APPENDIX FOR CHAPTER C8 SEWERAGE PLANNING AND DESIGN BASES

AC8.1 Population and Service Population

Based on the present population as of 2015, the population up to 2038 has been estimated by Union Council base. Table AC8.1 shows the population and service population in the west and the east zone, respectively. The service population in the target year of 2038 is the design bases for the sewerage system.

Table AC.8.1 Population in Sewerage Planning Area

Zone	UU No.	2015 Area		2038 Area		Population Projection					Population in Sewerage Service Area				
		km^2	ha	km^2	ha	2015	2023	2028	2033	2038	2015	2023	2028	2033	2038
West	148	-	-	18.4532	1,845	16,121	19,150	21,010	22,860	24,700	-	-	-	-	24,700
	167	-	-	18.0137	1,801	23,813	27,290	29,410	31,520	33,640	-	-	-	-	33,640
	174	-	-	6.5170	652	28,654	32,830	35,380	37,940	40,480	-	-	-	-	40,480
	178	-	-	1.5221	152	18,619	22,170	24,340	26,510	28,670	-	-	-	-	28,670
	179	-	-	7.8612	786	26,258	30,080	32,430	34,760	37,100	-	30,080	32,430	34,760	37,100
	180	-	-	2.8328	283	25,179	26,210	26,830	27,460	28,080	-	26,210	26,830	27,460	28,080
	181	-	-	2.9324	293	40,851	42,540	43,530	44,540	45,550	-	42,540	43,530	44,540	45,550
	182	-	-	5.1526	515	6,392	7,130	7,570	8,020	8,460	-	-	7,570	8,020	8,460
	183	0.9526	95	0.9526	95	26,003	28,970	30,780	32,590	34,400	26,003	28,970	30,780	32,590	34,400
	184	3.2228	322	3.2228	322	23,732	26,440	28,090	29,740	31,390	23,732	26,440	28,090	29,740	31,390
	185	5.4311	543	5.4311	543	21,683	24,160	25,670	27,170	28,690	21,683	24,160	25,670	27,170	28,690
	186	5.0156	502	5.0156	502	24,323	27,100	28,800	30,490	32,170	24,323	27,100	28,800	30,490	32,170
	187	1.0127	101	1.0127	101	29,397	32,660	35,770	38,860	41,940	29,397	32,660	35,770	38,860	41,940
	188	1.7958	180	1.7958	180	23,133	25,770	27,380	28,990	30,600	23,133	25,770	27,380	28,990	30,600
	189	7.4805	748	7.4805	748	26,193	29,190	31,010	32,830	34,650	26,193	29,190	31,010	32,830	34,650
	190	3.1633	316	3.1633	316	24,940	27,780	29,520	31,260	32,990	24,940	27,780	29,520	31,260	32,990
	191	-	-	4.1174	412	23,666	26,370	28,010	29,660	31,310	-	26,370	28,010	29,660	31,310
	192	-	-	9.3513	935	27,773	30,950	32,880	34,810	36,740	-	30,950	32,880	34,810	36,740
	193	5.5215	552	5.5215	552	24,121	26,880	28,550	30,230	31,910	24,121	26,880	28,550	30,230	31,910
	194	2.3577	236	2.3577	236	22,745	25,350	26,920	28,510	30,080	22,745	25,350	26,920	28,510	30,080
	195	2.6645	266	2.6645	266	31,883	37,510	40,950	44,390	48,550	31,883	37,510	40,950	44,390	48,550
	196	2.8628	286	2.8628	286	26,293	29,300	31,130	32,960	34,780	26,293	29,300	31,130	32,960	34,780
	197	0.9033	90	0.9033	90	24,961	27,660	29,290	30,940	32,580	24,961	27,660	29,290	30,940	32,580
	198	0.7175	72	0.7175	72	9,268	10,270	10,880	11,490	12,100	9,268	10,270	10,880	11,490	12,100
	199	1.5431	154	1.5431	154	10,418	11,550	12,230	12,920	13,600	10,418	11,550	12,230	12,920	13,600
	200	4.7652	477	0.0000	0	23,381	0	0	0	0	23,381	0	0	0	0
	201	3.4049	340	0.0000	0	27,036	0	0	0	0	27,036	0	0	0	0
	202	4.3705	437	0.0000	0	26,064	0	0	0	0	26,064	0	0	0	0
	203	2.0801	208	0.0000	0	23,046	0	0	0	0	23,046	0	0	0	0
	204	0.8550	86	0.0000	0	22,717	0	0	0	0	22,717	0	0	0	0
	205	0.8403	84	0.0000	0	26,945	0	0	0	0	26,945	0	0	0	0
	206	1.4951	150	0.9344	93	26,960	18,670	19,770	20,880	21,990	26,960	18,670	19,770	20,880	21,990
	207	0.9160	92	0.8455	85	21,841	22,340	23,660	24,990	26,310	21,841	22,340	23,660	24,990	26,310
	208	1.1430	114	1.1430	114	25,232	30,100	33,090	36,080	39,770	25,232	30,100	33,090	36,080	39,770
	209	0.7192	72	0.7192	72	29,570	32,950	35,000	37,070	36,950	29,570	32,950	35,000	37,070	36,950
	210	1.3377	134	1.3377	134	25,380	30,270	33,270	36,260	39,960	25,380	30,270	33,270	36,260	39,960
	211	0.3969	40	0.3969	40	25,010	24,900	24,800	24,710	24,640	25,010	24,900	24,800	24,710	24,640
	212	0.4086	41	0.4086	41	25,357	25,250	25,150	25,060	24,980	25,357	25,250	25,150	25,060	24,980
	213	0.8340	83	0.4227	42	7,234	6,420	6,860	7,310	7,840	7,234	6,420	6,860	7,310	7,840

Table AC.8.1 Population in Sewerage Planning Area

Zone	UU No.	2015 Area		2038 Area		Population Projection					Population in Sewerage Service Area				
		km^2	ha	km^2	ha	2015	2023	2028	2033	2038	2015	2023	2028	2033	2038
West	214	0.6276	63	0.6276	63	26,227	29,060	30,780	32,500	32,400	26,227	29,060	30,780	32,500	32,400
	215	1.1073	111	1.1073	111	28,738	32,450	34,720	36,980	39,700	28,738	32,450	34,720	36,980	39,700
	216	0.6541	65	0.0000	0	17,669	0	0	0	0	17,669	0	0	0	0
	218	0.2418	24	0.0000	0	4,682	0	0	0	0	4,682	0	0	0	0
	230	1.0154	102	1.0154	102	7,208	7,990	8,470	8,940	9,410	7,208	7,990	8,470	8,940	9,410
	231	0.7532	75	0.7532	75	6,325	7,700	8,530	9,790	11,030	6,325	7,700	8,530	9,790	11,030
	232	0.5363	54	0.5363	54	22,850	25,460	27,050	26,960	26,870	22,850	25,460	27,050	26,960	26,870
	233	0.4040	40	0.4040	40	21,833	21,730	21,650	21,570	21,510	21,833	21,730	21,650	21,570	21,510
	262	5.2994	530	5.2994	530	22,844	25,460	27,040	28,630	30,220	-	25,460	27,040	28,630	30,220
	263	1.4624	146	1.4624	146	28,719	33,340	37,040	40,710	44,390	28,719	33,340	37,040	40,710	44,390
	264	0.4843	48	0.4843	48	24,901	24,790	24,690	24,610	24,530	24,901	24,790	24,690	24,610	24,530
	265	0.4870	49	0.4870	49	23,950	26,610	26,510	26,410	26,330	23,950	26,610	26,510	26,410	26,330
	266	0.9697	97	0.9697	97	22,997	26,210	28,170	30,130	32,090	22,997	26,210	28,170	30,130	32,090
	267	2.3303	233	2.3303	233	20,401	23,330	25,130	26,910	28,690	20,401	23,330	25,130	26,910	28,690
	268	1.2559	126	1.2559	126	22,012	24,460	25,950	27,430	28,920	22,012	24,460	25,950	27,430	28,920
	269	0.4061	41	0.4061	41	22,831	22,730	22,640	22,560	22,490	22,831	22,730	22,640	22,560	22,490
	270	-	-	2.8135	281	22,178	25,300	27,210	29,110	31,010	-	25,300	27,210	29,110	31,010
	271	1.6228	162	1.6228	162	26,389	29,970	32,180	34,360	36,560	26,389	29,970	32,180	34,360	36,560
	272	2.4358	244	2.4358	244	21,554	23,950	25,400	26,870	28,320	21,554	23,950	25,400	26,870	28,320
	273	1.9375	194	1.9375	194	29,658	33,310	35,740	38,180	40,620	29,658	33,310	35,740	38,180	40,620
	274	5.6490	565	5.6490	565	34,363	38,180	40,490	42,830	45,150	34,363	38,180	40,490	42,830	45,150
	275	3.3843	338	3.3843	338	29,295	32,550	34,530	36,510	38,490	29,295	32,550	34,530	36,510	38,490
	276	0.6636	66	0.6636	66	30,947	34,380	34,250	34,130	34,020	30,947	34,380	34,250	34,130	34,020
	277	0.8364	84	0.8364	84	29,070	32,290	35,380	38,450	41,510	29,070	32,290	35,380	38,450	41,510
	278	0.6964	70	0.6964	70	24,980	27,750	29,440	31,140	32,820	24,980	27,750	29,440	31,140	32,820
	279	0.8851	89	0.8851	89	21,161	23,870	25,720	27,590	29,440	21,161	23,870	25,720	27,590	29,440
	280	1.4646	146	1.4646	147	26,001	29,250	31,430	33,620	35,810	26,001	29,250	31,430	33,620	35,810
	281	0.2291	23	0.2291	23	21,424	21,320	21,240	21,170	21,100	21,424	21,320	21,240	21,170	21,100
	282	0.6354	64	0.6354	64	24,642	27,380	29,040	30,710	32,380	24,642	27,380	29,040	30,710	32,380
	283	1.3583	136	1.3583	136	29,738	33,400	35,840	38,270	40,710	29,738	33,400	35,840	38,270	40,710
	284	0.4666	47	0.4666	47	20,900	23,240	23,130	23,060	22,990	20,900	23,240	23,130	23,060	22,990
	285	0.6670	67	0.6670	67	24,626	27,710	29,810	31,900	34,000	24,626	27,710	29,810	31,900	34,000
	286	1.2726	127	1.2726	127	30,715	34,470	36,990	39,500	42,000	30,715	34,470	36,990	39,500	42,000
	287	0.8514	85	0.8514	85	30,351	34,080	36,560	39,040	41,520	30,351	34,080	36,560	39,040	41,520
	288	0.9412	94	0.9412	94	30,780	34,200	36,270	38,360	40,440	30,780	34,200	36,270	38,360	40,440
	289	1.7415	174	1.7415	174	30,112	34,890	38,680	42,460	46,220	30,112	34,890	38,680	42,460	46,220
	Sub Total	**113.9848**	**11,400**	**175.2975**	**17,530**	**1,785,263**	**1,779,020**	**1,887,660**	**1,995,200**	**2,101,290**	**1,502,915**	**1,670,450**	**1,777,520**	**1,876,370**	**2,101,290**

Table AC.8.1 Population in Sewerage Planning Area

Zone	UU No.	2015 Area		2038 Area		Population Projection					Population in Sewerage Service Area				
		km^2	ha	km^2	ha	2015	2023	2028	2033	2038	2015	2023	2028	2033	2038
East	144	-	-	24.8595	2,486	35,316	42,040	46,160	50,270	54,370	-	-	-	-	54,370
	145	-	-	22.5021	2,250	45,493	54,160	59,450	64,750	70,030	-	-	-	-	70,030
	148	-	-	17.1021	1,710	14,941	17,740	19,470	21,180	22,890	-	-	-	-	22,890
	182	-	-	18.5920	1,859	23,065	25,690	27,300	28,900	30,510	-	-	27,300	28,900	30,510
	176	0.0000	0	6.7540	675	25,377	29,080	31,330	33,600	35,850	-	-	-	-	35,850
	177	0.0000	0	9.5076	951	35,198	38,990	41,310	43,620	45,920	-	38,990	41,310	43,620	45,920
	178	-	-	1.8013	180	22,033	26,220	28,790	31,360	33,910	-	-	-	-	33,910
	198	1.2062	120	1.2062	120	15,578	17,260	18,270	19,300	20,320	15,578	17,260	18,270	19,300	20,320
	199	1.8334	183	1.8334	183	12,378	13,710	14,520	15,330	16,150	12,378	13,710	14,520	15,330	16,150
	200	0.0000	0	4.7652	477	0	25,900	27,440	28,970	30,510	0	25,900	27,440	28,970	30,510
	201	0.0000	0	3.4049	341	0	29,950	31,730	33,500	35,280	0	29,950	31,730	33,500	35,280
	202	0.0000	0	4.3705	437	0	28,880	30,590	32,300	34,020	0	28,880	30,590	32,300	34,020
	203	0.1908	19	2.2709	227	2,113	27,870	29,530	31,180	32,830	2,113	27,870	29,530	31,180	32,830
	204	0.0866	9	0.9416	94	2,302	27,710	29,360	31,000	32,650	2,302	27,710	29,360	31,000	32,650
	205	0.0000	0	0.8403	84	0	29,860	31,620	33,390	35,160	0	29,860	31,620	33,390	35,160
	206	0.0000	0	0.5607	56	0	11,200	11,870	12,530	13,190	0	11,200	11,870	12,530	13,190
	207	0.0000	0	0.0705	7	0	1,860	1,970	2,080	2,190	0	1,860	1,970	2,080	2,190
	213	2.5425	254	1.7561	176	22,054	26,650	28,490	30,350	32,560	22,054	26,650	28,490	30,350	32,560
	216	0.1163	12	0.7704	77	3,142	23,660	25,410	27,150	29,360	3,142	23,660	25,410	27,150	29,360
	217	0.2385	24	0.2385	24	21,743	21,650	21,560	21,490	21,420	21,743	21,650	21,560	21,490	21,420
	218	0.7412	74	0.9830	98	14,349	21,690	23,320	24,960	27,030	14,349	21,690	23,320	24,960	27,030
	219	4.8939	489	4.8939	489	25,891	28,690	30,380	32,090	33,790	25,891	28,690	30,380	32,090	33,790
	34	0.0000	0	3.4041	340	22,978	25,120	26,470	27,810	29,150	-	-	-	-	29,150
	220	0.0000	0	7.8276	783	28,043	31,070	32,910	34,750	36,600	-	31,070	32,910	34,750	36,600
	221	2.3957	240	2.3957	240	26,272	29,110	30,830	32,560	34,280	26,272	29,110	30,830	32,560	34,280
	222	2.2620	226	2.2620	226	26,107	28,920	30,640	32,350	34,060	26,107	28,920	30,640	32,350	34,060
	223	1.1080	111	1.1080	111	28,411	31,480	33,350	35,210	37,080	28,411	31,480	33,350	35,210	37,080
	224	1.1653	117	1.1653	117	22,037	24,420	25,860	27,310	28,750	22,037	24,420	25,860	27,310	28,750
	225	2.5360	254	2.5360	254	24,462	27,100	28,710	30,310	31,920	24,462	27,100	28,710	30,310	31,920
	226	0.0000	0	1.5621	156	30,641	33,950	35,960	37,980	39,980	-	33,950	35,960	37,980	39,980
	227	0.0000	0	2.4566	246	24,093	26,700	28,280	29,860	31,440	-	26,700	28,280	29,860	31,440
	228	1.3252	133	1.3252	133	21,132	23,410	24,800	26,190	27,570	21,132	23,410	24,800	26,190	27,570
	229	1.1190	112	1.1190	112	21,362	23,670	25,070	26,470	27,880	21,362	23,670	25,070	26,470	27,880
	230	2.0246	202	2.0246	202	14,374	15,920	16,860	17,810	18,750	14,374	15,920	16,860	17,810	18,750
	231	2.2840	228	2.2840	228	19,181	23,320	25,860	29,650	33,440	19,181	23,320	25,860	29,650	33,440
	234	0.9436	94	0.9436	94	23,519	26,200	27,840	29,480	31,110	23,519	26,200	27,840	29,480	31,110
	235	0.6334	63	0.6334	63	22,550	25,130	26,690	28,260	29,830	22,550	25,130	26,690	28,260	29,830
	236	0.9093	91	0.9093	91	21,046	23,450	24,910	26,370	27,840	21,046	23,450	24,910	26,370	27,840
	237	1.1077	111	1.1077	111	23,907	26,640	28,300	29,960	31,620	23,907	26,640	28,300	29,960	31,620

Table AC.8.1 Population in Sewerage Planning Area

Zone	UU No.	2015 Area		2038 Area		Population Projection					Population in Sewerage Service Area				
		km^2	ha	km^2	ha	2015	2023	2028	2033	2038	2015	2023	2028	2033	2038
East	238	0.0000	0	1.3596	136	24,139	26,750	28,330	29,920	31,500	-	26,750	28,330	29,920	31,500
	239	0.9956	100	0.9956	100	23,705	26,410	28,060	29,700	31,360	23,705	26,410	28,060	29,700	31,360
	240	1.4300	143	1.4300	143	30,851	34,370	39,680	49,300	40,810	30,851	34,370	39,680	49,300	40,810
	241	0.6820	68	0.6820	68	25,316	28,210	29,970	31,730	33,490	25,316	28,210	29,970	31,730	33,490
	242	2.5352	254	2.5352	254	20,436	22,770	24,190	25,620	27,030	20,436	22,770	24,190	25,620	27,030
	243	1.1366	114	1.1366	114	28,544	32,840	35,830	38,800	42,080	28,544	32,840	35,830	38,800	42,080
	244	0.4892	49	0.4892	49	25,055	24,960	24,860	24,770	24,700	25,055	24,960	24,860	24,770	24,700
	245	0.5412	54	0.5412	54	27,227	27,110	27,000	26,910	26,820	27,227	27,110	27,000	26,910	26,820
	246	0.6428	64	0.6428	64	29,188	32,520	32,400	32,280	32,180	29,188	32,520	32,400	32,280	32,180
	247	0.9326	93	0.9326	93	28,169	32,420	35,380	38,330	41,590	28,169	32,420	35,380	38,330	41,590
	248	0.8698	87	0.8698	87	28,624	32,920	35,920	38,900	42,190	28,624	32,920	35,920	38,900	42,190
	249	0.0000	0	6.2845	629	30,800	36,660	40,260	43,840	47,410	-	36,660	40,260	43,840	47,410
	250	0.0000	0	7.4426	744	21,854	24,350	25,870	27,390	28,910	-	24,350	25,870	27,390	28,910
	251	1.4172	142	1.4172	142	27,727	30,890	32,820	34,740	36,670	27,727	30,890	32,820	34,740	36,670
	252	1.4780	148	1.4780	148	26,576	29,620	31,460	33,310	35,160	26,576	29,620	31,460	33,310	35,160
	253	0.6169	62	0.6169	62	25,434	28,340	30,100	31,880	31,780	25,434	28,340	30,100	31,880	31,780
	254	1.1784	118	1.1784	118	21,206	23,630	25,110	26,580	28,060	21,206	23,630	25,110	26,580	28,060
	255	2.7722	277	2.7722	277	24,151	26,910	28,590	30,270	31,950	24,151	26,910	28,590	30,270	31,950
	256	1.0888	109	1.0888	109	23,346	26,010	27,640	29,260	30,880	23,346	26,010	27,640	29,260	30,880
	257	1.0771	108	1.0771	108	24,717	28,570	31,290	34,000	37,020	24,717	28,570	31,290	34,000	37,020
	258	1.2083	121	1.2083	121	22,527	25,100	26,660	28,230	29,800	22,527	25,100	26,660	28,230	29,800
	259	0.8413	84	0.8413	84	22,118	25,680	28,210	30,740	33,580	22,118	25,680	28,210	30,740	33,580
	260	0.6033	60	0.6033	60	22,874	25,490	27,080	28,670	30,260	22,874	25,490	27,080	28,670	30,260
	261	0.9009	90	0.9009	90	31,324	35,930	39,110	42,290	45,760	31,324	35,930	39,110	42,290	45,760
	262	0.0000	0	0.4546	45	1,959	2,180	2,320	2,460	2,590	-	2,180	2,320	2,460	2,590
	Sub Total	**55.1006**	**5,511**	**204.0677**	**20,407**	**1,338,955**	**1,706,710**	**1,821,350**	**1,941,550**	**2,044,820**	**953,025**	**1,486,660**	**1,609,680**	**1,712,580**	**2,044,820**
Total		**169.0854**	**16,911**	**379.3652**	**37,937**	**3,124,218**	**3,485,730**	**3,709,010**	**3,936,750**	**4,146,110**	**2,455,940**	**3,157,110**	**3,387,200**	**3,588,950**	**4,146,110**
FDA City (West)						0	18,750	37,500	56,250	75,000	0	18,750	37,500	56,250	75,000
Grand Total						**3,124,218**	**3,504,480**	**3,746,510**	**3,993,000**	**4,221,110**	**2,455,940**	**3,175,860**	**3,424,700**	**3,645,200**	**4,221,110**

APPENDIX FOR CHAPTER C9 STUDY ON ALTERNATIVE SEWERAGE SYSTEM

AC9.1 Sewer Alternatives in the Western SWD

Two sewer alternatives are prepared for the western SWD. In case of applying oxidation ponds system that require large land space but most easy to operate to maintain, the present land area at Chokera WWTP is not enough, in other words, addition site is required.

Table AC9.1.1 shows the sewer alternative SW-1: the Chokera WWTP is only used to treat the design influent flow rate by upgrading the wastewater treatment processes. Table AC9.1.2 shows the sewer alternative SW-2: the Chokera WWTP and the New West WWTP.

Table AC9.1.3 and Table AC9.1.4 summarize the construction cost required for the sewer alternative SW-1 and SW-2, respectively.

AC9.2 Sewer Alternatives in the Eastern SWD

Since the site is fixed for the new east WWTP, a trunk sewer plan accessing the WWTP has been prepared by gravity flow. But the trunk sewer connecting to the WWTP is needed to install at lower than 30m from the ground level. Therefore, two sewer alternatives are prepared for the eastern SWD: one is the single trunk sewer route case, namely the sewer alternative SE-1 and another one is the double trunk sewer routes case, namely the sewer alternative SE-2.

Table AC9.2.1 shows the sewer alternative SE-1. Table AC9.1.2 shows the sewer alternative SE-2.

Table AC9.2.3 and Table AC9.2.4 summarize the construction cost required for the sewer alternative SE-1 and SE-2, respectively.

Table AC9.1.1 Sewer Alterntive SW-1 : One WWTP in the Western SWD

Western SWD

Name	Sewer ID.	Dia. (mm)	Length (m)	Connect
Paharang Interceptor	**WB1-1**	**1,050**	708	
	WB1-2	**1,200**	1,062	
	WB1-3	**1,500**	1,640	
	WB2	**2,250**	1,520	
	WB3	**2,400**	3,110	
	WB9	**2,700**	2,450	
	WB10	**2,700**	600	**to New PS**
Trunk Sewer Paharang (Upstream of Paharang Interceptor)	W4	1,050	3,910	
	W5	750	1,790	
	W5-1	**1,050**	740	to WB1
Trunk Sewer FDA-Paharang	**W6**	**1,500**	4,130	to WB2
Interceptor No.1	**WB4**	**1,050**	720	
	WB5	**450**	1,640	
	WB6	**1,050**	790	
	WB7	**1,200**	2,500	
	WB8-1	**1,350**	2,106	
	WB8-2	**1,500**	804	to WB9
Interceptor No.3	**WB11**	**1,500**	330	
	WB12	**1,500**	960	
	WB13-1	**1,650**	3,950	
	WB13-2	**1,950**	1,450	**to New PS**
Trunk Sewer No.3 (Upstream of Interceptor No.3)	**W1**	**1,050**	1,600	
	W2	525	2,190	
	W3-1	**1,050**	1,254	
	W3-2	**1,500**	446	to WB11
Trunk Sewer South	W17	675	1,400	
	W18	750	1,030	
	W19	750	1,510	
	W20	**1,050**	2,460	**to New PS**
Trunk Sewer Paharang Right	W7	525	710	
	W8	600	1,310	
	W9	600	1,600	
	W10	900	1,090	
	W11	375	1,610	
	W12	**1,050**	3,170	
	W13	525	2,040	
	W13-1	**1,050**	270	
	W14	525	2,910	
	W15	600	1,910	
	W16	**1,200**	2,160	to WB10
Main Sewer Sadhar	**W21**	**300**	7,000	**to W1**

(1) Interceptor Sewer

Sewer ID.	Dia. (mm)	Length (m)	
WB5	**450**	1,640	**1,640**
WB1-1	**1,050**	708	
WB4	**1,050**	720	
WB6	**1,050**	790	**2,218**
WB1-2	**1,200**	1,062	
WB7	**1,200**	2,500	**3,562**
WB8-1	**1,350**	2,106	2,106
WB1-3	**1,500**	1,640	
WB8-2	**1,500**	804	
WB11	**1,500**	330	
WB12	**1,500**	960	**3,734**
WB13-1	**1,650**	3,950	3,950
WB13-2	**1,950**	1,450	1,450
WB2	**2,250**	1,520	**1,520**
WB3	**2,400**	3,110	**3,110**
WB9	**2,700**	2,450	
WB10	**2,700**	600	**3,050**
		26,340	26,340

(2) Trunk Sewer

Sewer ID	Dia. (mm)	Length (m)	
W1	**1,050**	1,600	
W3-1	**1,050**	1,254	
W5-1	**1,050**	740	
W12	**1,050**	3,170	
W13-1	**1,050**	270	
W20	**1,050**	2,460	**9,494**
W16	**1,200**	2,160	**2,160**
W6	**1,500**	4,130	
W3-2	**1,500**	446	**4,576**
		16,230	16,230

(3) Main Sewer

Sewer ID.	Dia. (mm)	Length (m)	
W11	375	1,610	1,610
W13	525	2,040	
W2	525	2,190	
W7	525	710	
W14	525	2,910	7,850
W9	600	1,600	
W15	600	1,910	
W8	600	1,310	4,820
W17	675	1,400	1,400
W5	750	1,790	
W18	750	1,030	
W19	750	1,510	4,330
W10	900	1,090	1,090
W4	1,050	3,910	3,910
W21	300	7,000	7,000
		32,010	32,010
		74,580	74,580

Table AC9.1.2 Sewer Alterntive SW-2 : Two WWTPs in the Western SWD

Western SWD

Name	Sewer ID.	Dia. (mm)	Length (m)	Connect
Paharang Interceptor	**WB1-1**	**1,050**	708	
	WB1-2	**1,200**	1,062	
	WB1-3	**1,500**	1,640	
	WB2	**2,250**	1,520	
	WB3	**2,400**	3,110	
	WB9	**2,700**	2,450	
	WB10	**2,700**	600	
Trunk Sewer Paharang (Upstream of Paharang Interceptor)	W4	1,050	3,910	
	W5	750	1,790	
	W5-1	**1,050**	740	to WB1
Trunk Sewer FDA-Paharang	**W6**	**1,500**	4,130	to WB2
Interceptor No.1	**WB4**	**1,050**	720	
	WB5	**450**	1,640	
	WB6	**1,050**	790	
	WB7	**1,200**	2,500	
	WB8-1	**1,350**	2,106	
	WB8-2	**1,500**	804	to WB9
Interceptor No.3	**WB11**	**1,350**	330	
	WB12	**1,350**	960	
	WB13-1	**1,500**	3,950	
	WB13-2	**1,800**	1,450	
Trunk Sewer No.3 (Upstream of Interceptor No.3)	**W1**	**900**	1,600	
	W2	525	2,190	
	W3-1	**900**	1,254	
	W3-2	**1,350**	446	to WB11
Trunk Sewer South	W17	675	1,400	
	W18	750	1,030	
	W19	750	1,510	
	W20	**1,050**	2,460	
Trunk Sewer Paharang Right	W7	525	710	
	W8	600	1,310	
	W9	600	1,600	
	W10	900	1,090	
	W11	375	1,610	
	W12	**1,050**	3,170	
	W13	525	2,040	
	W13-1	**1,050**	270	
	W14	525	2,910	
	W15	600	1,910	
	W16	**1,200**	2,160	to WB10
Trunk Sewer West WWTP	**W22**	**1,600**	4,950	to New West WWTP
Main Sewer Sadhar	**W21**	**300**	4,800	to New West WWTP

(1) Interceptor Sewer

Sewer ID.	Dia. (mm)	Length (m)	
WB5	**450**	1,640	1,640
WB1-1	**1,050**	708	
WB4	**1,050**	720	
WB6	**1,050**	790	2,218
WB1-2	**1,200**	1,062	
WB7	**1,200**	2,500	3,562
WB8-1	**1,350**	2,106	
WB11	**1,350**	330	
WB12	**1,350**	960	3,396
WB1-3	**1,500**	1,640	
WB8-2	**1,500**	804	
WB13-1	**1,500**	3,950	6,394
WB13-2	**1,800**	1,450	1,450
WB2	**2,250**	1,520	1,520
WB3	**2,400**	3,110	3,110
WB9	**2,700**	2,450	
WB10	**2,700**	600	3,050
		26,340	26,340

(2) Trunk Sewer

Sewer ID	Dia. (mm)	Length (m)	
W1	**900**	1,600	
W3-1	**900**	1,254	2,854
W5-1	**1,050**	740	
W12	**1,050**	3,170	
W13-1	**1,050**	270	
W20	**1,050**	2,460	6,640
W16	**1,200**	2,160	2,160
W3-2	**1,350**	446	446
W6	**1,500**	4,130	4,130
W22	**1,600**	4,950	4,950
		21,180	21,180

(3) Main Sewer

Sewer ID.	Dia. (mm)	Length (m)	
W11	375	1,610	1,610
W13	525	2,040	
W2	525	2,190	
W7	525	710	
W14	525	2,910	7,850
W9	600	1,600	
W15	600	1,910	
W8	600	1,310	4,820
W17	675	1,400	1,400
W5	750	1,790	
W18	750	1,030	
W19	750	1,510	4,330
W10	900	1,090	1,090
W4	1,050	3,910	3,910
W21	300	4,800	4,800
		29,810	29,810
		77,330	77,330

Table AC9.1.3 Construction Cost of Sewer Alternative SW-1 : One WWTP

(1) Interceptor Sewer

Sewer ID.	Dia. (mm)	Length (m)	Length (m)	Construction Method	Estimated Cost
WB5	**450**	1,640	1,640	Open-cut	19,680
WB4	**1,050**	720		Pipe Jacking	40,104
WB6	**1,050**	790	1,510	Pipe Jacking	44,003
WB7	**1,200**	2,500	2,500	Pipe Jacking	146,000
WB1-1	**1,050**	708		Pipe Jacking	39,436
WB1-2	**1,200**	1,062		Pipe Jacking	62,021
WB1-3	**1,500**	1,640		Pipe Jacking	110,044
WB8-1	**1,350**	2,106		Pipe Jacking	130,993
WB8-2	**1,500**	804	6,320	Pipe Jacking	53,948
WB9	**2,700**	2,450		Pipe Jacking	270,743
WB10	**2,700**	600	3,050	Pipe Jacking	66,304
WB2	**2,250**	1,520	1,520	Pipe Jacking	147,728
WB3	**2,400**	3,110	3,110	Pipe Jacking	314,858
WB11	**1,500**	330		Pipe Jacking	22,143
WB12	**1,500**	960	1,290	Pipe Jacking	64,416
WB13-1	**1,650**	3,950		Pipe Jacking	288,350
WB13-2	**1,950**	1,450	5,400	Pipe Jacking	128,035
				Sub-total	**1,948,806**
		26,340	26,340		

(2) Trunk Sewer

Sewer ID	Dia. (mm)	Length (m)	Length (m)	Construction Method	Estimated Cost
W6	**1,500**	4,130	4,130	Open-cut	156,114
W1	**1,050**	1,600	1,600	Pipe Jacking	89,120
W3-1	**1,050**	1,254		Pipe Jacking	69,848
W3-2	**1,500**	446	1,700	Pipe Jacking	29,927
W5-1	**1,050**	740		Pipe Jacking	41,218
W12	**1,050**	3,170		Open-cut	74,178
W13-1	**1,050**	270	4,180	Pipe Jacking	15,039
W20	**1,050**	2,460		Pipe Jacking	137,022
W16	**1,200**	2,160	4,620	Pipe Jacking	126,144
				Sub-total	**738,610**
		16,230	16,230		

(3) Main Sewer

Sewer ID.	Dia. (mm)	Length (m)	Length (m)	Construction Method	Estimated Cost
W2	525	2,190	2,190	Open-cut	28,251
W5	750	1,790		Open-cut	29,714
W11	375	1,610	3,400	Open-cut	18,032
W13	525	2,040		Open-cut	26,316
W7	525	710		Open-cut	9,159
W14	525	2,910	5,660	Open-cut	37,539
W9	600	1,600		Open-cut	22,400
W15	600	1,910		Pipe Jacking	76,782
W8	600	1,310	4,820	Open-cut	18,340
W17	675	1,400	1,400	Open-cut	21,280
W18	750	1,030		Pipe Jacking	50,058
W19	750	1,510	2,540	Open-cut	25,066
W10	900	1,090	1,090	Open-cut	21,473
W4	1,050	3,910	3,910	Open-cut	91,494
W21	300	7,000	7,000	Open-cut	73,500
				Sub-taotal	**549,404**
		32,010	32,010		

Total Cost	**3,236,820**

Table AC9.1.4 Construction Cost of Sewer Alternative SW-2 : Two WWTPs

(1) Interceptor Sewer

Sewer ID.	Dia. (mm)	Length (m)	Length (m)
WB5	**450**	1,640	1,640
WB4	**1,050**	720	
WB6	**1,050**	790	1,510
WB7	**1,200**	2,500	2,500
WB1-1	**1,050**	708	
WB1-2	**1,200**	1,062	
WB1-3	**1,500**	1,640	
WB8-1	**1,350**	2,106	
WB8-2	**1,500**	804	6,320
WB9	**2,700**	2,450	
WB10	**2,700**	600	3,050
WB2	**2,250**	1,520	1,520
WB3	**2,400**	3,110	3,110
WB11	**1,350**	330	
WB12	**1,350**	960	1,290
WB13-1	**1,500**	3,950	
WB13-2	**1,800**	1,450	5,400
		26,340	26,340

Construction Method	Estimated Cost
Open-cut	19,680
Pipe Jacking	40,104
Pipe Jacking	44,003
Pipe Jacking	146,000
Pipe Jacking	39,436
Pipe Jacking	62,021
Pipe Jacking	110,044
Pipe Jacking	130,993
Pipe Jacking	53,948
Pipe Jacking	270,743
Pipe Jacking	66,304
Pipe Jacking	147,728
Pipe Jacking	314,858
Pipe Jacking	20,526
Pipe Jacking	59,712
Pipe Jacking	265,045
Pipe Jacking	116,145
Sub-total	**1,907,290**

(2) Trunk Sewer

Sewer ID	Dia. (mm)	Length (m)	Length (m)
W6	**1,500**	4,130	4,130
W1	**900**	1,600	1,600
W3-1	**900**	1,254	
W3-2	**1,350**	446	1,700
W5-1	**1,050**	740	
W12	**1,050**	3,170	
W13-1	**1,050**	270	4,180
W20	**1,050**	2,460	
W16	**1,200**	2,160	4,620
		16,230	16,230

Construction Method	Estimated Cost
Open-cut	156,114
Pipe Jacking	86,560
Pipe Jacking	67,841
Pipe Jacking	27,741
Pipe Jacking	41,218
Open-cut	74,178
Pipe Jacking	15,039
Pipe Jacking	137,022
Pipe Jacking	126,144
Sub-total	**731,857**

(3) Main Sewer

Sewer ID.	Dia. (mm)	Length (m)	Length (m)
W2	525	2,190	2,190
W5	750	1,790	
W11	375	1,610	3,400
W13	525	2,040	
W7	525	710	
W14	525	2,910	5,660
W9	600	1,600	
W15	600	1,910	
W8	600	1,310	4,820
W17	675	1,400	1,400
W18	750	1,030	
W19	750	1,510	2,540
W10	900	1,090	1,090
W4	1,050	3,910	3,910
W21	300	4,800	4,800
W22	1600	4,950	4,950
		34,760	34,760

Construction Method	Estimated Cost
Open-cut	28,251
Open-cut	29,714
Open-cut	18,032
Open-cut	26,316
Open-cut	9,159
Open-cut	37,539
Open-cut	22,400
Pipe Jacking	76,782
Open-cut	18,340
Open-cut	21,280
Pipe Jacking	50,058
Open-cut	25,066
Open-cut	21,473
Open-cut	91,494
Open-cut	50,400
Open-cut	187,110
Sub-total	**713,414**

Total Cost	**3,352,561**

Table AC9.2.1 Sewer Alternative SE-1:Single Trunk Sewers in the Eastern SWD

Eastern SWD - 1

Name	Sewer ID.	Dia. (mm)	Length (m)	Connect
Interceptor East	**EB2-1**	**1,350**	1,150	
	EB2-2	**1,650**	2,500	
	EB2-3	**1,950**	1,040	
	EB3	**2,400**	530	
	EB4	**2,400**	940	
	EB5	**2,550**	1,430	
	EB6	**2,550**	1,350	to E57
Trunk Sewer East Central	**E57**	**2,550**	1,060	
	E58	**2,700**	3,500	
	E59	**2,700**	6,270	to New East WWTP
Trunk Sewer North	E1-1	**350**	5,670	**Kurianwala, Pressured**
	E1-2	**1,050**	1,830	
	E2	**1,050**	2,980	
	E3	600	1,200	
	E4	**1,350**	1,940	
	E5	675	1,200	
	E6	**1,350**	2,020	
	E7	450	760	
	E8	**1,350**	330	
	E9	600	960	
	E10	**1,500**	2,360	
	EB1	**2,250**	3,390	to EB3
Trunk Sewer North-West	E11	900	2,390	
	E12	825	2,440	
	E13	**1,050**	1,240	
	E14-1	1,050	3,640	
	E14	**1,350**	2,510	
	E15	**1,950**	760	
	E16	600	710	
	E17-1	**1,950**	5,220	to EB1
	E17-2	**300**	680	
	E17-3	**750**	1,450	
	E17-4	**1,950**	1,000	to EB1

(1) Interceptor Sewer

Sewer ID.	Dia. (mm)	Length (m)	
EB2-1	**1,350**	1,150	1,150
EB2-2	**1,650**	2,500	2,500
EB2-3	**1,950**	1,040	1,040
EB3	**2,400**	530	
EB4	**2,400**	940	1,470
EB5	**2,550**	1,430	
EB6	**2,550**	1,350	2,780
		8,940	8,940

(2) Trunk Sewer

Sewer ID.	Dia. (mm)	Length (m)	
E53	**825**	4,620	**4,620**
E45	**900**	1,020	
E47	**900**	1,390	**2,410**
E2	**1,050**	2,980	
E13	**1,050**	1,240	
E26	**1,050**	1,340	
E28	**1,050**	980	
E31	**1,050**	1,050	
E49	**1,050**	2,620	
E55	**1,050**	2,450	**12,660**
E4	**1,350**	1,940	
E6	**1,350**	2,020	
E8	**1,350**	330	
E14	**1,350**	2,510	
E34	**1,350**	1,350	**8,150**
E10	**1,500**	2,360	
E37	**1,500**	1,440	**3,800**
E15	**1,950**	760	
E17-1	**1,950**	5,220	
E17-4	**1,950**	1,000	**6,980**
EB1	**2,250**	3,390	**3,390**
E57	**2,550**	1,060	**1,060**
E58	**2,700**	3,500	
E59	**2,700**	6,270	**9,770**
		52,840	52,840

Name	Sewer ID.	Dia. (mm)	Length (m)	Connect
	E18	450	1,980	
	E19	750	1,380	
	E20	750	1,680	
	E21	675	1,240	
	E22	900	760	
	E23	300	1,780	
	E24	300	1,200	
	E25	450	1,310	
	E26	**1,050**	1,340	
Trunk Sewer	E27	225	280	
North-East	**E28**	**1,050**	980	
	E29	525	960	
	E30	225	650	
	E31	**1,050**	1,050	
	E32	1,050	990	
	E33	225	630	
	E34	**1,350**	1,350	
	E35	525	990	
	E36	225	490	
	E37	**1,500**	1,440	to E58

Eastern SWD - 2

Name	Sewer ID.	Dia. (mm)	Length (m)	Connect
Trunk Sewer Madhuana Right	E38	750	2,530	
	E39	825	2,810	
	E40	300	950	
	E41	900	1,660	
	E42	300	1,300	
	E43	900	1,050	
	E44	300	1,230	
	E45	**900**	1,020	
	E46	375	1,590	
	E47	**900**	1,390	
	E48	450	1,930	
	E49	**1,050**	2,620	to E59
Main Sewer South-1	E50	675	4,230	
	E50-1	675	2,160	
	E50-2	675	1,700	to EB2
Main Sewer South-2	E51	375	1,910	to EB2
Trunk Sewer South-3	E52	525	2,940	
	E53	**825**	4,620	
	E54	675	1,840	
	E55	**1,050**	2,450	to EB5
Main Sewer South-4	E56	600	1,520	to E57
Main Serive Pipe	EP7S	1,050	680	to E57
Main Serive Pipe	EP4S	1,350	700	to E57
			133,760	

(3) Main Sewer

Sewer ID.	Dia. (mm)	Length (m)	
E27	225	280	
E30	225	650	
E33	225	630	
E36	225	490	2,050
E17-2	300	680	
E23	300	1,780	
E24	300	1,200	
E40	300	950	
E42	300	1,300	
E44	300	1,230	7,140
E46	375	1,590	
E51	375	1,910	3,500
E7	450	760	
E18	450	1,980	
E25	450	1,310	
E48	450	1,930	5,980
E29	525	960	
E35	525	990	
E52	525	2,940	4,890
E3	600	1,200	
E9	600	960	
E16	600	710	
E56	600	1,520	4,390
E21	675	1,240	
E5	675	1,200	
E50	675	4,230	
E54	675	1,840	
E50-1	675	2,160	
E50-2	675	1,700	12,370
E17-3	750	1,450	
E19	750	1,380	
E20	750	1,680	
E38	750	2,530	7,040
E12	825	2,440	
E39	825	2,810	5,250
E11	900	2,390	
E22	900	760	
E41	900	1,660	
E43	900	1,050	5,860
E1-2	1,050	1,830	
E14-1	1,050	3,640	
E32	1,050	990	
EP7S	1,050	680	7,140
EP4S	1,350	700	700
E1-1	350	5,670	5,670
		71,980	71,980
		133,760	133,760

Pressured line =>

Table AC9.2.2 Sewer Alternative SE-2: Double Routes Trunk Sewers in the Eastern SWD

Route-1

Name	Sewer ID.	Dia. (mm)	Length (m)	Connect
Interceptor	**EB3**	**2,250**	530	
	EB4	**2,250**	940	
	EB5	**2,250**	1,430	
	EB6	**2,250**	1,350	to E57
Trunk Sewer East Central	**E57**	**2,250**	1,060	
	E58	**2,400**	3,500	
	E59-1	**2,550**	6,170	
	E59-2	**2,700**	100	to New East WWTP
			15,080	
Trunk Sewer North	E1-1	**350**	5,670	**Kurianwala, Pressured**
	E1-2	**1,050**	1,830	
	E2	**1,050**	2,980	
	E3	600	1,200	
	E4	**1,350**	1,940	
	E5	675	1,200	
	E6	**1,350**	2,020	
	E7	450	760	
	E8	**1,350**	330	
	E9	600	960	
	E10	**1,500**	2,360	
	EB1	**2,250**	3,390	to EB3
			24,640	
Trunk Sewer North-West	E11	900	2,390	
	E12	825	2,440	
	E13	**1,050**	1,240	
	E14-1	1,050	3,640	
	E14	**1,350**	2,510	
	E15	**1,950**	760	
	E16	600	710	
	E17-1	**1,950**	5,220	to EB1
	E17-2	**300**	680	
	E17-3	**750**	1,450	
	E17-4	**1,950**	1,000	to EB1
			22,040	

(1) Interceptor Sewer

Sewer ID.	Dia. (mm)	Length (m)	
EB3	**2,250**	530	
EB4	**2,250**	940	
EB5	**2,250**	1,430	
EB6	**2,250**	1,350	4,250
		4,250	4,250

(2) Trunk Sewer

Sewer ID.	Dia. (mm)	Length (m)	
E45	**900**	1,020	
E47	**900**	1,390	**2,410**
E2	**1,050**	2,980	
E13	**1,050**	1,240	
E26	**1,050**	1,340	
E28	**1,050**	980	
E31	**1,050**	1,050	
E49	**1,050**	2,620	**10,210**
E4	**1,350**	1,940	
E6	**1,350**	2,020	
E8	**1,350**	330	
E14	**1,350**	2,510	
E34	**1,350**	1,350	**8,150**
E10	**1,500**	2,360	
E37	**1,500**	1,440	**3,800**
E15	**1,950**	760	
E17-1	**1,950**	5,220	
E17-4	**1,950**	1,000	**6,980**
EB1	**2,250**	3,390	
E57	**2,250**	1,060	**4,450**
E58	**2,400**	3,500	**3,500**
E59-1	**2,550**	6,170	**6,170**
E59-2	**2,700**	100	**100**
		45,770	45,770

Name	Sewer ID.	Dia. (mm)	Length (m)	Connect
	E18	450	1,980	
	E19	750	1,380	
	E20	750	1,680	
	E21	675	1,240	
	E22	900	760	
	E23	300	1,780	
	E24	300	1,200	
	E25	450	1,310	
	E26	**1,050**	1,340	
Trunk Sewer	E27	225	280	
North-East	**E28**	**1,050**	980	
	E29	525	960	
	E30	225	650	
	E31	**1,050**	1,050	
	E32	1,050	990	
	E33	225	630	
	E34	**1,350**	1,350	
	E35	525	990	
	E36	225	490	
	E37	**1,500**	1,440	to E58
			22,480	

Name	Sewer ID.	Dia. (mm)	Length (m)	Connect
	E38	750	2,530	
	E39	825	2,810	
	E40	300	950	
	E41	900	1,660	
	E42	300	1,300	
Trunk Sewer	E43	900	1,050	
Madhuana Right	E44	300	1,230	
	E45	**900**	1,020	
	E46	375	1,590	
	E47	**900**	1,390	
	E48	450	1,930	
	E49	**1,050**	2,620	to E59
			20,080	
Main Sewer South-4	E56	525	1,520	to E57
			1,520	

R-1 **105,840**

(3) Main Sewer

Sewer ID.	Dia. (mm)	Length (m)	
E27	225	280	
E30	225	650	
E33	225	630	
E36	225	490	2,050
E17-2	300	680	
E23	300	1,780	
E24	300	1,200	
E40	300	950	
E42	300	1,300	
E44	300	1,230	7,140
E46	375	1,590	1,590
E7	450	760	
E18	450	1,980	
E25	450	1,310	
E48	450	1,930	5,980
E29	525	960	
E35	525	990	
E56	525	1,520	3,470
E3	600	1,200	
E9	600	960	
E16	600	710	2,870
E21	675	1,240	
E5	675	1,200	2,440
E17-3	750	1,450	
E19	750	1,380	
E20	750	1,680	
E38	750	2,530	7,040
E12	825	2,440	
E39	825	2,810	5,250
E11	900	2,390	
E22	900	760	
E41	900	1,660	
E43	900	1,050	5,860
E1-2	1,050	1,830	
E14-1	1,050	3,640	
E32	1,050	990	6,460
E1-1	350	5,670	5,670
		55,820	55,820
	R-1	**105,840**	**105,840**

Pressured line =>

Route -2

Interceptor

Name	Sewer ID.	Dia. (mm)	Length (m)	Connect
Interceptor	**EB2-1**	**1,350**	2,450	
	EB2-2	**1,650**	1,150	
			3,600	

Trunk Sewer

Name	Sewer ID.	Dia. (mm)	Length (m)	Connect
	E51-1	1,950	2,350	
	E55-2	2,250	5,970	to E59-2
			8,320	

Main Sewer

Name	Sewer ID.	Dia. (mm)	Length (m)	Connect
Service Main Sewer	EP4S	1,350	700	to EB2-1
Service Main Sewer	EP7S	1,050	680	to EB2-2
Main Sewer South-1	E50	675	4,230	
	E50-1	675	2,160	
	E50-2	675	1,700	to EB2
Main Sewer South-2	E51	375	1,910	to E51-1
Trunk Sewer South-3	E52	525	2,940	
	E53	750	2,550	
	E54	675	1,840	
	E55	600	2,300	to E55-1
	E55-1	900	2,050	
			23,060	

R-2 **34,980**
Total **140,820**

(1) Interceptor Sewer

Sewer ID.	Dia. (mm)	Length (m)	
EB2-1	**1,350**	2,450	2,450
EB2-2	**1,650**	1,150	1,150
		3,600	3,600

(2) Trunk Sewer

Sewer ID.	Dia. (mm)	Length (m)	
E55	600	2,300	2,300
E53	750	2,550	2,550
E51-1	1,950	2,350	2,350
E55-2	2,250	5,970	5,970
		13,170	13,170

(3) Main Sewer

Sewer ID.	Dia. (mm)	Length (m)	
E51	375	1,910	1,910
E52	525	2,940	2,940
E50	675	4,230	
E50-1	675	2,160	
E50-2	675	1,700	
E54	675	1,840	9,930
E55-1	900	2,050	2,050
EP7S	1,050	680	680
EP4S	1,350	700	700
		18,210	18,210

R-2 **34,980**
Total **140,820**

Table AC9.2.3 Construction Cost of Sewer Alternative SE-1: Single Route Trunk Sewers

Sewer No.	Dia. (mm)	Length (m)	Ave. Earth Cover (m)	Excavation （m）	Installation Method	Unit Price (x10^4JPY /m)	Cost (x10^4 JPY)
E1-1	350	5,670	2	2.55	Open-Cut	3.4	19,278
E1-2	1050	1,830	2.72	3.97	Open-Cut	11.7	21,411
E2	1050	2,980	3.82	5.07	Open-Cut	11.7	34,866
E3	600	1,200	3	3.8	Open-Cut	6.3	7,560
E4	1350	1,940	2.95	4.5	Open-Cut	16.2	31,428
E5	675	1,200	2.2	3.075	Open-Cut	7.0	8,400
E6	1350	2,020	2.43	3.98	Open-Cut	16.2	32,724
E7	450	760	2	2.65	Open-Cut	4.8	3,648
E8	1350	330	2.83	4.38	Open-Cut	16.2	5,346
E9	600	960	2.99	3.79	Open-Cut	6.3	6,048
E10	1500	2,360	3.69	5.39	Open-Cut	18.9	44,604
E11	900	2,390	2.6	3.7	Open-Cut	9.9	23,661
E12	825	2,440	2.14	3.165	Open-Cut	9.1	22,204
E13	1050	1,240	4.74	5.99	Open-Cut	11.7	14,508
E14-1	1050	3,640	2.79	4.04	Open-Cut	11.7	42,588
E14	1350	2,510	7.28	8.83	Pipe Jacking	62.2	156,122
E15	1950	760	9.7	11.85	Pipe Jacking	88.3	67,108
E16	600	710	3.21	4.01	Open-Cut	6.3	4,473
E17-1	1950	5,220	8.51	10.66	Pipe Jacking	88.3	460,926
E17-2	300	680	6.94	7.44	Pipe Jacking	29.2	19,856
E17-3	750	1,450	6.84	7.79	Pipe Jacking	48.6	70,470
E17-4	1950	1,000	7.02	9.17	Pipe Jacking	88.3	88,300
E18	450	1,980	4.06	4.71	Open-Cut	4.8	9,504
E19	750	1,380	3.42	4.37	Open-Cut	8.0	11,040
E20	750	1,680	6.33	7.28	Pipe Jacking	48.6	81,648
E21	675	1,240	2.71	3.585	Open-Cut	7.0	8,680
E22	900	760	7.34	8.44	Pipe Jacking	54.1	41,116
E23	300	1,780	4.76	5.26	Open-Cut	2.7	4,806
E24	300	1,200	3.49	3.99	Open-Cut	2.7	3,240
E25	450	1,310	7.02	7.67	Pipe Jacking	33.8	44,278
E26	1050	1,340	8.39	9.64	Pipe Jacking	55.7	74,638
E27	225	280	2.26	2.685	Open-Cut	2.4	672
E28	1050	980	9.21	10.46	Pipe Jacking	55.7	54,586
E29	525	960	4.31	5.035	Open-Cut	5.4	5,184
E30	225	650	3.06	3.485	Open-Cut	2.4	1,560
E31	1050	1,050	9.8	11.05	Pipe Jacking	55.7	58,485
E32	1050	990	3.1	4.35	Open-Cut	11.7	11,583
E33	225	630	3.02	3.445	Open-Cut	2.4	1,512
E34	1350	1,350	8.47	10.02	Pipe Jacking	62.2	83,970
E35	525	990	3.3	4.025	Open-Cut	5.4	5,346
E36	225	490	2.72	3.145	Open-Cut	2.4	1,176
E37	1500	1,440	7.61	9.31	Pipe Jacking	67.1	96,624
E38	750	2,530	2.4	3.35	Open-Cut	8.0	20,240
E39	825	2,810	5.29	6.315	Pipe Jacking	53.7	150,897
E40	300	950	3.96	4.46	Open-Cut	2.7	2,565
E41	900	1,660	8	9.1	Open-Cut	54.1	89,806
E42	300	1,300	3.73	4.23	Open-Cut	2.7	3,510
E43	900	1,050	8.33	9.43	Pipe Jacking	54.1	56,805
E44	300	1,230	3.43	3.93	Open-Cut	2.7	3,321
E45	900	1,020	7.03	8.13	Pipe Jacking	54.1	55,182
E46	375	1,590	2.16	2.735	Open-Cut	4.3	6,837
E47	900	1,390	6.4	7.5	Pipe Jacking	54.1	75,199

Sewer No.	Dia. (mm)	Length (m)	Ave. Earth Cover (m)	Excavation （m）	Installation Method	Unit Price (x10^4JPY /m)	Cost (x10^4 JPY)
E48	450	1,930	2.78	3.43	Open-Cut	4.8	9,264
E49	1050	2,620	6.66	7.91	Pipe Jacking	55.7	145,934
E50	675	4,230	9.5	10.375	Pipe Jacking	44.2	186,966
E50-1	675	2,160	13.38	14.255	Pipe Jacking	44.2	95,472
E50-2	675	1,700	13.87	14.745	Pipe Jacking	44.2	75,140
E51	375	1,910	2.77	3.345	Open-Cut	4.3	8,213
E52	525	2,940	2	2.725	Open-Cut	5.4	15,876
E53	**825**	**4,620**	**4.07**	**5.095**	Open-Cut	**9.1**	**42,042**
E54	675	1,840	2.1	2.975	Open-Cut	7.0	12,880
E55	**1050**	**2,450**	**8.63**	**9.88**	Pipe Jacking	**55.7**	**136,465**
E56	**600**	**1,520**	**2.4**	**3.2**	Open-Cut	**6.3**	**9,576**
E57	**2550**	**1,060**	**17.89**	**20.64**	Pipe Jacking	**129.9**	**137,694**
E58	**2700**	**3,500**	**18.44**	**21.34**	Pipe Jacking	**135.8**	**475,300**
E59	**2700**	**6,270**	**20.88**	**23.78**	Pipe Jacking	**135.8**	**851,466**
EB1	**2250**	**3,390**	**7.24**	**9.69**	Pipe Jacking	**97.2**	**329,508**
EB2-1	**1350**	**1,150**	**14.26**	**15.81**	Pipe Jacking	**62.2**	**71,530**
EB2-2	**1650**	**2,500**	**15.42**	**17.27**	Pipe Jacking	**73.0**	**182,500**
EB2-3	**1950**	**1,040**	**15.29**	**17.44**	Pipe Jacking	**88.3**	**91,832**
EB3	**2400**	**530**	**15.28**	**17.88**	Pipe Jacking	**101.2**	**53,636**
EB4	**2400**	**940**	**18.43**	**21.03**	Pipe Jacking	**124.4**	**116,936**
EB5	**2550**	**1,430**	**18.05**	**20.8**	Pipe Jacking	**129.9**	**185,757**
EB6	**2550**	**1,350**	**17.32**	**20.07**	Pipe Jacking	**129.9**	**175,365**
EP7S	1050	680	5.77	7.02	Pipe Jacking	55.7	37,876
EP4S	1350	700	5.41	6.96	Pipe Jacking	62.2	43,540
Total		133,760	MAX=	23.78		**x 10^4 JPY**	**5,740,307**

0.942161	**PKR/JPY**	**Mil. PKR**	**54,083**

Table AC9.2.4 Construction Cost of Sewer Alternative SE-2: Double Routes Trunk Sewers

Sewer No.	Dia. (mm)	Length (m)	Ave. Earth Cover (m)	Excavation (m)	Installation Method	Unit Price (x10^4JPY /m)	Cost (x10^4 JPY)
E1-1	350	5,670	2.0	2.6	Open-Cut	3.4	19,278
E1-2	1050	1,830	2.7	4.0	Open-Cut	11.7	21,411
E2	1050	2,980	3.8	5.1	Open-Cut	11.7	34,866
E3	600	1,200	3.0	3.8	Open-Cut	6.3	7,560
E4	1350	1,940	3.0	4.5	Open-Cut	16.2	31,428
E5	675	1,200	2.2	3.1	Open-Cut	7.0	8,400
E6	1350	2,020	2.4	4.0	Open-Cut	16.2	32,724
E7	450	760	2.0	2.7	Open-Cut	4.8	3,648
E8	1350	330	2.8	4.4	Open-Cut	16.2	5,346
E9	600	960	3.0	3.8	Open-Cut	6.3	6,048
E10	1500	2,360	3.7	5.4	Open-Cut	18.9	44,604
E11	900	2,390	2.6	3.7	Open-Cut	9.9	23,661
E12	825	2,440	2.1	3.2	Open-Cut	9.1	22,204
E13	1050	1,240	4.7	6.0	Open-Cut	11.7	14,508
E14-1	1050	3,640	2.8	4.0	Open-Cut	11.7	42,588
E14	1350	2,510	7.3	8.8	Pipe Jacking	62.2	156,122
E15	1950	760	9.7	11.9	Pipe Jacking	88.3	67,108
E16	600	710	3.2	4.0	Open-Cut	6.3	4,473
E17-1	1950	5,220	8.5	10.7	Pipe Jacking	88.3	460,926
E17-2	300	680	6.9	7.4	Pipe Jacking	29.2	19,856
E17-3	750	1,450	6.8	7.8	Pipe Jacking	48.6	70,470
E17-4	1950	1,000	7.0	9.2	Pipe Jacking	88.3	88,300
E18	450	1,980	4.1	4.7	Open-Cut	4.8	9,504
E19	750	1,380	3.4	4.4	Open-Cut	8.0	11,040
E20	750	1,680	6.3	7.3	Pipe Jacking	48.6	81,648
E21	675	1,240	2.7	3.6	Open-Cut	7.0	8,680
E22	900	760	7.3	8.4	Pipe Jacking	54.1	41,116
E23	300	1,780	4.8	5.3	Open-Cut	2.7	4,806
E24	300	1,200	3.5	4.0	Open-Cut	2.7	3,240
E25	450	1,310	7.0	7.7	Pipe Jacking	33.8	44,278
E26	1050	1,340	8.4	9.6	Pipe Jacking	55.7	74,638
E27	225	280	2.3	2.7	Open-Cut	2.4	672
E28	1050	980	9.2	10.5	Pipe Jacking	55.7	54,586
E29	525	960	4.3	5.0	Open-Cut	5.4	5,184
E30	225	650	3.1	3.5	Open-Cut	2.4	1,560
E31	1050	1,050	9.8	11.1	Pipe Jacking	55.7	58,485
E32	1050	990	3.1	4.4	Open-Cut	11.7	11,583
E33	225	630	3.0	3.4	Open-Cut	2.4	1,512
E34	1350	1,350	8.5	10.0	Pipe Jacking	62.2	83,970
E35	525	990	3.3	4.0	Open-Cut	5.4	5,346
E36	225	490	2.7	3.1	Open-Cut	2.4	1,176
E37	1500	1,440	7.6	9.3	Pipe Jacking	67.1	96,624
E38	750	2,530	2.4	3.4	Open-Cut	8.0	20,240
E39	825	2,810	5.3	6.3	Pipe Jacking	53.7	150,897
E40	300	950	4.0	4.5	Open-Cut	2.7	2,565
E41	900	1,660	8.0	9.1	Pipe Jacking	54.1	89,806
E42	300	1,300	3.7	4.2	Open-Cut	2.7	3,510
E43	900	1,050	8.3	9.4	Pipe Jacking	54.1	56,805
E44	300	1,230	3.4	3.9	Open-Cut	2.7	3,321
E45	900	1,020	7.0	8.1	Pipe Jacking	54.1	55,182
E46	375	1,590	2.2	2.7	Open-Cut	4.3	6,837
E47	900	1,390	6.4	7.5	Pipe Jacking	54.1	75,199

Sewer No.	Dia. (mm)	Length (m)	Ave. Earth Cover (m)	Excavation (m)	Installation Method	Unit Price (x10^4JPY /m)	Cost (x10^4 JPY)
E48	450	1,930	2.8	3.4	Open-Cut	4.8	9,264
E49	1050	2,620	6.7	7.9	Pipe Jacking	55.7	145,934
E50	675	4,230	9.5	10.4	Pipe Jacking	44.2	186,966
E50-1	675	2,160	13.4	14.3	Pipe Jacking	44.2	95,472
E50-2	675	1,700	13.9	14.7	Pipe Jacking	44.2	75,140
E51	375	1,910	2.8	3.3	Open-Cut	4.3	8,213
E52	525	2,940	2.0	2.7	Open-Cut	5.4	15,876
E53	**750**	**2,550**	**3.1**	**4.1**	Open-Cut	**8.0**	**20,400**
E54	675	1,840	2.1	3.0	Open-Cut	7.0	12,880
E55	**600**	**2,300**	**2.0**	**2.8**	Open-Cut	**6.3**	**14,490**
E55-1	**900**	**2,050**	**2.8**	**3.9**	Open-Cut	**9.9**	**20,295**
E55-2	**2250**	**5,970**	**13.5**	**16.0**	Pipe Jacking	**97.2**	**580,220**
E56	525	1,520	2.5	3.3	Open-Cut	5.4	8,208
E57	**2250**	**1,060**	**10.2**	**12.7**	Pipe Jacking	**97.2**	**103,021**
E58	**2400**	**3,500**	**11.4**	**14.0**	Pipe Jacking	**101.2**	**354,342**
E59-1	**2550**	**6,170**	**14.2**	**16.9**	Pipe Jacking	**105.7**	**652,044**
E59-2	**2700**	**100**	**17.1**	**20.0**	Pipe Jacking	**110.5**	**11,051**
EB1	**2250**	**3,390**	**7.2**	**9.7**	Pipe Jacking	**97.2**	**329,472**
EB2-1	**1350**	**2,450**	**6.7**	**8.3**	Pipe Jacking	**62.2**	**152,390**
EB2-2	**1650**	**1,150**	**6.8**	**8.7**	Pipe Jacking	**73.0**	**83,950**
E51-1	**1950**	**2,350**	**13.6**	**15.8**	Pipe Jacking	**88.3**	**207,505**
EB3	**2250**	**530**	**7.6**	**10.0**	Pipe Jacking	**97.2**	**51,510**
EB4	**2250**	**940**	**10.7**	**13.2**	Pipe Jacking	**97.2**	**91,358**
EB5	**2250**	**1,430**	**10.4**	**12.8**	Pipe Jacking	**97.2**	**138,981**
EB6	**2250**	**1,350**	**9.7**	**12.1**	Pipe Jacking	**97.2**	**131,206**
EP7S	1050	680	5.8	7.0	Pipe Jacking	55.7	37,876
EP4S	1350	700	5.4	7.0	Pipe Jacking	62.2	43,540
Total		140,820	MAX=	20.0	Pipe Jacking		**5,831,143**

0.942161	**PKR/JPY**	**Mil. PKR**	**54,939**

	Total Cost in JPY		Total Cost in PKR		
Double Route	**5,831,143**	x10^4 JPY	**54,939**	Mil. PKR	**2,887,050**
Single Route	**5,740,307**	x10^4 JPY	**54,083**	Mil. PKR	**2,671,454**
Differnce	**90,836**	x10^4 JPY	**856**	Mil. PKR	**215,596**

AC9.3 Four Options of Wastewater Treatment Process

AC9.3.1 Design Conditions

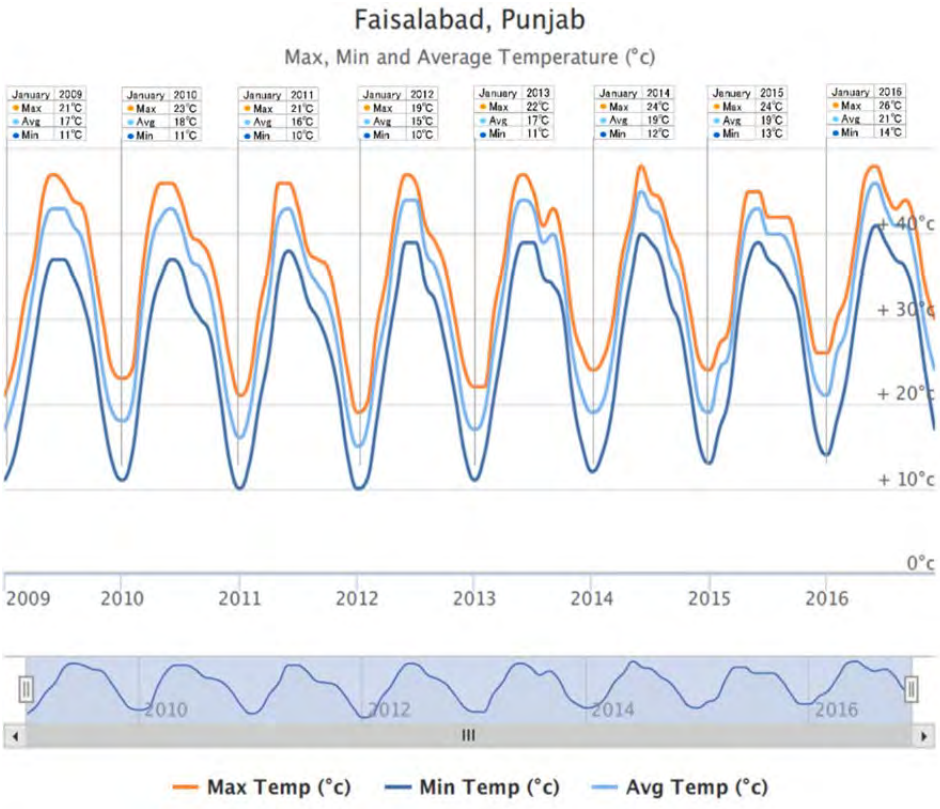
The design conditions are set as follows to compare the four options of wastewater treatment processes. The influent and effluent BOD concentrations are the same as the design bases for the Chokera WWTP and New East WWTP. But the influent flow rate is fixed at 100,000 m3/d for primary comparison.

- Influent flow rate: 100,000 m^3/d
- Influent BOD concentration: 320 mg/L
- Effluent BOD concentration: 80 mg/L
- Design air temperature is 17.5℃

The design air temperature is set considering the low air temperature data in Faisalabad as shown in Table below: the average 17.75 degree in Celsius, thus 17.5 degree in Celsius is applied for the design

Table AC9.3.1 Low Average Temperature Data

	01.2009	01.2010	01.2011	01.2012	01.2013	01.2014	01.2015	01.2016
Low temperature	17	18	16	15	17	19	19	21



Source: World Weather Online.com

Figure AC9.3.1 Air Temperature Data

AC9.3.2 Design Calculation for the Option.1 (Anaerobic pond+ Facultative pond)

(a) Anaerobic ponds

Facility design based on the concept of Duncan Mara

Anaerobic pond volume is derived by the following equation:

$V_a = L_i \cdot Q/\lambda_v$

where,

V_a=anaerobic ponds volume, m^3

L_i=influent wastewater BOD, mg/L;

Q=influent wastewater average flow, m^3/d;

λ_v = volumetric design loading, $g/m^3 d$

From Table AC9.3.1., the design loading(λ_v) for17.5℃ is 250 g BOD/m^3 /day.

Table AC9.3.2 Variation of design volumetric BOD loading and removal ratio in anaerobic ponds

Temperature (℃)	Design loading (g/m^3 d): λ_v	BOD removal (%)
<10	100	40
10-20	20*T-100	2*T+20
20-25	10*T+100	2*T+20
>25	350	70

Note: *T=temperature,℃
Source: Duncan Mara

Thus the anaerobic pond volume (V_a) :

$V_a = L_i \cdot Q/\lambda_v = 320*100{,}000/250 = 128{,}000 m^3$

For Check

The anaerobic pond retention time(θ a, d)is then calculated from:

subject to a practical minimum value for θ_a of 1day

θ a= V_a/Q=128,000/100,000=1.28d As θ_a > 1day…….Ok

Assuming a depth of 4 m, the anaerobic pond area is 32,000 m^2 or 3.2 ha or 7.0 acre

Noted that the depth is normally in the range 2 to 5m. Ideally the deeper the better.

At 17.5℃ the BOD removal (See Table AC9.3.2) is 55%, so the BOD concentration of the anaerobic pond effluent is 144 mg/L (=0.45 × 320).

(b) Facultative Pond

Facultative Pond are designed on the basis of surface BOD loading (λs, kg/ha d), given by Mara's equation.

At 17.5℃ the BOD removal (See Table AC9.3.2) is 55%= (2*17.5) +20, so the BOD of the anaerobic pond effluent is (0.45 × 320), i.e. 144.0 mg/L.

$\lambda_s = 350\ (1.107 - 0.002\,T)^{T-25} = 350\ (1.107 - 0.002*17.5)^{-7.5} = 208$ kg/ha d

The pond area (A_f, m^2) is given by:

$A_f = 10 L_i \cdot Q / \lambda_s = (10*144.0*100{,}000)/208 = 692{,}308\ m^2 = 69.2$ha $= 171.0$ acre

where, Li is the influent BOD concentration to the facultative pond: 144.0mg/L（the anaerobic pond effluent）

Pond depth varies from 1 to 2 m, with 1.5 m being typical. Taking the depth as 1.5 m = D_f

The pond retention time(θ_f,d) is given by:

$\theta_f = 2A_fD_f/(2Q_i - 0.001eA_f) = 2*692{,}308*1.5/(2*100{,}000 - 0.001*5*692{,}308)$

$= 10.6$ days

subject to practical minimum value for θ_f of 4 days

where, D_f=facultative pond depth :1.5m

Qi=influent wastewater flow: 100,000 m^3/d

e= the net evaporation rate: 5mm/day.

The BOD removal ratio is 80%, so the facultative pond effluent is (0.20 ×320) ,i.e. 68.0mg/L

＜References：Design manual for waste stabilization ponds in India/Duncan Mara.>

Quoted that: The BOD removal in primary facultative pond is usually in the rage 70 to 80 percent based on unfiltered samples (that is, including the BOD exerted by the algae), and usually above 90 percent based on filtered samples. In secondary facultative ponds the removal is less, but the combined performance of anaerobic and secondary facultative ponds generally approximates (or is slightly better than) that achieved by primary facultative ponds.

AC9.3.3 Design Calculation for Option 2 (UASB + Facultative pond)

(a) UASB (Up flow anaerobic sludge blanket)

Design flow rate is set for UASB Reactor as follows:

Average daily flow : 100,000 m^3/d

Maximum daily flow : 120,000 m^3/d, (Peak factor1.2 times of average daily flow)

Maximum hourly flow: 160,000 m^3/d

Influent SS	340 mg/L
BOD removal ratio	70 %
BOD of the UASB effluent	(1-0.7)*320 = 96 mg/L

Design of UASB reactor

Reactor dimension (Daily max flow, m^3/day)/ (up flow velocity, m/day)

= (120,000m^3 per day)/((0.5m/h*24h per day)=10,000m^2 or 1.0ha or 2.5acre

In order to retain any flocculent sludge in reactor at all times, experience has shown that the up flow velocity should not be more than 0.5m/h at average flow and not more than 1.2m/h at peak flow.

Check the flow rate (m/h):

i) Daily average flow: (100,000m^3/24h) /10,000m^2 = 0.41 m/h

ii) Hourly max flow: (100,000*1.6 m^3/24h) /10,000m2 = 0.67 m/h

Height of reactor: 5.0 m

Volume of reactor: 50,000 m^3 (=10,000*5.0)

Hydraulic retention time: (50,000m^3)*(24h/d)/(120,000m^3/d) = 10 hour

In the UASB process, the whole waste is passed through the anaerobic reactor in an up flow mode, with a hydraulic retention time (HRT) of only about 8-10 hours at the maximum daily flow.

Height of gas collector is 1.5 m

(b) Facultative Pond

Facultative Pond are designed on the basis of surface BOD loading (λs, kg/ha d), given by Mara's (1987) equation:

The BOD removal of UASB is 70%, so the BOD of the effluent is ((1-0.7) × 320), i.e. 96.0 mg/L.

$\lambda_s = 350\,(1.107 - 0.002\,T)^{T-25} = 350\,(1.107 - 0.002*17.5)^{-7.5} = 208$kg/ha d

The pond area (A_f, m^2) is given by:

$A_f = 10 L_i \cdot Q / \lambda_s$ = (10*96.0*100,000)/208= 461,538 m^2 or 46.2ha or 114.0 acre

where, Li=influent BOD to facultative pond of 96.0mg/L.

Pond depth varies from 1 to 2 m, with 1.5 m being typical. Taking the depth as 1.5 m = D_f

The pond retention time(θ_f,d)is given by:

$\theta_f = 2A_fD_f/(2Q_i - 0.001eA_f) = 2*461,538*1.5/(2*100,000 - 0.001*5*461,538) = 7.0$ days

subject to practical minimum value for θ_f of 4 days

where, D_f=facultative pond depth: 1.5 m

e= the net evaporation rate: 5 mm/day.

The BOD removal is 80%, so the facultative pond effluent is (0.20 ×340), i.e. 68.0mg/L

＜References：Design manual for waste stabilization ponds in India/Duncan Mara.>

Quoted that: The BOD removal in primary facultative pond is usually in the rage 70 to 80 percent based on unfiltered samples (that is, including the BOD exerted by the algae), and usually above 90 percent based on filtered samples. In secondary facultative ponds the removal is less, but the combined performance of anaerobic and secondary facultative ponds generally approximates (or is slightly better than) that achieved by primary facultative ponds.

AC9.3.4 Design calculation for Option 3 (Anaerobic pond + Aerated lagoon)

(a) Anaerobic pond

See Section AC9.3.2 (a).

(b) Aerated lagoon

The design calculation was made with reference to PP of "Wastewater Engineering"[1].

The design of aerated lagoon can be calculated by hydraulic retention time (HRT) and the mean cell residence time or solids retention time (SRT). Typical design value of HRT and SRT (0c), for suspended growth aerated lagoon varies from about 3 to 6 days, while for facultative aerated lagoon the HRT and SRT for aerated lagoon varies from 4 to 10 days.

1) Influent BOD = 144.0 g/m^3
2) Effluent BOD = 144.0/(1+d)=144.0/(1+5)= 24.0 g/m^3
3) BOD removal ≒ 80 %
4) Lagoon depth = 3.0 m
5) Design HRT = 5 days
6) Power required for mixing = 5 to 8 kW/10^3/m^3
7) SS removal = 80%

Based on the HRT of 5 days, the surface area required for the lagoon:

Volume = *Q* x HRT = (100,000 m^3/d) (5 d) = 500,000 m^3

Surface area of lagoon = *V/D* = 500,000m^3/3.0 m = 166,667 m^2 or 16.7 ha or 41.2 acer

Energy requirement for mixing: The aerated lagoons should be mixed with an energy level of about 0.8 to 1.0 W/m^3 of basin volume (1kW/1000 m^3). The threshold energy input for the suspension of bio solids is about 1.5 to 1.75 kw/1000 m^3. The energy requirement to maintain all of the solids in suspension is 5 to 8 kW/ 1000 m^3. Aerators ranging from 2 to 55 kW are now readily available.
Thus, the power is required about 2,500 to 4,000 kW(= 500,000 m^3 x (5 to 8 kW/1000 m^3)).

Aerator options: depending upon the lagoon configuration, the following aerator options are possible
46 or 73 - 55kW aerators.

[1] Wastewater Engineering, METCALF & EDDY (FOURTH EDITION), 8-8 Suspended Growth Aerated Lagoons, pp 840 to 843.

AC9.3.5 Design calculation for the Option 4 (Anaerobic pond + Trickling filter)

(a) Anaerobic pond

See Section AC9.3.2 (a).

(b) Trickling Filter

There are various types of trickling filter depending on the hydraulic and organic loading and filter media as shown in table below. In the study, the "low or standard rate" type is applied for comparison for the four treatment processes, which requires large area but is easiest to operate and maintain with high BOD removal effect.

Table AC9.3.3 Various Types of Trickling Filters

Design Parameter	Type depending on loading rate and filter media				
	Low or standard rate	**Inter-mediate rate**	**High Rate with rock media**	**High Rate with plastic media**	**Very High Rate**
Filter Media	Rock	Rock	Rock	Plastic	Rock/plastic
Hydraulic loading ($m^3/m^2 \cdot d$)	1-4	4-10	10-40	10-75	40-200
Organic loading (kg BOD/m^3 • d)	0.07-0.22	0.24-0.48	0.4-2.4	0.6-3.2	>1.5
Recirculation ratio	0	0-1	1-2	1-2	0-2
Filter flies	Many	Varies	Few	Few	Few
Sloughing	Intermittent	Intermittent	Continuous	Continuous	Continuous
Depth (m)	1.8-2.4	1.8-2.4	1.8-2.4	3.0-12.2	0.9-6
BOD removal efficiency (%)	80-90	50-80	50-90	60-90	40-70
Effluent quality	Well nitrified	Some nitrification	No nitrification	No nitrification	No nitrification
Power ($kW/10^3m^3$)	2-4	2-8	6-10	6-10	10-20

Design conditions (Low or standard rate type of trickling filter):

1) Wastewater flowrate = 100,000 m^3/d
2) The influent BOD concentration to the trickling filter = 144 mg/L (g/m^3)
3) BOD removal efficiency = 80(%)
4) Effluent BOD = 144.0*(1-0.8)=144.0*0.2= 29.0 g/m^3 (29 mg/L)
5) Hydraulic loading ＝ 1 to 4 ($m^3/m^2 \cdot d$)

Design of trickling filters:

1) Water tank diameter = 40 m
2) Number of filter tanks = 32 number
3) Depth of packing of filter media = 2.4 m

For check:
Tank area(m^2) = 40^2*π/4*32 = 40,192 m^2 or 4.0 ha or 9.9 acer
Hydraulic loading = 100,000 / 40,192 = 2.49, which is the range of 1 to 4, then it is OK.

The power required is 200 to 400 kW (100,000/1,000) x (2 to 4)

(c) Polishing pond
The effluent of trickling filter often contains biofilm peeled off from filter media depending on the influent quality and maintenance conditions. In order to treat the peeled biofilm, an polishing pond is designed with the hydraulic retention time of 4 days and pond depth of 2.0m.

Volume = *Q* x HRT = (100,000 m^3/d) *(4 d) = 400,000 m^3
Surface area = *V/D* = 400,000m^3/2.0 m = 200,000 m^2 or 20.0 ha or 49.4 acre

AC9.4 Wastewater Treatment Process for the Western SWD

Preliminary designs for three wastewater treatment alternatives for the western SWD have been prepared in the followings.

AC9.4.1-(1) Option.1 (Anaerobic pond + Facultative pond) for the Chokera WWTP

Design conditions:

- Influent flow rate: 228,670 m^3/d
- Influent BOD concentration: 320 mg/L
- Effluent BOD concentration: 80 mg/L
- Design air temperature is 17.5℃

(a) Anaerobic ponds anaerobic pond

Anaerobic pond volume is derived by the following equation[1]

$V_a = L_i \cdot Q / \lambda_v$

where,

V_a=anaerobic ponds volume, m^3

L_i=influent wastewater BOD, mg/L;

Q=influent wastewater average flow, m^3/d;

λ_v = volumetric design loading, g/m^3d

From Table AC9.3.2, the design loading(λ_v) for17.5℃ is 250 g BOD/m^3 /day.

Table AC9.3.2 Variation of design volumetric BOD loading on, and BOD removal in, anaerobic ponds

Temperature (℃)	Design loading (g/m^3 d): λ_v	BOD removal (%)
<10	100	40
10-20	20*T-100	2*T+20
20-25	10*T+100	2*T+20
>25	350	70

Note: *T=temperature,℃
Source: Design manual for waste stabilization ponds in India/Duncan Mara.

Thus the anaerobic pond volume (V_a) :

$V_a = L_i \cdot Q / \lambda_v = 320*228{,}670/250 = 292{,}698 m^3$

For Check

The anaerobic pond retention time(θ a, d) is then calculated from:

[1] Design manual for waste stabilization ponds in India/Duncan Mara.

subject to a practical minimum value for θ_a of 1day

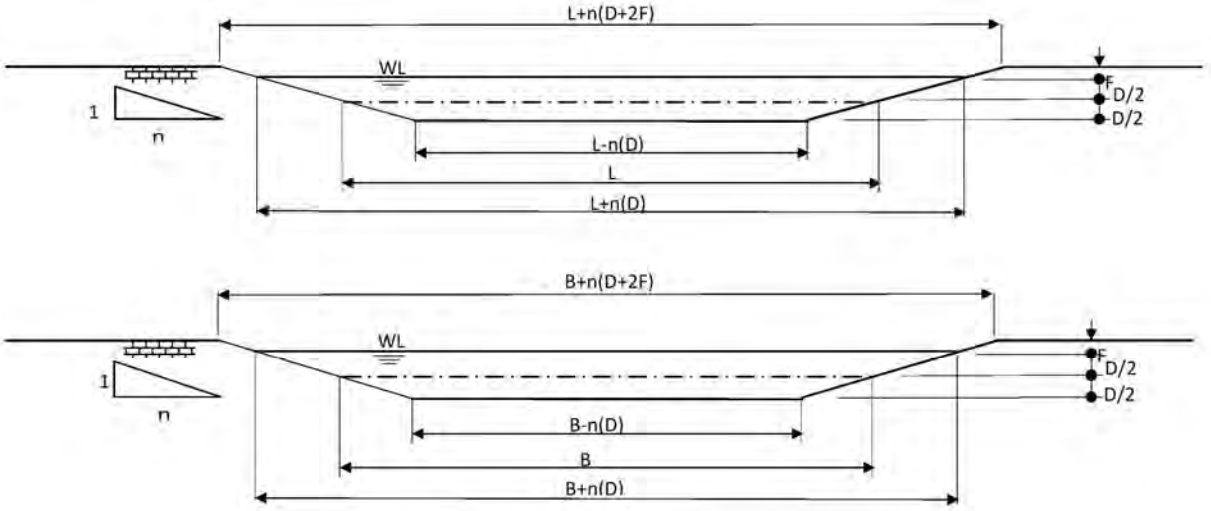
θ a= V_a/Q=292,698/228,670=1.28d As θ_a > 1day…….Ok

Assuming a depth of 4 m, the anaerobic pond area is 73,174 m^2 or 7.3 ha or 18.1 acre.

Noted that the depth is normally in the range 2 to 5 m. Ideally the deeper the better.

At 17.5℃ the BOD removal (Table AC9.31.2) is 55%, so the BOD of the anaerobic pond effluent is (0.45 × 320), i.e. 144.0mg/L.

Check ponds volume

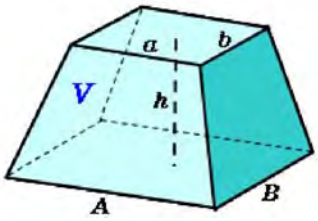


Where

F: free board	m	0.5
n: side slope(1:n)		3
Embank ment	m	illustration [(L+(D+2F) or B+(D+2F)]

Calculates the volume of a obelisk given the base and top sides, and height

Volume; $V = h/6(Ab + aB + 2(ab + AB))$



		TYPE.1	TYPE.2	
top side a ; L-n(D)	m	133.0		
top side b ; B-n(D)	m	133.0		
top side A ; L+n(D)	m	157.0		
top side B ; B+n(D)	m	157.0		
hight h ; D	m	4.0		
Volume	m^3	84,292		
Unit		4	0	Total
Total volume	m^3	337,168	337,168	> 292,698….OK

(b)Facultative Pond

Facultative Pond are designed on the basis of surface BOD loading (λs, kg/ha d), given by Mara's equation.

At 17.5℃ the BOD removal (Table AC9.3.2) is 55%= (2*17.5) +20, so the BOD of the anaerobic pond effluent is (0.45 × 320), i.e. 144.0 mg/L.

λ_s = 350 (1.107－0.002 T)$^{T-25}$= 350 (1.107－0.002*17.5)$^{-7.5}$= 208 kg/ha d

where, T=mean air temperature of the coldest month,17.5℃

The pond area (A_f, m^2) is given by:

A_f=10L_i・Q/ λ_s=(10*144.0*228,670)/208=1,583,100 m^2

where Li=influent BOD concentration to the facultative pond, 144.0mg/L.

The pond depth varies from 1 to 2 m, with 1.5 m being typical. Taking the depth as 1.5 m = D_f

The pond retention time (θ_f,d) is given by:

θ_f=2$A_f D_f$/(2Q_i－0.001eA_f)＝2*1,583,100*1.5/ （2*228,670－0.001*5*1,583,100）

＝10.6 d

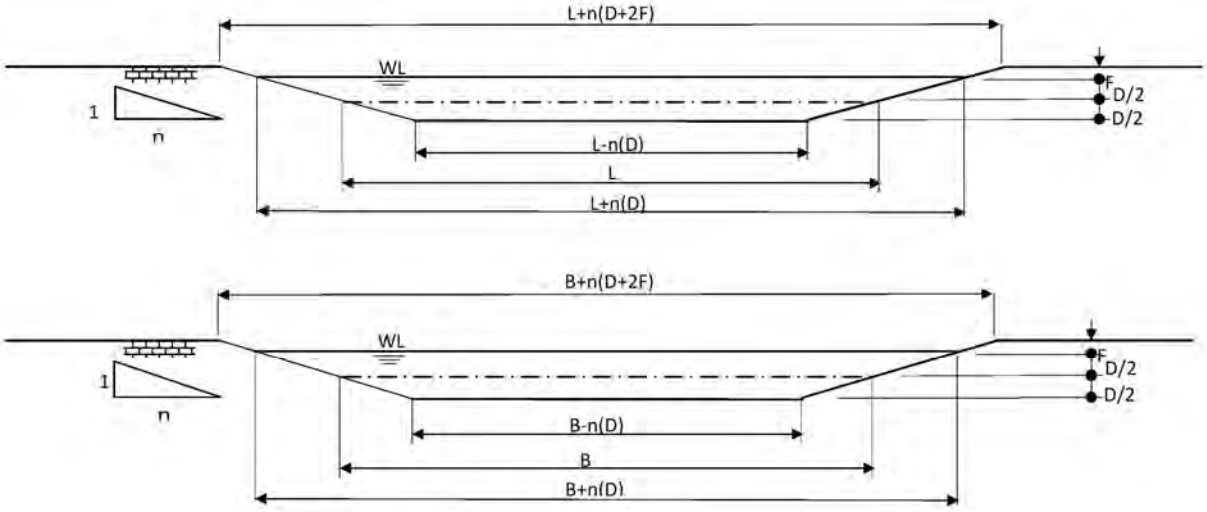
subject to practical minimum value for θ_f of 4days

where, D_f=facultative pond depth:1.5 m

Qi=influent wastewater flow: 228,670 m^3/d

e= the net evaporation rate: 5mm/day.

The BOD removal is 80%, so the facultative pond effluent is (0.20 ×320) ,i.e. 68.0mg/L



Where

F: free board m 0.5

n: side slope(1:n) 3

Embank ment m illustration [(L+(D+2F) or B+(D+2F)]

		TYPE.1	TYPE.2	
L	m	472.5	393	
B	m	692.5	393	
Area	m^2	327,206	154,056	
Unit		4	2	Total
Total Area	m^2	1,308,824	308,112	1,616,936 > 1,583,100….OK

AC9.4.1-(2) New West WWTP Option.1 (Anaerobic pond + Facultative pond)

Design conditions:

- Influent flow rate: 205,130 m^3/d
- Influent BOD concentration: 320 mg/L
- Effluent BOD concentration: 80 mg/L
- Design air temperature is 17.5℃

(a) Anaerobic ponds

The anaerobic pond volume (V_a) :

$V_a = L_i \cdot Q / \lambda_v = 320*205{,}130/250 = 262{,}566 m^3$

For Check

The anaerobic pond retention time(θ a, d)is then calculated from:

subject to a practical minimum value for θ_a of 1day

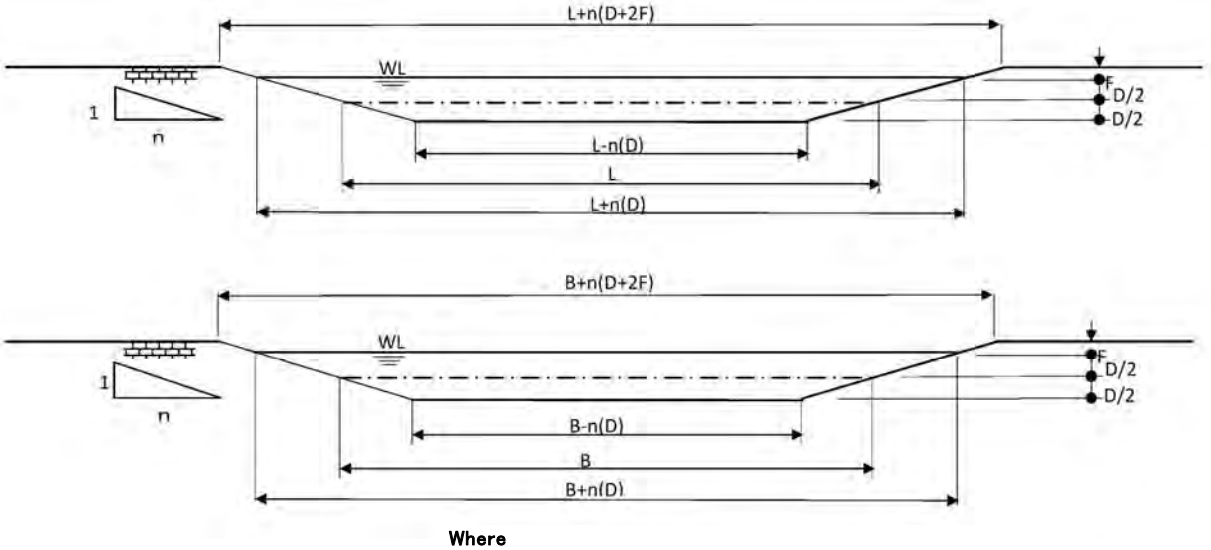
θ a= V_a/Q=262,566/205,130= 1.28d As θ_a > 1day…….Ok

Assuming a depth of 4 m, the anaerobic pond area is 65,642 m^2 or6.6 ha or 16.2 acre.

Note that the depth is normally in the range 2 to 5 m. Ideally the deeper the better.

At 17.5℃ the BOD removal (Table AC9.3.2) is 55%, so the BOD of the anaerobic pond effluent is (0.45 × 320), i.e. 144.0mg/L.

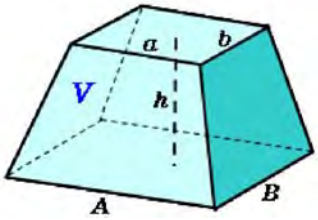
Check ponds volume



Where		
F: free board	m	0.5
n: side slope(1:n)		3
Embank ment	m	illustration [(L+(D+2F) or B+(D+2F)]

Calculates the volume of a obelisk given the base and top sides, and height

Volume; $V = h/6(Ab + aB + 2(ab + AB))$



		TYPE.1	TYPE.2	
top side a ; L-n(D)	m	123.0		
top side b ; B-n(D)	m	123.0		
top side A ; L+n(D)	m	147.0		
top side B ; B+n(D)	m	147.0		
hight h ; D	m	4.0		
Volume	m^3	73,092		
Unit		4	0	Total
Total volume	m^3	292,368	292,368	> 262,566…OK

(b)Facultative Pond

Facultative Pond are designed on the basis of surface BOD loading (λs, kg/ha d), given by Mara's equation

At 17.5℃ the BOD removal (Table 1.1) is 55%＝ (2*17.5) +20, so the BOD of the anaerobic pond effluent is (0.45 × 320), i.e. 144.0 mg/L.

$\lambda_s = 350\,(1.107-0.002T)^{T-25} = 350\,(1.107-0.002*17.5)^{-7.5} = 208$ kg/ha d

where T=mean air temperature of the coldest month,17.5℃

The pond area (A_f, m^2) is given by:

$A_f = 10L_i \cdot Q/\lambda_s = (10*144.0*205{,}130)/208 = 1{,}420{,}131 m^2$

where, Li=influent BOD, 144.0mg/L（the anaerobic pond effluent）

Pond depth varies from 1 to 2m, with 1.5m being typical. Taking the depth as 1.5m=D_f

The pond retention time(θ_f,d)is given by:

$\theta_f = 2A_fD_f/(2Q_i - 0.001eA_f) = 2*1{,}420{,}131*1.5/(2*205{,}130 - 0.001*5*1{,}420{,}131)$

$= 10.6$ d

subject to practical minimum value for θ_f of 4days

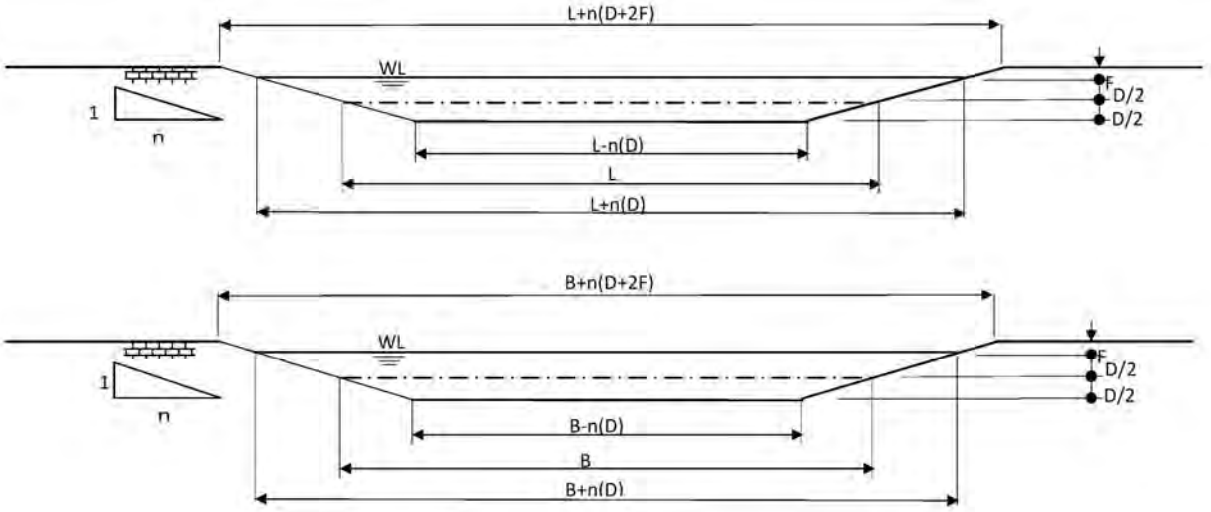
where D_f=facultative pond depth, m:1.5m

Qi=influent wastewater flow, m^3/d; 205,131m^3/d

e= the net evaporation rate, mm/day; 5mm/day.

The BOD removal is 80%,so the facultative pond effluent is 68 mg/L (=0.20 ×320).

Check ponds area



Where

F: free board	m	0.5
n: side slope(1:n)		3
Embank ment	m	illustration [(L+(D+2F) or B+(D+2F)]

		TYPE.1	TYPE.2	
L	m	742.5	543	
B	m	292.5	543	
Area	m^2	217,181	294,306	
Unit		4	2	Total
Total Area	m^2	868,724	588,612	1,457,336 > 1,420,131….OK

C9.4.2 Option.2 (UASB + Facultative pond) for Chokera WWTP

Design conditions:

- Influent flow rate: 433,800 m^3/d
- Influent BOD concentration: 320 mg/L
- Effluent BOD concentration: 80 mg/L
- Design air temperature is 17.5℃

(a) UASB (Up flow anaerobic sludge blanket)

Design flow rate is set for UASB Reactor as follows:

Average daily flow : 433,800 m^3/d

Maximum daily flow : 520,560 m^3/d, (Peak factor1.2 times of average daily flow)

Maximum hourly flow: 694,080 m^3/d

Influent SS: 340 mg/L

BOD removal ratio: 70 %

BOD of the UASB effluent: (1-0.7)*320 = 96 mg/L

Design of UASB reactor

Reactor dimension: (Daily max flow, m^3/day)/ (up flow velocity, m/day)

= (520,560 m^3 per day)/((0.5m/h*24h per day)= 43,380 m^2 or 4.3 ha or 10.7 acre

In order to retain any flocculent sludge in reactor at all times, experience has shown that the up flow velocity should not be more than 0.5m/h at average flow and not more than 1.2m/h at peak flow.

Check the up flow velocity (m/h)

at the average daily flow: (433,800m^3/24h) /43,380m^2= 0.41 m/h

at the maximum hourly flow: (433,800*1.6 m^3/24h) /43,380m2= 0.67m/h

Height of reactor: 5.0 m

Volume of reactor: 216,900 m^3 (=433,800x5.0)

Hydraulic retention time: 10 hour (=(216,900m^3)x(24h/d)/(520,560m^3/d)

In the UASB process, the whole waste is passed through the anaerobic reactor in an up flow mode, with a hydraulic retention time (HRT) of only about 8 to 10 hours at the maximum daily flow.

Height of gas collector: 1.5m

(b) Facultative Pond

The BOD removal of UASB is 70%, so the BOD of the anaerobic pond effluent is ((1-0.7) × 320), i.e.

96.0 mg/L.

λ_s = 350 (1.107－0.002 T)$^{T-25}$= 350 (1.107－0.002*17.5)$^{-7.5}$= 208kg/ha d

The pond area (A_f, m^2) is given by:

A_f=10L_i ･Q/ λ_s=(10*96.0*433,800)/208= 2,002,154 m^2 or 200.2 ha or 497.7 acre

where, Li=influent BOD 96.0mg/L.

Pond depth varies from 1 to 2 m, with 1.5m being typical. Taking the depth as 1.5 m = D_f

The pond retention time(θ_f,d) is given by:

θ_f=2$A_f$$D_f$/(2$Q_i$－0.001e$A_f$)=2*2,002,154*1.5/（2*433,800－0.001*5*2,002,154）=7.0 days

subject to practical minimum value for θ_f of 4 days

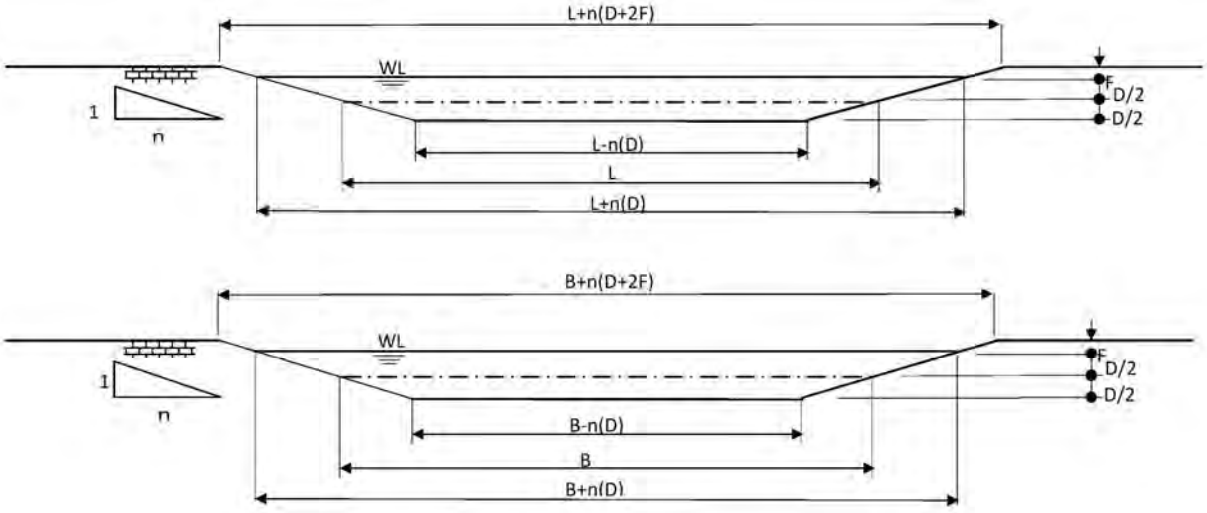
where, D_f=facultative pond depth: 1.5 m

Qi=influent wastewater flow; 433,800 m^3/d

e= the net evaporation rate: 5 mm/day.

The BOD removal is 80%, so the facultative pond effluent is 68.0mg/L (=0.20 ×340).

Check ponds area



Where

F: free board m 0.5

n: side slope(1:n) 3

Embank ment m illustration [(L+(D+2F) or B+(D+2F)]

		TYPE.1	TYPE.2		
L	m	542.5	393		
B	m	542.5	443		
Area	m^2	294,306	173,681		
Unit		6	2	Total	
Total Area	m^2	1,765,836	347,362	2,113,198	> 2,002,154….OK

Pond treatment Technology/Edited by Andy

Sludge disposal plan

Suppose that 70% of the inflow SS amount is removed by the UASB.

Removal SS amount per day (solids amount) ＝(433,800*340)*70/100*10-3= 103,244 kg/day

Sludge generation rate = organic content 60% × digestibility 40% + inorganic content 40% = 76%

Therefore, the sludge generation amount (solid matter amount)＝103,244kg/day×76/100＝ 78,465 kg/day

1) Design of sludge drying bed

Plan facilities that can dry sludge withdrawn from UASB for 7 days.

Excess sludge (digested sludge) Estimated water content 98%	Solid amount kg/day	78,465
	Sludge amount m^3/day	78,465*100/(100-98)*10^{-3}=3,923
	Sludge amount m^3/day*7days	3,923*7=27,463

Therefore the facility size of Sludge drying bed

Sludge storage depth * length * width =0.25*150*750=28,125m^3 > 27,463m^3・・・・・・・・・・・ok

2) Calculation of sludge disposal volume after drying

Drawing out sludge Estimated water content 50%	Solid amount kg/day	78,465
	Sludge amount m^3/day	78,465*100/(100-50)*10^{-3}=156.9
	Sludge amount m^3/year	156.9*365=57,269

AC9.4.3 Option 4 (Anaerobic pond + Trickling filter) for Chokera WWTP

Design conditions:

- Influent flow rate: 433,800 m^3/d
- Influent BOD concentration: 320 mg/L
- Effluent BOD concentration: 80 mg/L
- Design air temperature is 17.5℃

(a) Anaerobic pond

Anaerobic pond volume is derived by the following equation

$V_a = L_i \cdot Q / \lambda_v$

From Table AC9.3.2 the design loading(λ_v) for17.5℃ is 250 g BOD/m^3 per day.

The anaerobic pond volume (V_a) : $= L_i \cdot Q / \lambda_v = 320*433,800/250 = 555,264\ m^3$

For check

The anaerobic pond retention time(θ a, d) is then calculated from:

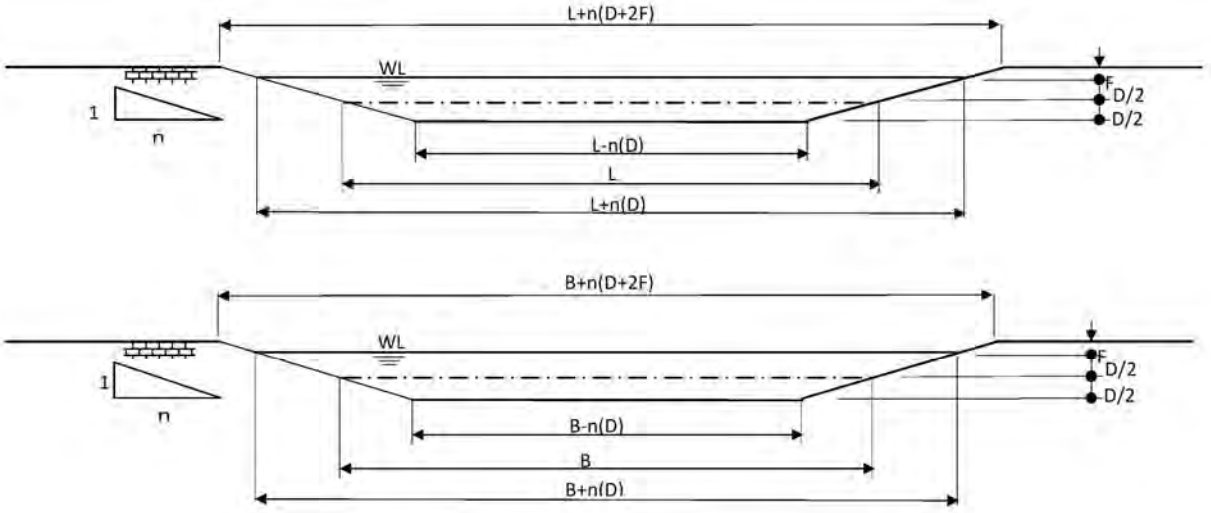
subject to a practical minimum value for θ_a of 1day

$\theta_a = V_a / Q = 555,264/433,800 = 1.28$ d As θ_a > 1day…….Ok

Assuming a depth of 4 m, the anaerobic pond area is 138,816 m^2 or 13.9 ha or 34.3 acre

Noted that the depth is normally in the range 2 to 5m. Ideally the deeper the better.

