base flow event this manhole posted the highest of all results for chromium, at 0.205 mg/L, and the highest of all manholes for zinc at 0.206 mg/L. Both of these values exceeded the Ohio EPA ORC for these metals. The base flow sample from MH-33 also was among the highest in fluoride, at 2.8 mg/L. An elevated fluoride concentration was also found in the storm flow sample, which was 1.4 mg/L, despite having a 50 times higher measured flow rate than the base flow. The storm flow sample for MH-33 was also by far the highest in total organic carbon, at 94 mg/L, and total organic halogens, at 0.9 mg/L. Manhole-33 is near the laundry and was also tested for 1,1,1-TCA, TCE, and PERC. The only one of these parameters detected was 1,1,1-TCA at 4.6 ug/L.

The load of suspended solids carried by the storm sewers is relatively low when expressed as mg/L concentrations. It is possible to estimate the daily mass in Kg/day of suspended solids based on the concentration and the rate of flow. (Constant flow rate and TSS content are assumed). The estimated daily load of suspended solids carried by MH-75, the farthest down stream

manhole sampled, was 40 Kg/day during base flow conditions. During the same base flow conditions upstream manholes that would be expected to contribute to the load of MH-75 and their estimated loads are as follows: 1) MH-33 at 0.218 Kg/day; 2) MH-22 at <0.022 Kg/day; and, 3) MH-17 at 0.327 Kg/day. It should be noted that the estimated flow in these three manholes was no greater than 10 gpm when sampled in the morning. However, when MH-75 was sampled in the afternoon, the flow rates had increased and the estimated flow rate in MH-75 was then 200 gpm. Accordingly, the sum total of the loading rates for the three contributing manholes is probably not directly comparable to the 40 Kg/day estimated for the flow measured at MH-75.

Suspended solid loads for the storm flow of 20 and 21 July 1988 are based on an assumed two-hour duration for the storm water flow measured at the time of sampling. During this two-hour storm event MH-75 was estimated to carry 24 Kg of suspended solids while, upstream, MH-33 carried 18.8 Kg, MH-22 carried 4.3 Kg, and MH-17 carried 1.5 Kg. The sum of the loads from these three manholes was 24.6 Kg, a difference of only 2.5 percent from the load of MH-75.

High fluoride levels were found in MH-22 in addition to those in MH-33. The base flow concentration for MH-22 was 3.2 mg/L. While the concentration of fluoride during the stormflow event was lower at 1.4 mg/L, the actual amount of fluoride carried at that time may have been much greater due to the higher flow. Both MH-22 and MH-33 are located in close proximity to Plant 4 where hydrofluoric acid is used.

4.0 CONCLUSIONS

The most significant finding of the stormwater sampling program are the levels of contaminants in MH-26. Since some of the highest values for many parameters analyzed from sampling the FMPC storm sewer system occurred at MH-26, including levels of TDS, uranium-238, gross alpha radiation, and gross beta radiation, WMCO should investigate potential sources of contamination at MH-26 and take measures to reduce contaminant levels entering the manhole when sources are identified.

The other issue that arises from the results of the stormwater sampling program is the levels of total suspended solids (TSS) carried in the storm sewer and drainage ditch flows. In general, there appears to be a correlation between the concentrations of TSS and other contaminants in the stormwater samples. The samples were not filtered before analysis, so that the reported concentrations represent the sum of both dissolved and suspended contaminants. The TSS values support the need for the expansion of the storm water retention basin to accommodate a 10-year rainfall event storm sewer flow and possibly to receive the surface runoff from the waste storage and fly ash areas. This expansion would reduce the suspended solids, radionuclides, fluoride, nitrate, and metals (carried with the suspended sediment load) being discharged to Paddy's Run from the FMPC site by allowing suspended solids to settle. The amounts of suspended solids that would be entering the expanded basin indicate that provisions may have to be made for removal of settled solids from the basin.

Two other interesting results of the stormwater sampling program were the organic levels in MH-33 and the fluoride levels in MH-22 and MH-33. Manhole 33 was tested for 1,1,1-TCA, TCE, and PERC since it is located in the area of the laundry where solvents are used. None of these halogenated organic solvents were detected at levels greater than 0.005 mg/L; however, during the storm flow event sampling, the total halogenated organic content (TOX) at MH-33 was the highest of all samples at 0.9 mg/L. Further investigation at this location may be warranted to determine the nature of the halogenated organics at MH-33 and the source. The consistent excessive fluoride levels (greater than the 1 ppm limit of Ohio EPA ORC) at MH-22 and MH-33 indicate that WMCO should investigate potential fluoride sources in the area to determine if actions can be taken to lower the levels reaching these manholes.

APPENDIX

FLOW ESTIMATION METHODS

Three methods were used to obtain reliable estimates of the flow at sample stations. Flow in most of the manholes was estimated using Manning's formula, based on measurement of the depth of flow, the known size of the pipes, and elevation information from engineering diagrams, as shown in the examples below. Flow in some of the manholes and most of the drainage ditches was estimated by timing a float to get current velocity and multiplying by the measured cross-sectional area of flow. A few of the drainage ditches had too little flow to use this method and in these cases flow was measured by timing the flow as it filled a five gallon bucket. Sample calculations are provided below for flow estimates arrived at using Manning's formula by calculation and by nomograph.