At 17.5℃ the BOD removal (Table A9.3.2) is 55%, so the BOD of the anaerobic pond effluent is 144 mg/L (=0.45 × 320).

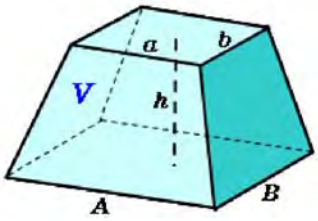


Where

F: free board	m	0.5
n: side slope(1:n)		3
Embank ment	m	illustration [(L+(D+2F) or B+(D+2F)]

Calculates the volume of a obelisk given the base and top sides, and height

Volume; $V = h/6(Ab + aB + 2(ab + AB))$



		TYPE.1	TYPE.2	
top side a ; L−n(D)	m	385.0		
top side b ; B−n(D)	m	435.0		
top side A ; L+n(D)	m	397.0		
top side B ; B+n(D)	m	447.0		
hight h ; D	m	2.0		
Volume	m^3	344,886		
Unit		4	0	Total
Total volume	m^3	1,379,544		1,379,544 > 1,301,400….OK

(b) Trickling filter designs

There are various types of trickling filter depending on the hydraulic and organic loading and filter media as shown in Table AC9.4.3. In the study, the “low or standard rate” type is applied for comparison for the four treatment processes, which requires large area but is easiest to operate and maintain with high BOD removal effect.

Design conditions (Low or standard rate type of trickling filter):

1) Wastewater flowrate = 433,800 m^3/d
2) The influent BOD concentration to the trickling filter = 144 mg/L (g/m^3)
3) BOD removal efficiency = 80(%)
4) Effluent BOD = 144.0*(1-0.8)=144.0*0.2= 29.0 g/m^3 (29 mg/L)
5) Hydraulic loading = 1 to 4 (m^3/m^2•d)

Design of trickling filters:

1) Water tank diameter = 40 m
2) Number of filter tanks = 144 number
3) Depth of packing of filter media = 2.4 m

For check:
Tank area(m^2) = 40^2* π /4*144 = 180,864 m^2 or 18.1 ha or 44.7 acer.
Hydraulic loading = 433,800/180,864 = 2.40, which is the range of 1 to 4, then it is OK.

The power required is 868 to 1,735 kW (= 433,800/1,000 x (2 to 4))
Check ponds volume

(c) Polishing pond

An effluent of trickling filter often contains biofilm peeled off from filter media depending on the in influent quality and maintenance conditions. In order to treat the peeled biofilm, Polishing pond with the hydraulic retention time of 3 days and pond depth of 2.0 m.

Volume = *Q* x HRT = 433,800(m^3/d) *(3 d) = 1,301,400 m^3
Surface area = *V/D* = 1,301,400m^3/2.0 m = 650,700 m^2 or 65.07 ha or 160.8 acre

AC9.4.4 Construction Costs for the Wastewater Treatment Options for the WWTPs in the Western SWD

Following tables summarizes the total construction cost estimates for the wastewater treatement options for the WWTPs in the western SWD.

Table AC9.4.4 (1a) Construction Cost of Option 1 for the Chokera WWTP

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
Chokera Option.1 (Treatment capacity 228,670m3/d)							
1-1	Anaerobic ponds	Earth work, concrete lining	Ls	1	-	487	Whole work
2-1	Facultative ponds	Earth work, concrete lining	Ls	1	-	3,496	Whole work
	Influent channel	Open channel	m	1,150	297,000	342	Whole work
	Distribution tank	Cast-in-place structure 2 units(4×4×4)	m3	128	15,000	2	Whole work
	Landscaping work	Mainly construction of internal road	m2	320,000	800	256	Whole work
Civil and Building Works Total			—	—	—	**4,583**	—
Mechanical and Electrical Works Total			—	—	—	**0**	—
Total Construction Cost			—	—	—	**4,583**	—

Breakdown

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
1-1	Anaerobic ponds						
	Earth work	Excavation, transportation	m3	387,600	700	271	All 4 ponds
		Disposal of surplus soil	m3	387,600	300	116	〃
	Pond structure	Concrete lining (t=0.2m)	m2	33,400	3,000	100	〃
	Civil and Building Works Total		—	—	—	487	—
2-1	Facultative ponds						
	Earth work ①	Excavation, transportation	m3	2,637,408	700	1,846	All 4 ponds
		Disposal of surplus soil	m3	2,637,408	300	791	〃
	Earth work ②	Excavation, transportation	m3	620,992	700	435	All 2 ponds
		Disposal of surplus soil	m3	620,992	300	186	〃
	Pond structure ①	Concrete lining	m2	59,200	3,000	178	All 4 ponds
	Pond structure ②	Concrete lining	m2	19,900	3,000	60	〃
	Civil and Building Works Total		—	—	—	3,496	—

Table AC9.4.4 (1b) Construction Cost of Option 1 for the New West WWTP

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
New WEST Option.1 (Treatment capacity 205,130m3/d)							
1-2	Anaerobic ponds	Earth work, concrete lining	Ls	1	-	430	Whole work
2-2	Facultative ponds	Earth work, concrete lining	Ls	1	-	3,184	Whole work
	Influent channel	Open channel	m	1,350	297,000	401	Whole work
	Distribution tank	Cast-in-place structure 2 units (4×4×4)	m3	128	15,000	2	Whole work
	Landscaping work	Mainly construction of internal road	m2	290,000	800	232	Whole work
Civil and Building Works Total			—	—	—	**4,249**	—
Mechanical and Electrical Works Total			—	—	—	**0**	—
Total Construction Cost			—	—	—	**4,249**	—

Breakdown

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
1-2	Anaerobic ponds						
	Earth work	Excavation, transportation	m3	336,400	700	236	All 4 ponds
		Disposal of surplus soil	m3	336,400	300	101	〃
	Pond structure	Concrete lining (t=0.2m)	m2	31,100	3,000	93	〃
	Civil and Building Works Total		—	—	—	430	—
2-2	Facultative ponds						
	Earth work ①	Excavation, transportation	m3	1,758,888	700	1,231	All 4 ponds
		Disposal of surplus soil	m3	1,758,888	300	528	〃
	Earth work ②	Excavation, transportation	m3	1,183,792	700	829	All 2 ponds
		Disposal of surplus soil	m3	1,183,792	300	355	〃
	Pond structure ①	Concrete lining	m2	52,600	3,000	158	All 4 ponds
	Pond structure ②	Concrete lining	m2	27,500	3,000	83	〃
	Civil and Building Works Total		—	—	—	3,184	—

Table AC9.4.4 (2) Construction Cost of Option 2 for the Chokera WWTP

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
Chokera Option.2 (Treatment capacity 433,800m3/d)							
3-1	UASB	Structural works	Ls	224,000	20,000	4,480	Whole work
2-3	Facultative ponds	Earth work, concrete lining	Ls	1	-	4,573	Whole work
	Influent channel	Open channel	m	1,150	297,000	342	Whole work
	Distribution tank	Cast-in-place structure	m3	128	15,000	2	Whole work
	Landscaping work	Mainly construction of internal road	m^2	300,000	800	250	Whole work
	Sludge drying bed	Earth work,Sand,Gravel,Open pipe	m^2	112,500	10,750	1,209	Whole work
Civil and Building Works Total			—	—	—	**9,647**	—
3-1	UASB	Transmission pump facility	Unit	12	50,556,000	607	Whole work
Mechanical and Electrical Works Total			—	—	—	**607**	—
Total Construction Cost			—	—	—	**10,254**	—

Breakdown

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
3-1	UASB						
	Structural works	Reactor and gas holder	m3	224,000	20,000	4,480	Whole work
	Civil and Building Works Total		—	—	—	4,480	—
	Pumping facility	Mechanical and electrical works	Unit	12	50,556,000	607	Whole work
	Mechanical and Electrical Works Total		—	—	—	607	—
2-3	Facultative pond						
	Earth work ①	Excavation, transportation	m3	3,561,132	700	2493	All 4 ponds
		Disposal of surplus soil	m3	3,561,132	300	1068	〃
	Earth work ②	Excavation, transportation	m3	699,792	700	490	All 2 ponds
		Disposal of surplus soil	m3	699,792	300	210	〃
	Pond structure ①	Concrete lining	m2	82,687	3,000	248	All 4 ponds
	Pond structure ②	Concrete lining	m2	21,200	3,000	64	〃
	Civil and building works Total		—	—	—	4,573	—

Table AC9.4.4 (3) Construction Cost of Option 4 for the Chokera WWTP

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
Chokera Option.4 (Treatment capacity 433,800m3/d)							
1-3	Anaerobic ponds	Earth work, concrete lining	Ls	1	-	792	Whole work
5-1	Trickling filter	Tank structure, filter pack		139	42,000,000	5,838	Whole work
6-1	Polishing pond	Earth work, concrete lining	Ls	1		1,895	Whole work
	Influent channel	Open channel	m	1,150	297,000	342	Whole work
	Distribution tank	Cast-in-place structure 2 units (4×4×4)	m3	128	15,000	2	Whole work
	Landscaping work	Mainly construction of internal road	m2	320,000	800	231	Whole work
	Civil and Building Works Total		—	—	—	**9,100**	—
5-2	Rotating sprinkler	D40m	Unit	139	147,600,000	2,052	Whole work
	Pumping facility	D450-55KW	Unit	20	22,620,000	452	
Mechanical and Electrical Works Total			—	—	—	**2,504**	—
Total Construction Cost			—	—	—	**11,604**	—

Breakdown

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
1-3	Anaerobic ponds						
	Earth work	Excavation, transportation	m3	660,744	700	463	All 4 ponds
		Disposal of surplus soil	m3	660,744	300	198	〃
	Pond structure	Concrete lining (t=0.2m)	m2	43,601	3,000	131	〃
	Civil and Building Works Total		—	—	—	792	—
5-1	Trickling filter (one unit tank)						
	One Unit Tank	Concrete works	m3	597	30,000	18	One tank
		Formwork setting	m2	754	13,000	10	One tank
		Filter media packing	m3	3,014	4,500	14	One tank
	Civil and Building Works Total		—	—	—	42	—
6-1	Polishing ponds						
	Earth work	Excavation, transportation	m3	1,737,000	700	1,216	All 4 ponds
		Disposal of surplus soil	m3	1,737,000	300	521	〃
	Pond structure	Concrete lining (t=0.2m)	m2	52,810	3,000	158	〃
	Civil and Building Works Total		—	—	—	1,895	—
5-2	Trickling filter (one water tank)						
	Sprinkler	Rotating sprinkler(D40m)	Unit	1	147,600,000	148	One tank
	Pumping facility	Pumping facility(D450-55kw)	Unit	1	22,620,000	23	Two tanks
	Mechanical and Electrical Works Total		—	—	—	171	—

AC9.5 Wastewater Treatment Process for the Eastern SWD

AC9.5.1 Option 1 (Anaerobic pond + Facultative pond) for the New East WWTP

Design conditions:

- Influent flow rate: 434,000 m^3/d
- Influent BOD concentration: 320 mg/L
- Effluent BOD concentration: 80 mg/L
- Design air temperature is 17.5℃

(a) Anaerobic ponds

See Section AC9.3.2.

The anaerobic pond volume (V_a)

$V_a = L_i \cdot Q / \lambda_v = 320*434{,}000/250 = 555{,}250\ m^3$

for Check

The anaerobic pond retention time(θ a,d) is then calculated from:

subject to a practical minimum value for θ_a of 1day

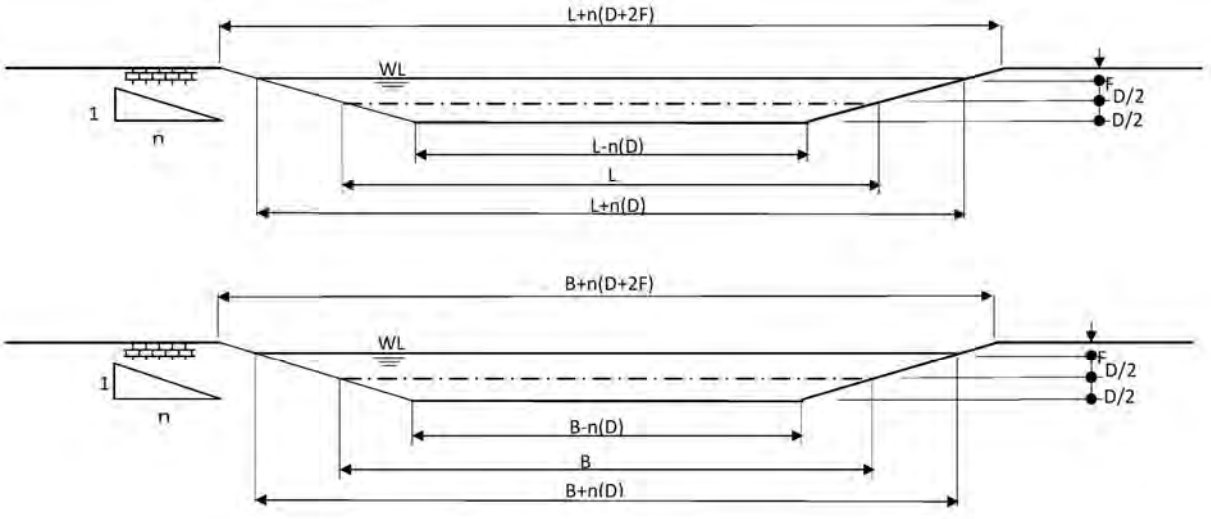
θ a= V_a/Q=555,250/434,000=1.28 days As $\theta_a > 1$ day…….Ok

Assuming a depth of 4 m, the anaerobic pond area is 138,812 m^2 or 3.2 ha or 7.0 acre.

Noted that the depth is normally in the range 2 to 5m. Ideally the deeper the better.

At 17.5℃ the BOD removal (Table AC9.3.2) is 55%, so the BOD of the anaerobic pond effluent is (0.45 × 320), i.e. 144 mg/L.

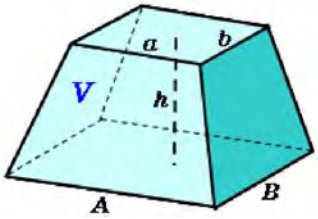
Check ponds volume



Where			
F: free board	m	0.5	
n: side slope(1:n)		3	
Embank ment	m	illustration [(L+(D+2F) or B+(D+2F)]	

Calculates the volume of a obelisk given the base and top sides, and height

Volume; $V = h/6(Ab + aB + 2(ab + AB))$



		TYPE.1	TYPE.2	
top side a ; L−n(D)	m	133.0		
top side b ; B−n(D)	m	233.0		
top side A ; L+n(D)	m	157.0		
top side B ; B+n(D)	m	257.0		
hight h ; D	m	4.0		
Volume	m^3	142,292		
Unit		4	0	Total
Total volume	m^3	569,168		569,168 > 555,250….OK

(b)Facultative Pond

$\lambda_s = 350\ (1.107 - 0.002\,T)^{T-25} = 350\ (1.107 - 0.002*17.5)^{-7.5} = 208$ kg/ha d

The pond area (A_f, m^2) is given by:

$A_f = 10L_i \cdot Q / \lambda_s = (10*144.0*434{,}000)/208 = 3{,}004{,}615\ m^2 = 69.2$ ha $= 171.0$ acre

where, Li=influent BOD, 144.0mg/L （the anaerobic pond effluent）

Pond depth varies from 1 to 2m, with 1.5m being typical. Taking the depth as 1.5m=D_f

The pond retention time(θ_f,d)is given by:

$\theta_f = 2A_fD_f/(2Q_i - 0.001eA_f) = 2*3{,}004{,}615*1.5/(2*434{,}000 - 0.001*5*3{,}004{,}615)$

$= 10.6$ days

subject to practical minimum value for θ_f of 4days

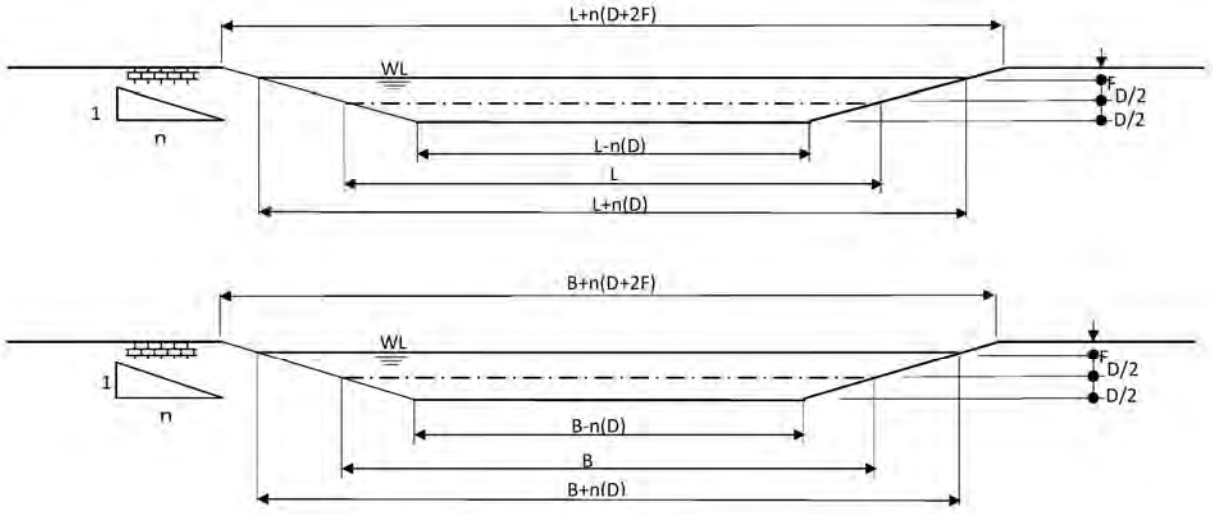
where, D_f=facultative pond depth::1.5m

Qi=influent wastewater flow: 434,000 m^3/d

e= the net evaporation rate: 5mm/day.

The BOD removal is 80%, so the facultative pond effluent is 68 mg/L (= 0.20 ×320)

Check ponds area



Where

F: free board	m	0.5
n: side slope(1:n)		3
Embank ment	m	illustration [(L+(D+2F) or B+(D+2F)]

		TYPE.1	TYPE.2		
L	m	1,192.5	443		
B	m	542.5	493		
Area	m^2	646,931	217,931		
Unit		4	2	Total	
Total Area	m^2	2,587,724	435,862	3,023,586	> 3,004,615….OK

(c) Prediction sludge accumulation

Saqquar and Pascod developed a model to describe sludge accumulation in primary anaerobic ponds[1].

The volume of sludge when only limited information is available. They argue that sludge accumulation per capita can vary considerably from place to place, and cite estimated accumulation as 0.03-0.05 m3/capita.

Rules of thumb sometime provided as to the frequency with sludge removal should take place.

Mara and Pearson (1998) suggest that anaerobic ponds require desludging when they are around one third full of sludge (by volume).

They also provide a formula to calculate when this is occur:

n＝Va/3 p s

where,

n: the number of years to reach 1/3 of the volume available;

Va: volume of the anaerobic pond in m^3;

p: population served;

s: sludge accumulation rate,m^3/capita year.（0.03m^3/capita year）

Table AC9.5.1 estimates the number of years that sludge accumulation amount reaches 1/3 capacity of

[1] IWA pond treatment technology, pp 266

Anaerobic pond.

Table AC9.5.1 Estimated Year to accumulate the sludge reach to one-third capacity of the anaerobic pond

Parameter	Eastern SWD	Reference for the Western SWD
Design flow rate(m^3/d)	434,000	433,800
InfluentBOD_5 concentration: (mg/L)	314	311
Temperature :degrees Celsius	17.5	17.5
Retention time (day)	1.26	1.24
Va (m^3)	546,840	537,912
Va/3 (m^3)	182,280	179,304
P (person)	2,085,820	2,206,290
s (m^3/capita year)	0.03	0.03
P･s(m^3/year)	62,575	73,543
n (year) ＝V a/3･ P･s the number of years to reach 1/3 of the volume available	2.91	2.44

In total plan, the number of years that sludge accumulation amount of Anaerobic pond reaches 1/3 capacity of pond is 2.44 to 2. 91 years. In addition, as shown in the above Figure, anaerobic pond provided a sludge reservoir of 0.5 m in depth at the bottom of the pond so that a certain amount of grace could be secured. The accumulated sludge stops the anaerobic pond, pulls out the water of the pond, it goes out of the place after sun drying.
At this time, since anaerobic pond stops the processing function, it puts a spare anaerobic pond (stand-by).

Next, calculate the amount of generated sludge per year assuming that 70% of the inflow SS amount is sludge to be discharged.

Table AC9.5.2 Sludge Projection at the Anaerobic Pond

Parameter	Unit	Eastern SWD	Reference for Western SWD
Influent SS concentration:	mg/L	338	336
70% or above	mg/L	237	235
Design Average flow rate	m^3/day	434,000	433,800
Sludge accumulation weight	t/year	(237*434,000*365)*10^{-6}= 37,543	(235*433,800*365)*10^{-6}= 37,209
Amount of sun-dried sludge (moisture content 50%)	― m^3/year	37,543*100/(100-50) =75,100	37,209*100/(100-50) =74,400

As a result, the amount of sludge after sun drying which is discharged annually from New East WWTP is 75,100 m^3 / year.

AC9.5.2 Option.2 (UASB + Facultative pond) for the New East WWTP

Design conditions:

- Influent flow rate: 434,000 m^3/d
- Influent BOD concentration: 320 mg/L
- Effluent BOD concentration: 80 mg/L
- Design air temperature is 17.5℃

(a) UASB (Up flow anaerobic sludge blanket)

Design flow rate is set for UASB Reactor as follows:

Average daily flow : 434,000 m^3/d

Maximum daily flow : 520,800 m^3/d, (Peak factor1.2 times of average daily flow)

Maximum hourly flow: 694,400 m^3/d

Influent SS: 340 mg/L

BOD removal ratio: 70 %

BOD of the UASB effluent: (1-0.7)*320 = 96 mg/L

Design of UASB reactor

Reactor dimension: (Daily max flow, m^3/day)/ (up flow velocity, m/day)

= (520,800 m^3 per day)/((0.5m/h*24h per day)= 43,400 m^2 or 4.3 ha or 10.7 acre

In order to retain any flocculent sludge in reactor at all times, experience has shown that the up flow velocity should not be more than 0.5m/h at average flow and not more than 1.2m/h at peak flow.

Check the up flow velocity (m/h)

at the average daily flow: (434,000m^3/24h) /43,400m^2= 0.41 m/h

at the maximum hourly flow: (434,000*1.6 m^3/24h) /43,400m2= 0.67m/h

Height of reactor: 5.0 m

Volume of reactor: 217,000 m^3 (=43,400x5.0)

Hydraulic retention time: 10 hour (=(217,000m^3)x(24h/d)/(520,800m^3/d)

In the UASB process, the whole waste is passed through the anaerobic reactor in an up flow mode, with a hydraulic retention time (HRT) of only about 8 to 10 hours at the maximum daily flow.

Height of gas collector: 1.5m

(b)Facultative Pond

The pond area (A_f, m^2) is given by:

A_f=10L_i・Q/ λ_s=(10*96.0*434,000)/208= 2,003,077 m^2 or 200.3 ha or 495.0 acre

where Li=influent BOD concentration of 96.0mg/L.

Pond depth varies from 1 to 2m, with 1.5m being typical. Taking the depth as 1.5 m = D_f

The pond retention time(θ_f,d)is given by:

$\theta_f = 2A_f D_f/(2Q_i - 0.001eA_f) = 2*2{,}003{,}077*1.5/(2*434{,}000 - 0.001*5*2{,}003{,}077) = 7.0$ d

subject to practical minimum value for θ_f of 4 days

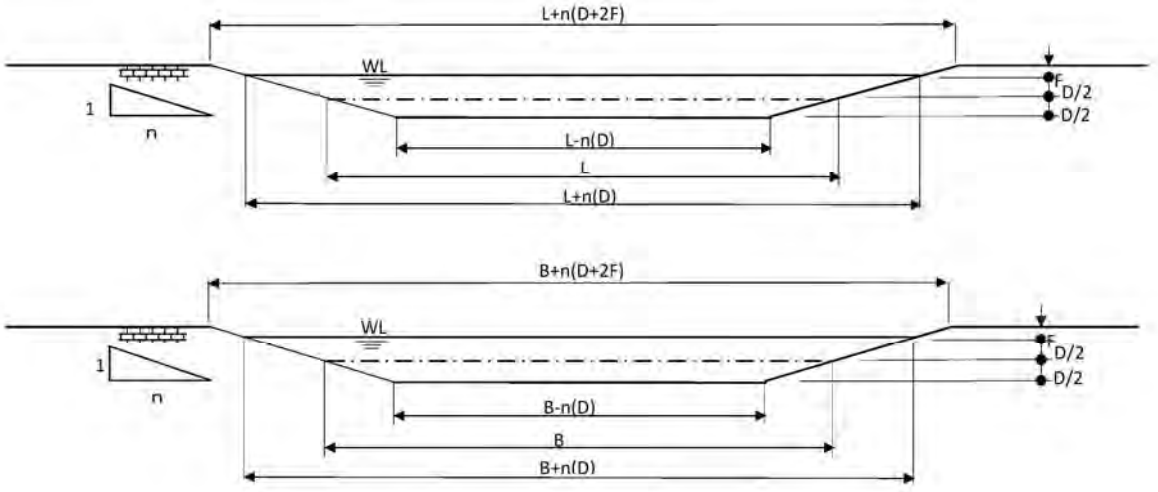
where D_f=facultative pond depth: 1.5 m

Qi=influent wastewater flow: 434,000 m^3/d

e= the net evaporation rate: 5 mm/day.

The BOD removal is 80%, so the facultative pond effluent is 68 mg/L (= 0.20 ×340).

Check ponds area



Where

F: free board	m	0.5
n: side slope(1:n)		3
Embank ment	m	illustration [(L+(D+2F) or B+(D+2F)]

		TYPE.1	TYPE.2		
L	m	542.5	393		
B	m	792.5	493		
Area	m^2	429,931	193,306		
Unit		6	2	Total	
Total Area	m^2	2,579,586	386,612	2,966,198	> 2,003,077….OK

Sludge disposal plan

Suppose that 70% of the inflow SS amount is removed by the UASB.

Removal SS amount per day (solids amount)=(434,000*340)*70/100*10-3=103,292kg/day

Sludge generation rate = organic content 60% × digestibility 40% + inorganic content 40% = 76%

Therefore, the sludge generation amount (solid matter amount)＝103,292kg/day×76/100＝78,502 kg/day

1) Design of sludge drying bed

Plan facilities that can dry sludge withdrawn from UASB for 7 days.

Excess sludge (digested sludge) Estimated water content 98%	Solid amount kg/day	78,502
	Sludge amount m^3/day	78,502*100/(100-98)*10^{-3}=3,925
	Sludge amount m^3/day*7days	3,925*7=27,475

Therefore the facility size of Sludge drying bed

Sludge storage depth * length * width =0.25*150*750=28,125m^3 > 27,475m^3・・・・・・・・・・・ok

2) Calculation of discharged sludge volume after sun drying

Drawing out sludge Estimated water content 50%	Solid amount kg/day	78,502
	Sludge amount m^3/day	78,502*100/(100-50)*10^{-3}=157.0
	Sludge amount m^3/year	157.0*365=57,305

AC9.5.3 Option.4 (Anaerobic pond + Trickling filter + Polishing pond) for the New East WWTP

Design conditions:

- Influent flow rate: 434,000 m^3/d
- Influent BOD concentration: 320 mg/L
- Effluent BOD concentration: 80 mg/L
- Design air temperature is 17.5℃

(a) Anaerobic pond

See Section AC9.5.1

(b) Trickling filter

There are various types of trickling filter depending on the hydraulic and organic loading and filter media as shown in Table AC9.4.3. In the study, the "low or standard rate" type is applied for comparison for the four treatment processes, which requires large area but is easiest to operate and maintain with high BOD removal effect.

Design conditions (Low or standard rate type of trickling filter):

1) Wastewater flowrate = 434,000 m^3/d
2) The influent BOD concentration to the trickling filter = 144 mg/L (g/m^3)
3) BOD removal efficiency = 80(%)
4) Effluent BOD = 144.0*(1-0.8)=144.0*0.2= 29.0 g/m^3 (29 mg/L)
5) Hydraulic loading ＝ 1 to 4 (m^3/m^2•d)

Design of trickling filters:

1) Water tank diameter = 40 m
2) Number of filter tanks = 144 number
3) Depth of packing of filter media = 2.4 m

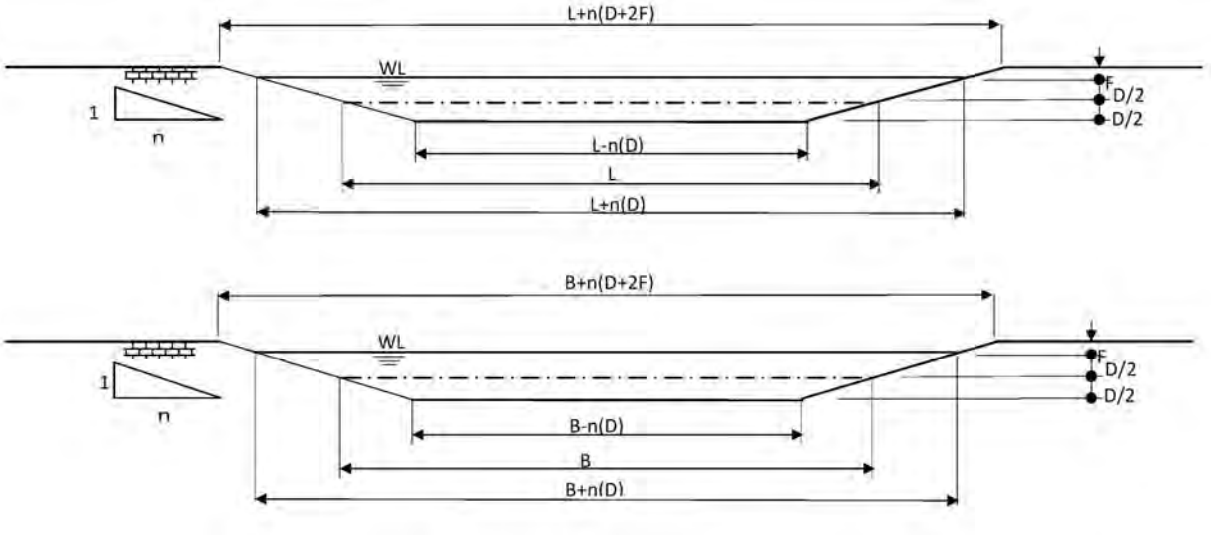
For check:

Tank area(m^2) = 40^2* π /4*144 = 180,864 m^2 or 18.1 ha or 44.7 acer.

Hydraulic loading = 434,000/180,864 = 2.40, which is the range of 1 to 4, then it is OK.

The power required is 868 to 1,736 kW (= 434,000/1,000 x (2 to 4))

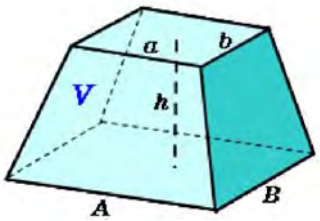
Check ponds volume



F: free board	m	0.5
n: side slope(1:n)		3
Embank ment	m	illustration [(L+(D+2F) or B+(D+2F)]

Calculates the volume of a obelisk given the base and top sides, and height

Volume; $V = h/6(Ab + aB + 2(ab + AB))$



		TYPE.1	TYPE.2	
top side a ; L-n(D)	m	385.0		
top side b ; B-n(D)	m	435.0		
top side A ; L+n(D)	m	397.0		
top side B ; B+n(D)	m	447.0		
hight h ; D	m	2.0		
Volume	m^3	344,886		
Unit		4	0	Total
Total volume	m^3	1,379,544		1,379,544 > 1,302,000….OK

(c) Polishing pond

An effluent of trickling filter often contains biofilm peeled off from filter media depending on the in influent quality and maintenance conditions. In order to treat the peeled biofilm, Polishing pond with the hydraulic retention time of 3 days and pond depth of 2.0 m.

Volume = Q x HRT = 434,000 (m^3/d) *(3 d) = 1,302,000 m^3

Surface area = V/D = 1,302,000m^3/2.0 m = 651,000 m^2 or 65.1 ha or 160.8 acre.

AC9.5.4 Construction Costs for the Wastewater Treatment Options for the WWTPs in the Eastern SWD

Following tables summarizes the total construction cost estimates for the wastewater treatement options for the WWTPs in the western SWD.

Table AC9.5.4 (1) Construction Cost of Option 1 for the New East WWTP

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
New EAST Option.1 (Treatment capacity 434,000m3/d)							
1-1	Anaerobic ponds	Earth work, concrete lining	Ls	1	-	785	Whole work
2-1	Facultative ponds	Earth work, concrete lining	Ls	1	-	6,424	Whole work
	Influent channel	Open channel	m	2,200	297,000	653	Whole work
	Distribution tank	Cast-in-place structure 2 units (4×4×4)	m3	128	15,000	2	Whole work
	Landscaping work	Mainly construction of internal road	m2	600,000	800	480	Whole work
Civil and Building Works Total			—	—	—	**8,344**	—
Mechanical and Electrical Works			—	—	—	**0**	
Total Construction Cost			—	—	—	**8,344**	—

Breakdown

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million	Remark
1-1	Anaerobic ponds						
	Earth work	Excavation, transportation	m3	651,200	700	456	All 4 ponds
		Disposal of surplus soil	m3	651,200	300	195	〃
	Pond structure	Concrete lining (t=0.2m)	m2	44,700	3,000	134	〃
	Civil and Building Works Total		—	—	—	785	—
2-1	Facultative ponds						
	Earth work ①	Excavation, transportation	m3	5,218,048	700	3,653	All 4 ponds
		Disposal of surplus soil	m3	5,218,048	300	1,565	〃
	Earth work ②	Excavation, transportation	m3	877,392	700	614	All 2 ponds
		Disposal of surplus soil	m3	877,392	300	263	〃
	Pond structure ①	Concrete lining	m2	86,000	3,000	258	All 4 ponds
	Pond structure ②	Concrete lining	m2	23,700	3,000	71	〃
	Civil and Building Works Total		—	—	—	6,424	—

Table AC9.5.4 (2) Construction Cost of Option 2 for the New East WWTP

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
New EAST Option.2 (Treatment capacity 434,000m3/d)							
3-1	UASB	Structural works	Ls	236,500	20,000	4,730	Whole work
2-3	Facultative ponds	Earth work, concrete lining	Ls	1	-	4,511	Whole work
	Influent channel	Open channel	m	950	297,000	282	Whole work
	Distribution tank	Cast-in-place structure	m3	128	15,000	2	Whole work
	Landscaping work	Mainly construction of internal road	m^2	548,000	800	484	Whole work
	Sludge drying bed	Earth work,Sand,Gravel,Open pipe	m^2	112,500	10,750	1,209	Whole work
Civil and Building Works Total			—	—	—	**11,218**	—
3-2	UASB	Transmission pump facility	Unit	12	50,556,000	607	Whole work
Mechanical and Electrical Works Total			—	—	—	**607**	—
Total Construction Cost			—	—	—	**11,825**	—

Breakdown

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
3-1	UASB						
	Structural works	Reactor and gas holder	m3	236,500	20,000	4,730	Whole work
	Civil and Building Works Total		—	—	—	4,730	—
3-2	UASB						
	Pumping facility	Mechanical and electrical works	Unit	12	50,556,000	607	Whole work
	Mechanical and Electrical Works Total		—	—	—	607	—
2-3	Facultative ponds						
	Earth work ①	Excavation, transportation	m3	3,462,088	700	2423	All 4 ponds
		Disposal of surplus soil	m3	3,462,088	300	1039	〃
	Earth work ②	Excavation, transportation	m3	778,592	700	545	All 2 ponds
		Disposal of surplus soil	m3	778,592	300	234	〃
	Pond structure ①	Concrete lining	m2	67,774	3,000	203	All 4 ponds
	Pond structure ②	Concrete lining	m2	22,465	3,000	67	〃
	Civil and Building Works Total		—	—	—	4,511	—

Table AC9.5.4 (3) Construction Cost of Option 4 for the New East WWTP

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
New EAST Option.4 (Treatment capacity 434,000m3/d)							
1-3	Anaerobic ponds	Earth work, concrete lining	Ls	1	-	785	Whole work
5-1	Trickling filter	Tank structure, filter pack		139	42,000,000	5,838	Whole work
6-1	Polishing pond	Earth work, concrete lining	Ls	1		1,895	Whole work
	Influent channel	Open channel	m	3,500	297,000	1,039	Whole work
	Distribution tank	Cast-in-place structure 2 units (4×4×4)	m3	128	15,000	2	Whole work
	Landscaping work	Mainly construction of internal road	m2	676,000	800	540	Whole work
	Civil and Building Works Total		**—**	**—**	—	**10,099**	—
5-2	Rotating sprinkler	D40m	Unit	139	147,600,000	2,052	Whole work
	Pumping facility	D450-55KW	Unit	20	22,620,000	452	
Mechanical and Electrical Works Total			**—**	**—**	—	**2,504**	—
Total Construction Cost			**—**	**—**	—	**12,603**	—

Breakdown

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
1-3	Anaerobic pond (Treatment capacity 434,000m3/d) Whole Works						
	Earth work	Excavation, transportation	m3	651,200	700	456	All 4 ponds
		Disposal of surplus soil	m3	651,200	300	195	〃
	Pond structure	Concrete lining (t=0.2m)	m2	44,700	3,000	134	〃
	Civil and building works Total		**—**	**—**	—	785	—
5-1	Trickling filter (one unit tank)						
	One Unit Tank	Concrete works	m3	597	30,000	18	One tank
		Formwork setting	m2	754	13,000	10	One tank
		Filter packing	m3	3,014	4,500	14	One tank
	Civil and building works Total		**—**	**—**	—	42	—
6-1	Polishing pond (Treatment capacity 434,000m3/d) Whole Works						
	Earth work	Excavation, transportation	m3	1,737,000	700	1,216	All 4 ponds
		Disposal of surplus soil	m3	1,737,000	300	521	〃
	Pond structure	Concrete lining (t=0.2m)	m2	52,810	3,000	158	〃
	Civil and building works Total		**—**	**—**	—	1,895	—
5-2	Trickling filter (one water tank)						
	Sprinkler	Rotating sprinkler (D40m)	Unit	1	147,600,000	148	One tank
	Pumping facility	Pumping facility (D450-55kw)	Unit	1	22,620,000	23	Two tanks
	Mechanical and Electrical works Total		**—**	**—**	—	171	—

APPENDIX FOR CHAPTER C10 DRAINAGE PLAN

AC10.1 Drainage Planning Bases

AC 10.1.1 Rainfall Intensity Analysis

(1) Rainfall Intensity Formula

Rainfall intensity formula expresses the relationship between the rainfall intensity and rainfall duration. There are three typical rainfall intensity formula as follows:

- Talbot type: $I = a / (t + b)$
- Sherman type: $I = a / t^n$
- Cleveland type: $I = a / (t^n + b)$

Where, I= rainfall intensity (mm/h)
t= rainfall duration (min.)
a, b, n= constant

In this Study, Cleveland type is adopted as the rainfall intensity formula because of recorded rainfall data are limited to daily rainfall and hourly rainfall. The hourly rainfall data are only available from 2010.

(2) Probable Rainfall Intensity Formula

Table AC10.1.1 summarizes the maximum daily rainfall data during 1944 and 2016. The data from 1944 to 1992 was reported in the Environmental Infrastructure M/P Study, 1993. The data from 1993 to 2016 is collected from Pakistan Meteorological Department (PMD).

Hourly rainfall data in 2010, 2013, 2014, and 2015 are also collected from PMD. **Table AC10.1.2** shows accumulated rainfall from one to four hours of one rainfall event when it is recorded the maximum daily rainfall in the year. Table A**C10.1.3** shows the maximum daily rainfall in each year and the calculated hourly rainfall.

Table AC10.1.1 Maximum Daily Rainfall Data from 1944 to 2016

No.	Year	Maximum Daily Rainfall (mm)	No.	Year	Maximum Daily Rainfall (mm)	No.	Year	Maximum Daily Rainfall (mm)
1	1944	45.0	25	1968	48.3	49	1992	50.1
2	1945	65.8	26	1969	66.6	50	1993	45.0
3	1946	82.5	27	1970	24.6	51	1994	51.0
4	1947	73.7	28	1971	50.3	52	1995	38.0
5	1948	47.7	29	1972	27.9	53	1996	30.4
6	1949	41.1	30	1973	113.3	54	1997	136.0
7	1950	98.3	31	1974	43.7	55	1998	82.0
8	1951	79.2	32	1975	76.7	56	1999	35.0
9	1952	43.9	33	1976	71.8	57	2000	33.0
10	1953	55.4	34	1977	50.4	58	2001	70.0
11	1954	46.5	35	1978	93.6	59	2002	58.2
12	1955	76.0	36	1979	129.9	60	2003	66.3
13	1956	53.1	37	1980	46.2	61	2004	38.0
14	1957	47.7	38	1981	107.0	62	2005	42.0
15	1958	51.3	39	1982	175.0	63	2006	49.4
16	1959	75.4	40	1983	113.5	64	2007	70.0
17	1960	47.0	41	1984	89.2	65	2008	62.1
18	1961	65.0	42	1985	53.0	66	2009	54.0
19	1962	47.0	43	1986	95.5	67	2010	101.6
20	1963	40.4	44	1987	57.5	68	2011	47.9
21	1964	61.0	45	1988	49.0	69	2012	80.0
22	1965	58.9	46	1989	82.0	70	2013	129.6
23	1966	31.2	47	1990	61.0	71	2014	129.5
24	1967	71.1	48	1991	32.0	72	2015	73.4
						73	2016	81.0

Source: Environmental Infrastructure M/P Study, 1993, and Pakistan Meteorological Department (PMD).

Table AC10.1.2 Maximum Hourly Rainfall Data During from One to Four Hours

1 hour	2 hour	3 hour	4 hour	Date	Maximum Daily Rainfall Data
59.0 mm	75.0 mm	77.0 mm	82.6 mm	2010-7-12	101.6 mm/day
55.0 mm	101.0 mm	126.0 mm	127.6 mm	2013-8-13	129.6 mm/day
35.2 mm	53.7 mm	56.7 mm	59.7 mm	2014-9- 3	129.5 mm/day
38.8 mm	42.4 mm	62.8 mm	66.8 mm	2015-3- 7	73.4 mm/day

Note: Four hours are the maximum duration of one rainfall event.
Source: Pakistan Meteorological Department (PMD).

Table AC10.1.3 Maximum Daily Rainfall Data and its Calculated Hourly Rainfall

No.	Date	Maximum Daily Rainfall	*Calculated Hourly Rainfall
1	2010-7-13	101.6 mm/day	4.23 mm/h
2	2013-8-13	129.6 mm/day	5.40 mm/h
3	2014-9- 3	129.5 mm/day	5.40 mm/h
4	2015-3- 7	73.4 mm/day	3.06 mm/h

Note: The maximum daily rainfall is divided by 24hours to calculate the hourly rainfall.
Source: Pakistan Meteorological Department (PMD) and JICA Mission Team

Table AC10.1.4 presents the ratio between 1 hour to 4 hour rainfall and the calculated hourly rainfall. The average ratios are used to estimate the one hour rainfall, two hour rainfall, three hour rainfall and four hour rainfall from the maximum daily rainfall data for 73 years from 1944 to 2016. The sorted rainfall data are shown in Table **AC10.1.5** for the case of calculating one hour rainfall. Figure A**C10.1.1** shows a plot between the hourly rainfall and 1/ (return period + 1). From this, each rainfall of two hours, three hours and four hours is read for each return period of one year to 10 years. The results are summarized in Table A**C10.1.6**.

Table AC10.1.4 Ratio between One to Four Hours Rainfall* and the Calculated Hourly Rainfall

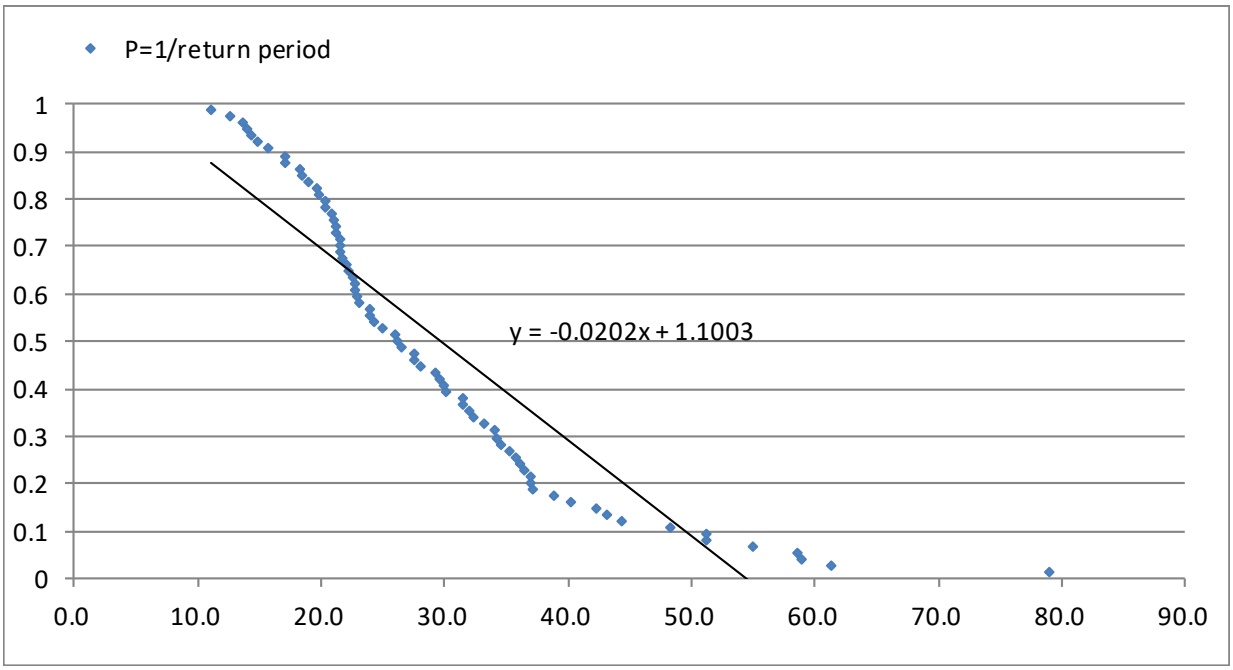
1 hour Rainfall	**Ratio	2 hour Rainfall	**Ratio	3 hour Rainfall	**Ratio	4 hour Rainfall	**Ratio
59.0 mm	13.9	75.0 mm	17.7	77.0 mm	18.2	82.6 mm	19.5
55.0 mm	10.2	101.0 mm	18.7	126.0 mm	23.3	127.6 mm	23.6
35.2 mm	6.5	53.7 mm	10.0	56.7 mm	10.5	59.7 mm	11.1
38.8 mm	12.7	42.4 mm	13.9	62.8 mm	20.5	66.8 mm	21.8
Average	**10.8**	**Average**	**15.1**	**Average**	**18.1**	**Average**	**19.0**

Note: * That is one event rainfall.
** The ratio is estimated each hour rainfall divided by calculated hourly rainfall in Table AC10.1.3.
Source: JICA Mission Team

Table AC10.1.5 Sorted Maximum Daily Rainfall Data and Calculated Hourly Rainfall

No.	Year	Daily Rainwater (mm)	Hourly Rainwater (mm/h)	P	Hourly Maximum Rainwater (mm)	Ranking order
39	1982	175.0	79.0	0.0135135	79.0	1
54	1997	136.0	61.4	0.0270270	61.4	2
67	2010	101.6	59.0	0.0405405	59.0	3
36	1979	129.9	58.6	0.0540541	58.6	4
70	2013	129.6	55.0	0.0675676	55.0	5
40	1983	113.5	51.2	0.0810811	51.2	6
30	1973	113.3	51.1	0.0945946	51.1	7
38	1981	107.0	48.3	0.1081081	48.3	8
7	1950	98.3	44.4	0.1216216	44.4	9
43	1986	95.5	43.1	0.1351351	43.1	10
35	1978	93.6	42.2	0.1486486	42.2	11
41	1984	89.2	40.3	0.1621622	40.3	12
72	2015	73.4	38.8	0.1756757	38.8	13
3	1946	82.5	37.2	0.1891892	37.2	14
46	1989	82.0	37.0	0.2027027	37.0	15
55	1998	82.0	37.0	0.2162162	37.0	16
73	2016	81.0	36.6	0.2297297	36.6	17
69	2012	80.0	36.1	0.2432432	36.1	18
8	1951	79.2	35.7	0.2567568	35.7	19
71	2014	129.5	35.2	0.2702703	35.2	20
32	1975	76.7	34.6	0.2837838	34.6	21
12	1955	76.0	34.3	0.2972973	34.3	22
16	1959	75.4	34.0	0.3108108	34.0	23
4	1947	73.7	33.3	0.3243243	33.3	24
33	1976	71.8	32.4	0.3378378	32.4	25
24	1967	71.1	32.1	0.3513514	32.1	26
58	2001	70.0	31.6	0.3648649	31.6	27
64	2007	70.0	31.6	0.3783784	31.6	28
26	1969	66.6	30.1	0.3918919	30.1	29
60	2003	66.3	29.9	0.4054054	29.9	30
2	1945	65.8	29.7	0.4189189	29.7	31
18	1961	65.0	29.3	0.4324324	29.3	32
65	2008	62.1	28.0	0.4459459	28.0	33
21	1964	61.0	27.5	0.4594595	27.5	34
47	1990	61.0	27.5	0.4729730	27.5	35
22	1965	58.9	26.6	0.4864865	26.6	36
59	2002	58.2	26.3	0.5000000	26.3	37
44	1987	57.5	26.0	0.5135135	26.0	38
10	1953	55.4	25.0	0.5270270	25.0	39
66	2009	54.0	24.4	0.5405405	24.4	40
13	1956	53.1	24.0	0.5540541	24.0	41
42	1985	53.0	23.9	0.5675676	23.9	42
15	1958	51.3	23.2	0.5810811	23.2	43
51	1994	51.0	23.0	0.5945946	23.0	44
34	1977	50.4	22.7	0.6081081	22.7	45
28	1971	50.3	22.7	0.6216216	22.7	46
49	1992	50.1	22.6	0.6351351	22.6	47
63	2006	49.4	22.3	0.6486486	22.3	48
45	1988	49.0	22.1	0.6621622	22.1	49
25	1968	48.3	21.8	0.6756757	21.8	50
68	2011	47.9	21.6	0.6891892	21.6	51
5	1948	47.7	21.5	0.7027027	21.5	52
14	1957	47.7	21.5	0.7162162	21.5	53
17	1960	47.0	21.2	0.7297297	21.2	54
19	1962	47.0	21.2	0.7432432	21.2	55
11	1954	46.5	21.0	0.7567568	21.0	56
37	1980	46.2	20.9	0.7702703	20.9	57
1	1944	45.0	20.3	0.7837838	20.3	58
50	1993	45.0	20.3	0.7972973	20.3	59
9	1952	43.9	19.8	0.8108108	19.8	60
31	1974	43.7	19.7	0.8243243	19.7	61
62	2005	42.0	19.0	0.8378378	19.0	62
6	1949	41.1	18.6	0.8513514	18.6	63
20	1963	40.4	18.2	0.8648649	18.2	64
52	1995	38.0	17.2	0.8783784	17.2	65
61	2004	38.0	17.2	0.8918919	17.2	66
56	1999	35.0	15.8	0.9054054	15.8	67
57	2000	33.0	14.9	0.9189189	14.9	68
48	1991	32.0	14.4	0.9324324	14.4	69
23	1966	31.2	14.1	0.9459459	14.1	70
53	1996	30.4	13.7	0.9594595	13.7	71
29	1972	27.9	12.6	0.9729730	12.6	72
27	1970	24.6	11.1	0.9864865	11.1	73

Note: P: Ranking Order／（Number of Date: 73+1）
Source: JICA Mission Team



Source: JICA Mission Team

Figure AC10.1.1 Hourly Rainfall Hyetograph

Table AC10.1.6 Results of Hourly Rainfall for Each Return Period

Return Period	Y : (1/Return Period+1)	Hourly Rainfall (mm)
1 year	0.5000	29.7
2 Year	0.3333	38.0
3 Year	0.2500	42.1
4 Year	0.2000	44.6
5 Year	0.1667	46.2
6 Year	0.1429	47.4
7 Year	0.1250	48.3
8 Year	0.1111	49.0
9 Year	0.1000	49.5
10Year	0.0909	50.0

Source: JICA Mission Team

In the same manner, rainfall of two hours (120min.), three hours (180min.), four hours (240min.) and 24 hours (1440min.) against the return period from one year to 10 years are calculated and summarized in **Table AC10.1.7**.

Table AC10.1.7 Results of Rainfall for Each Return Period (unit: mm)

T / t	10	9	8	7	6	5	4	3	2	**1**
60	50.0	49.5	49.0	48.3	47.4	46.2	44.6	42.1	38.0	**29.7**
120	69.7	69.1	68.3	67.4	66.1	64.5	62.2	58.7	52.9	**41.3**
180	84.4	83.6	82.7	81.5	80.0	78.0	75.2	71.0	64.0	**50.0**
240	88.1	87.3	86.3	85.1	83.5	81.4	78.5	74.1	66.8	**52.2**
1,440	111.6	110.6	109.3	107.8	105.8	103.1	99.4	93.9	84.6	**66.1**

Note: t: Rainfall Duration (min.), T: Return Period (-)

Source: JICA Mission Team

For planning a drainage system to be realized easily or implemented step by step considering inundation and traffic nuisance are major damages in Faisalabad, the return period of one year (one probable year) is selected. Probable Rainfall Intensity Formula of 1-year excess probability (1/1) are proposed to use for planning drainage system in Faisalabad. The constant of Cleveland formula is calculated by least square method assuming "n=1.0- 0.5". The constant "n" has been adopted "n=1.0". The calculation of constants and the Cleveland type probable rainfall intensity formula are presented in **Table AC10.1.8**. The probable rainfall intensity for one year is 30 mm/hr.

Table AC10.1.8 Calculation of Constants in Probable Rainfall Intensity Formula

【1Year Probability】 n=1.0

N	t(min)	r(mm/h)	$t^{1.0}$	$r \cdot t^{1.0}$	r^2	$r^2 \cdot t^{1.0}$
1	60	29.7	60.0	1,783.07	883.15	52,988.94
2	120	20.7	120.0	2,488.70	430.11	51,613.38
3	180	16.6	180.0	2,981.22	274.31	49,375.87
4	240	13.0	240.0	3,123.78	169.41	40,658.44
5	1440	2.8	1,440.0	3,966.67	7.59	10,926.70
計		82.79	2,040.00	14,343.43	1,764.57	205,563.33

$$a = \frac{82.79 \times 205{,}563.33 - 1{,}764.57 \times 14{,}343.43}{82.79 \times 82.79 - 5 \times 1{,}764.57} = 4{,}212$$

$$b = \frac{5 \times 205{,}563.33 - 82.79 \times 14{,}343.43}{82.79 \times 82.79 - 5 \times 1{,}764.57} = 81.10$$

$$r = \frac{4{,}212}{t^{1.0} + 81.10}$$

Source: JICA Mission Team

Table AC10.1.9 Proposed Probable Rainfall Intensity

Return Period	Probable Rainfall Intensity	Probable Rainfall Intensity Formula
1 Year	30 mm/hr	$r = \frac{4{,}212}{t^{1.0} + 81.10}$

Source: JICA Mission Team

AC10.1.2 Runoff Coefficient

The total rainfall on any area is dispersed as percolation, evaporation, storage in ponds or reservoir and surface runoff. The runoff coefficient can defined as a fraction, which is multiplied with the quantity of total rainfall to determine the quantity of rain water which will reach the drains or drainage channels. The runoff coefficient depends on the porosity of soil cover, wetness and ground cover. The overall runoff coefficient for the catchment area can be worked out as follows:

Overall runoff coefficient, $C = (A_1xC_1+A_2xC_2+\text{-------} +A_nxC_n) / (A_1+A_2+\text{------}+A_n)$

Where, A_1, A_2, ------- A_n are types of area
C_1, C_2, ------- C_n as their coefficient of runoff

Table AC10.2.1 provides the runoff coefficients for the different ground cover, which are defined in the Punjab provincial standards and design criteria. The mean values are applied to estimated the overall runoff coefficients for target drainage areas.

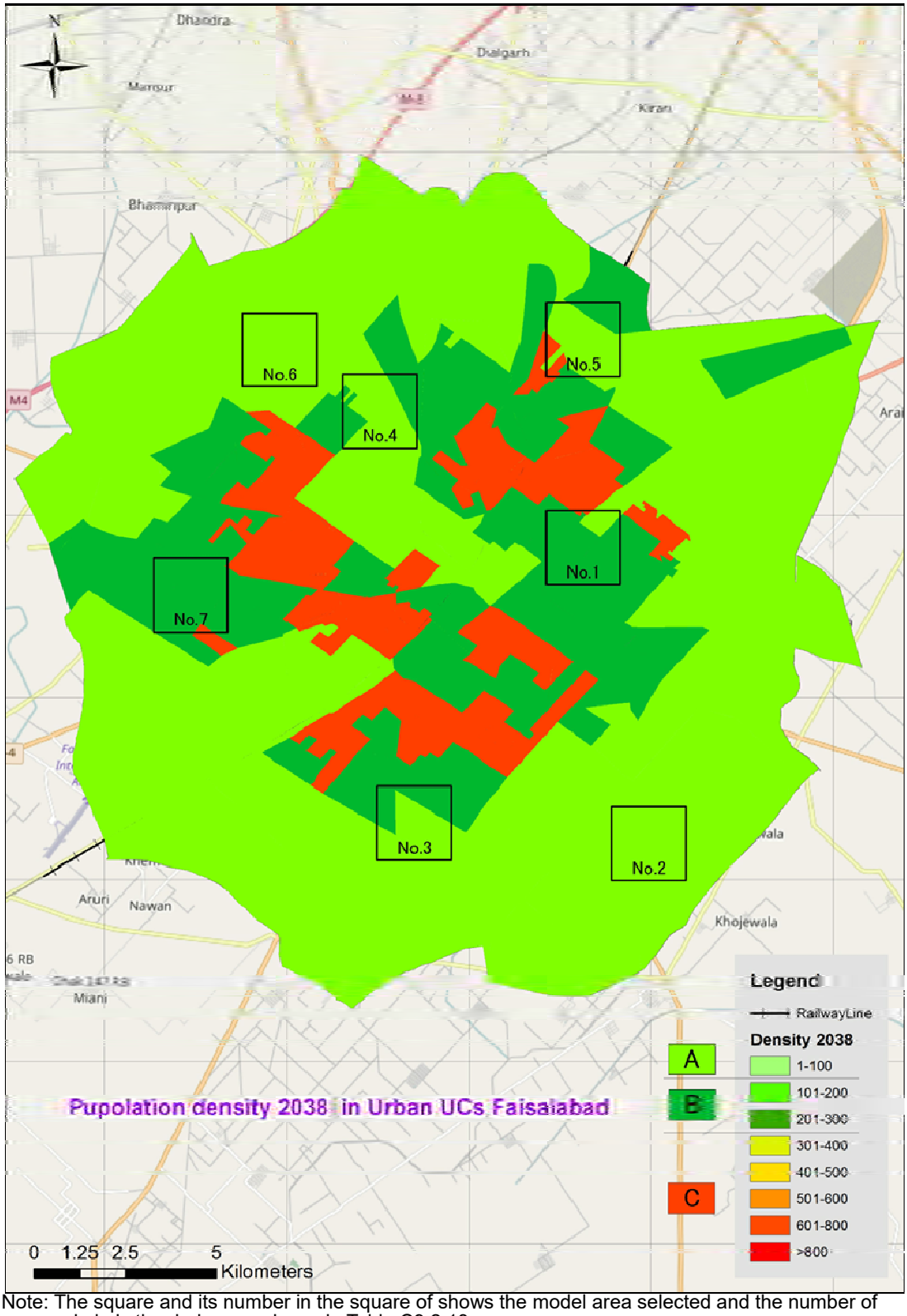
Table AC10.1.10 Runoff Coefficient for Different Type of Ground Cover

Type of ground cover	Runoff Coefficient*	Applied Basic Runoff Coefficient
Roof	0.75 - 0.95	0.85
Pavement / Brick	0.70 - 0.85	0.78
Asphalt / Concrete	0.70 – 0.95	0.83
Lawns / sandy soil	0.13 – 0.17	0.15
Parks / cemetery	0.10 – 0.25	0.18

Source: Source: Technical and Service Delivery Standards for Water Supply and Sanitation Sectors, April 2008

To estimate the overall runoff coefficients in the areas, model areas are selected as shown in **Figure AC.10.1.2**. The roof, road, vacant space, etc., are identified by the satellite image and the overall runoff coefficient in each model area is calculated as shown in **Table AC.10.1.11.**

The overall runoff coefficient are about 0.4: central area of 0.44 and other area of 0.30**.** The overall runoff coefficient of 0.4 is applied to the design of drainage facilities to be proposed.



Note: The square and its number in the square of shows the model area selected and the number of circle is the drain area shown in Table C9.2.13.

Source: JICA Mission Team

Figure C10.1.2 Model Areas Selected for Estimation of Overall Runoff Coefficients

Table AC10.1.11 Results of Overall Runoff Coefficients for Model Areas

1. Central Area

No.1 Center	①Area (ha)	②Runoff Coefficient	③=①×②	③/①
Roof	240.0	0.60	142.8	
Cropyard	49.1	0.15	7.4	
Road	52.4	0.15	7.9	
Sandy Soil	22.5	0.15	3.4	
Asphalt	9.5	0.83	7.9	
Park	21.0	0.18	3.8	
Channel	5.5	1.00	5.5	
Total	400.0		178.6	0.45

No.4Center	①Area (ha)	②Runoff Coefficient	③=①×②	③/①
Roof	245.0	0.60	145.8	
Cropyard	27.6	0.15	4.1	
Road	56.2	0.15	8.4	
Sandy Soil	55.3	0.15	8.3	
Asphalt	8.6	0.83	7.1	
Park	7.3	0.18	1.3	
Channel	0.0	1.00	0.0	
Total	400.0		175.1	0.44

Average in Central Area

Center AV	①Area (ha)	②Runoff Coefficient	③=①×②	③/①
Roof	242.5	0.60	144.3	
Cropyard	38.4	0.15	5.8	
Road	54.3	0.15	8.1	
Sandy Soil	38.9	0.15	5.8	
Asphalt	9.0	0.83	7.5	
Park	14.2	0.18	2.5	
Channel	2.8	1.00	2.8	
Total	400.0		176.8	0.44

2. Other Area

No.2 Suburbs	①Area (ha)	②Runoff Coefficient	③=①×②	③/①
Roof	44.8	0.60	26.7	
Cropyard	190.5	0.15	28.6	
Road	149.2	0.15	22.4	
Sandy Soil	6.7	0.15	1.0	
Asphalt	4.2	0.83	3.5	
Park	3.2	0.18	0.6	
Channel	1.4	1.00	1.4	
Total	400.0		84.1	0.21

No.5 Suburbs	①Area (ha)	②Runoff Coefficient	③=①×②	③/①
Roof	69.4	0.60	41.3	
Cropyard	225.6	0.15	33.8	
Road	70.9	0.15	10.6	
Sandy Soil	11.0	0.15	1.7	
Asphalt	16.9	0.83	14.0	
Park	6.0	0.18	1.1	
Channel	0.2	1.00	0.2	
Total	400.0		102.7	0.26

No.3 Suburbs	①Area (ha)	②Runoff Coefficient	③=①×②	③/①
Roof	160.6	0.60	95.6	
Cropyard	157.2	0.15	23.6	
Road	32.3	0.15	4.8	
Sandy Soil	19.2	0.15	2.9	
Asphalt	19.1	0.80	15.3	
Park	9.3	0.10	0.9	
Channel	2.3	1.00	2.3	
Total	400.0		145.4	0.36

No.6 Suburbs	①Area (ha)	②Runoff Coefficient	③=①×②	③/①
Roof	78.7	0.60	46.8	
Cropyard	139.5	0.15	20.9	
Road	159.3	0.15	23.9	
Sandy Soil	4.3	0.15	0.6	
Asphalt	18.2	0.83	15.1	
Park	0.0	0.18	0.0	
Channel	0.0	1.00	0.0	
Total	400.0		107.4	0.27

No.7 Suburbs	①Area (ha)	②Runoff Coefficient	③=①×②	③/①
Roof	202.5	0.60	120.5	
Cropyard	125.0	0.15	18.8	
Road	21.1	0.15	3.2	
Sandy Soil	45.0	0.15	6.8	
Asphalt	2.4	0.83	2.0	
Park	0.0	0.18	0.0	
Channel	4.0	1.00	4.0	
Total	400.0		155.1	0.39

Average in Other Area.

Suburbs AV	①Area (ha)	②Runoff Coefficient	③=①×②	③/①
Roof	111.2	0.60	66.2	
Cropyard	167.6	0.15	25.1	
Road	86.5	0.15	13.0	
Sandy Soil	17.2	0.15	2.6	
Asphalt	12.2	0.83	10.1	
Park	3.7	0.18	0.7	
Channel	1.6	1.00	1.6	
Total	400.0		119.2	0.30

3. Average (Overall Runoff Coeffieicent)

All AV	①Area (ha)	②Runoff Coefficient	③=①×②	③/①
Roof	176.9	0.60	105.2	
Cropyard	103.0	0.15	15.4	
Road	70.4	0.15	10.6	
Sandy Soil	28.1	0.15	4.2	
Asphalt	10.6	0.83	8.8	
Park	8.9	0.18	1.6	
Channel	2.2	1.00	2.2	
Total	400.0		148.0	0.37

The average value of **0.40** (0.37≒0.40**)** is applied to the planning of drainage facilities.

Source: JICA Mission Team

AC10.2 Storm Water Disposal Pumping Stations

The following pumps are designed to use as storm water pumps at each pumping station where trunk sewer or interceptor sewers would be installed and when the pumping station would be rehabilitated. But it should be noted that the design shall be updated based on the latest flow rates which are actually measured at each pumping station under wet weather conditions.

AC10.2.1 Mechanical Works

(1) WP11 PS-27

1-1) Design inflow rate of storm water pumping station

Planned maximum storm water inflow	
(m3/sec)	(m3/min)
0.511	30.66

1-2) Number of pump set

To cope with incoming storm water inflow of pumping station, three (3) pump sets are designed.
Pump unit discharge is 10.2 m3/min (6 cfs).
In storm water pumping station, no standby pump set is installed.

1-3) Pump total head

Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
175.80	182.30	6.50	3.50	10

1-4) Pump motor capacity

Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Where,

γ	: density of wastewater	1
Q	: amount of discharge	10.2 (m3/min) (= 6 cfs)
H	: total head	10 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor

(0.163 x 1 x 10.2 x 10 / 0.8) x (1 + 0.1) = 22.86 [kW]

Hence, nominal motor capacity of 30 kW is adopted.

1-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	10.2 m3/min (6cfs)
Total head	10 m
Motor capacity	30 kW
Pump set quantity	3

(2) WP12 Weavers Colony

2-1) Design inflow rate of storm water pumping station

Planned maximum storm water inflow	
(m3/sec)	(m3/min)
0.173	10.38

2-2) Number of pump set
To cope with incoming storm water inflow of pumping station, two (2) pump sets are designed.
Pump unit discharge is 6.8 m3/min (4 cfs).
In storm water pumping station, no standby pump set is installed.

2-3) Pump total head
Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
179.90	182.80	2.90	2.10	5

2-4) Pump motor capacity
Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Where,

γ	: density of wastewater	1
Q	: amount of discharge	6.8 (m3/min) (= 4 cfs)
H	: total head	5 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor
(0.163 x 1 x 6.8 x 5 / 0.8) x (1 + 0.1) = 7.62 [kW]
Hence, nominal motor capacity of 11 kW is adopted.

2-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	6.8 m3/min (4cfs)
Total head	5 m
Motor capacity	11 kW
Pump set quantity	2

(3) WP16 Liaqat Town

3-1) Design inflow rate of storm water pumping station

Planned maximum storm water inflow	
(m3/sec)	(m3/min)
0.084	5.04

3-2) Number of pump set
To cope with incoming storm water inflow of pumping station, two (2) pump sets are designed.
Pump unit discharge is 3.4 m3/min (2 cfs).

In storm water pumping station, no standby pump set is installed.

3-3) Pump total head
Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
180.00	183.50	3.50	2.50	6

3-4) Pump motor capacity
Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Where,

γ	: density of wastewater	1
Q	: amount of discharge	3.4 (m3/min) (= 2 cfs)
H	: total head	6 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor
(0.163 x 1 x 3.4 x 6 / 0.8) x (1 + 0.1) = 4.57 [kW]
Hence, nominal motor capacity of 5.5 kW is adopted.

3-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	3.4 m3/min (2cfs)
Total head	6 m
Motor capacity	5.5 kW
Pump set quantity	2

(4) EP7 D-type

4-1) Design inflow rate of storm water pumping station

Planned maximum storm water inflow	
(m3/sec)	(m3/min)
0.472	28.32

4-2) Number of pump set
To cope with incoming storm water inflow of pumping station, three (3) pump sets are designed.
Pump unit discharge is 10.2 m3/min (6 cfs).
In storm water pumping station, no standby pump set is installed.

4-3) Pump total head
Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
177.55	182.00	4.45	2.55	7

4-4) Pump motor capacity

Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Where,

γ	: density of wastewater	1
Q	: amount of discharge	10.2 (m3/min) (= 6 cfs)
H	: total head	7 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor

(0.163 x 1 x 10.2 x 7 / 0.8) x (1 + 0.1) = 16.00 [kW]

Hence, nominal motor capacity of 18.5 kW is adopted.

4-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	10.2 m3/min (6cfs)
Total head	7 m
Motor capacity	18.5 kW
Pump set quantity	3

AC10.2.2 Electrical Works

(1) WP11 PS-27

1-1) Transformer

Transformer is not required due to stormwater pumping station.

1-2) Generator

The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Stormwater Pump	30	3	90
Building Lighting and other miscellaneous load	3	1	3
Total [kW]			**93**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [kVA]$$

Where,

ΣP_0	: sum of the load	93 [kW]
η_L	: total load efficiency	0.85
φ_L	: total power factor	0.8
α	: demand factor	1.0

S_f : the increase coefficient of electric current by unbalanced load

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{3}{93} = 1.019$$

Δp : Sum of unbalance element by single phase load

$$= \frac{93}{0.85 \times 0.8} \times 1.0 \times 1.019$$

= **139.4 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

P_m	: maximum motor capacity	30 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1/3
X_d'	: generator's constant	0.25
ΔE	: allowable voltage drop rate	0.25

$$= 3.7 \times 7.2 \times 1/3 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

= **54 [kVA]**

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1}	: decrease coefficient of loading	1.0
ΣP_0	: sum of the load	93 [kW]
η_L	: total load efficiency	0.85
α	: demand factor	1.0
P_m	: maximum motor capacity	30 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1/3
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (93 - 30) \times \frac{1.0}{0.85 \times 0.8} + 30 \times 7.2 \times 1/3 \}$$

= **109.8 [kVA]**

d) Generator capacity

PG_1 = 139.4 **(MAXIMUM)**
PG_2 = 54
PG_3 = 109.8

Therefore, **<u>150</u> [kVA]** is selected.

(2) WP12 Weavers Colony

2-1) Transformer
Transformer is not required due to storm-water pumping station.

2-2) Generator
The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Stormwater Pump	11	2	22
Building Lighting and other miscellaneous load	3	1	3
Total [kW]			**25**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [kVA]$$

Where,

ΣP_0 : sum of the load 25 [kW]
η_L : total load efficiency 0.85
φ_L : total power factor 0.8
α : demand factor 1.0
S_f : the increase coefficient of electric current by unbalanced load

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{3}{25} = 1.072$$

Δp : Sum of unbalance element by single phase load

$$= \frac{25}{0.85 \times 0.8} \times 1.0 \times 1.072$$

= **39.4 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

P_m : maximum motor capacity 25 [kW]
β : starting kVA per 1kW of maximum motor capacity 7.2
C : coefficient by starter 1/3
X_d' : generator's constant 0.25
ΔE : allowable voltage drop rate 0.25

$$= 25 \times 7.2 \times 1/3 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

= **19.8 [kVA]**

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1}	: decrease coefficient of loading	1.0
ΣP_0	: sum of the load	25 [kW]
η_L	: total load efficiency	0.85
α	: demand factor	1.0
P_m	: maximum motor capacity	11 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1/3
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (25 - 11) \times \frac{1.0}{0.85 \times 0.8} + 11 \times 7.2 \times 1/3 \}$$

= **31.3 [kVA]**

d) Generator capacity

PG_1 = 39.4
PG_2 = 19.8 **(MAXIMUM)**
PG_3 = 31.3

Therefore, **<u>50</u> [kVA]** is selected.

(3) WP16 Liaqat Town

3-1) Transformer
Transformer is not required due to stormwater pumping station.

3-2) Generator
The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Stormwater Pump	5.5	2	11.0
Building Lighting and other miscellaneous load	3	1	3
Total [kW]			**14**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [kVA]$$

Where,

ΣP_0	: sum of the load	14 [kW]
η_L	: total load efficiency	0.85

φ_L : total power factor 0.8
α : demand factor 1.0
S_f : the increase coefficient of electric current by unbalanced load

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{3}{14} = 1.129$$

Δp : Sum of unbalance element by single phase load

$$= \frac{14}{0.85 \times 0.8} \times 1.0 \times 1.129$$

= **23.2 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

P_m	: maximum motor capacity	5.5 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1.0
X_d'	: generator's constant	0.25
ΔE	: allowable voltage drop rate	0.25

$$= 5.5 \times 7.2 \times 1.0 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

= **29.7 [kVA]**

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1}	: decrease coefficient of loading	1.0
ΣP_0	: sum of the load	14 [kW]
η_L	: total load efficiency	0.85
α	: demand factor	1.0
P_m	: maximum motor capacity	5.5 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1.0
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (14 - 5.5) \times \frac{1.0}{0.85 \times 0.8} + 5.5 \times 7.2 \times 1.0 \}$$

= 34**.7 [kVA]**

d) Generator capacity

PG_1 = 23.2
PG_2 = 29.7
PG_3 = 34.7 **(MAXIMUM)**

Therefore, **<u>50</u> [kVA]** is selected.

(4) EP7 D-type

4-1) Transformer
Transformer is not required due to stormwater pumping station.

4-2) Generator
The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Stormwater Pump	18.5	3	55.5
Building Lighting and other miscellaneous load	20	30%	6
Total [kW]			**61.5**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [kVA]$$

Where,

ΣP_0 : sum of the load 61.5 [kW]
η_L : total load efficiency 0.85
φ_L : total power factor 0.8
α : demand factor 1.0
S_f : the increase coefficient of electric current by unbalanced load

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{6}{61.5} = 1.059$$

Δp : Sum of unbalance element by single phase load

$$= \frac{61.5}{0.85 \times 0.8} \times 1.0 \times 1.059$$

= **95.8 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

P_m : maximum motor capacity 18.5 [kW]
β : starting kVA per 1kW of maximum motor capacity 7.2
C : coefficient by starter 1/3
X_d' : generator's constant 0.25
ΔE : allowable voltage drop rate 0.25

$$= 18.5 \times 7.2 \times 1/3 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

= **33.3 [kVA]**

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1}	: decrease coefficient of loading	1.0
ΣP_0	: sum of the load	61.5 [kW]
η_L	: total load efficiency	0.85
α	: demand factor	1.0
P_m	: maximum motor capacity	18.5 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1/3
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (61.5 - 18.5) \times \frac{1.0}{0.85 \times 0.8} + 18.5 \times 7.2 \times 1/3 \}$$

= **71.8 [kVA]**

d) Generator capacity

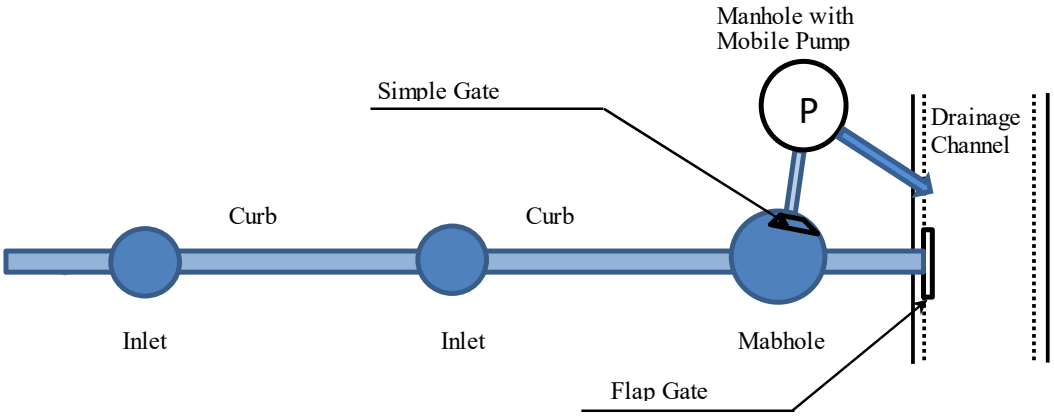
PG_1 = 95.8 **(MAXIMUM)**
PG_2 = 33.3
PG_3 = 71.8

Therefore, **<u>100</u> [kVA]** is selected.

AC10.3 Proposed Street Drain System

AC10.3.1 Proposed Street Drain System

Figure AC10.3.1 shows the proposed drain system schematically. The drain system consists of curb, inlet, manhole, and manhole for mobile pump, and flap gate. The curbs are installed at the center or both sides of street. The inlet is constructed at street cross section or at the point where the dimensions of curb are changed to larger size. A flap gate is equipped at the outlet of curb to prevent the storm water flows backwards. Where the water level of drainage open channel is higher than that at the outlet of curve, then two manholes are needed. The first manhole is to divert the storm water flow to another manhole through a simple gate, the second manhole equipped with a mobile pump system, using submergible pump, is to discharge the storm water to the drainage open channel.

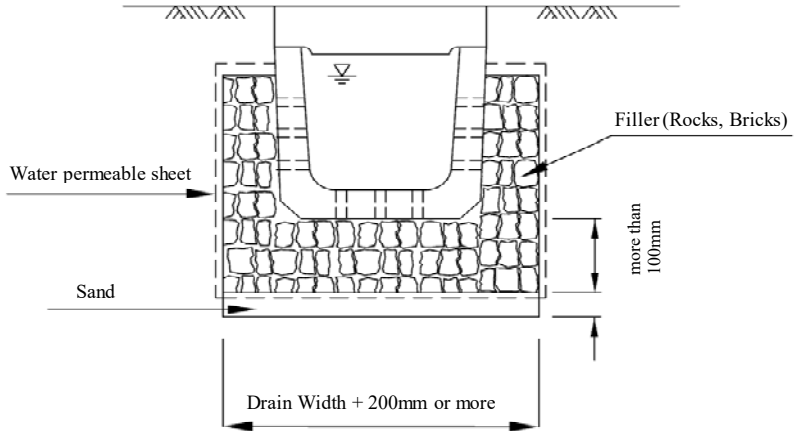


Source: JICA Mission Team

Figure AC10.3.1 Proposed Street Drain System for the Area near the Drainage Channels

1) Curb

Curb, constructed with perviousness concrete and refilled with bricks and rocks at bottom and wall as shown in **Figure AC10.3.2**. The some portion of collected storm water can be penetrated into soil through bottom and wall surface. The infiltration capacity is reduced by the accumulation of sand, solid wastes etc., appropriate cleaning work of curb is essential to maintain the flow capacity and some infiltration.

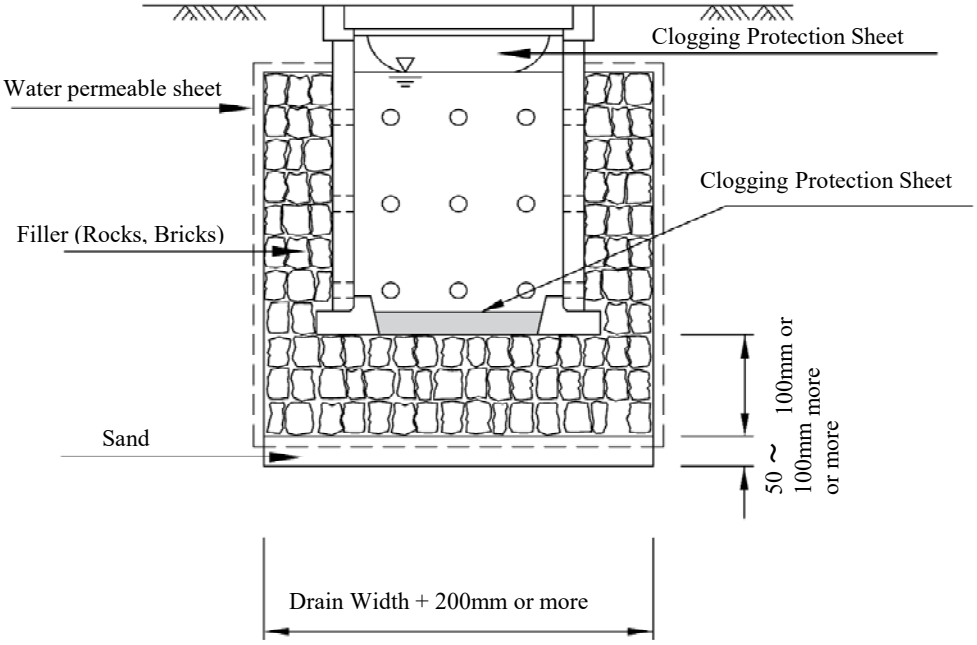


Source: JICA Mission Team

Figure AC.10.3.2 Structure of Proposed Curb

2) Inlet

Figure AC10.3.3 illustrates the proposed inlet. The inlet wall has holes and the inlet is surrounded with bricks and rocks, the storm water is expected to discharge through the holes of wall or bottom. The same as the curb, the appropriate cleaning work is essential for the proper function of flow and infiltration.



Source: JICA Mission Team

Figure AC10.3.3 Structure of Proposed Inlet

The infiltration capacity is depending on the subsurface soil conditions. The infiltration capacity of curb is limited, but the inlet could be expected when it is installed deeper position, because the subsurface deeper than 3m or 5m below, a sand layer is reveal according to the data of geotechnical investigation for water supply facility design provided by WASA-F.

3) Covers

Two kinds of cover are proposed for curb and inlet, concrete covers are used at off-duty to prevent coming sand and solid wastes into them, FRP covers with many holes are used at on-duty which enable to cleaning easily. When the concrete cover change to the FRP cover, the curb and inlet shall be cleaned and to ready to use for their full capacity.

AC10.3.2 Design of Proposed Street Drain System

The design of curb are standardized in the followings. The design conditions are summarized in **Table AC10.3.1**.

Table AC.10.3.1 Design Conditions of Proposed Curb

Item	Description
1) Structure	Bottom and side wall are made of brick or stone, with concrete cover except rainy season, but with FRP cover with holes during rainy season.
2) Slope	Standard figures shall not be defined, considered as a street drain
3) Width of catchment area	20m each from the street drain
4) Time of concentration	Inlet time = 7 min. Time of travel = drain length (m) / 0.8(m/sec) x 60 (m/min)
6) Probable rainfall intensity formula	As shown in Table C10.2.1 in the Main Report

Item	Description
7) Runoff Coefficient	0.4
8) Roughness coefficient (n)	0.025

Source: JICA Mission Team

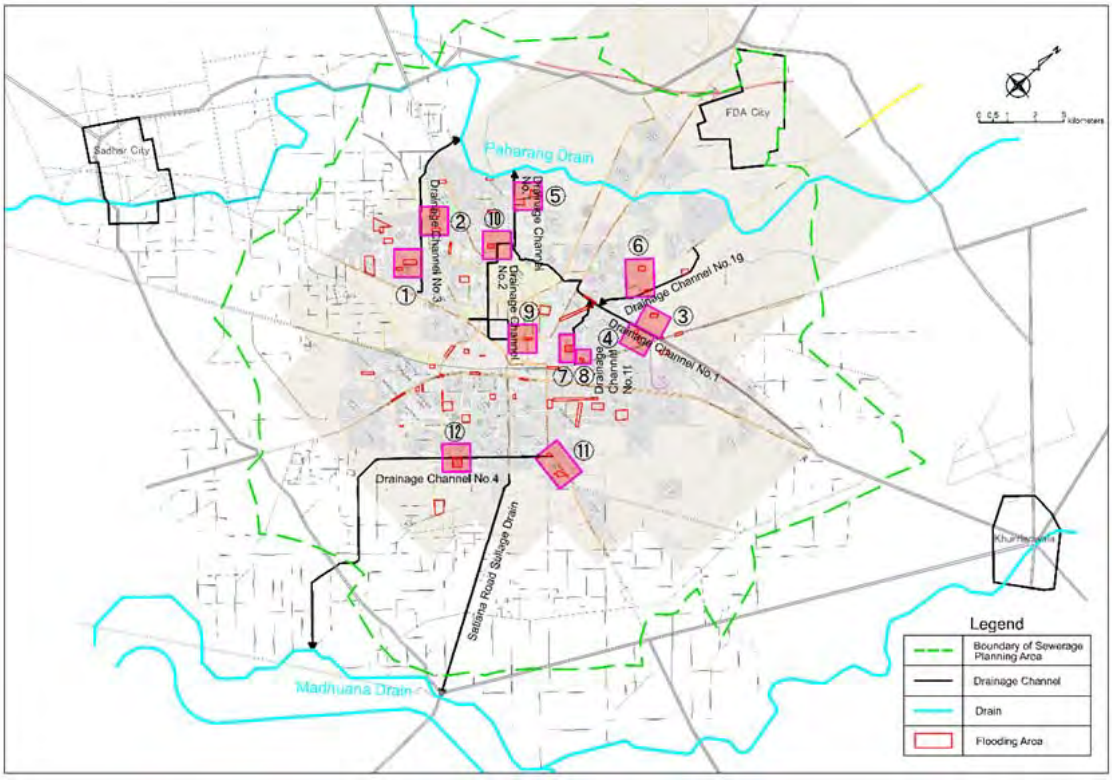
Table AC10.3.2 summarizes the required section of curb when the length of curb is identified for the case of central or one side installation and for both side installation, respectively.

Table AC10.3.2 Standardized Size of Proposed Curb

Length of Curb （m）	Run-off （m^3/s）	Required Section of Curb (mmW x mmH)
0~100	0~0.011	300×300
101~200	0.012~0.024	400×400
201~300	0.025~0.032	450×450
301~400	0.033~0.043	500×500
401~500	0.044~0.055	550×550
501~700	0.056~0.069	600×600
701~1,000	0.070~0.086	650×650
1,001~1,200	0.087~0.105	700×700
1,201~1,600	0.106~0.126	750×750
1,601~2,100	0.127~0.150	800×800
2,101~2,700	0.151~0.176	850×850
2,701~3,500	0.177~0.206	900×900

Source: JICA Mission Team

Figure AC10.3.4 shows the target area for the design of proposed street drain system.

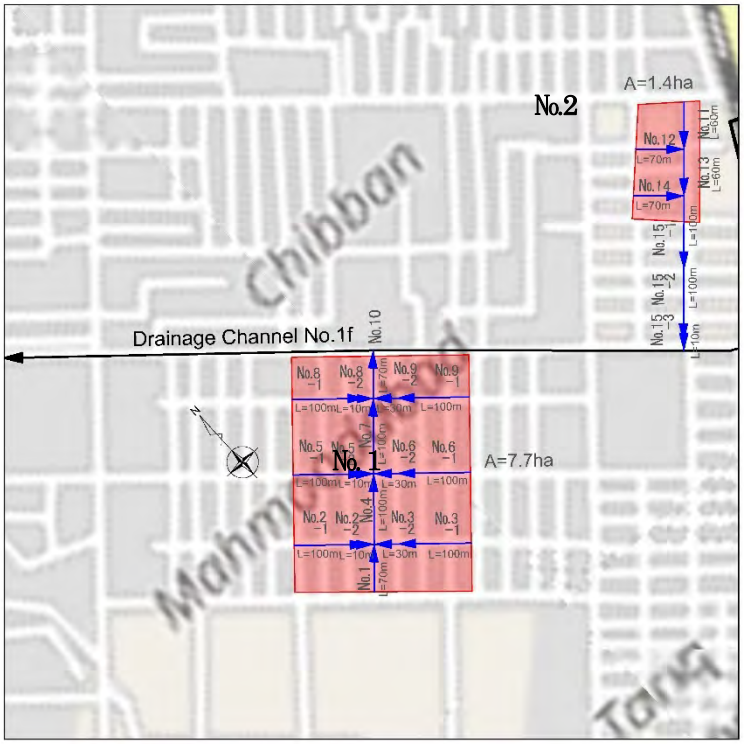


Source: JICA Mission Team

Figure AC10.3.4 Proposed Areas for Design of Street Drain System

Figure AC10.3.5 shows the design sample of curbs to be installed in the two inundated areas.

No.1 and No.2



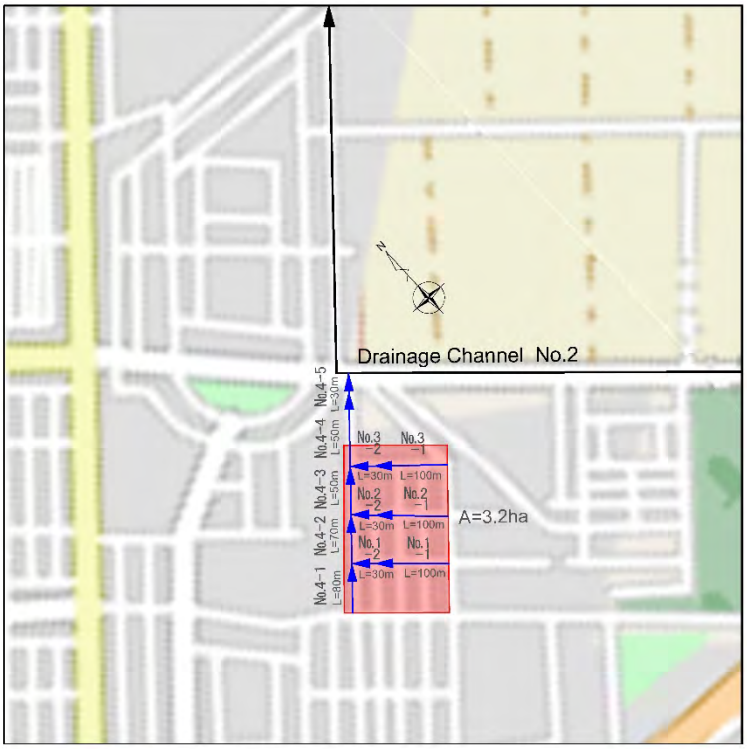
No.1 Inundation Area: 7.7 ha

No.	Wateyway Extension (m)	Cumulative Extension (m)	Cross-Sectional Shape (mm)
1	70	70	300×300
2-1	100	100	300×300
2-2	10	110	400×400
3-1	100	100	300×300
3-2	30	130	400×400
4	100	410	550×550
5-1	100	100	300×300
5-2	10	110	400×400
6-1	100	100	300×300
6-2	30	130	400×400
7	100	750	650×650
8-1	100	100	300×300
8-2	10	110	400×400
9-1	100	100	300×300
9-2	30	130	400×400
10	70	1,060	700×700

No.2 Inundation Area: 1.4 ha

No.	Wateyway Extension (m)	Cumulative Extension (m)	Cross-Sectional Shape (mm)
11	60	60	300×300
12	70	70	300×300
13	60	190	400×400
13	70	70	300×300
15-1	100	360	500×500
15-2	100	460	550×550
15-3	10	470	550×550

No.3

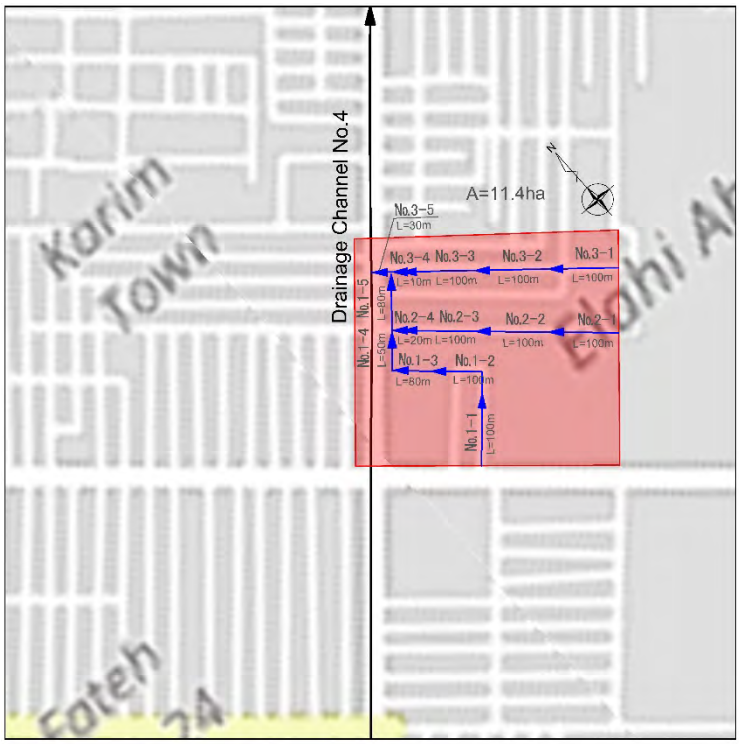


No.3 Inundation Area:3.2ha

No.	Wateyway Extension (m)	Cumulative Extension (m)	Cross-Sectional Shape (mm)
1-1	100	100	300×300
1-2	30	130	400×400
2-1	100	100	300×300
2-2	30	130	400×400
3-1	100	100	300×300
3-2	30	130	400×400
4-1	80	80	300×300
4-2	70	280	450×450
4-3	50	460	550×550
4-4	50	640	600×600
4-5	30	670	600×600

No.4

No.4 Inundation Area:11.4ha



No.	Wateyway Extension (m)	Cumulative Extension (m)	Cross-Sectional Shape (mm)
1-1	100	100	300×300
1-2	100	200	400×400
1-3	80	280	450×450
1-4	50	330	500×500
1-5	80	730	650×650
2-1	100	100	300×300
2-2	100	200	400×400
2-3	100	300	450×450
2-4	20	320	500×500
3-1	100	100	300×300
3-2	100	200	400×400
3-3	100	300	450×450
3-4	10	310	500×500
3-5	30	1,070	700×700

Note: Area marked in red color are planning area of the street drain system
Source: JICA Mission Team

Figure AC10.3.5 A Sample of Design of Street Drain System

AC10.3.3 Construction Cost Estimation

The construction cost of street drain system is based on the unit cost shown in **Table C10.3.3**.

The construction cost required for the proposed street drain shown in **Figure C10.3.4** has been done and the results are shown in **Table C10.3.4**. Their design and cost estimation are presented in **Table C10.3.5**.

Table C10.3.3 Unit Construction Cost for the Components of Street Drain System

Drain Dimension (mm)	Unit Construction Cost				
	Curb (PKR/m)	Inlet (PKR/unit)	Simple Gate (PKR/unit)	Manhole (PKR/unit)	Flap Gate (PKR/unit)
300×300	8,000	21,000	417,000	33,000	375,000
400×400	12,000	30,000	490,000	52,000	603,000
450×450	14,000	34,000	528,000	62,000	718,000
500×500	16,000	39,000	564,000	71,000	832,000
550×550	18,000	43,000	601,000	80,000	946,000
600×600	20,000	48,000	638,000	90,000	1,059,000
650×650	26,000	50,000	684,000	107,000	1,094,000
700×700	31,000	51,000	731,000	124,000	1,127,000
800×800	42,000	55,000	825,000	158,000	1,195,000
900×900	52,000	59,000	918,000	191,000	1,261,000

Source: JICA Mission Team

Table C10.3.4 Construction Cost for the Proposed Street Drain System

Western Zone		Eastern Zone		Total Cost (Million PKR)
Area No.	Construction Cost (Million PKR)	Area No.	Construction Cost (Million PKR)	
1	43	11-1	5	-
2-1	26	11-2	36	-
2-2	35	12	17	-
3	22	-	-	-
4-1	14	-	-	-
4-2	14	-	-	-
5-1	37	-	-	-
5-2	13	-	-	-
6	33	-	-	-
7	16	-	-	-
8	8	-	-	-
9	49	-	-	-
10	11	-	-	-
Western Zone Total	321	Eastern Zone Total	58	379

Source: JICA Mission Team

APPENDIX FOR CHAPTER C11 LONG-TERM SEWERAGE AND DRAINAGE SYSTEM DEVELOPMENT AND PRIORITY PROJECT

AC11.1 Sewer Capacity Assessment

Table AC11.1.1 and Table AC11.1.2 show the sewer capacity calculation sheets for the existing and new sewers for the western SWD and the eastern SWD, respectively.

Table AC11.1.1 Sewer Capacity Calculation Sheet for the Existing and New Sewers in the Western SWD

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population (x10^{3})	Peaking Factor	Population (x10^{3})	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total		Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
																	OK means the diameter of present sewer is appropriate in light of the design standards of capacity allowance.	
1		163.10 163.10		175.00	12.815 12.815	12.815 12.815	3.5	0.072	0.000	0.004	0.002	0.078	○ 600	0.75	0.60	0.168	OK	0.46
2		64.30 227.40		1,236.00	5.787 18.602	5.787 18.602	3.5	0.104	0.000	0.006	0.003	0.113	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.67
			To Sewer No.WB1-2															
3		201.90 201.90		158.00	9.559 9.559	9.559 9.559	4.0	0.061	0.021 0.021	0.005	0.003	0.090	○ 600	0.75	0.60	0.168	OK	0.54
4		23.00 224.90		182.00	0.917 10.476	0.917 10.476	3.5	0.059	0.021	0.006	0.003	0.089	○ 675	0.65	0.60	0.214	OK	0.41
			To Sewer No.WB1-2															
5		42.00 42.00		690.00	3.507 3.507	3.507 3.507	4.5	0.025	0.000	0.001	0.001	0.027	○ 1050	0.40	0.63	0.546	OK	0.05
			To Sewer No. 7															
6		41.30 41.30		969.00	9.697 9.697	9.697 9.697	4.0	0.062	0.000	0.001	0.001	0.064	○ 600	0.75	0.60	0.168	OK	0.38
7	5	173.70 257.00		1,033.00	42.811 56.015	42.811 56.015	2.5	0.224	0.000	0.007	0.004	0.235	○ 1350	0.30	0.65	0.924	OK	0.25
8		215.70 472.70		1,118.00	21.291 77.306	21.291 77.306	2.5	0.309	0.000	0.012	0.006	0.327	○ 1350	0.30	0.65	0.924	OK	0.35
9		17.60 490.30		606.00	0.946 78.252	0.946 78.252	2.5	0.312	0.000	0.013	0.007	0.332	○ 1350	0.30	0.65	0.924	OK	0.36
10		29.50 519.80		487.00	1.911 80.163	1.911 80.163	2.5	0.320	0.000	0.014	0.007	0.341	○ 1500	0.25	0.63	1.116	OK	0.31
11		29.50 549.30		489.00	1.433 81.596	1.433 81.596	2.5	0.326	0.000	0.014	0.007	0.347	○ 1500	0.25	0.63	1.116	OK	0.31
			To Sewer No. 13															
12		15.00 15.00		853.00	1.191 1.191	1.191 1.191	4.5	0.009	0.000	0.000	0.000	0.009	○ 675	0.65	0.60	0.214	OK	0.04
13	11	13.60 577.90		637.00	1.797 84.584	1.797 84.584	2.5	0.338	0.015 0.015	0.015	0.008	0.376	○ 1500	0.25	0.63	1.116	OK	0.34
14		7.20 585.10		229.00	0.790 85.374	0.790 85.374	2.5	0.341	0.015	0.015	0.008	0.379	○ 1650	0.20	0.60	1.289	OK	0.29
			To Sewer No. 16															
15		193.00 193.00		848.00	31.212 31.212	31.212 31.212	3.0	0.150	0.000	0.005	0.003	0.158	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 750 mm, based on the design standards of capacity allowance.	0.94

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^{3}$)	Peaking Factor	Population ($x10^{3}$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total	Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
16	14	148.30 926.40	1,972.00	13.892 130.478	13.892 130.478	2.0	0.417	0.015	0.024	0.013	0.469	○ 1650	0.20	0.60	1.289	OK	0.36
		To Sewer No.WB1-3															
17		81.80 81.80	409.00	23.516 23.516	23.516 23.516	3.5	0.131	0.000	0.002	0.001	0.134	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.80
18		85.40 167.20	747.00	21.042 44.558	21.042 44.558	3.0	0.214	0.000	0.004	0.002	0.220	○ 750	0.60	0.62	0.272	The sewer is planned to be repaced with the new sewer having dia. 825 mm, based on the design standards of capacity allowance.	0.81
19		18.90 186.10	286.00	7.611 52.169	7.611 52.169	2.5	0.208	0.000	0.005	0.003	0.216	○ 825	0.50	0.60	0.321	OK	0.67
20		57.30 243.40	339.00	14.977 67.146	14.977 67.146	2.5	0.268	0.000	0.006	0.003	0.277	○ 900	0.45	0.60	0.384	OK	0.72
		To Sewer No. 22															
21		17.60 17.60	458.00	6.054 6.054	6.054 6.054	4.0	0.039	0.000	0.000	0.000	0.039	○ 600	0.75	0.60	0.168	OK	0.23
22	20	17.00 278.00	607.00	5.488 78.688	5.488 78.688	2.5	0.314	0.000	0.007	0.004	0.325	○ 900	0.45	0.60	0.384	The sewer is planned to be repaced with the new sewer having dia. 1050 mm, based on the design standards of capacity allowance.	0.85
		To Sewer No. 26															
23		33.10 33.10	177.00	16.302 16.302	16.302 16.302	3.5	0.091	0.000	0.001	0.000	0.092	○ 600	0.75	0.60	0.168	OK	0.55
24		37.10 70.20	472.00	15.509 31.811	15.509 31.811	3.0	0.152	0.000	0.002	0.001	0.155	○ 675	0.65	0.60	0.214	The sewer is planned to be repaced with the new sewer having dia. 750 mm, based on the design standards of capacity allowance.	0.73
25		4.70 74.90	86.00	2.098 33.909	2.098 33.909	3.0	0.162	0.000	0.002	0.001	0.165	○ 675	0.65	0.60	0.214	The sewer is planned to be repaced with the new sewer having dia. 750 mm, based on the design standards of capacity allowance.	0.77
26	22	43.70 396.60	248.00	12.363 124.960	12.363 124.960	2.0	0.399	0.000	0.01	0.005	0.414	○ 900	0.45	0.60	0.384	The sewer is planned to be repaced with the new sewer having dia. 1050 mm because of inefficient capacity.	1.08
27		24.90 421.50	68.00	4.682 129.642	4.682 129.642	2.0	0.414	0.000	0.011	0.006	0.431	○ 1050	0.40	0.63	0.546	The sewer is planned to be repaced with the new sewer having dia. 1200 mm, based on the design standards of capacity allowance.	0.79
28		128.70 550.20	1,082.00	32.700 162.342	32.700 162.342	2.0	0.519	0.276 0.276	0.014	0.008	0.817	○ 1200	0.30	0.60	0.675	The sewer is planned to be repaced with the new sewer having dia. 1500 mm. Lift station of WP7, PS-28, Noor Pur 84.9m3/min, 1.415m^3/are being operated.	1.21
29		67.60 617.80	709.00	9.729 172.071	9.729 172.071	2.0	0.550	0.276	0.016	0.008	0.850	○ 1200	0.30	0.60	0.675	The sewer is planned to be repaced with the new sewer having dia. 1500 mm because of inefficient capacity.	1.26
30		34.90 652.70	574.00	2.304 174.375	2.304 174.375	2.0	0.557	0.276	0.017	0.009	0.859	○ 1350	0.30	0.65	0.924	The sewer is planned to be repaced with the new sewer having dia. 1500 mm, based on the design standards of capacity allowance.	0.93
		To Sewer No. 32															
31		154.20 154.20	531.00	16.570 16.570	16.570 16.570	3.5	0.093	0.000	0.004	0.002	0.099	○ 1350	0.30	0.65	0.924	OK	0.11

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^{3}$)	Peaking Factor	Population ($x10^{3}$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total		Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
32	30	15.10 822.00		180.00	1.216 192.161	1.216 192.161	2.0	0.614	0.276	0.022	0.011	0.923	○ 1350	0.30	0.65	0.924	The sewer is planned to be repaced with the new sewer having dia. 1500 mm, based on the design standards of capacity allowance.	1.00
33		261.70 1,083.70		1,128.00	21.853 214.014	21.853 214.014	2.0	0.684	0.276	0.028	0.015	1.003	○ 1650	0.20	0.60	1.289	OK	0.78
			To Sewer No.WB2															
		Sewer No. 34 to No. 46 Move to the Eastern SWD.																
47		50.20 50.20		2,309.00	12.688 12.688	12.688 12.688	3.5	0.071	0.000	0.001	0.001	0.073	○ 1200	0.30	0.60	0.675	OK	0.11
			To Sewer No. 49															
48		76.30 76.30		545.00	36.934 36.934	36.934 36.934	3.0	0.177	0.000	0.002	0.001	0.180	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 750 mm because of inefficient capacity.	1.07
49	47	15.80 142.30		314.00	6.380 56.002	6.380 56.002	2.5	0.224	0.000	0.004	0.002	0.230	○ 1200	0.30	0.60	0.675	OK	0.34
50		14.40 156.70		345.00	7.612 63.614	7.612 63.614	2.5	0.254	0.000	0.004	0.002	0.260	○ 1200	0.30	0.60	0.675	OK	0.39
			To Sewer No. 53															
51		11.20 11.20		381.00	3.219 3.219	3.219 3.219	4.5	0.023	0.000	0.000	0.000	0.023	○ 525	0.90	0.60	0.129	OK	0.18
52		30.80 42.00		361.00	6.519 9.738	6.519 9.738	4.0	0.062	0.000	0.001	0.001	0.064	○ 525	0.90	0.60	0.129	OK	0.50
53	50	14.40 213.10		790.00	9.780 83.132	9.780 83.132	2.5	0.332	0.000	0.006	0.003	0.341	○ 1200	0.30	0.60	0.675	OK	0.51
			To Sewer No.WB4															
54		42.30 42.30		636.00	10.666 10.666	10.666 10.666	3.5	0.060	0.000	0.001	0.001	0.062	○ 750	0.60	0.62	0.272	OK	0.23
			To Sewer No.WB4															
55		2.70 2.70		508.00	0.874 0.874	0.874 0.874	4.5	0.006	0.018 0.018	0.000	0.000	0.024	○ 1350	0.30	0.65	0.924	OK	0.03
56	77	28.60 228.60		380.00	7.792 29.965	7.792 29.965	3.0	0.144	0.018	0.006	0.003	0.171	○ 1350	0.30	0.65	0.924	OK	0.18
57		68.30 296.90		1,615.00	4.134 34.099	4.134 34.099	3.0	0.163	0.018	0.008	0.004	0.193	○ 1650	0.20	0.60	1.289	OK	0.15
			To Sewer No. 79															
58		11.00 11.00		171.00	1.016 1.016	1.016 1.016	4.5	0.007	0.000	0.000	0.000	0.007	○ 525	0.90	0.60	0.129	OK	0.06
59		15.20 26.20		241.00	1.418 2.434	1.418 2.434	4.5	0.017	0.000	0.001	0.000	0.018	○ 525	0.90	0.60	0.129	OK	0.14

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^{3}$)	Peaking Factor	Population ($x10^{3}$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total	Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
60		8.20 34.40	241.00	0.862 3.296	0.862 3.296	4.5	0.024	0.000	0.001	0.000	0.025	○ 600	0.75	0.60	0.168	OK	0.15
		To Sewer No. 62															
61		18.10 18.10	654.00	2.609 2.609	2.609 2.609	4.5	0.019	0.000	0.000	0.000	0.019	○ 675	0.65	0.60	0.214	OK	0.09
62	60	4.20 56.70	107.00	0.461 6.366	0.461 6.366	4.0	0.041	0.000	0.001	0.001	0.043	○ 675	0.65	0.60	0.214	OK	0.20
		To Sewer No.WB5															
63		19.30 19.30	165.00	1.663 1.663	1.663 1.663	4.5	0.012	0.000	0.001	0.000	0.013	○ 525	0.90	0.60	0.129	OK	0.10
64		6.40 25.70	341.00	0.590 2.253	0.590 2.253	4.5	0.016	0.000	0.001	0.000	0.017	○ 525	0.90	0.60	0.129	OK	0.13
65		20.50 46.20	120.00	1.857 4.110	1.857 4.110	4.5	0.030	0.000	0.001	0.001	0.032	○ 525	0.90	0.60	0.129	OK	0.24
66		31.90 78.10	364.00	3.187 7.297	3.187 7.297	4.0	0.047	0.000	0.002	0.001	0.050	○ 675	0.65	0.60	0.214	OK	0.23
67		15.50 93.60	906.00	3.187 10.484	3.187 10.484	3.5	0.059	0.000	0.002	0.001	0.062	○ 900	0.45	0.60	0.384	OK	0.16
		To Sewer No. 70															
68		9.30 9.30	585.00	0.916 0.916	0.916 0.916	4.5	0.007	0.000	0.000	0.000	0.007	○ 1050	0.40	0.63	0.546	OK	0.01
69		0.20 9.50	63.00	0.020 0.936	0.020 0.936	4.5	0.007	0.000	0.000	0.000	0.007	○ 1050	0.40	0.63	0.546	OK	0.01
70	67	1.00 104.10	133.00	0.096 11.516	0.096 11.516	3.5	0.064	0.000	0.003	0.001	0.068	○ 900	0.45	0.60	0.384	OK, But the sewer has smaller diameter than that of upstream, confirmed by GIS data.	0.18
71		11.60 115.70	475.00	1.513 13.029	1.513 13.029	3.5	0.073	0.000	0.003	0.002	0.078	○ 1050	0.40	0.63	0.546	OK	0.14
		To Sewer No. 77															
72		13.20 13.20	306.00	1.152 1.152	1.152 1.152	4.5	0.008	0.000	0.000	0.000	0.008	○ 525	0.90	0.60	0.129	OK	0.06
73		27.50 40.70	791.00	2.948 4.100	2.948 4.100	4.5	0.029	0.000	0.001	0.001	0.031	○ 600	0.75	0.60	0.168	OK	0.19
74		5.20 45.90	97.00	0.557 4.657	0.557 4.657	4.5	0.033	0.000	0.001	0.001	0.035	○ 1200	0.30	0.60	0.675	OK	0.05
		To Sewer No. 76															
75		23.10 23.10	1,177.00	2.212 2.212	2.212 2.212	4.5	0.016	0.000	0.001	0.000	0.017	○ 900	0.45	0.60	0.384	OK	0.04
76	74	2.90 71.90	232.00	0.265 7.134	0.265 7.134	4.0	0.046	0.000	0.002	0.001	0.049	○ 1200	0.30	0.60	0.675	OK	0.07
77	71	9.70 197.30	282.00	1.136 21.299	1.136 21.299	3.5	0.119	0.000	0.005	0.003	0.127	○ 1200	0.30	0.60	0.675	OK	0.19
		To Sewer No. 56															
78		4.40 4.40	236.00	0.234 0.234	0.234 0.234	4.5	0.002	0.000	0.000	0.000	0.002	○ 1050	0.40	0.63	0.546	OK	0.00

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population (x10$^{3)}$	Peaking Factor	Population (x10$^{3)}$	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total	Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
79	57	93.70 / 395.00	1,059.00	4.964 / 39.297	4.964 / 39.297	3.0	0.188	0.102 / 0.120	0.010	0.005	0.323	○ 1800	0.20	0.64	1.625	OK	0.20
		To Sewer No. 91															
80		91.50 / 91.50	693.00	5.946 / 5.946	5.946 / 5.946	4.0	0.038	0.000	0.002	0.001	0.041	○ 600	0.75	0.60	0.168	OK	0.24
81		9.10 / 100.60	545.00	0.563 / 6.509	0.563 / 6.509	4.0	0.042	0.000	0.003	0.001	0.046	○ 675	0.65	0.60	0.214	OK	0.21
		To Sewer No. 91															
82		52.60 / 52.60	415.00	5.860 / 5.860	5.860 / 5.860	4.0	0.037	0.000	0.001	0.001	0.039	○ 675	0.65	0.60	0.214	OK	0.18
		To Sewer No. 85															
83		182.00 / 182.00	242.00	22.221 / 22.221	22.221 / 22.221	3.5	0.124	0.000	0.005	0.002	0.131	○ 675	0.65	0.60	0.214	OK	0.61
84		2.40 / 184.40	249.00	0.129 / 22.350	0.129 / 22.350	3.5	0.125	0.000	0.005	0.003	0.133	○ 750	0.60	0.62	0.272	OK	0.49
85	82	10.60 / 247.60	514.00	0.595 / 28.805	0.595 / 28.805	3.0	0.138	0.000	0.007	0.003	0.148	○ 750	0.60	0.62	0.272	OK	0.54
86		21.30 / 268.90	432.00	1.230 / 30.035	1.230 / 30.035	3.0	0.144	0.000	0.007	0.004	0.155	○ 1200	0.30	0.60	0.675	OK	0.23
		To Sewer No. 90															
87		28.10 / 28.10	321.00	9.985 / 9.985	9.985 / 9.985	4.0	0.064	0.000	0.001	0.000	0.065	○ 525	0.90	0.60	0.129	OK	0.50
88		32.70 / 60.80	371.00	5.026 / 15.011	5.026 / 15.011	3.5	0.084	0.000	0.002	0.001	0.087	○ 675	0.65	0.60	0.214	OK	0.41
89		13.00 / 73.80	339.00	0.000 / 15.011	0.000 / 15.011	3.5	0.084	0.000	0.002	0.001	0.087	○ 750	0.60	0.62	0.272	OK	0.32
90	86	10.20 / 352.90	494.00	0.793 / 45.839	0.793 / 45.839	3.0	0.220	0.000	0.009	0.005	0.234	○ 1200	0.30	0.60	0.675	OK	0.35
91	79 / 81	135.20 / 983.70	2,614.00	16.118 / 107.763	16.118 / 107.763	2.0	0.344	0.120	0.026	0.013	0.503	○ 1800	0.20	0.64	1.625	OK	0.31
		To Sewer No.WB3															
92		182.70 / 182.70	1,111.00	21.839 / 21.839	21.839 / 21.839	3.5	0.122	0.000	0.005	0.002	0.129	○ 525	0.90	0.60	0.129	The sewer is planned to be repaced with the new sewer having dia. 675 mm because of inefficient capacity.	1.00
		To Sewer No.WB7															
93		77.10 / 77.10	772.00	19.633 / 19.633	19.633 / 19.633	3.5	0.110	0.009 / 0.009	0.002	0.001	0.122	○ 525	0.90	0.60	0.129	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.94
94		2.30 / 79.40	76.00	0.122 / 19.755	0.122 / 19.755	3.5	0.110	0.009	0.002	0.001	0.122	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.73
95		2.30 / 81.70	269.00	0.118 / 19.873	0.118 / 19.873	3.5	0.111	0.009	0.002	0.001	0.123	○ 675	0.65	0.60	0.214	OK	0.57

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population (x10^{3})	Peaking Factor	Population (x10^{3})	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total		Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
96		0.00 81.70		149.00	0.023 19.896	0.023 19.896	3.5	0.111	0.009	0.002	0.001	0.123	○ 750	0.60	0.62	0.272	OK	0.45
			To Sewer No.WB7															
97		68.80 68.80		1,012.00	5.356 5.356	5.356 5.356	4.0	0.034	0.000	0.002	0.001	0.037	○ 600	0.75	0.60	0.168	OK	0.22
			To Sewer No.WB7															
98		12.30 12.30		948.00	4.372 4.372	4.372 4.372	4.5	0.031	0.000	0.000	0.000	0.031	○ 1050	0.40	0.63	0.546		0.06
			To Sewer No. 103															
99		14.70 14.70		167.00	4.435 4.435	4.435 4.435	4.5	0.032	0.000	0.000	0.000	0.032	○ 525	0.90	0.60	0.129	OK	0.25
100		73.10 87.80		801.00	30.362 34.797	30.362 34.797	3.0	0.167	0.000	0.002	0.001	0.170	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 750 mm because of inefficient capacity.	1.01
			To Sewer No. 102															
101		15.80 15.80		267.00	7.355 7.355	7.355 7.355	4.0	0.047	0.000	0.000	0.000	0.047	○ 525	0.90	0.60	0.129	OK	0.36
102	100	6.40 110.00		320.00	2.156 44.308	2.156 44.308	3.0	0.212	0.021 0.021	0.003	0.001	0.237	○ 675	0.65	0.60	0.214	The sewer is planned to be repaced with the new sewer having dia. 825 mm because of inefficient capacity.	1.11
103	98	69.80 192.10		491.00	37.492 86.172	37.492 86.172	2.5	0.344	0.021	0.005	0.003	0.373	○ 1050	0.40	0.63	0.546	OK	0.68
			To Sewer No.WB8-2															
104		80.10 80.10		811.00	25.950 25.950	25.950 25.950	3.0	0.124	0.000	0.002	0.001	0.127	○ 1050	0.40	0.63	0.546	OK	0.23
			To Sewer No.WB9															
105		20.60 20.60		739.00	4.974 4.974	4.974 4.974	4.5	0.036	0.000	0.001	0.000	0.037	○ 525	0.90	0.60	0.129	OK	0.28
			To Sewer No.WB9															
106		47.40 47.40			17.742 17.742	17.742 17.742	3.5	0.099	0.000	0.001	0.001	0.101	○ 450	1.10	0.60	0.095	The sewer is planned to be repaced with the new sewer having dia. 600 mm because of inefficient capacity.	1.07
			To Sewer No.WB8-1															
107		31.00 31.00		271.00	3.963 3.963	3.963 3.963	4.5	0.028	0.000	0.001	0.000	0.029	○ 525	0.90	0.60	0.129	OK	0.23

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population (x10^{3})	Peaking Factor	Population (x10^{3})	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total		Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
108		11.10 42.10		277.00	1.679 5.642	1.679 5.642	4.0	0.036	0.000	0.001	0.001	0.038	○ 600	0.75	0.60	0.168	OK	0.23
			To WP1(PS) and discharge to Sewer No. 109		Tariq Abad(LP/S) 5.9m^3/min=0.098m^3/s													
109	108	61.50 103.60		1,413.00	20.024 25.666	20.024 25.666	3.0	0.123	0.000	0.003	0.001	0.127	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.76
			To WP20(PS) and discharged to Sewer No. 112		Girja Ghar(LP/S)1.4m^3/min=0.023m^3/s													
110		8.00 8.00		354.00	4.094 4.094	4.094 4.094	4.5	0.029	0.000	0.000	0.000	0.029	○ 525	0.90	0.60	0.129	OK	0.23
			To Sewer No. 112															
111		132.50 132.50	**To WP20(PS) and discharged to Sewer No. 112**		16.367 16.367	16.367 16.367	3.5	0.091	0.000	0.003	0.002	0.096	○ 450	1.10	0.60	0.095	The sewer is planned to be repaced with the new sewer having dia. 600 mm. Lift P/S Chenab Chork, 6.8m^3/min=0.113m^3/s, is being operated.	1.02
112	109 110	66.40 310.50		2,163.00	49.105 95.232	49.105 95.232	2.5	0.380	0.000	0.008	0.004	0.392	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 1050 mm because of inefficient capacity.	2.33
113		0.00 310.50		103.00	0.000 95.232	0.000 95.232	2.5	0.380	0.000	0.008	0.004	0.392	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 1050 mm because of inefficient capacity.	2.33
			To Sewer No. 123															
114		24.00 24.00		217.00	7.603 7.603	7.603 7.603	4.0	0.049	0.000	0.001	0.000	0.050	○ 675	0.65	0.60	0.214	OK	0.23
			To Sewer No. 117															
115		9.20 9.20		670.00	4.448 4.448	4.448 4.448	4.5	0.032	0.000	0.000	0.000	0.032	○ 525	0.90	0.60	0.129	OK	0.25
			To Sewer No. 117															
116		3.60 3.60		623.00	1.143 1.143	1.143 1.143	4.5	0.008	0.000	0.000	0.000	0.008	○ 525	0.90	0.60	0.129	OK	0.06
117	114,115	41.30 78.10		647.00	13.512 26.706	13.512 26.706	3.0	0.128	0.000	0.002	0.001	0.131	○ 750	0.60	0.62	0.272	OK	0.48
			To Sewer No. 122															
118		31.50 31.50		623.00	9.227 9.227	9.227 9.227	4.0	0.059	0.000	0.001	0.000	0.060	○ 525	0.90	0.60	0.129	OK	0.46
119		40.20 71.70		921.00	10.590 19.817	10.590 19.817	3.5	0.111	0.000	0.002	0.001	0.114	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.68
			To Sewer No. 121															
120		16.80 16.80		477.00	4.787 4.787	4.787 4.787	4.5	0.034	0.000	0.000	0.000	0.034	○ 600	0.75	0.60	0.168	OK	0.20
121	119	0.00 88.50		320.00	0.000 24.604	0.000 24.604	3.5	0.138	0.000	0.002	0.001	0.141	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.84

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^{3}$)	Peaking Factor	Population ($x10^{3}$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total	Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
122	117	2.50 169.10	131.00	0.684 51.994	0.684 51.994	2.5	0.208	0.000	0.004	0.002	0.214	○ 750	0.60	0.62	0.272	The sewer is planned to be repaced with the new sewer having dia. 825 mm, based on the design standards of capacity allowance.	0.78
123	113	53.50 533.10	535.00	19.367 166.593	19.367 166.593	2.0	0.532	0.000	0.014	0.007	0.553	○ 1050	0.40	0.63	0.546	The sewer is planned to be repaced with the new sewer having dia. 1350 mm because of inefficient capacity.	1.01
		To Sewer No. 126															
124		17.90 17.90	785.00	3.099 3.099	3.099 3.099	4.5	0.022	0.000	0.000	0.000	0.022	○ 600	0.75	0.60	0.168	OK	0.13
125		18.10 36.00	693.00	6.902 10.001	6.902 10.001	3.5	0.056	0.000	0.001	0.000	0.057	○ 600	0.75	0.60	0.168	OK	0.34
126	123	8.50 577.60	344.00	4.367 180.961	4.367 180.961	2.0	0.578	0.000	0.015	0.008	0.601	○ 1050	0.40	0.63	0.546	The sewer is planned to be repaced with the new sewer having dia. 1350 mm because of inefficient capacity.	1.10
		To Sewer No. 127															
126-1		9.40 9.40		3.453 3.453	3.453 3.453	4.5	0.025	0.000	0.000	0.000	0.025	○ 375	1.50	0.62	0.068	OK	0.37
		To WP14(PS) and discharge to Sewer No. 127		Ghulshan Colony(DP/S) 6.8m^3/min=0.113m^3/s													
127	126 132,126-1	141.60 889.00	1,325.00	56.927 288.491	56.927 288.491	2.0	0.922	0.000	0.023	0.012	0.957	○ 1350	0.30	0.65	0.924	The sewer is planned to be repaced with the new sewer having dia. 1650 mm because of inefficient capacity.	1.04
		To Sewer No. 136															
128		19.70 19.70	342.00	6.059 6.059	6.059 6.059	4.0	0.039	0.000	0.001	0.000	0.040	○ 525	0.90	0.60	0.129	OK	0.31
129		34.40 54.10	420.00	13.107 19.166	13.107 19.166	3.5	0.107	0.000	0.001	0.001	0.109	○ 600	0.75	0.60	0.168	OK	0.65
130		6.70 60.80	183.00	0.000 19.166	0.000 19.166	3.5	0.107	0.000	0.002	0.001	0.110	○ 600	0.75	0.60	0.168	OK	0.66
		To Sewer No. 132															
131		19.20 19.20	693.00	8.779 8.779	8.779 8.779	4.0	0.056	0.000	0.001	0.000	0.057	○ 600	0.75	0.60	0.168	OK	0.34
132	130	80.40 160.40	793.00	19.205 47.150	19.205 47.150	3.0	0.226	0.000	0.004	0.002	0.232	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 825 mm because of inefficient capacity.	1.38
		To WP15(PS) and discharge to Sewer No. 127		Metropole(LP/S) 27.2m^3/min=0.453m^3/s													
133		18.60 18.60	275.00	9.567 9.567	9.567 9.567	4.0	0.061	0.000	0.000	0.000	0.061	○ 525	0.90	0.60	0.129	OK	0.47
134		14.00 32.60	183.00	7.985 17.552	7.985 17.552	3.5	0.098	0.000	0.001	0.000	0.099	○ 525	0.90	0.60	0.129	The sewer is planned to be repaced with the new sewer having dia. 600 mm, based on the design standards of capacity allowance.	0.77
135		22.20 54.80	688.00	8.617 26.169	8.617 26.169	3.0	0.125	0.000	0.001	0.001	0.127	○ 675	0.65	0.60	0.214	OK	0.59
136	127	48.90 992.70	548.00	24.893 339.553	24.893 339.553	2.0	1.085	0.000	0.026	0.014	1.125	○ 1350	0.30	0.65	0.924	The sewer is planned to be repaced with the new sewer having dia. 1650 mm because of inefficient capacity.	1.22
		To Sewer No. 143															

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population (x10^{3})	Peaking Factor	Population (x10^{3})	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha)		Sewer Length	Domestic Wastewater Flow				Point Souce			Design	Sewer Line Design				Remarks	Ratio of Design Flow against Capacity
					Unit Generation Rate (LPCD)			138										
		Increment			Population (thousand)	Service Population (thousand)	Peak Factor	Domestic WW Flow	Industrial WW Flow	Commercial WW Flow	I/I of Ground water Flow	Max. Flow	Dia.	Slope	Velocity	Capacity		
		Total		(m)	Increment Total	Increment Total		(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(mm)	(‰)	(m/sec)	(m^3/sec)		
137		58.30 58.30		744.00	19.983 19.983	19.983 19.983	3.5	0.112	0.000	0.002	0.001	0.115	○ 525	0.90	0.60	0.129	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.89
138		12.20 70.50		401.00	6.054 26.037	6.054 26.037	3.0	0.125	0.000	0.002	0.001	0.128	○ 675	0.65	0.60	0.214	OK	0.60
			To Sewer No. 143															
139		5.60 5.60		309.00	0.694 0.694	0.694 0.694	4.5	0.005	0.000	0.000	0.000	0.005	○ 750	0.60	0.62	0.272	OK	0.02
			To Sewer No. 142															
140		59.40 59.40		306.00	7.845 7.845	7.845 7.845	4.0	0.050	0.000	0.002	0.001	0.053	○ 525	0.90	0.60	0.129	OK	0.41
141		15.60 75.00		261.00	3.888 11.733	3.888 11.733	3.5	0.066	0.000	0.002	0.001	0.069	○ 675	0.65	0.60	0.214	OK	0.32
142	139	39.50 120.10		956.00	13.869 26.296	13.869 26.296	3.0	0.126	0.000	0.003	0.002	0.131	○ 750	0.60	0.62	0.272	OK	0.48
143	136 138	9.80 1,193.10		385.00	4.499 396.385	4.499 396.385	2.0	1.266	0.018 0.018	0.031	0.016	1.331	○ 1950	0.20	0.67	2.012	OK	0.66
			To Sewer No. 145															
144		90.40 90.40		1,164.00	23.787 23.787	23.787 23.787	3.5	0.133	0.000	0.002	0.001	0.136	○ 750	0.60	0.62	0.272	OK	0.50
145	143	11.40 1,294.90		274.00	4.500 424.672	4.500 424.672	2.0	1.357	0.018	0.034	0.018	1.427	○ 1950	0.20	0.67	2.012	OK	0.71
			To Sewer No. 148															
146		17.70 17.70		360.00	6.013 6.013	6.013 6.013	4.0	0.038	0.000	0.000	0.000	0.038	○ 525	0.90	0.60	0.129	OK	0.30
147		29.50 47.20		707.00	8.601 14.614	8.601 14.614	3.5	0.082	0.000	0.001	0.001	0.084	○ 675	0.65	0.60	0.214	OK	0.39
148	145	6.10 1,348.20		333.00	1.609 440.895	1.609 440.895	2.0	1.408	0.018	0.035	0.018	1.479	○ 1950	0.20	0.67	2.012	OK	0.74
			To Sewer No. 151															
149		106.50 106.50		705.00	45.459 45.459	45.459 45.459	3.0	0.218	0.000	0.003	0.001	0.222	○ 750	0.60	0.62	0.272	OK	0.81
150		20.50 127.00		784.00	5.772 51.231	5.772 51.231	2.5	0.205	0.000	0.003	0.002	0.210	○ 750	0.60	0.62	0.272	OK	0.77
151	148	262.40 1,737.60		1,783.00	57.645 549.771	57.645 549.771	2.0	1.756	0.018	0.046	0.024	1.844	○ 1950	0.20	0.67	2.012	OK	0.92
152		76.70 1,814.30		900.00	7.209 556.980	7.209 556.980	2.0	1.779	0.018	0.048	0.025	1.870	○ 2250	0.15	0.64	2.551	OK	0.73
			To Sewer No. 166															
153		37.00 37.00		187.00	3.059 3.059	3.059 3.059	4.5	0.022	0.000	0.001	0.001	0.024	○ 525	0.90	0.60	0.129	OK	0.19
154		0.90 37.90		150.00	0.047 3.106	0.047 3.106	4.5	0.022	0.000	0.001	0.001	0.024	○ 750	0.60	0.62	0.272	OK	0.09
155		35.90 73.80		951.00	3.065 6.171	3.065 6.171	4.0	0.039	0.000	0.002	0.001	0.042	○ 1200	0.30	0.60	0.675	OK	0.06

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population (x10^{3})	Peaking Factor	Population (x10^{3})	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total		Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
156		9.00 82.80		1,492.00	2.174 8.345	2.174 8.345	4.0	0.053	0.000	0.002	0.001	0.056	○ 1350	0.30	0.65	0.924	OK	0.06
157		1.50 84.30		297.00	0.488 8.833	0.488 8.833	4.0	0.056	0.000	0.002	0.001	0.059	○ 1650	0.20	0.60	1.289	OK	0.05
158		3.50 87.80		676.00	0.493 9.326	0.493 9.326	4.0	0.060	0.000	0.002	0.001	0.063	○ 1650	0.20	0.60	1.289	OK	0.05
159		2.90 90.70		352.00	0.332 9.658	0.332 9.658	4.0	0.062	0.000	0.002	0.001	0.065	○ 1800	0.20	0.64	1.625	OK	0.04
			To Sewer No. 161															
160		3.10 3.10		129.00	0.381 0.381	0.381 0.381	4.5	0.003	0.000	0.000	0.000	0.003	○ 525	0.90	0.60	0.129	OK	0.02
161	159	42.70 136.50		1,413.00	7.499 17.538	7.499 17.538	3.5	0.098	0.000	0.004	0.002	0.104	○ 1800	0.20	0.64	1.625	OK	0.06
			To Sewer No. 165															
162		341.10 341.10		805.00	26.209 26.209	26.209 26.209	3.0	0.126	0.000	0.009	0.005	0.140	○ 675	0.65	0.60	0.214	OK	0.65
163		121.50 462.60		780.00	22.501 48.710	22.501 48.710	3.0	0.233	0.000	0.012	0.006	0.251	○ 675	0.65	0.60	0.214	The sewer is planned to be repaced with the new sewer having dia. 825 mm because of inefficient capacity.	1.17
			To Sewer No. 165															
164		6.20 6.20		262.00	0.925 0.925	0.925 0.925	4.5	0.007	0.000	0.000	0.000	0.007	○ 600	0.75	0.60	0.168	OK	0.04
165	161 163	145.60 750.90		4,056.00	20.876 88.049	20.876 88.049	2.5	0.352	0.012 0.012	0.020	0.010	0.394	○ 1800	0.20	0.64	1.625	OK	0.24
166	152	0.00 2,565.20		23.00	0.000 645.029	0.000 645.029	2.0	2.061	0.030	0.067	0.035	2.193	○ 2250	0.15	0.64	2.551	OK	0.86
			To WP21(PS)		PS-3 Chokera(DP/S) 305.8m^3/min=5.097m^3/s													
167		27.80 27.80		312.00	6.877 6.877	6.877 6.877	4.0	0.044	0.000	0.001	0.000	0.045	○ 525	0.90	0.60	0.129	OK	0.35
			To Sewer No.WB12															
168		107.20 107.20		922.00	4.073 4.073	4.073 4.073	4.5	0.029	0.000	0.003	0.001	0.033	○ 525	0.90	0.60	0.129	OK	0.26
169		84.30 191.50		126.00	4.597 8.670	4.597 8.670	4.0	0.055	0.000	0.005	0.003	0.063	○ 675	0.65	0.60	0.214	OK	0.30
			To Sewer No.W3															
170		104.80 104.80		654.00	20.546 20.546	20.546 20.546	3.5	0.115	0.000	0.003	0.001	0.119	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.71
171		1.50 106.30		107.00	0.227 20.773	0.227 20.773	3.5	0.116	0.000	0.003	0.001	0.120	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.71
172		9.10 115.40		224.00	0.609 21.382	0.609 21.382	3.5	0.120	0.000	0.003	0.002	0.125	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.74

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population (x10^{3})	Peaking Factor	Population (x10^{3})	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total		Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
173		27.10 142.50		219.00	5.522 26.904	5.522 26.904	3.0	0.129	0.000	0.004	0.002	0.135	○ 675	0.65	0.60	0.214	OK	0.63
			To Sewer No. W3															
174		53.10 53.10		765.00	25.215 25.215	25.215 25.215	3.0	0.121	0.000	0.001	0.001	0.123	○ 675	0.65	0.60	0.214	OK	0.57
			To Sewer No. 176															
175		70.10 70.10		593.00	20.035 20.035	20.035 20.035	3.5	0.112	0.000	0.002	0.001	0.115	○ 525	0.90	0.60	0.129	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.89
176	174	7.60 130.80		316.00	2.241 47.491	2.241 47.491	3.0	0.228	0.000	0.003	0.002	0.233	○ 750	0.60	0.62	0.272	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.85
			To Sewer No. 178															
177		9.90 9.90		304.00	2.156 2.156	2.156 2.156	4.5	0.015	0.000	0.000	0.000	0.015	○ 675	0.65	0.60	0.214	OK	0.07
178	176	0.00 140.70		325.00	0.000 49.647	0.000 49.647	3.0	0.238	0.000	0.004	0.002	0.244	○ 750	0.60	0.62	0.272	The sewer is planned to be repaced with the new sewer having dia. 825 mm, based on the design standards of capacity allowance.	0.90
179		8.10 148.80		718.00	2.451 52.098	2.451 52.098	2.5	0.208	0.000	0.004	0.002	0.214	○ 750	0.60	0.62	0.272	The sewer is planned to be repaced with the new sewer having dia. 825 mm, based on the design standards of capacity allowance.	0.79
			To Sewer No. 181															
180		166.90 166.90		296.00	23.619 23.619	23.619 23.619	3.5	0.132	0.000	0.004	0.002	0.138	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.82
181	179	10.10 325.80		686.00	2.474 78.191	2.474 78.191	2.5	0.312	0.027 0.027	0.009	0.004	0.352	○ 1050	0.40	0.63	0.546	OK	0.64
			To Sewer No. 184															
182		14.00 14.00		221.00	1.316 1.316	1.316 1.316	4.5	0.009	0.000	0.000	0.000	0.009	○ 675	0.65	0.60	0.214	OK	0.04
183		2.70 16.70		272.00	0.155 1.471	0.155 1.471	4.5	0.011	0.000	0.000	0.000	0.011	○ 675	0.65	0.60	0.214	OK	0.05
184	181	28.10 370.60		796.00	8.085 87.747	8.085 87.747	2.5	0.350	0.027	0.010	0.005	0.392	○ 1050	0.40	0.63	0.546	OK	0.72
			To Sewer No. 186															
185		34.50 34.50		255.00	1.964 1.964	1.964 1.964	4.5	0.014	0.000	0.001	0.000	0.015	○ 525	0.90	0.60	0.129	OK	0.12
186	184	3.80 408.90		390.00	0.390 90.101	0.390 90.101	2.5	0.360	0.027	0.011	0.006	0.404	○ 1050	0.40	0.63	0.546	OK	0.74
			To Sewer No. W3															

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^{3}$)	Peaking Factor	Population ($x10^{3}$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total	Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
187		77.30 77.30	636.00	13.409 13.409	13.409 13.409	3.5	0.075	0.000	0.002	0.001	0.078	○ 525	0.90	0.60	0.129	OK	0.60
188		62.50 139.80	432.00	18.268 31.677	18.268 31.677	3.0	0.152	0.000	0.004	0.002	0.158	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 750 mm, based on the design standards of capacity allowance.	0.94
189		65.70 205.50	606.00	9.875 41.552	9.875 41.552	3.0	0.199	0.000	0.005	0.003	0.207	○ 675	0.65	0.60	0.214	The sewer is planned to be repaced with the new sewer having dia. 750 mm, based on the design standards of capacity allowance.	0.97
		To Sewer No.WB13-1															
190		3.10 3.10	250.00	0.035 0.035	0.035 0.035	4.5	0.000	0.000	0.000	0.000	0.000	○ 525	0.90	0.60	0.129	OK	0.00
		To Sewer No. 192															
191		1.50 1.50	449.00	0.128 0.128	0.128 0.128	4.5	0.001	0.000	0.000	0.000	0.001	○ 525	0.90	0.60	0.129	OK	0.01
192	190	14.70 19.30	469.00	0.349 0.512	0.349 0.512	4.5	0.004	0.000	0.001	0.000	0.005	○ 525	0.90	0.60	0.129	OK	0.04
		To Sewer No. 194															
193		29.20 29.20	99.00	0.656 0.656	0.656 0.656	4.5	0.005	0.000	0.001	0.000	0.006	○ 525	0.90	0.60	0.129	OK	0.04
194	192	0.20 48.70	31.00	0.002 1.170	0.002 1.170	4.5	0.008	0.000	0.001	0.001	0.010	○ 525	0.90	0.60	0.129	OK	0.08
195		77.40 126.10	437.00	2.409 3.579	2.409 3.579	4.5	0.026	0.000	0.003	0.002	0.031	○ 600	0.75	0.60	0.168	OK	0.18
196		10.10 136.20	262.00	0.133 3.712	0.133 3.712	4.5	0.027	0.000	0.004	0.002	0.033	○ 750	0.60	0.62	0.272	OK	0.12
		To Sewer No. 198															
197		43.20 43.20	242.00	0.595 0.595	0.595 0.595	4.5	0.004	0.000	0.001	0.001	0.006	○ 525	0.90	0.60	0.129	OK	0.05
198	196	16.70 196.10	448.00	0.219 4.526	0.219 4.526	4.5	0.033	0.000	0.005	0.003	0.041	○ 750	0.60	0.62	0.272	OK	0.15
199		316.50 512.60	3,979.00	3.895 8.421	3.895 8.421	4.0	0.054	0.000	0.013	0.007	0.074	○ 1050	0.40	0.63	0.546	OK	0.14
		To Sewer No.W1															
W21	(Main Sewer Sadhar)		7,000.00 Sadhar City	30.000 30.000	30.000 30.000	3.0	0.125	0.009	0.000	0.000	0.134	○ 300	pressured	1.90	0.134		1.00
W1	199	1,127.40 1,640.00	1,600.00	16.307 24.728	16.307 24.728	3.5	0.138	0.042 0.042	0.043	0.022	0.245	○ 1050	0.40	0.63	0.546		0.45
		To Sewer No.W3-1															
W2		453.20 453.20	2,190.00	10.281 10.281	10.281 10.281	3.5	0.057	0.000	0.012	0.006	0.075	○ 525	0.90	0.60	0.129		0.59
W3-1	W1	0.00 2,093.20	1,254.00	0.000 35.009	0.000 35.009	3.0	0.168	0.004 0.046	0.055	0.029	0.298	○ 1050	0.40	0.63	0.546		0.55
W3-2	169, 173, 186	0.00 2,836.10	446.00	0.000 160.684	0.000 160.684	2.0	0.513	0.005 0.078	0.075	0.039	0.705	○ 1500	0.25	0.63	1.116		0.63

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^{3}$)	Peaking Factor	Population ($x10^{3}$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total	Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
WB11		0.00 2,836.10	330.00	0.000 160.684	0.000 160.684	2.0	0.513	0.078	0.075	0.039	0.705	○ 1500	0.25	0.63	1.116		0.63
WB12	167	0.00 2,863.90	960.00	0.000 167.561	0.000 167.561	2.0	0.535	0.078	0.075	0.039	0.727	○ 1500	0.25	0.63	1.116		0.65
WB13-1	189	0.00 3,069.40	3,950.00	0.000 209.113	0.000 209.113	2.0	0.668	0.078	0.081	0.042	0.869	○ 1650	0.20	0.60	1.289		0.67
		To Sewer No.WB13-2															
W4		766.60 766.60	3,910.00	71.904 71.904	71.904 71.904	2.5	0.287	0.000	0.020	0.010	0.317	○ 1050	0.40	0.63	0.546		0.58
		To Sewer No.W5-1															
W5		558.70 558.70	1,790.00	30.454 30.454	30.454 30.454	3.0	0.146	0.000	0.015	0.008	0.169	○ 750	0.60	0.62	0.272		0.62
W5-1	W4	17.10 1,342.40	740.00	0.669 103.027	0.669 103.027	2.0	0.329	0.000	0.035	0.018	0.382	○ 1050	0.40	0.63	0.546		0.70
WB1-1		0.00 1,342.40	708.00	0.000 103.027	0.000 103.027	2.0	0.329	0.000	0.035	0.018	0.382	○ 1050	0.40	0.63	0.546		0.70
WB1-2	2,4	0.00 1,794.70	1,062.00	0.000 132.105	0.000 132.105	2.0	0.422	0.021	0.047	0.024	0.514	○ 1200	0.30	0.60	0.675		0.76
WB1-3	16	0.00 2,721.10	1,640.00	0.000 262.583	0.000 262.583	2.0	0.839	0.036	0.071	0.037	0.983	○ 1500	0.25	0.63	1.116		0.88
		To Sewer No.WB2															
W6		1,579.50 1,579.50	4,130.00	92.286 92.286	92.286 92.286	2.5	0.369	0.165 0.165	0.041	0.022	0.597	○ 1500	0.25	0.63	1.116	From FDA (75,000 person equivalent, Domestic WW Q=0.300m3/s) Commercial WW Qc=0.014m3/s)	0.53
WB2	WB1-3 33	0.00 5,384.30	1,520.00	0.000 568.883	0.000 568.883	2.0	1.817	0.477	0.141	0.073	2.508	○ 2250	0.25	0.83	3.295		0.76
WB3	91	190.10 6,558.10	3,110.00	34.851 711.497	34.851 711.497	2.0	2.273	0.597	0.172	0.089	3.131	○ 2400	0.25	0.87	3.911		0.80
		To Sewer No.WB9															
WB4	53,54	0.00 255.40	720.00	0.000 93.798	0.000 93.798	2.5	0.375	0.000	0.007	0.003	0.385	○ 1050	0.40	0.63	0.546		0.70
		To Sewer No.WB6															
WB5	62	0.00 56.70	1,640.00	0.000 6.366	0.000 6.366	4.0	0.041	0.000	0.001	0.001	0.043	○ 450	1.10	0.60	0.095		0.45
WB6	WB4	0.00 312.10	790.00	0.000 100.164	0.000 100.164	2.0	0.320	0.000	0.008	0.004	0.332	○ 1050	0.40	0.63	0.546		0.61
WB7	92,96 97	0.00 645.30	2,500.00	0.000 147.255	0.000 147.255	2.0	0.470	0.009	0.017	0.009	0.505	○ 1200	0.30	0.60	0.675		0.75
WB8-1	106	0.00 692.70	2,106.00	0.000 164.997	0.000 164.997	2.0	0.527	0.009	0.018	0.009	0.563	○ 1350	0.30	0.65	0.924		0.61
WB8-2	103	0.00 884.80	804.00	0.000 251.169	0.000 251.169	2.0	0.802	0.030	0.023	0.012	0.867	○ 1500	0.25	0.63	1.116		0.78
WB9	WB3 104,105	0.00 7,543.60	2,450.00	0.000 993.590	0.000 993.590	2.0	3.174	0.627	0.198	0.103	4.102	○ 2700	0.25	0.94	5.356		0.77
		To Sewer No.WB10															

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^{3}$)	Peaking Factor	Population ($x10^{3}$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total	Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
W7		230.50 230.50	710.00	10.934 10.934	10.934 10.934	3.5	0.061	0.000	0.006	0.003	0.070	○ 525	0.90	0.60	0.129		0.54
W8		134.20 364.70	1,310.00	6.341 17.275	6.341 17.275	3.5	0.097	0.000	0.010	0.005	0.112	○ 600	0.75	0.60	0.168		0.66
		To Sewer No. W10															
W9		403.30 403.30	1,600.00	12.730 12.730	12.730 12.730	3.5	0.071	0.009 0.009	0.011	0.005	0.096	○ 600	0.75	0.60	0.168		0.57
W10	W8	210.70 978.70	1,090.00	9.931 39.936	9.931 39.936	3.0	0.191	0.009	0.026	0.013	0.239	○ 900	0.45	0.60	0.384		0.62
		To Sewer No. W12															
W11		149.50 149.50	1,610.00	3.568 3.568	3.568 3.568	4.5	0.026	0.000	0.004	0.002	0.032	○ 375	1.50	0.62	0.068		0.47
W12	W10	263.10 1,391.30	3,170.00	18.634 62.138	18.634 62.138	2.5	0.248	0.009	0.037	0.019	0.313	○ 1050	0.40	0.63	0.546		0.57
		To Sewer No. W13-1															
W13		144.90 144.90	2,040.00	2.727 2.727	2.727 2.727	4.5	0.020	0.027 0.027	0.004	0.002	0.053	○ 525	0.90	0.60	0.129		0.41
W13-1	W12	0.00 1,536.20	270.00	0.000 64.865	0.000 64.865	2.5	0.259	0.036	0.040	0.021	0.356	○ 1050	0.40	0.63	0.546		0.65
		To Sewer No. W16															
W14		432.00 432.00	2,910.00	8.108 8.108	8.108 8.108	4.0	0.052	0.006 0.006	0.011	0.006	0.075	○ 525	0.90	0.60	0.129		0.58
W15		159.90 591.90	1,910.00	3.008 11.116	3.008 11.116	3.5	0.062	0.006	0.016	0.008	0.092	○ 600	0.75	0.60	0.168		0.55
W16	W13-1	428.90 2,557.00	2,160.00	34.035 110.016	34.035 110.016	2.0	0.351	0.042	0.067	0.035	0.495	○ 1200	0.30	0.60	0.675		0.73
WB10	WB9	0.00 10,100.60	600.00	0.000 1,103.606	0.000 1,103.606	2.0	3.525	0.669	0.265	0.138	4.597	○ 2700	0.25	0.94	5.356		0.86
		To New Influent P/S at the East WWTP															
W17		275.40 275.40	1,400.00	18.166 18.166	18.166 18.166	3.5	0.102	0.000	0.007	0.004	0.113	○ 675	0.65	0.60	0.214		0.53
W18		93.60 369.00	1,030.00	13.246 31.412	13.246 31.412	3.0	0.151	0.000	0.010	0.005	0.166	○ 750	0.60	0.62	0.272		0.61
		To Sewer No. W20															
W19		226.60 226.60	1,510.00	28.788 28.788	28.788 28.788	3.0	0.138	0.000	0.006	0.003	0.147	○ 750	0.60	0.62	0.272		0.54
W20	W18	150.10 745.70	2,460.00	10.432 70.632	10.432 70.632	2.5	0.282	0.006 0.006	0.020	0.010	0.318	○ 1050	0.40	0.63	0.546		0.58
WB13-2	WB13-1	1,049.10 4,864.20	1,450.00	72.910 352.655	72.910 352.655	2.0	1.127	0.084	0.128	0.066	1.405	○ 1950	0.20	0.67	2.012		0.70
		To New Influent P/S at the East WWTP															

Population (x10^{3})	Peaking Factor	Population (x10^{3})	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment	Sewerage Area (ha) Cumulative Total	Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 120 — Population (thousand) Increment	Population (thousand) Total	Service Population (thousand) Increment	Service Population (thousand) Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
S1		38.00	38.00	495.00	5.787	5.787	5.787	5.787	4.0	0.032	0.009	0.000	0.000	0.041	○ 375	1.50	0.62	0.068		0.61
S2		65.00	103.00	1,563.00	9.898	15.685	9.898	15.685	3.5	0.076	0.009	0.000	0.000	0.085	○ 525	0.90	0.60	0.129		0.66
			To S4																	
S3		71.00	71.00	1,038.00	10.812	10.812	10.812	10.812	3.5	0.053	0.000	0.000	0.000	0.053	○ 450	1.10	0.60	0.095		0.56
S4	S2	23.00	197.00	1,372.00	3.503	30.000	3.503	30.000	3.0	0.125	0.009	0.000	0.000	0.134	○ 675	0.65	0.60	0.214		0.63
		To W21 by PS																		

Table AC11.1.2 Sewer Capacity Calculation Sheet for the Existing and New Sewers in the Eastern SWD

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total		Sewer Length (m)	Domestic Wastewater Generation: Unit Generation Rate (LPCD) 138; Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peaking Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
																	OK means the diameter of present sewer is appropriate in light of the design standards of capacity allowance.	
34		36.70 36.70		735.00	9.134 9.134	9.134 9.134	4.0	0.058	0.000	0.001	0.000	0.059	○ 525	0.90	0.60	0.129	OK	0.46
35		24.90 61.60		899.00	6.729 15.863	6.729 15.863	3.5	0.089	0.000	0.001	0.001	0.091	○ 600	0.75	0.60	0.168	OK	0.54
			To Sewer No. E14															
36		217.70 217.70		2,524.00	49.623 49.623	49.623 49.623	3.0	0.238	0.000	0.005	0.003	0.246	○ 750	0.60	0.62	0.272	The sewer is planned to be repaced with the new sewer having dia. 825 mm, based on the design standards of capacity allowance.	0.90
37		13.10 230.80		398.00	4.336 53.959	4.336 53.959	2.5	0.215	0.000	0.005	0.003	0.223	○ 1050	0.40	0.63	0.546	OK	0.41
			To Sewer No. 42															
38		63.30 63.30		324.00	21.014 21.014	21.014 21.014	3.5	0.117	0.000	0.001	0.001	0.119	○ 525	0.90	0.60	0.129	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.93
39		7.40 70.70		340.00	2.392 23.406	2.392 23.406	3.5	0.131	0.000	0.002	0.001	0.134	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.80
40		92.30 163.00		279.00	33.145 56.551	33.145 56.551	2.5	0.226	0.000	0.004	0.002	0.232	○ 675	0.65	0.60	0.214	The sewer is planned to be repaced with the new sewer having dia. 825 mm because of inefficient capacity.	1.08
41		31.60 194.60		438.00	10.424 66.975	10.424 66.975	2.5	0.267	0.000	0.005	0.002	0.274	○ 750	0.60	0.62	0.272	The sewer is planned to be repaced with the new sewer having dia. 900 mm because of inefficient capacity.	1.01
42	37	8.50 433.90		393.00	2.695 123.629	2.695 123.629	2.0	0.395	0.000	0.010	0.005	0.410	○ 1050	0.40	0.63	0.546	OK	0.75
			To Sewer No. E14															
43		75.70 75.70		286.00	25.967 25.967	25.967 25.967	3.0	0.124	0.000	0.002	0.001	0.127	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.76
			To Sewer No. 46															
44		27.00 27.00		292.00	5.007 5.007	5.007 5.007	4.0	0.032	0.000	0.001	0.000	0.033	○ 600	0.75	0.60	0.168	OK	0.20
45		4.20 31.20		383.00	0.421 5.428	0.421 5.428	4.0	0.035	0.000	0.001	0.000	0.036	○ 600	0.75	0.60	0.168	OK	0.21
46	43	8.40 115.30		180.00	3.097 34.492	3.097 34.492	3.0	0.165	0.000	0.003	0.001	0.169	○ 750	0.60	0.62	0.272	OK	0.62
			To Sewer No. E14															

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total	Sewer Length (m)	Domestic Wastewater Generation: Unit Generation Rate (LPCD) 138; Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peaking Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
301		7.30 7.30	833.00	0.485 0.485	0.485 0.485	4.5	0.003	0.000	0.000	0.000	0.003	○ 1200	0.30	0.60	0.675	OK	0.01
		To Sewer No. 303															
302		62.10 62.10	830.00	9.302 9.302	9.302 9.302	4.0	0.059	0.000	0.001	0.001	0.061	○ 1350	0.30	0.65	0.924	OK	0.07
303	301	7.90 77.30	486.00	0.706 10.493	0.706 10.493	3.5	0.059	0.000	0.002	0.001	0.062	○ 1350	0.30	0.65	0.924	OK	0.07
304		1.20 78.50	239.00	0.148 10.641	0.148 10.641	3.5	0.059	0.027 0.027	0.002	0.001	0.089	○ 1350	0.30	0.65	0.924	OK	0.10
		To Sewer No. 342															
305		23.70 23.70	418.00	2.180 2.180	2.180 2.180	4.5	0.016	0.000	0.001	0.000	0.017	○ 600	0.75	0.60	0.168	OK	0.10
		To Sewer No. 17-2		Abdullahpur(LP/S) 23.8㎥/min=0.397㎥/s													
306	305	10.20 10.20	587.00	0.890 0.890	0.890 0.890	4.5	0.006	0.000	0.000	0.000	0.006	○ 900	0.45	0.60	0.384	OK	0.02
		To Sewer No. 309															
307		8.90 8.90	238.00	0.730 0.730	0.730 0.730	4.5	0.005	0.000	0.000	0.000	0.005	○ 600	0.75	0.60	0.168	OK	0.03
308		25.90 34.80	63.00	2.016 2.746	2.016 2.746	4.5	0.020	0.000	0.001	0.000	0.021	○ 675	0.65	0.60	0.214	OK	0.10
309	306	5.70 50.70	470.00	0.563 4.199	0.563 4.199	4.5	0.030	0.000	0.001	0.001	0.032	○ 1050	0.40	0.63	0.546	OK	0.06
		To Sewer No. 312															
310		24.20 24.20	338.00	2.647 2.647	2.647 2.647	4.5	0.019	0.000	0.001	0.000	0.020	○ 600	0.75	0.60	0.168	OK	0.12
311		11.70 35.90	252.00	1.209 3.856	1.209 3.856	4.5	0.028	0.000	0.001	0.000	0.029	○ 750	0.60	0.62	0.272	OK	0.11
312	309	5.50 92.10	403.00	0.719 8.774	0.719 8.774	4.0	0.056	0.000	0.002	0.001	0.059	○ 1050	0.40	0.63	0.546	OK	0.11
313		100.90 193.00	630.00	17.824 26.598	17.824 26.598	3.0	0.127	0.119 0.119	0.004	0.002	0.252	○ 1200	0.30	0.60	0.675	OK	0.37
		To Sewer No. 326															
314		18.50 18.50	460.00	3.830 3.830	3.830 3.830	4.5	0.028	0.000	0.000	0.000	0.028	○ 600	0.75	0.60	0.168	OK	0.16
315		4.90 23.40	546.00	1.119 4.949	1.119 4.949	4.5	0.036	0.000	0.001	0.000	0.037	○ 750	0.60	0.62	0.272	OK	0.13
		To Sewer No. 319															
316		79.70 79.70	200.00	13.534 13.534	13.534 13.534	3.5	0.076	0.000	0.002	0.001	0.079	○ 600	0.75	0.60	0.168	OK	0.47

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total		Sewer Length (m)	Domestic Wastewater Generation: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peaking Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
317		7.70 87.40		405.00	0.922 14.456	0.922 14.456	3.5	0.081	0.000	0.002	0.001	0.084	○ 750	0.60	0.62	0.272	OK	0.31
			To Sewer No. 319															
318		7.10 7.10		248.00	0.632 0.632	0.632 0.632	4.5	0.005	0.000	0.000	0.000	0.005	○ 600	0.75	0.60	0.168	OK	0.03
319	315 317	1.20 119.10		221.00	0.094 20.131	0.094 20.131	3.5	0.113	0.000	0.003	0.001	0.117	○ 900	0.45	0.60	0.384	OK	0.30
			To Sewer No. 17-3		Mansoorabad(LP/S) 27.2m^3/min=0.453m^3/s													
320		51.20 51.20		318.00	6.895 6.895	6.895 6.895	4.0	0.044	0.000	0.001	0.001	0.046	○ 600	0.75	0.60	0.168	OK	0.27
			To Sewer No. 17-3		Mansoorabad(LP/S) 27.2m^3/min=0.453m^3/s					Sewer No. 319+320=		0.163						
321	319 320	204.10 204.10		165.00	42.481 42.481	42.481 42.481	3.0	0.204	0.000	0.005	0.002	0.211	○ 1050	0.40	0.63	0.546	OK	0.39
			To Sewer No. 323															
322		20.10 20.10		348.00	4.280 4.280	4.280 4.280	4.5	0.031	0.000	0.000	0.000	0.031	○ 525	0.90	0.60	0.129	OK	0.24
323	321	60.30 284.50		656.00	8.274 55.035	8.274 55.035	2.5	0.220	0.000	0.007	0.003	0.230	○ 1050	0.40	0.63	0.546	OK	0.42
			To Sewer No. 325															
324		5.50 5.50		287.00	1.280 1.280	1.280 1.280	4.5	0.009	0.000	0.000	0.000	0.009	○ 600	0.75	0.60	0.168	OK	0.05
325	323	2.60 292.60		1,194.00	11.104 67.419	11.104 67.419	2.5	0.269	0.000	0.007	0.003	0.279	○ 1050	0.40	0.63	0.546	OK	0.51
326	313	79.50 565.10		1,262.00	26.000 120.017	26.000 120.017	2.0	0.383	0.119	0.013	0.007	0.522	○ 1200	0.30	0.60	0.675	The sewer is planned to be repaced with the new sewer having dia. 1350 mm, based on the design standards of capacity allowance.	0.77
			To Sewer No. 341															
327		3.50 3.50		425.00	0.719 0.719	0.719 0.719	4.5	0.005	0.000	0.000	0.000	0.005	○ 600	0.75	0.60	0.168	OK	0.03
328		4.20 7.70		439.00	0.875 1.594	0.875 1.594	4.5	0.011	0.000	0.000	0.000	0.011	○ 675	0.65	0.60	0.214	OK	0.05
			To Sewer No. 331															
329		2.60 2.60		332.00	0.591 0.591	0.591 0.591	4.5	0.004	0.000	0.000	0.000	0.004	○ 600	0.75	0.60	0.168	OK	0.03
330		4.50 7.10		260.00	0.994 1.585	0.994 1.585	4.5	0.011	0.000	0.000	0.000	0.011	○ 750	0.60	0.62	0.272	OK	0.04
331	328	17.90 32.70		150.00	3.770 6.949	3.770 6.949	4.0	0.044	0.000	0.001	0.000	0.045	○ 750	0.60	0.62	0.272	OK	0.17
332		6.40 39.10		227.00	1.183 8.132	1.183 8.132	4.0	0.052	0.000	0.001	0.000	0.053	○ 1050	0.40	0.63	0.546	OK	0.10
			To Sewer No. 334															
333		30.20 30.20		443.00	4.853 4.853	4.853 4.853	4.5	0.035	0.000	0.001	0.000	0.036	○ 675	0.65	0.60	0.214	OK	0.17

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total	Sewer Length (m)	Domestic Wastewater Generation: Unit Generation Rate (LPCD) 138; Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peaking Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
334	332	16.60 85.90	288.00	3.189 16.174	3.189 16.174	3.5	0.090	0.000	0.002	0.001	0.093	○ 1050	0.40	0.63	0.546	OK	0.17
335		2.20 88.10	460.00	0.531 16.705	0.531 16.705	3.5	0.093	0.000	0.002	0.001	0.096	○ 1050	0.40	0.63	0.546	OK	0.18
336		13.80 101.90	97.00	5.445 22.150	5.445 22.150	3.5	0.124	0.000	0.002	0.001	0.127	○ 1050	0.40	0.63	0.546	OK	0.23
		To Sewer No. 340															
337		33.80 33.80	204.00	9.286 9.286	9.286 9.286	4.0	0.059	0.000	0.001	0.000	0.060	○ 525	0.90	0.60	0.129	OK	0.47
338		1.40 35.20	240.00	0.331 9.617	0.331 9.617	4.0	0.061	0.000	0.001	0.000	0.062	○ 525	0.90	0.60	0.129	OK	0.48
339		0.50 35.70	158.00	0.177 9.794	0.177 9.794	4.0	0.063	0.000	0.001	0.000	0.064	○ 525	0.90	0.60	0.129	OK	0.49
340	336	121.00 258.60	741.00	27.263 59.207	27.263 59.207	2.5	0.236	0.042 0.042	0.006	0.003	0.287	○ 1050	0.40	0.63	0.546	OK	0.53
341	326	87.50 911.20	1,329.00	23.524 202.748	23.524 202.748	2.0	0.648	0.161	0.021	0.011	0.841	○ 1650	0.20	0.60	1.289	OK	0.65
342	304	91.10 1,080.80	1,370.00	24.616 238.005	24.616 238.005	2.0	0.760	0.188	0.025	0.013	0.986	○ 1800	0.20	0.64	1.625	OK	0.61
		To Sewer No. EB4															
343		15.20 15.20	248.00	1.964 1.964	1.964 1.964	4.5	0.014	0.000	0.000	0.000	0.014	○ 600	0.75	0.60	0.168	OK	0.08
344		2.20 17.40	197.00	0.220 2.184	0.220 2.184	4.5	0.016	0.000	0.000	0.000	0.016	○ 825	0.50	0.60	0.321	OK	0.05
		To Sewer No. 346															
345	345	17.00 17.00		4.552 4.552	4.552 4.552	4.5	0.033	0.000	0.000	0.000	0.033	○ 300	2.00	0.61	0.043	The sewer is planned to be repaced with the new sewer having dia. 375 mm, based on the design standards of capacity allowance.	0.76
		To EP8 (PS) and discharge to Sewer No. 346		Sharifpura(LP/S) 13.6㎥/min=0.226㎥/s													
346	344 345	2.80 37.20	327.00	0.288 7.024	0.288 7.024	4.0	0.045	0.000	0.001	0.000	0.046	○ 900	0.45	0.60	0.384	OK	0.12
347		0.00 37.20	847.00	0.000 7.024	0.000 7.024	4.0	0.045	0.000	0.001	0.000	0.046	○ 900	0.45	0.60	0.384	OK	0.12
		To Sewer No. 360															
348		8.60 8.60	741.00	1.079 1.079	1.079 1.079	4.5	0.008	0.000	0.000	0.000	0.008	○ 600	0.75	0.60	0.168	OK	0.05
349		111.90 120.50	825.00	33.178 34.257	33.178 34.257	3.0	0.164	0.000	0.003	0.001	0.168	○ 900	0.45	0.60	0.384	OK	0.44
		To Sewer No. 360															
350		11.80 11.80	442.00	1.528 1.528	1.528 1.528	4.5	0.011	0.000	0.000	0.000	0.011	○ 750	0.60	0.62	0.272	OK	0.04
		To Sewer No. 352															
351		1.80 1.80	205.00	0.204 0.204	0.204 0.204	4.5	0.001	0.000	0.000	0.000	0.001	○ 900	0.45	0.60	0.384	OK	0.00

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total	Sewer Length (m)	Domestic Wastewater Generation: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peaking Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
352	350	0.60 14.20	62.00	0.079 1.811	0.079 1.811	4.5	0.013	0.000	0.000	0.000	0.013	○ 900	0.45	0.60	0.384	OK	0.03
		To Sewer No. 354															
353		1.70 1.70	123.00	0.189 0.189	0.189 0.189	4.5	0.001	0.000	0.000	0.000	0.001	○ 750	0.60	0.62	0.272	OK	0.00
354	352	4.80 20.70	582.00	0.569 2.569	0.569 2.569	4.5	0.018	0.000	0.000	0.000	0.018	○ 1050	0.40	0.63	0.546	OK	0.03
355		3.70 24.40	313.00	0.380 2.949	0.380 2.949	4.5	0.021	0.000	0.001	0.000	0.022	○ 1050	0.40	0.63	0.546	OK	0.04
356		3.00 27.40	214.00	0.254 3.203	0.254 3.203	4.5	0.023	0.000	0.001	0.000	0.024	○ 1050	0.40	0.63	0.546	OK	0.04
		To Sewer No. 359															
357		22.30 22.30	139.00	2.257 2.257	2.257 2.257	4.5	0.016	0.000	0.001	0.000	0.017	○ 675	0.65	0.60	0.214	OK	0.08
358		5.50 27.80	315.00	0.572 2.829	0.572 2.829	4.5	0.020	0.000	0.001	0.000	0.021	○ 675	0.65	0.60	0.214	OK	0.10
359	356	0.90 56.10	740.00	0.086 6.118	0.086 6.118	4.0	0.039	0.000	0.001	0.001	0.041	○ 1050	0.40	0.63	0.546	OK	0.08
360	347 349	38.20 252.00	737.00	3.635 51.034	3.635 51.034	2.5	0.204	0.304 0.304	0.006	0.003	0.517	○ 1350	0.30	0.65	0.924	OK	0.56
		To Sewer No. 362															
361		29.20 29.20	116.00	6.166 6.166	6.166 6.166	4.0	0.039	0.000	0.001	0.000	0.040	○ 525	0.90	0.60	0.129	OK	0.31
362	360	52.90 334.10	1,113.00	19.758 76.958	19.758 76.958	2.5	0.307	0.304	0.008	0.004	0.623	○ 1350	0.30	0.65	0.924	OK	0.67
		To Sewer No. 364															
363		263.90 263.90	649.00	88.046 88.046	88.046 88.046	2.5	0.352	0.000	0.006	0.003	0.361	○ 525	0.90	0.60	0.129	The sewer is planned to be repaced with the new sewer having dia. 1050 mm because of inefficient capacity.	2.80
364	362	1.90 599.90	180.00	0.543 165.547	0.543 165.547	2.0	0.529	0.304	0.014	0.007	0.854	○ 1350	0.30	0.65	0.924	The sewer is planned to be repaced with the new sewer having dia. 1500 mm, based on the design standards of capacity allowance.	0.92
		To Sewer No. EB4															
365		34.00 34.00	489.00	10.502 10.502	10.502 10.502	3.5	0.059	0.000	0.001	0.000	0.060	○ 525	0.90	0.60	0.129	OK	0.46
		To Sewer No. EB4															
366		398.80 398.80	2,013.00	62.698 62.698	62.698 62.698	2.5	0.250	0.000	0.009	0.005	0.264	○ 900	0.45	0.60	0.384	OK	0.69
		To Sewer No. 368															
367		64.90 64.90	383.00	10.368 10.368	10.368 10.368	3.5	0.058	0.000	0.002	0.001	0.061	○ 600	0.75	0.60	0.168	OK	0.36
368	366	48.80 512.50	638.00	6.622 79.688	6.622 79.688	2.5	0.318	0.000	0.012	0.006	0.336	○ 900	0.45	0.60	0.384	The sewer is planned to be repaced with the new sewer having dia. 1050 mm, based on the design standards of capacity allowance.	0.88
369		51.70 564.20	1,037.00	6.946 86.634	6.946 86.634	2.5	0.346	0.000	0.013	0.007	0.366	○ 1050	0.40	0.63	0.546	OK	0.67

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha)		Sewer Length	Domestic Wastewater Generation				Point Souce			Design	Sewer Line Design				Remarks	Ratio of Design Flow against Capacity
					Unit Generation Rate (LPCD)			138										
					Population (thousand)	Service Population (thousand)	Peaking Factor	Domestic WW Flow	Industrial WW Flow	Commercial WW Flow	I/I of Ground water Flow	Max. Flow	Dia.	Slope	Velocity	Capacity		
		Increment			Increment	Increment												
		Total		(m)	Total	Total		(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(mm)	(‰)	(m/sec)	(m^3/sec)		
370		52.40 616.60		1,034.00	5.919 92.553	5.919 92.553	2.5	0.370	0.000	0.014	0.007	0.391	○ 1050	0.40	0.63	0.546	OK	0.72
371		18.80 635.40		977.00	2.461 95.014	2.461 95.014	2.5	0.379	0.000	0.015	0.007	0.401	○ 1350	0.30	0.65	0.924	OK	0.43
372		4.60 640.00		336.00	0.861 95.875	0.861 95.875	2.5	0.383	0.000	0.015	0.007	0.405	○ 1350	0.30	0.65	0.924	OK	0.44
373		35.50 675.50		549.00	5.960 101.835	5.960 101.835	2.0	0.325	0.000	0.016	0.008	0.349	○ 1350	0.30	0.65	0.924	OK	0.38
374		26.30 701.80		96.00	7.077 108.912	7.077 108.912	2.0	0.348	0.000	0.016	0.008	0.372	○ 1350	0.30	0.65	0.924	OK	0.40
			To Sewer No. 376															
375		71.80 71.80		527.00	10.154 10.154	10.154 10.154	3.5	0.057	0.000	0.002	0.001	0.060	○ 750	0.60	0.62	0.272	OK	0.22
376	374	6.90 780.50		594.00	1.877 120.943	1.877 120.943	2.0	0.386	0.000	0.018	0.009	0.413	○ 1500	0.25	0.63	1.116	OK	0.37
			To Sewer No. 378															
377		20.40 20.40		206.00	5.676 5.676	5.676 5.676	4.0	0.036	0.000	0.000	0.000	0.036	○ 525	0.90	0.60	0.129	OK	0.28
378	376	56.50 857.40		482.00	14.683 141.302	14.683 141.302	2.0	0.451	0.000	0.020	0.010	0.481	○ 1500	0.25	0.63	1.116	OK	0.43
379		74.40 931.80		672.00	19.099 160.401	19.099 160.401	2.0	0.512	0.000	0.022	0.011	0.545	○ 1500	0.25	0.63	1.116	OK	0.49
			To Sewer No. 381															
380		31.00 31.00		445.00	7.932 7.932	7.932 7.932	4.0	0.051	0.000	0.001	0.000	0.052	○ 600	0.75	0.60	0.168	OK	0.31
381	379	71.10 1,033.90		1,620.00	12.428 180.761	12.428 180.761	2.0	0.577	0.000	0.024	0.012	0.613	○ 1800	0.20	0.64	1.625	OK	0.38
			To Sewer No. 385															
382		85.40 85.40		751.00	10.386 10.386	10.386 10.386	3.5	0.058	0.000	0.002	0.001	0.061	○ 525	0.90	0.60	0.129	OK	0.47
383		91.40 176.80		1,256.00	15.728 26.114	15.728 26.114	3.0	0.125	0.000	0.004	0.002	0.131	○ 750	0.60	0.62	0.272	OK	0.48
384		128.20 305.00		1,828.00	14.508 40.622	14.508 40.622	3.0	0.195	0.000	0.007	0.004	0.206	○ 900	0.45	0.60	0.384	OK	0.54
385	381	103.60 1,442.50		803.00	5.398 226.781	5.398 226.781	2.0	0.724	0.015 0.015	0.033	0.017	0.789	○ 1800	0.20	0.64	1.625	OK	0.49
			To Sewer No. EB6															
386		202.10 202.10		1,187.00	10.848 10.848	10.848 10.848	3.5	0.061	0.000	0.005	0.002	0.068	○ 600	0.75	0.60	0.168	OK	0.40
			To Sewer No. EB6															
387		6.70 6.70		206.00	2.860 2.860	2.860 2.860	4.5	0.021	0.000	0.000	0.000	0.021	○ 600	0.75	0.60	0.168	OK	0.12
388		1.30 8.00		336.00	0.545 3.405	0.545 3.405	4.5	0.024	0.000	0.000	0.000	0.024	○ 750	0.60	0.62	0.272	OK	0.09

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha)	Sewer Length	Domestic Wastewater Generation				Point Souce			Design	Sewer Line Design				Remarks	Ratio of Design Flow against Capacity
				Unit Generation Rate (LPCD)			138										
				Population (thousand)	Service Population (thousand)	Peaking Factor	Domestic WW Flow	Industrial WW Flow	Commercial WW Flow	I/I of Ground water Flow	Max. Flow	Dia.	Slope	Velocity	Capacity		
		Increment		Increment	Increment												
		Total	(m)	Total	Total		(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(mm)	(‰)	(m/sec)	(m^3/sec)		
389		18.40 26.40	410.00	6.438 9.843	6.438 9.843	4.0	0.063	0.000	0.001	0.000	0.064	○ 750	0.60	0.62	0.272	OK	0.23
		To Sewer No. 391															
390		25.20 25.20	419.00	7.392 7.392	7.392 7.392	4.0	0.047	0.000	0.001	0.000	0.048	○ 600	0.75	0.60	0.168	OK	0.29
391	389	59.40 111.00	256.00	15.150 32.385	15.150 32.385	3.0	0.155	0.132 0.132	0.003	0.001	0.291	○ 1200	0.30	0.60	0.675	OK	0.43
392		98.70 209.70	674.00	20.968 53.353	20.968 53.353	2.5	0.213	0.132	0.005	0.002	0.352	○ 1200	0.30	0.60	0.675	OK	0.52
		To Sewer No. EP4S															
393		25.00 25.00	402.00	9.814 9.814	9.814 9.814	4.0	0.063	0.000	0.001	0.000	0.064	○ 600	0.75	0.60	0.168	OK	0.38
		To Sewer No. EP4S															
394		54.60 54.60	265.00	23.593 23.593	23.593 23.593	3.5	0.132	0.000	0.001	0.001	0.134	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 675 mm, based on the design standards of capacity allowance.	0.80
395		21.20 75.80	418.00	7.817 31.410	7.817 31.410	3.0	0.151	0.000	0.002	0.001	0.154	○ 750	0.60	0.62	0.272	OK	0.56
396		10.10 85.90	252.00	4.434 35.844	4.434 35.844	3.0	0.172	0.000	0.002	0.001	0.175	○ 750	0.60	0.62	0.272	OK	0.64
397		11.90 97.80	179.00	5.262 41.106	5.262 41.106	3.0	0.197	0.000	0.002	0.001	0.200	○ 750	0.60	0.62	0.272	OK	0.73
398		2.10 99.90	388.00	0.960 42.066	0.960 42.066	3.0	0.202	0.000	0.002	0.001	0.205	○ 750	0.60	0.62	0.272	OK	0.75
399		4.60 104.50	286.00	0.533 42.599	0.533 42.599	3.0	0.204	0.000	0.002	0.001	0.207	○ 750	0.60	0.62	0.272	OK	0.76
400		3.20 107.70	235.00	1.525 44.124	1.525 44.124	3.0	0.211	0.000	0.002	0.001	0.214	○ 825	0.50	0.60	0.321	OK	0.67
		To Sewer No. 402															
401		50.10 50.10	290.00	28.700 28.700	28.700 28.700	3.0	0.138	0.000	0.001	0.001	0.140	○ 525	0.90	0.60	0.129	The sewer is planned to be repaced with the new sewer having dia. 675 mm because of inefficient capacity.	1.08
402	400	20.10 177.90	467.00	8.745 81.569	8.745 81.569	2.5	0.326	0.000	0.004	0.002	0.332	○ 825	0.50	0.60	0.321	The sewer is planned to be repaced with the new sewer having dia. 1050 mm because of inefficient capacity.	1.03
403		11.00 188.90	55.00	4.558 86.127	4.558 86.127	2.5	0.344	0.000	0.004	0.002	0.350	○ 825	0.50	0.60	0.321	The sewer is planned to be repaced with the new sewer having dia. 1050 mm because of inefficient capacity.	1.09
		To Sewer No. EP4S															
404		48.80 48.80	607.00	6.371 6.371	6.371 6.371	4.0	0.041	0.000	0.001	0.001	0.043	○ 525	0.90	0.60	0.129	OK	0.33
405		51.60 100.40	472.00	4.799 11.170	4.799 11.170	3.5	0.062	0.000	0.002	0.001	0.065	○ 600	0.75	0.60	0.168	OK	0.39
		To Sewer No. EP7S															

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total	Sewer Length (m)	Domestic Wastewater Generation: Unit Generation Rate (LPCD) 138 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peaking Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
406		19.60 19.60	137.00	1.975 1.975	1.975 1.975	4.5	0.014	0.000	0.000	0.000	0.014	○ 525	0.90	0.60	0.129	OK	0.11
407		3.70 23.30	635.00	0.452 2.427	0.452 2.427	4.5	0.017	0.000	0.001	0.000	0.018	○ 600	0.75	0.60	0.168	OK	0.11
408		4.50 27.80	278.00	0.758 3.185	0.758 3.185	4.5	0.023	0.000	0.001	0.000	0.024	○ 825	0.50	0.60	0.321	OK	0.07
		To Sewer No. 424															
409		27.60 27.60	194.00	8.578 8.578	8.578 8.578	4.0	0.055	0.000	0.001	0.000	0.056	○ 600	0.75	0.60	0.168	OK	0.33
410		33.10 60.70	327.00	8.340 16.918	8.340 16.918	3.5	0.095	0.000	0.001	0.001	0.097	○ 675	0.65	0.60	0.214	OK	0.45
411		16.30 77.00	331.00	4.117 21.035	4.117 21.035	3.5	0.118	0.000	0.002	0.001	0.121	○ 675	0.65	0.60	0.214	OK	0.56
412		14.90 91.90	184.00	3.753 24.788	3.753 24.788	3.5	0.139	0.000	0.002	0.001	0.142	○ 675	0.65	0.60	0.214	OK	0.66
413		2.00 93.90	165.00	0.198 24.986	0.198 24.986	3.5	0.140	0.000	0.002	0.001	0.143	○ 825	0.50	0.60	0.321	OK	0.45
		To Sewer No. 418															
414		2.50 2.50	153.00	1.159 1.159	1.159 1.159	4.5	0.008	0.000	0.000	0.000	0.008	○ 600	0.75	0.60	0.168	OK	0.05
		To Sewer No. 416															
415		26.60 26.60	533.00	8.504 8.504	8.504 8.504	4.0	0.054	0.000	0.001	0.000	0.055	○ 525	0.90	0.60	0.129	OK	0.43
416	414	0.20 29.30	73.00	0.100 9.763	0.100 9.763	4.0	0.062	0.000	0.001	0.000	0.063	○ 600	0.75	0.60	0.168	OK	0.38
417		31.70 61.00	643.00	11.651 21.414	11.651 21.414	3.5	0.120	0.000	0.001	0.001	0.122	○ 750	0.60	0.62	0.272	OK	0.45
418	413	0.70 155.60	148.00	0.075 46.475	0.075 46.475	3.0	0.223	0.000	0.004	0.002	0.229	○ 825	0.50	0.60	0.321	OK	0.71
419		65.50 221.10	423.00	9.598 56.073	9.598 56.073	2.5	0.224	0.018 0.018	0.005	0.003	0.250	○ 1050	0.40	0.63	0.546	OK	0.46
420		2.70 223.80	154.00	0.236 56.309	0.236 56.309	2.5	0.225	0.018	0.005	0.003	0.251	○ 1200	0.30	0.60	0.675	OK	0.37
		To Sewer No. 424															
421		40.80 40.80	637.00	7.970 7.970	7.970 7.970	4.0	0.051	0.000	0.001	0.000	0.052	○ 675	0.65	0.60	0.214	OK	0.24
422		2.50 43.30	205.00	0.459 8.429	0.459 8.429	4.0	0.054	0.000	0.001	0.001	0.056	○ 600	0.75	0.60	0.168	OK	0.33
423		15.30 58.60	303.00	1.038 9.467	1.038 9.467	4.0	0.060	0.000	0.001	0.001	0.062	○ 675	0.65	0.60	0.214	OK	0.29
424	408 420	0.50 310.70	109.00	0.127 69.088	0.127 69.088	2.5	0.276	0.018	0.007	0.004	0.305	○ 1200	0.30	0.60	0.675	OK	0.45
		To Sewer No. EP7S															
425		51.90 51.90	359.00	13.284 13.284	13.284 13.284	3.5	0.074	0.000	0.001	0.001	0.076	○ 525	0.90	0.60	0.129	OK	0.59

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population (x10^3)	Peaking Factor	Population (x10^3)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha)	Sewer Length	Domestic Wastewater Generation				Point Souce			Design	Sewer Line Design				Remarks	Ratio of Design Flow against Capacity
				Unit Generation Rate (LPCD)			138										
				Population (thousand)	Service Population (thousand)	Peaking Factor	Domestic WW Flow	Industrial WW Flow	Commercial WW Flow	I/I of Ground water Flow	Max. Flow	Dia.	Slope	Velocity	Capacity		
		Increment / Total	(m)	Increment / Total	Increment / Total		(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(mm)	(‰)	(m/sec)	(m^3/sec)		
426		6.50 58.40	243.00	1.438 14.722	1.438 14.722	3.5	0.082	0.000	0.001	0.001	0.084	○ 600	0.75	0.60	0.168	OK	0.50
427		5.20 63.60	331.00	1.095 15.817	1.095 15.817	3.5	0.088	0.000	0.001	0.001	0.090	○ 675	0.65	0.60	0.214	OK	0.42
428		7.10 70.70	676.00	0.900 16.717	0.900 16.717	3.5	0.093	0.000	0.002	0.001	0.096	○ 1350	0.30	0.65	0.924	OK	0.10
429		2.20 72.90	334.00	0.101 16.818	0.101 16.818	3.5	0.094	0.000	0.002	0.001	0.097	○ 1350	0.30	0.65	0.924	OK	0.10
		To Sewer No. 431															
430		20.80 20.80	138.00	2.135 2.135	2.135 2.135	4.5	0.015	0.000	0.000	0.000	0.015	○ 525	0.90	0.60	0.129	OK	0.12
431	429	8.90 102.60	805.00	0.578 19.531	0.578 19.531	3.5	0.109	0.000	0.002	0.001	0.112	○ 1350	0.30	0.65	0.924	OK	0.12
432		7.20 109.80	254.00	0.297 19.828	0.297 19.828	3.5	0.111	0.000	0.003	0.001	0.115	○ 1350	0.30	0.65	0.924	OK	0.12
		To Sewer No. E51-1															
433		108.00 108.00	129.00	9.111 9.111	9.111 9.111	4.0	0.058	0.000	0.003	0.001	0.062	○ 600	0.75	0.60	0.168	OK	0.37
434		2.10 110.10	194.00	0.040 9.151	0.040 9.151	4.0	0.058	0.000	0.003	0.001	0.062	○ 600	0.75	0.60	0.168	OK	0.37
		To Pump No.EP5 and discharged to Sewer No. 438		PS-34 Samanabad(LP/S) 44.2m^3/min=0.736m^3/s													
435		10.80 10.80	838.00	1.271 1.271	1.271 1.271	4.5	0.009	0.000	0.000	0.000	0.009	○ 600	0.75	0.60	0.168	OK	0.05
436		83.20 94.00	324.00	28.519 29.790	28.519 29.790	3.0	0.143	0.000	0.002	0.001	0.146	○ 600	0.75	0.60	0.168	The sewer is planned to be repaced with the new sewer having dia. 750 mm, based on the design standards of capacity allowance.	0.87
437		4.20 98.20	417.00	0.632 30.422	0.632 30.422	3.0	0.146	0.000	0.002	0.001	0.149	○ 675	0.65	0.60	0.214	The sewer is planned to be repaced with the new sewer having dia. 750 mm, based on the design standards of capacity allowance.	0.69
		To Pump No.EP5 and discharged to Sewer No. 438		PS-34 Samanabad(LP/S) 44.2m^3/min=0.736m^3/s					Sewer No. 434+437=		0.211						
438	434 437	8.70 217.00	261.00	1.433 41.006	1.433 41.006	3.0	0.196	0.000	0.005	0.003	0.204	○ 675	0.65	0.60	0.214	The sewer is planned to be repaced with the new sewer having dia. 825 mm, based on the design standards of capacity allowance.	0.95
439		11.40 228.40	311.00	3.511 44.517	3.511 44.517	3.0	0.213	0.000	0.005	0.003	0.221	○ 675	0.65	0.60	0.214	The sewer is planned to be repaced with the new sewer having dia. 825 mm, based on the design standards of capacity allowance.	1.03
440		266.40 494.80	935.00	34.369 78.886	34.369 78.886	2.5	0.315	0.000	0.011	0.006	0.332	○ 750	0.60	0.62	0.272	The sewer is planned to be repaced with the new sewer having dia. 1050 mm because of inefficient capacity.	1.22
		To Sewer No. 445															
441		39.30 39.30	1,018.00	12.989 12.989	12.989 12.989	3.5	0.073	0.000	0.001	0.000	0.074	○ 600	0.75	0.60	0.168	OK	0.44
		To Sewer No. 445															
442		71.90 71.90	649.00	4.441 4.441	4.441 4.441	4.5	0.032	0.000	0.002	0.001	0.035	○ 525	0.90	0.60	0.129	OK	0.27

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha)	Sewer Length	Domestic Wastewater Generation				Point Souce			Design	Sewer Line Design				Remarks	Ratio of Design Flow against Capacity
				Unit Generation Rate (LPCD)			138										
				Population (thousand)	Service Population (thousand)	Peaking Factor	Domestic WW Flow	Industrial WW Flow	Commercial WW Flow	I/I of Ground water Flow	Max. Flow	Dia.	Slope	Velocity	Capacity		
		Increment		Increment	Increment												
		Total	(m)	Total	Total		(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(mm)	(‰)	(m/sec)	(m^3/sec)		
443		3.30 75.20	364.00	1.036 5.477	1.036 5.477	4.0	0.035	0.000	0.002	0.001	0.038	○ 600	0.75	0.60	0.168	OK	0.23
		To Sewer No. 445															
444		66.70 66.70	193.00	4.861 4.861	4.861 4.861	4.5	0.035	0.000	0.002	0.001	0.038	○ 525	0.90	0.60	0.129	OK	0.29
445	440、441 443	2.60 678.60	377.00	0.771 102.984	0.771 102.984	2.0	0.329	0.000	0.016	0.008	0.353	○ 750	0.60	0.62	0.272	The sewer is planned to be repaced with the new sewer having dia. 1050 mm because of inefficient capacity.	1.30
		To Sewer No. 450															
446		48.40 48.40	270.00	8.796 8.796	8.796 8.796	4.0	0.056	0.000	0.001	0.001	0.058	○ 600	0.75	0.60	0.168	OK	0.35
		To Sewer No. 448															
447		8.70 8.70	358.00	1.129 1.129	1.129 1.129	4.5	0.008	0.000	0.000	0.000	0.008	○ 600	0.75	0.60	0.168	OK	0.05
448	446	8.50 65.60	343.00	1.792 11.717	1.792 11.717	3.5	0.066	0.000	0.002	0.001	0.069	○ 600	0.75	0.60	0.168	OK	0.41
449		45.90 111.50	2,151.00	22.084 33.801	22.084 33.801	3.0	0.162	0.000	0.003	0.001	0.166	○ 675	0.65	0.60	0.214	The sewer is planned to be repaced with the new sewer having dia. 750 mm, based on the design standards of capacity allowance.	0.77
450	445	18.20 808.30	1,005.00	4.293 141.078	4.293 141.078	2.0	0.451	0.000	0.019	0.009	0.479	○ 750	0.60	0.62	0.272	The sewer is planned to be repaced with the new sewer having dia. 1200 mm because of inefficient capacity.	1.76
		To Sewer No. 453															
451		0.00 0.00	193.00	0.000 0.000	0.000 0.000	4.5	0.000	0.000	0.000	0.000	0.000	○ 525	0.90	0.60	0.129	OK	0.00
452		9.10 9.10	129.00	0.801 0.801	0.801 0.801	4.5	0.006	0.000	0.000	0.000	0.006	○ 825	0.50	0.60	0.321	OK	0.02
453	450	0.00 817.40	310.00	0.000 141.879	0.000 141.879	2.0	0.453	0.000	0.019	0.010	0.482	○ 825	0.50	0.60	0.321	The sewer is planned to be repaced with the new sewer having dia. 1200 mm because of inefficient capacity.	1.50
454		129.90 947.30	668.00	6.431 148.310	6.431 148.310	2.0	0.474	0.000	0.022	0.011	0.507	○ 1200	0.30	0.60	0.675	OK	0.75
455		12.10 959.40	336.00	0.689 148.999	0.689 148.999	2.0	0.476	0.000	0.022	0.011	0.509	○ 1350	0.30	0.65	0.924	OK	0.55
		To Sewer No. 457															
456		7.70 7.70	178.00	0.797 0.797	0.797 0.797	4.5	0.006	0.000	0.000	0.000	0.006	○ 675	0.65	0.60	0.214	OK	0.03
457	455	60.60 1,027.70	674.00	1.281 151.077	1.281 151.077	2.0	0.483	0.000	0.024	0.012	0.519	○ 1350	0.30	0.65	0.924	OK	0.56
458		8.80 1,036.50	197.00	0.121 151.198	0.121 151.198	2.0	0.483	0.000	0.024	0.012	0.519	○ 1350	0.30	0.65	0.924	OK	0.56
		To Sewer No.E51-1															
459		70.30 70.30	659.00	0.949 0.949	0.949 0.949	4.5	0.007	0.000	0.002	0.001	0.010	○ 525	0.90	0.60	0.129	OK	0.08
460		23.40 93.70	487.00	0.292 1.241	0.292 1.241	4.5	0.009	0.000	0.002	0.001	0.012	○ 525	0.90	0.60	0.129	OK	0.09

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha)	Sewer Length	Domestic Wastewater Generation				Point Souce			Design	Sewer Line Design				Remarks	Ratio of Design Flow against Capacity
				Unit Generation Rate (LPCD)			138										
				Population (thousand)	Service Population (thousand)	Peaking Factor	Domestic WW Flow	Industrial WW Flow	Commercial WW Flow	I/I of Ground water Flow	Max. Flow	Dia.	Slope	Velocity	Capacity		
		Increment		Increment	Increment												
		Total	(m)	Total	Total		(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(mm)	(‰)	(m/sec)	(m^3/sec)		
461		0.00 93.70	393.00	0.000 1.241	0.000 1.241	4.5	0.009	0.000	0.002	0.001	0.012	○ 600	0.75	0.60	0.168	OK	0.07
			To Sewer No. E50														
EP11		17.30 17.30	Jhal Khnuana	2.591 2.591	2.591 2.591	4.5	0.019	0.000	0.000	0.000	0.019	○ 300	2.00	0.61	0.043	Design flow rate is estimated using population served by the pumping station because the sewer data was not available.	0.43
			Sewer No. 302 coverage area is 17.3 ha out of 62.10 ha and the population of 9,302. The service population by the sewer and pumping station is estimated about 2,591 (=9,302×17.3/62.1)														
E1-1		0.00 0.00	5,670.00	41.000 41.000	41.000 41.000	3.0	0.171	0.000	0.000	0.000	0.171	○ 350	圧送	1.78	0.171	The design flow rate of Q=0.171 m3/s of the domestic wastewater generated by the population of 41,000 in Kurrianwala.	1.00
E1-2		347.40 347.40	1,830.00	17.461 17.461	17.461 17.461	3.5	0.098	0.003 0.003	0.008	0.004	0.113	○ 1050	0.40	0.63	0.546		0.21
E2		274.50 621.90	2,980.00	12.723 30.184	12.723 30.184	3.0	0.145	0.003	0.014	0.007	0.169	○ 1050	0.40	0.63	0.546		0.31
			To Sewer No. E4														
E3		341.60 341.60	1,200.00	15.982 15.982	15.982 15.982	3.5	0.089	0.000	0.008	0.004	0.101	○ 600	0.75	0.60	0.168		0.60
E4	E2	354.80 1,318.30	1,940.00	16.836 63.002	16.836 63.002	2.5	0.252	0.003	0.031	0.015	0.301	○ 1350	0.30	0.65	0.924		0.33
			To Sewer No. E6														
E5		144.20 144.20	1,200.00	22.783 22.783	22.783 22.783	3.5	0.127	0.000	0.003	0.002	0.132	○ 675	0.65	0.60	0.214		0.62
E6	E4	328.90 1,791.40	2,020.00	18.515 104.300	18.515 104.300	2.0	0.333	0.003	0.041	0.021	0.398	○ 1350	0.30	0.65	0.924		0.43
			To Sewer No. E8														
E7		140.00 140.00	760.00	7.401 7.401	7.401 7.401	4.0	0.047	0.000	0.003	0.002	0.052	○ 450	1.10	0.60	0.095		0.55
E8	E6	15.40 1,946.80	330.00	1.607 113.308	1.607 113.308	2.0	0.362	0.003	0.045	0.023	0.433	○ 1350	0.30	0.65	0.924		0.47
			To Sewer No. E10														
E9		126.50 126.50	960.00	17.615 17.615	17.615 17.615	3.5	0.098	0.000	0.003	0.001	0.102	○ 600	0.75	0.60	0.168		0.61
E10	E8	227.70 2,301.00	2,360.00	28.282 159.205	28.282 159.205	2.0	0.509	0.003	0.053	0.027	0.592	○ 1500	0.25	0.63	1.116		0.53
EB1	E17-4	0.00 5,344.10	3,390.00	0.000 650.841	0.000 650.841	2.0	2.079	0.053	0.12	0.063	2.314	○ 2250	0.25	0.83	3.295		0.70
			To Sewer No. EB3														
E50	461	1,034.20 1,127.90	4,230.00	12.785 14.026	12.785 14.026	3.5	0.078	0.000	0.026	0.013	0.117	○ 675	0.65	0.60	0.214		0.55
E50-1		130.00 1,257.90	2,160.00	2.394 16.420	2.394 16.420	3.5	0.092	0.000	0.029	0.015	0.136	○ 675	0.65	0.60	0.214		0.63

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Total	Sewer Length (m)	Domestic Wastewater Generation: Unit Generation Rate (LPCD) 138; Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peaking Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
E50-2		0.00 1,257.90	1,700.00	0.000 16.420	0.000 16.420	3.5	0.092	0.000	0.029	0.015	0.136	○ 675	0.65	0.60	0.214		0.63
		To Sewer No. E51-1															
EP7S	405 424	0.00 411.10	680.00	0.000 80.258	0.000 80.258	2.5	0.320	0.018	0.010	0.005	0.353	○ 1050	0.40	0.63	0.546		0.65
		To Sewer No. EB2-2															
EP4S	393 393 40	0.00 423.60	700.00	0.000 149.294	0.000 149.294	2.0	0.477	0.132	0.010	0.005	0.624	○ 1350	0.30	0.65	0.924		0.68
		To Sewer No.EB2-1															
E51		325.20 325.20	1,910.00	4.448 4.448	4.448 4.448	4.5	0.032	0.000	0.008	0.004	0.044	○ 375	1.50	0.62	0.068		0.65
		To Sewer No. E51-1															
EB2-1	EP4S	0.00 423.60	2,450.00	0.000 149.294	0.000 149.294	2.0	0.477	0.132	0.010	0.005	0.624	○ 1350	0.30	0.65	0.924		0.68
EB2-2	EP7S	0.00 834.70	1,150.00	0.000 229.552	0.000 229.552	2.0	0.733	0.150	0.019	0.010	0.912	○ 1650	0.20	0.60	1.289		0.71
E51-1	E50-2 E51 432 458	256.00 3,820.10	2,350.00	7.411 428.857	7.411 428.857	2.0	1.370	0.001 0.151	0.088	0.045	1.654	○ 1950	0.20	0.67	2.012		0.82
		To Sewer No. E55-2															
EB3	EB1	0.00 5,344.10	530.00	0.000 650.841	0.000 650.841	2.0	2.079	0.053	0.124	0.063	2.319	○ 2250	0.25	0.83	3.295		0.70
EB4	342 364 365	0.00 7,058.80	940.00	0.000 1,064.895	0.000 1,064.895	2.0	3.402	0.545	0.164	0.083	4.194	○ 2250	0.80	1.48	5.894		0.71
EB5		0.00 7,058.80	1,430.00	0.000 1,064.895	0.000 1,064.895	2.0	3.402	0.545	0.164	0.083	4.194	○ 2250	0.80	1.48	5.894		0.71
EB6	385,386	0.00 8,703.40	1,350.00	0.000 1,302.524	0.000 1,302.524	2.0	4.161	0.560	0.202	0.102	5.025	○ 2250	0.80	1.48	5.894		0.85
		To Sewer No. E57															
E11		589.70 589.70	2,390.00	67.860 67.860	67.860 67.860	2.5	0.271	0.000	0.014	0.007	0.292	○ 900	0.45	0.60	0.384		0.76
		To Sewer No. E13															
E12		447.00 447.00	2,440.00	40.253 40.253	40.253 40.253	3.0	0.193	0.000	0.010	0.005	0.208	○ 825	0.50	0.60	0.321		0.65
E13	E11	137.40 1,174.10	1,240.00	15.094 123.207	15.094 123.207	2.0	0.394	0.000	0.027	0.014	0.435	○ 1050	0.40	0.63	0.546		0.80
		To Sewer No. E15															
E14-1		869.70 869.70	3,640.00	66.654 66.654	66.654 66.654	2.5	0.266	0.000	0.020	0.010	0.296	○ 1050	0.40	0.63	0.546		0.54
		To Sewer No. E15															
E14	35、42,46	0.00 610.80	2,510.00	0.000 173.984	0.000 173.984	2.0	0.556	0.050 0.050	0.014	0.007	0.627	○ 1350	0.30	0.65	0.924		0.68

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha)	Sewer Length	Domestic Wastewater Generation				Point Souce			Design	Sewer Line Design				Remarks	Ratio of Design Flow against Capacity
				Unit Generation Rate (LPCD)			138										
				Population (thousand)	Service Population (thousand)	Peaking Factor	Domestic WW Flow	Industrial WW Flow	Commercial WW Flow	I/I of Ground water Flow	Max. Flow	Dia.	Slope	Velocity	Capacity		
		Increment / Total	(m)	Increment / Total	Increment / Total		(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(mm)	(‰)	(m/sec)	(m^3/sec)		
E15	E13、E14-1	33.60 2,688.20	760.00	66.654 430.499	66.654 430.499	2.0	1.375	0.050	0.062	0.031	1.518	○ 1950	0.20	0.67	2.012		0.75
		To Sewer No. E17-1															
E16		54.80 54.80	710.00	16.905 16.905	16.905 16.905	3.5	0.095	0.000	0.001	0.001	0.097	○ 600	0.75	0.60	0.168		0.57
E17-1	E15	106.10 2,849.10	5,220.00	15.026 462.430	15.026 462.430	2.0	1.477	0.050	0.066	0.033	1.626	○ 1950	0.20	0.67	2.012		0.81
		To Sewer No. E17-4															
E17-2	305	0.00 23.70	680.00	0.000 2.180	0.000 2.180	4.5	0.016	0.000	0.001	0.000	0.017	○ 300	2.00	0.61	0.043		0.39
E17-3	319 320	0.00 194.00	1,450.00	0.000 29.206	0.000 29.206	3.0	0.140	0.000	0.004	0.002	0.146	○ 750	0.60	0.62	0.272		0.54
E17-4	E17-1	0.00 3,043.10	1,000.00	0.000 491.636	0.000 491.636	2.0	1.571	0.050	0.070	0.036	1.727	○ 1950	0.20	0.67	2.012		0.86
		To Sewer No. EB1															
E18		271.00 271.00	1,980.00	8.309 8.309	8.309 8.309	4.0	0.053	0.000	0.006	0.003	0.062	○ 450	1.10	0.60	0.095		0.66
		To Sewer No. E20															
E19		197.00 197.00	1,380.00	24.502 24.502	24.502 24.502	3.5	0.137	0.000	0.005	0.002	0.144	○ 750	0.60	0.62	0.272		0.53
E20	E18	131.70 599.70	1,680.00	7.153 39.964	7.153 39.964	3.0	0.191	0.000	0.014	0.007	0.212	○ 750	0.60	0.62	0.272		0.78
		To Sewer No. E22															
E21		156.80 156.80	1,240.00	19.814 19.814	19.814 19.814	3.5	0.111	0.000	0.004	0.002	0.117	○ 675	0.65	0.60	0.214		0.55
E22	E20	40.70 797.20	760.00	0.822 60.600	0.822 60.600	2.5	0.242	0.000	0.018	0.009	0.269	○ 900	0.45	0.60	0.384		0.70
		To Sewer No. E26															
E23		119.80 119.80	1,780.00	2.419 2.419	2.419 2.419	4.5	0.017	0.000	0.003	0.001	0.021	○ 300	2.00	0.61	0.043		0.50
		To Sewer No. E25															
E24		151.00 151.00	1,200.00	3.049 3.049	3.049 3.049	4.5	0.022	0.000	0.003	0.002	0.027	○ 300	2.00	0.61	0.043		0.62
E25	E23	74.40 345.20	1,310.00	1.502 6.970	1.502 6.970	4.0	0.045	0.000	0.008	0.004	0.057	○ 450	1.10	0.60	0.095		0.60
E26	E22	109.90 1,252.30	1,340.00	2.218 69.788	2.218 69.788	2.5	0.279	0.000	0.029	0.015	0.323	○ 1050	0.40	0.63	0.546		0.59
		To Sewer No. E28															
E27		73.20 73.20	280.00	1.478 1.478	1.478 1.478	4.5	0.011	0.000	0.002	0.001	0.014	○ 225	3.00	0.62	0.025		0.55
E28	E26	39.40 1,364.90	980.00	0.796 72.062	0.796 72.062	2.5	0.288	0.000	0.032	0.016	0.336	○ 1050	0.40	0.63	0.546		0.61
		To Sewer No. E31															

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha)	Sewer Length	Domestic Wastewater Generation				Point Souce			Design	Sewer Line Design				Remarks	Ratio of Design Flow against Capacity
				Unit Generation Rate (LPCD)			138										
				Population (thousand)	Service Population (thousand)	Peaking Factor	Domestic WW Flow	Industrial WW Flow	Commercial WW Flow	I/I of Ground water Flow	Max. Flow	Dia.	Slope	Velocity	Capacity		
		Increment		Increment	Increment												
		Total	(m)	Total	Total		(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(mm)	(‰)	(m/sec)	(m^3/sec)		
E29		241.80 241.80	960.00	8.985 8.985	8.985 8.985	4.0	0.057	0.000	0.006	0.003	0.066	○ 525	0.90	0.60	0.129		0.51
			To Sewer No. E31														
E30		41.90 41.90	650.00	0.846 0.846	0.846 0.846	4.5	0.006	0.000	0.001	0.000	0.007	○ 225	3.00	0.62	0.025		0.29
E31	E28, E29	51.90 1,700.50	1,050.00	1.048 82.941	1.048 82.941	2.5	0.331	0.000	0.039	0.020	0.390	○ 1050	0.40	0.63	0.546		0.71
			To Sewer No. E34														
E32		328.00 328.00	990.00	16.714 16.714	16.714 16.714	3.5	0.093	0.273 0.273	0.008	0.004	0.378	○ 1050	0.40	0.63	0.546		0.69
			To Sewer No. E31														
E33		59.30 59.30	630.00	1.219 1.219	1.219 1.219	4.5	0.009	0.000	0.001	0.001	0.011	○ 225	3.00	0.62	0.025		0.44
E34	E31、E32	77.30 2,165.10	1,350.00	2.138 103.012	2.138 103.012	2.0	0.329	0.273	0.050	0.025	0.677	○ 1350	0.30	0.65	0.924		0.73
			To Sewer No. E37														
E35		236.80 236.80	990.00	11.165 11.165	11.165 11.165	3.5	0.062	0.000	0.005	0.003	0.070	○ 525	0.90	0.60	0.129		0.55
			To Sewer No. E37														
E36		60.30 60.30	490.00	1.728 1.728	1.728 1.728	4.5	0.012	0.000	0.001	0.001	0.014	○ 225	3.00	0.62	0.025		0.59
E37	E34、E35	166.30 2,628.50	1,440.00	4.906 120.811	4.906 120.811	2.0	0.386	0.273	0.061	0.031	0.751	○ 1500	0.25	0.63	1.116		0.67
			To Sewer No. E58														
E38		581.70 581.70	2,530.00	34.449 34.449	34.449 34.449	3.0	0.165	0.000	0.013	0.007	0.185	○ 750	0.60	0.62	0.272		0.68
E39		189.30 771.00	2,810.00	7.954 42.403	7.954 42.403	3.0	0.203	0.000	0.018	0.009	0.230	○ 825	0.50	0.60	0.321		0.72
			To Sewer No. E41														
E40		108.00 108.00	950.00	2.168 2.168	2.168 2.168	4.5	0.016	0.000	0.003	0.001	0.020	○ 300	2.00	0.61	0.043		0.45
E41	E39	137.30 1,016.30	1,660.00	2.756 47.327	2.756 47.327	3.0	0.227	0.000	0.024	0.012	0.263	○ 900	0.45	0.60	0.384		0.68
			To Sewer No. E43														
E42		122.50 122.50	1,300.00	2.474 2.474	2.474 2.474	4.5	0.018	0.000	0.003	0.001	0.022	○ 300	2.00	0.61	0.043		0.50
E43	E41	81.80 1,220.60	1,050.00	1.650 51.451	1.650 51.451	2.5	0.205	0.000	0.028	0.014	0.247	○ 900	0.45	0.60	0.384		0.64
			To Sewer No. E45														
E44		109.70 109.70	1,230.00	2.216 2.216	2.216 2.216	4.5	0.016	0.000	0.003	0.001	0.020	○ 300	2.00	0.61	0.043		0.46

Ratio of Design Flow against Capacity			
More than 2.0		From 1.2 to 1.4	
From 1.8 to 2.0		From 1.0 to 1.2	
From 1.6 to 1.8		Less than 1.0	
From 1.4 to 1.6			

Population ($x10^3$)	Peaking Factor	Population ($x10^3$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha)	Sewer Length	Domestic Wastewater Generation				Point Souce			Design	Sewer Line Design				Remarks	Ratio of Design Flow against Capacity
				Unit Generation Rate (LPCD)			138										
				Population (thousand)	Service Population (thousand)	Peaking Factor	Domestic WW Flow	Industrial WW Flow	Commercial WW Flow	I/I of Ground water Flow	Max. Flow	Dia.	Slope	Velocity	Capacity		
		Increment		Increment	Increment												
		Total	(m)	Total	Total		(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(m^3/sec)	(mm)	(‰)	(m/sec)	(m^3/sec)		
E45	E43	63.60 1,393.90	1,020.00	1.284 54.951	1.284 54.951	2.5	0.219	0.000	0.032	0.016	0.267	○ 900	0.45	0.60	0.384		0.70
		To Sewer No. E47															
E46		159.80 159.80	1,590.00	3.228 3.228	3.228 3.228	4.5	0.023	0.000	0.004	0.002	0.029	○ 375	1.50	0.62	0.068		0.43
E47	E45	43.80 1,597.50	1,390.00	0.918 59.097	0.918 59.097	2.5	0.236	0.000	0.037	0.019	0.292	○ 900	0.45	0.60	0.384		0.76
		To Sewer No. E49															
E48		216.30 216.30	1,930.00	6.003 6.003	6.003 6.003	4.0	0.038	0.000	0.005	0.003	0.046	○ 450	1.10	0.60	0.095		0.49
E49	E47	110.60 1,924.40	2,620.00	3.166 68.266	3.166 68.266	2.5	0.273	0.000	0.045	0.023	0.341	○ 1050	0.40	0.63	0.546		0.62
		To Sewer No. E59															
E52		654.80 654.80	2,940.00	9.438 9.438	9.438 9.438	4.0	0.060	0.000	0.015	0.008	0.083	○ 525	0.90	0.60	0.129		0.65
E53		410.50 1,065.30	2,550.00	11.885 21.323	11.885 21.323	3.5	0.119	0.002 0.002	0.025	0.012	0.158	○ 750	0.60	0.62	0.272		0.58
		To Sewer No. E55-2															
E54		142.40 142.40	1,840.00	25.142 25.142	25.142 25.142	3.0	0.120	0.000	0.003	0.002	0.125	○ 675	0.65	0.60	0.214		0.59
		To Sewer No. E55-1															
E55		181.40 181.40	2,300.00	20.617 20.617	20.617 20.617	3.5	0.115	0.000	0.004	0.002	0.121	○ 600	1.00	0.69	0.194		0.62
E55-1	E54	294.00 617.80	2,050.00	8.511 54.270	8.511 54.270	2.5	0.217	0.002 0.002	0.014	0.007	0.240	○ 900	0.45	0.60	0.384		0.62
E55-2	E51-1 E53	325.50 5,828.70	5,970.00	9.981 514.431	9.981 514.431	2.0	1.643	0.001 0.156	0.135	0.068	2.002	○ 2250	0.15	0.64	2.551		0.78
		To Sewer No. E59-2															
E56		279.30 279.30	1,520.00	8.725 8.725	8.725 8.725	4.0	0.056	0.000	0.006	0.003	0.065	○ 525	0.90	0.60	0.129		0.50
E57	EB6	35.20 9,017.90	1,060.00	1.120 1,312.369	1.120 1,312.369	2.0	4.192	0.560	0.209	0.106	5.067	○ 2250	0.80	1.48	5.894		0.86
E58	E37	1,007.50 12,653.90	3,500.00	28.943 1,462.123	28.943 1,462.123	2.0	4.671	0.833	0.293	0.148	5.945	○ 2400	0.80	1.55	6.999		0.85
E59-1	E49	0.00 14,578.30	6,170.00	0.000 1,530.389	0.000 1,530.389	2.0	4.889	0.833	0.338	0.171	6.231	○ 2550	0.80	1.61	8.228		0.76
E59-2	E55-2	0.00 20,407.00	100.00	0.000 2,044.820	0.000 2,044.820	2.0	6.532	0.989	0.473	0.239	8.233	○ 2700	0.80	1.67	9.580		0.86
		To New EAST WWTP															