Example: flow (Q) by Manning's formula (calculated)

$$Q = (1.49/n)\ (A)\ (R)^{2/3}(S)^{1/2}$$

where: n = roughness coefficient
A = cross-sectional area
R = hydraulic radius = A/P
where: A = area
P = wetted perimeter
S = slope ratio

MH-75: Low flow event - bottom filled with sediment; handled as rectangular channel

n = 0.013 (majority of channel)
depth of flow = 2 inches (measured in field)
width of flow = 1.5 feet
area = 0.25 square feet
R = A/P = 0.25/1.83 = 0.14
S = 0.0031 (from FMPC storm sewer drawings)

$Q = (1.49/0.013)(0.25)(0.14)^{2/3}(0.0032)^{1/2}$
= 0.43 cubic feet per second (cfs)
or 193 gallons per minute (gpm)
(rounded to 200 gpm).

Example: flow by Manning's formula (nomograph)

MH-30: Storm flow event

where:

D = pipe size = 24 inches (from FMPC storm sewer drawings
d = flow depth = 3 inches (measured in field)
s = slope ratio = 0.0086 (from FMPC storm sewer drawings)

Using nomograph from Steel and McGhee, 1979 (see FIGURE A-1), to obtain full pipe flow (Q_f),

$Q_f = 21$

Using an additional nomograph from Steel and McGhee, 1979 (see FIGURE A-2), Q is obtained

for $d/D = 3/24 = 0.125$

then $q/Q_f = 0.03$

$Q = 0.03\ (21)$

$= 0.63$ cfm or 283 gpm (rounded to 300 gpm)