Population (x10^{3})	Peaking Factor	Population (x10^{3})	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment / Cumulative Total		Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 120 — Population (thousand) Increment / Total	Service Population (thousand) Increment / Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
K1		65.00 65.00		1,831.00	6.453 6.453	6.453 6.453	4.0	0.036	0.000	0.000	0.000	0.036	○ 375	1.50	0.62	0.068		0.53
			To K3															
K2		33.00 33.00		736.00	3.276 3.276	3.276 3.276	4.5	0.020	0.000	0.000	0.000	0.020	○ 300	2.00	0.61	0.043		0.47
K3	K1	0.00 98.00		119.00	0.000 9.729	0.000 9.729	4.0	0.054	0.000	0.000	0.000	0.054	○ 450	1.10	0.60	0.095		0.57
			To K6															
K4		146.00 146.00		1,111.00	14.494 14.494	14.494 14.494	3.5	0.070	0.000	0.000	0.000	0.070	○ 500	1.00	0.61	0.119		0.59
			To K6															
K5		53.00 53.00		857.00	5.262 5.262	5.262 5.262	4.0	0.029	0.000	0.000	0.000	0.029	○ 375	1.50	0.62	0.068		0.43
K6	K3, K4	0.00 297.00		51.00	0.000 29.484	0.000 29.484	3.0	0.123	0.000	0.000	0.000	0.123	○ 675	0.65	0.60	0.214		0.57
		To E1-1 by PS																
K7		116.00 116.00		1,253.00	11.516 11.516	11.516 11.516	3.5	0.056	0.000	0.000	0.000	0.056	○ 450	1.10	0.60	0.095		0.59
		To E1-1 by PS								Total Flow to E1-1		0.179						
P	K6, K7	0.00 413.00			0.000 41.000	0.000 41.000	3.0	0.171	0.000	0.000	0.000	0.171						

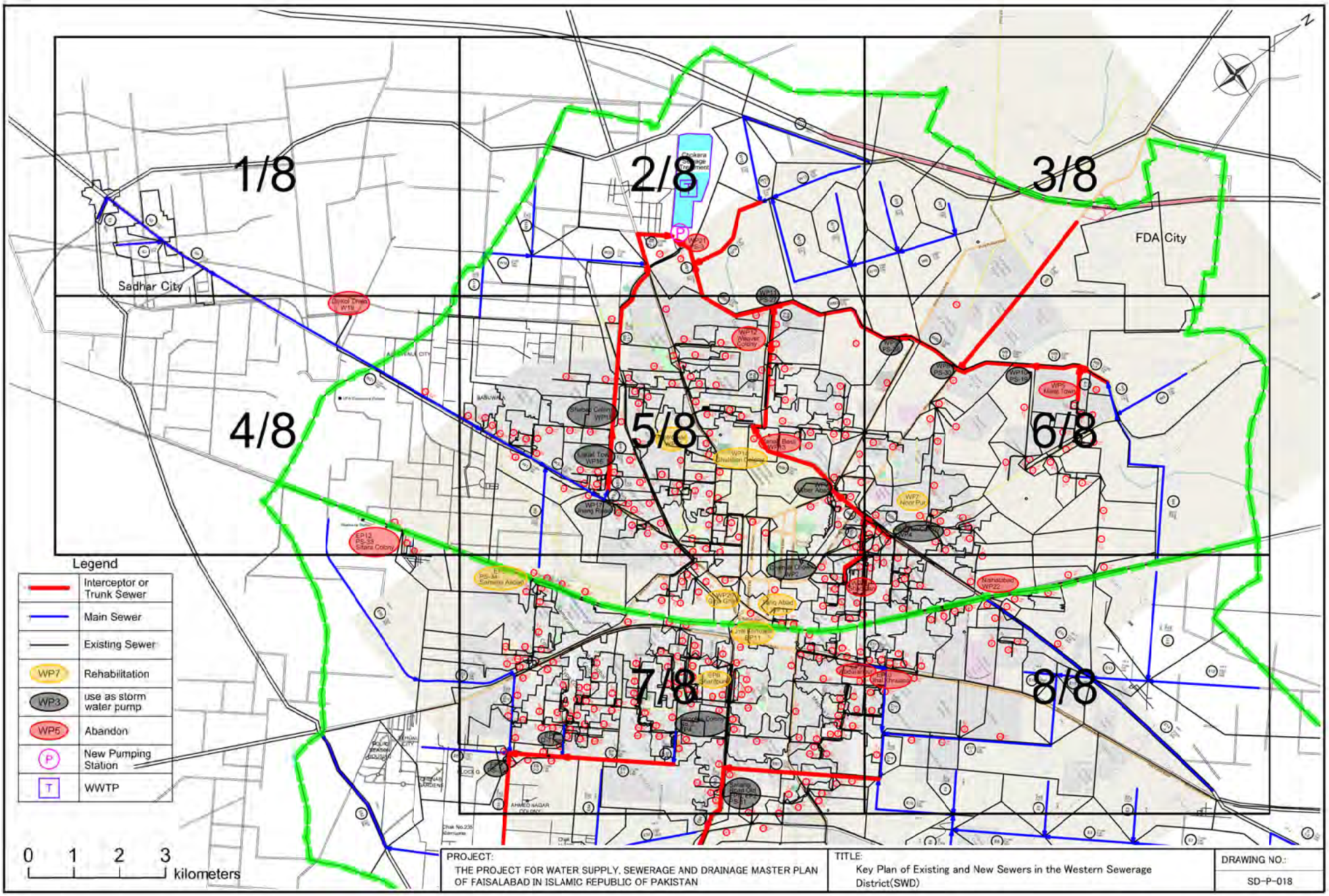
AC11.2 General Plan of Sewer System in 2038

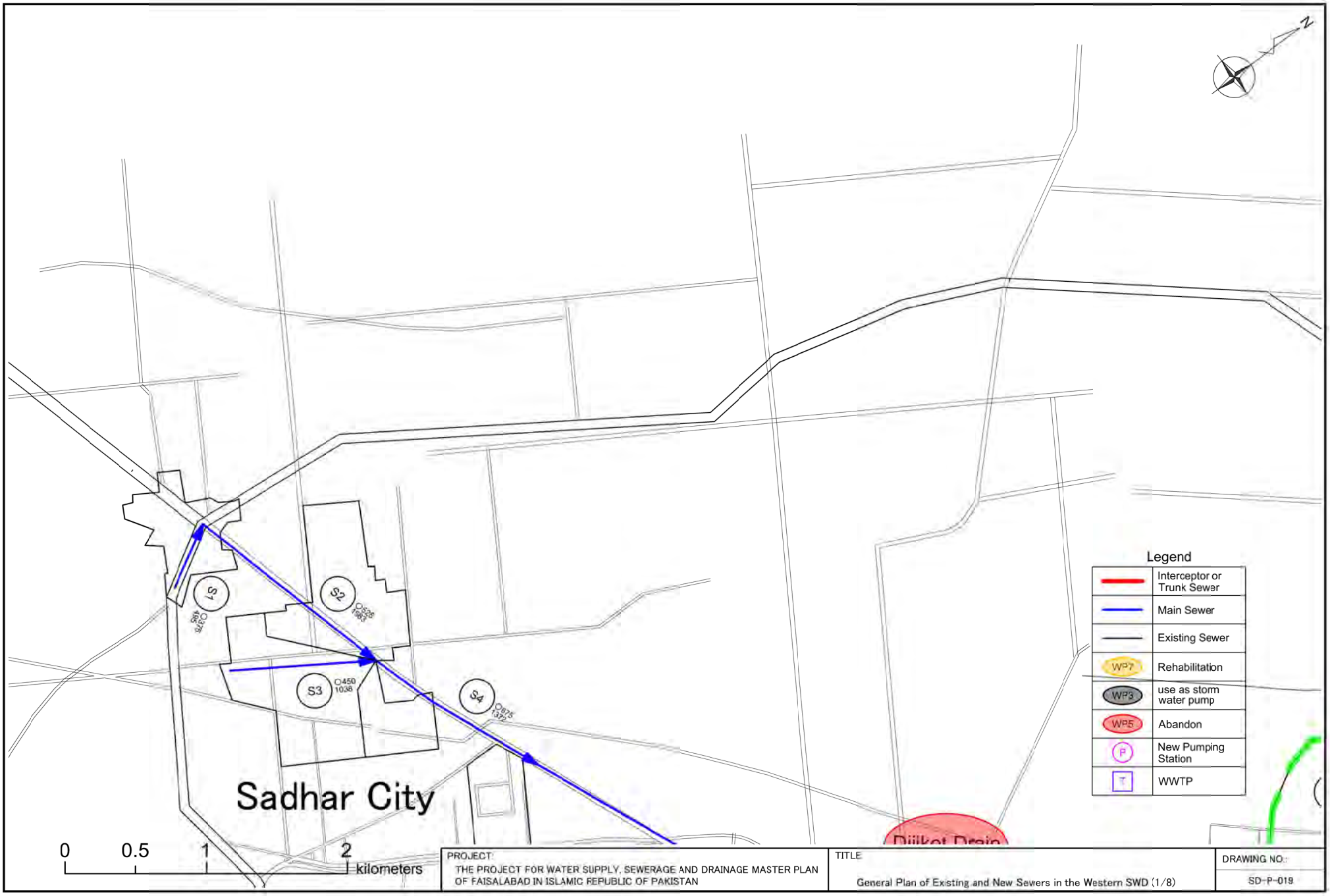
Table AC11.2.1 General Plan of the Sewer System in the Western Sewerage District

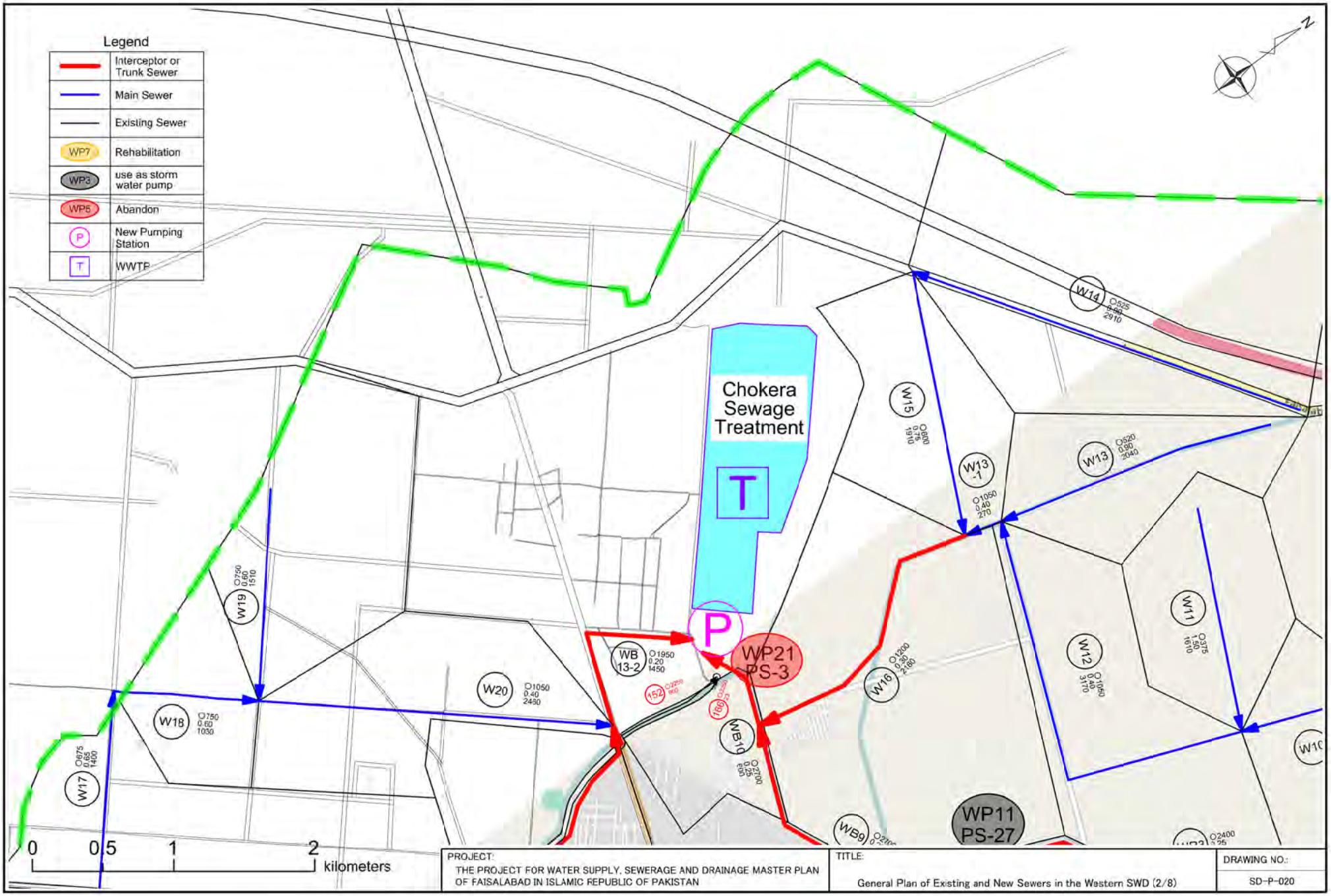
Drawing No.	Contents
SD-P- 018	Key Plan of Existing and New Sewers in the Western Sewerage District (SWD)
SD-P- 019	General Plan of Existing and New Sewers in the Western SWD (1/8)
SD-P- 020	General Plan of Existing and New Sewers in the Western SWD (2/8)
SD-P- 021	General Plan of Existing and New Sewers in the Western SWD (3/8)
SD-P- 022	General Plan of Existing and New Sewers in the Western SWD (4/8)
SD-P- 023	General Plan of Existing and New Sewers in the Western SWD (5/8)
SD-P- 024	General Plan of Existing and New Sewers in the Western SWD (6/8)
SD-P- 025	General Plan of Existing and New Sewers in the Western SWD (7/8)
SD-P- 026	General Plan of Existing and New Sewers in the Western SWD (8/8)

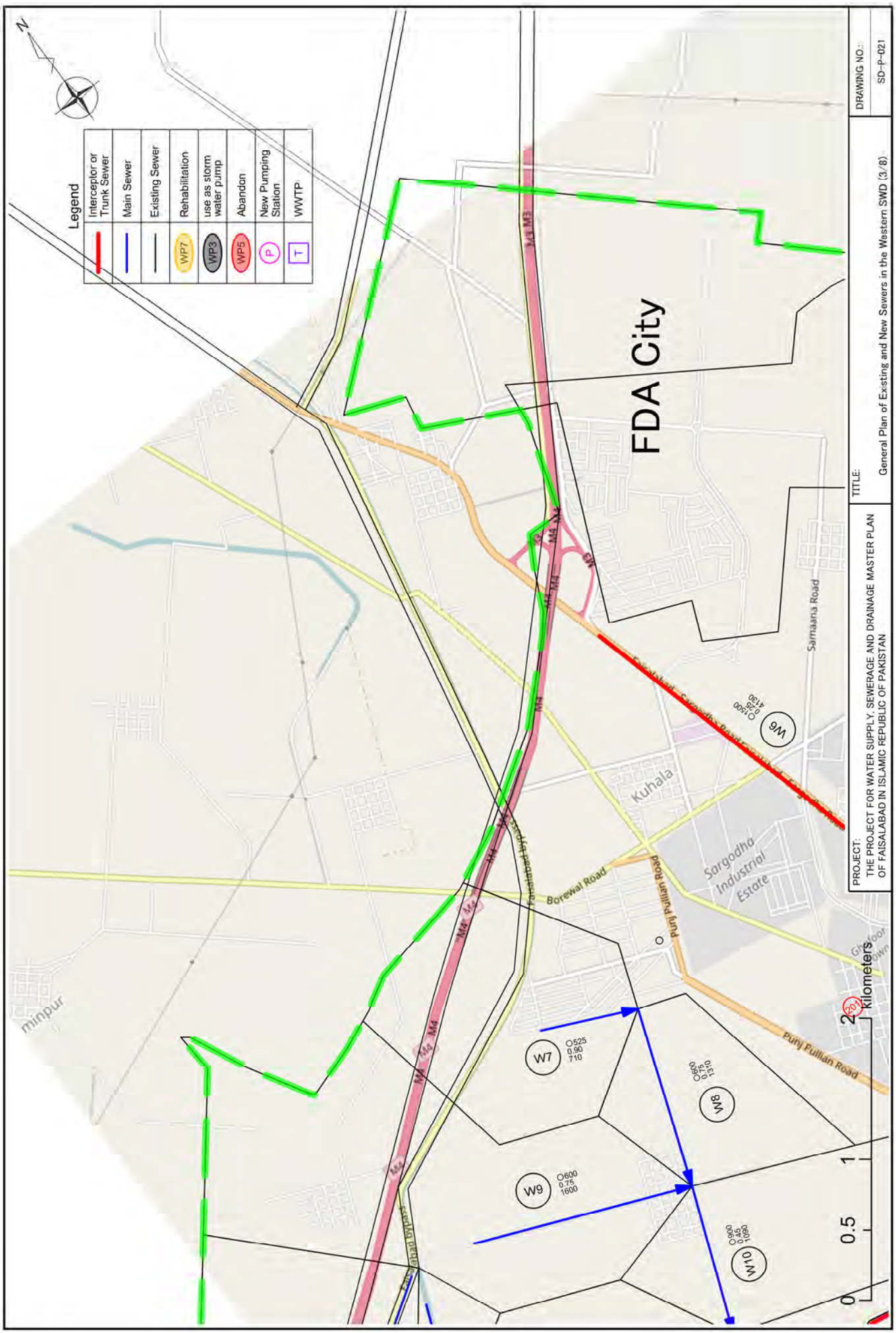
Table AC11.2.2 General Plan of the Sewer System in the Eastern Sewerage District

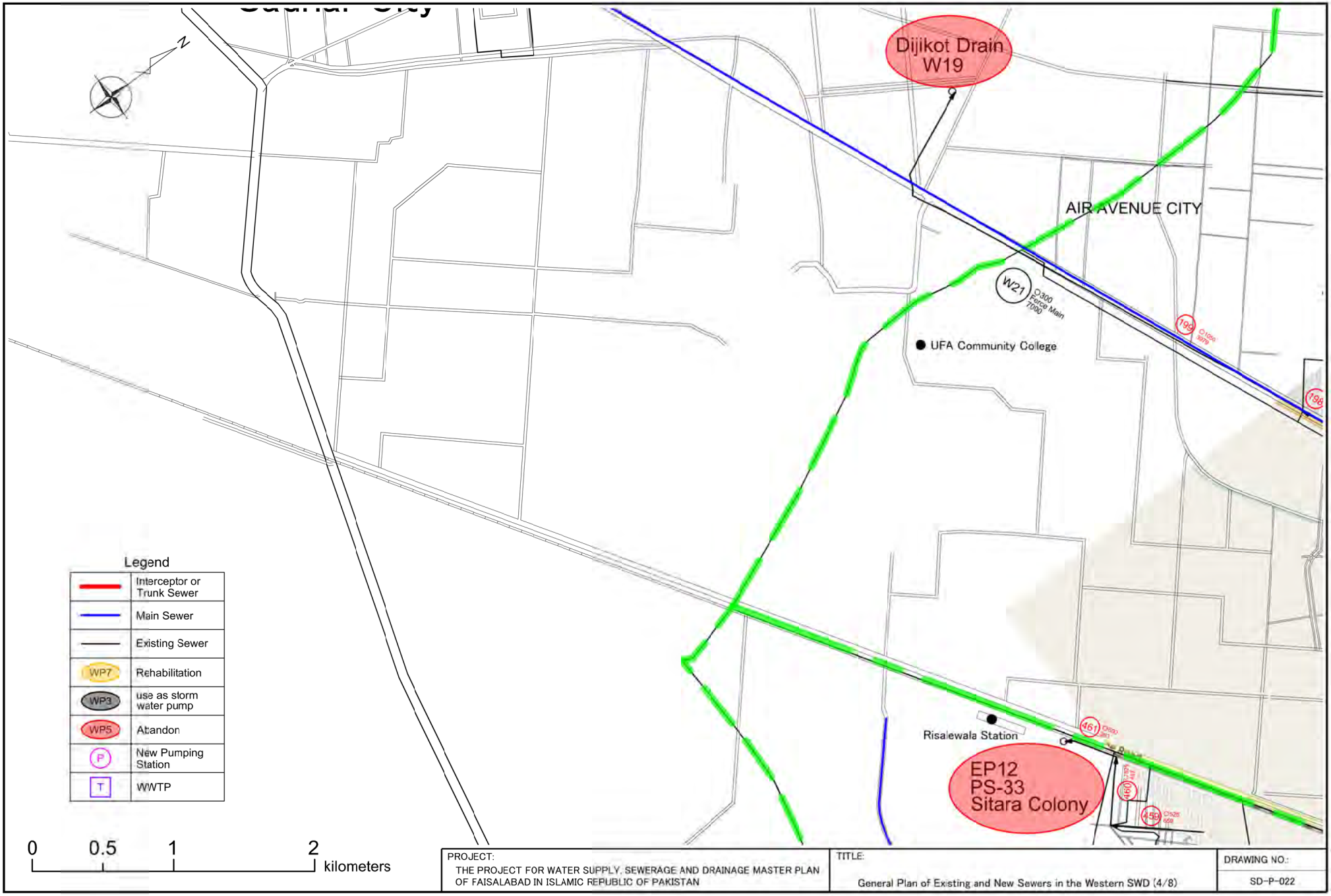
Drawing No.	Contents
SD-P- 027	Key Plan of Existing and New Sewers in the Eastern Sewerage District (SWD)
SD-P- 028	General Plan of Existing and New Sewers in the Eastern SWD (1/11)
SD-P- 029	General Plan of Existing and New Sewers in the Eastern SWD (2/11)
SD-P- 030	General Plan of Existing and New Sewers in the Eastern SWD (3/11)
SD-P- 031	General Plan of Existing and New Sewers in the Eastern SWD (4/11)
SD-P- 032	General Plan of Existing and New Sewers in the Eastern SWD (5/11)
SD-P- 033	General Plan of Existing and New Sewers in the Eastern SWD (6/11)
SD-P- 034	General Plan of Existing and New Sewers in the Eastern SWD (7/11)
SD-P- 035	General Plan of Existing and New Sewers in the Eastern SWD (8/11)
SD-P- 036	General Plan of Existing and New Sewers in the Eastern SWD (9/11)
SD-P- 037	General Plan of Existing and New Sewers in the Eastern SWD (10/11)
SD-P- 038	General Plan of Existing and New Sewers in the Eastern SWD (11/11)

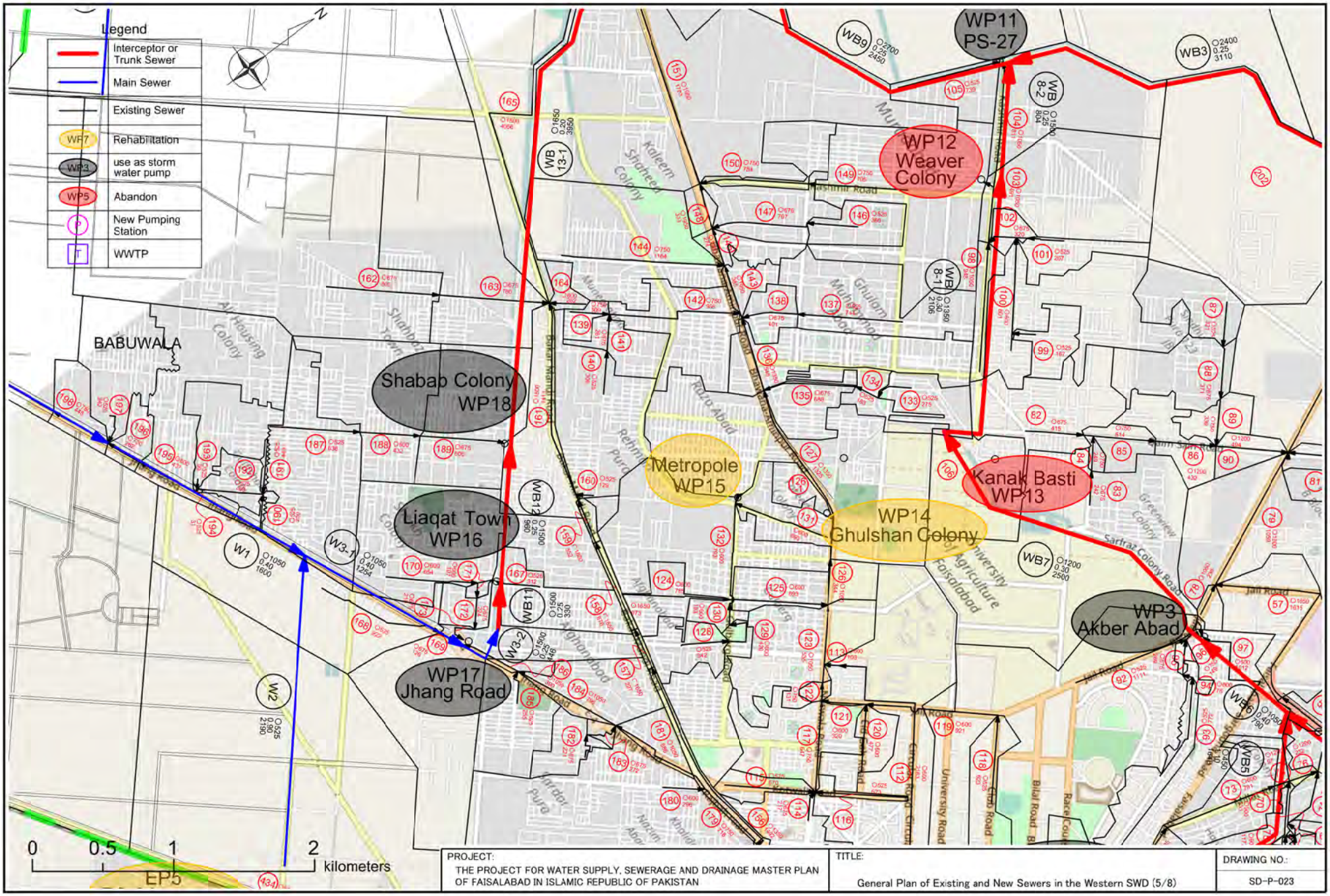

1/8
2/8
3/8
4/8
5/8
6/8
7/8
8/8
Sadhar City
FDA City
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
WP7 Rehabilitation
WP3 use as storm water pump
WP5 Abandon
P New Pumping Station
T WWTP
0 1 2 3 kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
Key Plan of Existing and New Sewers in the Western Sewerage District(SWD)
DRAWING NO.:
SD-P-018

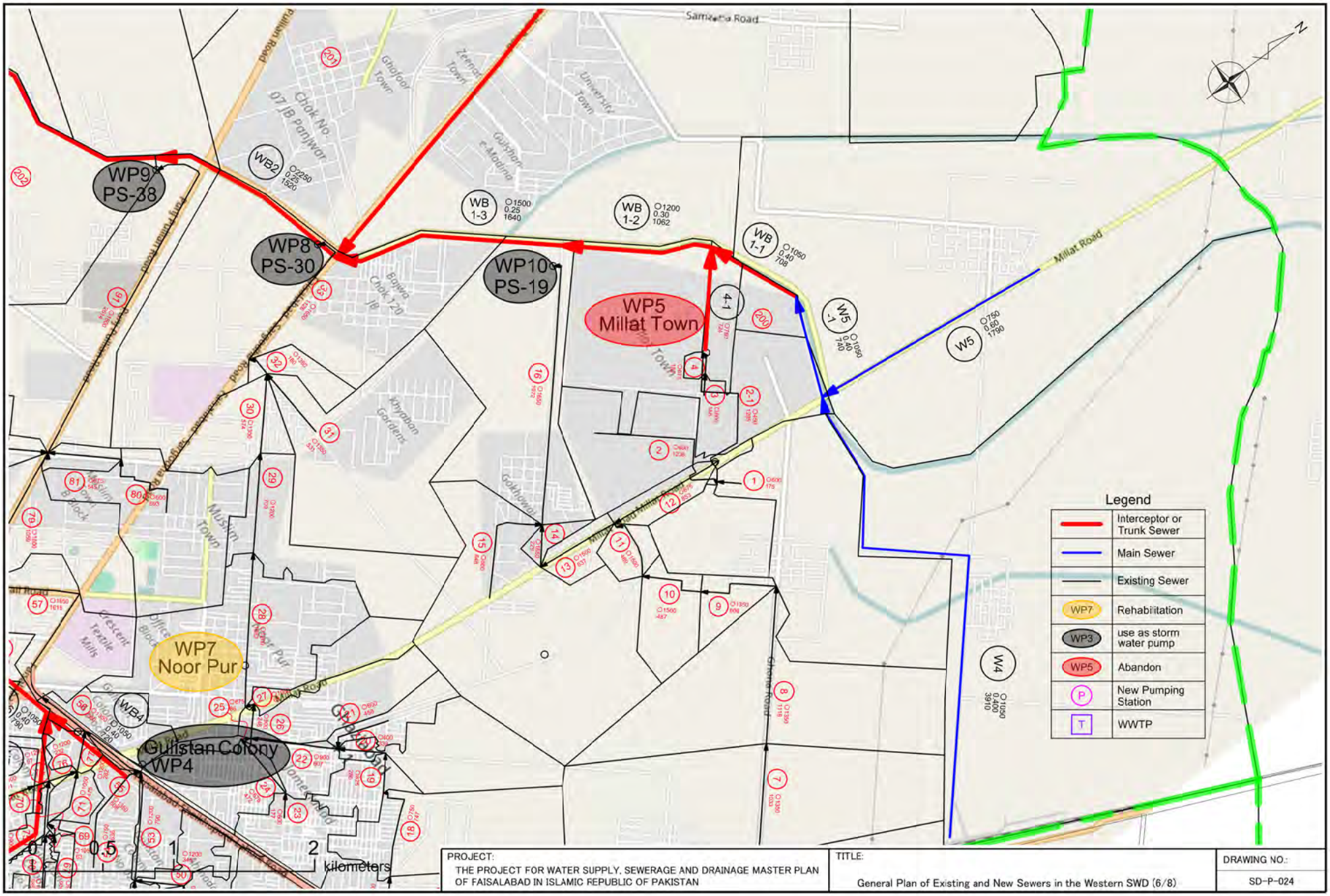

N
S1
S2
S3
S4
Sadhar City
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
WP7
Rehabilitation
WP3
use as storm water pump
WP5
Abandon
P
New Pumping Station
T
WWTP
0
0.5
1
2
kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE
General Plan of Existing and New Sewers in the Western SWD (1/8)
DRAWING NO.:
SD-P-019

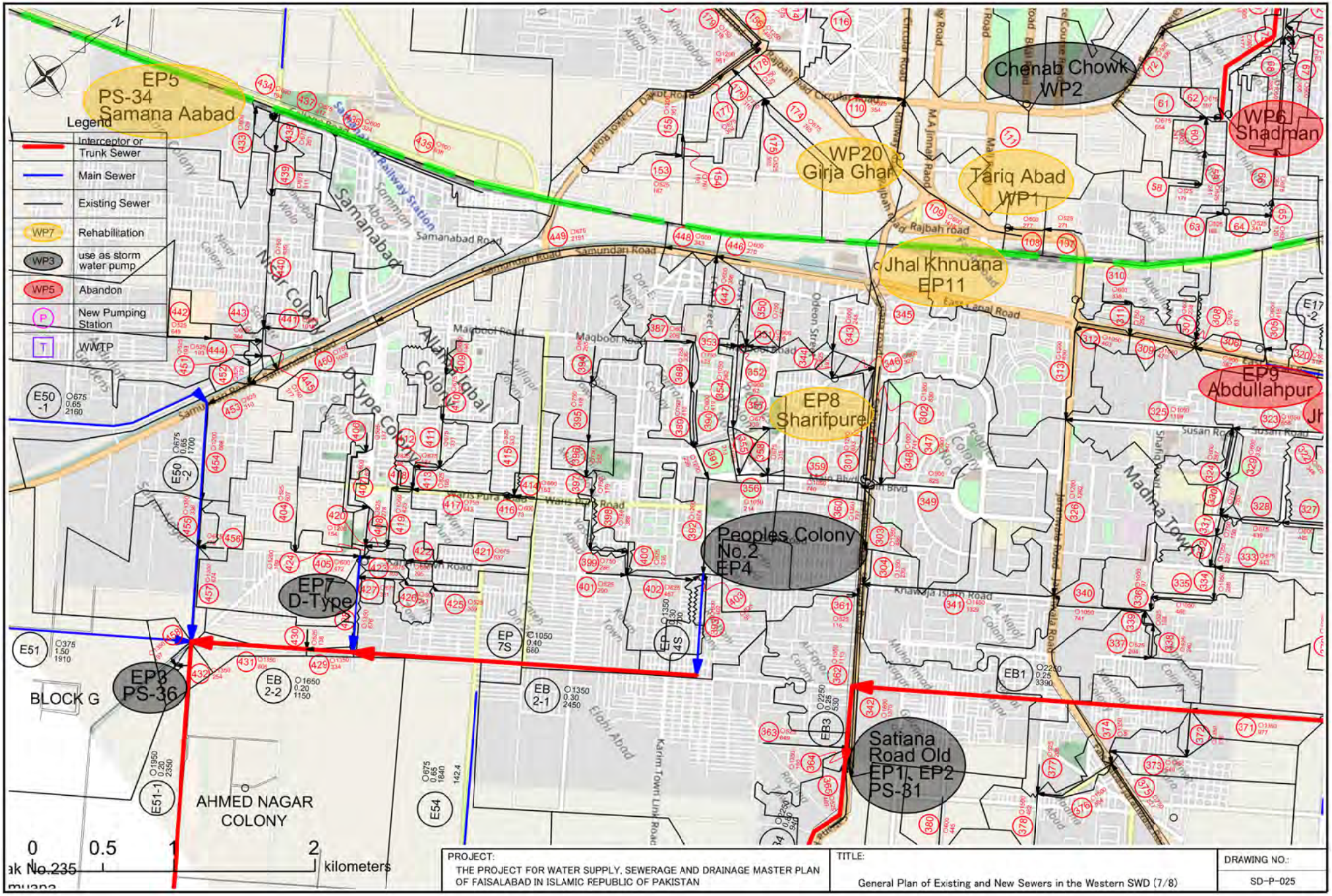

Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
WP7 Rehabilitation
WP3 use as storm water pump
WP6 Abandon
P New Pumping Station
T WWTP
Chokera Sewage Treatment
T
P
WP21 PS-3
WP11 PS-27
W14
W15
W13
W13-1
W12
W11
W16
W20
W19
W18
W17
WB 13-2
WB10
WB9
N
0 0.5 1 2 kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Western SWD (2/8)
DRAWING NO.:
SD-P-020

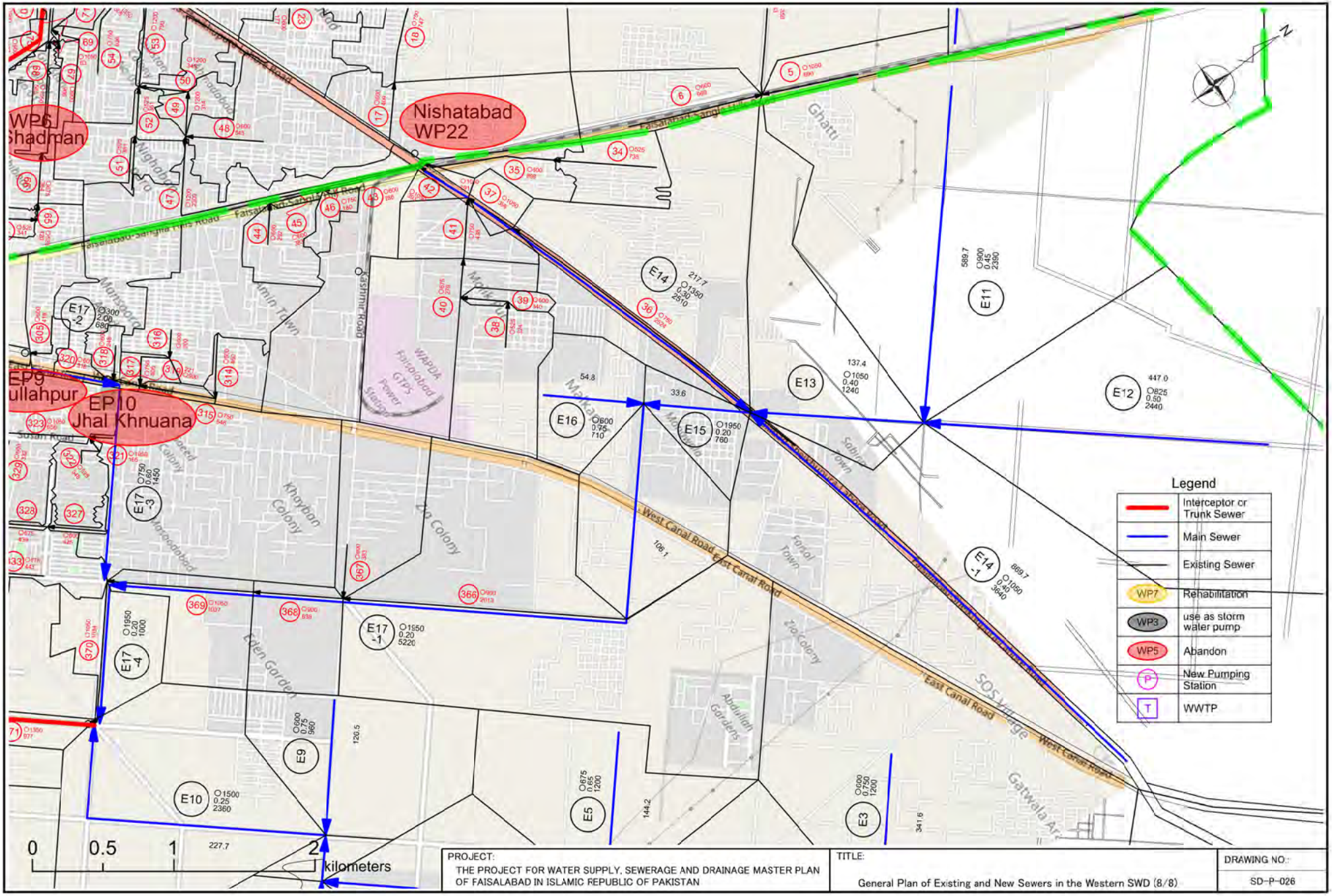

Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
WP7 Rehabilitation
WP3 use as storm water pump
WP5 Abandon
P New Pumping Station
T WWTP
FDA City
Kuhala
Sargodha Industrial Estate
Borewal Road
Punj Pullian Road
Sarnaana Road
Faisalabad bypass
minpur
W6
W7
W8
W9
W10
0 0.5 1 2 kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Western SWD (3/8)
DRAWING NO.:
SD-P-021

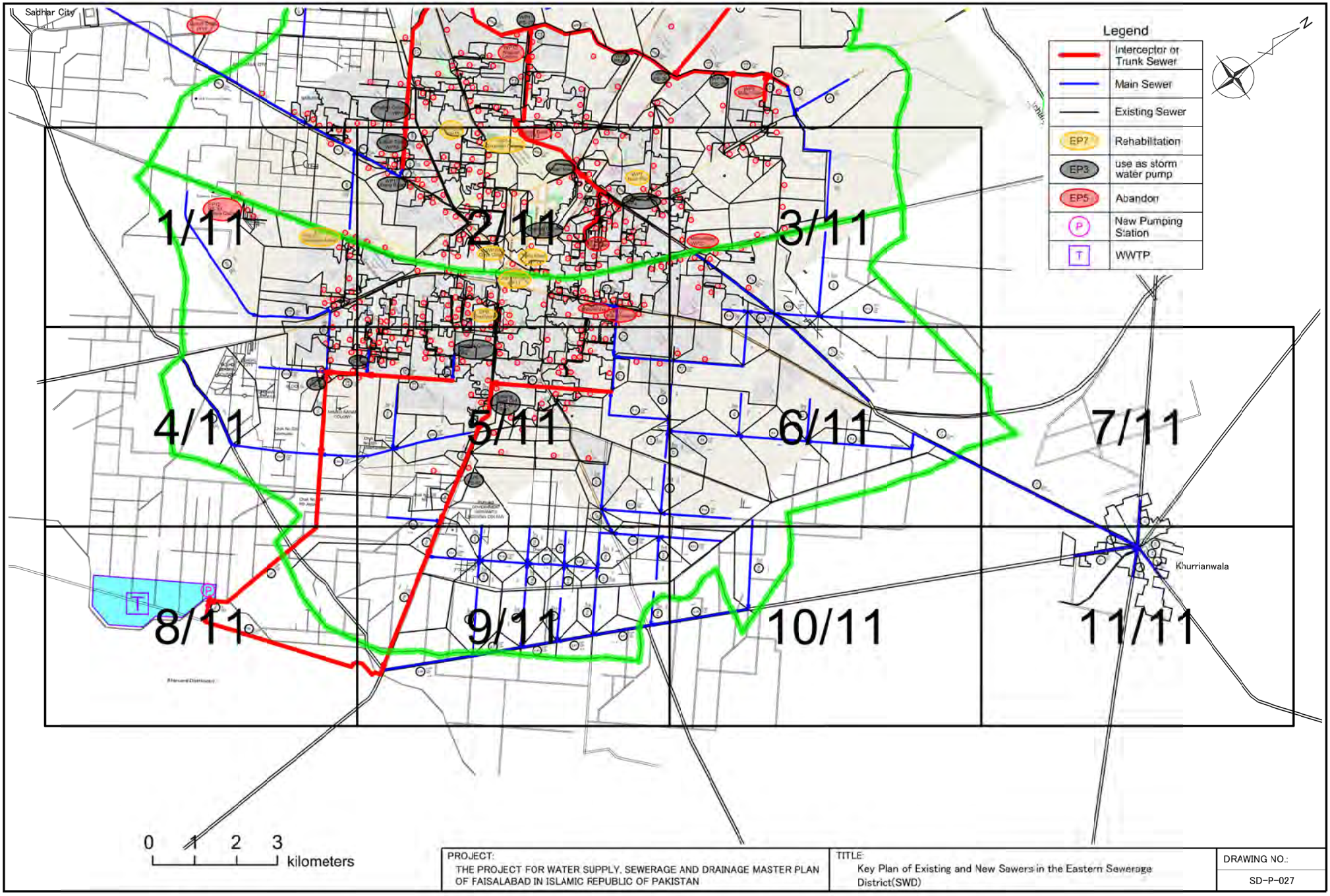

N
Dijikot Drain
W19
AIR AVENUE CITY
W21
Ø300
Force Main
7000
UFA Community College
Risalewala Station
EP12
PS-33
Sitara Colony
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
WP7
Rehabilitation
WP3
use as storm water pump
WP5
Abandon
P
New Pumping Station
T
WWTP
0
0.5
1
2
kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Western SWD (4/8)
DRAWING NO.:
SD-P-022

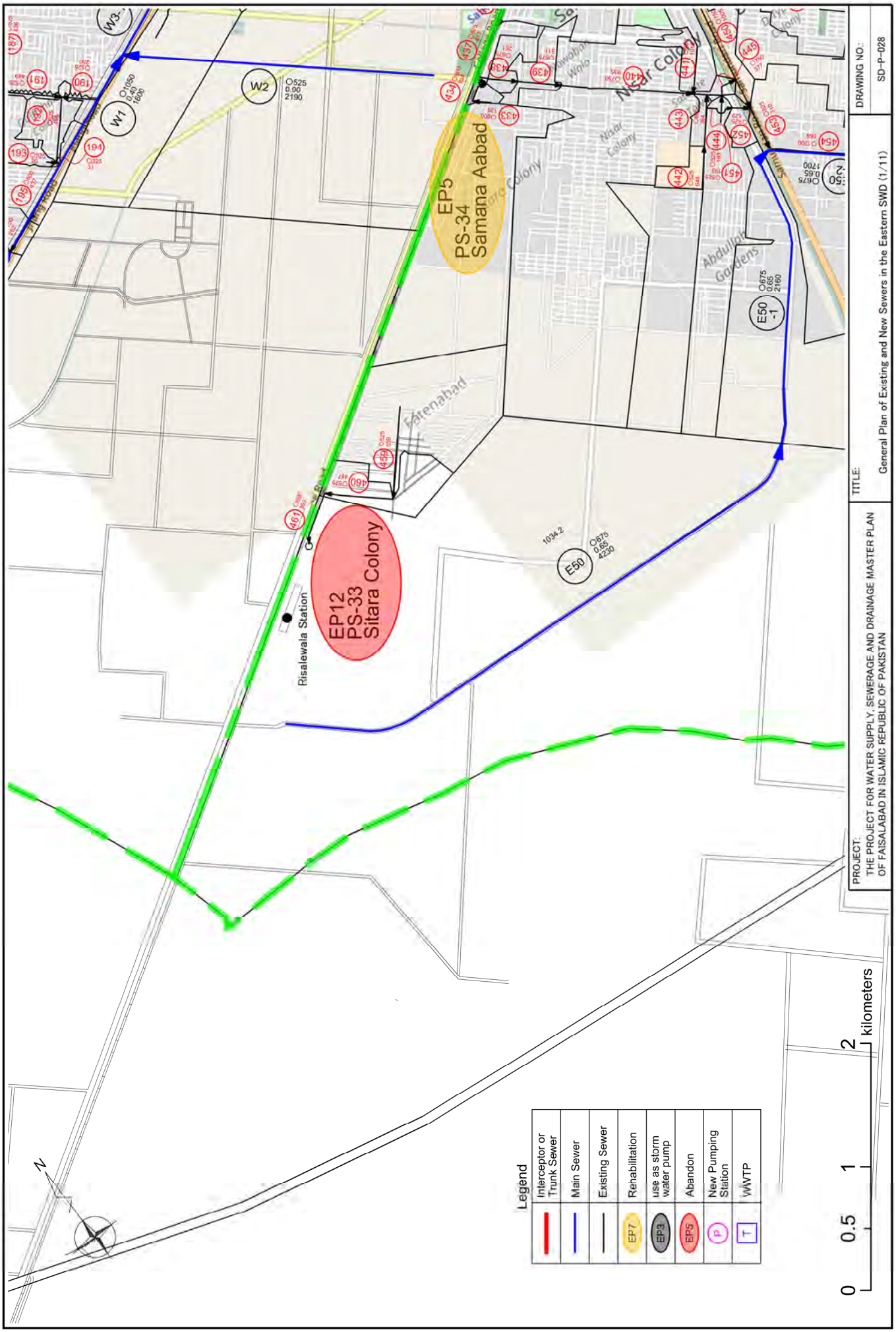

Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
WP7 Rehabilitation
WP3 use as storm water pump
WP5 Abandon
New Pumping Station
WWTP
WP11 PS-27
WP12 Weaver Colony
WP13 Kanak Basti
WP14 Ghulshan Colony
WP15 Metropole
WP16 Liaqat Town
WP17 Jhang Road
WP18 Shabab Colony
WP3 Akber Abad
BABUWALA
0 0.5 1 2 kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Western SWD (5/8)
DRAWING NO.:
SD-P-023


WP9
PS-38
WP8
PS-30
WP10
PS-19
WP5
Millat Town
WP7
Noor Pur
Gulistan Colony
WP4
WB2
WB
1-3
WB
1-2
WB
1-1
W5
-1
W5
W4
WB4
Millat Road
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
WP7
Rehabilitation
WP3
use as storm water pump
WP5
Abandon
P
New Pumping Station
T
WWTP
0
0.5
1
2
kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Western SWD (6/8)
DRAWING NO.:
SD-P-024

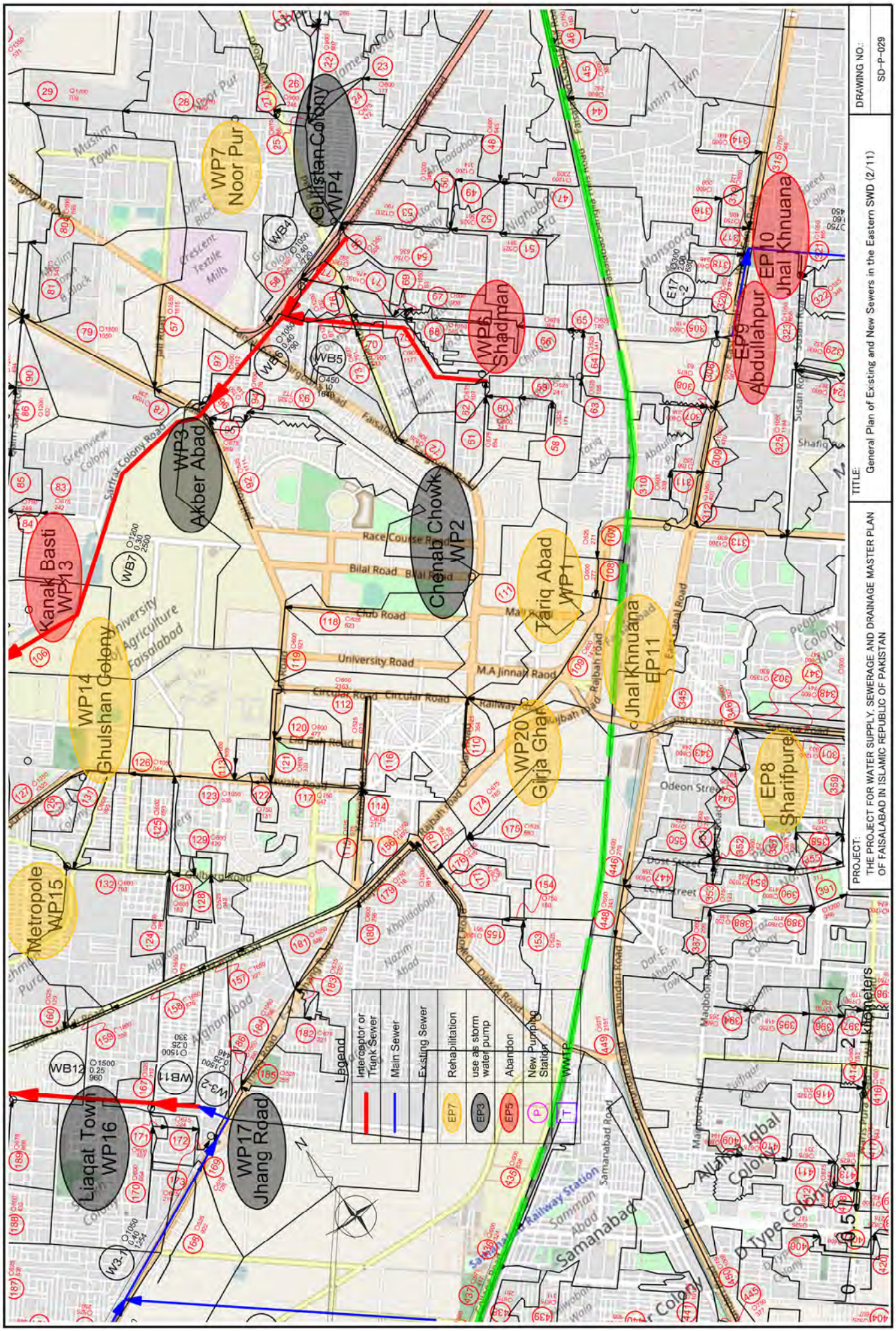

EP5
PS-34
Samana Aabad
Chenab Chowk
WP2
WP6
Shadman
WP20
Girja Ghar
Tariq Abad
WP1
Jhal Khnuana
EP11
EP8
Sharifpure
EP9
Abdullahpur
Peoples Colony
No.2
EP4
EP7
D-Type
EP3
PS-36
Satiana
Road Old
EP1, EP2
PS-31
BLOCK G
AHMED NAGAR
COLONY
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
Rehabilitation
use as storm water pump
Abandon
New Pumping Station
WWTP
0
0.5
1
2
kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Western SWD (7/8)
DRAWING NO.:
SD-P-025


Nishatabad
WP22
WP6
Shadman
EP9
ullahpur
EP10
Jhal Khnuana
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
WP7 Rehabilitation
WP3 use as storm water pump
WP5 Abandon
P New Pumping Station
T WWTP
0 0.5 1 2 kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Western SWD (8/8)
DRAWING NO.:
SD-P-026

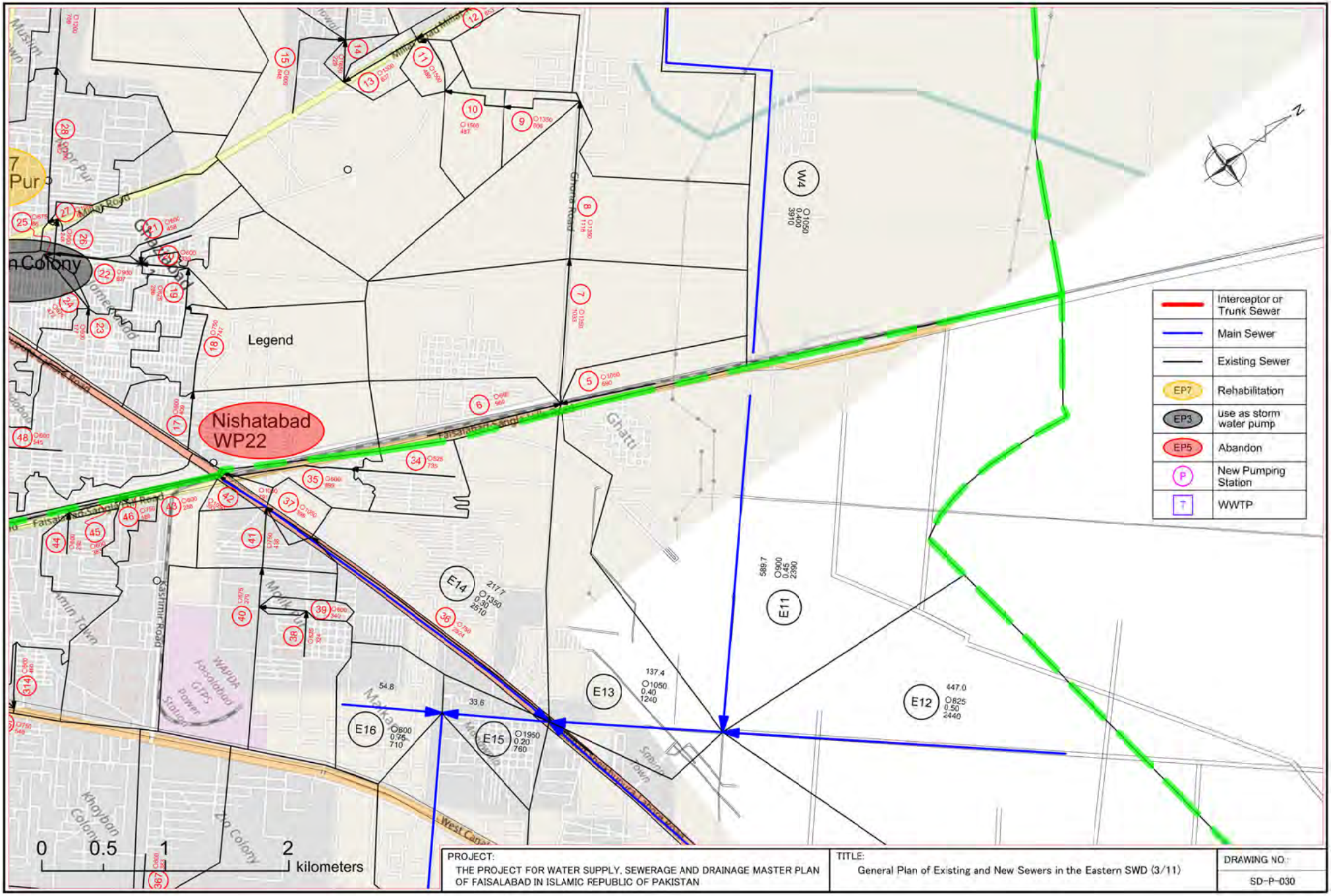

Sadhar City
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
EP7 Rehabilitation
EP3 use as storm water pump
EP5 Abandon
P New Pumping Station
T WWTP
N
1/11
2/11
3/11
4/11
5/11
6/11
7/11
8/11
9/11
10/11
11/11
Khurrianwala
0 1 2 3 kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
Key Plan of Existing and New Sewers in the Eastern Sewerage District(SWD)
DRAWING NO.:
SD-P-027

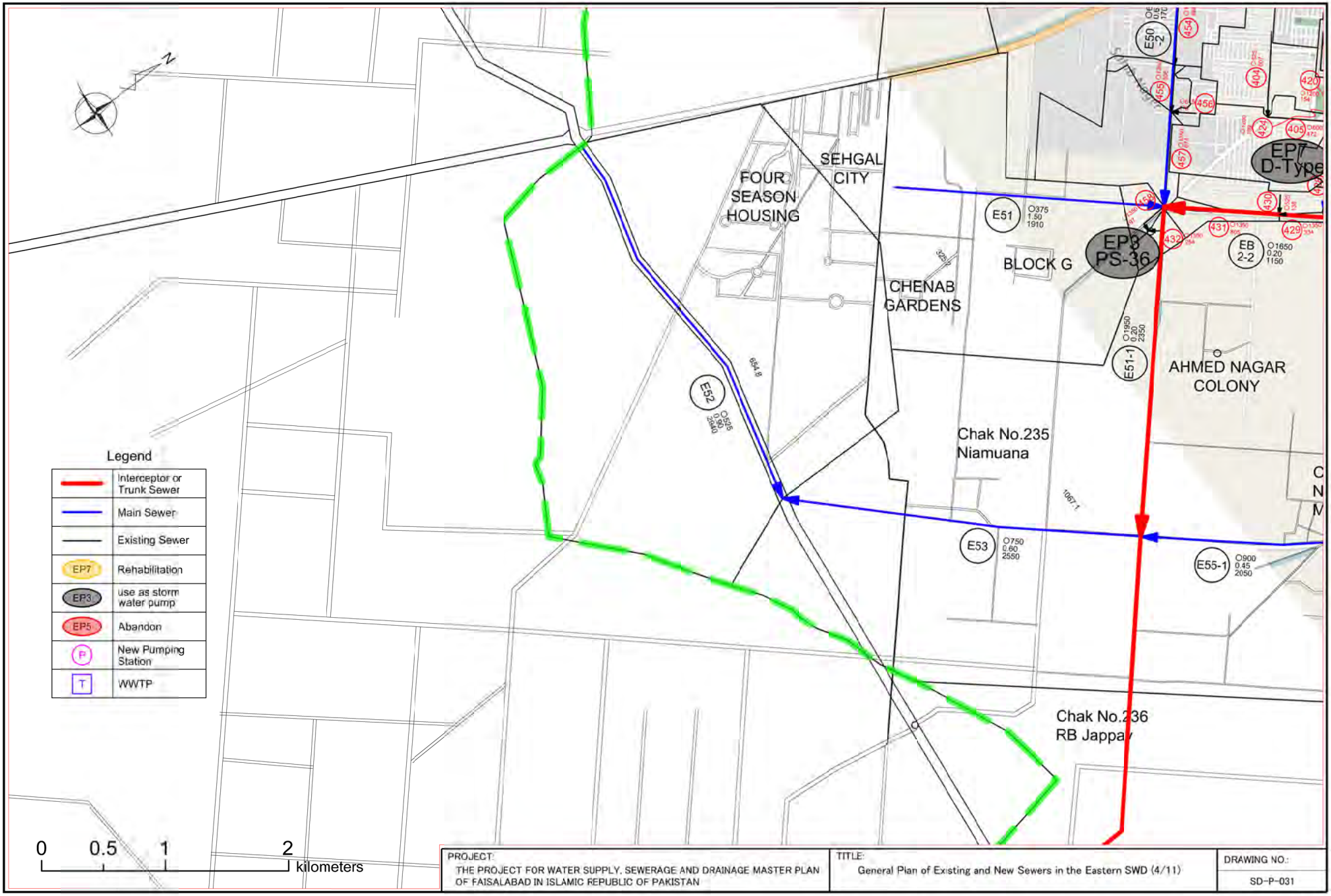


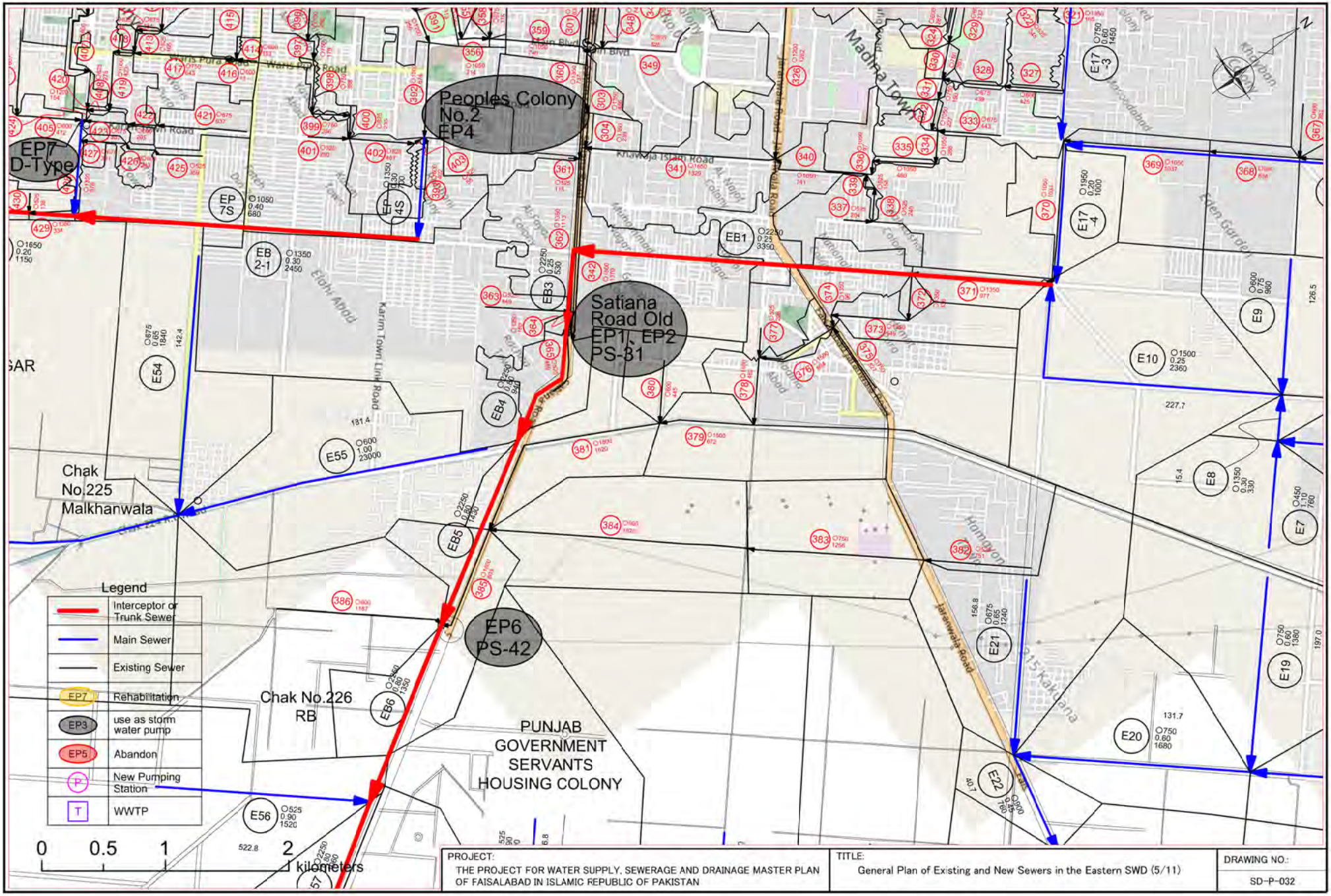
EP5
PS-34
Samana Aabad
EP12
PS-33
Sitara Colony
Risalewala Station
Fatenabad
Nisar Colony
Abdullah Gardens
W1
W2
E50
E50 -1
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
Rehabilitation
use as storm water pump
Abandon
New Pumping Station
WWTP
0
0.5
1
2
kilometers
N
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Eastern SWD (1/11)
DRAWING NO.:
SD-P-028

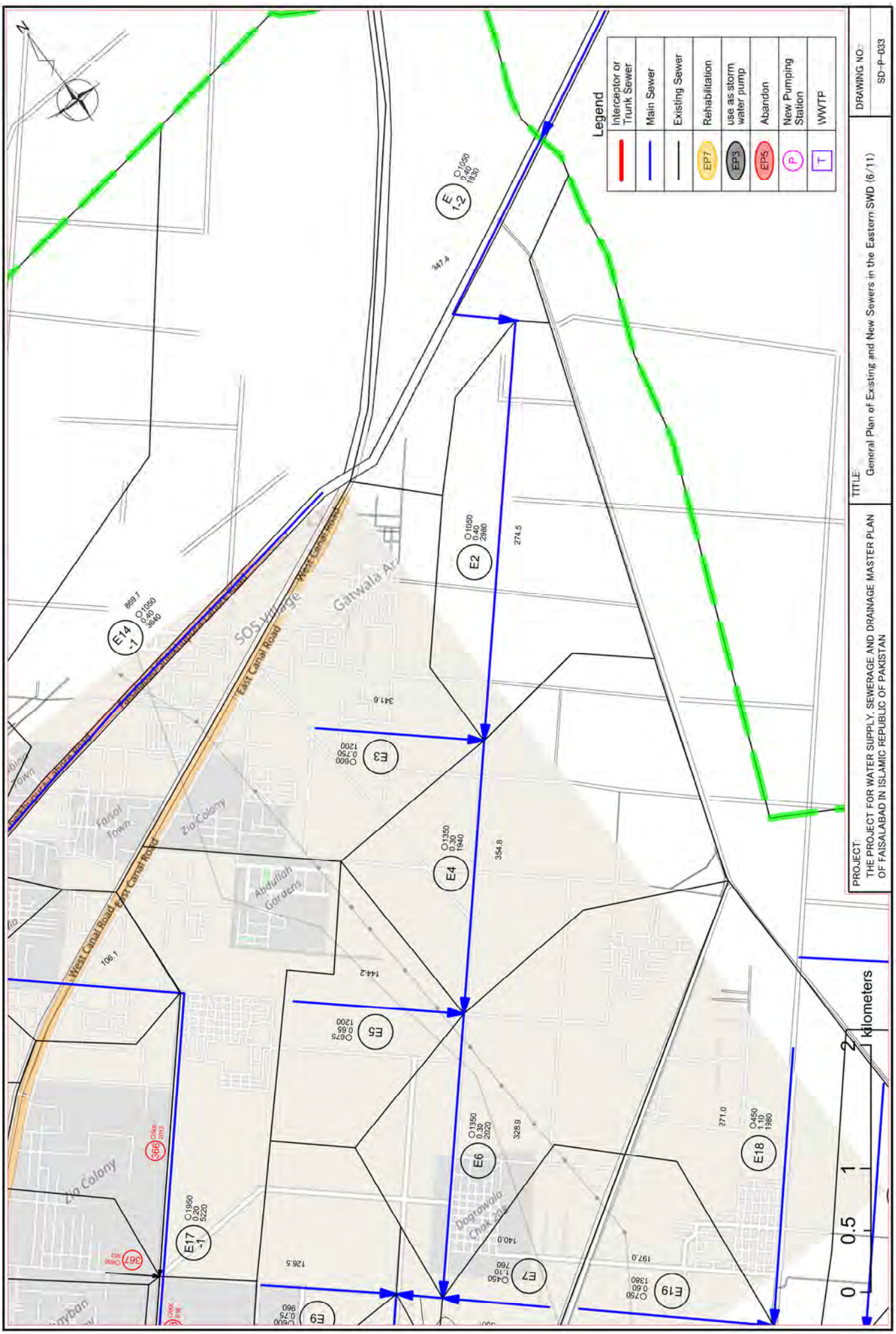


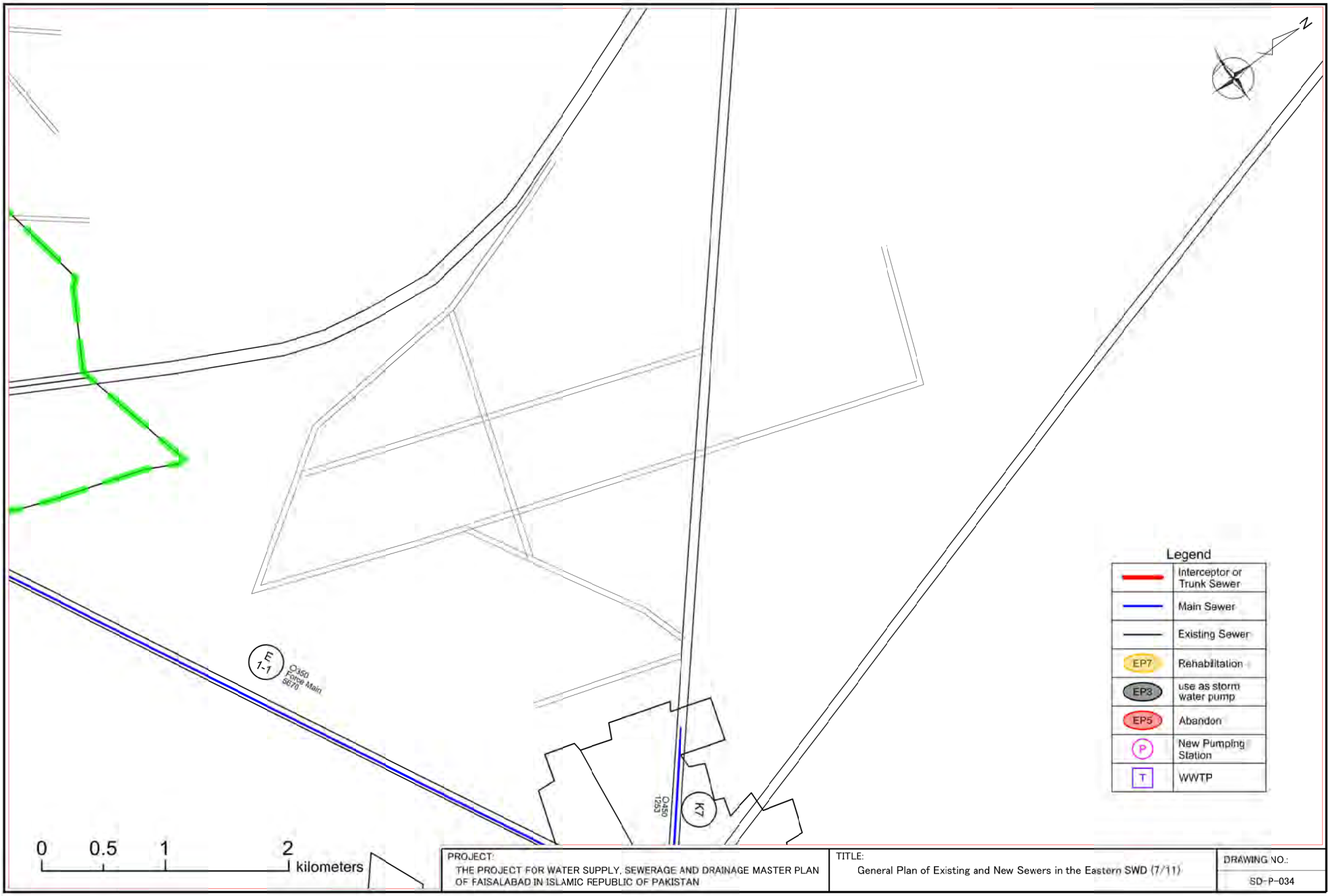
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Eastern SWD (2/11)
DRAWING NO.:
SD-P-029
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
Rehabilitation
use as storm water pump
Abandon
New Pumping Station
WWTP
WP7 Noor Pur
Gulistan Colony WP4
WP6 Shadman
EP10 Jhal Khnuana
EP9 Abdullahpur
WP3 Akber Abad
Chenab Chowk WP2
Tariq Abad WP1
Kanak Basti WP13
WP14 Ghulshan Colony
Jhal Khnuana EP11
WP20 Girja Ghar
EP8 Sharifpure
Metropole WP15
Liaqat Town WP16
WP17 Jhang Road
Race Course Road
Bilal Road
Club Road
University Road
M.A Jinnah Raod
Circular Road
Railway
Odeon Street
Samanabad
Allama Iqbal Colony
D Type Colony

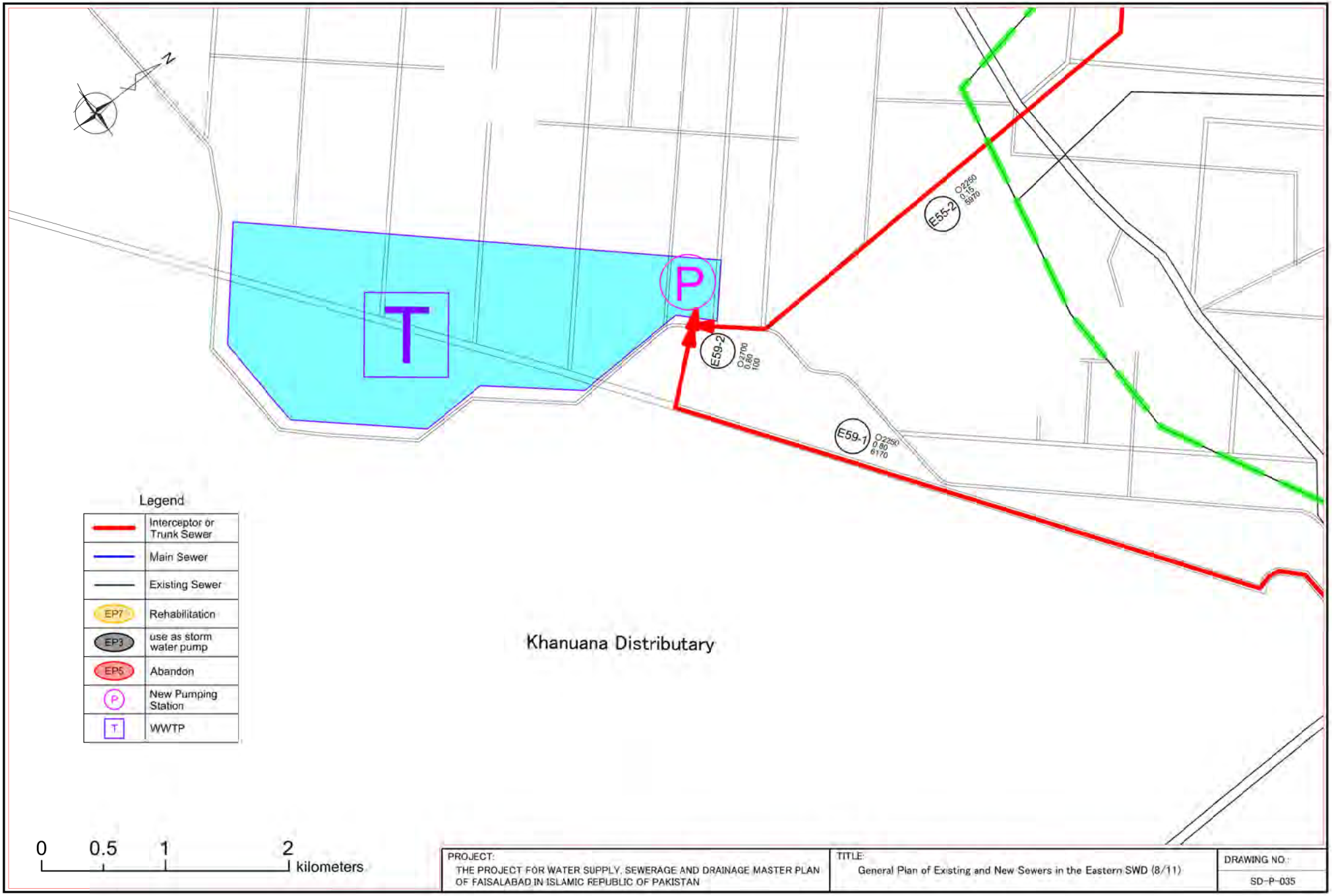

Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
EP7 Rehabilitation
EP3 use as storm water pump
EP5 Abandon
P New Pumping Station
T WWTP
Nishatabad WP22
W4
E11
E12
E13
E14
E15
E16
0 0.5 1 2 kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Eastern SWD (3/11)
DRAWING NO.:
SD-P-030

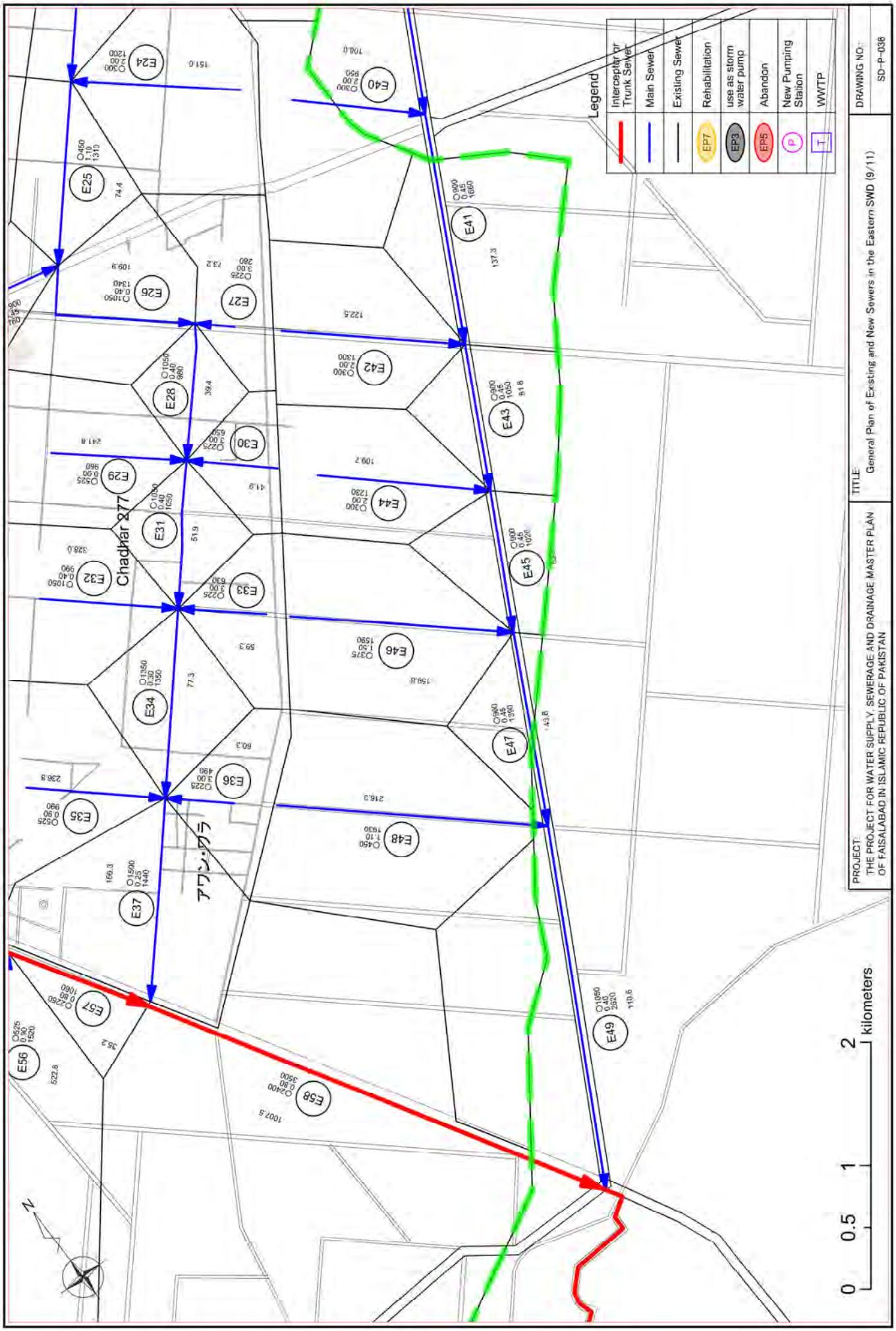

FOUR SEASON HOUSING
SEHGAL CITY
CHENAB GARDENS
BLOCK G
AHMED NAGAR COLONY
Chak No.235 Niamuana
Chak No.236 RB Jappa
EP7 D-Type
EP3 PS-36
E50-2
E51
E51-1
E52
E53
E55-1
EB 2-2
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
EP7 Rehabilitation
EP3 use as storm water pump
EP5 Abandon
P New Pumping Station
T WWTP
0 0.5 1 2 kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Eastern SWD (4/11)
DRAWING NO.:
SD-P-031

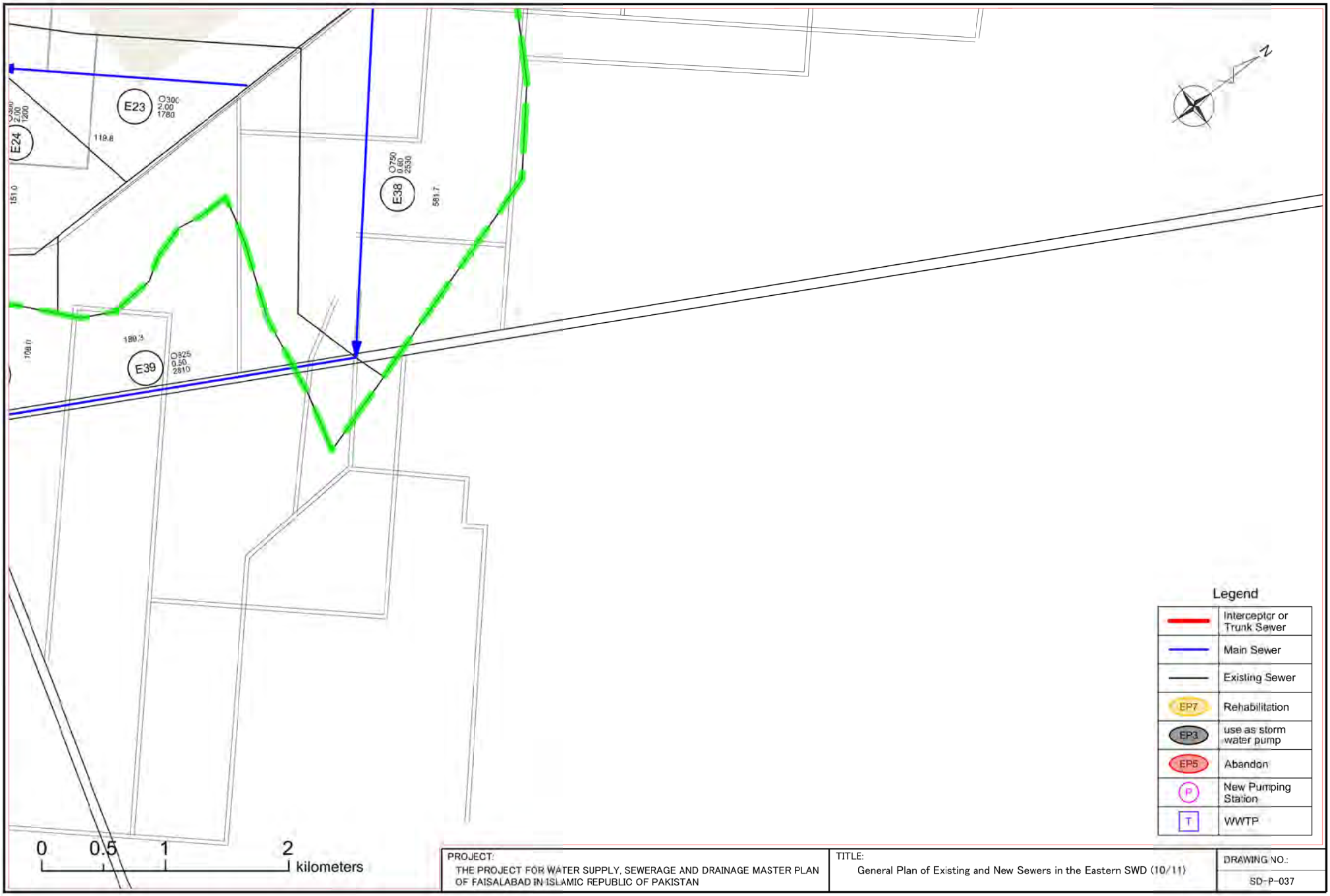

Peoples Colony No.2 EP4
EP7 D-Type
Satiana Road Old EP1, EP2 PS-31
EP6 PS-42
Chak No.225 Malkhanwala
Chak No.226 RB
PUNJAB GOVERNMENT SERVANTS HOUSING COLONY
Madina Town
Karim Town Link Road
Jaranwala Road
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
EP7 Rehabilitation
EP3 use as storm water pump
EP5 Abandon
P New Pumping Station
T WWTP
0 0.5 1 2 kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Eastern SWD (5/11)
DRAWING NO.:
SD-P-032

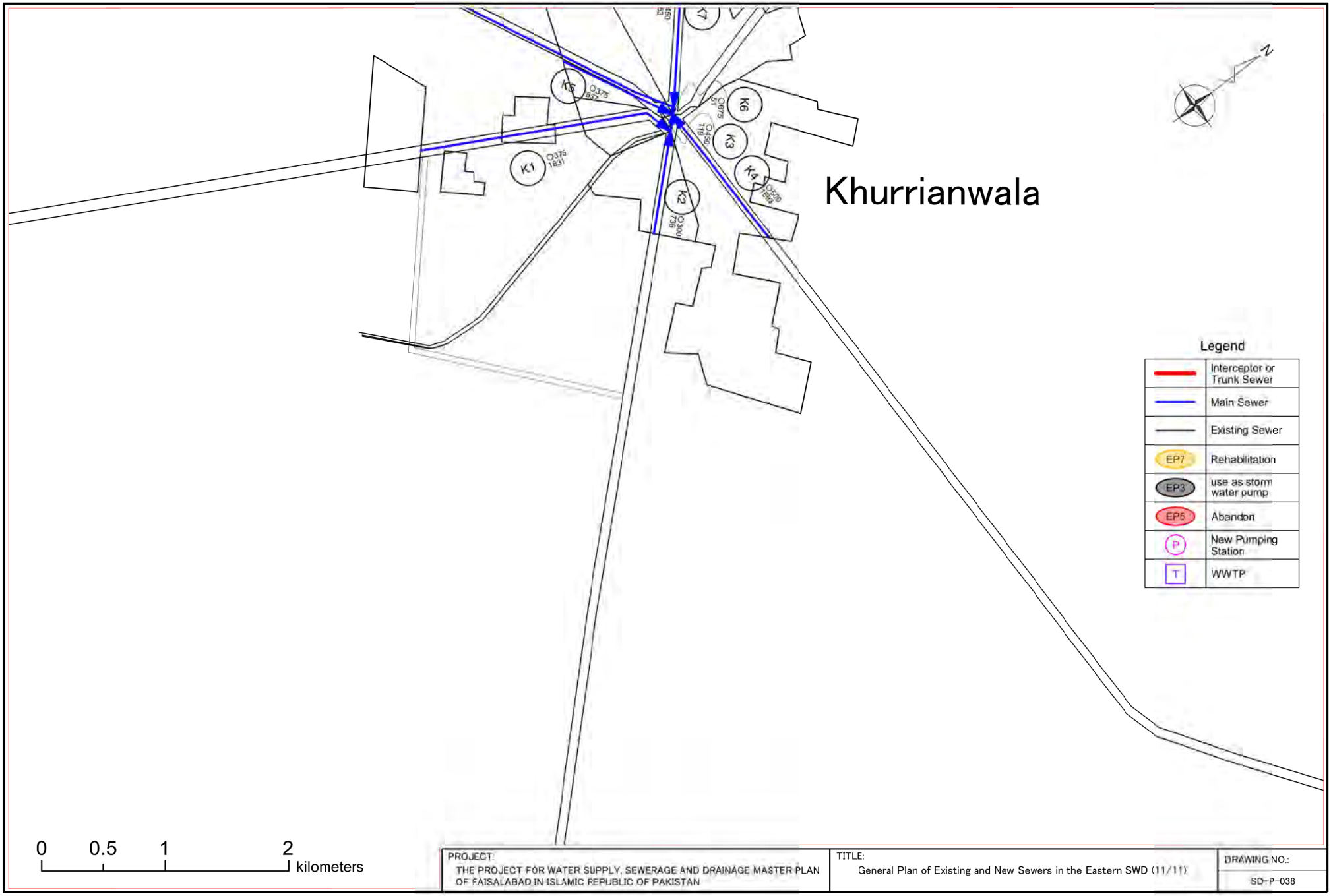

Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
Rehabilitation
use as storm water pump
Abandon
New Pumping Station
WWTP
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Eastern SWD (6/11)
DRAWING NO.:
SD-P-033
kilometers
0
0.5
1
2
E 1-2
E2
E3
E4
E5
E6
E7
E9
E14 -1
E17 -1
E18
E19
SOS Village
Gatwala Ar
East Canal Road
West Canal Road
Zia Colony
Faisal Town
Abdullah Gardens
Dograwala Chak 20
347.4
274.5
341.6
354.8
144.2
328.9
271.0
140.0
126.5
197.0
106.1
869.7


N
E 1-1
Ø450 Force Main 5670
K7
Ø450 1253
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
EP7
Rehabilitation
EP3
use as storm water pump
EP5
Abandon
P
New Pumping Station
T
WWTP
0
0.5
1
2
kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Eastern SWD (7/11)
DRAWING NO.:
SD-P-034


N
T
P
E55-2
O2250
0.75
5970
E59-2
O2700
0.80
100
E59-1
O2250
0.80
6170
Khanuana Distributary
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
EP7
Rehabilitation
EP3
use as storm water pump
EP5
Abandon
P
New Pumping Station
T
WWTP
0
0.5
1
2
kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Eastern SWD (8/11)
DRAWING NO.:
SD-P-035


Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
Rehabilitation
use as storm water pump
Abandon
New Pumping Station
WWTP
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Eastern SWD (9/11)
DRAWING NO.:
SD-P-036
Chadhar 277
アワン・ワラ
0 0.5 1 2 kilometers


E23
E24
E38
E39
N
0 0.5 1 2 kilometers
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
EP7
Rehabilitation
EP3
use as storm water pump
EP5
Abandon
P
New Pumping Station
T
WWTP
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Eastern SWD (10/11)
DRAWING NO.:
SD-P-037


Khurrianwala
K1
K2
K3
K4
K5
K6
K7
Legend
Interceptor or Trunk Sewer
Main Sewer
Existing Sewer
EP7
Rehabilitation
EP3
use as storm water pump
EP5
Abandon
P
New Pumping Station
T
WWTP
0
0.5
1
2
kilometers
PROJECT:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN
TITLE:
General Plan of Existing and New Sewers in the Eastern SWD (11/11)
DRAWING NO.:
SD-P-038

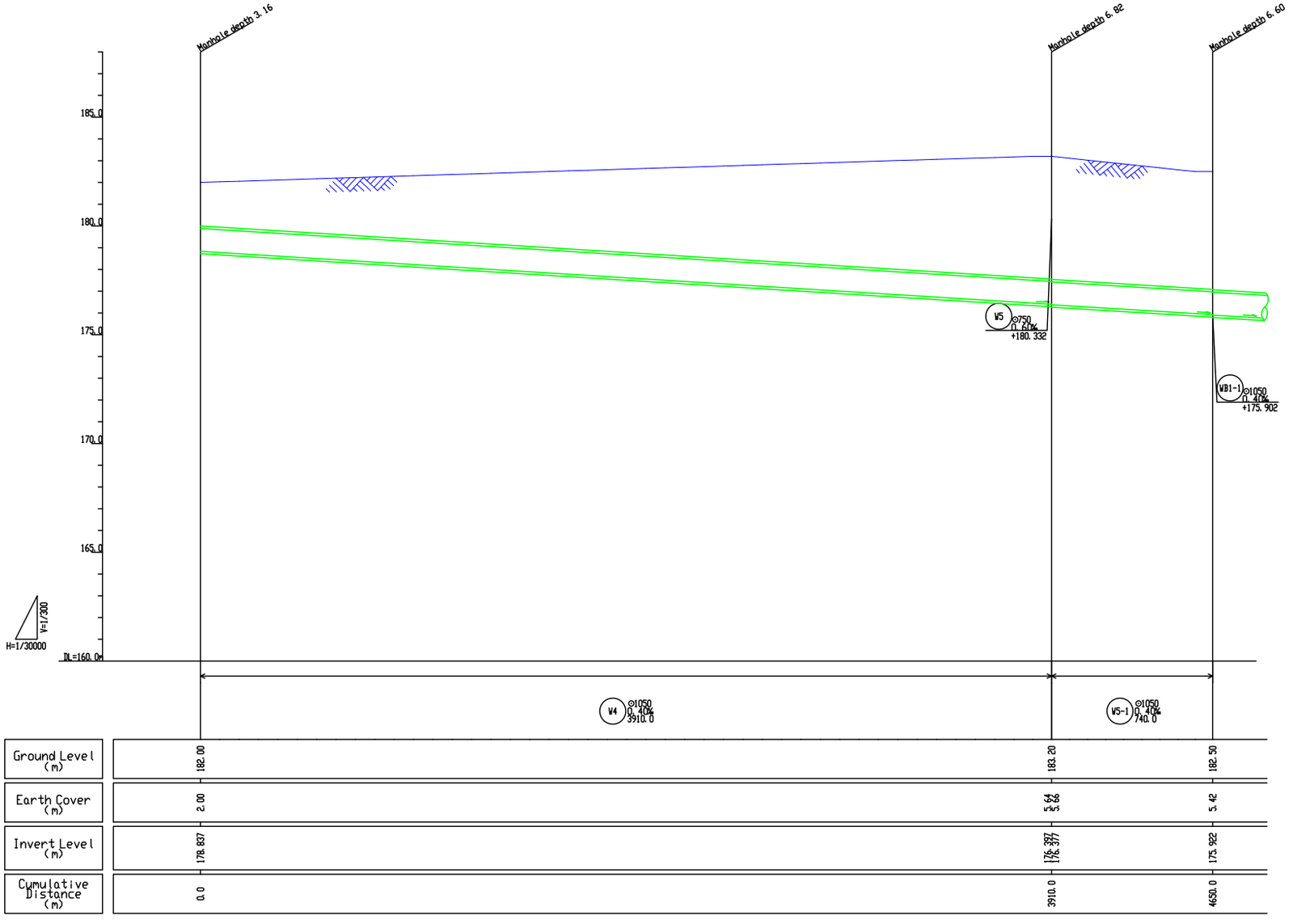
AC11.3 Longitudinal Section of Main, Trunk and Interceptor Sewers

The longitudinal section of main, trunk and interceptor sewers in the western SWD and in the eastern SWD are shown in the following draiwings. The lists of drawings are summarized in the following table.

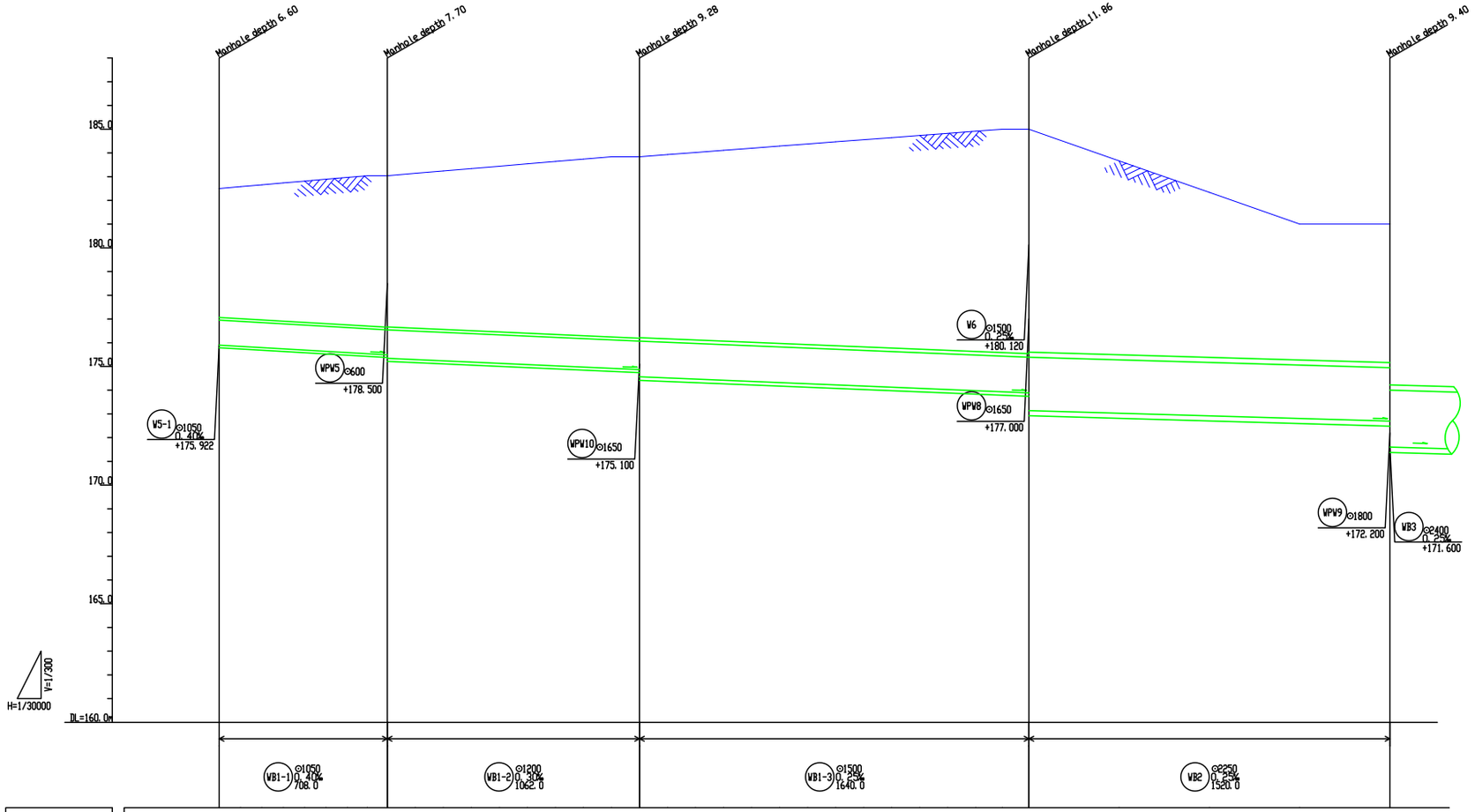
Noted that the data of distance and ground level are read from the Google Earth and the invert levels of the existing sewers at the disposal pumping stations are estimated by the reconnasisance of JICA Mission Team and the ground level provided by the Google Earth. Therefore, the longitudinal sections of Main, Trunk and Interceptor sewers should be reviewed and updated by the series of topographic surveys results in the following stages of Feasibility Study (F/S) and Detailed Design (D/D).

Table AC11.3.1 Longitudinal Section of Major Sewers in the Western SWD

Drawing No.	Contents
SD-P- 039	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (1/18)
SD-P- 040	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (2/18)
SD-P- 041	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (3/18)
SD-P- 042	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (4/18)
SD-P- 043	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (5/18)
SD-P- 044	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (6/18)
SD-P- 045	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (7/18)
SD-P- 046	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (8/18)
SD-P- 047	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (9/18)
SD-P- 048	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (10/18)
SD-P- 049	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (11/18)
SD-P- 050	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (12/18)
SD-P- 051	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (13/18)
SD-P- 052	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (14/18)
SD-P- 053	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (15/18)
SD-P- 054	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (16/18)
SD-P- 055	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (17/18)
SD-P- 056	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Western SWD (18/18)



PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(1/18)	DRAWING NO.: SD-P-039

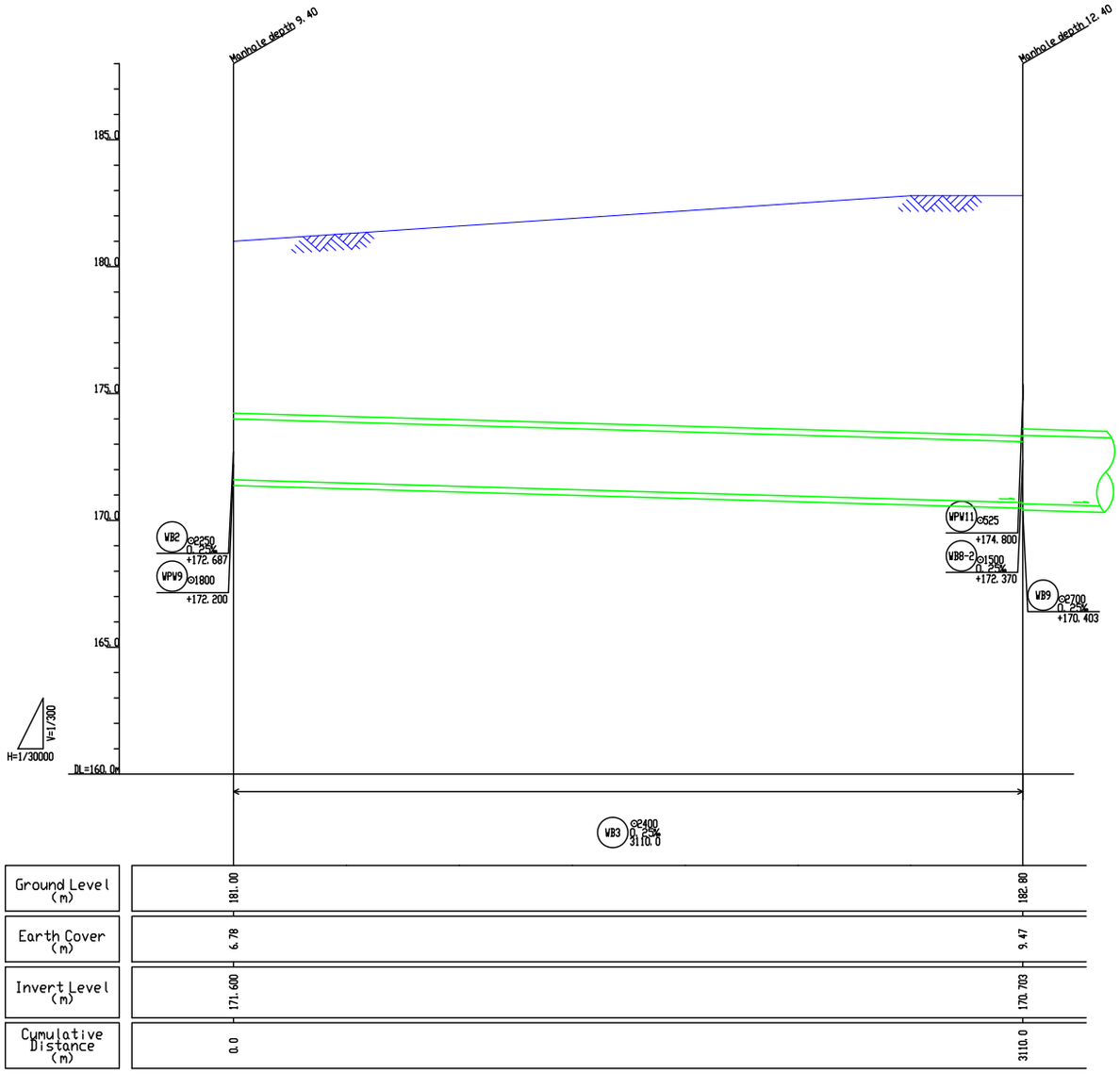


Ground Level (m)	182.50	183.04	183.84	185.00	181.00
Earth Cover (m)	5.44	6.40 6.39	7.66 7.64	8.47 9.41	5.85
Invert Level (m)	175.902	175.428 175.328	174.853 174.633	173.877 173.127	172.687
Cumulative Distance (m)	0.0	708.0	1770.0	3410.0	4930.0

Pipe No.

WB1-1	WB1-2	WB1-3	WB2	

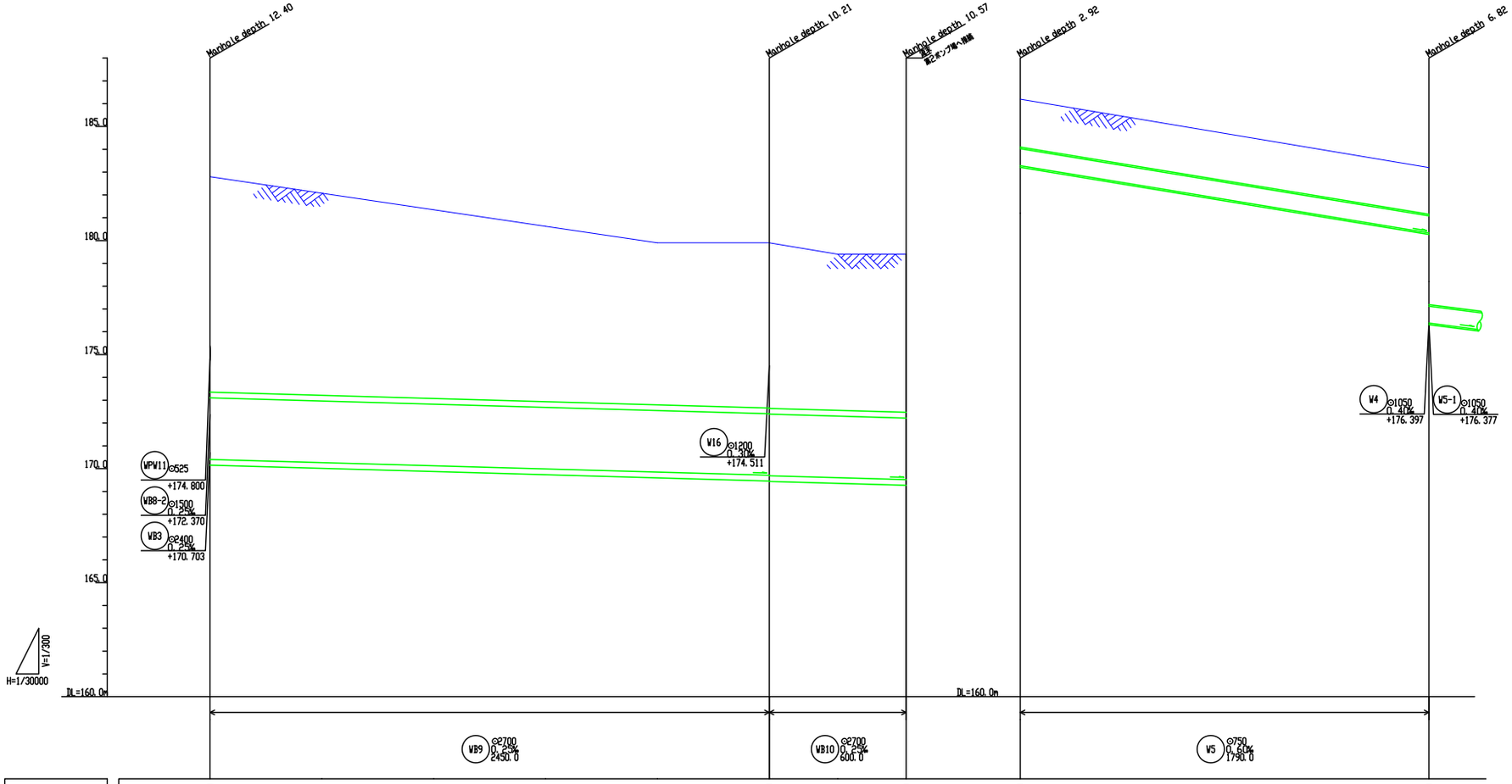
PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(2/18)	DRAWING NO.: SD-P-040



Pipe No.

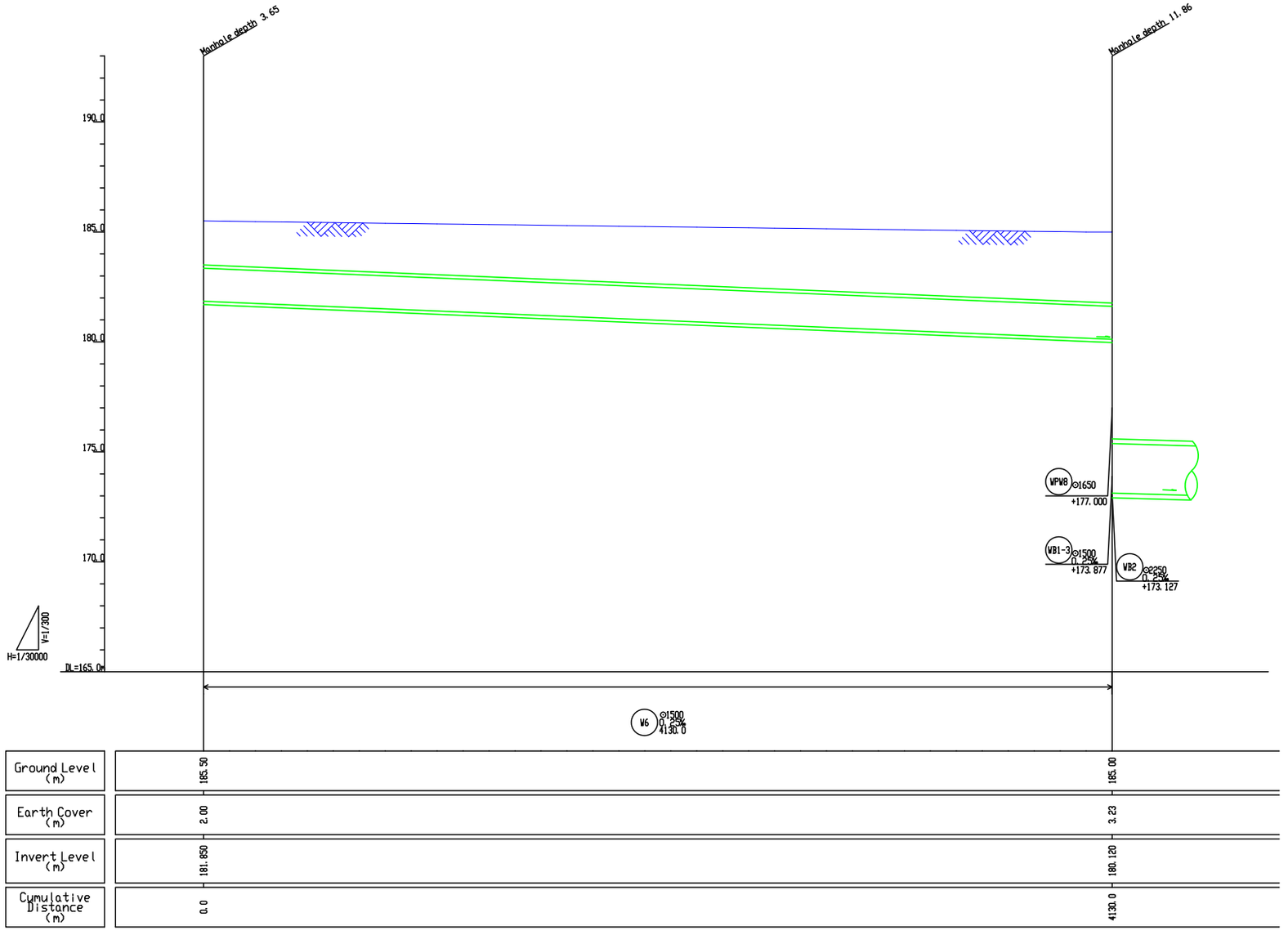
WB3				

PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(3/18)	SD-P-041



Ground Level (m)	182.80	179.90	179.40	186.20	183.20
Earth Cover (m)	9.45	7.24 / 7.26	6.93	2.10	2.05
Invert Level (m)	170.403	169.708 / 169.688	169.518	183.281	180.332
Cumulative Distance (m)	0.0	2450.0	3050.0	0.0	1790.0

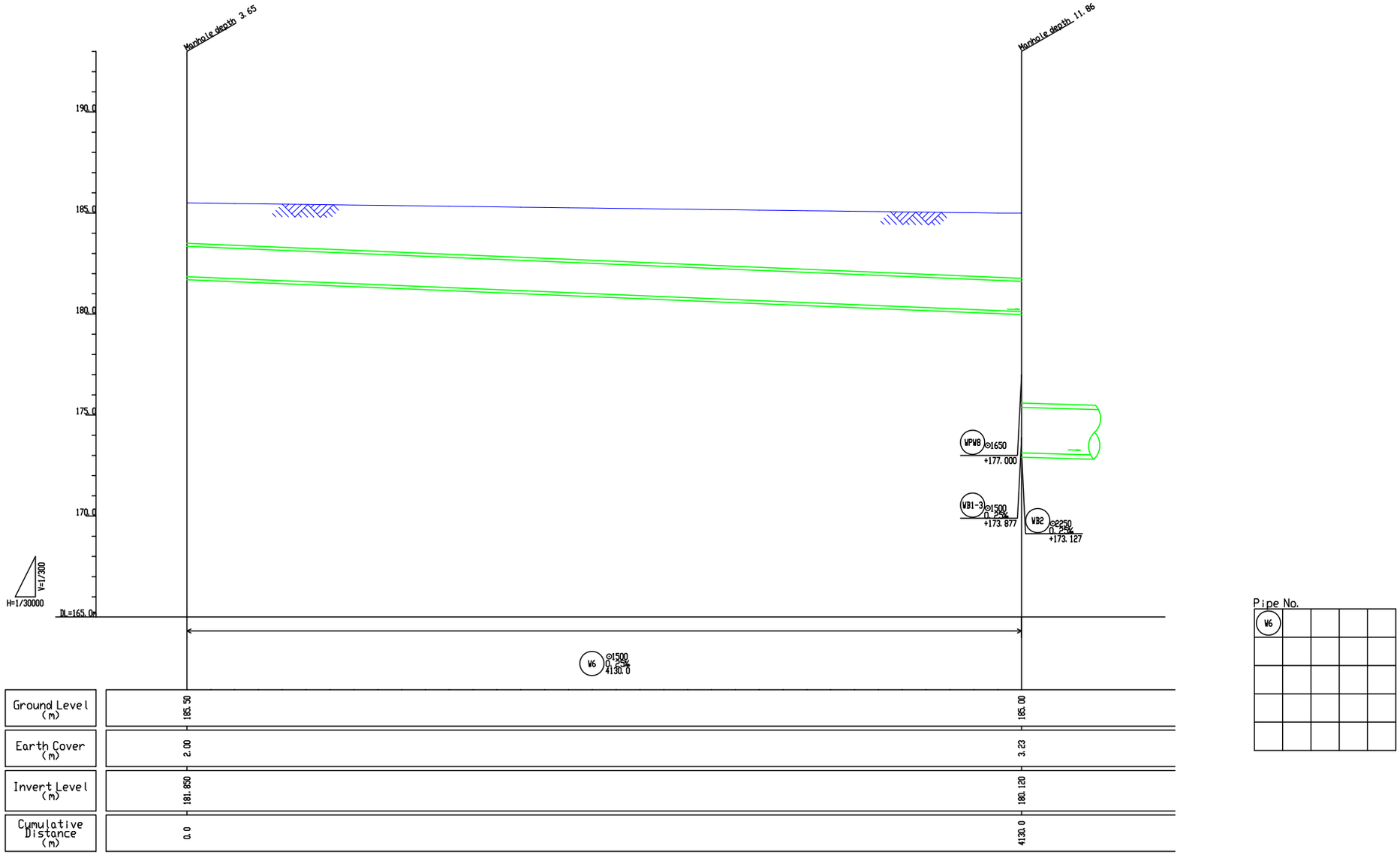
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(4/18)	SD-P-042



Pipe No.

W6				

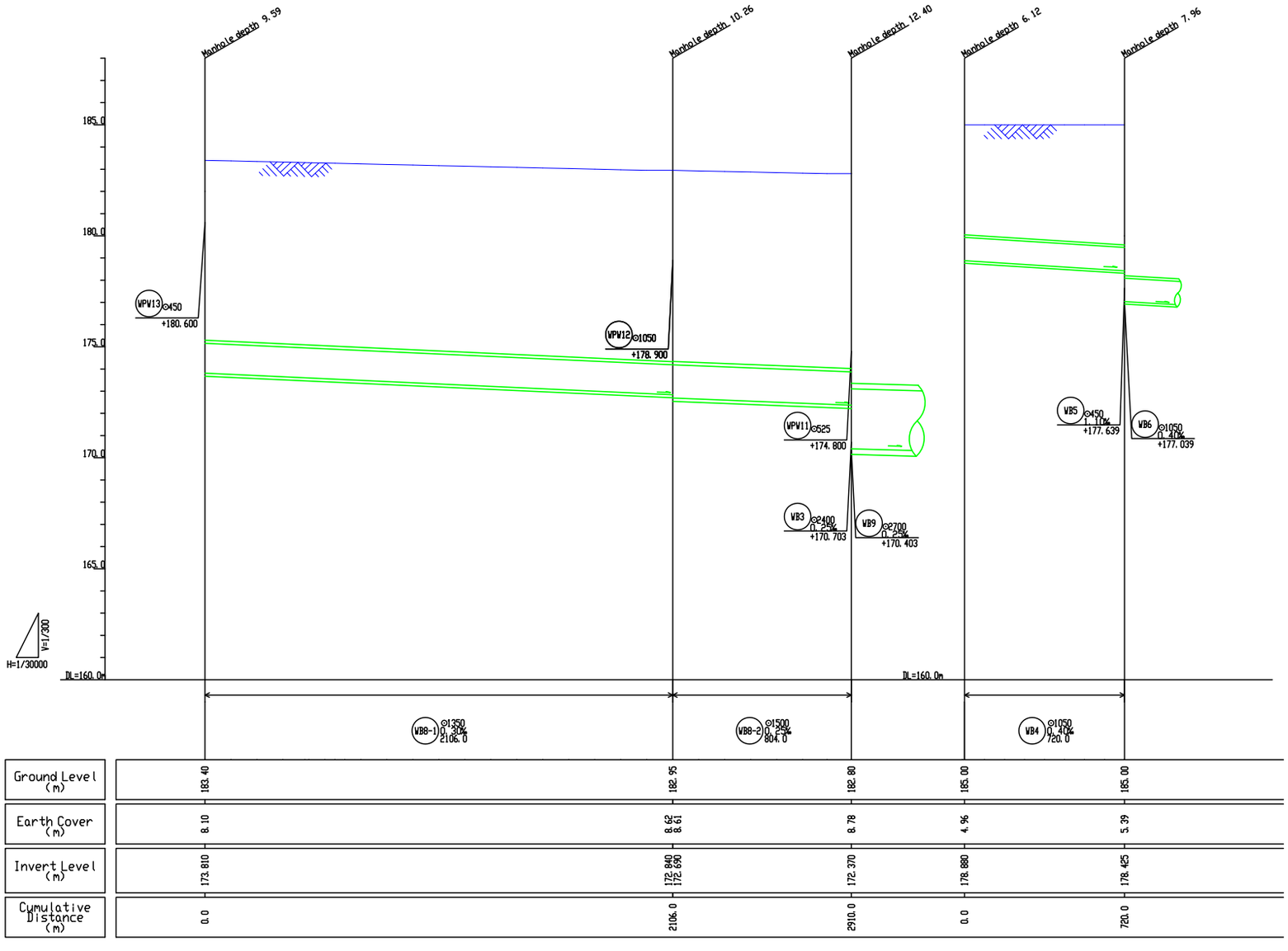
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(5/18)	SD-P-043



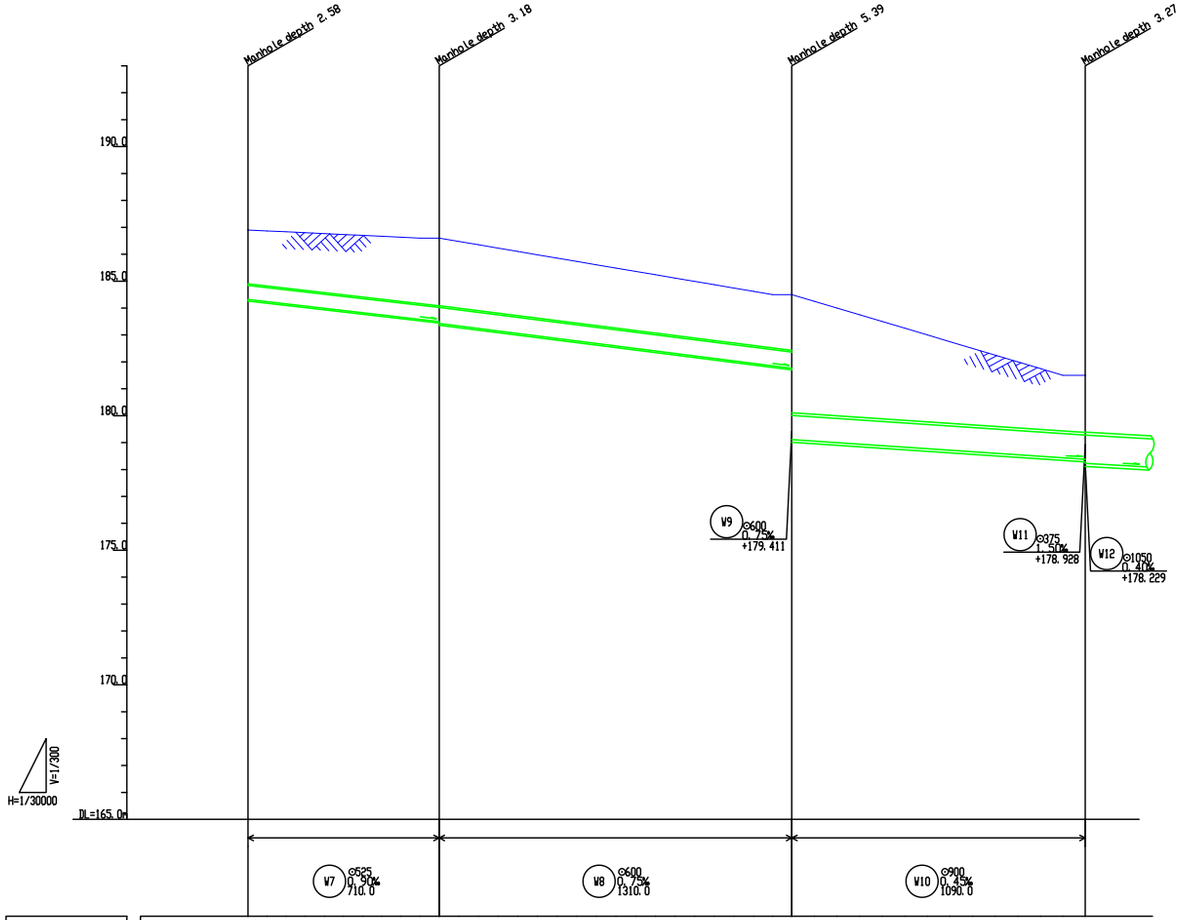
Pipe No.

W6				

PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(6/18)	SD-P-044



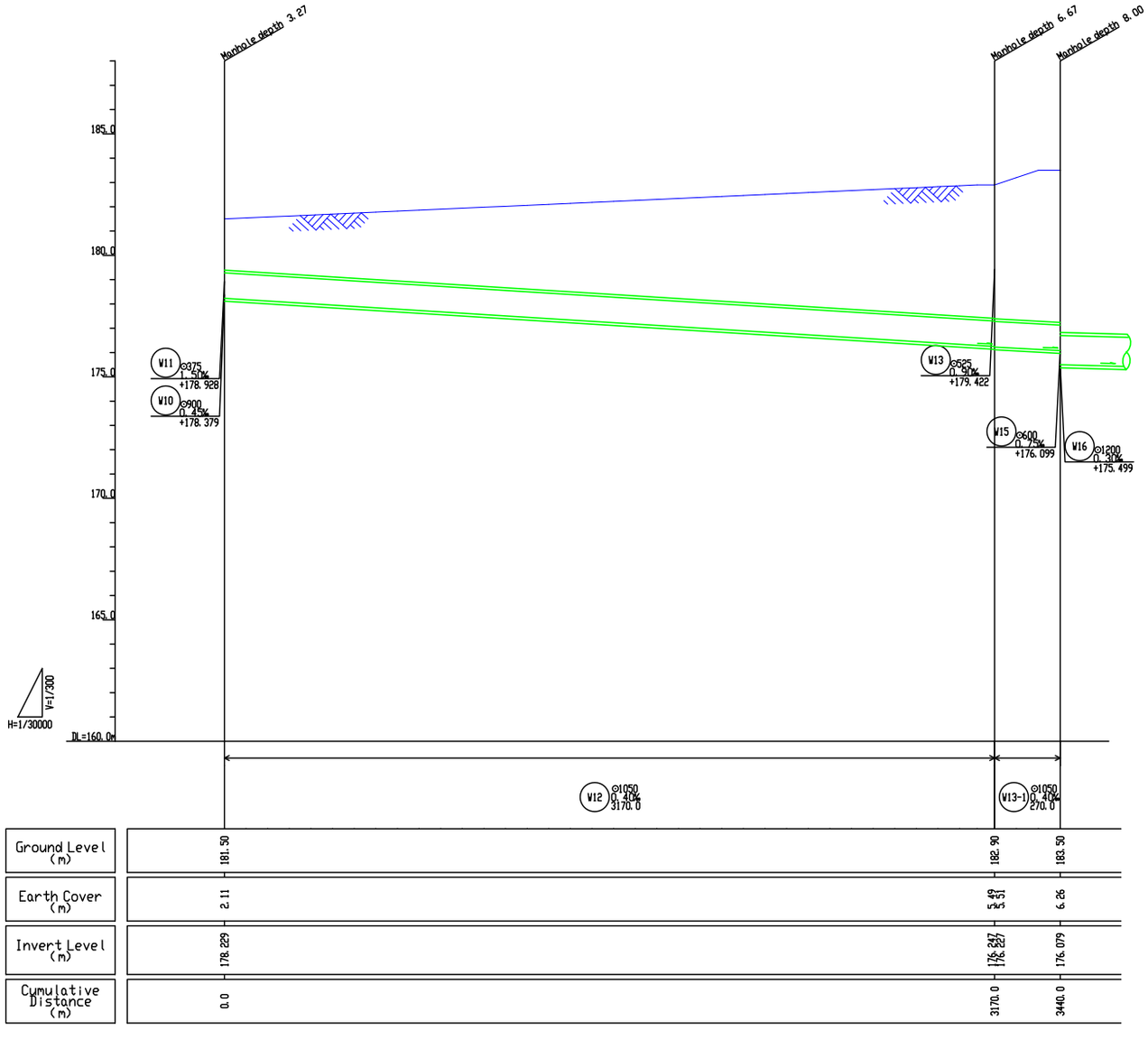
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(7/18)	SD-P-045



Pipe No.

W7	W8	W10		

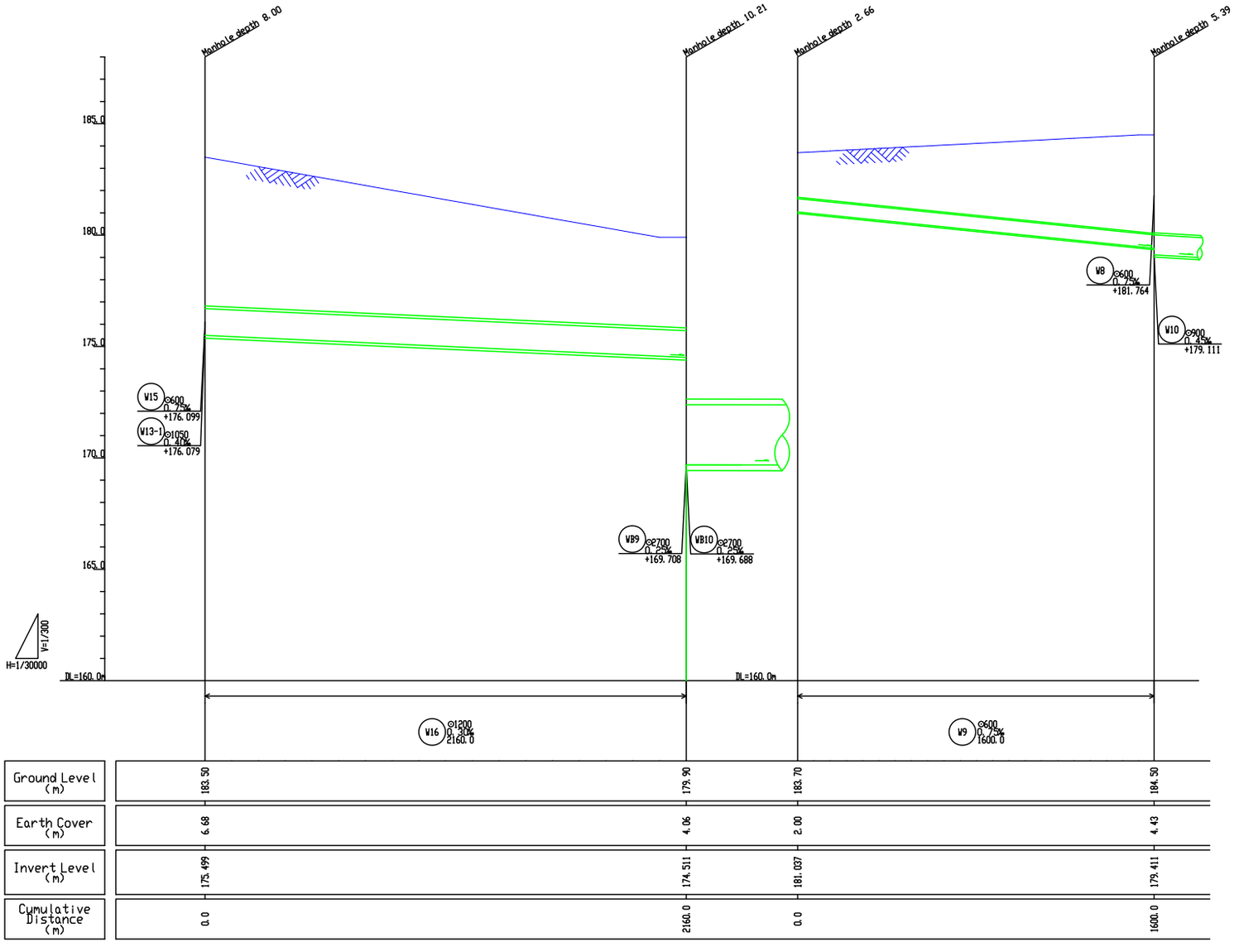
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(8/18)	SD-P-046



Pipe No.

W12	W13-1			

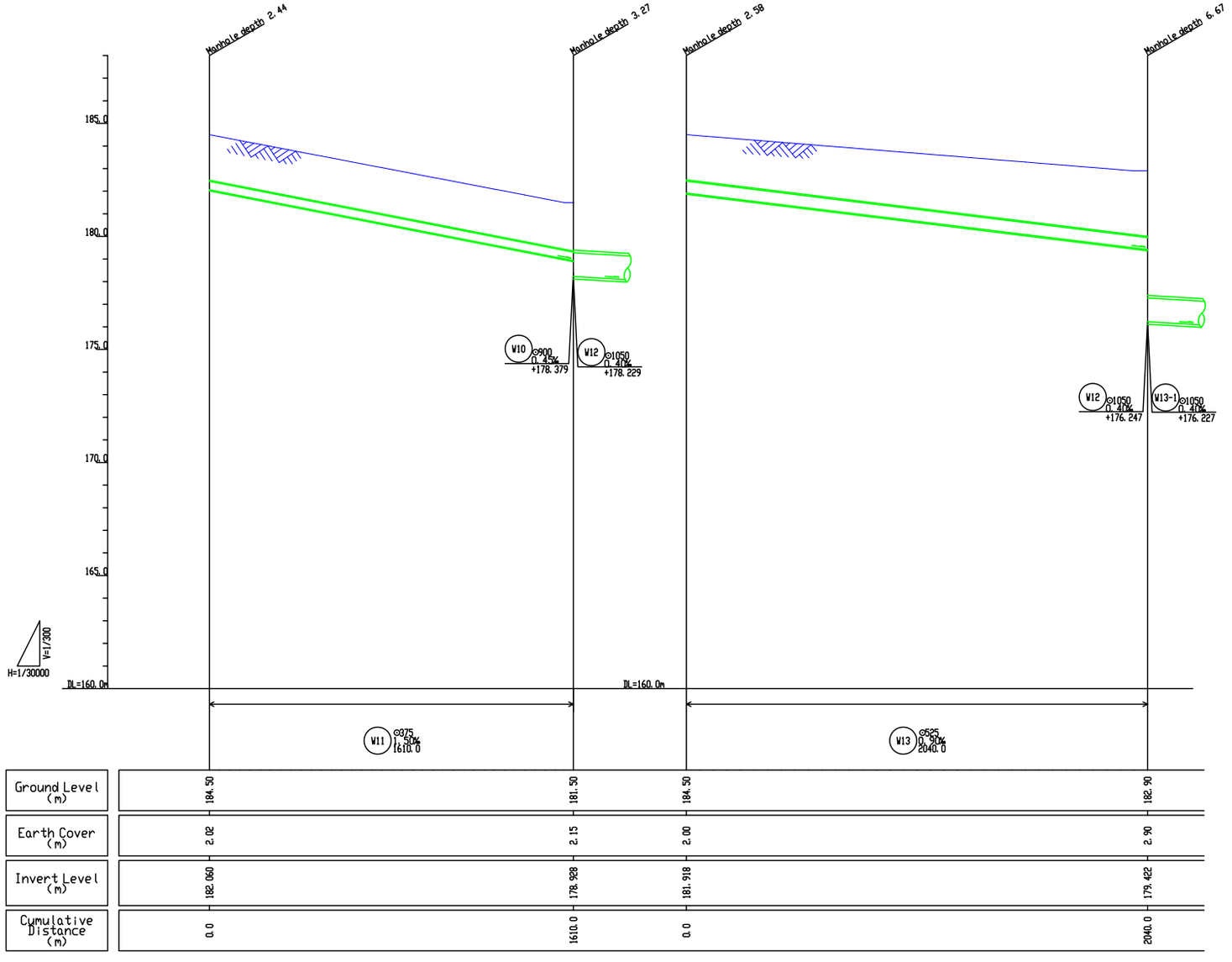
PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(9/18)	DRAWING NO.: SD-P-047



Pipe No.

W16	W9			

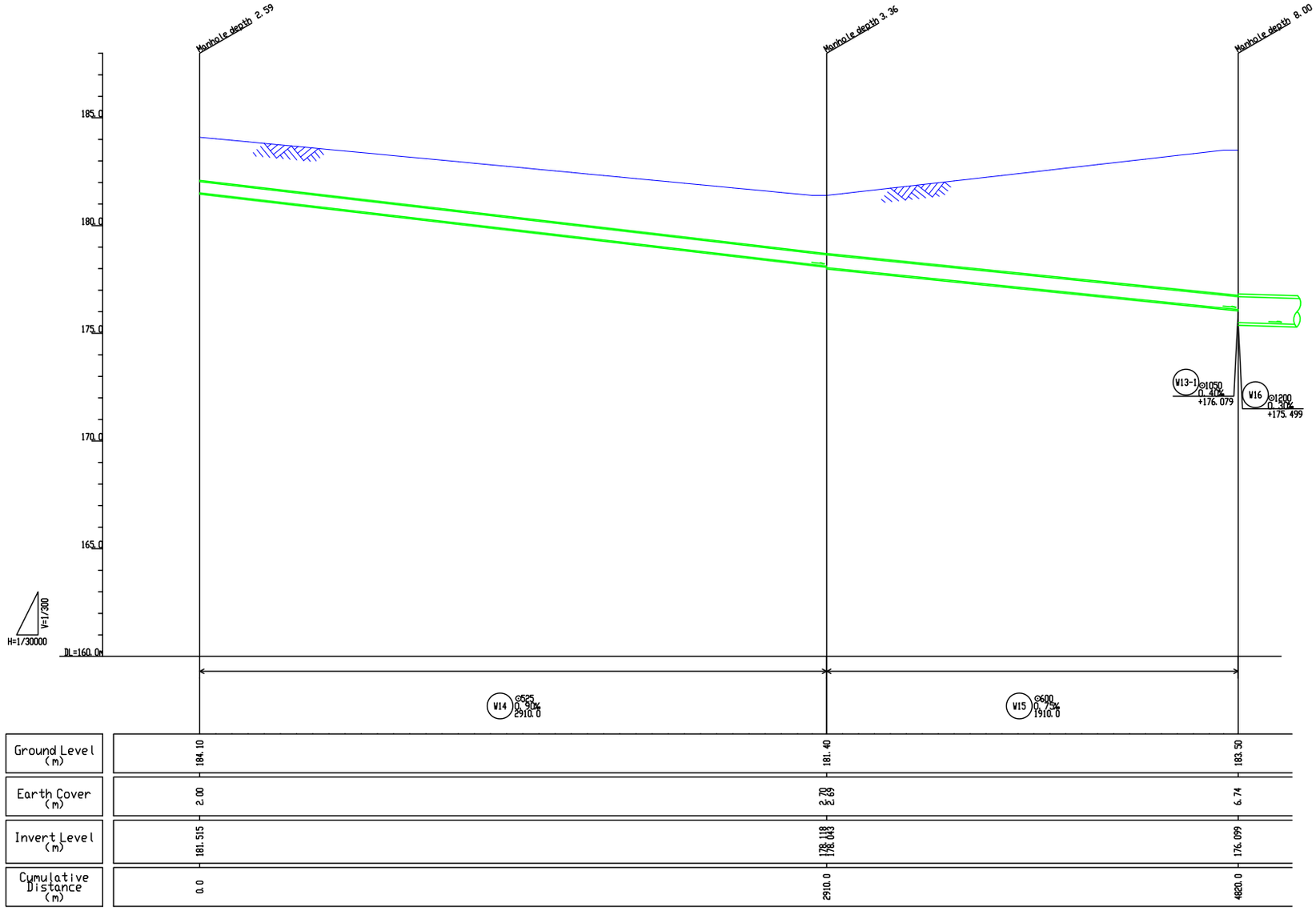
PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(10/18)	DRAWING NO.: SD-P-048



Pipe No.

W11	W13			

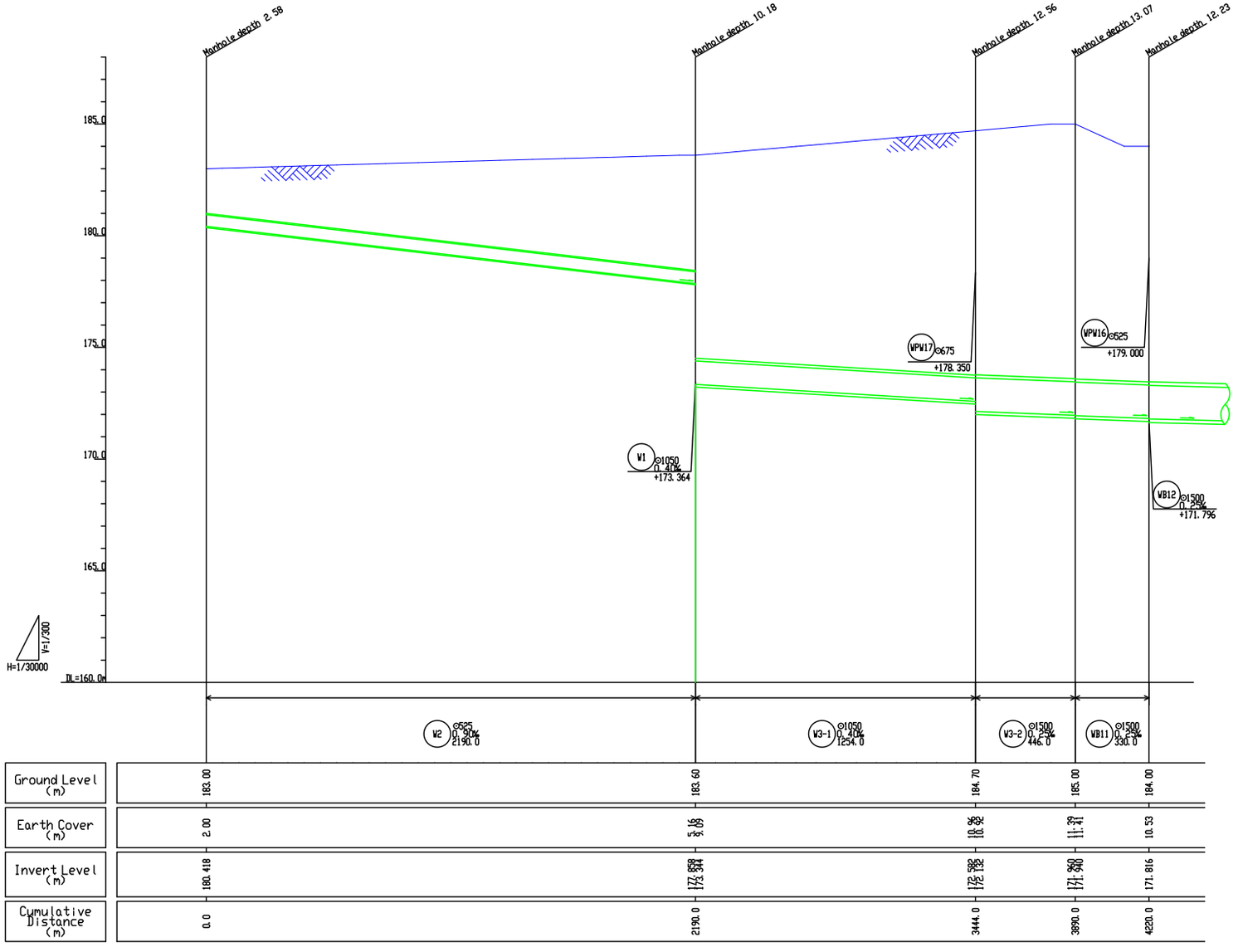
PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(11/18)	DRAWING NO.: SD-P-049



Pipe No.

W14	W15			

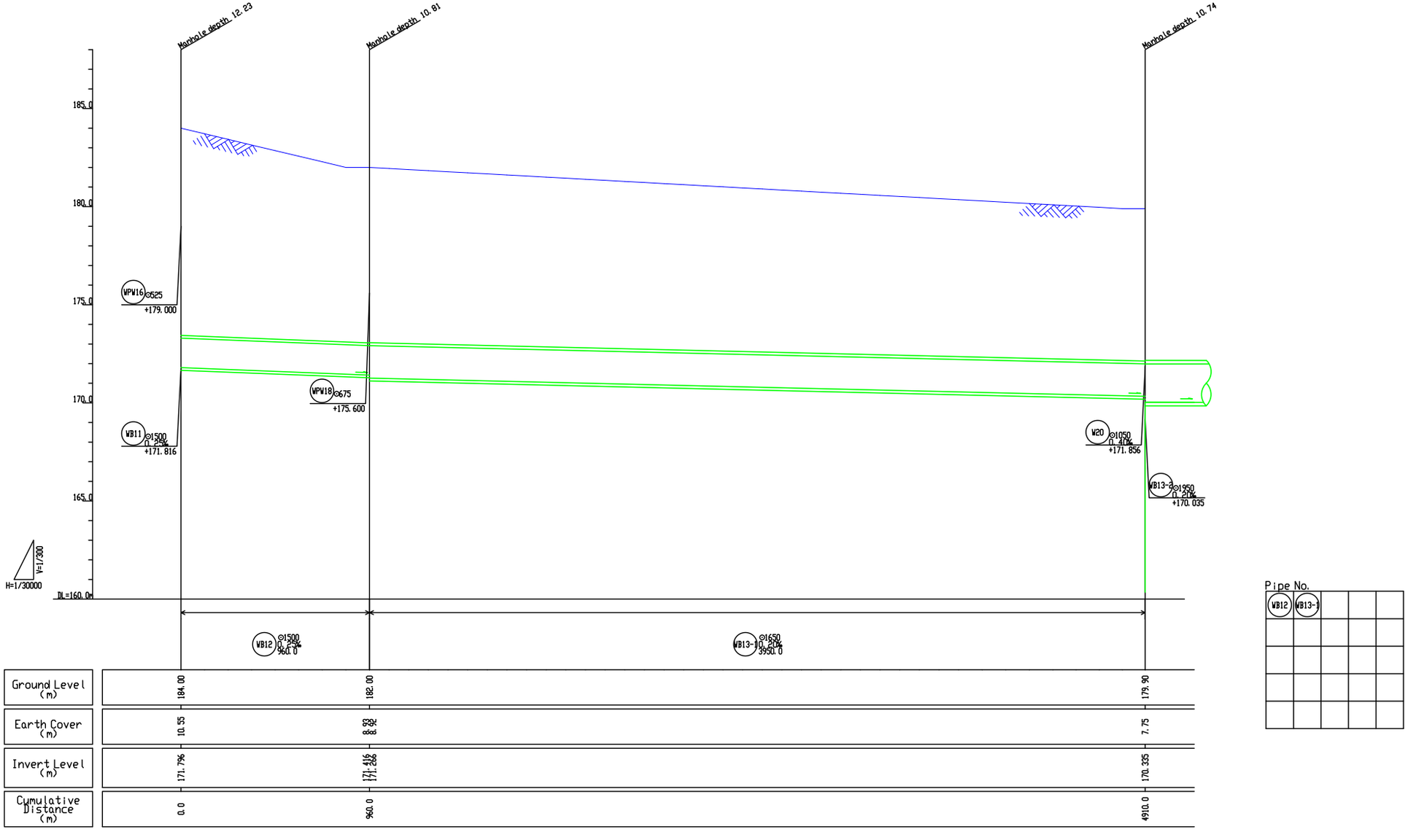
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(12/18)	SD-P-050



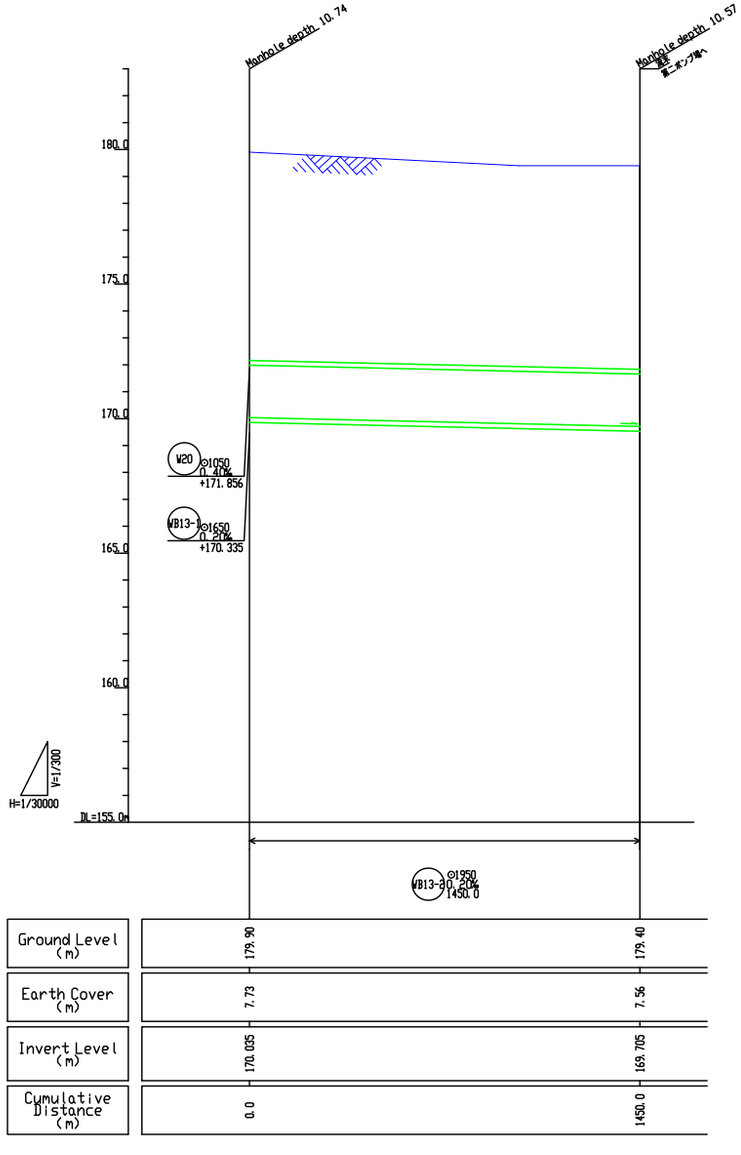
Pipe No.

W2	W3-1	W3-2	WB11	

PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(13/18)	SD-P-051



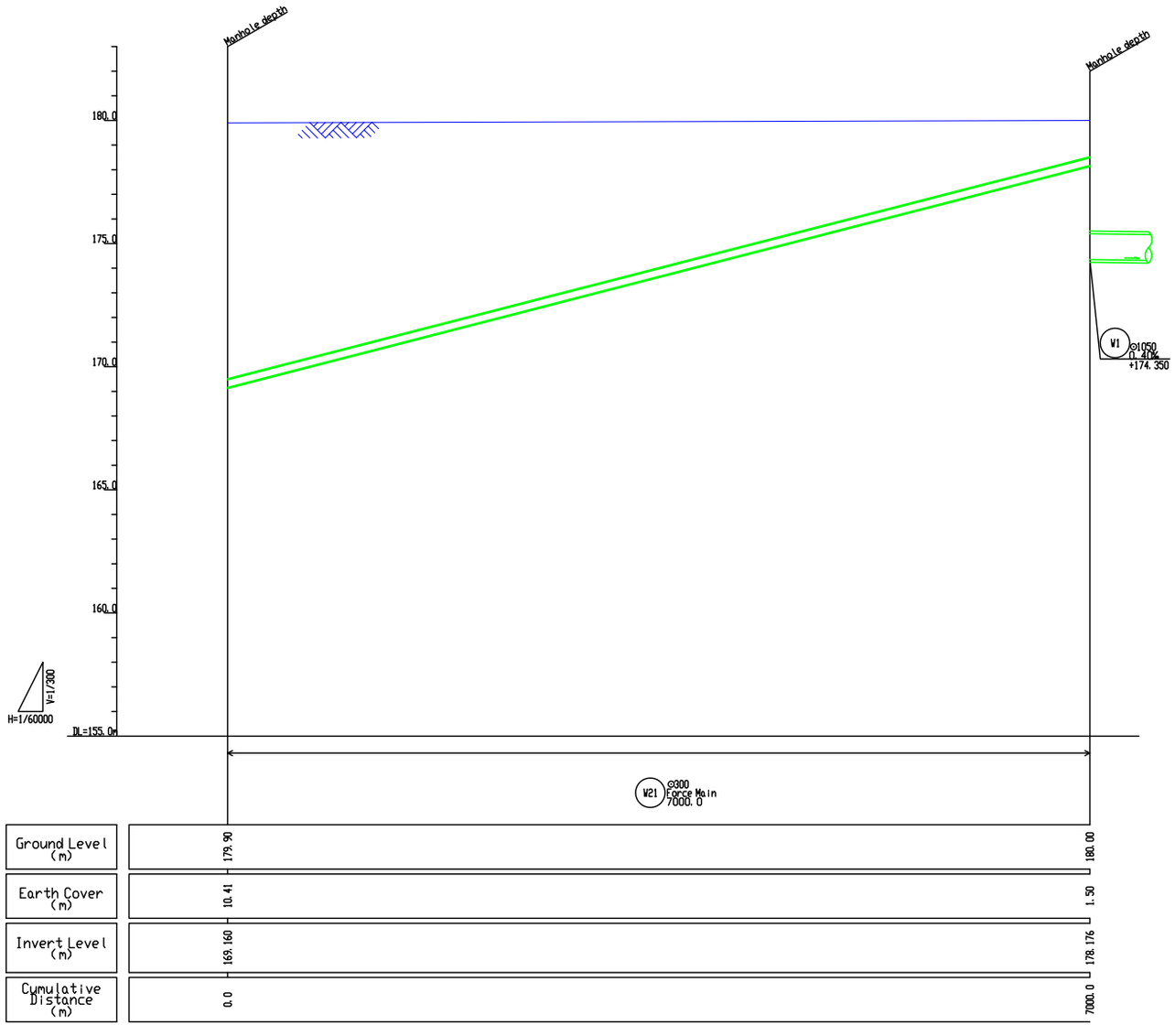
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(14/18)	SD-P-052



Pipe No.

WB13-3				

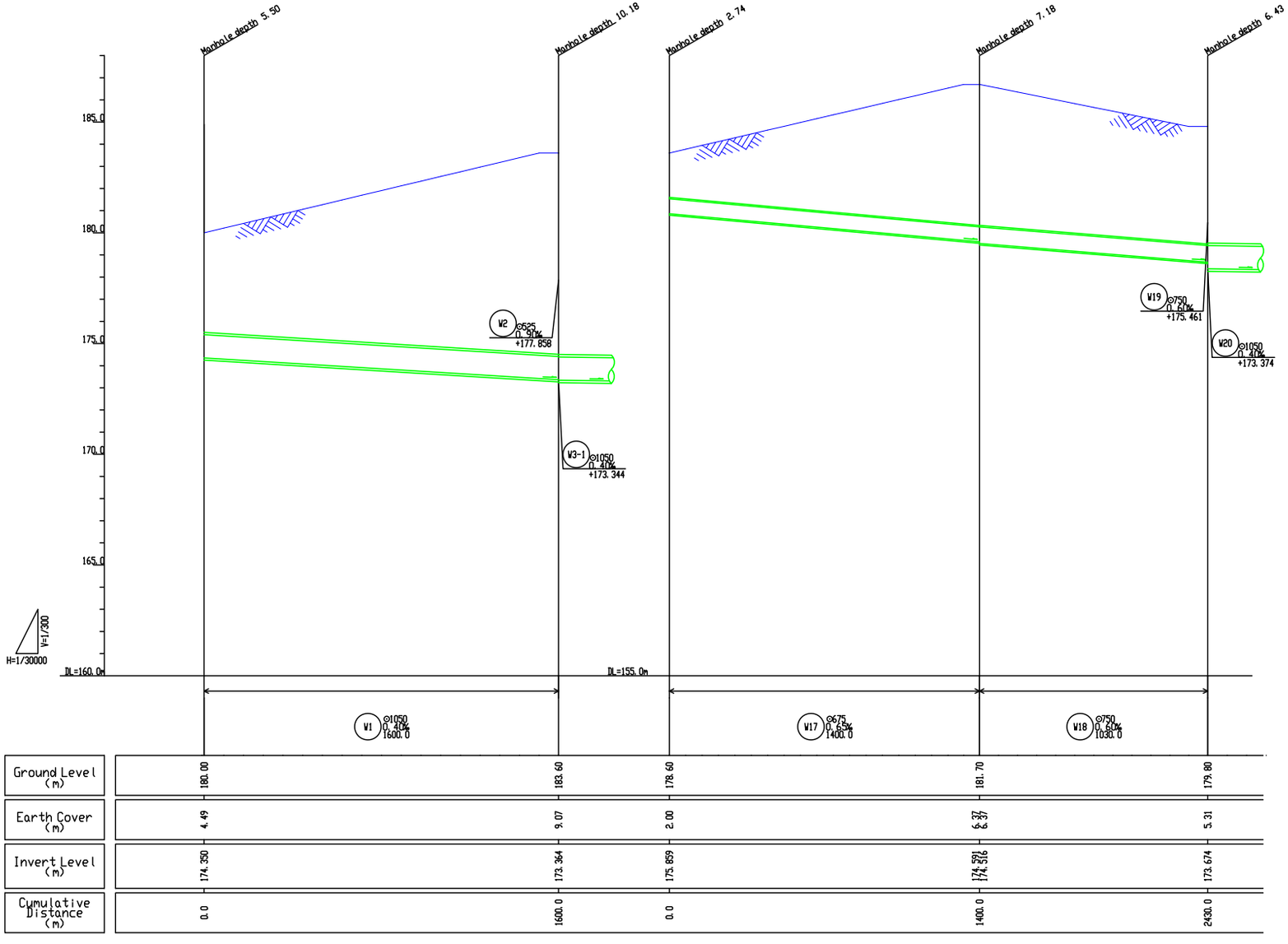
PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(15/18)	DRAWING NO.: SD-P-053



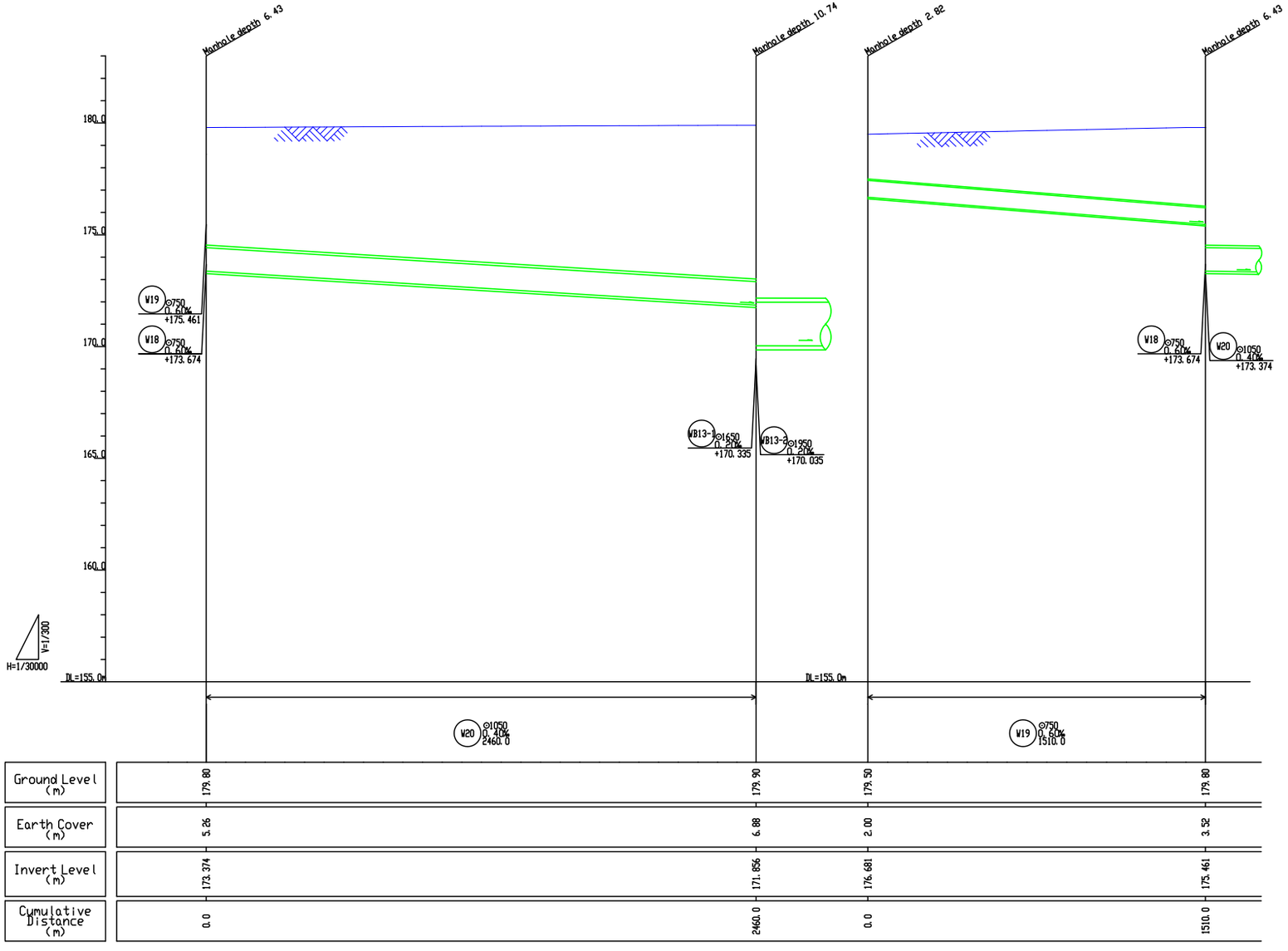
Pipe No.

W21				

PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(16/18)	SD-P-054



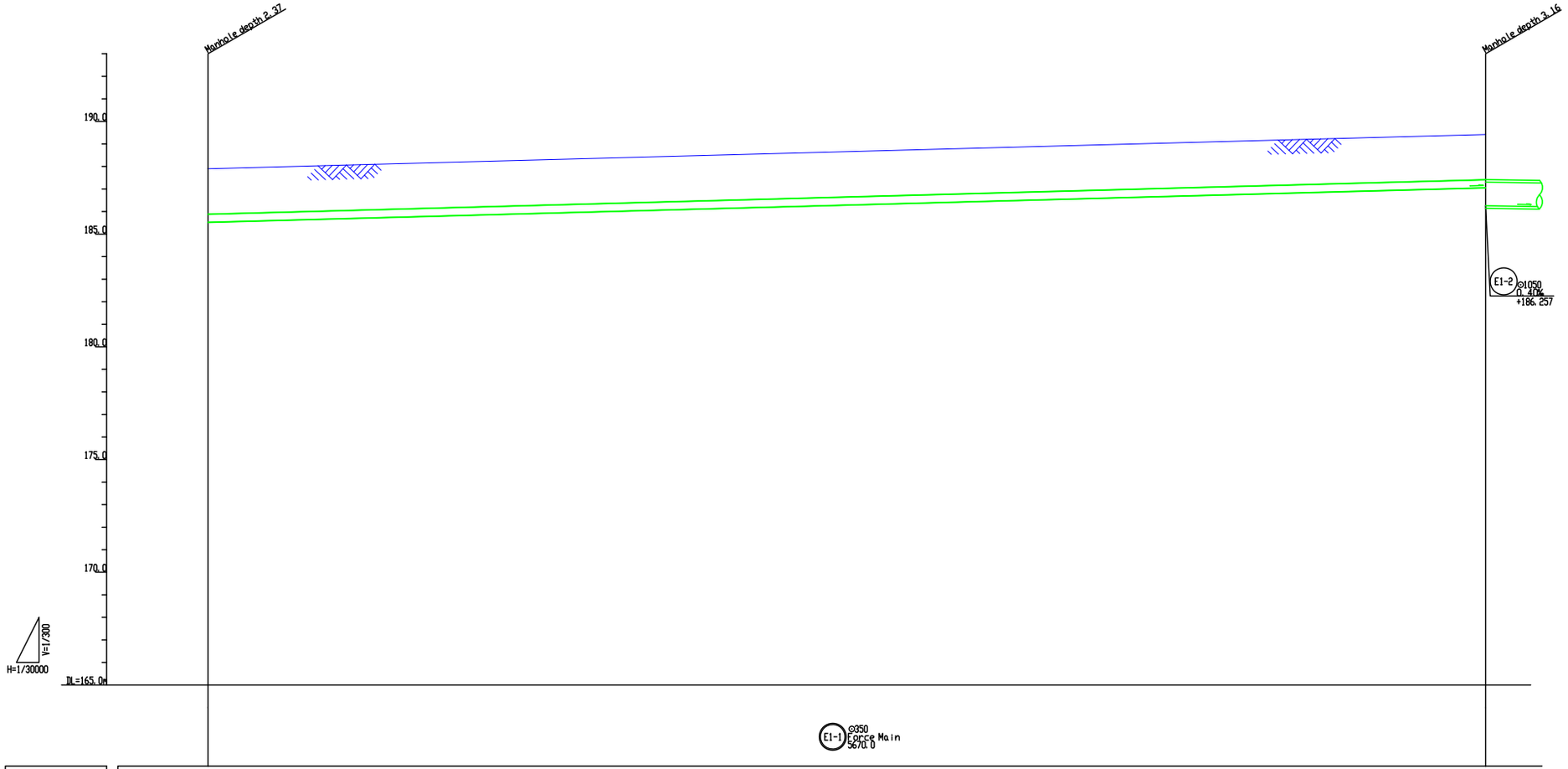
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(17/18)	SD-P-055



PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Western SWD(18/18)	SD-P-056

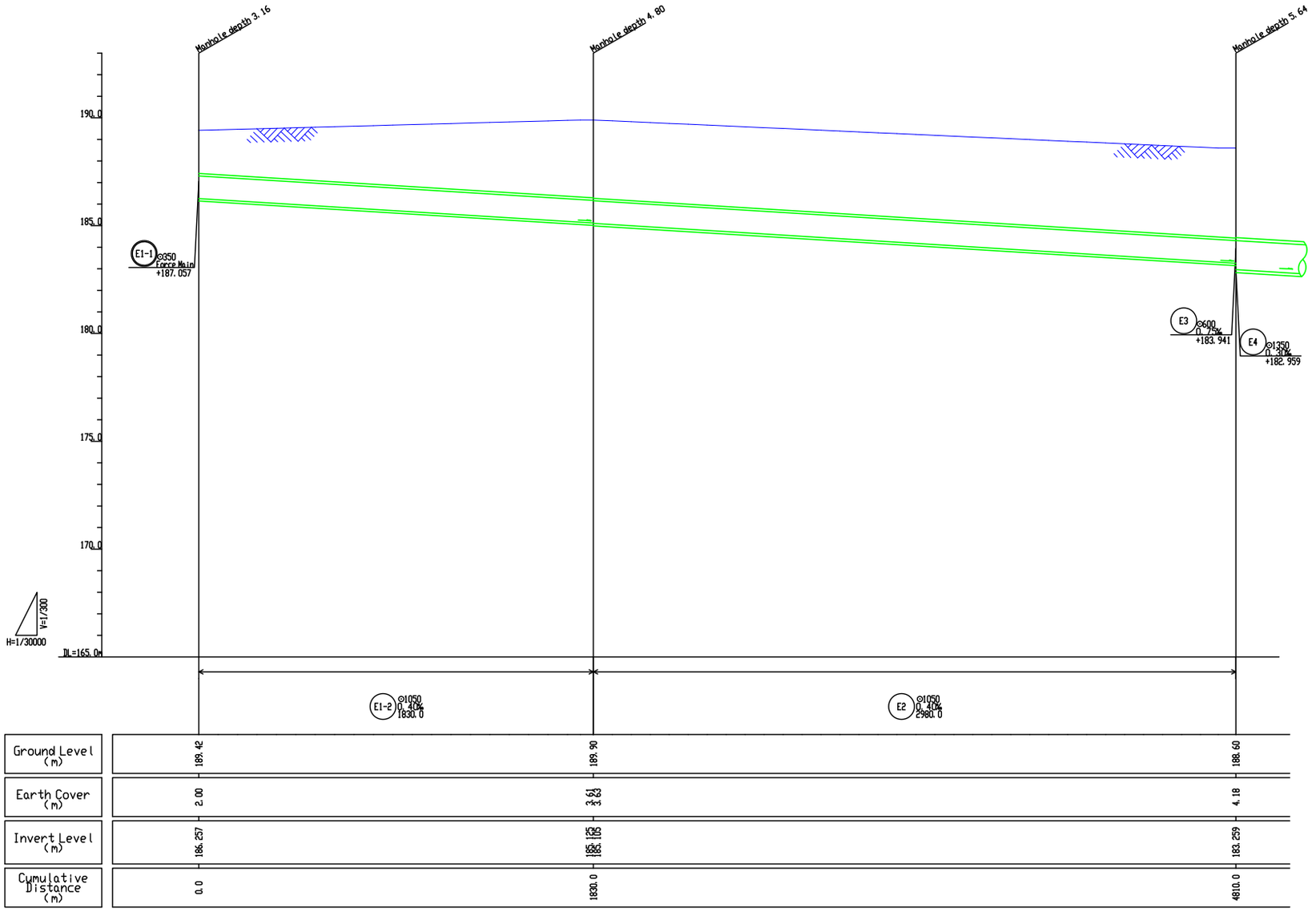
Table AC11.3.2 Longitudinal Section of Major Sewers in the Eastern SWD

Drawing No.	Contents
SD-P- 057	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (1/34)
SD-P- 058	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (2/34)
SD-P- 059	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (3/34)
SD-P- 060	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (4/34)
SD-P- 061	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (5/34)
SD-P- 062	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (6/34)
SD-P- 063	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (7/34)
SD-P- 064	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (8/34)
SD-P- 065	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (9/34)
SD-P- 066	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (10/34)
SD-P- 067	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (11/34)
SD-P- 068	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (12/34)
SD-P- 069	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (13/34)
SD-P- 070	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (14/34)
SD-P- 071	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (15/34)
SD-P- 072	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (16/34)
SD-P- 073	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (17/34)
SD-P- 074	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (18/34)
SD-P- 075	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (19/34)
SD-P- 076	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (20/34)
SD-P- 077	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (21/34)
SD-P- 078	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (22/34)
SD-P- 079	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (23/34)
SD-P- 080	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (24/34)
SD-P- 081	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (25/34)
SD-P- 082	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (26/34)
SD-P- 083	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (27/34)
SD-P- 084	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (28/34)
SD-P- 085	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (29/34)
SD-P- 086	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (30/34)
SD-P- 087	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (31/34)
SD-P- 088	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (32/34)
SD-P- 089	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (33/34)
SD-P- 090	Longitudinal Section of Main, Trunk, and Interceptor Sewers in the Eastern SWD (34/34)

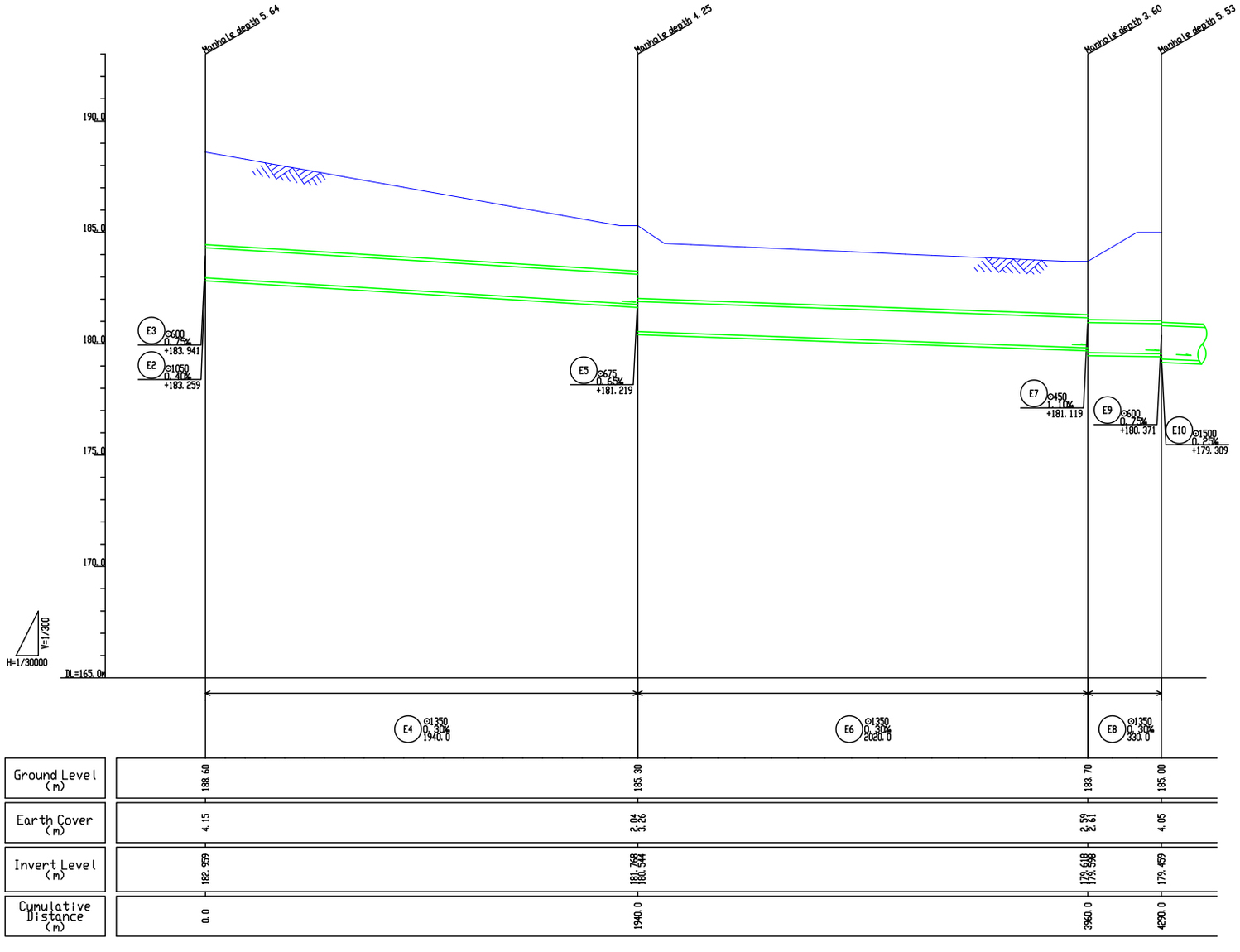


Ground Level (m)	187.90	189.42
Earth Cover (m)	2.01	2.00
Invert Level (m)	185.536	187.057
Cumulative Distance (m)	0.0	5670.0

PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(1/34)	DRAWING NO.: SD-P-057



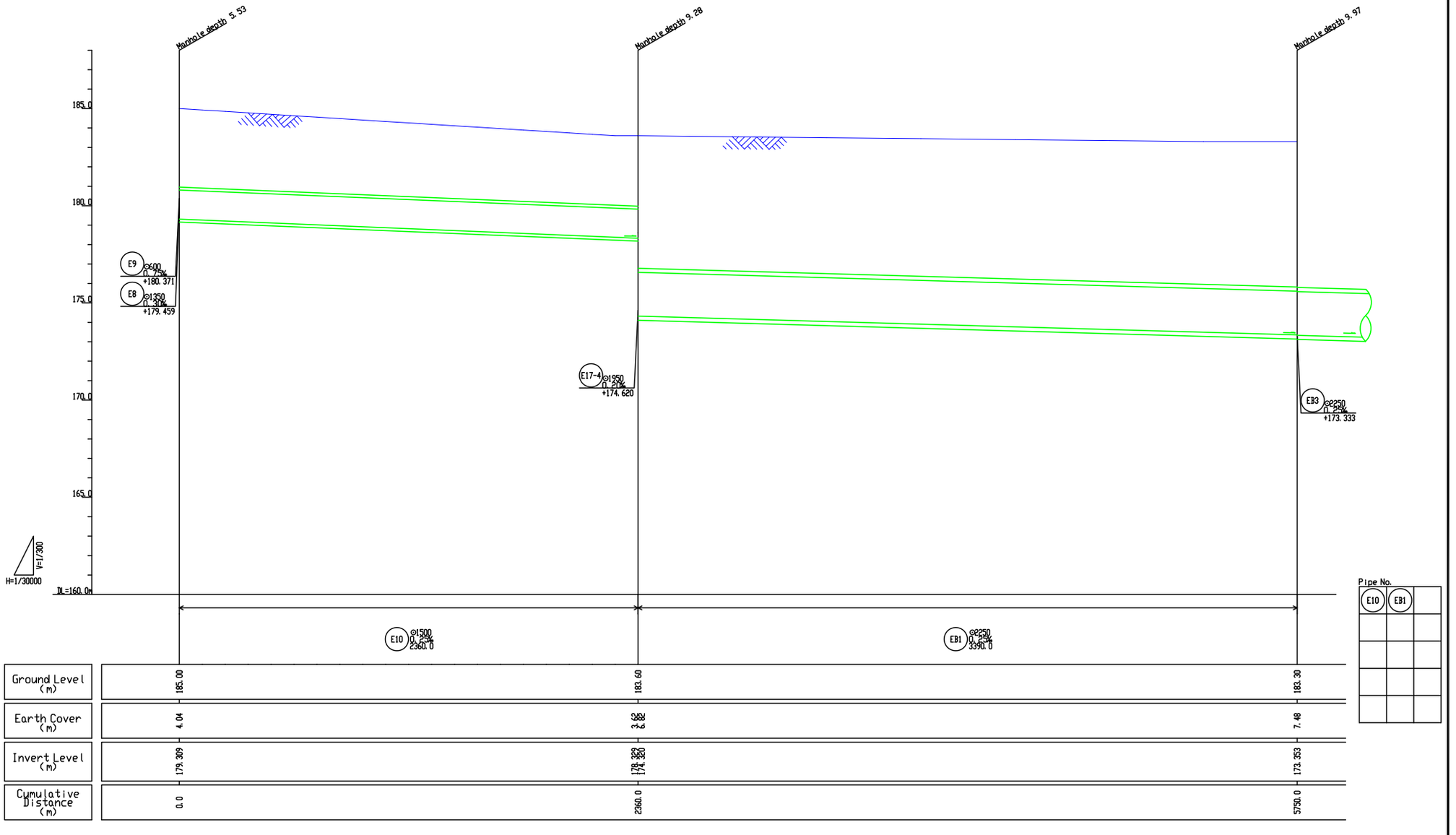
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(2/34)	SD-P-058



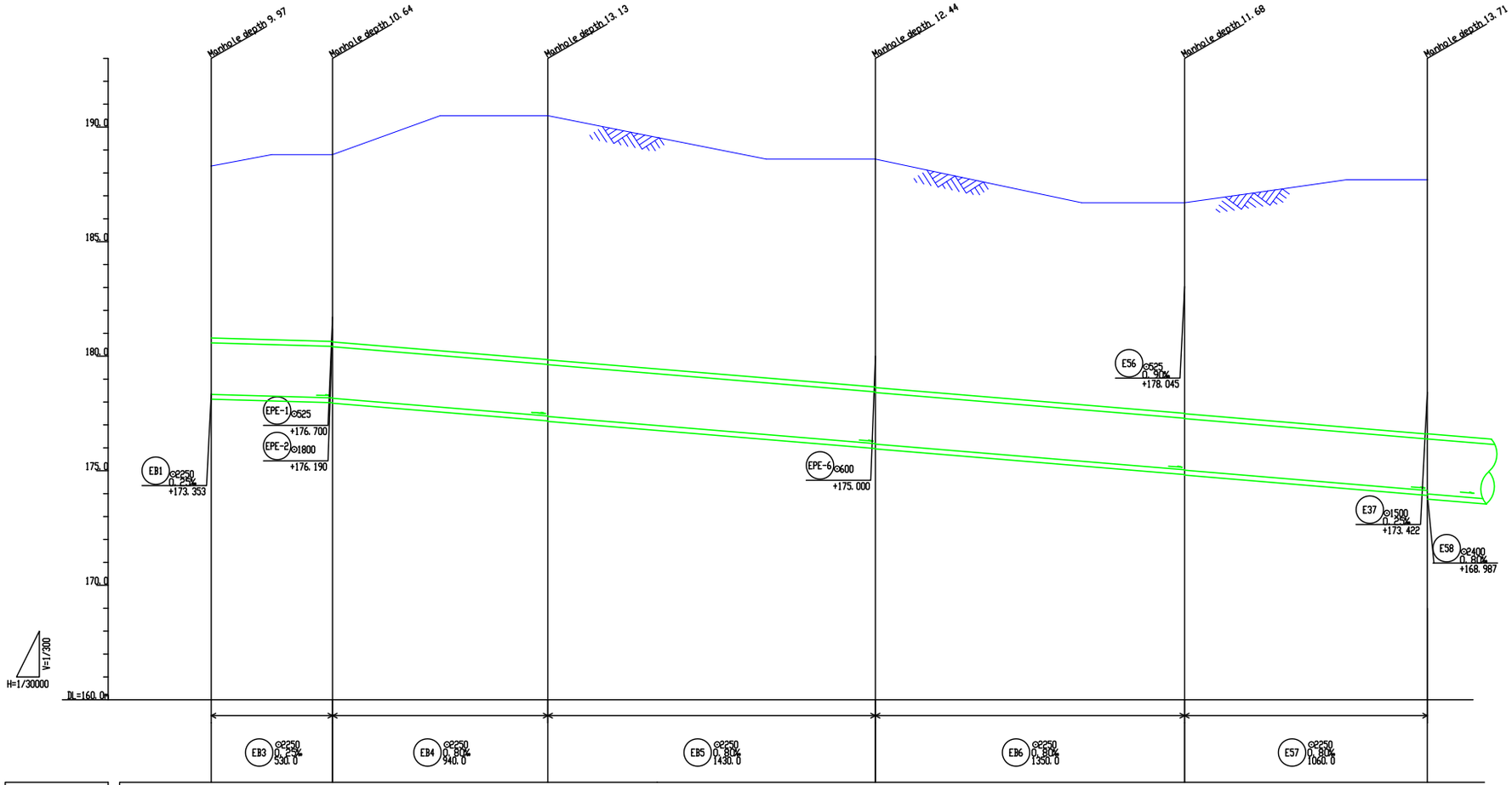
Pipe No.

E4	E6	E8		

PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(3/34)	SD-P-059



PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(4/34)	SD-P-060

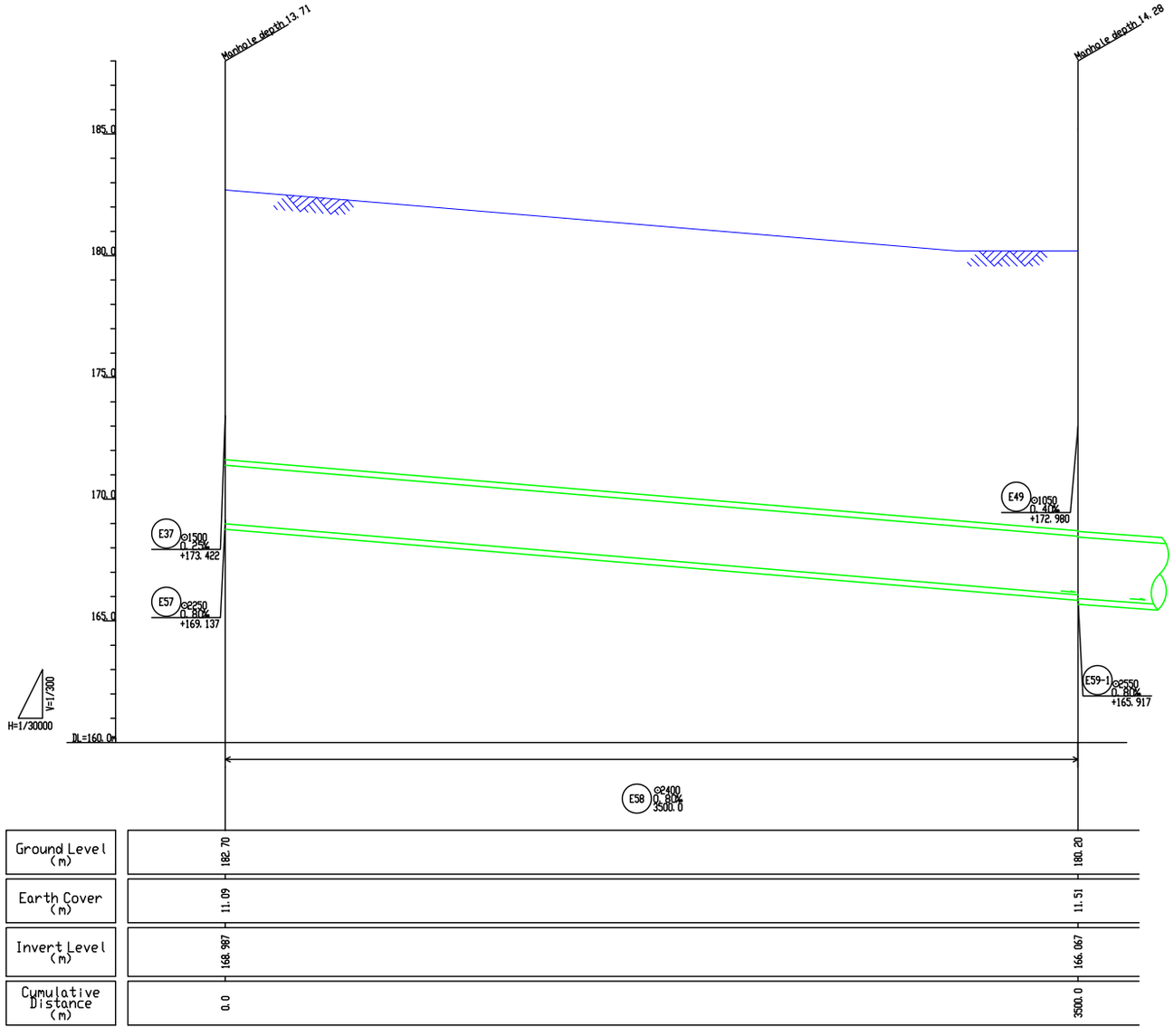


Ground Level (m)	183.30	183.80	185.50	183.60	181.70	182.70
Earth Cover (m)	7.50	8.16 / 8.18	10.67 / 10.67	9.95 / 9.97	9.19 / 9.21	11.10
Invert Level (m)	173.333	173.181 / 173.161	172.388 / 172.368	171.184 / 171.164	170.044 / 170.024	169.137
Cumulative Distance (m)	0.0	530.0	1470.0	2900.0	4250.0	5310.0

Pipe No.

EB3	EB4	EB5	EB6	E57

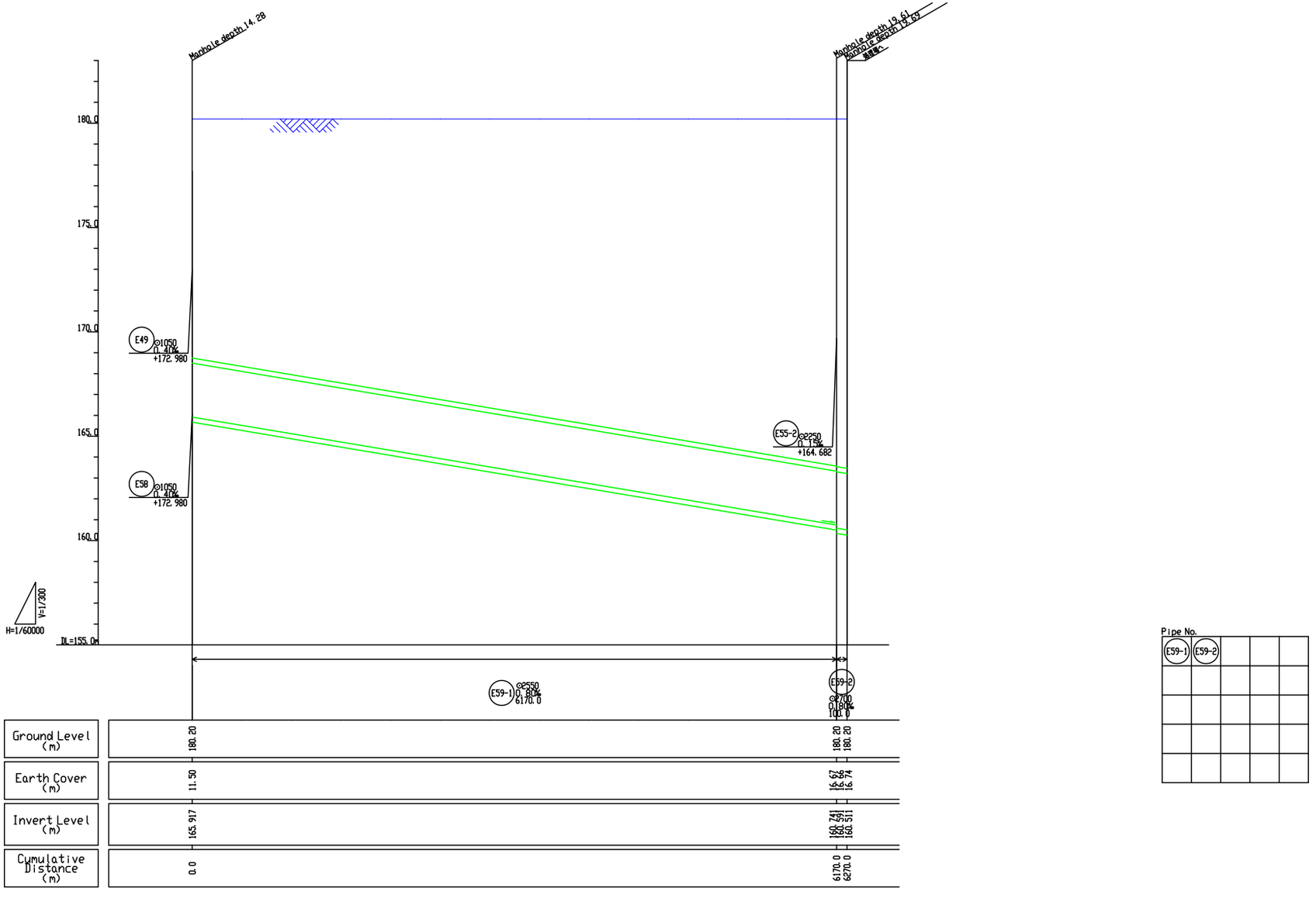
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(5/34)	SD-P-061



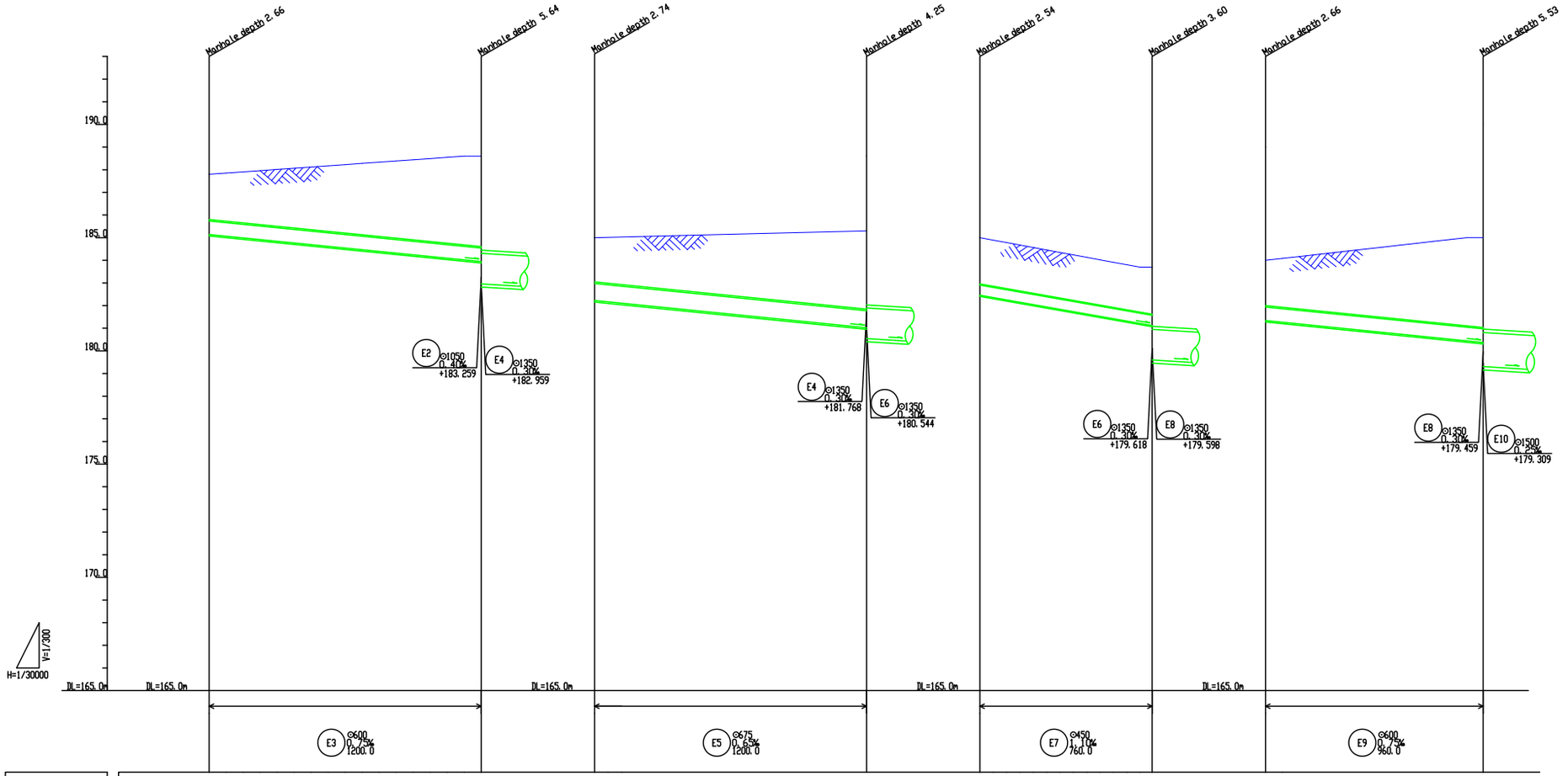
Pipe No.

E58				

PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(6/34)	SD-P-062



PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(7/34)	SD-P-063

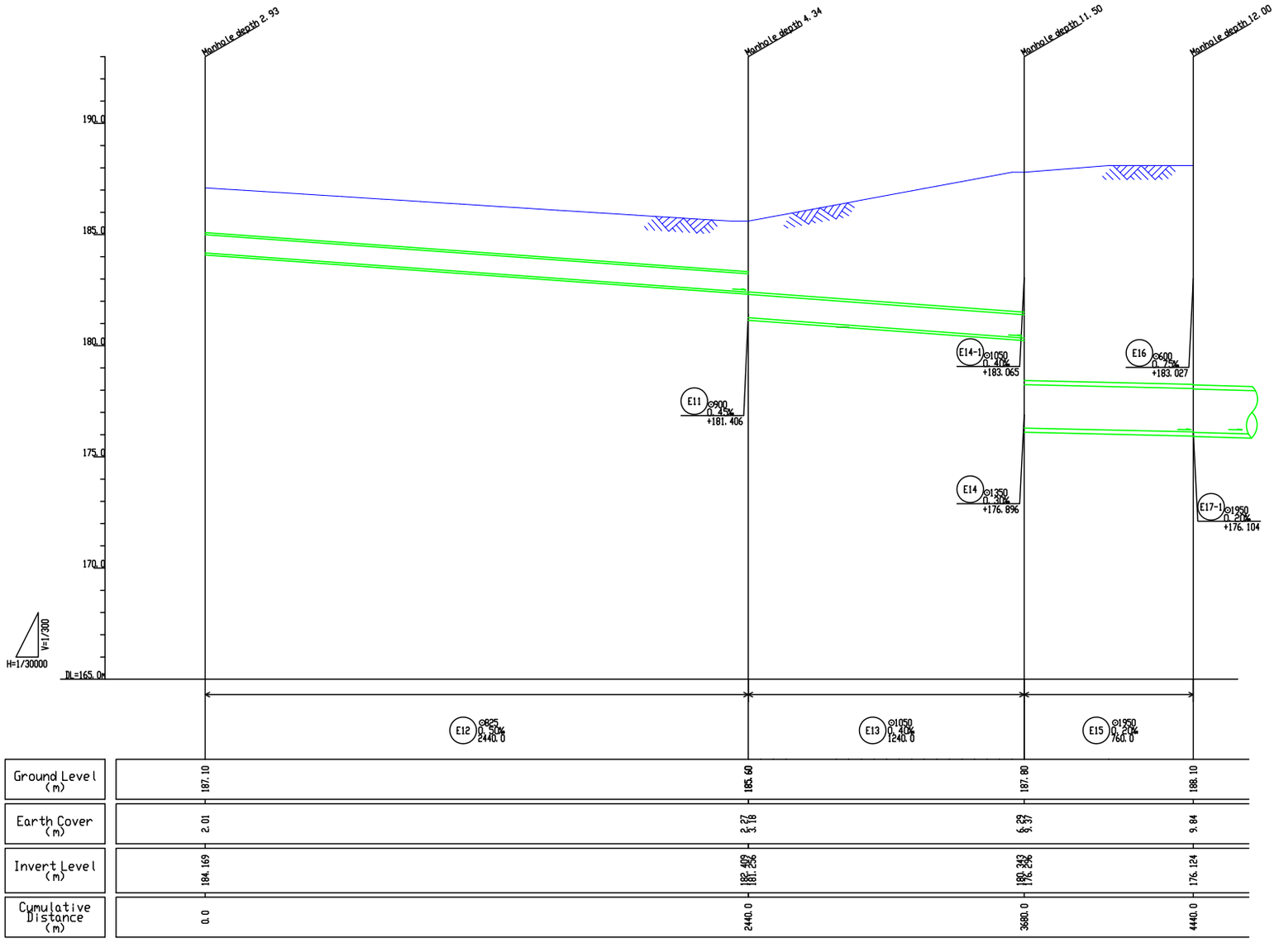


Pipe No.

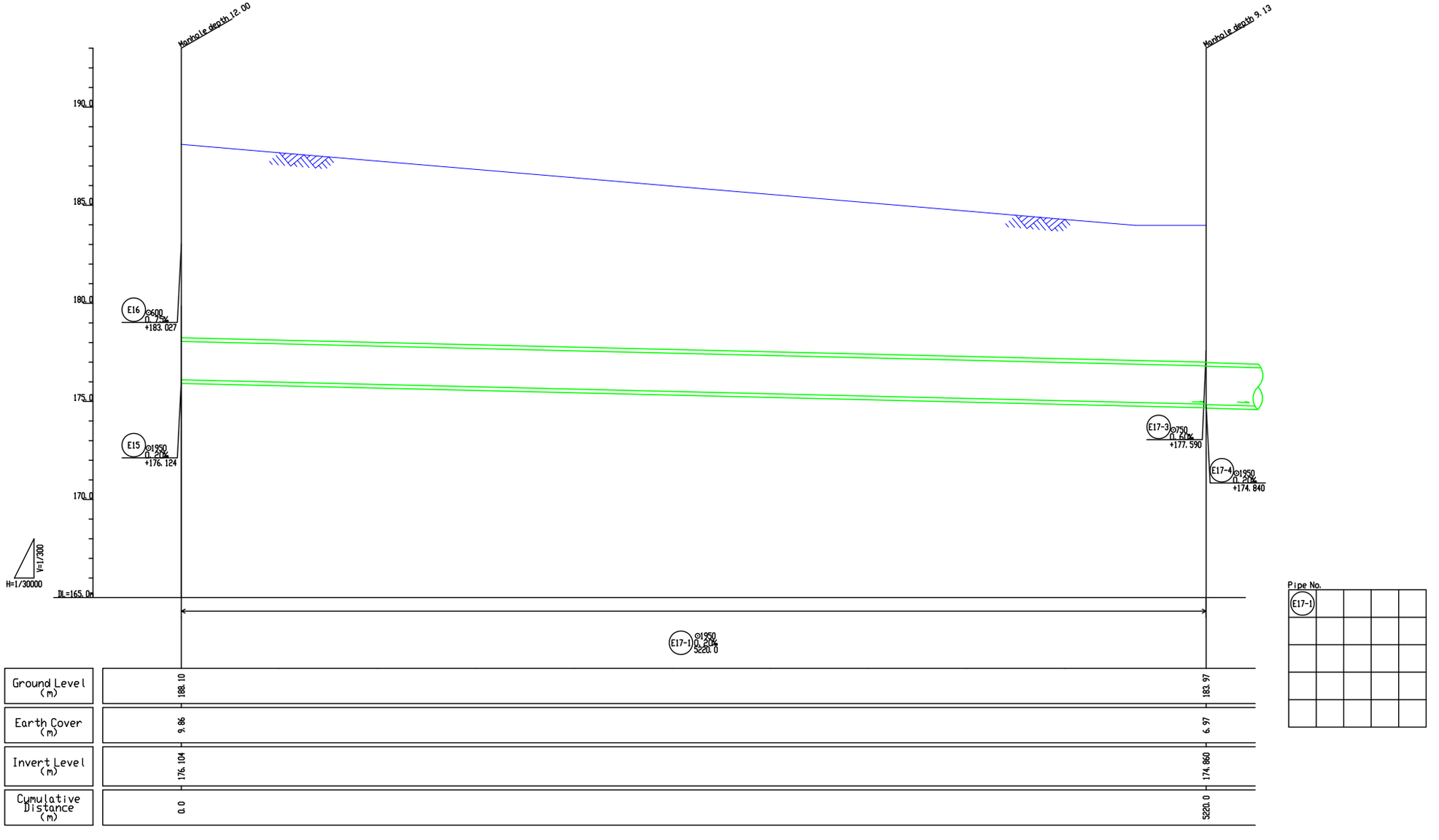
E3	E5	E7
E9		

Ground Level (m)	187.80	188.60	185.00	185.30	185.00	183.70	184.00	185.00
Earth Cover (m)	2.00	4.00	2.00	3.34	2.04	2.08	2.00	3.97
Invert Level (m)	185.137	183.941	182.259	181.219	182.456	181.119	181.337	180.371
Cumulative Distance (m)	0.0	1200.0	0.0	1200.0	0.0	760.0	0.0	960.0

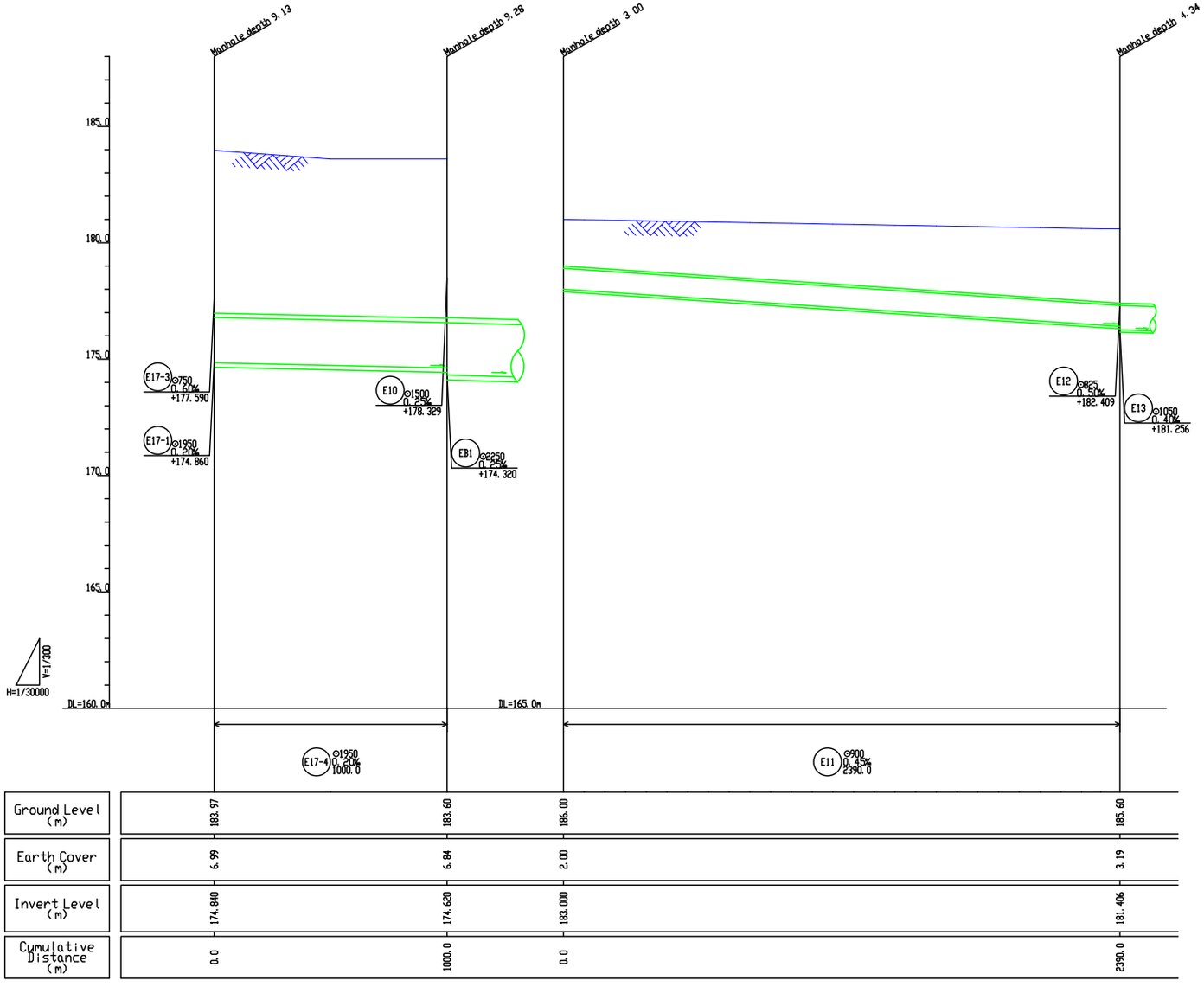
PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(8/34)	DRAWING NO.: SD-P-064



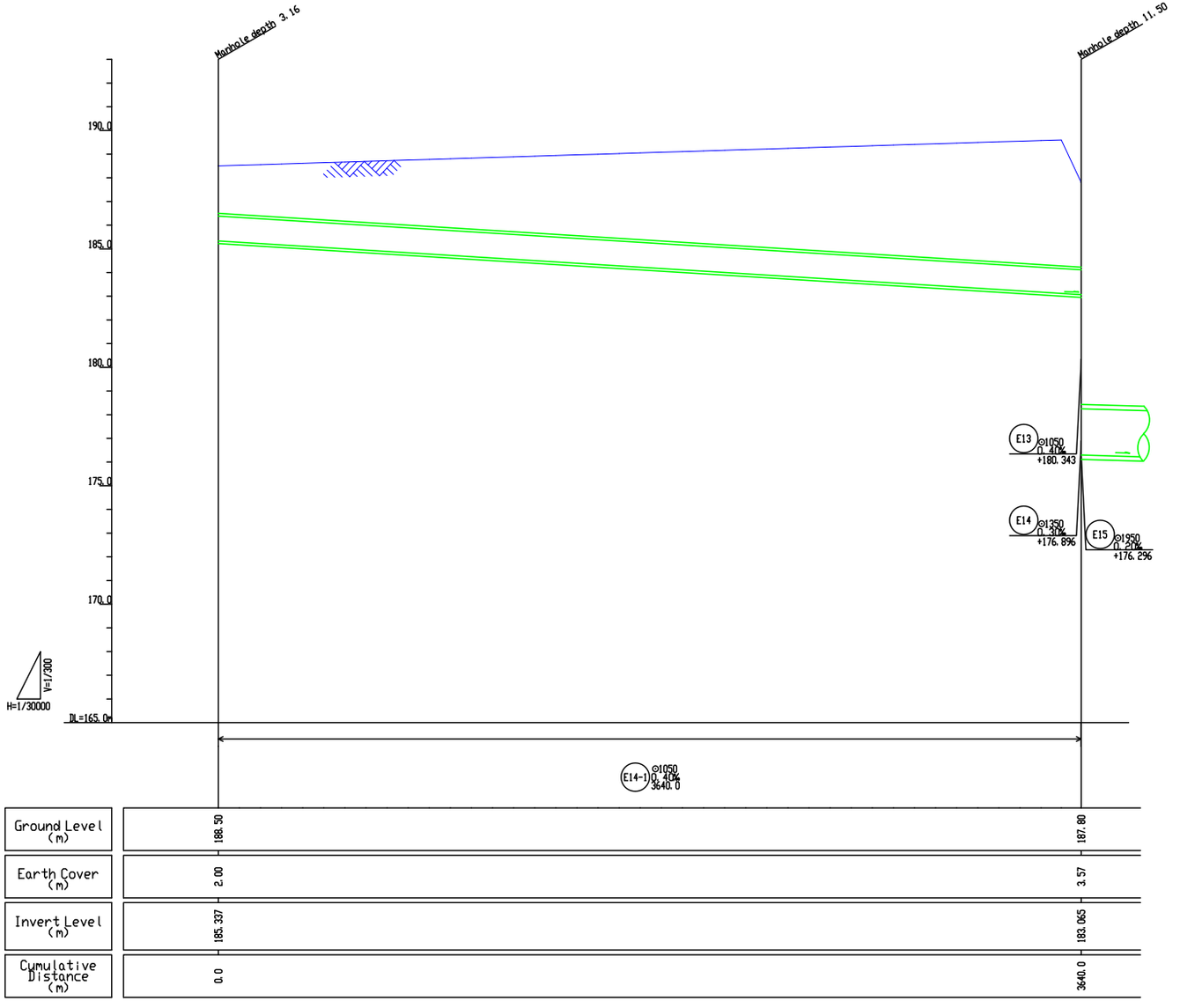
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(9/34)	SD-P-065



PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(10/34)	SD-P-066



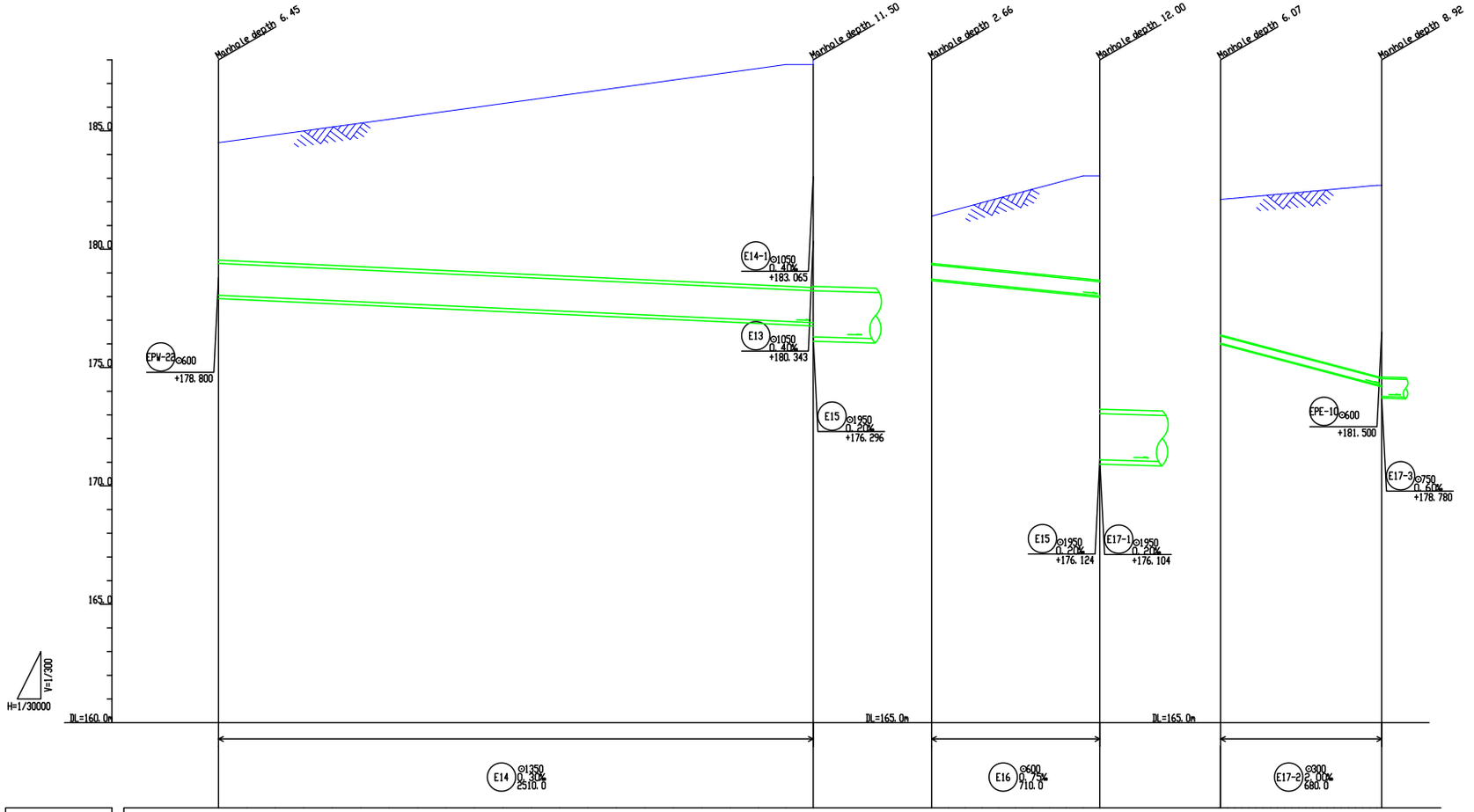
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(11/34)	SD-P-067



Pipe No.