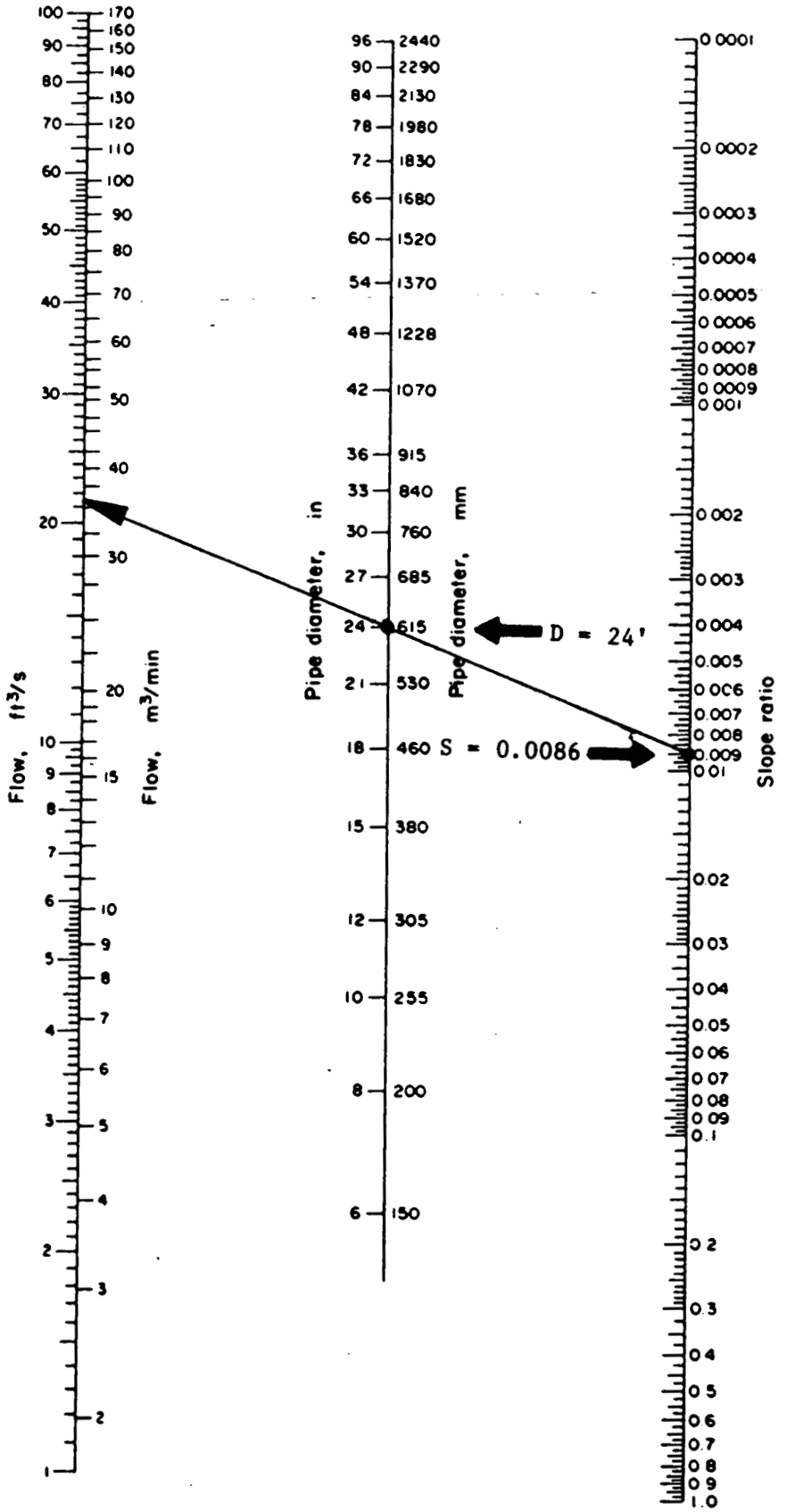

FIGURE A-1. Nomograph for solution of Manning formula for circular pipes flowing full, n = 0.013. Using D = 24 inches and S = 0.008, Q is found to be 21 cfs.

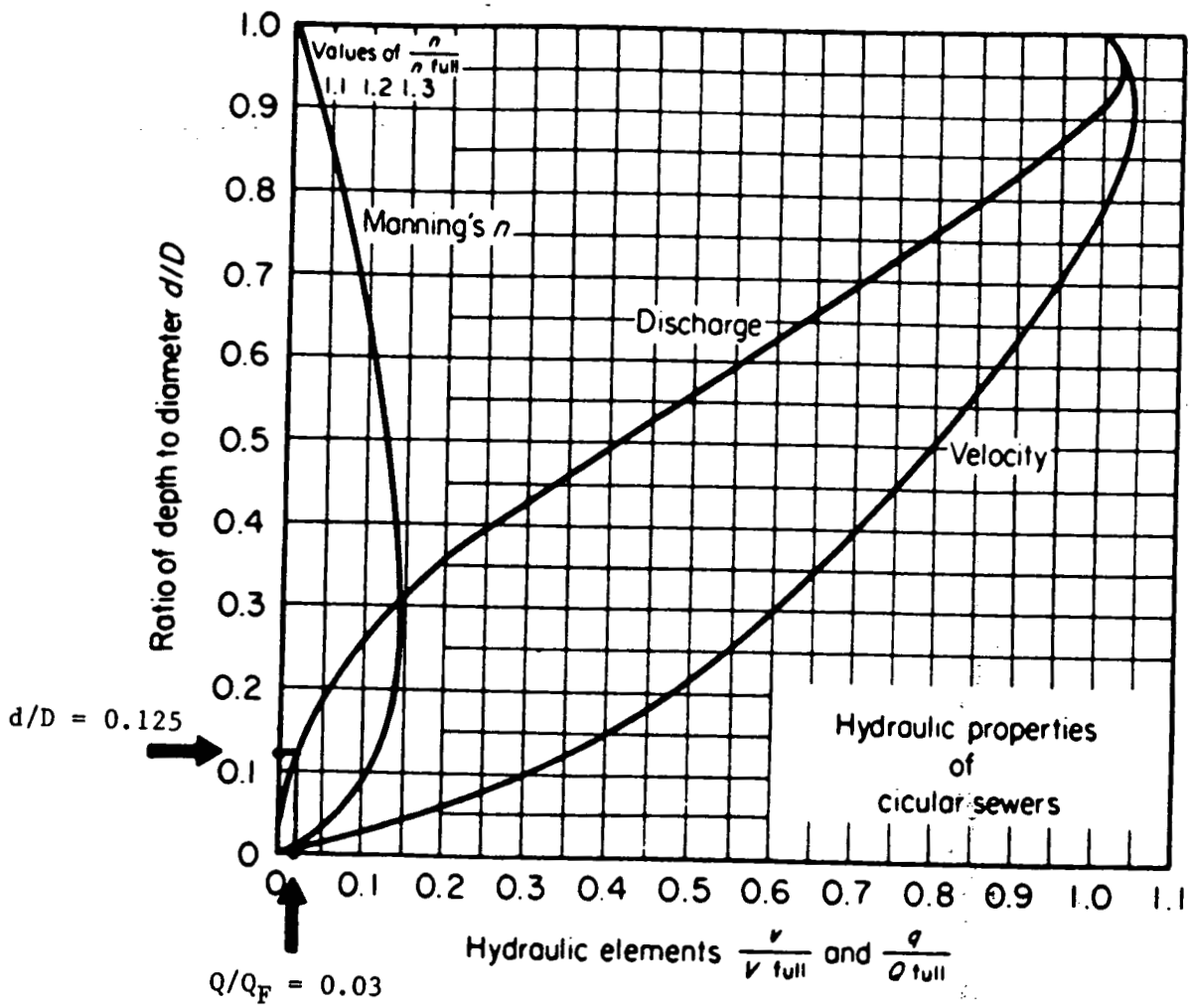

FIGURE A-2. Nomograph for solution of hydraulic elements of a circular pipe. A value of d/D of 0.125 for MH-30 gives $Q/Q_f = 0.03$.

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