E14-1				

PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(12/34)	SD-P-068

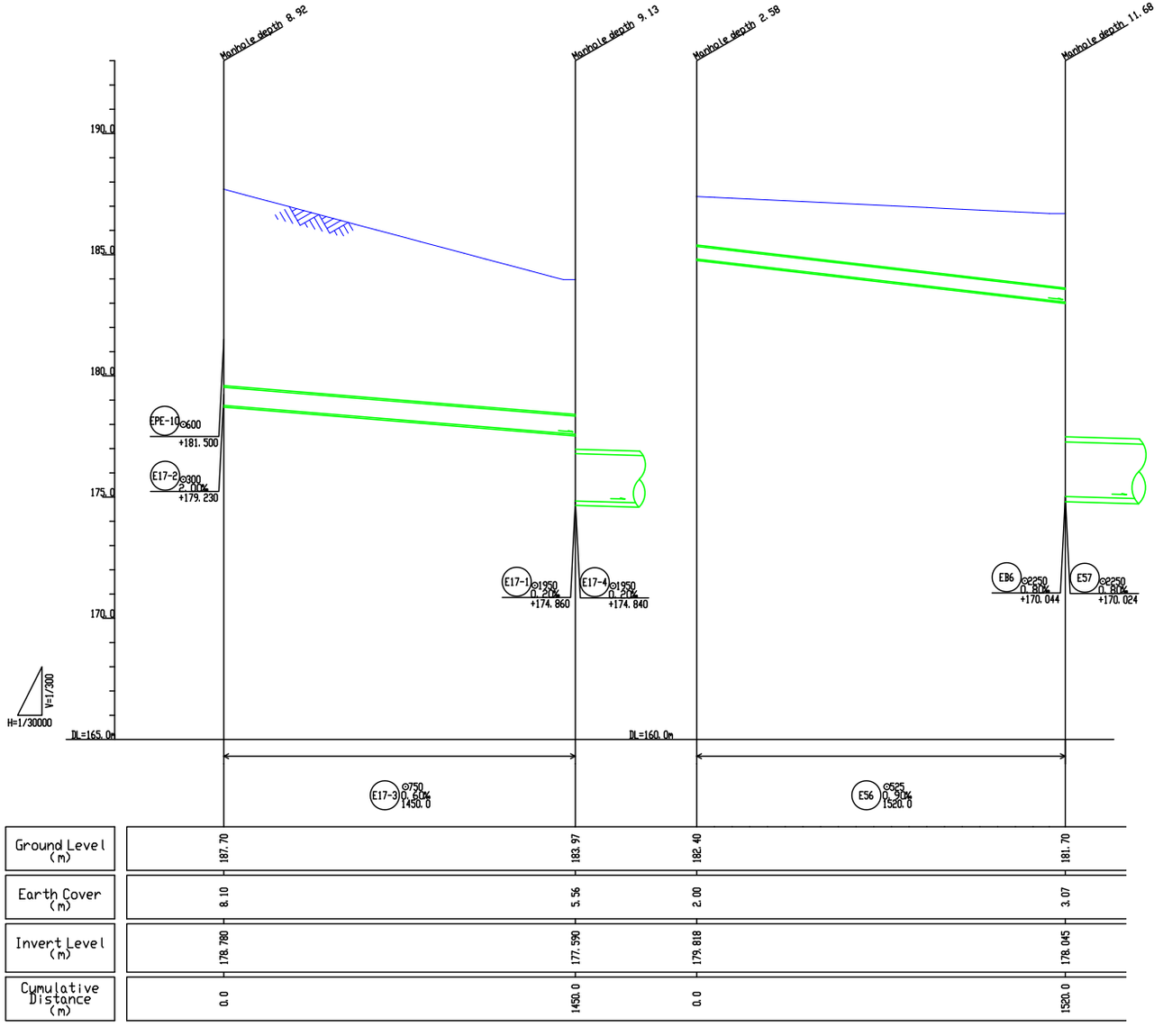


Pipe No.

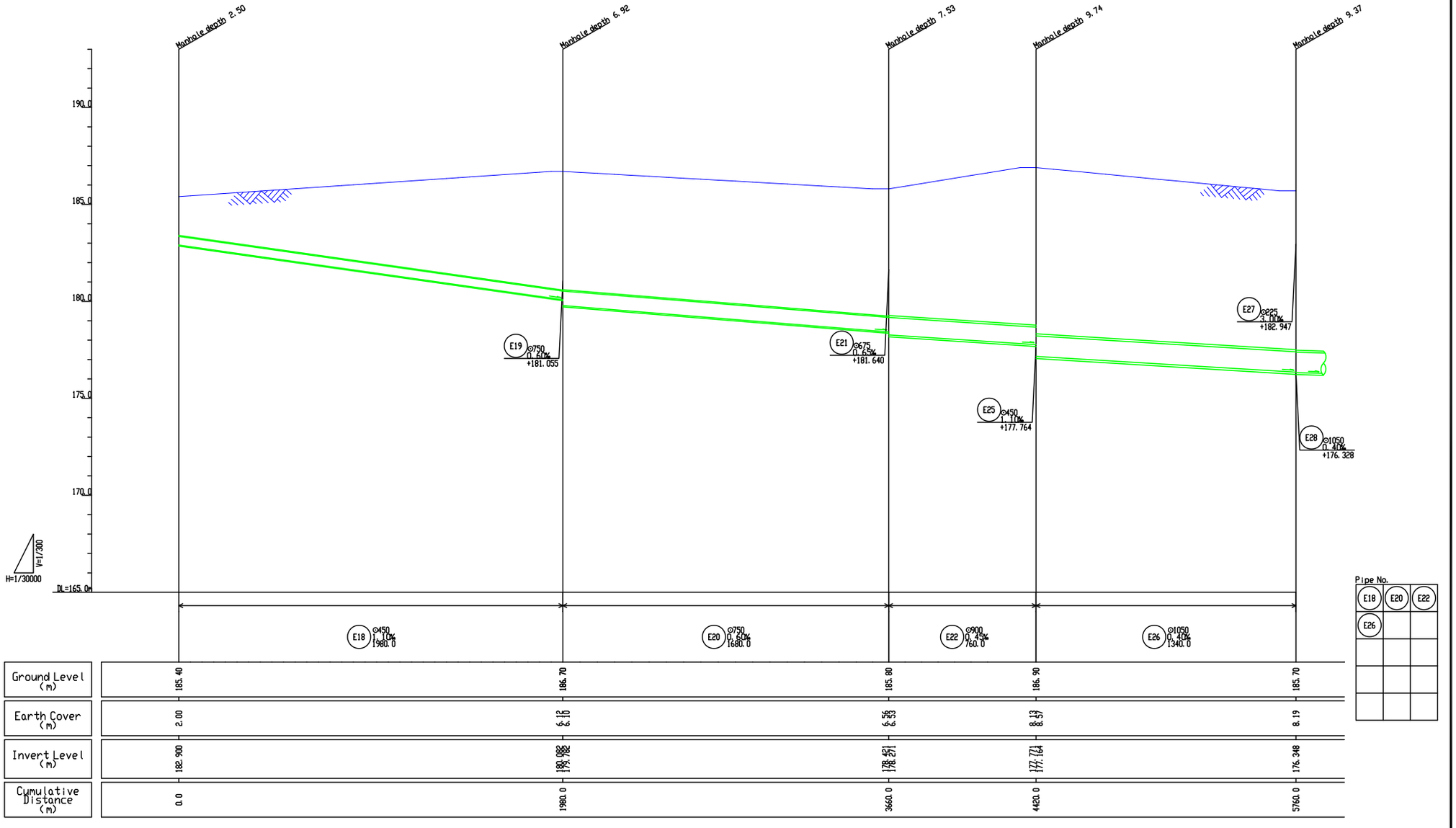
E14	E16	E17-2		

Ground Level (m)	184.50	187.80	186.40	188.10	187.10	187.70
Earth Cover (m)	4.96	9.42	2.00	4.41	5.73	8.13
Invert Level (m)	178.050	176.896	183.737	183.027	181.030	179.230
Cumulative Distance (m)	0.0	2510.0	0.0	710.0	0.0	680.0

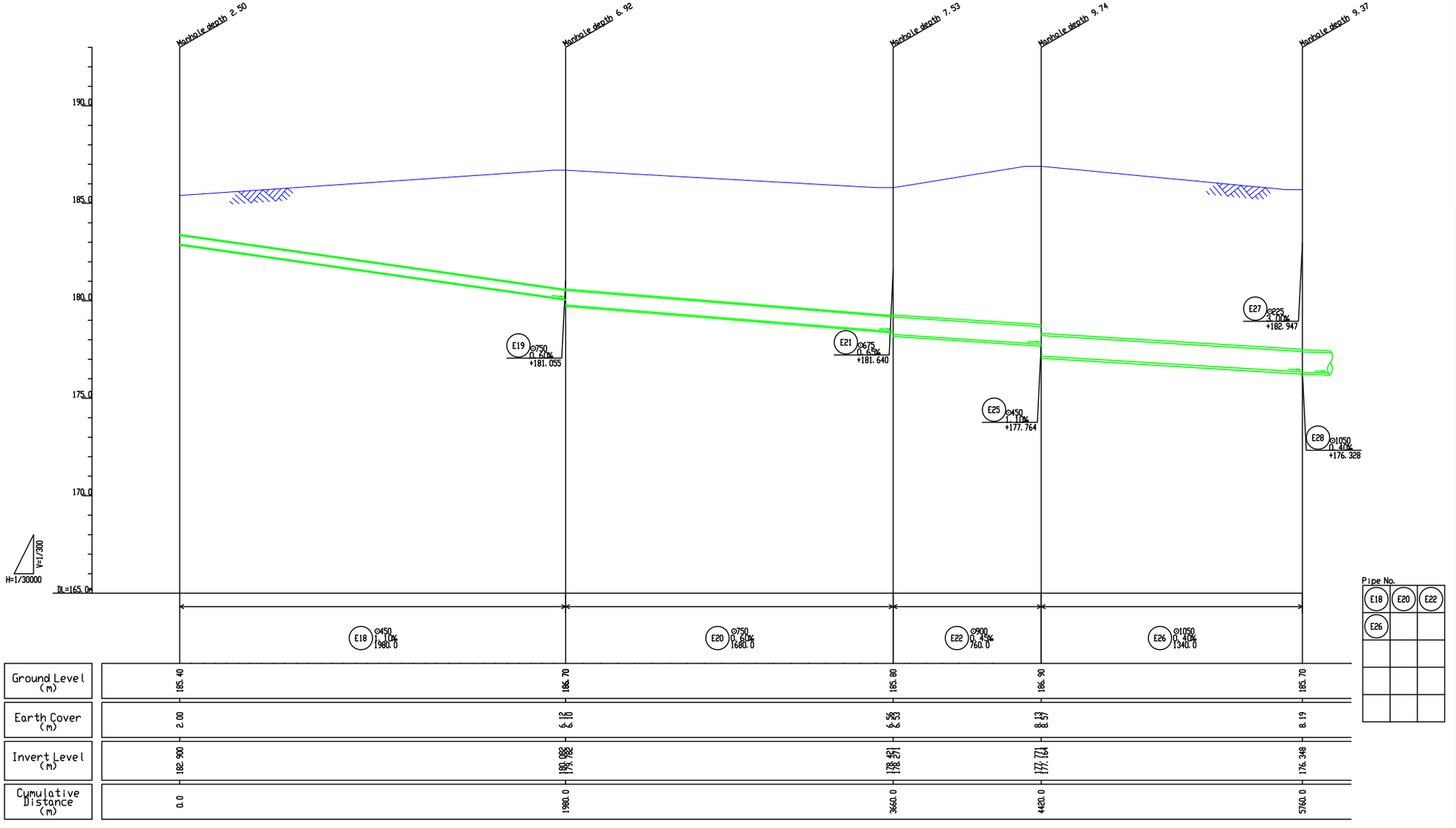
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(13/34)	SD-P-069



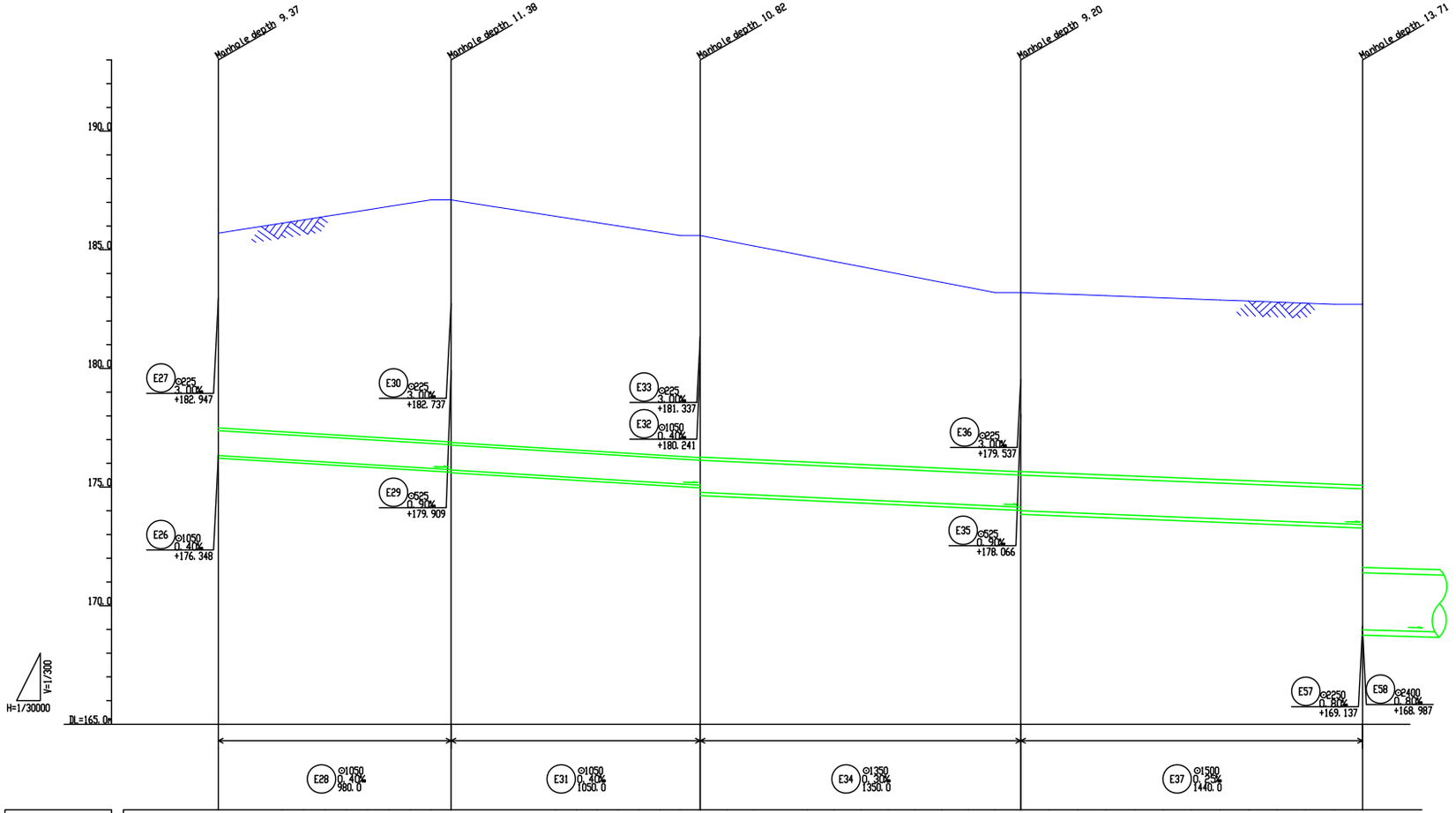
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(14/34)	SD-P-070



PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(15/34)	SD-P-071



PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(16/34)	SD-P-072

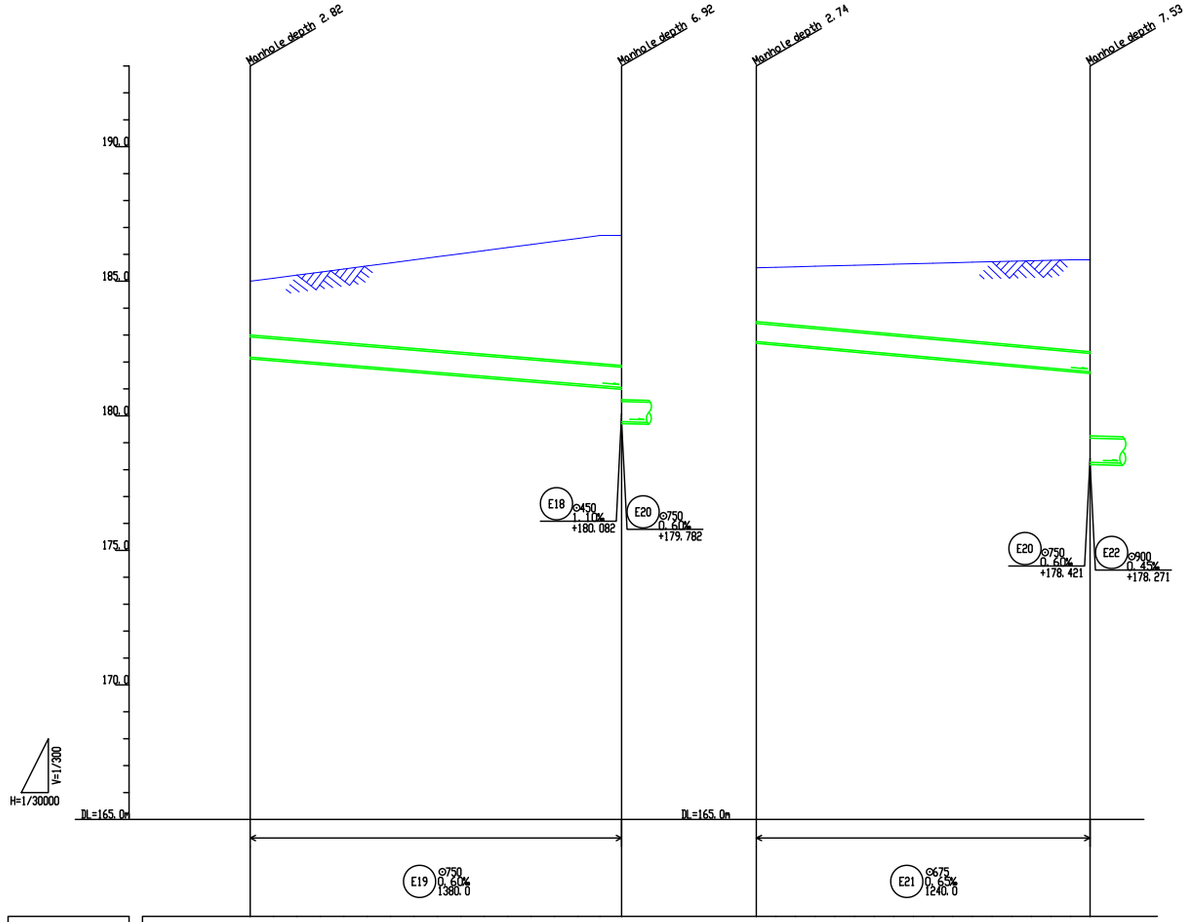


Ground Level (m)	185.70	187.10	185.60	183.20	182.70
Earth Cover (m)	8.21	10.20 10.22	9.36 9.33	7.56 7.55	7.63
Invert Level (m)	176.328	175.736 175.716	175.078 174.978	174.152 174.002	173.422
Cumulative Distance (m)	0.0	980.0	2030.0	3380.0	4820.0

Pipe No.

E28	E31	E34	E37	

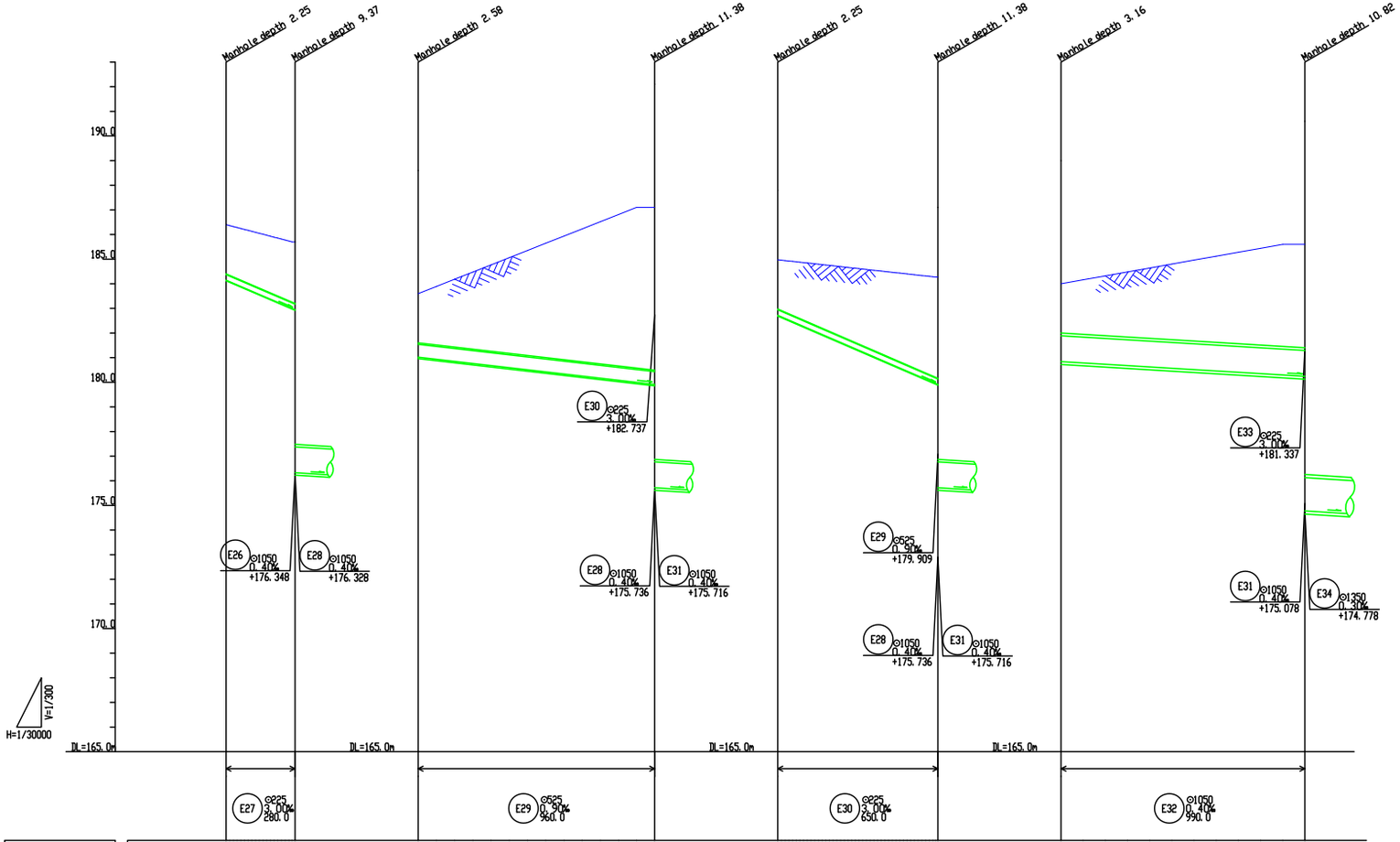
PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(17/34)	DRAWING NO.: SD-P-073



Pipe No.

E19	E21			

PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(18/34)	SD-P-074

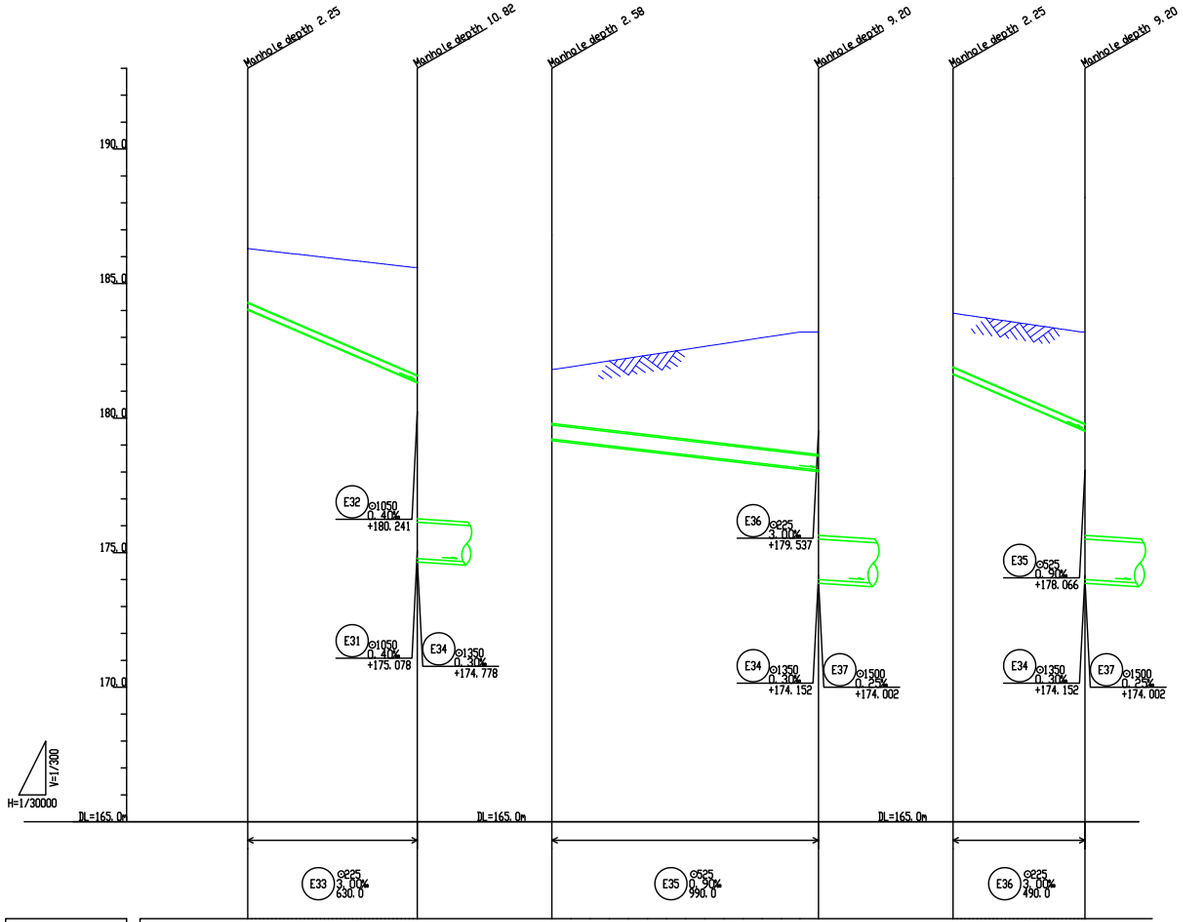


Pipe No.

E27	E29	E30	E32	

Ground Level (m)	186.40	185.70	183.60	187.10	187.80	187.10	184.00	185.60
Earth Cover (m)	2.00	2.50	2.00	6.61	2.00	4.11	2.00	4.20
Invert Level (m)	184.147	182.947	181.018	179.909	185.547	182.737	180.837	180.241
Cumulative Distance (m)	0.0	280.0	0.0	960.0	0.0	650.0	0.0	990.0

PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(19/34)	SD-P-075

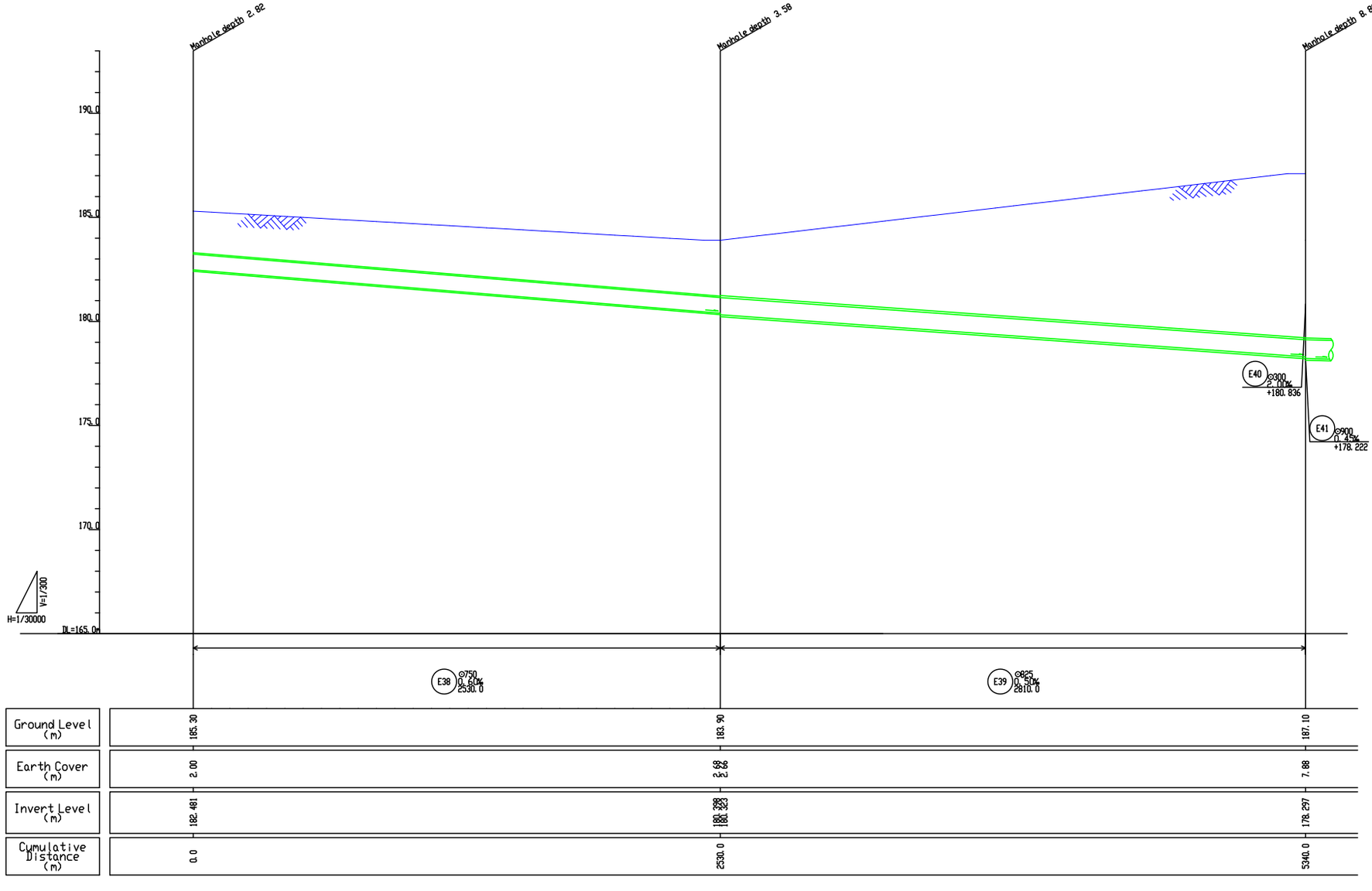


Ground Level (m)	186.30	185.60	181.80	183.20	183.90	183.20
Earth Cover (m)	2.00	4.01	2.00	4.55	2.00	3.41
Invert Level (m)	184.047	181.337	179.218	178.066	181.647	179.537
Cumulative Distance (m)	0.0	630.0	0.0	990.0	0.0	490.0

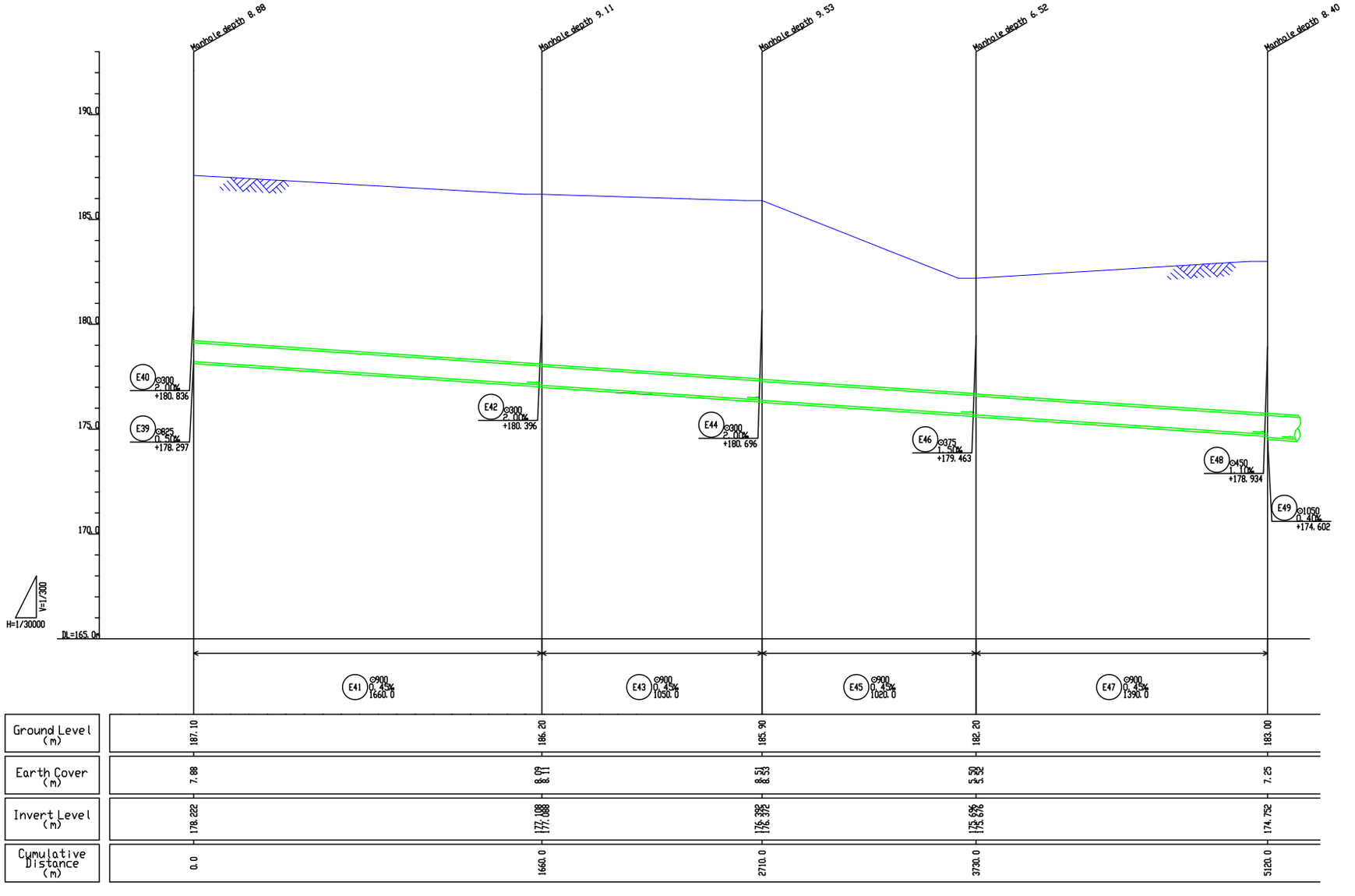
Pipe No.

E33	E35	E36		

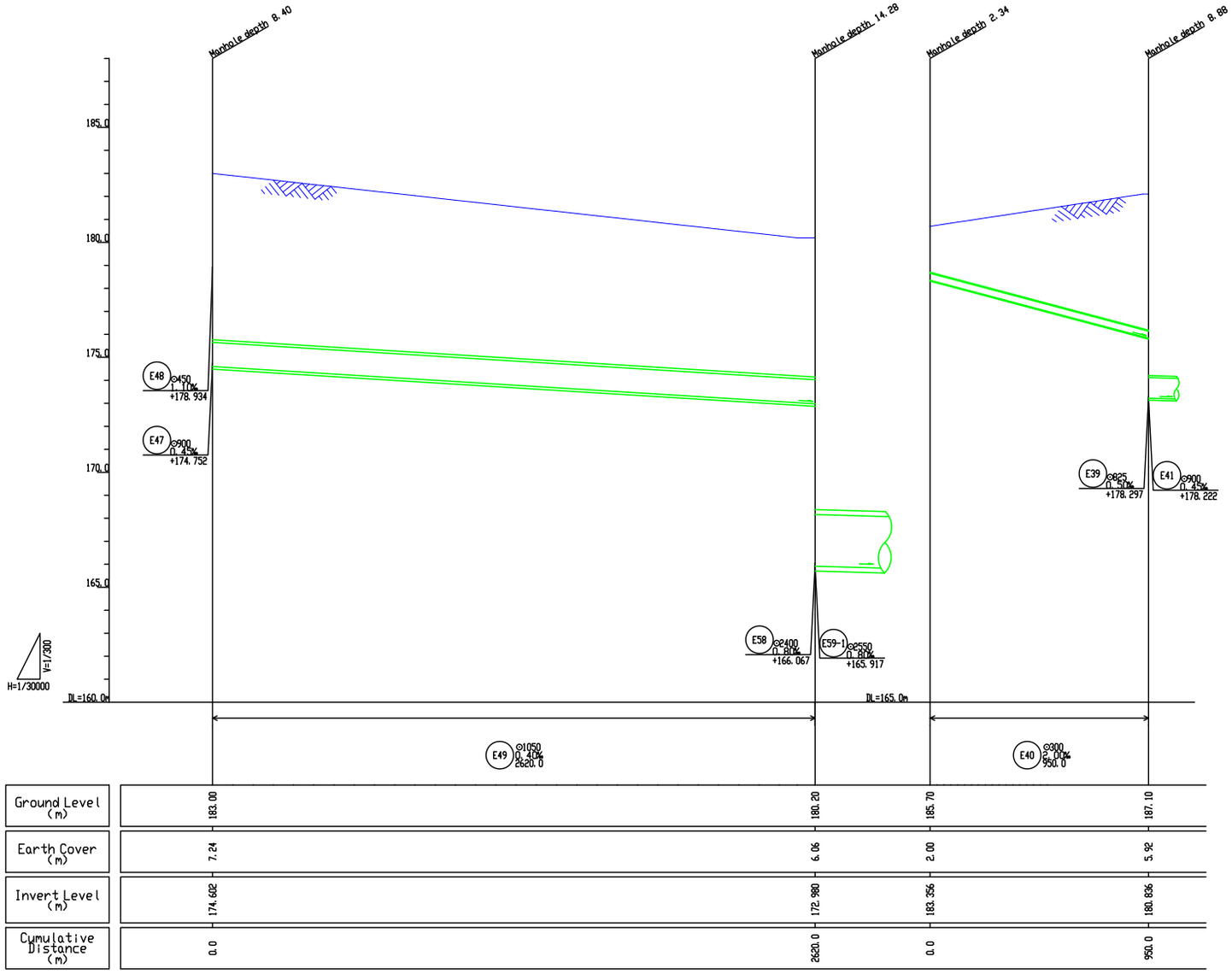
PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(20/34)	DRAWING NO.: SD-P-076



PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(21/34)	SD-P-077



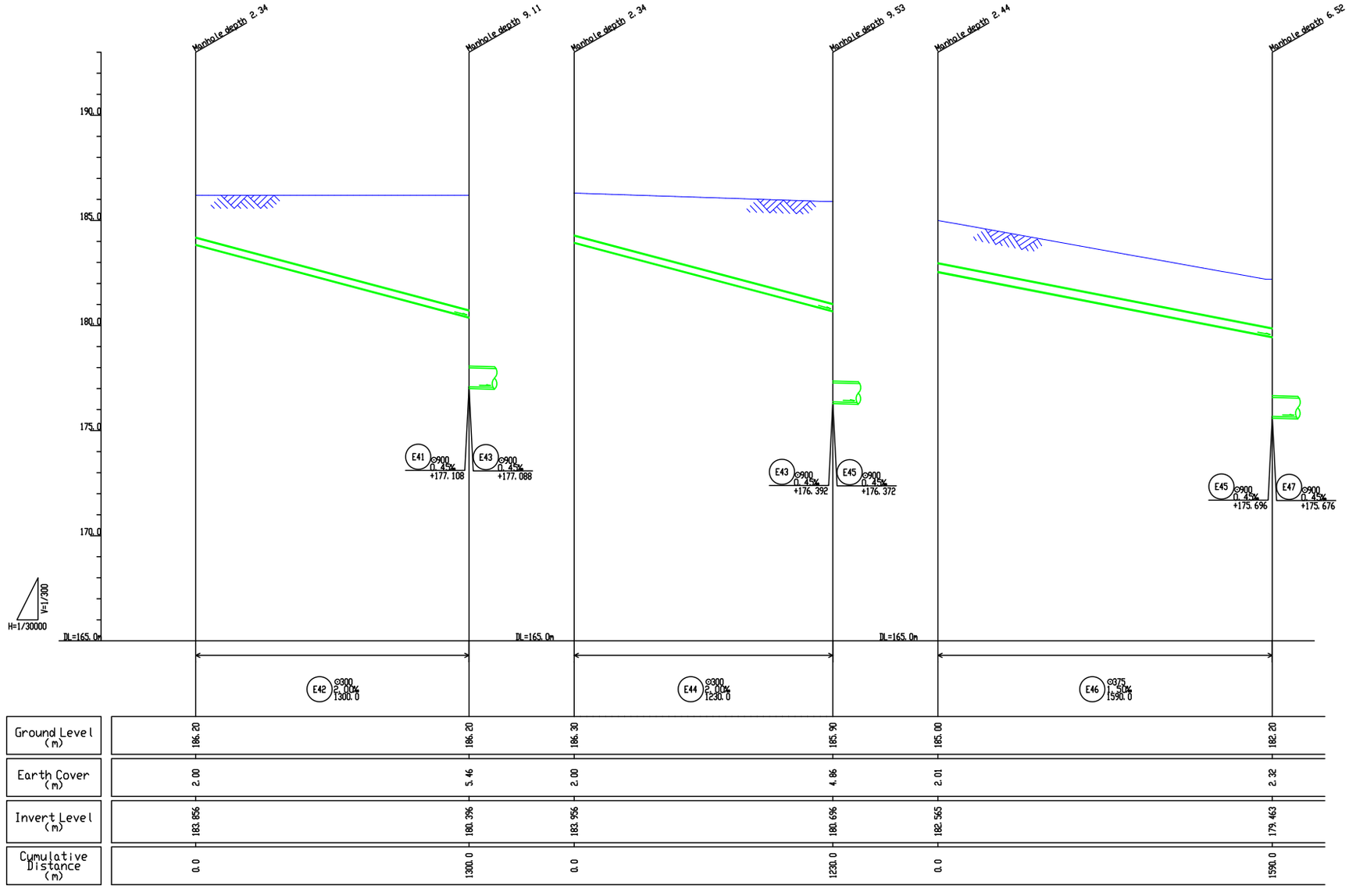
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(22/34)	SD-P-078



Pipe No.

E49	E40			

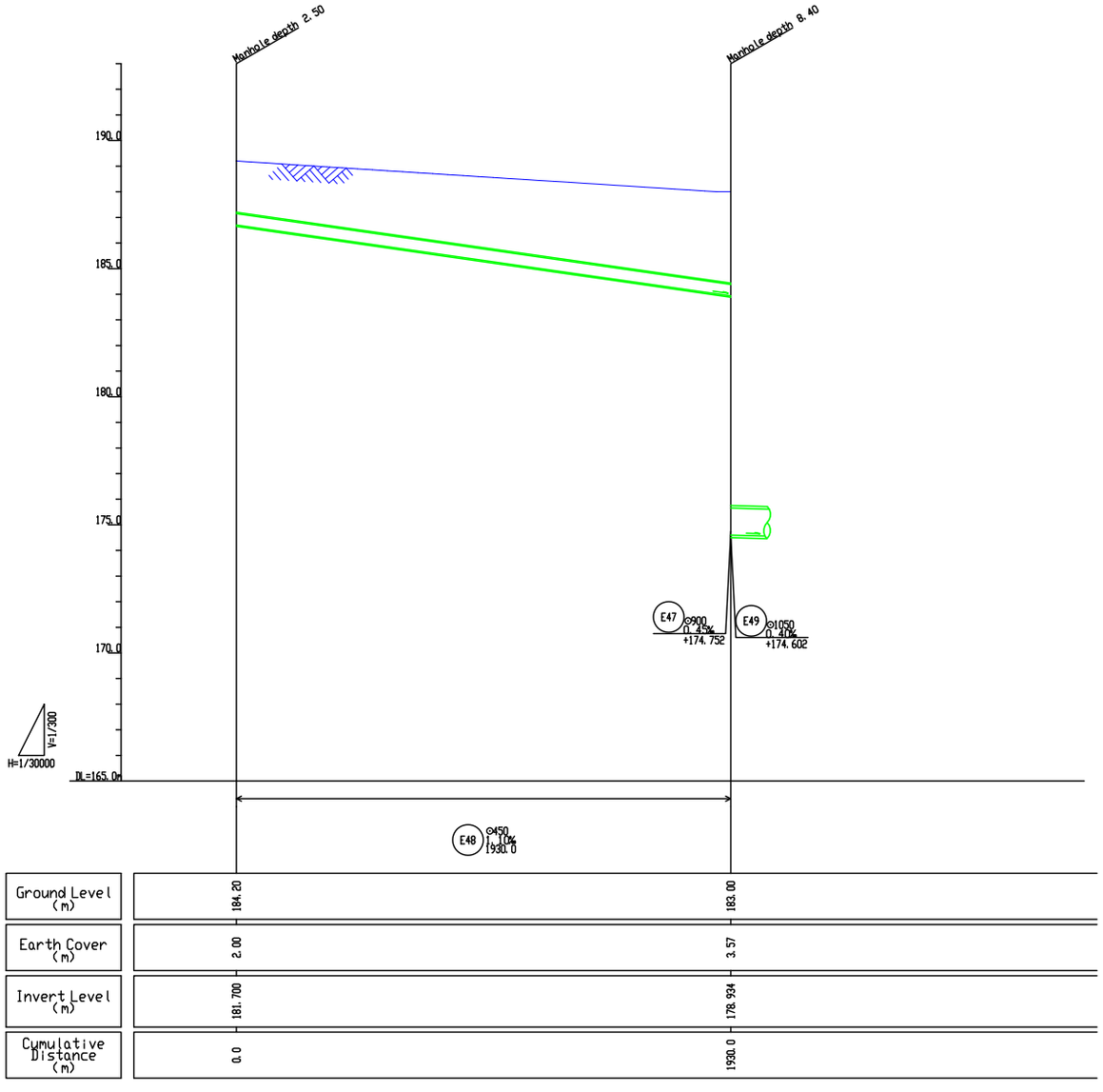
PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(23/34)	DRAWING NO.: SD-P-079



Pipe No.

E42	E44	E46		

PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(24/34)	SD-P-080

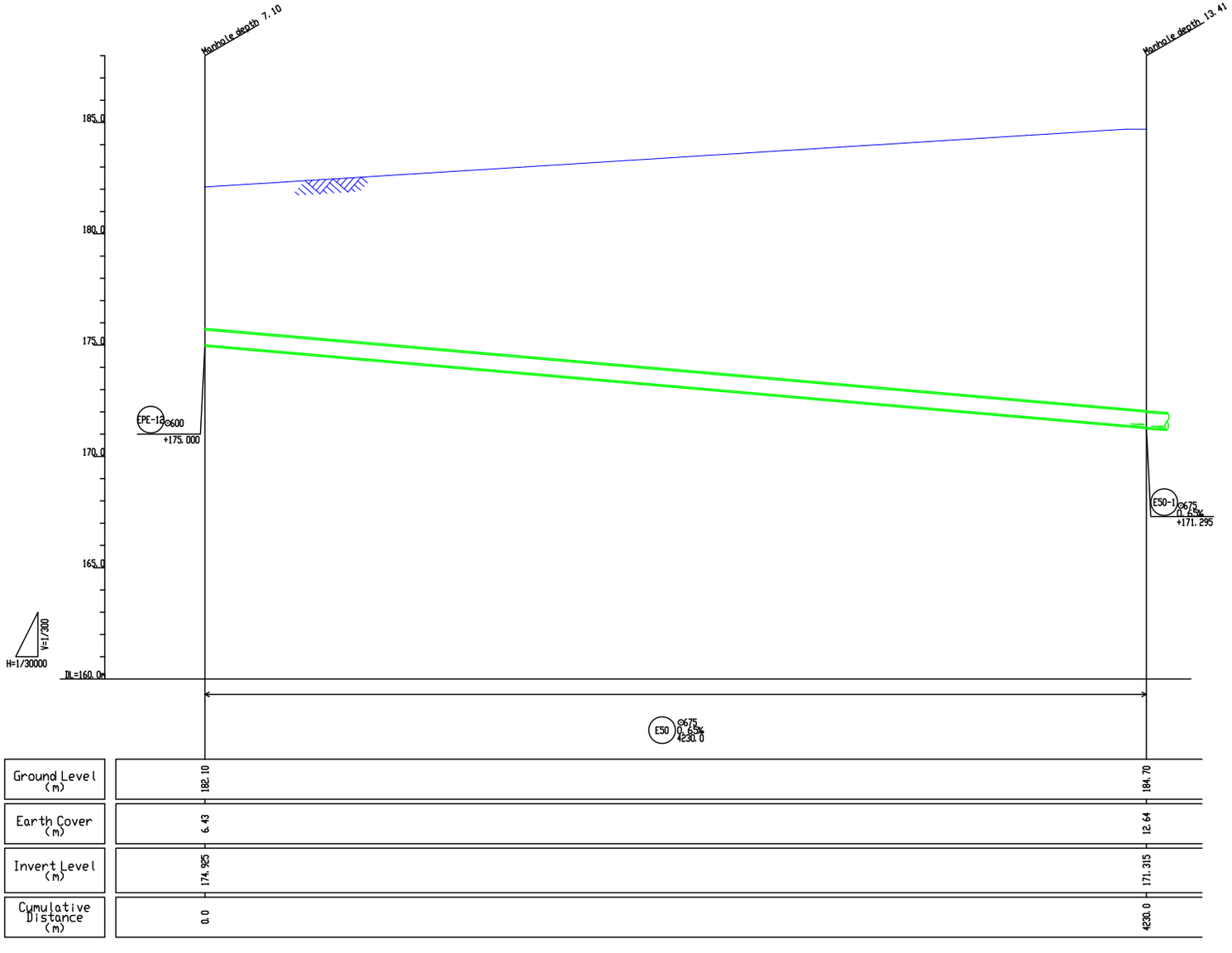


Pipe No.

E48				

PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(25/34)	SD-P-081

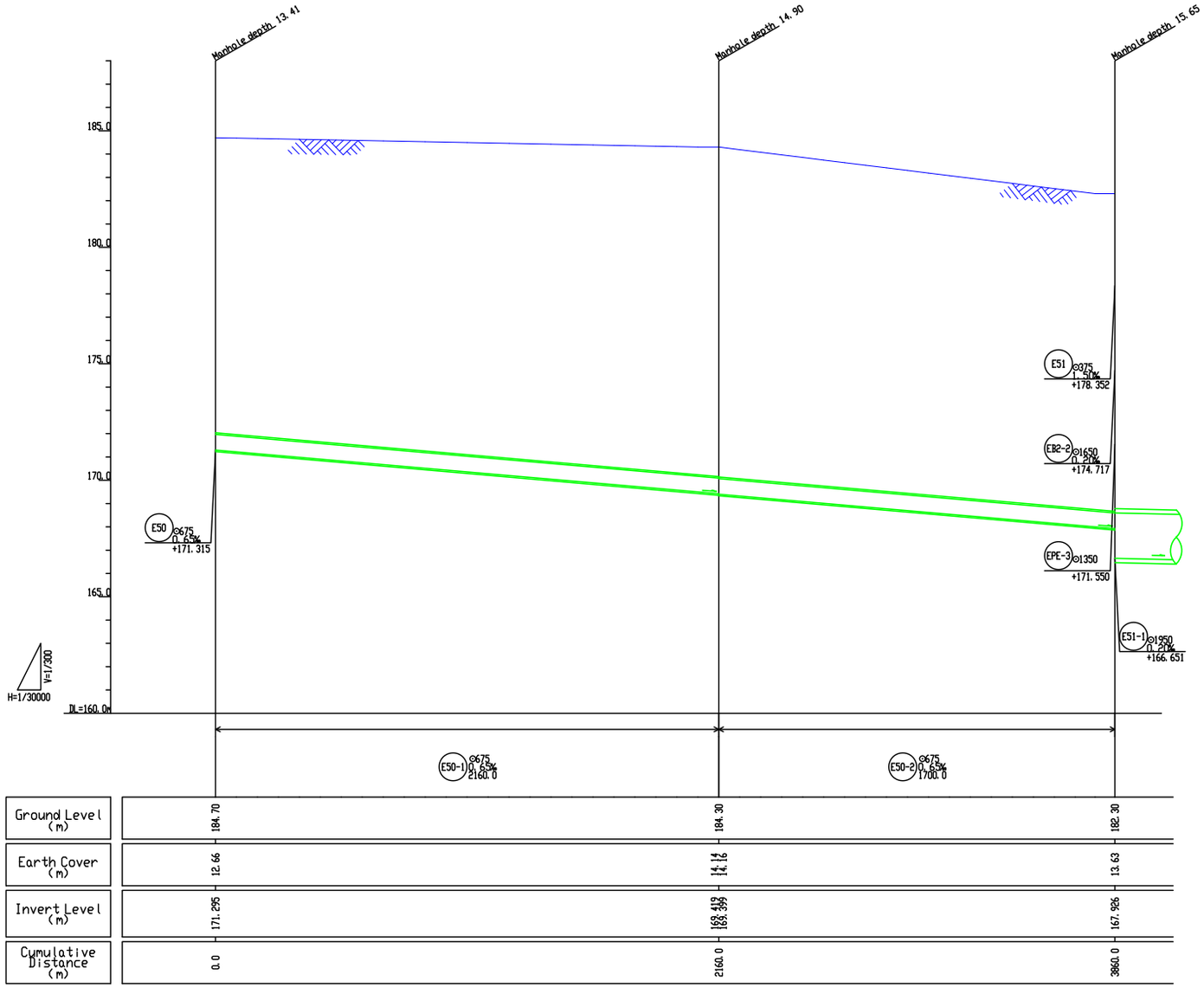
AC11 - 101



Pipe No.

E50				

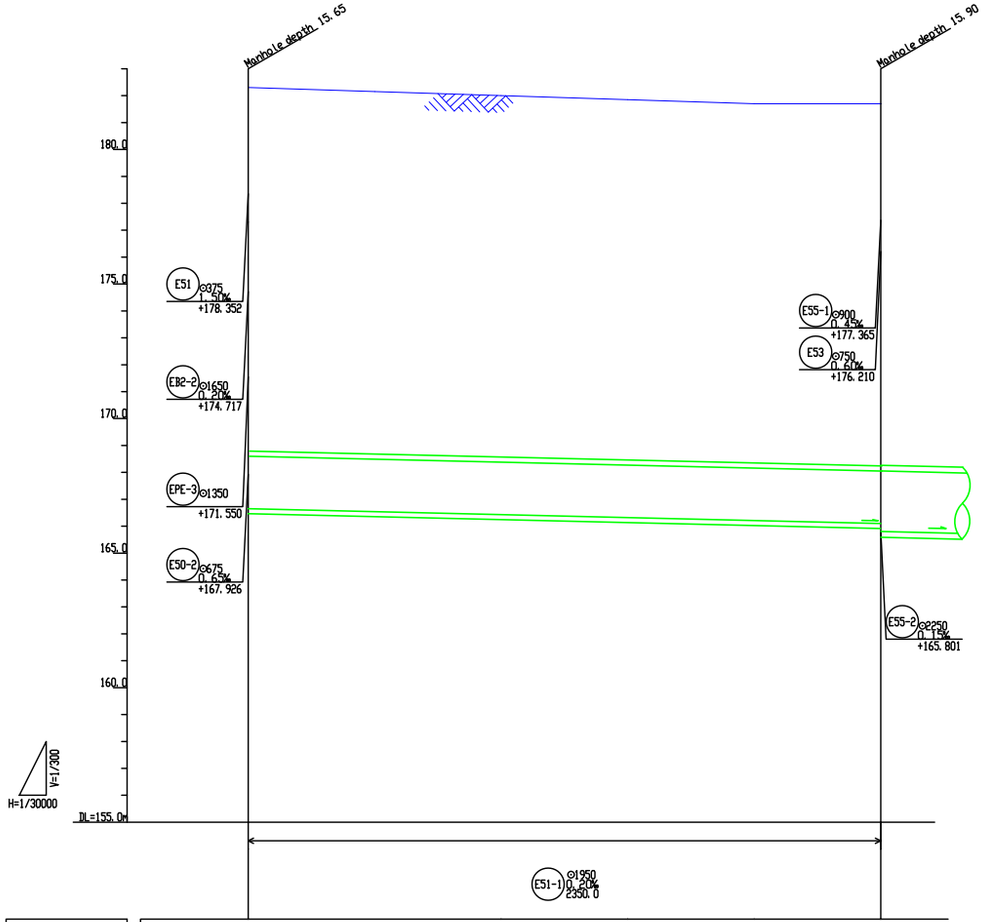
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(26/34)	SD-P-082



Pipe No.

E50-1	E50-2			

PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(27/34)	DRAWING NO.: SD-P-083

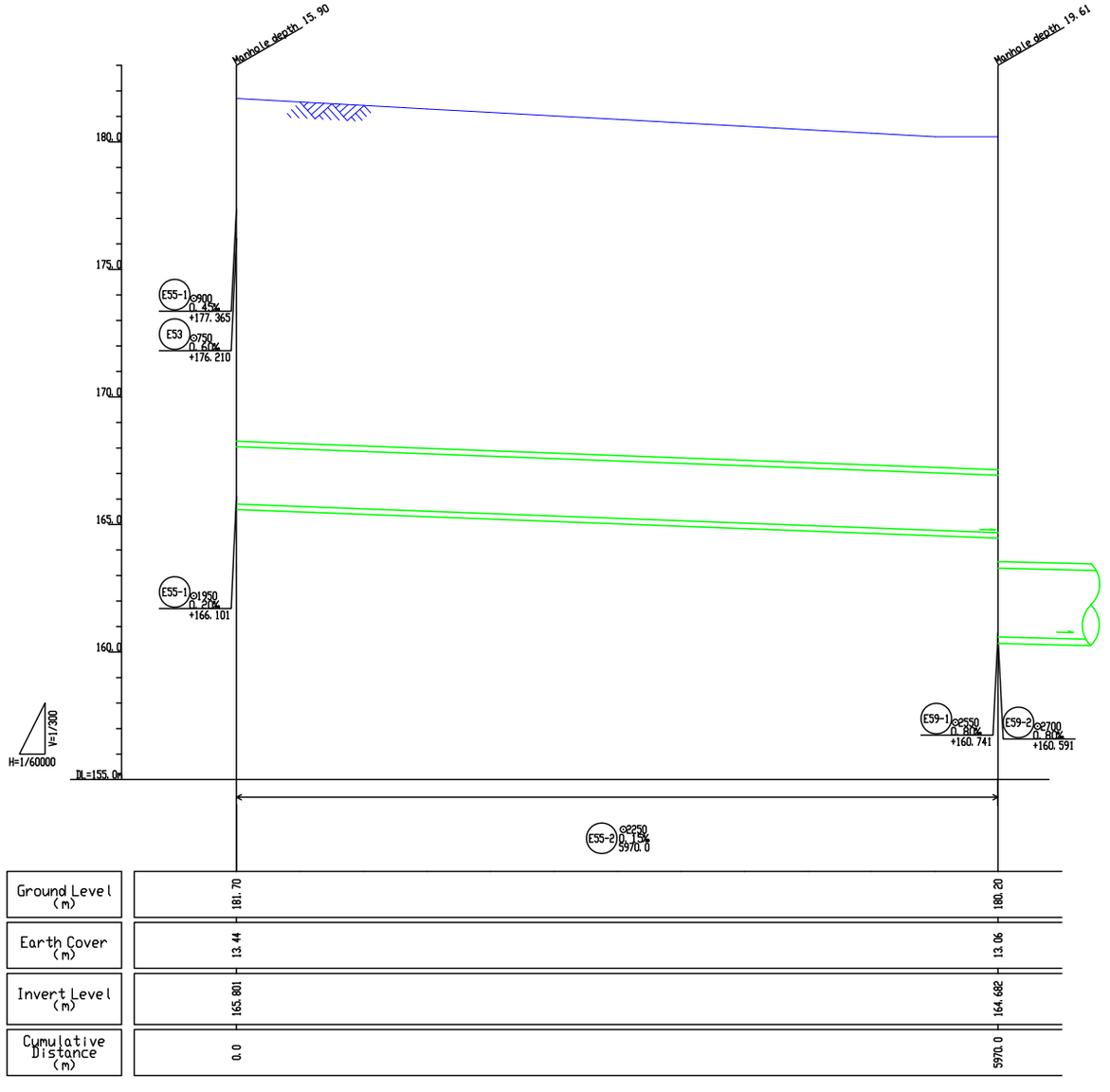


Ground Level (m)	182.30	181.70
Earth Cover (m)	13.51	13.46
Invert Level (m)	166.651	166.101
Cumulative Distance (m)	0.0	2350.0

Pipe No.

E51-1				

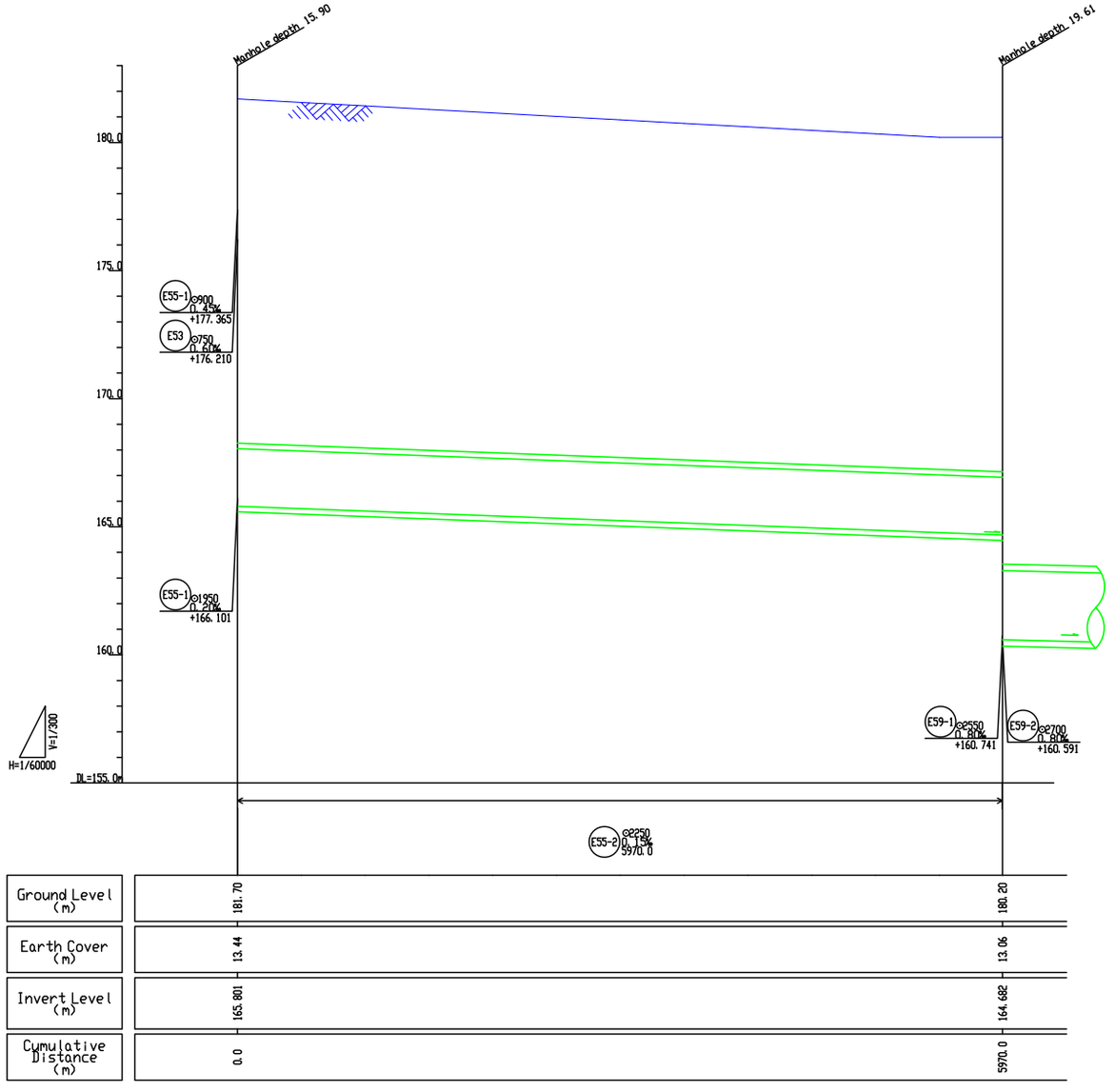
PROJECT: THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	TITLE: Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(28/34)	DRAWING NO.: SD-P-084



Pipe No.

E55-2				

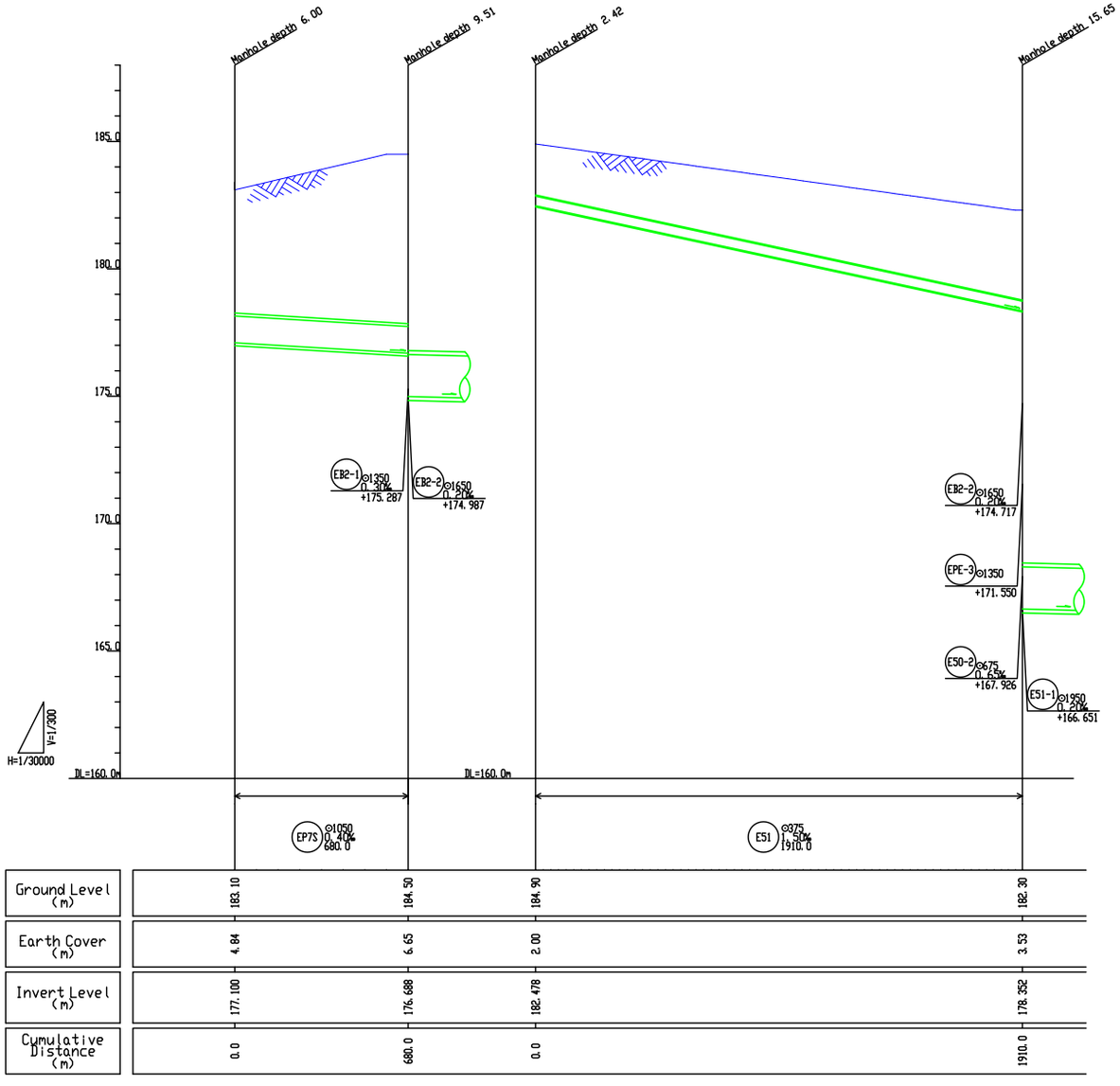
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(29/34)	SD-P-085



Pipe No.

E55-2				

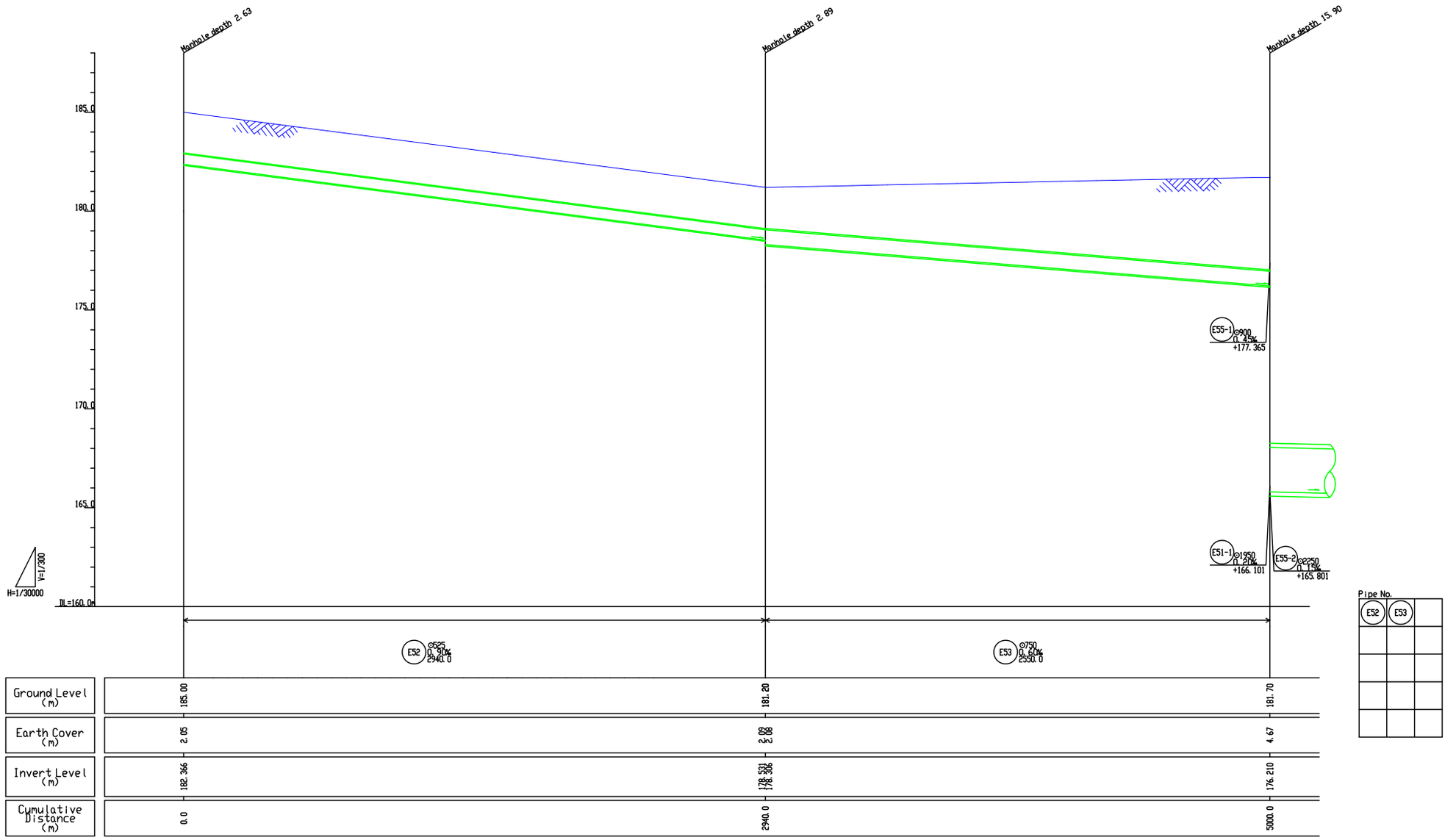
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(30/34)	SD-P-086



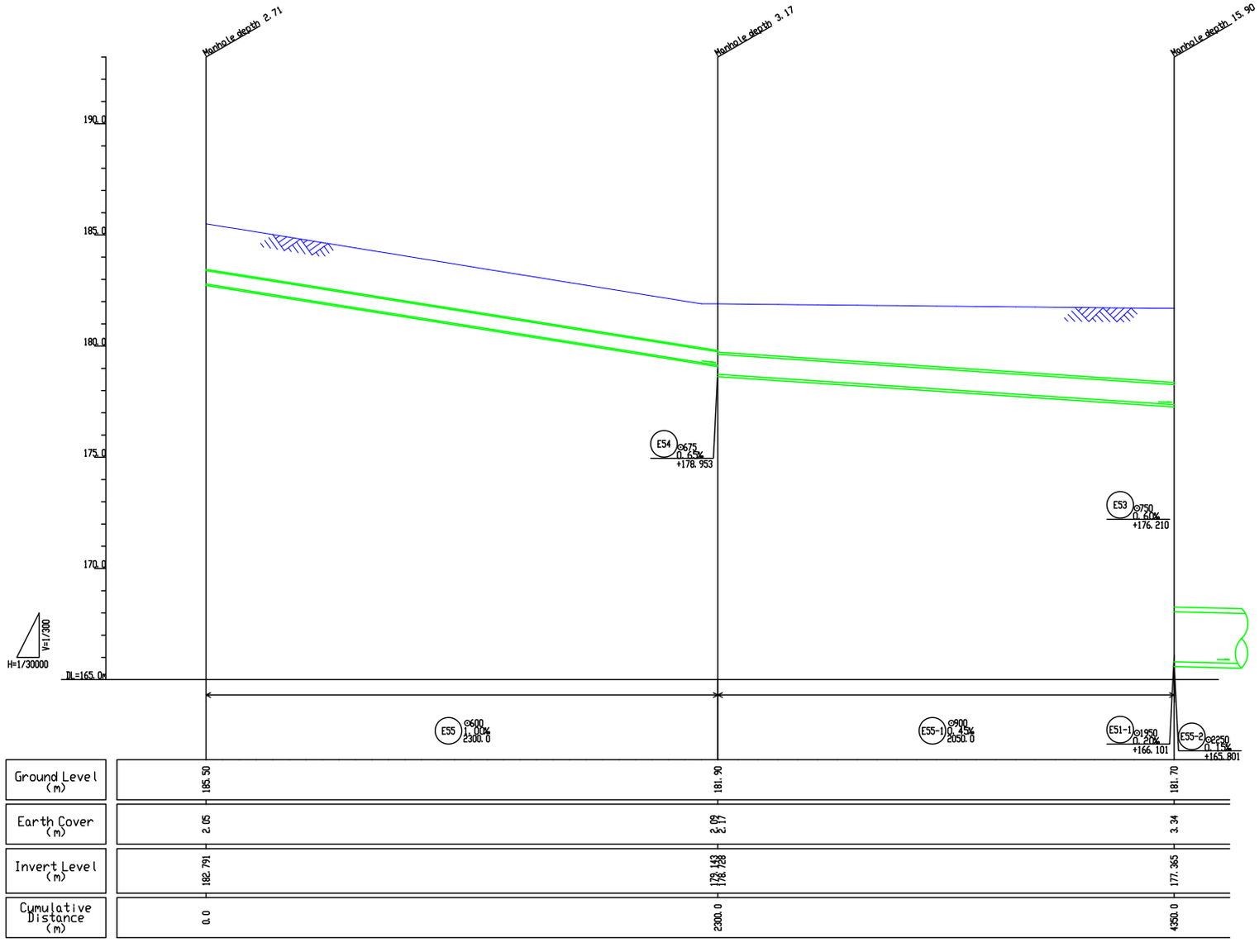
Pipe No.

EP7S	ES1			

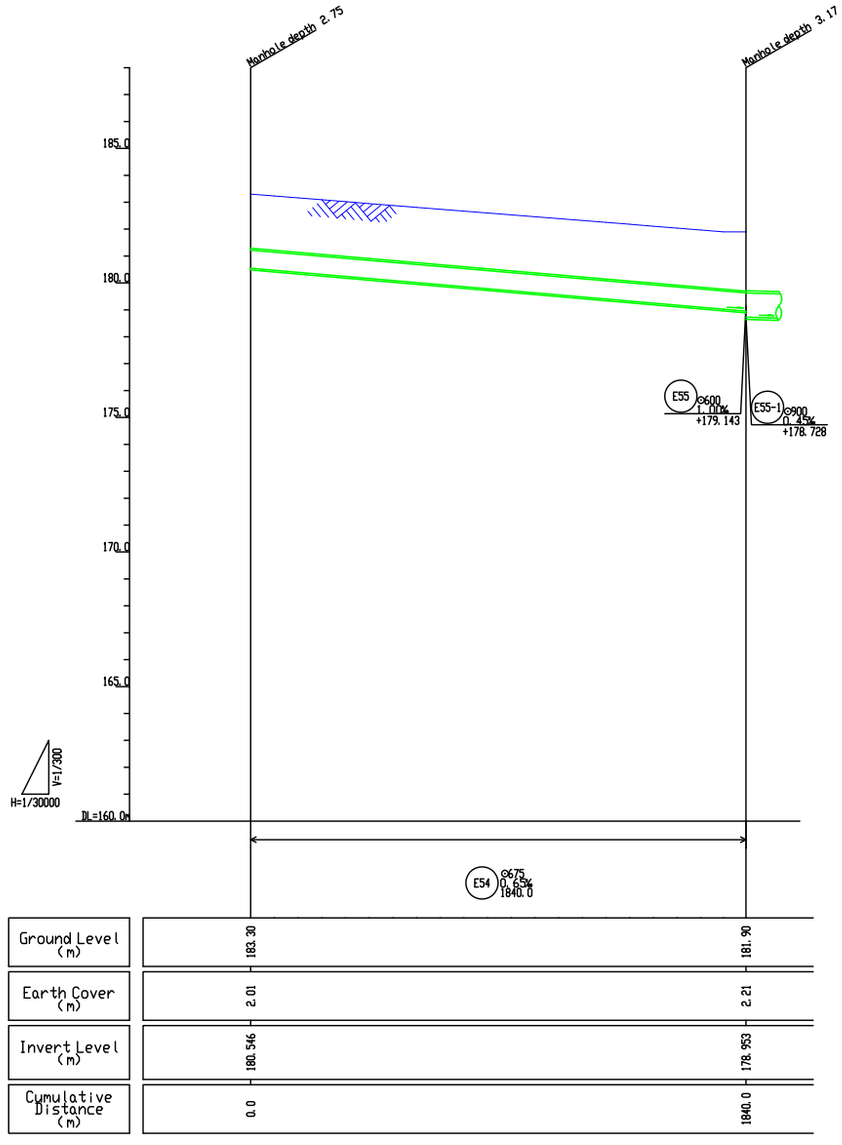
PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(31/34)	SD-P-087



PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(32/34)	SD-P-088



PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(33/34)	SD-P-089



Pipe No.

E54				

PROJECT:	TITLE:	DRAWING NO.:
THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD IN ISLAMIC REPUBLIC OF PAKISTAN	Longitudinal Section of Main,Trunk,and Interceptor Sewers in the Eastern SWD(34/34)	SD-P-090

AC11.4 Branch Sewers and Replaced Existing Sewers

AC11.4.1 Branch Sewers

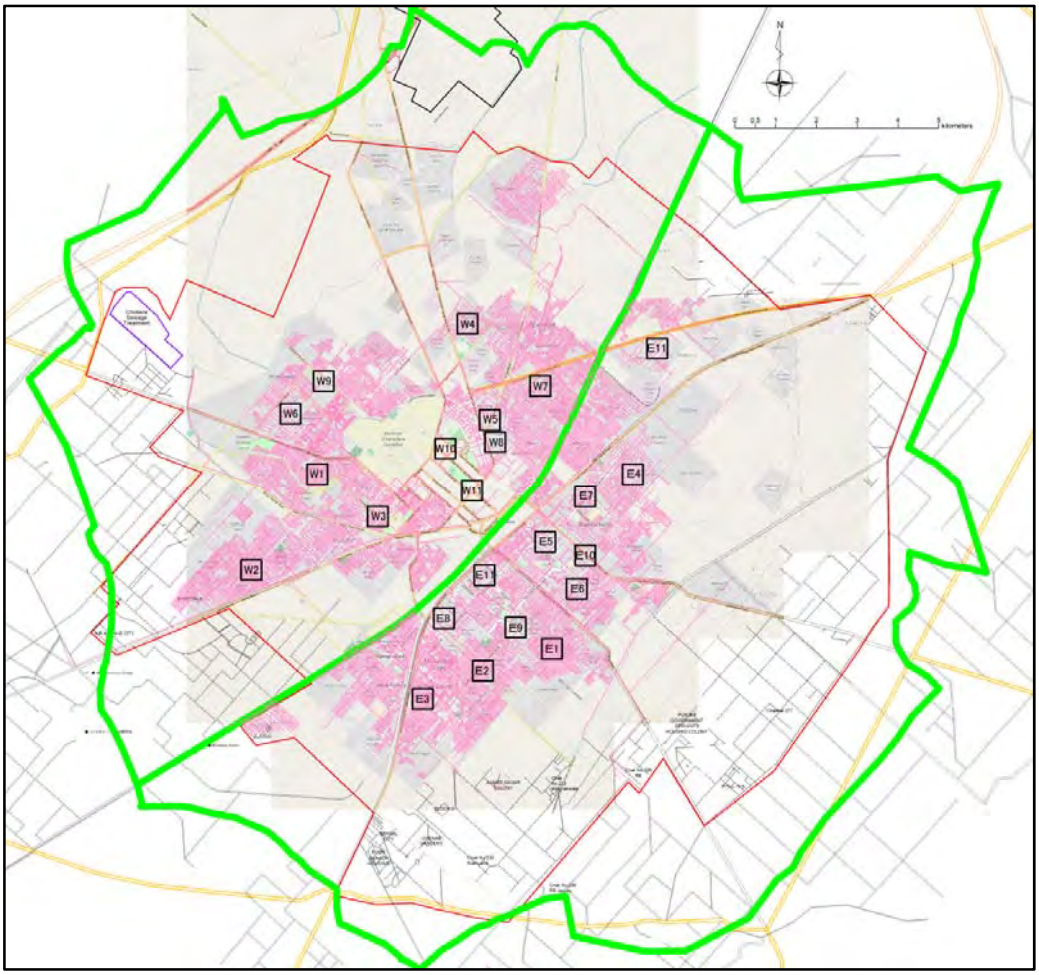
(1) General

Branch sewer is planned to collect the wastewater and parts of storm-water within their capacity in the Sewerage and Drainage M/P of Faisalabad. The branch sewer is a concrete pipe having diameter of 225mm. The design of branch sewers is not included in the scope of work for the M/P but will be conducted in the following project stages such as F/S and D/D. But the construction cost of branch sewers is required to estimate because the cost of branch sewers are one of important components of the sewerage project cost. The construction cost estimation of branch sewers is presented in the Appendix AC6.1.

In this section, the length of branch sewers is estimated based on the length of road where sewers are installed in the current WASA-F sewerage service area.

(2) Estimation of the unit road length (road length per hector) in the area where sewers are installed.

Figure AC11.4.1 presents the locations (each meshed rot: 500 m x 500 m, 250 ha) randomly selected for estimation of the unit road length based on the population density level of High, Medium and Low.

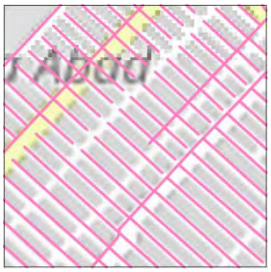
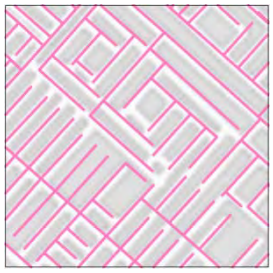
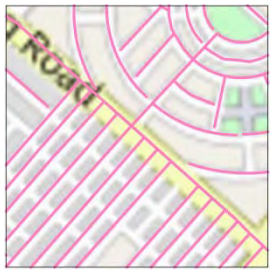
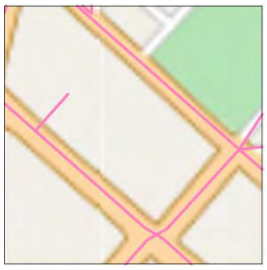


Source: JICA Mission Team

Figure AC11.4.1 Sampling Locations to Estimate the Unit Road Length

Table AC11.4.1 and **AC11.4.2** show the unit road length at the selected area based on population density in the western and the eastern sewerage district.

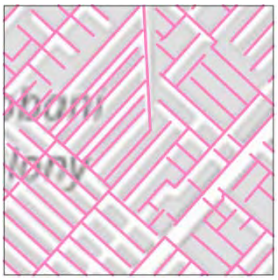
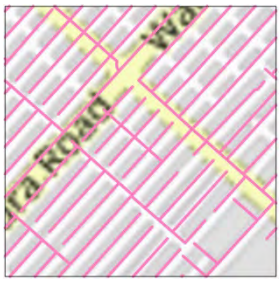
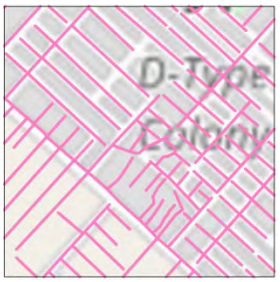
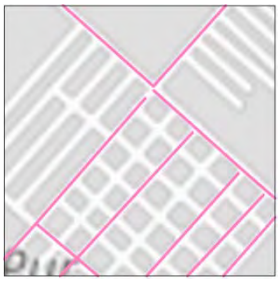
Table AC11.4.1 Unit Road Density in the Western SWD

High Density		Medium Density		Low Density	
1		4		8	
	m/ha＝324		m/ha＝186		m/ha＝49
2		5		9	
	m/ha＝292		m/ha＝111		m/ha＝85
3		6		10	
	m/ha＝245		m/ha＝114		m/ha＝63
	—	7		11	
	—		m/ha＝184		m/ha＝75
Average：290 m/ha		**Average：150 m/ha**		**Average：70 m/ha**	

Source: JICA Mission Team

The average figures of 290, 150, and 70 m/ha are used to estimate the length of branch sewers in the area of the high, medium and low population density in the western sewerage district.

Table AC11.4.2 Unit Road Density in the Eastern SWD

High Density		Medium Density		Low Density	
1		4		8	
	m/ha＝358		m/ha＝173		m/ha＝87
2		5		9	
	m/ha＝224		m/ha＝102		m/ha＝80
3		6		10	
	m/ha＝344		m/ha＝155		m/ha＝85
		7		11	
	－		m/ha＝165		m/ha＝87
Average：310 m/ha		**Average：150 m/ha**		**Average：85 m/ha**	

Source: JICA Mission Team

The average figures of 310, 150, and 85 m/ha are used to estimate the length of branch sewers in the area of the high, medium and low population density in the eastern sewerage district.

(3) Estimation of Length of Branch Sewer

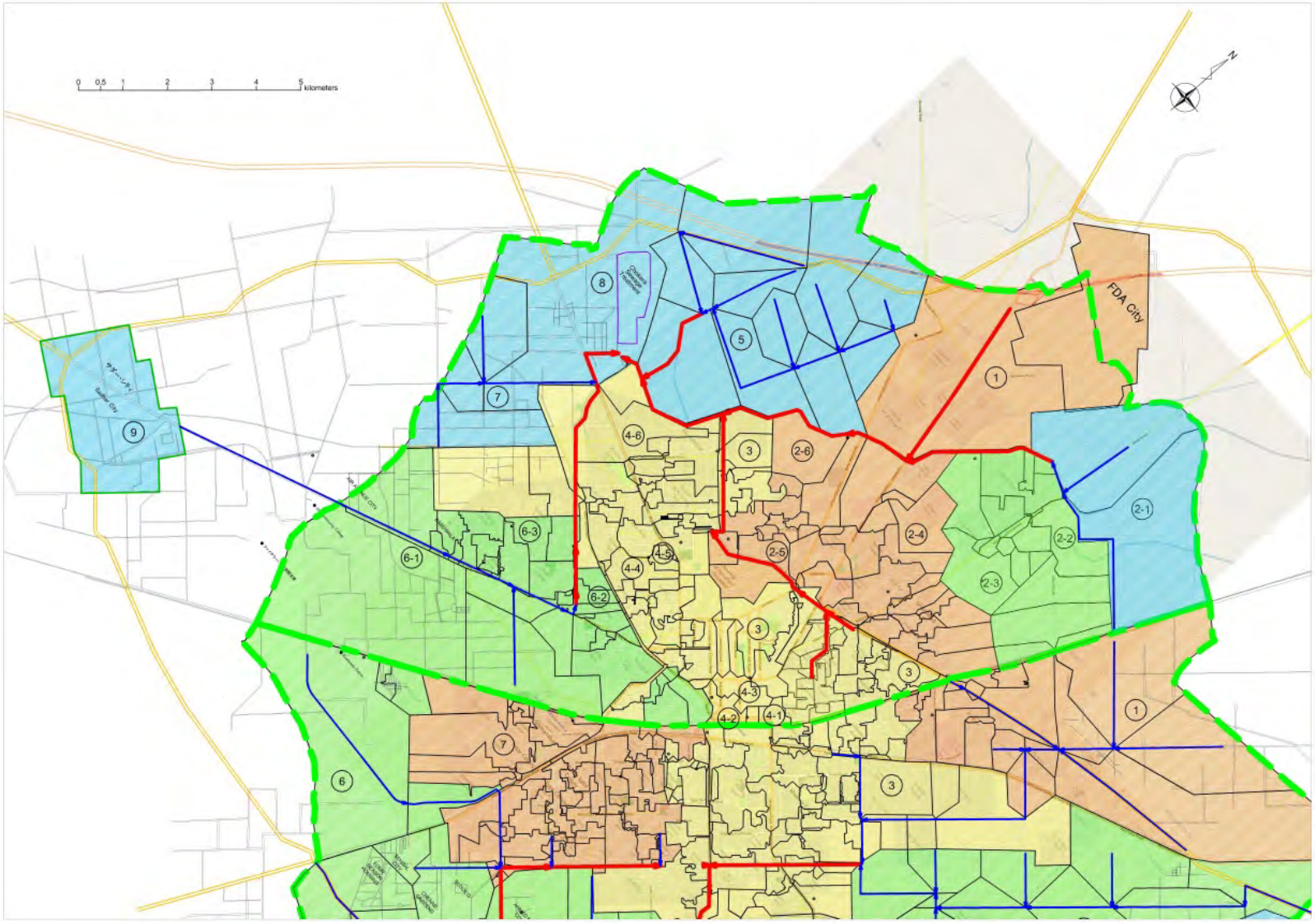
Table AC11.4.3 shows the estimated branch sewer length in the western SWD. Noted that the block

number shown in the table shall be referred to the number shown in **Figure AC2.6.2**. The branch sewer will be developed by 4 phase, accordingly the branch sewer length is arranged as shown in the table.

Table AC11.4.3 Estimated Branch Sewer Length in the Western SWD

Block	① Area (ha)	② Population	③ Design Flow (m3/d)	Population Density ② / ①		Flow per area ③ / ①			Applied Unit Sewer Legth (m/ha)	Sewer Length (m)	Phase 1	Phase 2	Phase 3	Phase 4	Total
1	1,579.5	167,286	43,947	106	M	28	M	M	150	236,925		236,925			236,925
2-1	1,342.4	103,027	18,847	77	M	14	M	M	150	201,360				201,360	201,360
2-2	452.3	29,078	7,381	64	M	16	M	M	150	67,845			67,845		67,845
2-3	926.4	130,478	22,494	141	H	24	M	HM	200	185,280			185,280		185,280
2-4	1,083.7	214,014	57,028	197	H	53	H	H	100	108,370		108,370			108,370
2-5	983.7	107,763	28,593	110	M	29	M	M	100	98,370		98,370			98,370
2-6	190.1	34,851	5,465	183	H	29	M	HM	150	28,515		28,515			28,515
2 Total	4,978.6	619,211	139,808	124		28				689,740					
3-1											0				0
3-2											0				0
3-3	329.0								150	49,350	49,350				49,350
3 Total	329.0	0	0	0	H	0	H	H		49,350					
4-1	42.1	5,642	925	134	M	22	M	M	0	0	0				0
4-2	61.5	20,024	2,975	326	H	48	H	H	0	0	0				0
4-3	132.5	16,367	2,716	124	M	20	M	M	0	0	0				0
4-4	160.4	47,150	7,060	294	H	44	H	H	0	0	0				0
4-5	9.4	3,453	509	367	H	54	H	H	0	0	0				0
4-6	2,159.3	552,393	86,265	256	H	40	H	H	150	323,895	323,895				323,895
4 Total	2,565.2	645,029	100,450	251		39				323,895					
5	2,557.0	110,016	27,620	43	L	11	L	L	80	204,560				204,560	204,560
6-1	2,836.1	160,684	38,671	57	L	14	M	L	80	226,888			226,888		226,888
6-2	27.8	6,877	1,045	247	H	38	H	H	0	0			0		0
6-3	205.5	41,552	6,449	202	H	31	H	H	0	0			0		0
6 Total	3,069.4	209,113	46,165	68		15				226,888					
7	745.7	70,632	12,836	95	M	17	M	M	150	111,855				111,855	111,855
8	1,049.1	72,910	13,679	69	M	13	M	M	150	157,365				157,365	157,365
9	779.0	30,000	4,599	39	L	6	L	L	80	62,320				62,320	62,320
Total		1,924,197	389,104							2,062,898	373,245	472,180	480,013	737,460	2,062,898

Source: JICA Mission Team



Source: JICA Mission Team

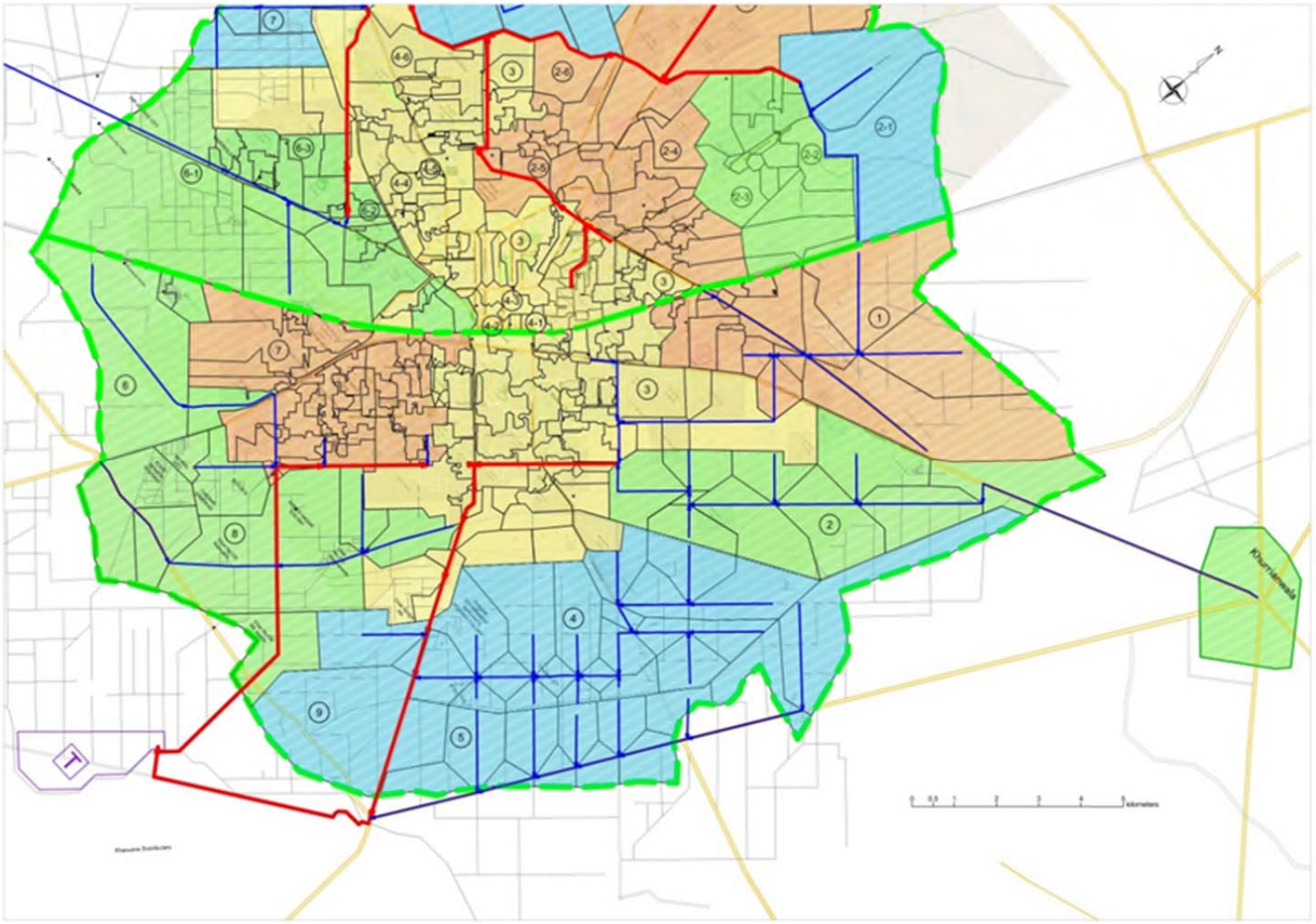
Figure AC11.4.2 Sub district to Estimate the Branch Sewer Length in the Western SWD

Table AC11.4.4 shows the estimated branch sewer length in the eastern SWD. Noted that the block number shown in the table shall be referred to the number shown in **Figure AC2.6.3**. The branch sewer will be developed by 4 phase, accordingly the branch sewer length is arranged as shown in the table.

Table AC11.4.4 Estimated Branch Sewer Length in the Eastern SWD

Block	① Area (ha)	② Population	③ Design Flow (m3/d)	Population Density ② / ①		Flow per area ③ / ①			Applied Unit Sewer Length (m/ha)	Sewer Length (m)	Phase 1	Phase 2	Phase 3	Phase 4	Total
1	2,849	462,430	76,726	162	H	27	M	HM	150	427,350		427,350			427,350
2	2,301	200,205	34,088	87	M	15	M	M	150	345,150			345,150		345,150
3	3,553	680,889	148,424	192	H	42	H	H	150	532,950	532,950				532,950
4	2,629	120,811	48,156	46	L	18	M	M	150	394,350				394,350	394,350
5	1,924	68,266	15,221	35	L	8	L	L	80	153,920				153,920	153,920
6	1,583	20,868	7,651	13	L	5	L	L	80	126,640			126,640		126,640
7	1,981	400,578	74,204	202	H	37	H	H	50	99,050		99,050			99,050
8	2,021	85,378	18,391	42	L	9	L	L	80	161,680			161,680		161,680
9	1,566	46,395	11,121	30	L	7	L	L	80	125,280				125,280	125,280
10	285								80	22,800				22,800	22,800
Total	20,692	2,085,820	433,982							2,389,170	532,950	526,400	633,470	696,350	2,389,170

Source: JICA Mission Team



Source: JICA Mission Team

Figure AC11.4.3 Sub district to Estimate the Branch Sewer Length in the Eastern SWD

AC11.4.2 Replaced Sewer

Based on the sewer capacity calculation for the design flow, the listed sewers are required to replace with the diamter shown in below.

Table AC11.4.5 Sewer to be replaced in the Western SWD

Sewer No.	Dia. (mm)	Length (m)
26	900	248
28	1,200	1,082
29	1,200	709
48	600	545
92	525	1,111
100	600	801
102	675	320
112	600	2,163
113	600	103
123	1,050	535
126	1,050	344
127	1,350	1,325
132	600	793
136	1,350	548
163	675	780
106	450	n.a.
111	450	n.a.
Total		11,407

Dia. (mm)	Length (m)	
450	n.a.	
450	n.a.	
525	1,111	1,111
600	545	
600	801	
600	2,163	
600	103	
600	793	4,405
675	320	
675	780	1,100
900	248	248
1,050	535	
1,050	344	879
1,200	1,082	
1,200	709	1,791
1,350	1,325	
1,350	548	1,873
Total	-	11,407

Table AC11.4.6 Sewer to be replaced in the Eastern SWD

Sewer No.	Dia. (mm)	Length (m)
40	675	279
41	750	438
363	525	649
401	525	290
402	825	467
403	825	55
439	675	311
440	750	935
445	750	377
450	750	1,005
453	825	310
Total	-	5,116

Dia. (mm)	Length (m)	
525	649	
525	290	939
675	279	
675	311	590
750	438	
750	935	
750	377	
750	1,005	2,755
825	467	
825	55	
825	310	832
Total	-	5,116

AC11.5 Lift Pumping Stations

AC11.5.1 Mechanical Works

(1) WP1 Tariq Abad

1-1) Design inflow rate of pumping station

Planned wastewater inflow	
(m3/sec)	(m3/min)
0.038	2.28

1-2) Number of pump set
To cope with incoming wastewater inflow of pumping station, one (1) pump set is designed.
Pump unit discharge is 3.4 m3/min (2 cfs).
In addition, one (1) standby pump set is installed in case of mechanical failures.

1-3) Pump total head
Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
182.80	185.70	2.9	2.1	5

1-4) Pump motor capacity
Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Where,

γ	: density of wastewater	1
Q	: amount of discharge	3.4 (m3/min) (= 2 cfs)
H	: total head	5 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor

(0.163 x 1 x 3.4 x 5 / 0.8) x (1 + 0.1) = 3.81 [kW]

Hence, nominal motor capacity of 5.5 kW is adopted.

1-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	3.4 m3/min (2cfs)
Total head	5 m
Motor capacity	5.5 kW
Pump set quantity	2 (including 1 standby)

(2) WP2 Chenab Chowk

2-1) Design inflow rate of pumping station

Planned wastewater inflow	
(m3/sec)	(m3/min)
0.096	5.76

2-2) Number of pump set
To cope with incoming wastewater inflow of pumping station, one (1) pump set is designed.
Pump unit discharge is 6.8 m3/min (4 cfs).
In addition, one (1) standby pump set is installed in case of mechanical failures.

2-3) Pump total head
Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
184.00	185.20	1.2	0.8	2

2-4) Pump motor capacity
Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Where,

γ	: density of wastewater	1
Q	: amount of discharge	6.8 (m3/min) (= 4 cfs)
H	: total head	2 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor

(0.163 x 1 x 6.8 x 2 / 0.8) x (1 + 0.1) = 3.05 [kW]

Hence, nominal motor capacity of 3.7 kW is adopted.

2-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	6.8 m3/min (4cfs)
Total head	2 m
Motor capacity	3.7 kW
Pump set quantity	2 (including 1 standby)

(3) WP7 PS-28

3-1) Design inflow rate of pumping station

Planned wastewater inflow	
(m3/sec)	(m3/min)
0.817	49.02

3-2) Number of pump set
To cope with incoming wastewater inflow of pumping station, four (4) pump sets are designed.

Pump unit discharge is 13.6 m3/min (8 cfs).
In addition, one (1) standby pump set is installed in case of mechanical failures.

3-3) Pump total head
Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
178.15	183.30	5.15	2.85	8

3-4) Pump motor capacity
Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Where,

γ	: density of wastewater	1
Q	: amount of discharge	13.6 (m3/min) (= 8 cfs)
H	: total head	8 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor
(0.163 x 1 x 13.6 x 8 / 0.8) x (1 + 0.1) = 24.38 [kW]
Hence, nominal motor capacity of 30 kW is adopted.

3-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	13.6 m3/min (8cfs)
Total head	8 m
Motor capacity	30 kW
Pump set quantity	5 (including 1 standby)

(4) WP14 Gulshan Colony

4-1) Design inflow rate of pumping station

Planned wastewater inflow	
(m3/sec)	(m3/min)
0.025	1.50

4-2) Number of pump set
To cope with incoming wastewater inflow of pumping station, one (1) pump set is designed.
Pump unit discharge is 1.7 m3/min (1 cfs).
In addition, one (1) standby pump set is installed in case of mechanical failures.

4-3) Pump total head
Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
181.30	182.95	1.65	1.35	3

4-4) Pump motor capacity
Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Where,

γ	: density of wastewater	1
Q	: amount of discharge	1.7 (m3/min) (= 1 cfs)
H	: total head	3 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor
(0.163 x 1 x 1.7 x 3 / 0.8) x (1 + 0.1) = 1.14 [kW]

Hence, nominal motor capacity of 1.5 kW is adopted.

4-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	1.7 m3/min (1cfs)
Total head	3 m
Motor capacity	1.5 kW
Pump set quantity	2 (including 1 standby)

(5) WP15 Metropole

5-1) Design inflow rate of pumping station

Planned wastewater inflow	
(m3/sec)	(m3/min)
0.232	13.92

5-2) Number of pump set
To cope with incoming wastewater inflow of pumping station, two (2) pump sets are designed.
Pump unit discharge is 8.5 m3/min (5 cfs).
In addition, one (1) standby pump set is installed in case of mechanical failures.

5-3) Pump total head
Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
179.90	180.85	0.95	1.05	2

5-4) Pump motor capacity
Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Where,

γ	: density of wastewater	1
Q	: amount of discharge	8.5 (m3/min) (= 5 cfs)
H	: total head	2 (m)

η : pump efficiency 0.8
α : allowance rate 0.1

Required capacity of motor
(0.163 x 1 x 8.5 x 2 / 0.8) x (1 + 0.1) = 3.81 [kW]
Hence, nominal motor capacity of 5.5 kW is adopted.

5-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	8.5 m3/min (5cfs)
Total head	2 m
Motor capacity	5.5 kW
Pump set quantity	3 (including 1 standby)

(6) WP20 Girja Ghar
6-1) Design inflow rate of pumping station

Planned wastewater inflow	
(m3/sec)	(m3/min)
0.127	7.62

6-2) Number of pump set
To cope with incoming wastewater inflow of pumping station, one (1) pump set is designed.
Pump unit discharge is 8.5 m3/min (5 cfs).
In addition, one (1) standby pump set is installed in case of mechanical failures.

6-3) Pump total head
Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
182.60	185.40	2.8	2.2	5

6-4) Pump motor capacity
Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]
Where,
γ : density of wastewater 1
Q : amount of discharge 8.5 (m3/min) (= 5 cfs)
H : total head 5 (m)
η : pump efficiency 0.8
α : allowance rate 0.1

Required capacity of motor
(0.163 x 1 x 8.5 x 5 / 0.8) x (1 + 0.1) = 9.52 [kW]
Hence, nominal motor capacity of 11 kW is adopted.

6-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	8.5 m3/min (5cfs)
Total head	5 m

Motor capacity	11 kW
Pump set quantity	2 (including 1 standby)

(7) EP5 PS-34

7-1) Design inflow rate of pumping station

Planned wastewater inflow	
(m3/sec)	(m3/min)
0.211	12.66

7-2) Number of pump set
To cope with incoming wastewater inflow of pumping station, one (1) pump set is designed.
Pump unit discharge is 13.6 m3/min (8 cfs).
In addition, one (1) standby pump set is installed in case of mechanical failures.

7-3) Pump total head
Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
177.25	182.33	5.08	2.92	8

7-4) Pump motor capacity
Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Where,

γ	: density of wastewater	1
Q	: amount of discharge	13.6 (m3/min) (= 8 cfs)
H	: total head	8 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor
(0.163 x 1 x 13.6 x 8 / 0.8) x (1 + 0.1) = 24.3 [kW]

Hence, nominal motor capacity of 30 kW is adopted.

7-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	13.6 m3/min (8cfs)
Total head	8 m
Motor capacity	30 kW
Pump set quantity	2 (including 1 standby)

(8) EP8 Sharifpura

8-1) Design inflow rate of pumping station

Planned wastewater inflow	
(m3/sec)	(m3/min)
0.033	1.98

8-2) Number of pump set
To cope with incoming wastewater inflow of pumping station, one (1) pump set is designed.
Pump unit discharge is 3.4 m3/min (2 cfs).
In addition, one (1) standby pump set is installed in case of mechanical failures.

8-3) Pump total head
Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
184.70	186.10	1.40	1.60	3

8-4) Pump motor capacity
Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Where,

γ	: density of wastewater	1
Q	: amount of discharge	3.4 (m3/min) (= 2 cfs)
H	: total head	3 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor
(0.163 x 1 x 3.4 x 3 / 0.8) x (1 + 0.1) = 2.28 [kW]

Hence, nominal motor capacity of 3.7 kW is adopted.

8-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	3.4 m3/min (2cfs)
Total head	3 m
Motor capacity	3.7 kW
Pump set quantity	2 (including 1 standby)

(9) EP11 Jhal Khanuana

9-1) Design inflow rate of pumping station

Planned wastewater inflow	
(m3/sec)	(m3/min)
0.019	1.14

9-2) Number of pump set
To cope with incoming wastewater inflow of pumping station, one (1) pump set is designed.
Pump unit discharge is 1.7 m3/min (1 cfs).
In addition, one (1) standby pump set is installed in case of mechanical failures.

9-3) Pump total head
Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Suction water level	Discharge water level	Static head	Loss head	Total head
(m)				
182.40	182.75	0.35	0.65	1

9-4) Pump motor capacity
Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Where,

γ	: density of wastewater	1
Q	: amount of discharge	1.7 (m3/min) (= 1 cfs)
H	: total head	1 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor
(0.163 x 1 x 1.7 x 1 / 0.8) x (1 + 0.1) = 0.38 [kW]

Hence, nominal motor capacity of 0.4 kW is adopted.

9-5) Pump set outline specification

Pump type	Horizontal shaft volute type
Discharge flow	1.7 m3/min (1cfs)
Total head	1 m
Motor capacity	0.4 kW
Pump set quantity	2 (including 1 standby)

AC11.5.2 Electrical Works

(1) WP1 Tariq Abad

1-1) Transformer

The required capacity of transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \text{ [kVA]}$$

Where,

φ	: total power factor	0.85
η	: total load efficiency	0.85
β	: demand factor	1.0
α	: allowance rate	1.1
Σ P	: sum of the load [kW]	

Three Phase	5.5
Single Phase	approx. 3.0

Required capacity of transformer

$$\frac{5.5 + 3.0}{0.85 \times 0.85} \times 1.0 \times 1.1 = 13[\text{kVA}]$$

Therefore, existing transformer which has the capacity of 50 [kVA] can be used.

1-2) Generator

The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Lift Pump	5.5	1	5.5
Building Lighting and other miscellaneous load	3	1	3
Total [kW]			**8.5**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [\text{kVA}]$$

Where,

ΣP_0 : sum of the load 8.5 [kW]
η_L : total load efficiency 0.85
φ_L : total power factor 0.8
α : demand factor 1.0
S_f : the increase coefficient of electric current by unbalanced load

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{3}{8.5} = 1.212$$

Δp : Sum of unbalance element by single phase load

$$= \frac{8.5}{0.85 \times 0.8} \times 1.0 \times 1.212$$

= **15.2 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [\text{kVA}]$$

Where,

P_m : maximum motor capacity 5.5 [kW]
β : starting kVA per 1kW of maximum motor capacity 7.2
C : coefficient by starter 1.0
X_d' : generator's constant 0.25
ΔE : allowable voltage drop rate 0.25

$$= 5.5x\ 7.2 \times 1.0 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

$$= \mathbf{29.7\ [kVA]}$$

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1}	: decrease coefficient of loading	1.0
ΣP_0	: sum of the load	8.5 [kW]
η_L	: total load efficiency	0.85
α	: demand factor	1.0
P_m	: maximum motor capacity	5.5 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1.0
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (8.5 - 5.5) \times \frac{1.0}{0.85 \times 0.8} + 5.5 \times 7.2 \times 1.0 \}$$

$$= \mathbf{29.3\ [kVA]}$$

d) Generator capacity

$PG_1 =$ 15.2
$PG_2 =$ 29.7 **(MAXIMUM)**
$PG_3 =$ 29.3

Therefore, **<u>30</u> [kVA]** is selected.

(2) WP2 Chenab Chowk

2-1) Transformer

The required capacity of transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \ [kVA]$$

Where,

φ	: total power factor	0.85
η	: total load efficiency	0.85
β	: demand factor	1.0
α	: allowance rate	1.1
ΣP	: sum of the load [kW]	
Three Phase		3.7
Single Phase		approx. 3.0

Required capacity of transformer

$$\frac{3.7 + 3.0}{0.85 \times 0.85} \times 1.0 \times 1.1 = 10[kVA]$$

Therefore, existing transformer which has the capacity of 50 [kVA] can be used.

2-2) Generator

The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Lift Pump	3.7	1	3.7
Building Lighting and other miscellaneous load	3	1	3
Total [kW]			**6.7**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [kVA]$$

Where,

ΣP_0 : sum of the load 6.7 [kW]

η_L : total load efficiency 0.85

φ_L : total power factor 0.8

α : demand factor 1.0

S_f : the increase coefficient of electric current by unbalanced load

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{3}{6.7} = 1.269$$

Δp : Sum of unbalance element by single phase load

$$= \frac{6.7}{0.85 \times 0.8} \times 1.0 \times 1.269$$

= **12.5 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

P_m : maximum motor capacity 3.7 [kW]

β : starting kVA per 1kW of maximum motor capacity 7.2

C : coefficient by starter 1.0

X_d' : generator's constant 0.25

ΔE : allowable voltage drop rate 0.25

$$= 3.7 \times 7.2 \times 1.0 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

= **20 [kVA]**

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1}	: decrease coefficient of loading	1.0
ΣP_0	: sum of the load	6.7 [kW]
η_L	: total load efficiency	0.85
α	: demand factor	1.0
P_m	: maximum motor capacity	3.7 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1.0
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (6.7 - 3.7) \times \frac{1.0}{0.85 \times 0.8} + 3.7 \times 7.2 \times 1.0 \}$$

= **20.7 [kVA]**

d) Generator capacity

PG_1 = 12.5
PG_2 = 20
PG_3 = 20.7 **(MAXIMUM)**

Therefore, **<u>30</u> [kVA]** is selected.

(3) WP7 PS-28

3-1) Transformer
The required capacity of transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \text{ [kVA]}$$

Where,

φ	: total power factor	0.85
η	: total load efficiency	0.85
β	: demand factor	1.0
α	: allowance rate	1.1
ΣP	: sum of the load [kW]	
Three Phase		120
Single Phase		approx. 20

Required capacity of transformer

$$\frac{120 + 20}{0.85 \times 0.85} \times 1.0 \times 1.1 = 213\text{[kVA]}$$

Therefore, existing transformer which has the capacity of 400 [kVA] can be used.

3-2) Generator
The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Lift Pump	30	4	120
Building Lighting and other miscellaneous load	20	0.3	6
Total [kW]			**126**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [kVA]$$

Where,

ΣP_0	: sum of the load	126 [kW]
η_L	: total load efficiency	0.85
φ_L	: total power factor	0.8
α	: demand factor	1.0
S_f	: the increase coefficient of electric current by unbalanced load	

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{6}{126} = 1.029$$

Δp : Sum of unbalance element by single phase load

$$= \frac{126}{0.85 \times 0.8} \times 1.0 \times 1.029$$

= **190.7 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

P_m	: maximum motor capacity	30 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1/3
X_d'	: generator's constant	0.25
ΔE	: allowable voltage drop rate	0.25

$$= 30 \times 7.2 \times 1/3 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

= **54 [kVA]**

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1}	: decrease coefficient of loading	1.0
ΣP_0	: sum of the load	126 [kW]
η_L	: total load efficiency	0.85
α	: demand factor	1.0
P_m	: maximum motor capacity	30 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1/3
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (126 - 30) \times \frac{1.0}{0.85 \times 0.8} + 30 \times 7.2 \times 1/3 \}$$

= **142.1 [kVA]**

d) Generator capacity

PG_1 = 190.7 **(MAXIMUM)**

PG_2 = 54

PG_3 = 142.1

Therefore, **<u>200</u> [kVA]** is selected.

(4) WP14 Ghulshan Colony

4-1) Transformer

The required capacity of transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \text{ [kVA]}$$

Where,

φ	: total power factor	0.85
η	: total load efficiency	0.85
β	: demand factor	1.0
α	: allowance rate	1.1
Σ P	: sum of the load [kW]	
Three Phase		1.5
Single Phase		approx. 3.0

Required capacity of transformer

$$\frac{1.5 + 3.0}{0.85 \times 0.85} \times 1.0 \times 1.1 = 7\text{[kVA]}$$

Therefore, existing transformer which has the capacity of 200 [kVA] can be used.

4-2) Generator

The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Lift Pump	1.5	1	1.5
Building Lighting and other miscellaneous load	3	1	3
Total [kW]			**4.5**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \text{ [kVA]}$$

Where,

ΣP_0 : sum of the load 4.5 [kW]
η_L : total load efficiency 0.85
φ_L : total power factor 0.8
α : demand factor 1.0
S_f : the increase coefficient of electric current by unbalanced load

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{3}{4.5} = 1.4$$

Δp : Sum of unbalance element by single phase load

$$= \frac{4.5}{0.85 \times 0.8} \times 1.0 \times 1.4$$

= **9.3 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

P_m : maximum motor capacity 1.5 [kW]
β : starting kVA per 1kW of maximum motor capacity 7.2
C : coefficient by starter 1.0
X_d' : generator's constant 0.25
ΔE : allowable voltage drop rate 0.25

$$= 1.5 \times 7.2 \times 1.0 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

= **8.1 [kVA]**

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1} : decrease coefficient of loading 1.0
ΣP_0 : sum of the load 4.5 [kW]
η_L : total load efficiency 0.85
α : demand factor 1.0
P_m : maximum motor capacity 1.5 [kW]
β : starting kVA per 1kW of maximum motor capacity 7.2
C : coefficient by starter 1.0
γ_G : generator strength against momentary overload 1.5

$$= \frac{1}{1.5} \{ (4.5 - 1.5) \times \frac{1.0}{0.85 \times 0.8} + 1.5 \times 7.2 \times 1.0 \}$$

= **10.1 [kVA]**

d) Generator capacity

PG_1 = 9.3
PG_2 = 8.1
PG_3 = 10.1 **(MAXIMUM)**

Therefore, **<u>30</u> [kVA]** is selected.

(5) WP15 Metropole

5-1) Transformer
The required capacity of transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \text{ [kVA]}$$

Where,

φ	: total power factor	0.85
η	: total load efficiency	0.85
β	: demand factor	1.0
α	: allowance rate	1.1
ΣP	: sum of the load [kW]	
Three Phase		11
Single Phase		approx. 3.0

Required capacity of transformer

$$\frac{11 + 3.0}{0.85 \times 0.85} \times 1.0 \times 1.1 = 21\text{[kVA]}$$

Therefore, existing transformer which has the capacity of 200 [kVA] can be used.

5-2) Generator
The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Lift Pump	5.5	2	11.0
Building Lighting and other miscellaneous load	3	1	3
Total [kW]			**14.0**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \text{ [kVA]}$$

Where,

ΣP_0	: sum of the load	14.0 [kW]
η_L	: total load efficiency	0.85
φ_L	: total power factor	0.8
α	: demand factor	1.0
S_f	: the increase coefficient of electric current by unbalanced load	

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{3}{14} = 1.129$$

Δp : Sum of unbalance element by single phase load

$$= \frac{14}{0.85 \times 0.8} \times 1.0 \times 1.129$$

= **23.2 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

P_m	: maximum motor capacity	5.5 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1.0
X_d'	: generator's constant	0.25
ΔE	: allowable voltage drop rate	0.25

$$= 5.5 \times 7.2 \times 1.0 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

= **29.7 [kVA]**

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1}	: decrease coefficient of loading	1.0
ΣP_0	: sum of the load	14.0 [kW]
η_L	: total load efficiency	0.85
α	: demand factor	1.0
P_m	: maximum motor capacity	5.5 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1.0
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (14.0 - 5.5) \times \frac{1.0}{0.85 \times 0.8} + 5.5 \times 7.2 \times 1.0 \}$$

= **34.7 [kVA]**

d) Generator capacity

PG_1 = 23.2
PG_2 = 29.7
PG_3 = 34.7 **(MAXIMUM)**

Therefore, **<u>50</u> [kVA]** is selected.

(6) WP20 Girya Guar

6-1) Transformer
The required capacity of transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \ [kVA]$$

Where,

φ	: total power factor	0.85

η	: total load efficiency	0.85
β	: demand factor	1.0
α	: allowance rate	1.1
ΣP	: sum of the load [kW]	
Three Phase		11
Single Phase		approx. 3.0

Required capacity of transformer

$$\frac{11 + 3.0}{0.85 \times 0.85} \times 1.0 \times 1.1 = 21[\text{kVA}]$$

Therefore, existing transformer which has the capacity of 200 [kVA] can be used.

6-2) Generator

The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Lift Pump	11	1	11
Building Lighting and other miscellaneous load	3	1	3
Total [kW]			**14**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [\text{kVA}]$$

Where,

ΣP_0	: sum of the load	14 [kW]
η_L	: total load efficiency	0.85
φ_L	: total power factor	0.8
α	: demand factor	1.0
S_f	: the increase coefficient of electric current by unbalanced load	

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{3}{14} = 1.129$$

Δp : Sum of unbalance element by single phase load

$$= \frac{14}{0.85 \times 0.8} \times 1.0 \times 1.129$$

$$= \mathbf{23.2\ [kVA]}$$

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [\text{kVA}]$$

Where,

P_m	: maximum motor capacity	11 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	2/3

X_d'	: generator's constant	0.25
ΔE	: allowable voltage drop rate	0.25

$$= 11 \times 7.2 \times 2/3 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

$$= \mathbf{39.6\ [kVA]}$$

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1}	: decrease coefficient of loading	1.0
ΣP_0	: sum of the load	14 [kW]
η_L	: total load efficiency	0.85
α	: demand factor	1.0
P_m	: maximum motor capacity	11 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	2/3
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (14 - 11) \times \frac{1.0}{0.85 \times 0.8} + 11 \times 7.2 \times 1.0 \}$$

$$= \mathbf{38.1\ [kVA]}$$

d) Generator capacity

$PG_1 =$ 23.2
$PG_2 =$ 39.6 **(MAXIMUM)**
$PG_3 =$ 38.1

Therefore, **<u>50</u> [kVA]** is selected.

(7) EP5 PS-34

7-1) Transformer
The required capacity of transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \ [kVA]$$

Where,

φ	: total power factor	0.85
η	: total load efficiency	0.85
β	: demand factor	1.0
α	: allowance rate	1.1
ΣP	: sum of the load [kW]	
Three Phase		30
Single Phase		approx. 3.0

Required capacity of transformer

$$\frac{30 + 3.0}{0.85 \times 0.85} \times 1.0 \times 1.1 = 50[\text{kVA}]$$

Therefore, existing transformer which has the capacity of 100 [kVA] can be used.

7-2) Generator

The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Lift Pump	30	1	30
Building Lighting and other miscellaneous load	3	1	3
Total [kW]			**33**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [\text{kVA}]$$

Where,

ΣP_0 : sum of the load 33 [kW]
η_L : total load efficiency 0.85
φ_L : total power factor 0.8
α : demand factor 1.0
S_f : the increase coefficient of electric current by unbalanced load

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{3}{33} = 1.055$$

Δp : Sum of unbalance element by single phase load

$$= \frac{33}{0.85 \times 0.8} \times 1.0 \times 1.055$$

= **51.2 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [\text{kVA}]$$

Where,

P_m : maximum motor capacity 30 [kW]
β : starting kVA per 1kW of maximum motor capacity 7.2
C : coefficient by starter 1/3
X_d' : generator's constant 0.25
ΔE : allowable voltage drop rate 0.25

$$= 30 \times 7.2 \times 1/3 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

= **54 [kVA]**

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1}	: decrease coefficient of loading	1.0
ΣP_0	: sum of the load	33 [kW]
η_L	: total load efficiency	0.85
α	: demand factor	1.0
P_m	: maximum motor capacity	30 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1/3
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (33 - 30) \times \frac{1.0}{0.85 \times 0.8} + 30 \times 7.2 \times 1/3 \}$$

= **43.3 [kVA]**

d) Generator capacity

PG_1 = 51.2
PG_2 = 54 **(MAXIMUM)**
PG_3 = 43.3

Therefore, **75 [kVA]** is selected.

(8) EP8 Sharifpura

8-1) Transformer
The required capacity of transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \ [kVA]$$

Where,

φ	: total power factor	0.85
η	: total load efficiency	0.85
β	: demand factor	1.0
α	: allowance rate	1.1
ΣP	: sum of the load [kW]	
Three Phase		3.7
Single Phase		approx. 3.0

Required capacity of transformer

$$\frac{3.7 + 3.0}{0.85 \times 0.85} \times 1.0 \times 1.1 = 10[kVA]$$

Therefore, existing transformer which has the capacity of 100 [kVA] can be used.

8-2) Generator
The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Lift Pump	3.7	1	3.7
Building Lighting and other miscellaneous load	3	1	3
Total [kW]			**6.7**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [kVA]$$

Where,

ΣP_0 : sum of the load 6.7 [kW]
η_L : total load efficiency 0.85
φ_L : total power factor 0.8
α : demand factor 1.0
S_f : the increase coefficient of electric current by unbalanced load

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{3}{6.7} = 1.269$$

Δp : Sum of unbalance element by single phase load

$$= \frac{6.7}{0.85 \times 0.8} \times 1.0 \times 1.269$$

= **12.5 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

P_m : maximum motor capacity 3.7 [kW]
β : starting kVA per 1kW of maximum motor capacity 7.2
C : coefficient by starter 1.0
X_d' : generator's constant 0.25
ΔE : allowable voltage drop rate 0.25

$$= 3.7 \times 7.2 \times 1.0 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

= **20 [kVA]**

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1} : decrease coefficient of loading 1.0
ΣP_0 : sum of the load 6.7 [kW]
η_L : total load efficiency 0.85

α	: demand factor	1.0
P_m	: maximum motor capacity	3.7 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1.0
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (6.7 - 3.7) \times \frac{1.0}{0.85 \times 0.8} + 3.7 \times 7.2 \times 1.0 \}$$

= **20.7 [kVA]**

d) Generator capacity

PG_1 = 12.5
PG_2 = 20
PG_3 = 20.7 **(MAXIMUM)**

Therefore, **<u>30</u> [kVA]** is selected.

(9) EP11 Jhal Khurana

9-1) Transformer
There is no existing transformer due to small pump capacity.

9-2) Generator
The target load for generator shall be selected below, to meet the minimum requirement even at emergency.

Name of Equipment	kW	Q'ty	Total kW
Lift Pump	0.4	1	0.4
Building Lighting and other miscellaneous load	3	1	3
Total [kW]			**3.4**

The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [kVA]$$

Where,

ΣP_0	: sum of the load	3.4 [kW]
η_L	: total load efficiency	0.85
φ_L	: total power factor	0.8
α	: demand factor	1.0
S_f	: the increase coefficient of electric current by unbalanced load	

$$S_f = 1 + 0.6 \times \frac{\Delta P}{\Sigma P_0} = 1 + 0.6 \times \frac{3}{3.4} = 1.529$$

Δp : Sum of unbalance element by single phase load

$$= \frac{3.4}{0.85 \times 0.8} \times 1.0 \times 1.529$$

= **7.6 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

P_m	: maximum motor capacity	0.4 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1.0
X_d'	: generator's constant	0.25
ΔE	: allowable voltage drop rate	0.25

$$= 0.4 \times 7.2 \times 1.0 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

= **2 [kVA]**

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1}	: decrease coefficient of loading	1.0
ΣP_0	: sum of the load	3.4 [kW]
η_L	: total load efficiency	0.85
α	: demand factor	1.0
P_m	: maximum motor capacity	0.4 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	1.0
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (3.4 - 0.4) \times \frac{1.0}{0.85 \times 0.8} + 0.4 \times 7.2 \times 1.0 \}$$

= **4 [kVA]**

d) Generator capacity

PG_1 = 7.6 **(MAXIMUM)**
PG_2 = 2
PG_3 = 4

Therefore, **<u>10</u> [kVA]** is selected.

AC11.6 Influent Pumping Stations

AC11.6.1 Mechanical Works

(1) Chokera WWTP Influent Pumping Station

1-1) Design inflow rate of pumping station

Planned wastewater inflow	
(m3/sec)	(m3/min)
8.643	518.58

1-2) Number of pump set and discharge quantity

To cope with incoming wastewater fluctuation, two different capacity pumps are designed.

Three (3) large discharge capacity pump sets are installed. In addition, one (1) standby pump set is installed in case of mechanical failures.

Discharge flow of small capacity pump is half of large discharge capacity pump and two (2) pump sets are installed.

Discharge quantity of large capacity pump set (P1) :

518.58 / 4 = 129.645 → 130 m3/min (4 pump sets including 1 standby)

Discharge quantity of small capacity pump set (P2) :

130 / 2 = 65 → 65 m3/min (2 pump sets)

Check: 130 m3/min x 3 set + 65 m3/min x 2 set = 520 m3/min > 518.58 m3/min (Planned wastewater inflow)

	Large capacity pump (P1)	Small capacity pump (P2)
Discharge quantity	130 m3/min	65 m3/min
Set	4 (including 1 standby)	2

1-3) Pump total head

Pump total head is designed from water levels of pumping station and estimated loss head.
Loss head is calculated as about 50% of static head.

Inlet sewer invert elevation	Ground level	Static head	Loss head	Total head
(m)				
169.513	179.400	9.887	5.113	15

1-4) Pump motor capacity

Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Large capacity pump (P1) :

Where,

γ	: density of wastewater	1
Q	: amount of discharge	130 (m3/min)
H	: total head	15 (m)
η	: pump efficiency	0.8

α : allowance rate 0.1

Required capacity of motor

(0.163 x 1 x 130 x 15 / 0.8) x (1 + 0.1) = 437.04 [kW]

Hence, nominal motor capacity of 440 kW is adopted.

Small capacity pump (P2) :

Where,

γ : density of wastewater 1

Q : amount of discharge 65 (m3/min)

H : total head 15 (m)

η : pump efficiency 0.8

α : allowance rate 0.1

Required capacity of motor

(0.163 x 1 x 65 x 15 / 0.8) x (1 + 0.1) = 218.52 [kW]

Hence, nominal motor capacity of 220 kW is adopted.

1-5) Pump nominal diameter

Pump nominal diameter is determined so that inlet velocity is between 1.5m/s and 3.0m/s.

Pump nominal diameter = $146 \times (Q / v)^{1/2}$ [mm]

Large capacity pump (P1) :

Where,

Q : amount of discharge 130 (m3/min)

v : inlet velocity 2.25 (m/s)

Pump nominal diameter

$146 \times (130 / 2.25)^{1/2} = 1109 \rightarrow 1000$ [mm]

Check: $v = (146)^2 \times 130 / (1000)^2 = 2.77$ m/s (between 1.5m/s and 3.0m/s)

Hence, pump nominal diameter of 1000 mm is adopted.

Small capacity pump (P2) :

Where,

Q : amount of discharge 65 (m3/min)

v : inlet velocity 2.25 (m/s)

Pump nominal diameter

$146 \times (65 / 2.25)^{1/2} = 784 \rightarrow 800$ [mm]

Check: $v = (146)^2 \times 65 / (800)^2 = 2.16$ m/s (between 1.5m/s and 3.0m/s)

Hence, pump nominal diameter of 800 mm is adopted.

1-6) Pump set outline specification

	Large capacity pump (P1)	Small capacity pump (P2)
Pump type	Vertical shaft volute type mixed flow	
Nominal diameter	1000 mm	800 mm
Discharge quantity	130 m3/min	65 m3/min
Total head	15 m	15 m
Motor capacity	440 kw	220 kw
Pump set quantity	4 (including 1 standby)	2

(2) New East WWTP Influent Pumping Station

2-1) Design inflow rate of pumping station

Planned wastewater inflow	
(m3/sec)	(m3/min)
8.404	504.24

2-2) Number of pump set and discharge quantity

To cope with incoming wastewater fluctuation, two different capacity pumps are designed.

Three (3) large discharge capacity pump sets are installed. In addition, one (1) standby pump set is installed in case of mechanical failures.

Discharge flow of small capacity pump is half of large discharge capacity pump and two (2) pump sets are installed.

Discharge quantity of large capacity pump set (P1) :

504.24 / 4 = 126.06 → 127 m3/min (4 pump sets including 1 standby)

Discharge quantity of small capacity pump set (P2) :

127 / 2 = 63.5 → 63 m3/min (2 pump sets)

Check: 127 m3/min x 3 set + 63 m3/min x 2 set = 507 m3/min > 504.24 m3/min (Planned wastewater inflow)

	Large capacity pump (P1)	Small capacity pump (P2)
Discharge quantity	127 m3/min	63 m3/min
Set	4 (including 1 standby)	2

2-3) Pump total head

Pump total head is designed from water levels of pumping station and estimated loss head.

Loss head is calculated as about 50% of static head.

Inlet sewer invert elevation	Ground level	Static head	Loss head	Total head
(m)				
160.511	180.200	19.689	10.311	30

2-4) Pump motor capacity

Required capacity of motor is calculated using following formula.

Capacity of motor = (0.163 x γ x Q x H / η) x (1 + α) [kW]

Large capacity pump (P1) :

Where,

γ	: density of wastewater	1
Q	: amount of discharge	127 (m3/min)
H	: total head	30 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor

(0.163 x 1 x 127 x 30 / 0.8) x (1 + 0.1) = 853.91 [kW]

Hence, nominal motor capacity of 855 kW is adopted.

Small capacity pump (P2) :

Where,

γ	: density of wastewater	1
Q	: amount of discharge	63 (m3/min)
H	: total head	30 (m)
η	: pump efficiency	0.8
α	: allowance rate	0.1

Required capacity of motor

(0.163 x 1 x 63 x 30 / 0.8) x (1 + 0.1) = 423.59 [kW]

Hence, nominal motor capacity of 425 kW is adopted.

2-5) Pump nominal diameter

Pump nominal diameter is determined so that inlet velocity is between 1.5m/s and 3.0m/s.

Pump nominal diameter = 146 x $(Q / v)^{1/2}$ [mm]

Large capacity pump (P1) :

Where,

Q	: amount of discharge	127 (m3/min)
v	: inlet velocity	2.25 (m/s)

Pump nominal diameter

146 x $(127 / 2.25)^{1/2}$ ＝1096 → 1000 [mm]

Check: v ＝ $(146)^2$ x 127 / $(1000)^2$ ＝ 2.71 m/s (between 1.5m/s and 3.0m/s)

Hence, pump nominal diameter of 1000 mm is adopted.

Small capacity pump (P2) :

Where,

Q	: amount of discharge	63 (m3/min)
v	: inlet velocity	2.25 (m/s)

Pump nominal diameter

146 x $(63 / 2.25)^{1/2}$ ＝772 → 800 [mm]

Check: v ＝ $(146)^2$ x 63 / $(800)^2$ ＝ 2.09 m/s (between 1.5m/s and 3.0m/s)

Hence, pump nominal diameter of 800 mm is adopted.

2-6) Pump set outline specification

	Large capacity pump (P1)	Small capacity pump (P2)
Pump type	Vertical shaft volute type mixed flow	
Inlet diameter	1000 mm	800 mm
Discharge quantity	127 m3/min	63 m3/min
Total head	30 m	30 m
Motor capacity	855 kw	425 kw
Pump set quantity	4 (including 1 standby)	2

AC11.6.2 Electrical Works

(1) Chokera WWTP Influent Pumping Station

1-1) Power Demand

The maximum demand of the West WWTP Influent Pumping Station is estimated as 2,060kW. Load list is shown below.

Name of Equipment	kW	Q'ty	Total kW
Influent Pump (Small)	220	2	440
Influent Pump (Large)	440	4(1)	1,320
Grit Removal Facility	approx.200	1	200
Building Lighting and other miscellaneous load	approx.100	1	100
Total [kW]			**2,060**

1-2) Power Receiving

Electric power will be supplied from FESCO by one or two circuit(s) of 11kV power line. General features of the supplied power are as follows:

- Power Source: FESCO
- Tariff Category: B3
- Voltage System: 11kV AC, 50Hz, 3 phase 3wire

In WWTP Influent Pumping Station, 11kV is stepped down to 6.6kV and 380V for influent pumps and other auxiliary equipment and lighting. For main substation, oil type transformer is selected taking advantage of its lower cost and availability in Pakistan. The required capacity of main transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \ [\text{kVA}]$$

Where,

φ	: total power factor	0.85
η	: total load efficiency	0.85
β	: demand factor	1.0
α	: allowance rate	1.1
ΣP	: sum of the load [kW]	2,060

Required capacity of transformer

$$\frac{2060}{0.85 \times 0.85} \times 1.0 \times 1.1 = 3136[\text{kVA}]$$

Confirmation of Voltage Drop

Required capacity for pump start

$$= \sqrt{(\text{base [kW]} + \text{starting [kW]})^2 + (\text{base [kVA]} + \text{starting [kVA]})}$$

$$= \sqrt{((2060-440)\times 0.9+440\times 7.2\times 0.64\times 0.4)^2+(2060-440)\times\sqrt{1-0.9^2}+440\times 7.2\times 0.64\times\sqrt{1-0.4^2}}$$

$$= \sqrt{(1458+811)^2 + (706+1858)^2}$$

$$= 3424 \ [\text{kVA}]$$

If 2000 [kVA] x 2 is selected, voltage drop = $\frac{3424}{2000 \times 2}$ x 6.0 =5.1 [%] → OK

Therefore, **2000 [kVA] x 2** shall be selected.

1-3) Emergency Power Supply

The target load for generator will be 30% of total load to meet the minimum requirement even at emergency. The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [kVA]$$

Where,

ΣP_0 : sum of the load 2,060 x 0.3 = 618 [kW]
η_L : total load efficiency 0.85
φ_L : total power factor 0.8
α : demand factor 1.0
S_f : the increase coefficient of electric current by unbalanced load 1.0

$= \frac{618}{0.85 \times 0.8} \times 1.0 \times 1.0$

= **908 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

P_m : maximum motor capacity 440 [kW]
β : starting kVA per 1kW of maximum motor capacity 7.2
C : coefficient by starter 0.64
X_d' : generator's constant 0.25
ΔE : allowable voltage drop rate 0.25

$= 440 \times 7.2 \times 0.64 \times 0.25 \times \frac{1 - 0.25}{0.25}$

= **1,520 [kVA]**

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1} : decrease coefficient of loading 1.0
ΣP_0 : sum of the load 618 [kW]
η_L : total load efficiency 0.85
α : demand factor 1.0
P_m : maximum motor capacity 440 [kW]
β : starting kVA per 1kW of maximum motor capacity 7.2

C : coefficient by starter 0.64

γ_G : generator strength against momentary overload 1.5

$$= \frac{1}{1.5} \{ (618 - 440) \times \frac{1.0}{0.85 \times 0.8} + 440 \times 7.2 \times 0.64 \}$$

= **1,526 [kVA]**

d) Generator capacity

PG_1 = 908

PG_2 = 1,520

PG_3 = 1,526 **(MAXIMUM)**

Therefore, **2,000 [kVA]** will be selected.

1-4) Overall Power Distribution Schematic

Overall Power Distribution Schematic for Chokera WWTP is shown in **Figure AC11.6.1**.

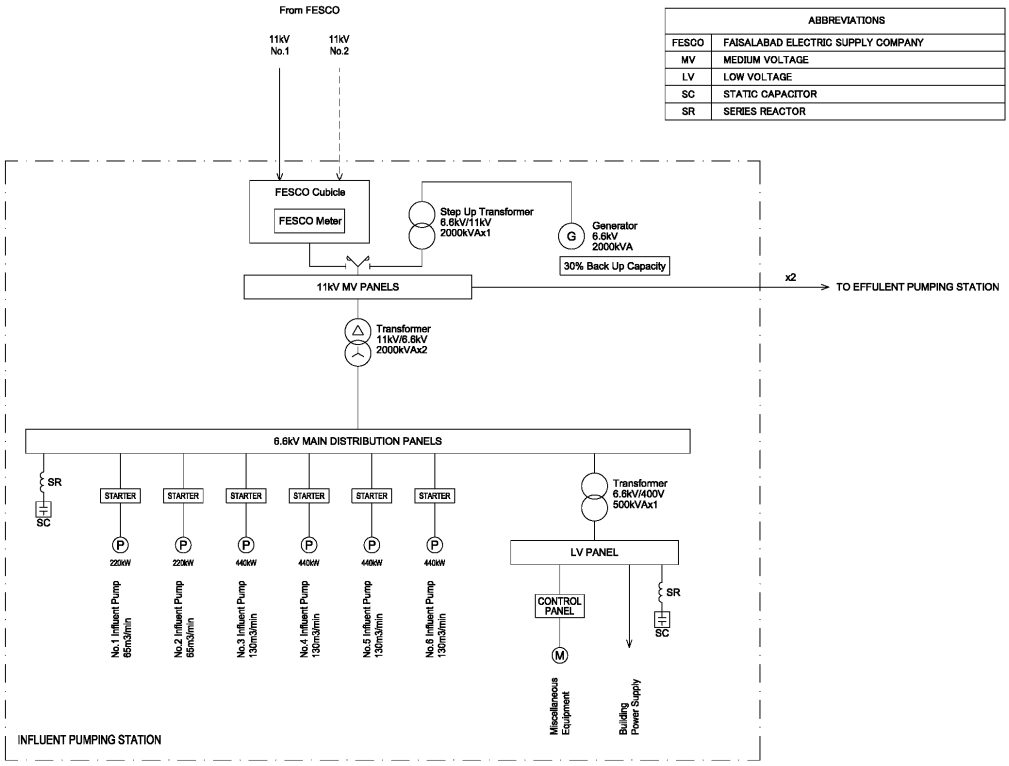
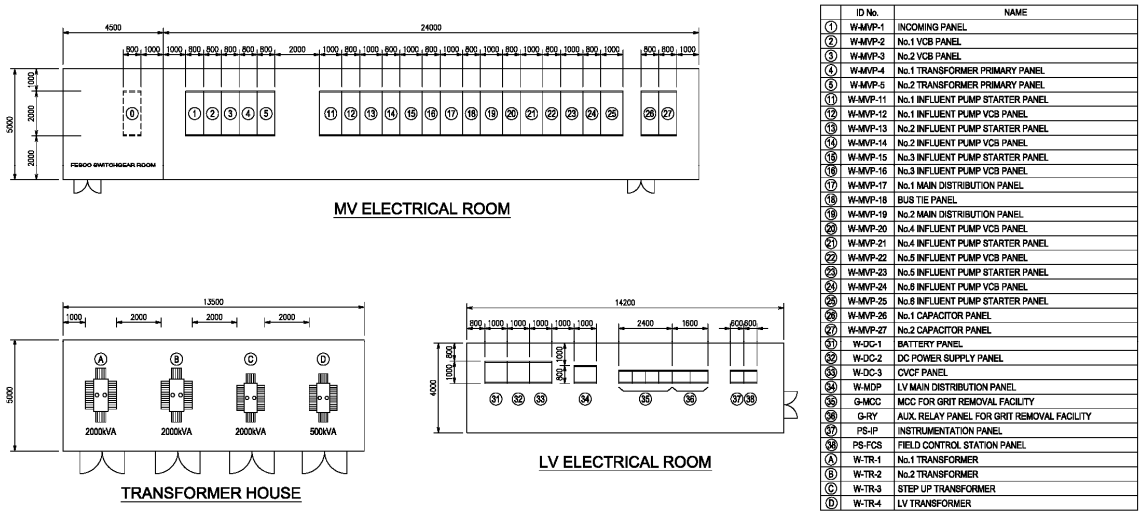


Figure AC11.6.1 Overall Power Distribution Schematic for Chokera WWTP

1-5) Electrical Room Layout

Proposed electrical room layout for Chokera WWTP is shown in **Figure AC11.6.2**.



	ID No.	NAME
①	W-MVP-1	INCOMING PANEL
②	W-MVP-2	No.1 VCB PANEL
③	W-MVP-3	No.2 VCB PANEL
④	W-MVP-4	No.1 TRANSFORMER PRIMARY PANEL
⑤	W-MVP-5	No.2 TRANSFORMER PRIMARY PANEL
⑪	W-MVP-11	No.1 INFLUENT PUMP STARTER PANEL
⑫	W-MVP-12	No.1 INFLUENT PUMP VCB PANEL
⑬	W-MVP-13	No.2 INFLUENT PUMP STARTER PANEL
⑭	W-MVP-14	No.2 INFLUENT PUMP VCB PANEL
⑮	W-MVP-15	No.3 INFLUENT PUMP STARTER PANEL
⑯	W-MVP-16	No.3 INFLUENT PUMP VCB PANEL
⑰	W-MVP-17	No.1 MAIN DISTRIBUTION PANEL
⑱	W-MVP-18	BUS TIE PANEL
⑲	W-MVP-19	No.2 MAIN DISTRIBUTION PANEL
⑳	W-MVP-20	No.4 INFLUENT PUMP VCB PANEL
㉑	W-MVP-21	No.4 INFLUENT PUMP STARTER PANEL
㉒	W-MVP-22	No.5 INFLUENT PUMP VCB PANEL
㉓	W-MVP-23	No.5 INFLUENT PUMP STARTER PANEL
㉔	W-MVP-24	No.6 INFLUENT PUMP VCB PANEL
㉕	W-MVP-25	No.6 INFLUENT PUMP STARTER PANEL
㉖	W-MVP-26	No.1 CAPACITOR PANEL
㉗	W-MVP-27	No.2 CAPACITOR PANEL
㉛	W-DC-1	BATTERY PANEL
㉜	W-DC-2	DC POWER SUPPLY PANEL
㉝	W-DC-3	CVCF PANEL
㉞	W-MDP	LV MAIN DISTRIBUTION PANEL
㉟	G-MCC	MCC FOR GRIT REMOVAL FACILITY
㊱	G-RY	AUX. RELAY PANEL FOR GRIT REMOVAL FACILITY
㊲	PS-IP	INSTRUMENTATION PANEL
㊳	PS-FCS	FIELD CONTROL STATION PANEL
Ⓐ	W-TR-1	No.1 TRANSFORMER
Ⓑ	W-TR-2	No.2 TRANSFORMER
Ⓒ	W-TR-3	STEP UP TRANSFORMER
Ⓓ	W-TR-4	LV TRANSFORMER

Figure AC11.6.2 Proposed Electrical Room Layout for Chokera WWTP

(2) New East WWTP Influent Pumping Station

2-1) Power Demand

The maximum demand of the East WWTP Influent Pumping Station is estimated as 3,715kW. Load list is shown below.

Name of Equipment	kW	Q'ty	Total kW
Influent Pump (Small)	425	2	850
Influent Pump (Large)	855	4(1)	2,565
Grit Removal Facility	approx.200	1	200
Building Lighting and other miscellaneous load	approx.100	1	100
Total [kW]			**3,715**

2-2) Power Receiving

Electric power will be supplied from FESCO by one or two circuit(s) of 11kV power line. General features of the supplied power are as follows:

- Power Source: FESCO
- Tariff Category: B3
- Voltage System: 11kV AC, 50Hz, 3 phase 3wire

In WWTP Influent Pumping Station, 11kV is stepped down to 6.6kV and 380V for influent pumps and other auxiliary equipment and lighting. For main substation, oil type transformer is selected taking advantage of its lower cost and availability in Pakistan. The required capacity of main transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \ [\text{kVA}]$$

Where,

φ	: total power factor	0.85
η	: total load efficiency	0.85
β	: demand factor	1.0
α	: allowance rate	1.1
Σ P	: sum of the load [kW]	3,715

Required capacity of transformer

$$\frac{3715}{0.85 \times 0.85} \times 1.0 \times 1.1 = 5{,}656\text{[kVA]}$$

Confirmation of Voltage Drop

Required capacity for pump start

$$= \sqrt{(\text{base [kW]} + \text{starting [kW]})^2 + (\text{base [kVA]} + \text{starting [kVA]})}$$

$$= \sqrt{((3715-855)\times0.9+855\times7.2\times0.64\times0.4)^2+(3715-855)\times\sqrt{1-0.9^2}+855\times7.2\times0.64\times\sqrt{1-0.4^2}}$$

$$= \sqrt{(2574+1575)^2 + (1246+3610)^2}$$

$$= 6388 \text{ [kVA]}$$

If 3000 [kVA] x 2 is selected, voltage drop = $\frac{6388}{3000 \times 2} \times 6.0 = 6.3$ [%] → OK

Therefore, **3000 [kVA] x 2** shall be selected.

2-3) Emergency Power Supply

The target load for generator will be 30% of total load to meet the minimum requirement even at emergency. The capacity of generator is determined using following formulas.

a) PG_1 is the capacity necessary for all load operation.

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \text{ [kVA]}$$

Where,

ΣP_0	: sum of the load	3,715 x 0.3 = 1,115 [kW]
η_L	: total load efficiency	0.85
φ_L	: total power factor	0.8
α	: demand factor	1.0
S_f	: the increase coefficient of electric current by unbalanced load	1.0

$$= \frac{1115}{0.85 \times 0.8} \times 1.0 \times 1.0$$

= **1,639 [kVA]**

b) PG_2 is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \text{ [kVA]}$$

Where,

P_m	: maximum motor capacity	855 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2

C	: coefficient by starter	0.64
X_d'	: generator's constant	0.25
ΔE	: allowable voltage drop rate	0.25

$$= 855x\ 7.2 \times 0.64 \times 0.25 \times \frac{1 - 0.25}{0.25}$$

$$= \mathbf{2{,}954\ [kVA]}$$

c) PG_3 is the capacity necessary for starting maximum motor lastly

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

f_{v1}	: decrease coefficient of loading	1.0
ΣP_0	: sum of the load	1,115 [kW]
η_L	: total load efficiency	0.85
α	: demand factor	1.0
P_m	: maximum motor capacity	855 [kW]
β	: starting kVA per 1kW of maximum motor capacity	7.2
C	: coefficient by starter	0.64
γ_G	: generator strength against momentary overload	1.5

$$= \frac{1}{1.5} \{ (1{,}115 - 855) \times \frac{1.0}{0.85 \times 0.8} + 855 \times 7.2 \times 0.64 \}$$

$$= \mathbf{2{,}881\ [kVA]}$$

d) Generator capacity

PG_1 = 1,639
PG_2 = 2,954
PG_3 = 2,881 **(MAXIMUM)**

Therefore, **<u>3,000</u> [kVA]** will be selected.

2-4) Overall Power Distribution Schematic

Overall Power Distribution Schematic for New East WWTP is shown in **Figure AC11.6.3**.

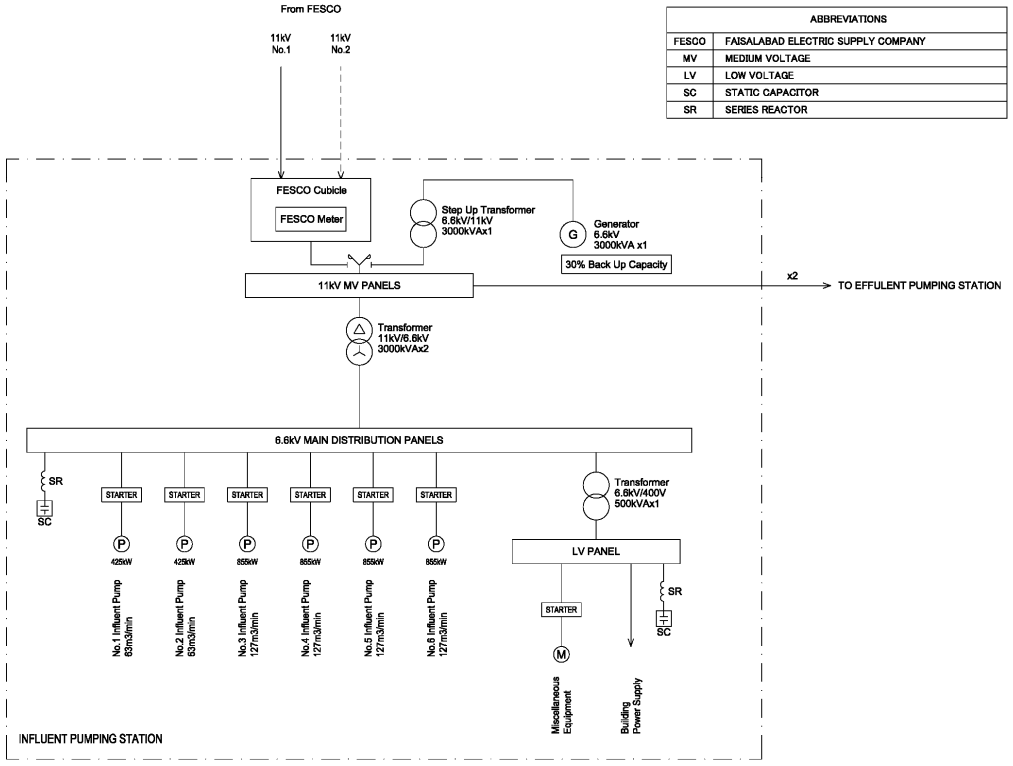


Figure AC11.6.3 Overall Power Distribution Schematic for New East WWTP

2-5) Electrical Room Layout

Proposed electrical room layout for New East WWTP is shown in **Figure AC11.6.4**.

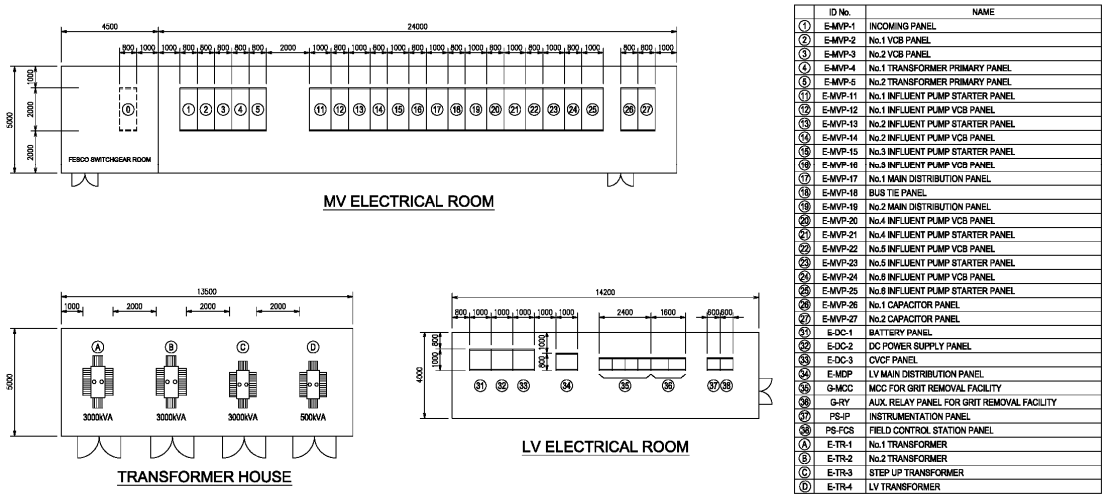


Figure AC11.6.4 Proposed Electrical Room Layout for New East WWTP

AC11.6.3 Civil Works

(1) Chokera WWTP Influent Pumping Station

Item	Calculation
§ 1 Design Parameters	
[1] Design condtion	
(1) Design Flow	
a) Daily Average Flow	433,800 m^3/d
b) Hourly Peak Flow	746.669 m^3/d
[2] Influent and Efluent	
(1) Inlet Pipe Condition	Diameter φ 2700 Slope 0.9 ‰ Invert Elevation ▽-169.513
(2)effluent a) Outlet Pipe	Diameter φ 2000 Slope 1.5 ‰
§2 Grit Chamber	
[1] Design Condition	
(1) Desgin Flow	Hourly Peak Flow = 746,669 m^3/d = 8.642 m^3/s
(2) Inlet Pipe	Diameter 2,700 Slope 0.9 ‰ Manning Number n = 0.013 Full Flow Rate 10.165 m^3/s Sewer Invert Elevation ▽-169.513
(3) Removal rate	50 % for the grit of more than 0.2mm sized grain
(4) Specific Gravity of Grit	2.65
(5) Settling Velocity	0.021 m/s
(6) Average Flow Velocity	0.230 m/s

Item	Calculation
[2] Dimension	
(1) Required Surface Area	$\frac{\text{Houly Peak Flow } (m^3/s)}{\text{Settling Velocity (m/s)}}$ $= \frac{8.642}{0.021} = 411.5 \quad m^2$
(2) Required Sectional Area	$\frac{\text{Hourly Peak Flow } (m^3/s)}{\text{Average Flow Velocity (m/s)}}$ $= \frac{8.642}{0.23} = 37.6 \quad m^2$
(3) Actual Width	$\frac{\text{Required Sectional Area } (m^2)}{\text{Actual Depth (m)} \times \text{Basins}}$ $= \frac{37.6}{2.10 \times 6} = 3.0 \rightarrow 3.0m$
(4) Length	$\frac{(m^2)}{\text{Width (m)} \times \text{basins}}$ $= \frac{411.5}{3.0 \times 6} = 22.9 \rightarrow 25.0m$
(5) Basin Size	W 3.0 m × L 25.0 m × Depth 2.10 m
(6) No. of basin	6 basins
[3] Check	
(1) Total Water Surface Area (m^2)	W3.0 m × L 25.0 m × 6 basins $= 450 \quad m^2$
(2) Surface Loading rate	$\frac{\text{Hourly Peak Flow } (m^3/d)}{\text{Total Water Surface Area } (m^2)}$ $= \frac{746,669}{450.0} = 1,659 \quad m^3/m^2/d$
(3) Velocity in Tank	$\frac{\text{Hourly Peak Flow } (m^3/d)}{\text{Width (m)} \times \text{Depth (m)} \times \text{Basins}}$ $= \frac{8.64}{3.0 \times 2.10 \times 6} = 0.229 \text{ m/s}$

Item	Calculation
(4) Retention Time	$\frac{\text{Actual Length (m)}}{\text{Velocity in Tank (m/s)}}$ $= \frac{25.0}{0.229} =$ 109.2 s
(5) Settling Time	$\frac{\text{Actual Depth (m)}}{\text{Settling Velocity (m/s)}}$ $= \frac{2.10}{0.021} =$ 100.0 s
(6) Removal Efficiency	$\left[1 - \frac{1}{1 + \frac{\text{Retention Time (s)}}{\text{Settling Time (s)}}} \right] \times 100$ $= \left[1 - \frac{1}{1 + \frac{109.2}{100.0}} \right] \times 100$ = 52.2% → 52%
(7) Amount of grift (Daily Ave.)	Estimated to be 0.01m3 per 1,000m3 of inflowing sewage. 433,800 m3/d $433{,}800 \times \frac{0.01}{1{,}000}$ = 4.34 m3/d
(8) Amount of screening (Daily Ave.)	Same as the amount of g = 4.34 m3/d

(2) New East WWTP Influent Pumping Station

Item	Calculation
§ 1 Design Parameters	
[1] Design condtion	
(1) Design Flow	
a) Daily Average Flow	434,000 m^3/d
b) Hourly Peak Flow	726,106 m^3/d
[2] Influent and Efluent	
(1) Inlet Pipe Condition	Diameter φ 2700 Slope 0.8 ‰ Invert Elevation ▽-160.511
(2)effluent	
a) Outlet Pipe	Diameter φ 2000 Slope 1.5 ‰
§2 Grit Chamber	
[1] Design Condition	
(1) Desgin Flow	Hourly Peak Flow = 726,106 m^3/d = 8.404 m^3/s
(2) Inlet Pipe	Diameter 2,700 Slope 0.8 ‰ Manning Number n = 0.013 Full Flow Rate 9.584 m^3/s Sewer Invert Elevation ▽-160.511
(3) Removal rate	50 % for the grit of more than 0.2mm sized grain
(4) Specific Gravity of Grit	2.65
(5) Settling Velocity	0.021 m/s
(6) Average Flow Velocity	0.230 m/s

Item	Calculation
[2] Dimension	
(1) Required Surface Area	$\frac{\text{Houly Peak Flow } (m^3/s)}{\text{Settling Velocity (m/s)}}$ $= \frac{8.404}{0.021} = 400.2 \quad m^2$
(2) Required Sectional Area	$\frac{\text{Hourly Peak Flow } (m^3/s)}{\text{Average Flow Velocity (m/s)}}$ $= \frac{8.404}{0.23} = 36.5 \quad m^2$
(3) Actual Width	$\frac{\text{Required Sectional Area } (m^2)}{\text{Actual Depth (m)} \times \text{Basins}}$ $= \frac{36.5}{2.10 \times 6} = 2.9 \rightarrow 3.0m$
(4) Length	$\frac{(m^2)}{\text{Width (m)} \times \text{basins}}$ $= \frac{400.2}{3.0 \times 6} = 22.2 \rightarrow 23.0m$
(5) Basin Size	W 3.0 m × L 23.0 m × Depth 2.10 m
(6) No. of basin	6 basins
[3] Check	
(1) Total Water Surface Area (m^2)	W3.0 m × L 23.0 m × 6 basins = 414 m^2
(2) Surface Loading rate	$\frac{\text{Hourly Peak Flow } (m^3/d)}{\text{Total Water Surface Area } (m^2)}$ $= \frac{726,106}{414.0} = 1,754 \quad m^3/m^2/d$
(3) Velocity in Tank	$\frac{\text{Hourly Peak Flow } (m^3/d)}{\text{Width (m)} \times \text{Depth (m)} \times \text{Basins}}$ $= \frac{8.40}{3.0 \times 2.10 \times 6} = 0.222 \text{ m/s}$
(4) Retention Time	$\frac{\text{Actual Length (m)}}{\text{Velocity in Tank (m/s)}}$

Item	Calculation
	$= \dfrac{23.0}{0.222} =$ 103.6 s
(5) Settling Time	$\dfrac{\text{Actual Depth (m)}}{\text{Settling Velocity (m/s)}}$
	$= \dfrac{2.10}{0.021} =$ 100.0 s
(6) Removal Efficiency	$\left(1 - \dfrac{1}{1 + \dfrac{\text{Retention Time (s)}}{\text{Settling Time (s)}}} \right) \times 100$
	$= \left(1 - \dfrac{1}{1 + \dfrac{103.6}{100.0}} \right) \times 100$
	= 50.9% → 51%
(7) Amount of grift (Daily Ave.)	Estimated to be 0.01m3 per 1,000m3 of inflowing sewage.
	434,000 m3/d
	$434{,}000 \times \dfrac{0.01}{1{,}000}$ = 4.34 m3/d
(8) Amount of screening (Daily Ave.)	Same as the amount of g = 4.34 m3/d

AC11.7 Effluent Pumping Station

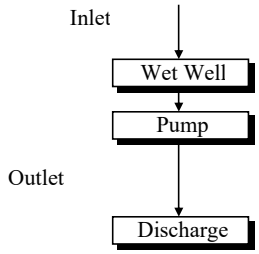
AC11.7.1 Effluent Pumping Station at the Chokera WWTP

(1) Basic Conditions

1) Design Flow Rate

Construction Stage	Item	m^3/d	m^3/hr	m^3/min	m^3/s	
Master Plan	Daily average flow	433,800	18075.0	301.3	5.022	1.00
	Daily maximum flow	433,800	18075.0	301.3	5.022	1.00
	Hourly maximum	433,800	18075.0	301.3	5.022	1.00
First Stage	Daily average flow	216,900	9037.5	150.6	2.510	1.00
	Daily maximum flow	216,900	9037.5	150.6	2.510	1.00
	Hourly maximum	216,900	9037.5	150.6	2.510	1.00

2) Flowsheet



3) Inlet, Outlet

Inlet pipe Diameter 2,700 mm
Material Hume pipe

Discharge Pipe Diameter 1,500 mm (Velocity 2.842 m^3/s)
Material Ductile cast-iron pipe
Length 14,550 m

4) Elevations

The elevation of inlet pipe invert 177.200 m

Discharge water elevation or outlet pipe invert elevation 180.200 m

The elevation of pipe invert highest discharge pipe 180.200 m

(2) Effluent Pumping Equipment

1) Pumping Plan

Construction Stage	Item	Pump Installation			Operation Schedule (unit)			
		Discharge Rate (m^3/min)	Number of pumps (unit)	Standby (unit)	1/3・Daily Average (m^3/min)	Daily Average (m^3/min)	Daily Maximum (m^3/min)	Hourly Maximum (m^3/min)
Master Plan	Design Flow	-	-	-	100.4	301.3	301.3	301.3
	Pump Capacity	-	-	-	150.8	301.6	301.6	301.6
	No.1	75.4	4	1	2	4	4	4
	No.2		0					
	Total		4	1	2	4	4	4
First Stage	Design Flow	-	-	-	50.2	150.6	150.6	150.6
	Pump Capacity	-	-	-	75.4	150.8	150.8	150.8
	No.1	75.4	2	1	1	2	2	2
	No.2		0					
	Total		2	1	1	2	2	2

2) Pump Head

a) L.W.L. 178.200 m (Min. water elevation)

b) Outlet elevation 180.200 m = Discharge water elevation or outlet pipe invert elevation

c) Actual ('Static) pump head 2.000 m

d) Discharge pipe diam. 1,500 mm ×2 (Section ar 1.767 m^2)

e) Flow velocity in the pipe 1.422 m/s

f) Friction loss of straight pipe

① Darcy-Weisbach formula (for turbulent flow or shorter pipelines

$$h_f = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$$

h_f : friction loss (m)
f : friction coefficient
New cast-iron pipe 0.024
New steel pipe 0.020
Polyvinyl chloride pipe 0.018
D : diameter of pipe (m)
L : length of pipe (m)
g : acceleration of gravity =9.8 m/s^2
V : velocity of flow (m/s)

② Hazen -Williams formula (for transition or longer pipelines

$$hf = 6.82 \cdot \frac{L}{D^{1.17}} \cdot \left[\frac{V}{C}\right]^{1.85}$$

C : coefficient of pipe smoothness (-)=110

g) Friction loss of bend

$$h\ be = f\ be \cdot \frac{V^2}{2g}$$

h be: head loss (m)
f be: friction coefficient (-)
$= \{0.131 + 1.847 (D/2R)^{3.5}\} \cdot (\theta/90)^{0.5}$
D: diameter (m)
R: radius (m)
θ : angle

h) Entrance loss

$$he = 1.0 \cdot \frac{V^2}{2g} \quad (m)$$

i) Calculation for head loss

Situation of loss Exist:1 No exist:0	Friction of straight pipe	Darcy formula	-	0	
		Hazen formula	-	1	
	Friction of bend		-	0	
	Entrance loss		-	1	
Dia. of pipe			D	1.500	m
Length of pipe			L	14,550	m
Flow velocity			V	1.422	m/s
Friction of straight pipe	Darcy formula	Friction Coef.	f	0.024	m
		Coef.	-	1.5	-
		Head loss	hf	0.000	m
	Hazen formula	Flow rate coef	C	110	-
		Head loss	hf	19.811	m
	Sub-total		Σhf	19.811	m
Friction of bend	90°	Radius	R	0.3	m
		Angle	θ	90	degree
		Friction Coef.	f be	0.13	-
		Number	-	0	unit
		Head loss	h be	0.000	m
	45°	Radius	R	0.3	m
		Angle	θ	45	degree
		Friction Coef.	f be	0.09	-
		Number	-	0	unit
		Head loss	h be	0.000	m
	30°	Radius	R	0.3	m
		Angle	θ	30	degree
		Friction Coef.	f be	0.08	-
		Number	-	0	unit
		Head loss	h be	0.000	m
	22.5°	Radius	R	0.3	m
		Angle	θ	22.5	degree
		Friction Coef.	f be	0.07	-
		Number	-	0	unit
		Head loss	h be	0.000	m
	Sub-total		Σh be	0.000	m
Entrance loss			he	0.103	m
pipe and valve loss			hp	3.000	m
Total head loss			Σh	22.914	m

j) Total Head

Actual ('Static) pump head	2.000	m
Head loss	22.914	m
Total head	24.9	m

k) Motor Power

Construction Stage	Pump	Diameter (mm)	Pump Capacity (m^3/min)	Pump Efficiency (%)	Needed Power (kW)	Rating Power (kW)
Master Plan	No. 1	800	75.4	81	434.5	450
	No. 2	-	-	-	-	-
First Stage	No. 1	800	75.4	81	434.5	450
	No. 2	-	-	-	-	-

l) Pump Installation

Construction Stage	Pump	Diameter (mm)	Discharge Rate (m^3/min)	Motor Power (kW)	Number of Pump (unit)	Standby (unit)	Total Installed Pumps (unit)
Master Plan	No.1	800	75.4	450	4	1	5
	No.2	-	-	-	-	-	-
First Stage	No.1	800	75.4	450	2	1	3
	No.2	-	-	-	-	-	-

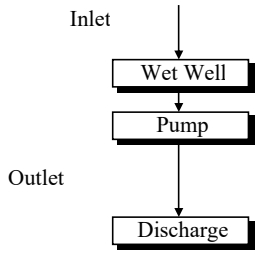
AC11.7.2 Effluent Pumping Station at the New East WWTP

(1) Basic Conditions

1) Design Flow Rate

Construction Stage	Item	m^3/d	m^3/hr	m^3/min	m^3/s	
Master Plan	Daily average flow	434,000	18083.3	301.4	5.023	1.00
	Daily maximum flow	434,000	18083.3	301.4	5.023	1.00
	Hourly maximum	434,000	18083.3	301.4	5.023	1.00
First Stage	Daily average flow	217,000	9041.7	150.7	2.512	1.00
	Daily maximum flow	217,000	9041.7	150.7	2.512	1.00
	Hourly maximum	217,000	9041.7	150.7	2.512	1.00

2) Flowsheet



3) Inlet, Outlet

Inlet pipe Diameter 2,700 mm
Material Hume pipe

Discharge Pipe Diameter 1,500 mm (Velocity 2.842 m^3/s)
Material Ductile cast-iron pipe
Length 12,300 m

4) Elevations

The elevation of inlet pipe invert	177.200 m
Discharge water elevation or outlet pipe invert elevation	180.200 m
The elevation of pipe invert highest discharge pipe	180.200 m

(2) Effluent Pumping Equipment

1) Pumping Plan

Construction Stage	Item	Pump Installation			Operation Schedule (unit)			
		Discharge Rate (m^3/min)	Number of pumps (unit)	Standby (unit)	1/3・Daily Average (m^3/min)	Daily Average (m^3/min)	Daily Maximum (m^3/min)	Hourly Maximum (m^3/min)
Master Plan	Design Flow	-	-	-	100.5	301.4	301.4	301.4
	Pump Capacity	-	-	-	150.8	301.6	301.6	301.6
	No.1	75.4	4	1	2	4	4	4
	No.2		0					
	Total		4	1	2	4	4	4
First Stage	Design Flow	-	-	-	50.2	150.7	150.7	150.7
	Pump Capacity	-	-	-	75.4	150.8	150.8	150.8
	No.1	75.4	2	1	1	2	2	2
	No.2		0					
	Total		2	1	1	2	2	2

2) Pump Head

a) L.W.L. 178.200 m (Min. water elevation)

b) Outlet elevation 180.200 m = Discharge water elevation or outlet pipe invert elevation

c) Actual ('Static) pump head 2.000 m

d) Discharge pipe diam. 1,500 mm ×2 (Section ar 1.767 m^2)

e) Flow velocity in the pipe 1.422 m/s

f) Friction loss of straight pipe

① Darcy-Weisbach formula (for turbulent flow or shorter pipelines

$$h_f = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$$

h_f : friction loss (m)
f : friction coefficient
New cast-iron pipe 0.024
New steel pipe 0.020
Polyvinyl chloride pipe 0.018
D : diameter of pipe (m)
L : length of pipe (m)
g : acceleration of gravity =9.8 m/s^2
V : velocity of flow (m/s)

② Hazen -Williams formula (for transition or longer pipelines

$$hf = 6.82 \cdot \frac{L}{D^{1.17}} \cdot \left[\frac{V}{C}\right]^{1.85}$$

C : coefficient of pipe smoothness (-)=110

g) Friction loss of bend

$$h\ be = f\ be \cdot \frac{V^2}{2g}$$

h be: head loss (m)
f be: friction coefficient (-)
$= \{0.131 + 1.847 (D/2R)^{3.5}\} \cdot (\theta/90)^{0.5}$
D: diameter (m)
R: radius (m)
θ : angle

h) Entrance loss

$$he = 1.0 \cdot \frac{V^2}{2g} \quad (m)$$

i) Calculation for head loss

Situation of loss Exist:1 No exist:0	Friction of straight pipe	Darcy formula	-	0	
		Hazen formula	-	1	
	Friction of bend		-	0	
	Entrance loss		-	1	
Dia. of pipe			D	1.500	m
Length of pipe			L	12,300	m
Flow velocity			V	1.422	m/s
Friction of straight pipe	Darcy formula	Friction Coef.	f	0.024	m
		Coef.	-	1.5	-
		Head loss	hf	0.000	m
	Hazen formula	Flow rate coef	C	110	-
		Head loss	hf	16.748	m
	Sub-total		Σhf	16.748	m
Friction of bend	90°	Radius	R	0.3	m
		Angle	θ	90	degree
		Friction Coef.	f be	0.13	-
		Number	-	0	unit
		Head loss	h be	0.000	m
	45°	Radius	R	0.3	m
		Angle	θ	45	degree
		Friction Coef.	f be	0.09	-
		Number	-	0	unit
		Head loss	h be	0.000	m
	30°	Radius	R	0.3	m
		Angle	θ	30	degree
		Friction Coef.	f be	0.08	-
		Number	-	0	unit
		Head loss	h be	0.000	m
	22.5°	Radius	R	0.3	m
		Angle	θ	22.5	degree
		Friction Coef.	f be	0.07	-
		Number	-	0	unit
		Head loss	h be	0.000	m
	Sub-total		Σh be	0.000	m
Entrance loss			he	0.103	m
pipe and valve loss			hp	3.000	m
Total head loss			Σh	19.851	m

j) Total Head

Actual ('Static) pump head	2.000	m
Head loss	19.851	m
Total head	21.9	m

k) Motor Power

Construction Stage	Pump	Diameter (mm)	Pump Capacity (m^3/min)	Pump Efficiency (%)	Needed Power (kW)	Rating Power (kW)
Master Plan	No. 1	800	75.4	81	382.1	400
	No. 2	-	-	-	-	-
First Stage	No. 1	800	75.4	81	382.1	400
	No. 2	-	-	-	-	-

l) Pump Installation

Construction Stage	Pump	Diameter (mm)	Discharge Rate (m^3/min)	Motor Power (kW)	Number of Pump (unit)	Standby (unit)	Total Installed Pumps (unit)
Master Plan	No.1	800	75.4	400	4	1	5
	No.2	-	-	-	-	-	-
First Stage	No.1	800	75.4	400	2	1	3
	No.2	-	-	-	-	-	-

AC11.8 Cost Estimations

Table AC11.8.1 to Table AC11.8.11 show the cost estimates for the proposed sewerage system for the western SWD and the eastern SWD.

Exchange Rate: JICA Dec. 2017 | 0.942161 PKR/JPY | 111.291000 JPY/USD | 104.854040 PKR/USD

Table AC11.8.1 Project Cost by Construction Phase in the Western SWD

	Component	Phase 1			Phase 2			Phase 3			Phase 4			Western SWD Total		
		FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Total
		Mill. USD	Mill. PKR	Mill. PKR	Mill. USD	Mill. PKR	Mill. PKR	Mill. USD	Mill. PKR	Mill. PKR	Mill. USD	Mill. PKR	Mill. PKR	Mill. USD	Mill. PKR	Mill. PKR
Direct Cost	Sewer Replacement	0.000	1,701	1,701	0.000	0	0	0.000	523	523	0.000	0	0	0.000	2,224	2,224
	Branch Sewer	0.000	8,440	8,440	0.000	10,677	10,677	0.000	10,854	10,854	0.000	16,675	16,675	0.000	46,646	46,646
	Major Sewer	54.062	1,491	7,160	33.244	1,606	5,092	64.935	1,813	8,622	32.079	2,768	6,132	184.320	7,678	27,006
	Lift & Influent PS	14.449	2,237	3,752	7.554	271	1,064	0.000	0	0	0.000	0	0	22.003	2,508	4,816
	WWTP	2.727	5,114	5,400	2.727	5,114	5,400	0.000	0	0	0.000	0	0	5.454	10,228	10,800
	Effluent PS + Pipe System	0.000	0	0	0.000	0	0	51.292	4,714	10,091	41.150	3,957	8,272	92.442	8,671	18,363
	Total Direct Cost	71.238	18,983	26,453	43.525	17,668	22,233	116.227	17,904	30,090	73.229	23,400	31,079	304.219	77,955	109,855
Indirect Cost	Consulting Service Fee 10%	7.124	1,898	2,646	4.353	1,767	2,223	11.623	1,790	3,009	7.323	2,340	3,108	30.423	7,795	10,986
	Land Acquisition	0.000	1,630	1,630	0.000	0	0	0.000	0	0	0.000	0	0	0.000	1,630	1,630
	Administration/Management: 5%	0.000	1,323	1,323	0.000	1,111	1,111	0.000	1,505	1,505	0.000	1,554	1,554	0.000	5,493	5,493
	Physical Cotingency: 2%	1.425	380	529	0.871	353	445	2.325	358	602	1.465	468	621	6.086	1,559	2,197
	Total Indirect Cost	8.549	5,231	6,128	5.224	3,231	3,779	13.948	3,653	5,116	8.788	4,362	5,283	36.509	16,477	20,306
	Value Added Tax (VAT): 16%	12.766	3,874	5,213	7.800	3,344	4,162	20.828	3,449	5,633	13.123	4,442	5,818	54.517	15,109	20,826
Total Projet Cost		92.553	28,088	37,794	56.549	24,243	30,174	151.003	25,006	40,839	95.140	32,204	42,180	395.245	109,541	150,987

Note: The Exchange Rate of 104.854040 PKR/USD and 111.291000 JPY/USD are applied to the FC and LC portions, respectively. The exchange rates are as of December 2017, from JICA homepage.
Source: JICA Mission Team

Land Acquisition	12,257,000 PKR/acre	French Project	About additioal area of **435** acre is required for the Eastern WWTP

Table AC11.8.1 Project Cost by Construction Phase in the Western SWD

	Component	Phase 1			Phase 2			Phase 3			Phase 4			Western SWD Total		
		FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Total
		Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR
Direct Cost	Sewer Replacement	0	1,701	1,701	0	0	0	0	523	523	0	0	0	0	2,224	2,224
	Branch Sewer	0	8,440	8,440	0	10,677	10,677	0	10,854	10,854	0	16,675	16,675	0	46,646	46,646
	Major Sewer	5,669	1,491	7,160	3,486	1,606	5,092	6,809	1,813	8,622	3,364	2,768	6,132	19,328	7,678	27,006
	Lift & Influent PS	1,515	2,237	3,752	792	271	1,063	0	0	0	0	0	0	2,307	2,508	4,815
	WWTP	286	5,114	5,400	286	5,114	5,400	0	0	0	0	0	0	572	10,228	10,800
	Effluent PS + Pipe System	0	0	0	0	0	0	5,378	4,714	10,092	4,315	3,957	8,272	9,693	8,671	18,364
	Total Direct Cost	7,470	18,983	26,453	4,564	17,668	22,232	12,187	17,904	30,091	7,679	23,400	31,079	31,900	77,955	109,855
Indirect Cost	Consulting Service Fee 10%	747	1,898	2,645	456	1,767	2,223	1,219	1,790	3,009	768	2,340	3,108	3,190	7,795	10,985
	Land Acquisition	0	1,630	1,630	0	0	0	0	0	0	0	0	0	0	1,630	1,630
	Administration/Management: 5%	0	1,323	1,323	0	1,111	1,111	0	1,505	1,505	0	1,554	1,554	0	5,493	5,493
	Physical Cotingency: 2%	149	380	529	91	353	444	244	358	602	154	468	622	638	1,559	2,197
	Total Indirect Cost	896	5,231	6,127	547	3,231	3,778	1,463	3,653	5,116	922	4,362	5,284	3,828	16,477	20,305
	Value Added Tax (VAT): 16%	1,339	3,874	5,213	818	3,344	4,162	2,184	3,449	5,633	1,376	4,442	5,818	5,717	15,109	20,826
Total Projet Cost		9,705	28,088	37,793	5,929	24,243	30,172	15,834	25,006	40,840	9,977	32,204	42,181	41,445	109,541	150,986

Exchange Rate: JICA Dec. 2017 | 0.942161 PKR/JPY | 111.291000 JPY/USD | 104.854040 PKR/USD

Table AC11.8.2 Project Cost by Construction Phase in the Eastern SWD

	Component	Phase 1			Phase 2			Phase 3			Phase 4			Eastern SWD Total		
		FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Total
		Mill. USD	Mill. PKR	Mill. PKR	Mill. USD	Mill. PKR	Mill. PKR	Mill. USD	Mill. PKR	Mill. PKR	Mill. USD	Mill. PKR	Mill. PKR	Mill. USD	Mill. PKR	Mill. PKR
Direct Cost	Sewer Replacement	0.000	110	110	0.000	748	748	0.000	0	0	0.000	0	0	0.000	858	858
	Branch Sewer	0.000	12,051	12,051	0.000	11,903	11,903	0.000	14,324	14,324	0.000	15,746	15,746	0.000	54,024	54,024
	Major Sewer	170.173	4,460	22,304	110.643	3,913	15,514	20.303	3,428	5,557	79.731	3,204	11,564	380.850	15,005	54,939
	Lift & Influent PS	12.510	2,076	3,387	6.743	210	917	0.000	0	0	0.000	0	0	19.253	2,286	4,304
	WWTP	0.000	3,931	3,931	0.000	3,931	3,931	0.000	0	0	0.000	0	0	0.000	7,862	7,862
	Effluent PS + Pipe System	0.000	0	0	0.000	0	0	45.631	4,120	8,904	35.489	3,364	7,085	81.120	7,484	15,989
	Total Direct Cost	182.683	22,628	41,783	117.386	20,705	33,013	65.934	21,872	28,785	115.220	22,314	34,395	481.223	87,519	137,976
Indirect Cost	Consulting Service Fee 10%	18.268	2,263	4,178	11.739	2,071	3,302	6.593	2,187	2,879	11.522	2,231	3,439	48.122	8,752	13,798
	Land Acquisition	0.000	5,332	5,332	0.000	0	0	0.000	0	0	0.000	0	0	0.000	5,332	5,332
	Administration/Management: 5%	0.000	2,089	2,089	0.000	1,651	1,651	0.000	1,439	1,439	0.000	1,720	1,720	0.000	6,899	6,899
	Physical Cotingency: 2%	3.654	453	836	2.348	414	660	1.319	437	576	2.304	446	688	9.625	1,750	2,760
	Total Indirect Cost	21.922	10,137	12,435	14.087	4,136	5,613	7.912	4,063	4,894	13.826	4,397	5,847	57.747	22,733	28,789
	Value Added Tax (VAT): 16%	32.737	5,242	8,675	21.036	3,975	6,180	11.815	4,150	5,389	20.647	4,274	6,439	86.235	17,641	26,683
Total Projet Cost		237.342	38,007	62,893	152.509	28,816	44,806	85.661	30,085	39,068	149.693	30,985	46,681	625.205	127,893	193,448

Note: The Exchange Rate of 104.854040 PKR/USD and 111.291000 JPY/USD are applied to the FC and LC portions, respectively. The exchange rates are as of December 2017, from JICA homepage.
Source: JICA Mission Team

Land Acquisition	12,257,000 PKR/acre	French Project	About additioal area of **435** acre is required for the Eastern WWTP

Table AC11.8.2 Project Cost by Construction Phase in the Eastern SWD

	Component	Phase 1			Phase 2			Phase 3			Phase 4			Eastern SWD Total		
		FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Total
		Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR	Mill. PKR
Direct Cost	Sewer Replacement	0	110	110	0	748	748	0	0	0	0	0	0	0	858	858
	Branch Sewer	0	12,051	12,051	0	11,903	11,903	0	14,324	14,324	0	15,746	15,746	0	54,024	54,024
	Major Sewer	17,843	4,460	22,303	11,601	3,913	15,514	2,129	3,428	5,557	8,360	3,204	11,564	39,933	15,005	54,938
	Lift & Influent PS	1,312	2,076	3,388	707	210	917	0	0	0	0	0	0	2,019	2,286	4,305
	WWTP	0	3,931	3,931	0	3,931	3,931	0	0	0	0	0	0	0	7,862	7,862
	Effluent PS + Pipe System	0	0	0	0	0	0	4,785	4,120	8,905	3,721	3,364	7,085	8,506	7,484	15,990
	Total Direct Cost	19,155	22,628	41,783	12,308	20,705	33,013	6,914	21,872	28,786	12,081	22,314	34,395	50,458	87,519	137,977
Indirect Cost	Consulting Service Fee 10%	1,915	2,263	4,178	1,231	2,071	3,302	691	2,187	2,878	1,208	2,231	3,439	5,045	8,752	13,797
	Land Acquisition	0	5,332	5,332	0	0	0	0	0	0	0	0	0	0	5,332	5,332
	Administration/Management: 5%	0	2,089	2,089	0	1,651	1,651	0	1,439	1,439	0	1,720	1,720	0	6,899	6,899
	Physical Cotingency: 2%	383	453	836	246	414	660	138	437	575	242	446	688	1,009	1,750	2,759
	Total Indirect Cost	2,298	10,137	12,435	1,477	4,136	5,613	829	4,063	4,892	1,450	4,397	5,847	6,054	22,733	28,787
	Value Added Tax (VAT): 16%	3,433	5,242	8,675	2,206	3,975	6,181	1,239	4,150	5,389	2,165	4,274	6,439	9,043	17,641	26,684
Total Projet Cost		24,886	38,007	62,893	15,991	28,816	44,807	8,982	30,085	39,067	15,696	30,985	46,681	65,555	127,893	193,448

Exchange Rate: JICA Dec. 2017 | 0.942161 PKR/JPY | 111.291000 JPY/USD | 104.854040 PKR/USD

Table AC11.8.3-1 Total Direct Costruction Cost Unit: 10^3 JPY

Item	Western SWD	Eastern SWD	Total
1. Sewer to be replaced			
Phase 1	1,806,269	116,820	1,923,089
Phase 2	0	793,489	793,489
Phase 3	555,075	0	555,075
Phase 4	0	0	0
Sewer Replacement Total	**2,361,344**	**910,309**	**3,271,653**
2. Branch Sewer			
Phase 1	8,957,880	12,790,800	21,748,680
Phase 2	11,332,320	12,633,600	23,965,920
Phase 3	11,520,310	15,203,280	26,723,590
Phase 4	17,699,040	16,712,400	34,411,440
Branch Sewer Total	**49,509,550**	**57,340,080**	**106,849,630**
3. Major Sewer			
3.1 Main Sewer			
Phase 1	0	903,260	903,260
Phase 2	0	2,494,820	2,494,820
Phase 3	118,260	3,857,520	3,975,780
Phase 4	2,942,980	5,827,980	8,770,960
Main Sewer Total	3,061,240	13,083,580	16,144,820
3.2 Trunk Sewer			
Phase 1	0	18,639,094	18,639,094
Phase 2	780,570	11,608,026	12,388,596
Phase 3	1,888,944	2,041,530	3,930,474
Phase 4	3,565,120	6,446,180	10,011,300
Trunk Sewer Total	6,234,634	38,734,830	44,969,464
3.3 Interceptor Sewer			
Phase 1	7,599,456	4,131,000	11,730,456
Phase 2	4,624,760	2,363,400	6,988,160
Phase 3	7,144,444	0	7,144,444
Phase 4	0	0	0
Interceptor Sewer Total	19,368,660	6,494,400	25,863,060
3.4 Major Sewer Total			
Phase 1	7,599,456	23,673,354	31,272,810
Phase 2	5,405,330	16,466,246	21,871,576
Phase 3	9,151,648	5,899,050	15,050,698
Phase 4	6,508,100	12,274,160	18,782,260
Major Sewer Total	**28,664,534**	**58,312,810**	**86,977,344**
4. Pump			
4.1 Lift PS	776,110	281,320	1,057,430
Phase 1	535,320	171,950	707,270
Phase 2	240,790	109,370	350,160
Phase 3	0	0	0
Phase 4	0	0	0
Lift PS Total	776,110	281,320	1,057,430
4.2 Influent PS	4,335,000	4,287,000	8,622,000
Phase 1	3,447,000	3,423,000	6,870,000
Phase 2	888,000	864,000	1,752,000
Phase 3	0	0	0
Phase 4	0	0	0
Inlet PS Total	4,335,000	4,287,000	8,622,000
4.3 Pump Total			
Phase 1	3,982,320	3,594,950	7,577,270
Phase 2	1,128,790	973,370	2,102,160
Phase 3	0	0	0
Phase 4	0	7,520,000	7,520,000
Pump Total	**5,111,110**	**12,088,320**	**17,199,430**
5. WWTP	11,463,000	8,344,000	19,807,000
Phase 1	5,731,500	4,172,000	9,903,500
Phase 2	5,731,500	4,172,000	9,903,500
Phase 3	0	0	0
Phase 4	0	0	0
WWTP Total	**11,463,000**	**8,344,000**	**19,807,000**
6. Effluent PS & Pipe	19,491,000	16,971,000	36,462,000
Phase 1	0	0	0
Phase 2	0	0	0
Phase 3	10,711,000	9,451,000	20,162,000
Phase 4	8,780,000	7,520,000	16,300,000
Treated WW PS Total	19,491,000	16,971,000	36,462,000

1. Storm Water PS			
Phase 1	204,050	0	204,050
Phase 2	0	134,960	134,960
Phase 3	50,330	0	50,330
Phase 4	0	0	0
Storm Water PS Total	**254,380**	**134,960**	**389,340**

Table AC11.8.3-2 Total Direct Costruction Cost

Item	Western SWD			Eastern SWD			Total		
	FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Total
	Mill. USD	Mill. PKR	Mill. PKR	Mill. USD	Mill. PKR	Mill. PKR	Mill. USD	Mill. PKR	Mill. PKR
1. Sewer to be replaced									
Phase 1	0.000	1,701	1,701	0.000	110	110	0.000	1,811	1,811
Phase 2	0.000	0	0	0.000	748	748	0.000	748	748
Phase 3	0.000	523	523	0.000	0	0	0.000	523	523
Phase 4	0.000	0	0	0.000	0	0	0.000	0	0
Sewer Replacement Total	0.000	2,224	2,224	0.000	858	858	0.000	3,082	3,082
2. Branch Sewer									
Phase 1	0.000	8,440	8,440	0.000	12,051	12,051	0.000	20,491	20,491
Phase 2	0.000	10,677	10,677	0.000	11,903	11,903	0.000	22,580	22,580
Phase 3	0.000	10,854	10,854	0.000	14,324	14,324	0.000	25,178	25,178
Phase 4	0.000	16,675	16,675	0.000	15,746	15,746	0.000	32,421	32,421
Branch Sewer Total	0.000	46,646	46,646	0.000	54,024	54,024	0.000	100,670	100,670
3. Major Sewer									
3.1 Main Sewer									
Phase 1	0.000	0	0	6.493	170	851	6.493	170	851
Phase 2	0.000	0	0	11.254	1,171	2,351	11.254	1,171	2,351
Phase 3	0.000	111	111	20.303	1,505	3,634	20.303	1,616	3,745
Phase 4	9.118	1,817	2,773	33.394	1,989	5,490	42.512	3,806	8,263
Main Sewer Total	9.118	1,928	2,884	71.444	4,835	12,326	80.562	6,763	15,210
3.2 Trunk Sewer									
Phase 1	0.000	0	0	133.985	3,512	17,561	133.985	3,512	17,561
Phase 2	0.000	735	735	82.400	2,297	10,937	82.400	3,032	11,672
Phase 3	13.578	356	1,780	0.000	1,923	1,923	13.578	2,279	3,703
Phase 4	22.961	951	3,359	46.337	1,215	6,074	69.298	2,166	9,433
Trunk Sewer Total	36.539	2,042	5,874	262.722	8,947	36,495	299.261	10,989	42,369
3.3 Interceptor Sewer									
Phase 1	54.062	1,491	7,160	29.695	778	3,892	83.757	2,269	11,052
Phase 2	33.244	871	4,357	16.989	445	2,226	50.233	1,316	6,583
Phase 3	51.357	1,346	6,731	0.000	0	0	51.357	1,346	6,731
Phase 4	0.000	0	0	0.000	0	0	0.000	0	0
Interceptor Sewer Total	138.663	3,708	18,248	46.684	1,223	6,118	185.347	4,931	24,366
3.4 Major Sewer Total									
Phase 1	54.062	1,491	7,160	170.173	4,460	22,304	224.235	5,951	29,464
Phase 2	33.244	1,606	5,092	110.643	3,913	15,514	143.887	5,519	20,606
Phase 3	64.935	1,813	8,622	20.303	3,428	5,557	85.238	5,241	14,179
Phase 4	32.079	2,768	6,132	79.731	3,204	11,564	111.810	5,972	17,696
Major Sewer Total	184.320	7,678	27,006	380.850	15,005	54,939	565.170	22,683	81,945
4. Pump									
4.1 Lift PS									
Phase 1	2.603	231	504	0.836	75	162	3.439	306	666
Phase 2	1.171	104	227	0.532	47	103	1.703	151	330
Phase 3	0.000	0	0	0.000	0	0	0.000	0	0
Phase 4	0.000	0	0	0.000	0	0	0.000	0	0
Lift PS Total	3.774	335	731	1.368	122	265	5.142	457	996
4.2 Influent PS									
Phase 1	11.846	2,006	3,248	11.674	2,001	3,225	23.520	4,007	6,473
Phase 2	6.383	167	837	6.211	163	814	12.594	330	1,651
Phase 3	0.000	0	0	0.000	0	0	0.000	0	0
Phase 4	0.000	0	0	0.000	0	0	0.000	0	0
Inlet PS Total	18.229	2,173	4,085	17.885	2,164	4,039	36.114	4,337	8,124
4.3 Pump Total									
Phase 1	14.449	2,237	3,752	12.510	2,076	3,387	26.959	4,313	7,139
Phase 2	7.554	271	1,064	6.743	210	917	14.297	481	1,981
Phase 3	0.000	0	0	0.000	0	0	0.000	0	0
Phase 4	0.000	0	0	0.000	0	0	0.000	0	0
Pump Total	22.003	2,508	4,816	19.253	2,286	4,304	41.256	4,794	9,120
5. WWTP									
Phase 1	2.727	5,114	5,400	0.000	3,931	3,931	2.727	9,045	9,331
Phase 2	2.727	5,114	5,400	0.000	3,931	3,931	2.727	9,045	9,331
Phase 3	0.000	0	0	0.000	0	0	0.000	0	0
Phase 4	0.000	0	0	0.000	0	0	0.000	0	0
WWTP Total	5.454	10,228	10,800	0.000	7,862	7,862	5.454	18,090	18,662
6. Effluent PS & Pipe									
Phase 1	0.000	0	0	0.000	0	0	0.000	0	0
Phase 2	0.000	0	0	0.000	0	0	0.000	0	0
Phase 3	51.292	4,714	10,091	45.631	4,120	8,904	96.923	8,834	18,995
Phase 4	41.150	3,957	8,272	35.489	3,364	7,085	76.639	7,321	15,357
Treated WW PS Total	92.442	8,671	18,363	81.120	7,484	15,989	173.562	16,155	34,352

1. Storm Water PS									
Phase 1	1.027	85	192	0	0	0	1.027	85	192
Phase 2	0	0	0	0.679	56	127	0.679	56	127
Phase 3	0.253	21	47	0	0	0	0.253	21	47
Phase 4	0	0	0	0	0	0	0.000	0	0
Inlet PS Total	1.280	106	239	0.679	56	127	1.959	162	366

Exchange Rate: JICA Dec. 2017 **0.942161** PKR/JPY **111.291000** JPY/USD **104.854040** PKR/USD

Pipe Jacking Method: **Ratio of FC portion = 0.80** **Ratio of LC portion = 0.20**

Open Cut Method: Ratio of FC portion = 0.00 **Ratio of LC portion = 1.00**

Unit: x10^3 JPY

Table AC11.8.4 Major Sewer Construction Cost Summary

SWD	Const. Metod	Phasing	Main Sewer	Trunk Sewer	Interceptor Sewer
Western	Pipe Jacking	Phase 1	0	0	7,520,736
		Phase 2	0	0	4,624,760
		Phase 3	0	1,888,944	7,144,444
		Phase 4	1,268,400	3,194,230	0
	Open-Cut	Phase 1	0	0	78,720
		Phase 2	0	780,570	0
		Phase 3	118,260	0	0
		Phase 4	1,674,580	370,890	0
	Both	Phase 1	0	0	7,599,456
		Phase 2	0	780,570	4,624,760
		Phase 3	118,260	1,888,944	7,144,444
		Phase 4	2,942,980	3,565,120	0
Eastern	Pipe Jacking	Phase 1	903,260	18,639,094	4,131,000
		Phase 2	1,565,560	11,462,946	2,363,400
		Phase 3	2,824,380	0	0
		Phase 4	4,645,500	6,446,180	0
	Open-Cut	Phase 1	0	0	0
		Phase 2	929,260	145,080	0
		Phase 3	1,033,140	2,041,530	0
		Phase 4	1,182,480	0	0
	Both	Phase 1	903,260	18,639,094	4,131,000
		Phase 2	2,494,820	11,608,026	2,363,400
		Phase 3	3,857,520	2,041,530	0
		Phase 4	5,827,980	6,446,180	0
Overall		Phase 1	903,260	18,639,094	11,730,456
		Phase 2	2,494,820	12,388,596	6,988,160
		Phase 3	3,975,780	3,930,474	7,144,444
		Phase 4	8,770,960	10,011,300	0
Grand Total			16,144,820	44,969,464	25,863,060
					86,977,344

Sewerage District (SWD)	Construction Method	Phasing	Main Sewer			Trunk Sewer			Interceptor Sewer			Total		
			FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
			Mil. USD	Mil PKR	Mil. PKR	Mil. USD	Mil PKR	Mil. PKR	Mil. USD	Mil PKR	Mil. PKR	Mil. USD	Mil PKR	Mil. PKR
Western	Pipe Jacking	Phase 1	0.000	0	0	0.000	0	0	54.062	1,417	7,086	54.062	1,417	7,086
		Phase 2	0.000	0	0	0.000	0	0	33.244	871	4,357	33.244	871	4,357
		Phase 3	0.000	0	0	13.578	356	1,780	51.357	1,346	6,731	64.935	1,702	8,511
		Phase 4	9.118	239	1,195	22.961	602	3,010	0.000	0	0	32.079	841	4,205
	Open-Cut	Phase 1	0	0	0	0	0	0	0	74	74	0	74	74
		Phase 2	0	0	0	0	735	735	0	0	0	0	735	735
		Phase 3	0	111	111	0	0	0	0	0	0	0	111	111
		Phase 4	0	1,578	1,578	0	349	349	0	0	0	0	1,927	1,927
	Both	Phase 1	0.000	0	0	0.000	0	0	54.062	1,491	7,160	54.062	1,491	7,160
		Phase 2	0.000	0	0	0.000	735	735	33.244	871	4,357	33.244	1,606	5,092
		Phase 3	0.000	111	111	13.578	356	1,780	51.357	1,346	6,731	64.935	1,813	8,622
		Phase 4	9.118	1,817	2,773	22.961	951	3,359	0.000	0	0	32.079	2,768	6,132
Eastern	Pipe Jacking	Phase 1	6.493	170	851	133.985	3,512	17,561	29.695	778	3,892	170.173	4,460	22,304
		Phase 2	11.254	295	1,475	82.400	2,160	10,800	16.989	445	2,226	110.643	2,900	14,501
		Phase 3	20.303	532	2,661	0.000	0	0	0.000	0	0	20.303	532	2,661
		Phase 4	33.394	875	4,376	46.337	1,215	6,074	0.000	0	0	79.731	2,090	10,450
	Open-Cut	Phase 1	0	0	0	0	0	0	0	0	0	0	0	0
		Phase 2	0	876	876	0	137	137	0	0	0	0	1,013	1,013
		Phase 3	0	973	973	0	1,923	1,923	0	0	0	0	2,896	2,896
		Phase 4	0	1,114	1,114	0	0	0	0	0	0	0	1,114	1,114
	Both	Phase 1	6.493	170	851	133.99	3,512	17,561	29.695	778	3,892	170.173	4,460	22,304
		Phase 2	11.254	1,171	2,351	82.40	2,297	10,937	16.989	445	2,226	110.643	3,913	15,514
		Phase 3	20.303	1,505	3,634	0.00	1,923	1,923	0.000	0	0	20.303	3,428	5,557
		Phase 4	33.394	1,989	5,490	46.34	1,215	6,074	0.000	0	0	79.731	3,204	11,564
Overall		Phase 1	6.493	170	851	133.99	3,512	17,561	83.757	2,269	11,052	224.235	5,951	29,464
		Phase 2	11.254	1,171	2,351	82.40	3,032	11,672	50.233	1,316	6,583	143.887	5,519	20,606
		Phase 3	20.303	1,616	3,745	13.58	2,279	3,703	51.357	1,346	6,731	85.238	5,241	14,179
		Phase 4	42.512	3,806	8,263	69.30	2,166	9,433	0.000	0	0	111.810	5,972	17,696

Table AC11.8.5-1 Sewer Construction Cost in the Western SWD: Alterntive SW-1 (Chokera WWTP only)

Sewer ID	Sewer Category	Construction Phase	Dia. (mm)	Length (m)	Ave. Earth Cover (m)	Excavation Depth (m)	Construction Method	Unit Cost (JPY 10^3/m)	Cost (JPY 10^3)
W1	T	3	1050	1,600	6.9	8.1	Pipe Jacking	557	891,200
W2	M	3	525	2,190	3.6	4.3	Open Cut	54	118,260
W3-1	T	3	1050	1,254	10.2	11.4	Pipe Jacking	557	698,478
W3-2	T	3	1500	446	11.4	13.1	Pipe Jacking	671	299,266
W4	M	4	1050	3,910	3.8	5.1	Open Cut	117	457,470
W5	M	4	750	1,790	2.0	3.0	Open Cut	80	143,200
W5-1	T	4	1050	740	5.5	6.8	Pipe Jacking	557	412,180
W6	T	2	1500	4,130	2.6	4.3	Open Cut	189	780,570
W7	M	4	525	710	2.2	3.0	Open Cut	54	38,340
W8	M	4	600	1,310	2.3	3.1	Open Cut	63	82,530
W9	M	4	600	1,600	3.2	4.0	Open Cut	63	100,800
W10	M	4	900	1,090	2.1	3.2	Open Cut	99	107,910
W11	M	4	375	1,610	2.0	2.6	Open Cut	43	69,230
W12	T	4	1050	3,170	3.8	5.1	Open Cut	117	370,890
W13	M	4	525	2,040	2.5	3.2	Open Cut	54	110,160
W13-1	T	4	1050	270	5.9	7.1	Pipe Jacking	557	150,390
W14	M	4	525	2,910	2.4	3.1	Open Cut	54	157,140
W15	M	4	600	1,910	5.4	6.2	Pipe Jacking	402	767,820
W16	T	4	1200	2,160	5.4	6.8	Pipe Jacking	584	1,261,440
W17	M	4	675	1,400	4.2	5.1	Open Cut	70	98,000
W18	M	4	750	1,030	5.8	6.8	Pipe Jacking	486	500,580
W19	M	4	750	1,510	2.8	3.7	Open Cut	80	120,800
W20	T	4	1050	2,460	5.9	7.1	Pipe Jacking	557	1,370,220
W21	M	4	300	7,000	1.5	2.0	Open Cut	27	189,000
WB1-1	I	3	1050	708	5.9	7.2	Pipe Jacking	557	394,356
WB1-2	I	3	1200	1,062	7.0	8.4	Pipe Jacking	584	620,208
WB1-3	I	3	1500	1,640	8.5	10.2	Pipe Jacking	671	1,100,440
WB2	I	2	2250	1,520	7.6	10.1	Pipe Jacking	972	1,477,440
WB3	I	2	2400	3,110	8.2	10.8	Pipe Jacking	1,012	3,147,320
WB4	I	1	1050	720	6.4	7.6	Pipe Jacking	557	401,040
WB5	I	1	450	1,640	5.3	6.0	Open Cut	48	78,720
WB6	I	1	1050	790	8.8	10.1	Pipe Jacking	557	440,030
WB7	I	1	1200	2,500	7.0	8.4	Pipe Jacking	584	1,460,000
WB8-1	I	1	1350	2,106	8.5	10.0	Pipe Jacking	622	1,309,932
WB8-2	I	1	1500	804	8.7	10.4	Pipe Jacking	671	539,484
WB9	I	1	2700	2,450	8.3	11.2	Pipe Jacking	1,105	2,707,250
WB10	I	1	2700	600	7.1	10.0	Pipe Jacking	1,105	663,000
WB11	I	3	1500	330	11.2	12.9	Pipe Jacking	671	221,430
WB12	I	3	1500	960	10.0	11.7	Pipe Jacking	671	644,160
WB13-1	I	3	1650	3,950	9.0	10.8	Pipe Jacking	730	2,883,500
WB13-2	I	3	1950	1,450	8.9	11.1	Pipe Jacking	883	1,280,350
Total				**74,580**					**28,664,534**

Table AC11.8.5-2 Sewer Construction Cost by Phasing in the Western SWD: Alternative SW-1

Sewer ID	Sewer Category	Construction Phase	Dia. (mm)	Length (m)	Ave. Earth Cover (m)	Excavation Depth (m)	Construction Method	Unit Cost (JPY 10^3/m)	Cost (JPY 10^3)
WB4	I	1	1050	720	6.4	7.6	Pipe Jacking	557	401,040
WB6	I	1	1050	790	8.8	10.1	Pipe Jacking	557	440,030
WB7	I	1	1200	2,500	7.0	8.4	Pipe Jacking	584	1,460,000
WB8-1	I	1	1350	2,106	8.5	10.0	Pipe Jacking	622	1,309,932
WB8-2	I	1	1500	804	8.7	10.4	Pipe Jacking	671	539,484
WB9	I	1	2700	2,450	8.3	11.2	Pipe Jacking	1,105	2,707,250
WB10	I	1	2700	600	7.1	10.0	Pipe Jacking	1,105	663,000
				9,970					7,520,736
WB5	I	1	450	1,640	5.3	6.0	Open Cut	48	78,720
				11,610			**Phase 1 Total**		**7,599,456**
WB2	I	2	2250	1,520	7.6	10.1	Pipe Jacking	972	1,477,440
WB3	I	2	2400	3,110	8.2	10.8	Pipe Jacking	1,012	3,147,320
				4,630					4,624,760
W6	T	2	1500	4,130	2.6	4.3	Open Cut	189	780,570
				8,760			**Phase 2 Total**		**5,405,330**
WB1-1	I	3	1050	708	5.9	7.2	Pipe Jacking	557	394,356
WB1-2	I	3	1200	1,062	7.0	8.4	Pipe Jacking	584	620,208
WB1-3	I	3	1500	1,640	8.5	10.2	Pipe Jacking	671	1,100,440
WB11	I	3	1500	330	11.2	12.9	Pipe Jacking	671	221,430
WB12	I	3	1500	960	10.0	11.7	Pipe Jacking	671	644,160
WB13-1	I	3	1650	3,950	9.0	10.8	Pipe Jacking	730	2,883,500
WB13-2	I	3	1950	1,450	8.9	11.1	Pipe Jacking	883	1,280,350
			I-total	10,100				I-total	7,144,444
W1	T	3	1050	1,600	6.9	8.1	Pipe Jacking	557	891,200
W3-1	T	3	1050	1,254	10.2	11.4	Pipe Jacking	557	698,478
W3-2	T	3	1500	446	11.4	13.1	Pipe Jacking	671	299,266
			T-total	3,300				T-total	1,888,944
W2	M	3	525	2,190	3.6	4.3	Open Cut	54	118,260
				15,590			**Phase 3 Total**		**9,151,648**
W5-1	T	4	1050	740	5.5	6.8	Pipe Jacking	557	412,180
W13-1	T	4	1050	270	5.9	7.1	Pipe Jacking	557	150,390
W20	T	4	1050	2,460	5.9	7.1	Pipe Jacking	557	1,370,220
W16	T	4	1200	2,160	5.4	6.8	Pipe Jacking	584	1,261,440
				5,630					3,194,230
W12	T	4	1050	3,170	3.8	5.1	Open Cut	117	370,890
			T-total	8,800				T-total	3,565,120
W15	M	4	600	1,910	5.4	6.2	Pipe Jacking	402	767,820
W18	M	4	750	1,030	5.8	6.8	Pipe Jacking	486	500,580
				2,940					1,268,400
W21	M	4	300	7,000	1.5	2.0	Open Cut	27	189,000
W11	M	4	375	1,610	2.0	2.6	Open Cut	43	69,230
W7	M	4	525	710	2.2	3.0	Open Cut	54	38,340
W13	M	4	525	2,040	2.5	3.2	Open Cut	54	110,160
W14	M	4	525	2,910	2.4	3.1	Open Cut	54	157,140
W8	M	4	600	1,310	2.3	3.1	Open Cut	63	82,530
W9	M	4	600	1,600	3.2	4.0	Open Cut	63	100,800
W17	M	4	675	1,400	4.2	5.1	Open Cut	70	98,000
W5	M	4	750	1,790	2.0	3.0	Open Cut	80	143,200
W19	M	4	750	1,510	2.8	3.7	Open Cut	80	120,800
W10	M	4	900	1,090	2.1	3.2	Open Cut	99	107,910
W4	M	4	1050	3,910	3.8	5.1	Open Cut	117	457,470
				26,880					1,674,580
			M-total	29,820				M-total	2,942,980
				38,620			**Phase 4 Total**		**6,508,100**
		Total Length		**11,610**			**Phase 1**	**Cost**	**7,599,456**
		Total Length		**8,760**			**Phase 2**	**Cost**	**5,405,330**
		Total Length		**15,590**			**Phase 3**	**Cost**	**9,151,648**
		Total Length		**38,620**			**Phase 4**	**Cost**	**6,508,100**
Total				**74,580**					**28,664,534**

Construction Method	Dia. (mm)	Unit Cost (JPY 10^3/m)
Pipe Jacking	600	402
	750	486
	1050	557
	1200	584
	1350	622
	1500	671
	1650	730
	1950	883
	2250	972
	2400	1,012
	2700	1,105

Open Cut	300	27
	375	43
	450	48
	525	54
	600	63
	675	70
	750	80
	900	99
	1050	117
	1500	189

Table AC11.8.5-3_Major Sewer in the Wester **Unit: x10^3 JPY**

Item		Main	Trunk	Interceptor	Total
By Pipe Jacking	Phase 1 Cost	0	0	7,520,736	7,520,736
	Phase 2 Cost	0	0	4,624,760	4,624,760
	Phase 3 Cost	0	1,888,944	7,144,444	9,033,388
	Phase 4 Cost	1,268,400	3,194,230	0	4,462,630
	Total	1,268,400	5,083,174	19,289,940	
By Open-Cut	Phase 1 Cost	0	0	78,720	78,720
	Phase 2 Cost	0	780,570	0	780,570
	Phase 3 Cost	118,260	0	0	118,260
	Phase 4 Cost	1,674,580	370,890	0	2,045,470
	Total	1,792,840	1,151,460	78,720	
Total	Phase 1 Cost	0	0	7,599,456	7,599,456
	Phase 2 Cost	0	780,570	4,624,760	5,405,330
	Phase 3 Cost	118,260	1,888,944	7,144,444	9,151,648
	Phase 4 Cost	2,942,980	3,565,120	0	6,508,100
	Total	3,061,240	6,234,634	19,368,660	28,664,534

Table AC11.8.6-1 Sewer Construction Cost in the Eastern SWD: Alternative SE-2 (Double Routes)

Sewer ID	Sewer Category	Construction Phase	Route	Dia. (mm)	Length (m)	Ave. Earth Cover (m)	Excavation Depth (m)	Construction Method	Unit Cost (JPY 10^3/m)	Cost (JPY 10^3)
E1-1	M	3	1	350	5,670	2.0	2.6	Open Cut	34	192,780
E1-2	M	3	1	1050	1,830	2.7	4.0	Open Cut	117	214,110
E2	T	3	1	1050	2,980	3.8	5.1	Open Cut	117	348,660
E3	M	3	1	600	1,200	3.0	3.8	Open Cut	63	75,600
E4	T	3	1	1350	1,940	3.0	4.5	Open Cut	162	314,280
E5	M	3	1	675	1,200	2.2	3.1	Open Cut	70	84,000
E6	T	3	1	1350	2,020	2.4	4.0	Open Cut	162	327,240
E7	M	3	1	450	760	2.0	2.7	Open Cut	48	36,480
E8	T	3	1	1350	330	2.8	4.4	Open Cut	162	53,460
E9	M	3	1	600	960	3.0	3.8	Open Cut	63	60,480
E10	T	3	1	1500	2,360	3.7	5.4	Open Cut	189	446,040
E11	M	2	1	900	2,390	2.6	3.7	Open Cut	99	236,610
E12	M	2	1	825	2,440	2.1	3.2	Open Cut	91	222,040
E13	T	2	1	1050	1,240	4.7	6.0	Open Cut	117	145,080
E14-1	M	2	1	1050	3,640	2.8	4.0	Open Cut	117	425,880
E14	T	2	1	1350	2,510	7.3	8.8	Pipe Jacking	622	1,561,220
E15	T	2	1	1950	760	9.7	11.9	Pipe Jacking	883	671,080
E16	M	2	1	600	710	3.2	4.0	Open Cut	63	44,730
E17-1a	T	2	1	1950	1,532	8.5	10.7	Pipe Jacking	883	1,352,756
E17-1b	T	1	1	1950	3,688	8.5	10.7	Pipe Jacking	883	3,256,504
E17-2	M	1	1	300	680	6.9	7.4	Pipe Jacking	292	198,560
E17-3	M	1	1	750	1,450	6.8	7.8	Pipe Jacking	486	704,700
E17-4	T	1	1	1950	1,000	7.0	9.2	Pipe Jacking	883	883,000
E18	M	4	1	450	1,980	4.1	4.7	Open Cut	48	95,040
E19	M	4	1	750	1,380	3.4	4.4	Open Cut	80	110,400
E20	M	4	1	750	1,680	6.3	7.3	Pipe Jacking	486	816,480
E21	M	4	1	675	1,240	2.7	3.6	Open Cut	70	86,800
E22	M	4	1	900	760	7.3	8.4	Pipe Jacking	541	411,160
E23	M	4	1	300	1,780	4.8	5.3	Open Cut	27	48,060
E24	M	4	1	300	1,200	3.5	4.0	Open Cut	27	32,400
E25	M	4	1	450	1,310	7.0	7.7	Pipe Jacking	338	442,780
E26	T	4	1	1050	1,340	8.4	9.6	Pipe Jacking	557	746,380
E27	M	4	1	225	280	2.3	2.7	Open Cut	24	6,720
E28	T	4	1	1050	980	9.2	10.5	Pipe Jacking	557	545,860
E29	M	4	1	525	960	4.3	5.0	Open Cut	54	51,840
E30	M	4	1	225	650	3.1	3.5	Open Cut	24	15,600
E31	T	4	1	1050	1,050	9.8	11.1	Pipe Jacking	557	584,850
E32	M	4	1	1050	990	3.1	4.4	Open Cut	117	115,830
E33	M	4	1	225	630	3.0	3.4	Open Cut	24	15,120
E34	T	4	1	1350	1,350	8.5	10.0	Pipe Jacking	622	839,700
E35	M	4	1	525	990	3.3	4.0	Open Cut	54	53,460
E36	M	4	1	225	490	2.7	3.1	Open Cut	24	11,760
E37	T	4	1	1500	1,440	7.6	9.3	Pipe Jacking	671	966,240
E38	M	4	1	750	2,530	2.4	3.4	Open Cut	80	202,400
E39	M	4	1	825	2,810	5.3	6.3	Pipe Jacking	537	1,508,970
E40	M	4	1	300	950	4.0	4.5	Open Cut	27	25,650
E41	M	4	1	900	1,660	8.0	9.1	Pipe Jacking	541	898,060
E42	M	4	1	300	1,300	3.7	4.2	Open Cut	27	35,100
E43	M	4	1	900	1,050	8.3	9.4	Pipe Jacking	541	568,050
E44	M	4	1	300	1,230	3.4	3.9	Open Cut	27	33,210
E45	T	4	1	900	1,020	7.0	8.1	Pipe Jacking	541	551,820
E46	M	4	1	375	1,590	2.2	2.7	Open Cut	43	68,370
E47	T	4	1	900	1,390	6.4	7.5	Pipe Jacking	541	751,990
E48	M	4	1	450	1,930	2.8	3.4	Open Cut	48	92,640
E49	T	4	1	1050	2,620	6.7	7.9	Pipe Jacking	557	1,459,340
E50	M	3	2	675	4,230	9.5	10.4	Pipe Jacking	442	1,869,660
E50-1	M	3	2	675	2,160	13.4	14.3	Pipe Jacking	442	954,720
E50-2	M	2	2	675	1,700	13.9	14.7	Pipe Jacking	442	751,400
E51	M	3	2	375	1,910	2.8	3.3	Open Cut	43	82,130
E52	M	3	2	525	2,940	2.0	2.7	Open Cut	54	158,760
E53	**T**	**3**	**2**	**750**	**2,550**	**3.1**	**4.1**	Open Cut	**80**	**204,000**
E54	M	3	2	675	1,840	2.1	3.0	Open Cut	70	128,800
E55	**T**	**3**	**2**	**600**	**2,300**	**2.0**	**2.8**	Open Cut	**63**	**144,900**
E55-1	**T**	**3**	**2**	**900**	**2,050**	**2.8**	**3.9**	Open Cut	**99**	**202,950**
E55-2	**T**	**2**	**2**	**2250**	**5,970**	**13.5**	**16.0**	Pipe Jacking	**972**	**5,802,840**
E56	M	4	1	525	1,520	2.5	3.3	Open Cut	54	82,080
E57	**T**	**1**	**1**	**2250**	**1,060**	**10.2**	**12.7**	Pipe Jacking	**972**	**1,030,320**
E58	**T**	**1**	**1**	**2400**	**3,500**	**11.4**	**14.0**	Pipe Jacking	**1,012**	**3,542,000**
E59-1	**T**	**1**	**1**	**2550**	**6,170**	**14.2**	**16.9**	Pipe Jacking	**1,057**	**6,521,690**
E59-2	**T**	**1**	**1**	**2700**	**100**	**17.1**	**20.0**	Pipe Jacking	**1,105**	**110,500**
EB1	**T**	**1**	**1**	**2250**	**3,390**	**7.2**	**9.7**	Pipe Jacking	**972**	**3,295,080**
EB2-1	**I**	**2**	**2**	**1350**	**2,450**	**6.7**	**8.3**	Pipe Jacking	**622**	**1,523,900**
EB2-2	**I**	**2**	**2**	**1650**	**1,150**	**6.8**	**8.7**	Pipe Jacking	**730**	**839,500**
E51-1	**T**	**2**	**2**	**1950**	**2,350**	**13.6**	**15.8**	Pipe Jacking	**883**	**2,075,050**
EB3	**I**	**1**	**1**	**2250**	**530**	**7.6**	**10.0**	Pipe Jacking	**972**	**515,160**
EB4	**I**	**1**	**1**	**2250**	**940**	**10.7**	**13.2**	Pipe Jacking	**972**	**913,680**
EB5	**I**	**1**	**1**	**2250**	**1,430**	**10.4**	**12.8**	Pipe Jacking	**972**	**1,389,960**
EB6	**I**	**1**	**1**	**2250**	**1,350**	**9.7**	**12.1**	Pipe Jacking	**972**	**1,312,200**
EP7S	M	2	2	1050	680	5.8	7.0	Pipe Jacking	557	378,760
EP4S	M	2	2	1350	700	5.4	7.0	Pipe Jacking	622	435,400
Total					**140,820**	Max. =	20.0			**58,312,810**

Table AC11.8.6-2 Sewer Construction Cost by Phasing in the Eastern SWD: Alternative SE-2 (Double Routes)

Sewer ID	Sewer Category	Construction Phase	Route	Dia. (mm)	Length (m)	Ave. Earth Cover (m)	Excavation Depth (m)	Construction Method	Unit Cost (JPY 10^3/m)	Cost (JPY 10^3)
EB3	I	1	1	2250	530	7.6	10.0	Pipe Jacking	972	515,160
EB4	I	1	1	2250	940	10.7	13.2	Pipe Jacking	972	913,680
EB5	I	1	1	2250	1,430	10.4	12.8	Pipe Jacking	972	1,389,960
EB6	I	1	1	2250	1,350	9.7	12.1	Pipe Jacking	972	1,312,200
					4,250					4,131,000
E17-1b	T	1	1	1950	3,688	8.5	10.7	Pipe Jacking	883	3,256,504
E17-4	T	1	1	1950	1,000	7.0	9.2	Pipe Jacking	883	883,000
E57	T	1	1	2250	1,060	10.2	12.7	Pipe Jacking	972	1,030,320
E58	T	1	1	2400	3,500	11.4	14.0	Pipe Jacking	1,012	3,542,000
E59-1	T	1	1	2550	6,170	14.2	16.9	Pipe Jacking	1,057	6,521,690
E59-2	T	1	1	2700	100	17.1	20.0	Pipe Jacking	1,105	110,500
EB1	T	1	1	2250	3,390	7.2	9.7	Pipe Jacking	972	3,295,080
					18,908					18,639,094
E17-2	M	1	1	300	680	6.9	7.4	Pipe Jacking	292	198,560
E17-3	M	1	1	750	1,450	6.8	7.8	Pipe Jacking	486	704,700
					2,130					903,260
			R-1		**25,288**		**R-1**	**Phase 1 Total**		**23,673,354**
E14	T	2	1	1350	2,510	7.3	8.8	Pipe Jacking	622	1,561,220
E15	T	2	1	1950	760	9.7	11.9	Pipe Jacking	883	671,080
E17-1a	T	2	1	1950	1,532	8.5	10.7	Pipe Jacking	883	1,352,756
					4,802					3,585,056
E13	T	2	1	1050	1,240	4.7	6.0	Open Cut	117	145,080
				T-total	6,042					3,730,136
E11	M	2	1	900	2,390	2.6	3.7	Open Cut	99	236,610
E12	M	2	1	825	2,440	2.1	3.2	Open Cut	91	222,040
E14-1	M	2	1	1050	3,640	2.8	4.0	Open Cut	117	425,880
E16	M	2	1	600	710	3.2	4.0	Open Cut	63	44,730
				M-total	9,180					929,260
			R-1		**15,222**		**R-1**	**Phase 2 Total**		**4,659,396**
E2	T	3	1	1050	2,980	3.8	5.1	Open Cut	117	348,660
E4	T	3	1	1350	1,940	3.0	4.5	Open Cut	162	314,280
E6	T	3	1	1350	2,020	2.4	4.0	Open Cut	162	327,240
E8	T	3	1	1350	330	2.8	4.4	Open Cut	162	53,460
E10	T	3	1	1500	2,360	3.7	5.4	Open Cut	189	446,040
				T-total	9,630					1,489,680
E1-1	M	3	1	350	5,670	2.0	2.6	Open Cut	34	192,780
E1-2	M	3	1	1050	1,830	2.7	4.0	Open Cut	117	214,110
E3	M	3	1	600	1,200	3.0	3.8	Open Cut	63	75,600
E5	M	3	1	675	1,200	2.2	3.1	Open Cut	70	84,000
E7	M	3	1	450	760	2.0	2.7	Open Cut	48	36,480
E9	M	3	1	600	960	3.0	3.8	Open Cut	63	60,480
				M-total	11,620					663,450
			R-1		**21,250**		**R-1**	**Phase 3 Total**		**2,153,130**
E26	T	4	1	1050	1,340	8.4	9.6	Pipe Jacking	557	746,380
E28	T	4	1	1050	980	9.2	10.5	Pipe Jacking	557	545,860
E31	T	4	1	1050	1,050	9.8	11.1	Pipe Jacking	557	584,850
E34	T	4	1	1350	1,350	8.5	10.0	Pipe Jacking	622	839,700
E37	T	4	1	1500	1,440	7.6	9.3	Pipe Jacking	671	966,240
E45	T	4	1	900	1,020	7.0	8.1	Pipe Jacking	541	551,820
E47	T	4	1	900	1,390	6.4	7.5	Pipe Jacking	541	751,990
E49	T	4	1	1050	2,620	6.7	7.9	Pipe Jacking	557	1,459,340
				T-total	11,190				T-total	6,446,180
E20	M	4	1	750	1,680	6.3	7.3	Pipe Jacking	486	816,480
E22	M	4	1	900	760	7.3	8.4	Pipe Jacking	541	411,160
E25	M	4	1	450	1,310	7.0	7.7	Pipe Jacking	338	442,780
E39	M	4	1	825	2,810	5.3	6.3	Pipe Jacking	537	1,508,970
E41	M	4	1	900	1,660	8.0	9.1	Pipe Jacking	541	898,060
E43	M	4	1	900	1,050	8.3	9.4	Pipe Jacking	541	568,050
					9,270					4,645,500
E18	M	4	1	450	1,980	4.1	4.7	Open Cut	48	95,040
E19	M	4	1	750	1,380	3.4	4.4	Open Cut	80	110,400
E21	M	4	1	675	1,240	2.7	3.6	Open Cut	70	86,800
E23	M	4	1	300	1,780	4.8	5.3	Open Cut	27	48,060
E24	M	4	1	300	1,200	3.5	4.0	Open Cut	27	32,400
E27	M	4	1	225	280	2.3	2.7	Open Cut	24	6,720
E29	M	4	1	525	960	4.3	5.0	Open Cut	54	51,840
E30	M	4	1	225	650	3.1	3.5	Open Cut	24	15,600
E32	M	4	1	1050	990	3.1	4.4	Open Cut	117	115,830
E33	M	4	1	225	630	3.0	3.4	Open Cut	24	15,120
E35	M	4	1	525	990	3.3	4.0	Open Cut	54	53,460
E36	M	4	1	225	490	2.7	3.1	Open Cut	24	11,760
E38	M	4	1	750	2,530	2.4	3.4	Open Cut	80	202,400
E40	M	4	1	300	950	4.0	4.5	Open Cut	27	25,650
E42	M	4	1	300	1,300	3.7	4.2	Open Cut	27	35,100
E44	M	4	1	300	1,230	3.4	3.9	Open Cut	27	33,210
E46	M	4	1	375	1,590	2.2	2.7	Open Cut	43	68,370
E48	M	4	1	450	1,930	2.8	3.4	Open Cut	48	92,640
E56	M	4	1	525	1,520	2.5	3.3	Open Cut	54	82,080
					23,620					1,182,480
				M-total	32,890				M-total	5,827,980
			R-1		**44,080**		**R-1**	**Phase 4 Total**		**12,274,160**

Construction Method	Dia. (mm)	Unit Cost (JPY 10^3/m)
Pipe Jacking	300	292
	450	338
	600	402
	675	442
	750	486
	825	537
	900	541
	1050	557
	1200	584
	1350	622
	1500	671
	1650	730
	1950	883
	2250	972
	2400	1,012
	2550	1,057
	2700	1,105

Open Cut	225	24
	300	27
	350	34
	375	43
	450	48
	525	54
	600	63
	675	70
	750	80
	825	91
	900	99
	1050	117
	1350	162
	1500	189

EB2-1	I	2	2	1350	2,450	6.7	8.3	Pipe Jacking	622	1,523,900
EB2-2	I	2	2	1650	1,150	6.8	8.7	Pipe Jacking	730	839,500
				I-total	3,600				I-total	2,363,400
E55-2	T	2	2	2250	5,970	13.5	16.0	Pipe Jacking	972	5,802,840
E51-1	T	2	2	1950	2,350	13.6	15.8	Pipe Jacking	883	2,075,050
				T-total	8,320				T-total	7,877,890
E50-2	M	2	2	675	1,700	13.9	14.7	Pipe Jacking	442	751,400
EP7S	M	2	2	1050	680	5.8	7.0	Pipe Jacking	557	378,760
EP4S	M	2	2	1350	700	5.4	7.0	Pipe Jacking	622	435,400
				M-total	3,080				M-total	1,565,560
			R-2		**15,000**		**R-2**	**Phase 2 Total**		**11,806,850**
E53	T	3	2	750	2,550	3.1	4.1	Open Cut	80	204,000
E55	T	3	2	600	2,300	2.0	2.8	Open Cut	63	144,900
E55-1	T	3	2	900	2,050	2.8	3.9	Open Cut	99	202,950
				T-total	6,900				T-total	551,850
E50	M	3	2	675	4,230	9.5	10.4	Pipe Jacking	442	1,869,660
E50-1	M	3	2	675	2,160	13.4	14.3	Pipe Jacking	442	954,720
					6,390					2,824,380
E51	M	3	2	375	1,910	2.8	3.3	Open Cut	43	82,130
E52	M	3	2	525	2,940	2.0	2.7	Open Cut	54	158,760
E54	M	3	2	675	1,840	2.1	3.0	Open Cut	70	128,800
					6,690					369,690
				M-total	13,080				M-total	3,194,070
			R-2		19,980		**R-2**	**Phase 3 Total**		**3,745,920**
					25,288			**Phase 1**		**23,673,354**
					30,222			**Phase 2**		**16,466,246**
					41,230			**Phase 3**		**5,899,050**
					44,080			**Phase 4**		**12,274,160**
Total					**140,820**	Max. =	20.0			**58,312,810**

Table AC11.8.8-3 Major Sewer in the Eastern **Unit: x10^3 JPY**

Item		**Main**	**Trunk**	**Interceptor**	**Total**
By Pipe Jacking	Phase 1 Cost	903,260	18,639,094	4,131,000	23,673,354
	Phase 2 Cost	1,565,560	11,462,946	2,363,400	15,391,906
	Phase 3 Cost	2,824,380	0	0	2,824,380
	Phase 4 Cost	4,645,500	6,446,180	0	11,091,680
	Total	9,938,700	36,548,220	6,494,400	
By Open-Cut	Phase 1 Cost	0	0	0	0
	Phase 2 Cost	929,260	145,080	0	1,074,340
	Phase 3 Cost	1,033,140	2,041,530	0	3,074,670
	Phase 4 Cost	1,182,480	0	0	1,182,480
	Total	3,144,880	2,186,610	0	
Total	Phase 1 Cost	903,260	18,639,094	4,131,000	23,673,354
	Phase 2 Cost	2,494,820	11,608,026	2,363,400	16,466,246
	Phase 3 Cost	3,857,520	2,041,530	0	5,899,050
	Phase 4 Cost	5,827,980	6,446,180	0	12,274,160
	Total	13,083,580	38,734,830	6,494,400	

Exchange Rate: JICA Dec. 2017

0.942161	PKR/JPY	111.291000	JPY/USD	104.854040	PKR/USD

Unit Price (x1000JPY/m) = 24

Open-Cut Method: Ratio of FC portion = 0.00

Ratio of LC portion = 1.00

Table AC11.7 Branch Sewer Construction Cost

SWD	Phasing	Length	Construction Cost	Construction Cost		
				FC	LC	Total
		(m)	(x 10^3 JPY)	Mil. USD	Mil. PKR	Mil. PKR
Western	Phase 1	373,245	8,957,880	0	8,440	8,440
	Phase 2	472,180	11,332,320	0	10,677	10,677
	Phase 3	480,013	11,520,310	0	10,854	10,854
	Phase 4	737,460	17,699,040	0	16,675	16,675
	Sub-Total	2,062,898	49,509,550	0	46,646	46,646
Eastern	Phase 1	532,950	12,790,800	0	12,051	12,051
	Phase 2	526,400	12,633,600	0	11,903	11,903
	Phase 3	633,470	15,203,280	0	14,324	14,324
	Phase 4	696,350	16,712,400	0	15,746	15,746
	Sub-Total	2,389,170	57,340,080	0	54,024	54,024
Total	Phase 1	906,195	21,748,680	0	20,491	20,491
	Phase 2	998,580	23,965,920	0	22,580	22,580
	Phase 3	1,113,483	26,723,590	0	25,178	25,178
	Phase 4	1,433,810	34,411,440	0	32,421	32,421
	Sub-Total	4,452,068	106,849,630	0	100,670	100,670

Exchange Rate: **0.942161 PKR/JPY**

Table AC11.8.8 (1) Replaced Sewer Construction Cost for the Western SWD

1) New Sewer Replacement in the Western SWD

Sewer No.	Dia. (mm)	Length (m)	Phasing
26	1,050	248	3
28	1,500	1,082	3
29	1,500	709	3
48	750	545	1
92	675	1,111	1
100	750	801	1
102	825	320	1
112	1,050	2,163	1
113	1,050	103	1
123	1,350	535	1
126	1,350	344	1
127	1,650	1,325	1
132	825	793	1
136	1,650	548	1
163	825	780	1
106	600	n.a.	-
111	600	n.a.	-
Total		11,407	

2) Sewer Replacmemt by Phasing in the Western SWD

Sewer No.	Dia. (mm)	Phase 1	Phase 2	Phase 3
26	1,050	0	0	248
28	1,500	0	0	1,082
29	1,500	0	0	709
48	750	545	0	0
92	675	1,111	0	0
100	750	801	0	0
102	825	320	0	0
112	1,050	2,163	0	0
113	1,050	103	0	0
123	1,350	535	0	0
126	1,350	344	0	0
127	1,650	1,325	0	0
132	825	793	0	0
136	1,650	548	0	0
163	825	780	0	0
106	600	-	-	-
111	600	-	-	-
Total		**9,368**	**0**	**2,039**

3) New Sewer Replacement Cost in the Western SWD (x1000 JPY)

Unit Cost (x1000 JPY)	Phase 1	Phase 2	Phase 3
180	0	0	44,640
285	0	0	308,370
285	0	0	202,065
127	69,215	0	0
112	124,432	0	0
127	101,727	0	0
142	45,440	0	0
180	389,340	0	0
180	18,540	0	0
248	132,680	0	0
248	85,312	0	0
329	435,925	0	0
142	112,606	0	0
329	180,292	0	0
142	110,760	0	0
102	-	-	-
102	-	-	-
Sub Total	1,806,269	0	555,075

4) New Sewer Replacement Cost in the Western SWD (Mil. PKR)

Phase 1	Phase 2	Phase 3
0	0	42
0	0	291
0	0	190
65	0	0
117	0	0
96	0	0
43	0	0
367	0	0
17	0	0
125	0	0
80	0	0
411	0	0
106	0	0
170	0	0
104	0	0
-	-	-
-	-	-
1,701	0	523

Exchange Rate: **0.942161 PKR/JPY**

Table AC11.8.8 (2) Replaced Sewer Construction Cost for the Eastern SWD

1) New Sewer Replacement in the Eastern SWD

Sewer No.	Dia. (mm)	Length (m)	Phasing
40	825	279	2
41	900	438	2
363	1,050	649	1
401	675	290	2
402	1,050	467	2
403	1,050	55	2
439	825	311	2
440	1,050	935	2
445	1,050	377	2
450	1,200	1,005	2
453	1,200	310	2
Total		5,116	

2) Sewer Replacmemt by Phasing in the Eastern SWD

Sewer No.	Dia. (mm)	Phase 1	Phase 2	Phase 3
40	825	0	279	0
41	900	0	438	0
363	1,050	649	0	0
401	675	0	290	0
402	1,050	0	467	0
403	1,050	0	55	0
439	825	0	311	0
440	1,050	0	935	0
445	1,050	0	377	0
450	1,200	0	1,005	0
453	1,200	0	310	0
Total		649	4,467	0

3) New Sewer Replacement Cost in the Eastern SWD (x1000 JPY)

Unit Cost (x1000 JPY)	Phase 1	Phase 2	Phase 3
142	0	39,618	0
153	0	67,014	0
180	116,820	0	0
112	0	32,480	0
180	0	84,060	0
180	0	9,900	0
142	0	44,162	0
180	0	168,300	0
180	0	67,860	0
213	0	214,065	0
213	0	66,030	0
Sub Total	116,820	793,489	0

4) New Sewer Replacement Cost in the Eastern SWD (Mil. PKR)

Phase 1	Phase 2	Phase 3
0	37	0
0	63	0
110	0	0
0	31	0
0	79	0
0	9	0
0	42	0
0	159	0
0	64	0
0	202	0
0	62	0
110	748	0

Unit Price of Sewer Replacement Work

No.	Dia. (nn)	Replace cost (x1,000 JPY/m)
1	225	48
2	300	54
3	350	61
4	375	71
5	400	73
6	450	79
7	500	80
8	525	88
9	600	102
10	675	112
11	750	127
12	825	142
13	900	153
14	1,050	180
15	1,200	213
16	1,350	248
17	1,500	285
18	1,650	329

Table AC11.8.9 (1) Pump Station Construction Cost in the Western SWD **Cost: in thousand JPY**

Pump Category	PS ID	Name of PS	Design Flow (m^3/min)	Specification			Unit No.		Equimemt Cost			Equipment Cost Total	Installation Cost	Other Cost and Profit	Equipment Cost	Civil and Piping Works	Total Cost	Phasing	Remarks
				Capacity (m^3/min)	Head (m)	P (kW)	Total	Stand-by	Pump	Generator	Flow Meter								
1. Lift Pumps																			
	WP1	Tariq Abad	2.28	3.4	5	5.5	2	1	9,710	5,060	5,660	20,430	10,220	14,300	44,950	19,260	64,210	1	Civil works is
	WP2	Chenab Chowk	5.76	6.8	2	3.7	2	1	13,060	5,060	5,660	23,780	11,890	16,650	52,320	22,420	74,740	1	assumed 30% of
	WP7	PS-28	49.02	13.6	8	30.0	5	1	52,590	14,500	9,520	76,610	38,310	53,630	168,550	72,240	240,790	2	total cost
	WP14	Ghulshan Colony	1.50	1.7	3	1.5	2	1	36,360	5,060	9,520	50,940	25,470	35,660	112,070	48,030	160,100	1	
	WP15	Metropole	13.92	8.5	2	5.5	3	1	28,440	6,300	9,520	44,260	22,130	30,980	97,370	41,730	139,100	1	
	WP20	Girya Guar	7.62	8.5	5	11.0	2	1	18,960	6,300	5,660	30,920	15,460	21,640	68,020	29,150	97,170	1	
	Total								159,120	42,280	45,540	246,940	123,480	172,860	543,280	232,830	776,110		
2. Influent Pump at WWTP																			
	New West Influent PS		259.29	65	17	250	2	0											
				130	17	500	2	1							1,648,000	1,799,000	3,447,000	1	1st Construction
			259.29	65	17	250	0	0											
				130	17	500	2	0							888,000	0	888,000	2	2nd Construction
			518.58	65	17	250	2	0											
				130	17	500	4	1							2,536,000	1,799,000	4,335,000		Total
3. Efflluent (Treated Wastewater) Pump to Irrigation Channel																			
	New Chokera Effluent PS		151	75.4	25	425	2	1							1,176,000	9,535,000	10,711,000	3	1st Construction
			151	75.4	25	425	2	0							632,000	8,148,000	8,780,000	4	2nd Construction
			301	75.4	25	425	4	1							1,808,000	17,683,000	19,491,000		Total
4. Storm-water Pump (converted from the disposal station, but additional pumps required)																			
	WP11	PS-27	30.66	10.2	10	37	3	0	28,440	14,500	0	42,940	21,470	30,060	94,470	40,490	134,960	1	Civil works is
	WP12	Weavers Colony	10.38	6.8	10	22	2	0	13,060	8,920	0	21,980	10,990	15,390	48,360	20,730	69,090	1	assumed 30% of
	WP16	Liaqat Town	5.04	5.04	10	11	2	0	9,710	6,300	0	16,010	8,010	11,210	35,230	15,100	50,330	3	total cost
	Total								51,210	29,720	0	80,930	40,470	56,660	178,060	76,320	254,380		

Table AC11.8.9 (2) Pump Station Construction Cost in the Eastern SWD **Cost: in thousand JPY**

Pump Category	PS ID	Name of PS	Design Flow (m^3/min)	Specification			Unit No.		Equimemt Cost				Installation Cost	Other Cost and Profit	Equipment Cost	Civil and Piping Works	Total Cost	Phasing	Remarks
				Capacity (m^3/min)	Head (m)	P (kW)	Total	Stand-by	Pump	Generator	Flow Meter	Sub-total							
1. Lift Pumps																			
	EP5	PS-34	12.66	13.6	8	30.0	2	1	21,040	8,100	5,660	34,800	17,400	24,360	76,560	32,810	109,370	2	Civil works is assumed 30% of total cost
	EP8	Sharifpura	1.98	3.4	3	3.7	2	1	9,710	5,060	8,500	23,270	11,640	16,290	51,200	21,940	73,140	1	
	EP11	Jha Khurana	1.14	1.7	1	n.a.	2	1	7,420	14,500	9,520	31,440	15,720	22,010	69,170	29,640	98,810	1	
									38,170	27,660	23,680	89,510	44,760	62,660	196,930	84,390	281,320		
2. Inlet Pump at WWTP																			
		New East Influent PS	252.12	63.03	30	425	2	0											
				126.06	30	850	2	1							1,624,000	1,799,000	3,423,000	1	1st Construction
			252.12	63.03	30	425	0	0											
				126.06	30	850	2	0							864,000	0	864,000	2	2nd Construction
			504.24	63.03	30	425	2	0											
				126.06	30	850	4	1							2,488,000	1,799,000	4,287,000		Total
3. Effluent (Treated Wastewater) Pump to Irrigation Channel																			
		New East Effluent PS	151	75.4	23	400	2	1							1,176,000	8,275,000	9,451,000	3	1st Construction
			151	75.4	23	400	2	0							632,000	6,888,000	7,520,000	4	2nd Construction
			301	75.4	23	400	4	1							1,808,000	15,163,000	16,971,000		Total
4. Storm-water Pump (converted from the disposal station)																			
	EP7	D-Type	28.32	10.2	10	37	3	0	28,440	14,500	0	42,940	21,470	30,060	94,470	40,490	134,960	2	

Table AC11.8.10 Construction Cost Estimates for the Chokera WWTP

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (x 1000 JPY)	Construction Cost (Million JPY)	Remark
1. Civil and Building Works of Treatment Facilities							
1.1	Influent channel	Open channel	m	1,150	297.0	342	
1.2	Distribution tank	Cast-in-place structure	m3	128	15.0	2	
1.3	UASB	Structural works	Ls	224,000	20.0	4,480	See Breakdown
1.4	Facultative ponds	Earth work, concrete lining	Ls	1	-	4,573	See Breakdown
1.5	Sludge drying bed	Earth work,Sand,Gravel,Open pipe	m^2	112,500	10.8	1,209	
1.6	Landscaping work	Mainly construction of internal road	m^2	310,000	0.8	250	
Civil and Building Works Total			**—**	**—**	—	**10,856**	
2. Mechanical and Electrical Works for Treatment Facilities							
2.1	UASB	Transmission pump facility	Unit	12	50,556	607	
Mechanical and Electrical Works Total			**—**	**—**	—	**607**	
3. Total Construction Cost of Treatment Facilities			**—**	**—**	—	**11,463**	

4. Treated Wastewater Transmission Facilities							
4.1	Effluent PS	Structural Works	Ls	1	-	1,359	
4.2	Surge tank	Concrete structure (H=15m×5m×15m)	Ls	1	-	28	
4.3	Treated Wastewater Tranmission pipe	Force main (DCIP) D1500	m	14,550	560	8,148	
		Force main (DCIP) D1500	m	14,550	560	8,148	
4.4	Effluent PS	Equipment	Ls	1	-	1,720	
Treated Wastewater Transmission Facilities Total			**—**	**—**	—	**19,403**	

Breakdown

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
1.3	UASB (Treatment capacity 433,800m3/d)						
	Structural works	Reactor and gas holder	m3	224,000	20,000	4,480	Whole work
	Total		**—**	**—**	—	**4,480**	—
1.4	Facultative pond (Treatment capacity 433,800m3/d)						
	Earth work ①	Excavation, transportation	m3	3,561,132	700	2,493	All 4 ponds
		Disposal of surplus soil	m3	3,561,132	300	1,068	〃
	Earth work ②	Excavation, transportation	m3	699,792	700	490	All 2 ponds
		Disposal of surplus soil	m3	699,792	300	210	〃
	Pond structure ①	Concrete lining	m2	82,687	3,000	248	All 4 ponds
	Pond structure ②	Concrete lining	m2	21,200	3,000	64	〃
	Total		**—**	**—**	—	**4,573**	—

Table AC11.8.11 Construction Cost Estimates for the New East WWTP

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (x 1000 JPY)	Construction Cost (Million JPY)	Remark
1. Civil and Building Works of Treatment Faclities							
1.1	Influent channel	Open channel	m	2,200	297.0	653	
1.2	Distribution tank	Cast-in-place structure 2 units（4×4×4）	m3	128	15.0	2	
1.3	Anaerobic ponds	Earth work, concrete lining	Ls	1	-	785	See Breakdown
1.4	Facultative ponds	Earth work, concrete lining	Ls	1	-	6,424	See Breakdown
1.5	Landscaping work	Mainly construction of internal road	m2	600,000	0.8	480	
Civil and Building Works Total			—	—	—	**8,344**	
2. Mechanical and Electrical Works Total			—	—	—	0	
3. Total Construction Cost of Treatment Facilities			-	-	-	**8,344**	
4. Treated Wastewater Transmission Faclities							
4.1	Effluent PS	Structural Works	Ls	1	-	1,359	
4.2	Surge tank	Concrete structure (H=15m×5m×15m)	Ls	1	-	28	
4.3	Treated Wastewater Tranmission pipe	Force main (DCIP) D1500	m	12,300	560	6,888	
		Force main (DCIP) D1500	m	12,300	560	6,888	
4.4	Effluent PS	Equipment	Ls	1	-	2,140	
Treated Wastewater Transmission Facilities Total			-	-	-	**17,303**	

Breakdown

No	Facility or work	Work Item	Unit	Quantity	Unit Cost (JPY)	Construction Cost (Million JPY)	Remark
1.3	Anaerobic ponds						
	Earth work	Excavation, transportation	m3	651,200	700	456	All 4 ponds
		Disposal of surplus soil	m3	651,200	300	195	〃
	Pond structure	Concrete lining (t=0.2m)	m2	44,700	3,000	134	〃
	Total		—	—	—	**785**	—
1.4	Facultative ponds						
	Earth work ①	Excavation, transportation	m3	5,218,048	700	3,653	All 4 ponds
		Disposal of surplus soil	m3	5,218,048	300	1,565	〃
	Earth work ②	Excavation, transportation	m3	877,392	700	614	All 2 ponds
		Disposal of surplus soil	m3	877,392	300	263	〃
	Pond structure ①	Concrete lining	m2	86,000	3,000	258	All 4 ponds
	Pond structure ②	Concrete lining	m2	23,700	3,000	71	〃
	Total		—	—	—	**6,424**	—

AC11.9.1 Financing Plan in the Long-term Sewerage Plans

WASA-F TOTAL Financing Plan

Total Construction Cost	344,437.0	PKR million		Construction and OM Cost	50,017.0	PKR million	
Financing Plan				Equity Investment			**Financing Plan**
WASA-F+Loan Investr	**50.0%**	**172,218.5**	PKR million		year 1	1.9%	Fiscal Transfer 50%
of which Loan Investme	80.0%	137,774.8	PKR million		year 2	2.0%	Loans 40%
of which Equity Investm	20.0%	34,443.7	PKR millio	Equity Loan	year 3	4.8%	WASA-F Own Fund 10%
Concessional Loan	40%	137,774.8	PKR millio	20.0% 80.0%	year 4	7.2%	Total 100%
Loan (Commercial)		0.0	PKR million		year 5	8.4%	
Government Transfer/ G	50%	172,218.5			year 6	6.2%	38.3376
					year 7	3.3%	

Parameters

Tariff Revenue			B simulater	**1.0**
OM cost			Cost	**1.0**
% Cost of sales	10.0%			
Fixed Cost Portion of the Total Loan	90.0%		**Interest Rate**	**1.0%**
Fixed costs for depreciation	154,996.7	PKR million		
Depreciation	20	years		
Straight Line Depreciation	7,749.8			
Non-opeartional revenue rate	0.0%			
Income tax (IT) rate	0.0%			
Reserve Fund Rate	0.0%			
Retined earnings	0.0%			
Dividends rate	100.0%		Discount Rate	6.1% FIRR

Table 1: 1,000

PL Statement 1,000,000

		WASA-F Own Fund Investment	Charge Revenue	Cost of sales	O/M	Depreciation*	Total Operating Cost	Operating Net Profit	Non-Operating Net Profit	EBIT	Interest Payments	Income Tax	Reserve Fund	Not Profit	Discounted Net Cashflow
			a	b	c	d	e	f	g	h=a-e+g	i	j	k	l=h-i-j-k	m
1	2019	641.2	0.0							0.0	25.65			-25.6	-24.2
2	2020	673.2	0.0							0.0	52.58			-52.6	-46.7
3	2021	1,643.7	0.0							0.0	118.32			-118.3	-99.1
4	2022	2,474.5	0.0							0.0	118.32			-118.3	-93.4
5	2023	2,889.3	0.0							0.0	225.00			-225.0	-167.3
6	2024	2,147.5	0.0							0.0	341.21			-341.2	-239.2
7	2025	1,134.0	4,677.0	467.7	1,175.0	4,530.9	6,173.6	-1,496.6	0.0	-1,496.6	464.14	0.0	0.0	-1,960.8	-1,295.4
8	2026	1,134.2	4,523.0	452.3	1,164.0	4,530.9	6,147.2	-1,624.2	0.0	-1,624.2	447.35	0.0	0.0	-2,071.6	-1,290.0
9	2027	1,763.6	4,373.0	437.3	1,153.0	4,530.9	6,121.2	-1,748.2	0.0	-1,748.2	475.94	0.0	0.0	-2,224.2	-1,305.3
10	2028	2,056.9	4,219.0	421.9	1,141.0	4,530.9	6,093.8	-1,874.8	0.0	-1,874.8	537.90	0.0	0.0	-2,412.7	-1,334.6
11	2029	1,435.5	4,066.0	406.6	1,128.0	4,530.9	6,065.5	-1,999.5	0.0	-1,999.5	604.08	0.0	0.0	-2,603.6	-1,357.4
12	2030	1,050.9	9,147.0	914.7	1,580.0	7,905.1	10,399.8	-1,252.8	0.0	-1,252.8	677.87	0.0	0.0	-1,930.7	-948.7
13	2031	1,051.1	8,830.0	883.0	1,560.0	7,905.1	10,348.1	-1,518.1	0.0	-1,518.1	648.05	0.0	0.0	-2,166.2	-1,003.2
14	2032	1,799.1	8,517.0	851.7	1,542.0	7,905.1	10,298.8	-1,781.8	0.0	-1,781.8	660.28	0.0	0.0	-2,442.1	-1,066.0
15	2033	2,089.2	8,204.0	820.4	1,523.0	7,905.1	10,248.5	-2,044.5	0.0	-2,044.5	711.53	0.0	0.0	-2,756.0	-1,133.8
16	2034	2,059.7	7,888.0	788.8	1,503.0	7,905.1	10,196.9	-2,308.9	0.0	-2,308.9	766.49	0.0	0.0	-3,075.4	-1,192.5
17	2035	1,641.9	8,613.0	861.3	1,913.0	11,500.9	14,275.2	-5,662.2	0.0	-5,662.2	874.41	0.0	0.0	-6,536.6	-2,388.9
18	2036	2,241.3	8,313.0	831.3	1,891.0	11,500.9	14,223.2	-5,910.2	0.0	-5,910.2	830.69	0.0	0.0	-6,740.9	-2,321.9
19	2037	2,249.4	8,010.0	801.0	1,869.0	11,500.9	14,170.9	-6,160.9	0.0	-6,160.9	876.62	0.0	0.0	-7,037.5	-2,284.7
20	2038	2,267.5	7,711.0	771.1	1,846.0	11,500.9	14,118.0	-6,407.0	0.0	-6,407.0	922.88	0.0	0.0	-7,329.9	-2,242.8
21	2039		8,446.0	844.6	2,002.0	15,499.7	18,346.3	-9,900.3	0.0	-9,900.3	969.86	0.0	0.0	-10,870.1	-3,134.8
22	2040		10,130.0	1,013.0	2,002.0	15,499.7	18,514.7	-8,384.7	0.0	-8,384.7	911.33	0.0	0.0	-9,296.0	-2,526.7
23	2041		10,130.0	1,013.0	2,002.0	15,499.7	18,514.7	-8,384.7	0.0	-8,384.7	852.80	0.0	0.0	-9,237.5	-2,366.5
24	2042		10,130.0	1,013.0	2,002.0	15,499.7	18,514.7	-8,384.7	0.0	-8,384.7	794.28	0.0	0.0	-9,178.9	-2,216.3
25	2043		10,130.0	1,013.0	2,002.0	15,499.7	18,514.7	-8,384.7	0.0	-8,384.7	735.75	0.0	0.0	-9,120.4	-2,075.5
26	2044		10,130.0	1,013.0	2,002.0	15,499.7	18,514.7	-8,384.7	0.0	-8,384.7	677.22	0.0	0.0	-9,061.9	-1,943.7
27	2045		10,130.0	1,013.0	2,002.0	10,968.8	13,983.8	-3,853.8	0.0	-3,853.8	618.69	0.0	0.0	-4,472.4	-904.1
28	2046		10,130.0	1,013.0	2,002.0	10,968.8	13,983.8	-3,853.8	0.0	-3,853.8	560.16	0.0	0.0	-4,413.9	-841.0
29	2047		10,130.0	1,013.0	2,002.0	10,968.8	13,983.8	-3,853.8	0.0	-3,853.8	501.63	0.0	0.0	-4,355.4	-782.1
30	2048		10,130.0	1,013.0	2,002.0	10,968.8	13,983.8	-3,853.8	0.0	-3,853.8	443.10	0.0	0.0	-4,296.9	-727.3
31	2049		5,740.0	574.0	1,180.0	10,968.8	12,722.8	-6,982.8	0.0	-6,982.8	384.58	0.0	0.0	-7,367.3	-1,175.3
32	2050		5,740.0	574.0	1,180.0	7,594.6	9,348.6	-3,608.6	0.0	-3,608.6	342.83	0.0	0.0	-3,951.4	-594.1
33	2051		5,740.0	574.0	1,180.0	7,594.6	9,348.6	-3,608.6	0.0	-3,608.6	301.08	0.0	0.0	-3,909.6	-554.0
34	2052		5,740.0	574.0	1,180.0	7,594.6	9,348.6	-3,608.6	0.0	-3,608.6	259.33	0.0	0.0	-3,867.9	-516.6
35	2053		2,360.0	236.0	561.0	7,594.6	8,391.6	-6,031.6	0.0	-6,031.6	217.59	0.0	0.0	-6,249.1	-786.7
36	2054		2,360.0	236.0	561.0	7,594.6	8,391.6	-6,031.6	0.0	-6,031.6	188.88	0.0	0.0	-6,220.4	-738.0
37	2055		2,360.0	236.0	561.0	3,998.7	4,795.7	-2,435.7	0.0	-2,435.7	160.17	0.0	0.0	-2,595.9	-290.3
38	2056		2,360.0	236.0	561.0	3,998.7	4,795.7	-2,435.7	0.0	-2,435.7	131.46	0.0	0.0	-2,567.2	-270.6
39	2057		2,360.0	236.0	561.0	3,998.7	4,795.7	-2,435.7	0.0	-2,435.7	102.76	0.0	0.0	-2,538.5	-252.2
40	2058		1,086.0	108.6	242.0	3,998.7	4,349.3	-3,263.3	0.0	-3,263.3	74.05	0.0	0.0	-3,337.4	-312.5
41	2059		1,086.0	108.6	242.0	0.0	350.6	735.4	0.0	735.4	59.24	0.0	0.0	676.2	59.7
42	2060		1,086.0	108.6	242.0	0.0	350.6	735.4	0.0	735.4	44.43	0.0	0.0	691.0	57.5
43	2061		1,086.0	108.6	242.0	0.0	350.6	735.4	0.0	735.4	29.62	0.0	0.0	705.8	55.3
44	2062		1,086.0	108.6	242.0	0.0	350.6	735.4	0.0	735.4	14.81	0.0	0.0	720.6	53.2
45	2063		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0
	Total	34,443.7	236,897.0	23,689.7	49,743.0	309,993.3	383,426.0	-146,529.0	0.0	-146,529.0	19,755.0	0.0	0.0	-166,284.0	-44,617.4

AC11.9.2 Economic and Financial Analysis for the Phase 1 Projects

East SWD IRR

	Year	Cost (million PKR)								Served water (million m3/ year)					
		Construction			O&M			Total							
		Foreign	Local	Sub Total	Foreign	Local	Sub Total	Foreign	Local	Total	Domestic	IND	COM	Gound Water	NON-Dom Total	Total
1	2019	554.0	3,990.0	4,544.0				554.0	3,990.0	4,544.0					0.0	0.0
2	2020	556.0	4,185.0	4,741.0				556.0	4,185.0	4,741.0					0.0	0.0
3	2021	5,543.0	5,636.0	11,179.0				5,543.0	5,636.0	11,179.0					0.0	0.0
4	2022	6,058.0	8,772.0	14,830.0				6,058.0	8,772.0	14,830.0					0.0	0.0
5	2023	6,080.0	8,927.0	15,007.0				6,080.0	8,927.0	15,007.0					0.0	0.0
6	2024	6,095.0	6,497.0	12,592.0				6,095.0	6,497.0	12,592.0					0.0	0.0
7	2025				0.0	538.0	538.0	0.0	538.0	538.0	27.9	59.8	4.0	4.6	68.5	96.4
8	2026				0.0	534.0	534.0	0.0	534.0	534.0	28.4	57.0	4.1	4.5	65.6	94.0
9	2027				0.0	529.0	529.0	0.0	529.0	529.0	28.9	54.1	4.2	4.4	62.6	91.5
10	2028				0.0	525.0	525.0	0.0	525.0	525.0	29.4	51.2	4.3	4.2	59.7	89.1
11	2029				0.0	520.0	520.0	0.0	520.0	520.0	29.9	48.3	4.3	4.1	56.8	86.7
12	2030				0.0	417.0	417.0	0.0	417.0	417.0	30.4	45.5	4.4	4.0	53.9	84.2
13	2031				0.0	411.0	411.0	0.0	411.0	411.0	30.9	42.6	4.5	3.9	50.9	81.8
14	2032				0.0	404.0	404.0	0.0	404.0	404.0	31.4	39.7	4.5	3.8	48.0	79.4
15	2033				0.0	397.0	397.0	0.0	397.0	397.0	31.8	36.8	4.6	3.7	45.1	76.9
16	2034				0.0	390.0	390.0	0.0	390.0	390.0	32.3	33.9	4.7	3.5	42.2	74.5
17	2035				0.0	416.0	416.0	0.0	416.0	416.0	32.8	31.1	4.8	3.4	39.2	72.1
18	2036				0.0	406.0	406.0	0.0	406.0	406.0	33.3	28.2	4.8	3.3	36.3	69.6
19	2037				0.0	397.0	397.0	0.0	397.0	397.0	33.8	25.3	4.9	3.2	33.4	67.2
20	2038				0.0	388.0	388.0	0.0	388.0	388.0	34.3	22.4	5.0	3.1	30.5	64.8
21	2039				0.0	364.0	364.0	0.0	364.0	364.0	34.3	19.6	5.0	2.9	27.5	61.8
22	2040				0.0	364.0	364.0	0.0	364.0	364.0	34.3	19.6	5.0	2.9	27.5	61.8
23	2041				0.0	364.0	364.0	0.0	364.0	364.0	34.3	19.6	5.0	2.9	27.5	61.8
24	2042				0.0	364.0	364.0	0.0	364.0	364.0	34.3	19.6	5.0	2.9	27.5	61.8
25	2043				0.0	364.0	364.0	0.0	364.0	364.0	34.3	19.6	5.0	2.9	27.5	61.8
26	2044				0.0	364.0	364.0	0.0	364.0	364.0	34.3	19.6	5.0	2.9	27.5	61.8
27	2045				0.0	364.0	364.0	0.0	364.0	364.0	34.3	19.6	5.0	2.9	27.5	61.8
28	2046				0.0	364.0	364.0	0.0	364.0	364.0	34.3	19.6	5.0	2.9	27.5	61.8
29	2047				0.0	364.0	364.0	0.0	364.0	364.0	34.3	19.6	5.0	2.9	27.5	61.8
30	2048				0.0	364.0	364.0	0.0	364.0	364.0	34.3	19.6	5.0	2.9	27.5	61.8
	Total	24,886.0	38,007.0	62,893.0	0.0	9,912.0	9,912.0	24,886.0	47,919.0	72,805.0	778.4	771.5	112.7	83.1	967.2	1,745.7
								34.2%			**0.45**	0.44	0.06	0.05	**0.55**	1.00

FIRR **FNPV** -38,181.6 PKR mill DR 6.1%

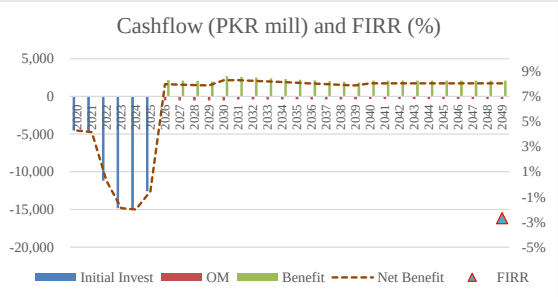
PKR/m3 1.5

Operating Income EXCL GW (mill PKR)

	Year	Initial Investment	OM	Cost Total	Benefit	Net Benefit	FIRR	Weighed Ave Tariff	Tariff Dom	Tariff Non-Dom	Domestic	IND	COM	Gound Water	NON-Dom Total	Total
1	2020	4,544.0		4,544.0		-4,544.0										0.0
2	2021	4,741.0		4,741.0		-4,741.0										0.0
3	2022	11,179.0		11,179.0		-11,179.0										0.0
4	2023	14,830.0		14,830.0		-14,830.0		0.0								0.0
5	2024	15,007.0		15,007.0		-15,007.0		0.0								0.0
6	2025	12,592.0		12,592.0		-12,592.0		0.0								0.0
7	2026		538.0	538.0	2,165.5	1,627.5		22.3	17.5	26.3	488.5	1,571.0	106.1	120.5	1,677.0	2,165.5
8	2027		534.0	534.0	2,100.4	1,566.4		22.3	17.5	26.3	497.1	1,495.4	107.9	117.4	1,603.3	2,100.4
9	2028		529.0	529.0	2,035.4	1,506.4		22.3	17.5	26.3	505.7	1,419.9	109.8	114.4	1,529.7	2,035.4
10	2029		525.0	525.0	1,970.3	1,445.3		22.3	17.5	26.3	514.3	1,344.3	111.7	111.3	1,456.0	1,970.3
11	2030		520.0	520.0	2,667.2	2,147.2		31.3	24.5	36.8	732.0	1,776.3	158.9	108.3	1,935.2	2,667.2
12	2031		417.0	417.0	2,576.1	2,159.1		31.3	24.5	36.8	744.0	1,670.5	161.5	105.3	1,832.1	2,576.1
13	2032		411.0	411.0	2,485.0	2,074.0		31.3	24.5	36.8	756.1	1,564.8	164.1	102.2	1,728.9	2,485.0
14	2033		404.0	404.0	2,393.8	1,989.8	-19.0%	31.3	24.5	36.8	768.1	1,459.0	166.7	99.2	1,625.7	2,393.8
15	2034		397.0	397.0	2,302.7	1,905.7	-16.3%	31.3	24.5	36.8	780.1	1,353.2	169.4	96.1	1,522.6	2,302.7
16	2035		390.0	390.0	2,211.6	1,821.6	-14.2%	31.3	24.5	36.8	792.1	1,247.5	172.0	93.1	1,419.4	2,211.6
17	2036		416.0	416.0	2,120.5	1,704.5	-12.6%	31.3	24.5	36.8	804.2	1,141.7	174.6	90.1	1,316.3	2,120.5
18	2037		406.0	406.0	2,029.3	1,623.3	-11.2%	31.3	24.5	36.8	816.2	1,035.9	177.2	87.0	1,213.1	2,029.3
19	2038		397.0	397.0	1,938.2	1,541.2	-10.0%	31.3	24.5	36.8	828.2	930.2	179.8	84.0	1,110.0	1,938.2
20	2039		388.0	388.0	1,847.1	1,459.1	-9.0%	31.3	24.5	36.8	840.3	824.4	182.4	81.0	1,006.8	1,847.1
21	2040		364.0	364.0	2,089.4	1,725.4	-8.0%	37.5	29.4	44.1	1,008.3	862.2	218.9	77.2	1,081.1	2,089.4
22	2041		364.0	364.0	2,089.4	1,725.4	-7.1%	37.5	29.4	44.1	1,008.3	862.2	218.9	77.2	1,081.1	2,089.4
23	2042		364.0	364.0	2,089.4	1,725.4	-6.3%	37.5	29.4	44.1	1,008.3	862.2	218.9	77.2	1,081.1	2,089.4
24	2043		364.0	364.0	2,089.4	1,725.4	-5.6%	37.5	29.4	44.1	1,008.3	862.2	218.9	77.2	1,081.1	2,089.4
25	2044		364.0	364.0	2,089.4	1,725.4	-5.0%	37.5	29.4	44.1	1,008.3	862.2	218.9	77.2	1,081.1	2,089.4
26	2045		364.0	364.0	2,089.4	1,725.4	-4.4%	37.5	29.4	44.1	1,008.3	862.2	218.9	77.2	1,081.1	2,089.4
27	2046		364.0	364.0	2,089.4	1,725.4	-3.9%	37.5	29.4	44.1	1,008.3	862.2	218.9	77.2	1,081.1	2,089.4
28	2047		364.0	364.0	2,089.4	1,725.4	-3.5%	37.5	29.4	44.1	1,008.3	862.2	218.9	77.2	1,081.1	2,089.4
29	2048		364.0	364.0	2,089.4	1,725.4	-3.1%	37.5	29.4	44.1	1,008.3	862.2	218.9	77.2	1,081.1	2,089.4
30	2049		364.0	364.0	2,089.4	1,725.4	-2.7%	37.5	29.4	44.1	1,008.3	862.2	218.9	77.2	1,081.1	2,089.4
	Total	62,893.0	9,912.0	72,805.0	51,737.3	-21,067.7		**28.8**			19,950.1	27,456.2	4,331.0	2,181.5	31,787.2	51,737.3

FIRR | **1 year-Delay Simulation** | 0.0

	Year	Initial Invest	OM	Benefit	Net Benefit	FIRR	Cost Total	Initial Invest	OM	Total Cost	BEN	NB	FIRR
1	2020	-4,544.0			-4,544.0		-4,544.0	4,544.0		4,544.0		-4,544.0	
2	2021	-4,741.0			-4,741.0		-4,741.0	4,741.0		4,741.0	0.0	-4,741.0	
3	2022	-11,179.0			-11,179.0		-11,179.0	6,289.3		6,289.3	0.0	-6,289.3	
4	2023	-14,830.0	0.0	0.0	-14,830.0		-14,830.0	12,578.6		12,578.6	0.0	-12,578.6	
5	2024	-15,007.0	0.0	0.0	-15,007.0		-15,007.0	12,578.6		12,578.6	0.0	-12,578.6	
6	2025	-12,592.0	0.0	0.0	-12,592.0		-12,592.0	12,578.6		12,578.6	0.0	-12,578.6	
7	2026		-538.0	2,165.5	1,627.5		-538.0			0.0	0.0	0.0	
8	2027		-534.0	2,100.4	1,566.4		-534.0		538.0	538.0	2,165.5	1,627.5	
9	2028		-529.0	2,035.4	1,506.4		-529.0		534.0	534.0	2,100.4	1,566.4	
10	2029		-525.0	1,970.3	1,445.3		-525.0		529.0	529.0	2,035.4	1,506.4	
11	2030		-520.0	2,667.2	2,147.2		-520.0		525.0	525.0	1,970.3	1,445.3	
12	2031		-417.0	2,576.1	2,159.1		-417.0		520.0	520.0	2,667.2	2,147.2	
13	2032		-411.0	2,485.0	2,074.0		-411.0		417.0	417.0	2,576.1	2,159.1	
14	2033		-404.0	2,393.8	1,989.8		-404.0		411.0	411.0	2,485.0	2,074.0	-18.1%
15	2034		-397.0	2,302.7	1,905.7		-397.0		404.0	404.0	2,393.8	1,989.8	-15.3%
16	2035		-390.0	2,211.6	1,821.6		-390.0		397.0	397.0	2,302.7	1,905.7	-13.1%
17	2036		-416.0	2,120.5	1,704.5		-416.0		390.0	390.0	2,211.6	1,821.6	-11.4%
18	2037		-406.0	2,029.3	1,623.3		-406.0		416.0	416.0	2,120.5	1,704.5	-9.9%
19	2038		-397.0	1,938.2	1,541.2		-397.0		406.0	406.0	2,029.3	1,623.3	-8.8%
20	2039		-388.0	1,847.1	1,459.1		-388.0		397.0	397.0	1,938.2	1,541.2	-7.8%
21	2040		-364.0	2,089.4	1,725.4		-364.0		388.0	388.0	1,847.1	1,459.1	-7.0%
22	2041		-364.0	2,089.4	1,725.4		-364.0		364.0	364.0	2,089.4	1,725.4	-6.1%
23	2042		-364.0	2,089.4	1,725.4		-364.0		364.0	364.0	2,089.4	1,725.4	-5.3%
24	2043		-364.0	2,089.4	1,725.4		-364.0		364.0	364.0	2,089.4	1,725.4	-4.6%
25	2044		-364.0	2,089.4	1,725.4		-364.0		364.0	364.0	2,089.4	1,725.4	-4.0%
26	2045		-364.0	2,089.4	1,725.4		-364.0		364.0	364.0	2,089.4	1,725.4	-3.5%
27	2046		-364.0	2,089.4	1,725.4		-364.0		364.0	364.0	2,089.4	1,725.4	-3.0%
28	2047		-364.0	2,089.4	1,725.4		-364.0		364.0	364.0	2,089.4	1,725.4	-2.6%
29	2048		-364.0	2,089.4	1,725.4		-364.0		364.0	364.0	2,089.4	1,725.4	-2.2%
30	2049		-364.0	2,089.4	1,725.4	-2.7%	-364.0		364.0	364.0	2,089.4	1,725.4	-1.9%
	Total	-62,893.0	-9,912.0	51,737.3	-21,067.7		-72,805.0	53310.1	9,548	62,858	49,648	-13,210	



Year	Initial Investmen	OM	Cost Total	Benefit	Net Benefit
2020	4,544.0		4,544.0		-4,544.0
2021	4,741.0		4,741.0		-4,741.0
2022	11,179.0		11,179.0		-11,179.0
2023	14,830.0	0.0	14,830.0	0.0	-14,830.0
2024		0.0	0.0	0.0	0.0
2025		0.0	0.0	0.0	0.0
⋮		⋮	⋮	⋮	⋮
2047		406.0	406.0	2,029.3	1,623.3
2048		397.0	397.0	1,938.2	1,541.2
2049		388.0	388.0	1,847.1	1,459.1
Total	62,893.0	9,912.0	72,805.0	51,737.3	-21,067.7

EIRR SCF **0.9**

	Year	Cost (million PKR)									Served water (million m3/ year)					
		Construction			O&M			Total								
		Foreign	Local	Sub Total	Foreign	Local	Sub Total	Foreign	Local	Total	Domestic	IND	COM	Gound Water	NON-Dom	Total
1	2020	554.0	3,591.0	4,145.0				554.0	3,591.0	4,145.0						
2	2021	556.0	3,766.5	4,322.5				556.0	3,766.5	4,322.5						
3	2022	5,543.0	5,072.4	10,615.4				5,543.0	5,072.4	10,615.4						
4	2023	6,058.0	7,894.8	13,952.8				6,058.0	7,894.8	13,952.8						
5	2024	6,080.0	8,034.3	14,114.3				6,080.0	8,034.3	14,114.3						
6	2025	6,095.0	5,847.3	11,942.3				6,095.0	5,847.3	11,942.3						
7	2026				0.0	484.2	484.2	0.0	484.2	484.2	27.9	59.8	4.0	4.6	68.5	96.4
8	2027				0.0	480.6	480.6	0.0	480.6	480.6	28.4	57.0	4.1	4.5	65.6	94.0
9	2028				0.0	476.1	476.1	0.0	476.1	476.1	28.9	54.1	4.2	4.4	62.6	91.5
10	2029				0.0	472.5	472.5	0.0	472.5	472.5	29.4	51.2	4.3	4.2	59.7	89.1
11	2030				0.0	468.0	468.0	0.0	468.0	468.0	29.9	48.3	4.3	4.1	56.8	86.7
12	2031				0.0	375.3	375.3	0.0	375.3	375.3	30.4	45.5	4.4	4.0	53.9	84.2
13	2032				0.0	369.9	369.9	0.0	369.9	369.9	30.9	42.6	4.5	3.9	50.9	81.8
14	2033				0.0	363.6	363.6	0.0	363.6	363.6	31.4	39.7	4.5	3.8	48.0	79.4
15	2034				0.0	357.3	357.3	0.0	357.3	357.3	31.8	36.8	4.6	3.7	45.1	76.9
16	2035				0.0	351.0	351.0	0.0	351.0	351.0	32.3	33.9	4.7	3.5	42.2	74.5
17	2036				0.0	374.4	374.4	0.0	374.4	374.4	32.8	31.1	4.8	3.4	39.2	72.1
18	2037				0.0	365.4	365.4	0.0	365.4	365.4	33.3	28.2	4.8	3.3	36.3	69.6
19	2038				0.0	357.3	357.3	0.0	357.3	357.3	33.8	25.3	4.9	3.2	33.4	67.2
20	2039				0.0	349.2	349.2	0.0	349.2	349.2	34.3	22.4	5.0	3.1	30.5	64.8
21	2040				0.0	327.6	327.6	0.0	327.6	327.6	34.3	19.6	5.0	2.9	27.5	61.8
22	2041				0.0	327.6	327.6	0.0	327.6	327.6	34.3	19.6	5.0	2.9	27.5	61.8
23	2042				0.0	327.6	327.6	0.0	327.6	327.6	34.3	19.6	5.0	2.9	27.5	61.8
24	2043				0.0	327.6	327.6	0.0	327.6	327.6	34.3	19.6	5.0	2.9	27.5	61.8
25	2044				0.0	327.6	327.6	0.0	327.6	327.6	34.3	19.6	5.0	2.9	27.5	61.8
26	2045				0.0	327.6	327.6	0.0	327.6	327.6	34.3	19.6	5.0	2.9	27.5	61.8
27	2046				0.0	327.6	327.6	0.0	327.6	327.6	34.3	19.6	5.0	2.9	27.5	61.8
28	2047				0.0	327.6	327.6	0.0	327.6	327.6	34.3	19.6	5.0	2.9	27.5	61.8
29	2048				0.0	327.6	327.6	0.0	327.6	327.6	34.3	19.6	5.0	2.9	27.5	61.8
30	2049				0.0	327.6	327.6	0.0	327.6	327.6	34.3	19.6	5.0	2.9	27.5	61.8
	Total	24,886.0	34,206.3	59,092.3	0.0	8,920.8	8,920.8	24,886.0	43,127.1	68,013.1	778.4	771.5	112.7	83.1	967.2	1,745.7

0.3659

WTP 12 months 30 days

Parameters

WTP PKR/HH/month	1,050
WT PKR/HH/year	18,000
water consumption pcpd	147
number of HH members	6
water concumption lit/HH/day	882
water concumption lit/HH/month	26,460
water litter/ m3	1,000
water concumption m3/HH/month	26.5
water concumption m3/HH/year	317.5
WTP PKR/m3	**56.7**

1,500 Alternative method (power cost of ground water pumping)

WTP-Non-Domestic coefficient	1.0
WTP-Non-Domestic	48.6

WTP Sanitation **28.3** 0.5

LRMC Pricing

Project Life 30 years

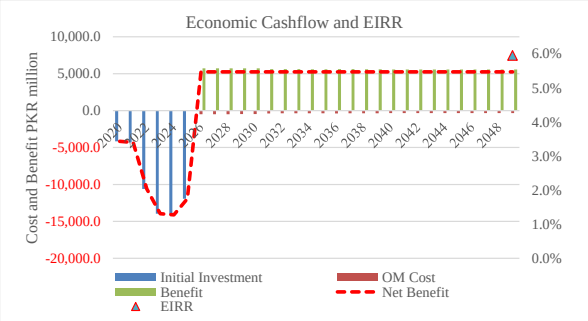
DR	6.0%	8.0%	10.0%	12.0%
CRF	0.073	0.089	0.106	0.124
Capital Inv BEN	4,293.0	5,249.0	6,268.5	7,335.9

ENPV -16,088.0 DR 8.0% **WTP EIRR**

	Year	Initial Investmen	OM	Cost Total	Benefit	Net Benefit	EIRR	BEN	NB	EIRR
1	2020	4,145.0		4,145.0		-4,145.0			-4,145.000000000000	
2	2021	4,322.5		4,322.5		-4,322.5			-4,322.500000000000	
3	2022	10,615.4		10,615.4		-10,615.4			##################	
4	2023	13,952.8		13,952.8		-13,952.8			##################	
5	2024	14,114.3		14,114.3		-14,114.3			##################	
6	2025	11,942.3		11,942.3		-11,942.3			##################	
7	2026		484.2	484.2	5,733.2	5,249.0		2,732.2	2,247.961564625850	
8	2027		480.6	480.6	5,729.6	5,249.0		2,663.2	2,182.627465986390	
9	2028		476.1	476.1	5,725.1	5,249.0		2,594.3	2,118.203713151930	
10	2029		472.5	472.5	5,721.5	5,249.0		2,525.4	2,052.869614512470	
11	2030		468.0	468.0	5,717.0	5,249.0		2,456.4	1,988.425170068030	
12	2031		375.3	375.3	5,624.3	5,249.0		2,387.5	2,012.201417233560	-24.7%
13	2032		369.9	369.9	5,618.9	5,249.0		2,318.6	1,948.667318594100	-20.7%
14	2033		363.6	363.6	5,612.6	5,249.0		2,249.6	1,886.043565759640	-17.7%
15	2034		357.3	357.3	5,606.3	5,249.0		2,180.7	1,823.409467120180	-15.2%
16	2035		351.0	351.0	5,600.0	5,249.0		2,111.8	1,760.765022675740	-13.2%
17	2036		374.4	374.4	5,623.4	5,249.0		2,042.8	1,668.441269841270	-11.6%
18	2037		365.4	365.4	5,614.4	5,249.0		1,973.9	1,608.517517006800	-10.3%
19	2038		357.3	357.3	5,606.3	5,249.0		1,905.0	1,547.683418367350	-9.1%
20	2039		349.2	349.2	5,598.2	5,249.0		1,836.1	1,486.870011337870	-8.2%
21	2040		327.6	327.6	5,576.6	5,249.0		1,750.3	1,422.713633786850	-7.3%
22	2041		327.6	327.6	5,576.6	5,249.0		1,750.3	1,422.713633786850	-6.6%
23	2042		327.6	327.6	5,576.6	5,249.0		1,750.3	1,422.713633786850	-5.9%
24	2043		327.6	327.6	5,576.6	5,249.0		1,750.3	1,422.713633786850	-5.3%
25	2044		327.6	327.6	5,576.6	5,249.0		1,750.3	1,422.713633786850	-4.7%
26	2045		327.6	327.6	5,576.6	5,249.0		1,750.3	1,422.713633786850	-4.2%
27	2046		327.6	327.6	5,576.6	5,249.0		1,750.3	1,422.713633786850	-3.8%
28	2047		327.6	327.6	5,576.6	5,249.0		1,750.3	1,422.713633786850	-3.4%
29	2048		327.6	327.6	5,576.6	5,249.0		1,750.3	1,422.713633786850	-3.0%
30	2049		327.6	327.6	5,576.6	5,249.0	6.0%	1,750.3	1,422.713633786850	-2.7%
	Total	59,092.3	5,644.8	64,737.1	10,893.8	14,393.9		49,480.6	-18,532.5	

1 year-Delay Simulation

	Year	Initial Investmen	OM Cost	Benefit	Net Benefit	EIRR	Cost Total	Initial Invest	OM	Total Cost	BEN	NB	EIRR
1	2020	-4,145.0			-4,145.0		-4,145.0	4,269.4		4,269.4		-4,269.4	
2	2021	-4,322.5			-4,322.5		-4,322.5	4,454.5		4,454.5		-4,454.5	
3	2022	-10,615.4			-10,615.4		-10,615.4	5,909.2		5,909.2		-5,909.2	
4	2023	-13,952.8	0.0	0.0	-13,952.8		-13,952.8	11,818.5		11,818.5		-11,818.5	
5	2024	-14,114.3	0.0	0.0	-14,114.3		-14,114.3	11,818.5		11,818.5		-11,818.5	
6	2025	-11,942.3	0.0	0.0	-11,942.3		-11,942.3	11,818.5		11,818.5		-11,818.5	
7	2026		-484.2	5,733.2	5,249.0		-484.2	9,003.8		9,003.8		-9,003.8	
8	2027		-480.6	5,729.6	5,249.0		-480.6		484.2	484.2	5,733.2	5,249.0	
9	2028		-476.1	5,725.1	5,249.0		-476.1		480.6	480.6	5,729.6	5,249.0	
10	2029		-472.5	5,721.5	5,249.0		-472.5		476.1	476.1	5,725.1	5,249.0	-28%
11	2030		-468.0	5,717.0	5,249.0		-468.0		472.5	472.5	5,721.5	5,249.0	-20%
12	2031		-375.3	5,624.3	5,249.0		-375.3		468.0	468.0	5,717.0	5,249.0	-14%
13	2032		-369.9	5,618.9	5,249.0		-369.9		375.3	375.3	5,624.3	5,249.0	-10%
14	2033		-363.6	5,612.6	5,249.0		-363.6		369.9	369.9	5,618.9	5,249.0	-7%
15	2034		-357.3	5,606.3	5,249.0		-357.3		363.6	363.6	5,612.6	5,249.0	-4.8%
16	2035		-351.0	5,600.0	5,249.0		-351.0		357.3	357.3	5,606.3	5,249.0	-3.0%
17	2036		-374.4	5,623.4	5,249.0		-374.4		351.0	351.0	5,600.0	5,249.0	-1.5%
18	2037		-365.4	5,614.4	5,249.0		-365.4		374.4	374.4	5,623.4	5,249.0	-0.3%
19	2038		-357.3	5,606.3	5,249.0		-357.3		365.4	365.4	5,614.4	5,249.0	0.7%
20	2039		-349.2	5,598.2	5,249.0		-349.2		357.3	357.3	5,606.3	5,249.0	1.6%
21	2040		-327.6	5,576.6	5,249.0		-327.6		349.2	349.2	5,598.2	5,249.0	2.3%
22	2041		-327.6	5,576.6	5,249.0		-327.6		327.6	327.6	5,576.6	5,249.0	2.9%
23	2042		-327.6	5,576.6	5,249.0		-327.6		327.6	327.6	5,576.6	5,249.0	3.4%
24	2043		-327.6	5,576.6	5,249.0		-327.6		327.6	327.6	5,576.6	5,249.0	3.8%
25	2044		-327.6	5,576.6	5,249.0		-327.6		327.6	327.6	5,576.6	5,249.0	4.2%
26	2045		-327.6	5,576.6	5,249.0		-327.6		327.6	327.6	5,576.6	5,249.0	4.5%
27	2046		-327.6	5,576.6	5,249.0		-327.6		327.6	327.6	5,576.6	5,249.0	4.8%
28	2047		-327.6	5,576.6	5,249.0		-327.6		327.6	327.6	5,576.6	5,249.0	5.1%
29	2048		-327.6	5,576.6	5,249.0		-327.6		327.6	327.6	5,576.6	5,249.0	5.3%
30	2049		-327.6	5,576.6	5,249.0	6.0%	-327.6		327.6	327.6	5,576.6	5,249.0	5.5%
	Total	-59,092.3	-8,920.8	134,897.2	66,884.1		-68,013.1	59,092.3	8,593.2	67,685.5	129,320.6	61,635.1	



Year	Initial Investmen	OM	Cost Total	Benefit	Net Benefit
2020	4,145.0		4,145.0		-4,145.0
2021	4,322.5		4,322.5		-4,322.5
2022	10,615.4		10,615.4		-10,615.4
2023	13,952.8		13,952.8		-13,952.8
2024	14,114.3		14,114.3		-14,114.3
2025	11,942.3		11,942.3		-11,942.3
2026		484.2	484.2	5,733.2	5,249.0
⋮	⋮	⋮	⋮	⋮	⋮
2047		365.4	365.4	5,614.4	5,249.0
2048		357.3	357.3	5,606.3	5,249.0
2049		349.2	349.2	5,598.2	5,249.0
Total	59,092.3	8,920.8	68,013.1	134,897.2	66,884.1

West SWD IRR

	Year	Cost (million PKR)									Served water (million m3/ year)					
		Construction			O&M			Total								
		Foreign	Local	Sub Total	Foreign	Local	Sub Total	Foreign	Local	Total	Domestic	IND	COM	Gound Water	NON-Dom Total	Total
1	2019	217.0	1,651.0	1,868.0				217.0	1,651.0	1,868.0					0.0	0.0
2	2020	217.0	1,772.0	1,989.0				217.0	1,772.0	1,989.0					0.0	0.0
3	2021	1,782.0	3,478.0	5,260.0				1,782.0	3,478.0	5,260.0					0.0	0.0
4	2022	2,542.0	7,378.0	9,920.0			0.0	2,542.0	7,378.0	9,920.0					0.0	0.0
5	2023	2,548.0	9,409.0	11,957.0			0.0	2,548.0	9,409.0	11,957.0					0.0	0.0
6	2024	2,399.0	4,400.0	6,799.0			0.0	2,399.0	4,400.0	6,799.0					0.0	0.0
7	2025				0.0	637.0	637.0	0.0	637.0	637.0	36.3	66.3	5.0	5.4	76.6	112.9
8	2026				0.0	630.0	630.0	0.0	630.0	630.0	37.1	62.3	5.1	5.2	72.6	109.7
9	2027				0.0	623.0	623.0	0.0	623.0	623.0	37.9	58.3	5.2	5.1	68.6	106.4
10	2028				0.0	616.0	616.0	0.0	616.0	616.0	38.7	54.3	5.3	4.9	64.6	103.2
11	2029				0.0	608.0	608.0	0.0	608.0	608.0	39.5	50.4	5.4	4.8	60.6	100.0
12	2030				0.0	524.0	524.0	0.0	524.0	524.0	40.3	46.4	5.5	4.6	56.5	96.8
13	2031				0.0	516.0	516.0	0.0	516.0	516.0	41.1	42.4	5.6	4.5	52.5	93.6
14	2032				0.0	508.0	508.0	0.0	508.0	508.0	41.9	38.5	5.7	4.3	48.5	90.4
15	2033				0.0	499.0	499.0	0.0	499.0	499.0	42.7	34.5	5.9	4.2	44.5	87.2
16	2034				0.0	492.0	492.0	0.0	492.0	492.0	43.5	30.5	6.0	4.0	40.5	84.0
17	2035				0.0	515.0	515.0	0.0	515.0	515.0	44.3	26.5	6.1	3.8	36.5	80.8
18	2036				0.0	504.0	504.0	0.0	504.0	504.0	45.1	22.6	6.2	3.7	32.5	77.5
19	2037				0.0	492.0	492.0	0.0	492.0	492.0	45.9	18.6	6.3	3.5	28.4	74.3
20	2038				0.0	480.0	480.0	0.0	480.0	480.0	46.7	14.6	6.4	3.4	24.4	71.1
21	2039				0.0	458.0	458.0	0.0	458.0	458.0	46.7	14.6	6.4	3.4	24.4	71.1
22	2040				0.0	458.0	458.0	0.0	458.0	458.0	46.7	14.6	6.4	3.4	24.4	71.1
23	2041				0.0	458.0	458.0	0.0	458.0	458.0	46.7	14.6	6.4	3.4	24.4	71.1
24	2042				0.0	458.0	458.0	0.0	458.0	458.0	46.7	14.6	6.4	3.4	24.4	71.1
25	2043				0.0	458.0	458.0	0.0	458.0	458.0	46.7	14.6	6.4	3.4	24.4	71.1
26	2044				0.0	458.0	458.0	0.0	458.0	458.0	46.7	14.6	6.4	3.4	24.4	71.1
27	2045				0.0	458.0	458.0	0.0	458.0	458.0	46.7	14.6	6.4	3.4	24.4	71.1
28	2046				0.0	458.0	458.0	0.0	458.0	458.0	46.7	14.6	6.4	3.4	24.4	71.1
29	2047				0.0	458.0	458.0	0.0	458.0	458.0	46.7	14.6	6.4	3.4	24.4	71.1
30	2048				0.0	458.0	458.0	0.0	458.0	458.0	46.7	14.6	6.4	3.4	24.4	71.1
	Total	9,705.0	28,088.0	**37,793.0**	0.0	12,224.0	12,224.0	9,705.0	40,312.0	50,017.0	1,047.7	712.5	143.8	95.2	951.4	1,999.1
								0.19403			**0.52**	0.36	0.07	0.05	**0.48**	1.00

FIRR **FNPV** -17,032.1 PKR mill DR 6.1%

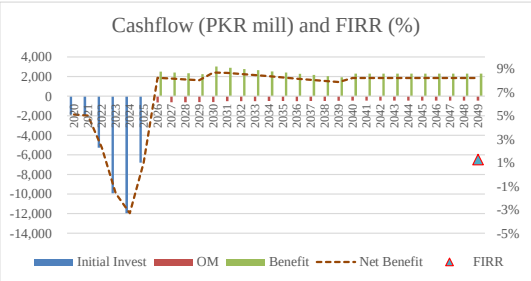
PKR/m3 1.5

Operating Income EXCL Ground Water (mill PKR)

	Year	Initial Investment	OM	Cost Total	Benefit	Net Benefit	FIRR	Weighed Ave Tariff	Tariff Dom	Tariff Non-Dom	Domestic	IND	COM	Gound Water	NON-Dom Total	Total
1	2020	1,868.0		1,868.0		-1,868.0										0.0
2	2021	1,989.0		1,989.0		-1,989.0										0.0
3	2022	5,260.0		5,260.0		-5,260.0										0.0
4	2023	9,920.0		9,920.0		-9,920.0		0.0								0.0
5	2024	11,957.0		11,957.0		-11,957.0		0.0								0.0
6	2025	6,799.0		6,799.0		-6,799.0		0.0								0.0
7	2026		637.0	637.0	2504.4	1,867.4		21.7	17.5	26.3	634.4	1,739.4	130.6	141.1	1,870.0	2,504.4
8	2027		630.0	630.0	2417.1	1,787.1		21.7	17.5	26.3	648.5	1,635.1	133.5	137.0	1,768.6	2,417.1
9	2028		623.0	623.0	2329.8	1,706.8		21.7	17.5	26.3	662.6	1,530.9	136.4	133.0	1,667.2	2,329.8
10	2029		616.0	616.0	2242.5	1,626.5		21.7	17.5	26.3	676.6	1,426.6	139.3	129.0	1,565.9	2,242.5
11	2030		608.0	608.0	3017.3	2,409.3		30.3	24.5	36.8	967.0	1,851.3	199.0	125.0	2,050.3	3,017.3
12	2031		524.0	524.0	2895.0	2,371.0	-19.0%	30.3	24.5	36.8	986.6	1,705.3	203.1	121.0	1,908.4	2,895.0
13	2032		516.0	516.0	2772.8	2,256.8	-15.0%	30.3	24.5	36.8	1,006.3	1,559.3	207.1	117.0	1,766.5	2,772.8
14	2033		508.0	508.0	2650.6	2,142.6	-12.0%	30.3	24.5	36.8	1,026.0	1,413.4	211.2	113.0	1,624.6	2,650.6
15	2034		499.0	499.0	2528.3	2,029.3	-9.7%	30.3	24.5	36.8	1,045.7	1,267.4	215.2	108.9	1,482.6	2,528.3
16	2035		492.0	492.0	2406.1	1,914.1	-7.9%	30.3	24.5	36.8	1,065.4	1,121.4	219.3	104.9	1,340.7	2,406.1
17	2036		515.0	515.0	2283.9	1,768.9	-6.6%	30.3	24.5	36.8	1,085.1	975.5	223.3	100.9	1,198.8	2,283.9
18	2037		504.0	504.0	2161.7	1,657.7	-5.4%	30.3	24.5	36.8	1,104.8	829.5	227.4	96.9	1,056.9	2,161.7
19	2038		492.0	492.0	2039.4	1,547.4	-4.5%	30.3	24.5	36.8	1,124.4	683.5	231.4	92.9	915.0	2,039.4
20	2039		480.0	480.0	1917.2	1,437.2	-3.8%	30.3	24.5	36.8	1,144.1	537.6	235.5	88.9	773.1	1,917.2
21	2040		458.0	458.0	2300.6	1,842.6	-2.9%	36.4	29.4	44.1	1,373.0	645.1	282.6	88.9	927.7	2,300.6
22	2041		458.0	458.0	2300.6	1,842.6	-2.2%	36.4	29.4	44.1	1,373.0	645.1	282.6	88.9	927.7	2,300.6
23	2042		458.0	458.0	2300.6	1,842.6	-1.5%	36.4	29.4	44.1	1,373.0	645.1	282.6	88.9	927.7	2,300.6
24	2043		458.0	458.0	2300.6	1,842.6	-1.0%	36.4	29.4	44.1	1,373.0	645.1	282.6	88.9	927.7	2,300.6
25	2044		458.0	458.0	2300.6	1,842.6	-0.5%	36.4	29.4	44.1	1,373.0	645.1	282.6	88.9	927.7	2,300.6
26	2045		458.0	458.0	2300.6	1,842.6	0.0%	36.4	29.4	44.1	1,373.0	645.1	282.6	88.9	927.7	2,300.6
27	2046		458.0	458.0	2300.6	1,842.6	0.3%	36.4	29.4	44.1	1,373.0	645.1	282.6	88.9	927.7	2,300.6
28	2047		458.0	458.0	2300.6	1,842.6	0.7%	36.4	29.4	44.1	1,373.0	645.1	282.6	88.9	927.7	2,300.6
29	2048		458.0	458.0	2300.6	1,842.6	1.0%	36.4	29.4	44.1	1,373.0	645.1	282.6	88.9	927.7	2,300.6
30	2049		458.0	458.0	2300.6	1,842.6	1.3%	36.4	29.4	44.1	1,373.0	645.1	282.6	88.9	927.7	2,300.6
	Total	37,793.0	12,224.0	50,017.0	57172.4	7,155.4		**27.9**			26,907.1	24,727.1	5,538.2	2,498.4	30,265.3	57,172.4

FIRR **1 year-Delay Simulation** 0.0

	Year	Initial Invest	OM	Benefit	Net Benefit	FIRR	Cost Total	Initial Invest	OM	Total Cost	BEN	NB	FIRR
1	2020	-1,868.0			(1868.0)		-1,868.0	1,868.0		1,868.0		-1,868.0	
2	2021	-1,989.0			(1989.0)		-1,989.0	1,989.0		1,989.0	0.0	-1,989.0	
3	2022	-5,260.0			(5260.0)		-5,260.0	3,779.3		3,779.3	0.0	-3,779.3	
4	2023	-9,920.0	0.0	0.0	(9920.0)		-9,920.0	7,558.6		7,558.6	0.0	-7,558.6	
5	2024	-11,957.0	0.0	0.0	(11957.0)		-11,957.0	9,448.3		9,448.3	0.0	-9,448.3	
6	2025	-6,799.0	0.0	0.0	(6799.0)		-6,799.0	5,669.0		5,669.0	0.0	-5,669.0	
7	2026		-637.0	2,504.4	1867.4		-637.0	7,480.9		7,480.9	0.0	-7,480.9	
8	2027		-630.0	2,417.1	1787.1		-630.0		637.0	637.0	2,504.4	1,867.4	
9	2028		-623.0	2,329.8	1706.8		-623.0		630.0	630.0	2,417.1	1,787.1	
10	2029		-616.0	2,242.5	1626.5		-616.0		623.0	623.0	2,329.8	1,706.8	
11	2030		-608.0	3,017.3	2409.3		-608.0		616.0	616.0	2,242.5	1,626.5	
12	2031		-524.0	2,895.0	2371.0		-524.0		608.0	608.0	3,017.3	2,409.3	-23.3%
13	2032		-516.0	2,772.8	2256.8		-516.0		524.0	524.0	2,895.0	2,371.0	-17.9%
14	2033		-508.0	2,650.6	2142.6		-508.0		516.0	516.0	2,772.8	2,256.8	-14.1%
15	2034		-499.0	2,528.3	2029.3		-499.0		508.0	508.0	2,650.6	2,142.6	-11.3%
16	2035		-492.0	2,406.1	1914.1		-492.0		499.0	499.0	2,528.3	2,029.3	-9.2%
17	2036		-515.0	2,283.9	1768.9		-515.0		492.0	492.0	2,406.1	1,914.1	-7.5%
18	2037		-504.0	2,161.7	1657.7		-504.0		515.0	515.0	2,283.9	1,768.9	-6.2%
19	2038		-492.0	2,039.4	1547.4		-492.0		504.0	504.0	2,161.7	1,657.7	-5.2%
20	2039		-480.0	1,917.2	1437.2		-480.0		492.0	492.0	2,039.4	1,547.4	-4.3%
21	2040		-458.0	2,300.6	1842.6		-458.0		480.0	480.0	1,917.2	1,437.2	-3.6%
22	2041		-458.0	2,300.6	1842.6		-458.0		458.0	458.0	2,300.6	1,842.6	-2.8%
23	2042		-458.0	2,300.6	1842.6		-458.0		458.0	458.0	2,300.6	1,842.6	-2.1%
24	2043		-458.0	2,300.6	1842.6		-458.0		458.0	458.0	2,300.6	1,842.6	-1.5%
25	2044		-458.0	2,300.6	1842.6		-458.0		458.0	458.0	2,300.6	1,842.6	-0.9%
26	2045		-458.0	2,300.6	1842.6		-458.0		458.0	458.0	2,300.6	1,842.6	-0.5%
27	2046		-458.0	2,300.6	1842.6		-458.0		458.0	458.0	2,300.6	1,842.6	0.0%
28	2047		-458.0	2,300.6	1842.6		-458.0		458.0	458.0	2,300.6	1,842.6	0.3%
29	2048		-458.0	2,300.6	1842.6		-458.0		458.0	458.0	2,300.6	1,842.6	0.7%
30	2049		-458.0	2,300.6	1842.6	1.3%	-458.0		458.0	458.0	2,300.6	1,842.6	1.0%
	Total	-37,793.0	-12,224.0	57,172.4	7155.4		-50,017.0	37793	11,766	49,559	54,872	5,313	



Year	Initial Investme	OM	Cost Total	Benefit	Net Benefit
2020	1,868.0		1,868.0		-1,868.0
2021	1,989.0		1,989.0		-1,989.0
2022	5,260.0		5,260.0		-5,260.0
2023	9,920.0	0.0	9,920.0	0.0	-9,920.0
2024		0.0	0.0	0.0	0.0
2025		0.0	0.0	0.0	0.0
⋮		⋮	⋮	⋮	⋮
2047		504.0	504.0	2161.7	1,657.7
2048		492.0	492.0	2039.4	1,547.4
2049		480.0	480.0	1917.2	1,437.2
Total	37,793.0	12,224.0	50,017.0	57172.4	7,155.4

EIRR SCF **0.9**

	Year	Cost (million PKR)									Served water (million m3/ year)					
		Construction			O&M			Total								
		Foreign	Local	Sub Total	Foreign	Local	Sub Total	Foreign	Local	Total	Domestic	IND	COM	Gound Water	NON-Dom	Total
1	2020	217.0	1,485.9	1,702.9				217.0	1,485.9	1,702.9						
2	2021	217.0	1,594.8	1,811.8				217.0	1,594.8	1,811.8						
3	2022	1,782.0	3,130.2	4,912.2				1,782.0	3,130.2	4,912.2						
4	2023	2,542.0	6,640.2	9,182.2				2,542.0	6,640.2	9,182.2						
5	2024	2,548.0	8,468.1	11,016.1				2,548.0	8,468.1	11,016.1						
6	2025	2,399.0	3,960.0	6,359.0				2,399.0	3,960.0	6,359.0						
7	2026				0.0	573.3	573.3	0.0	573.3	573.3	36.3	66.3	5.0	5.4	76.6	112.9
8	2027				0.0	567.0	567.0	0.0	567.0	567.0	37.1	62.3	5.1	5.2	72.6	109.7
9	2028				0.0	560.7	560.7	0.0	560.7	560.7	37.9	58.3	5.2	5.1	68.6	106.4
10	2029				0.0	554.4	554.4	0.0	554.4	554.4	38.7	54.3	5.3	4.9	64.6	103.2
11	2030				0.0	547.2	547.2	0.0	547.2	547.2	39.5	50.4	5.4	4.8	60.6	100.0
12	2031				0.0	471.6	471.6	0.0	471.6	471.6	40.3	46.4	5.5	4.6	56.5	96.8
13	2032				0.0	464.4	464.4	0.0	464.4	464.4	41.1	42.4	5.6	4.5	52.5	93.6
14	2033				0.0	457.2	457.2	0.0	457.2	457.2	41.9	38.5	5.7	4.3	48.5	90.4
15	2034				0.0	449.1	449.1	0.0	449.1	449.1	42.7	34.5	5.9	4.2	44.5	87.2
16	2035				0.0	442.8	442.8	0.0	442.8	442.8	43.5	30.5	6.0	4.0	40.5	84.0
17	2036				0.0	463.5	463.5	0.0	463.5	463.5	44.3	26.5	6.1	3.8	36.5	80.8
18	2037				0.0	453.6	453.6	0.0	453.6	453.6	45.1	22.6	6.2	3.7	32.5	77.5
19	2038				0.0	442.8	442.8	0.0	442.8	442.8	45.9	18.6	6.3	3.5	28.4	74.3
20	2039				0.0	432.0	432.0	0.0	432.0	432.0	46.7	14.6	6.4	3.4	24.4	71.1
21	2040				0.0	412.2	412.2	0.0	412.2	412.2	46.7	14.6	6.4	3.4	24.4	71.1
22	2041				0.0	412.2	412.2	0.0	412.2	412.2	46.7	14.6	6.4	3.4	24.4	71.1
23	2042				0.0	412.2	412.2	0.0	412.2	412.2	46.7	14.6	6.4	3.4	24.4	71.1
24	2043				0.0	412.2	412.2	0.0	412.2	412.2	46.7	14.6	6.4	3.4	24.4	71.1
25	2044				0.0	412.2	412.2	0.0	412.2	412.2	46.7	14.6	6.4	3.4	24.4	71.1
26	2045				0.0	412.2	412.2	0.0	412.2	412.2	46.7	14.6	6.4	3.4	24.4	71.1
27	2046				0.0	412.2	412.2	0.0	412.2	412.2	46.7	14.6	6.4	3.4	24.4	71.1
28	2047				0.0	412.2	412.2	0.0	412.2	412.2	46.7	14.6	6.4	3.4	24.4	71.1
29	2048				0.0	412.2	412.2	0.0	412.2	412.2	46.7	14.6	6.4	3.4	24.4	71.1
30	2049				0.0	412.2	412.2	0.0	412.2	412.2	46.7	14.6	6.4	3.4	24.4	71.1
	Total	9,705.0	25,279.2	34,984.2	0.0	11,001.6	11,001.6	9,705.0	36,280.8	45,985.8	1,047.7	712.5	143.8	95.2	951.4	1,999.1

WTP IRRs 180718シート 12.0 months 30 days

Parameters

WTP PKR/HH/month	1050.0	**1,500**	Alternative method (power cost of ground water pumping)	
WT PKR/HH/year	18000.0			
water consumption pcpd	147.0		WTP-Non-Domestic coefficient	1.0
number of HH members	6.0		WTP-Non-Domestic	48.6
water concumption lit/HH/day	882.0			
water concumption lit/HH/month	26460.0	**WTP Sanitation**	**28.3**	0.5
water litter/ m3	1000.0			
water concumption m3/HH/month	26.5			
water concumption m3/HH/year	317.5	12,600		
WTP PKR/m3	**56.7**	**39.7**		

LRMC Pricing

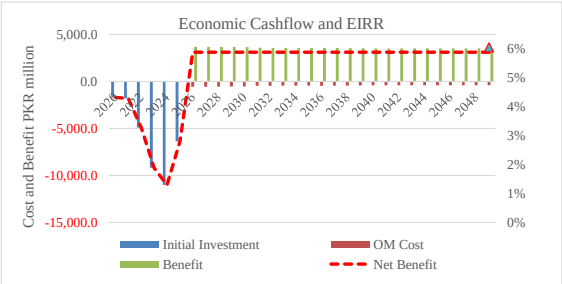
Project Life	30 years			
DR	6.0%	8.0%	0.1	12.0%
CRF	0.073	0.089	0.1	0.124
Capital Inv BEN	2,541.6	3,107.6	3711.1	4,343.1

ENPV -9,138.8 DR 8.0% **WTP EIRR**

	Year	Initial Investme	OM	Cost Total	Benefit	Net Benefit	EIRR	BEN	NB	EIRR
1	2020	1,702.9		1,702.9		-1,702.9			-1,702.900000000000	
2	2021	1,811.8		1,811.8		-1,811.8			-1,811.800000000000	
3	2022	4,912.2		4,912.2		-4,912.2			-4,912.200000000000	
4	2023	9,182.2		9,182.2		-9,182.2			-9,182.200000000000	
5	2024	11,016.1		11,016.1		-11,016.1			##################	
6	2025	6,359.0		6,359.0		-6,359.0			-6,359.000000000000	
7	2026		573.3	573.3	3680.9	3,107.6		3,199.1	2,625.809126984130	
8	2027		567.0	567.0	3674.6	3,107.6		3,108.1	2,541.086734693880	
9	2028		560.7	560.7	3668.3	3,107.6		3,017.1	2,456.374688208620	
10	2029		554.4	554.4	3662.0	3,107.6	-22.0%	2,926.1	2,371.652295918370	
11	2030		547.2	547.2	3654.8	3,107.6	-15.7%	2,835.0	2,287.840249433110	-20.0%
12	2031		471.6	471.6	3579.2	3,107.6	-11.2%	2,744.0	2,272.428202947850	-15.4%
13	2032		464.4	464.4	3572.0	3,107.6	-7.9%	2,653.0	2,188.605810657600	-12.0%
14	2033		457.2	457.2	3564.8	3,107.6	-5.3%	2,562.0	2,104.804109977320	-9.5%
15	2034		449.1	449.1	3556.7	3,107.6	-3.2%	2,471.0	2,021.881717687070	-7.4%
16	2035		442.8	442.8	3550.4	3,107.6	-1.6%	2,380.0	1,937.159325396830	-5.8%
17	2036		463.5	463.5	3571.1	3,107.6	-0.3%	2,289.0	1,825.457624716550	-4.5%
18	2037		453.6	453.6	3561.2	3,107.6	0.8%	2,197.9	1,744.335232426300	-3.5%
19	2038		442.8	442.8	3550.4	3,107.6	1.7%	2,106.9	1,664.112840136050	-2.6%
20	2039		432.0	432.0	3539.6	3,107.6	2.4%	2,015.9	1,583.900793650790	-1.9%
21	2040		412.2	412.2	3519.8	3,107.6	3.1%	2,015.9	1,603.700793650790	-1.2%
22	2041		412.2	412.2	3519.8	3,107.6	3.6%	2,015.9	1,603.700793650790	-0.7%
23	2042		412.2	412.2	3519.8	3,107.6	4.1%	2,015.9	1,603.700793650790	-0.2%
24	2043		412.2	412.2	3519.8	3,107.6	4.5%	2,015.9	1,603.700793650790	0.3%
25	2044		412.2	412.2	3519.8	3,107.6	4.9%	2,015.9	1,603.700793650790	0.7%
26	2045		412.2	412.2	3519.8	3,107.6	5.2%	2,015.9	1,603.700793650790	1.0%
27	2046		412.2	412.2	3519.8	3,107.6	5.4%	2,015.9	1,603.700793650790	1.4%
28	2047		412.2	412.2	3519.8	3,107.6	5.7%	2,015.9	1,603.700793650790	1.7%
29	2048		412.2	412.2	3519.8	3,107.6	5.9%	2,015.9	1,603.700793650790	1.9%
30	2049		412.2	412.2	3519.8	3,107.6	6.1%	2,015.9	1,603.700793650790	2.1%
	Total	34,984.2	6,879.6	41,863.8	9987.2	8,521.6		56,664.1	10,678.3	

1 year-Delay Simulation

	Year	Initial Investme	OM Cost	Benefit	Net Benefit	EIRR	Cost Total	Initial Invest	OM	Total Cost	BEN	NB	EIRR
1	2020	-1,702.9			(1702.9)		-1,702.9	1,729.2		1,729.2		-1,729.2	
2	2021	-1,811.8			(1811.8)		-1,811.8	1,841.2		1,841.2		-1,841.2	
3	2022	-4,912.2			(4912.2)		-4,912.2	3,498.4		3,498.4		-3,498.4	
4	2023	-9,182.2	0.0	0.0	(9182.2)		-9,182.2	6,996.8		6,996.8		-6,996.8	
5	2024	-11,016.1	0.0	0.0	(11016.1)		-11,016.1	8,746.1		8,746.1		-8,746.1	
6	2025	-6,359.0	0.0	0.0	(6359.0)		-6,359.0	5,247.6		5,247.6		-5,247.6	
7	2026	0.0	-573.3	3,680.9	3107.6		-573.3	6,924.9		6,924.9		-6,924.9	
8	2027		-567.0	3,674.6	3107.6		-567.0		573.3	573.3	3,680.9	3,107.6	
9	2028		-560.7	3,668.3	3107.6		-560.7		567.0	567.0	3,674.6	3,107.6	
10	2029		-554.4	3,662.0	3107.6		-554.4		560.7	560.7	3,668.3	3,107.6	
11	2030		-547.2	3,654.8	3107.6		-547.2		554.4	554.4	3,662.0	3,107.6	
12	2031		-471.6	3,579.2	3107.6		-471.6		547.2	547.2	3,654.8	3,107.6	
13	2032		-464.4	3,572.0	3107.6		-464.4		471.6	471.6	3,579.2	3,107.6	
14	2033		-457.2	3,564.8	3107.6		-457.2		464.4	464.4	3,572.0	3,107.6	
15	2034		-449.1	3,556.7	3107.6		-449.1		457.2	457.2	3,564.8	3,107.6	
16	2035		-442.8	3,550.4	3107.6		-442.8		449.1	449.1	3,556.7	3,107.6	
17	2036		-463.5	3,571.1	3107.6		-463.5		442.8	442.8	3,550.4	3,107.6	
18	2037		-453.6	3,561.2	3107.6		-453.6		463.5	463.5	3,571.1	3,107.6	
19	2038		-442.8	3,550.4	3107.6		-442.8		453.6	453.6	3,561.2	3,107.6	
20	2039		-432.0	3,539.6	3107.6		-432.0		442.8	442.8	3,550.4	3,107.6	
21	2040		-412.2	3,519.8	3107.6		-412.2		432.0	432.0	3,539.6	3,107.6	
22	2041		-412.2	3,519.8	3107.6		-412.2		412.2	412.2	3,519.8	3,107.6	
23	2042		-412.2	3,519.8	3107.6		-412.2		412.2	412.2	3,519.8	3,107.6	
24	2043		-412.2	3,519.8	3107.6		-412.2		412.2	412.2	3,519.8	3,107.6	
25	2044		-412.2	3,519.8	3107.6		-412.2		412.2	412.2	3,519.8	3,107.6	
26	2045		-412.2	3,519.8	3107.6		-412.2		412.2	412.2	3,519.8	3,107.6	
27	2046		-412.2	3,519.8	3107.6		-412.2		412.2	412.2	3,519.8	3,107.6	
28	2047		-412.2	3,519.8	3107.6		-412.2		412.2	412.2	3,519.8	3,107.6	
29	2048		-412.2	3,519.8	3107.6		-412.2		412.2	412.2	3,519.8	3,107.6	
30	2049		-412.2	3,519.8	3107.6	6.1%	-412.2		412.2	412.2	3,519.8	3,107.6	5.6%
	Total	-34,984.2	-11,001.6	85,583.0	39597.2	0.1	-45,985.8	34,984.2	10,589.4	45,573.6	82,063.2	36,489.6	



Year	Initial Investme	OM	Cost Total	Benefit	Net Benefit
2020	1,702.9		1,702.9		-1,702.9
2021	1,811.8		1,811.8		-1,811.8
2022	4,912.2		4,912.2		-4,912.2
2023	9,182.2		9,182.2		-9,182.2
2024	11,016.1		11,016.1		-11,016.1
2025	6,359.0		6,359.0		-6,359.0
2026		573.3	573.3	3680.9	3,107.6
⋮	⋮	⋮	⋮	⋮	⋮
2047		453.6	453.6	3561.2	3,107.6
2048		442.8	442.8	3550.4	3,107.6
2049		432.0	432.0	3539.6	3,107.6
Total	34,984.2	11,001.6	45,985.8	85583.0	39,597.2

AC11.9.3 Profit Loss Statement Analysis for the Phase 1 Project in the Western SWD

WEST - WASA-F Net Profit Simulation Model

Total Construction Cost	37,793.0	PKR million			Construction and OM Cc	50,017.0	PKR million					
Financing Plan							Equity Investment			**Financing Plan**		
WASA-F+Loan Inve	**50.0%**	**18,896.5**	PKR million				year 1	4.9%		Fiscal Transfer	50%	
of which Loan Investm	80.0%	15,117.2	PKR million				year 2	5.3%		Loans	40%	
of which Equity Invest	20.0%	3,779.3	PKR millic	Equity	Loan		year 3	13.9%		WASA-F Own Fund	10%	
Concessional Loan	40%	15,117.2	PKR millic	20.0%	80.0%		year 4	26.2%		Total	100%	
Loan (Commercial)		0.0	PKR million				year 5	31.6%				
Government Transfer/	50%	18,896.5					year 6	18.0%			38.3376	
								100%				

Parameters

Tariff Revenue			B simulater	**1.0**			
OM cost			Cost	**1.0**			
% Cost of sales	0.0%			**Parameter**			
Fixed Cost Portion of the Total Lo	100.0%		Interest rate	**1.0%**	3.0%	5.0%	
Fixed costs for depreciation	18,896.5	PKR million	Payback Period (years)	30			
Depreciation	20	years	of which grace period	6			
Straight Line Depreciation	944.8						
Non-opeartional revenue rate	0.0%						
Income tax (IT) rate	0.0%						
Reserve Fund Rate	0.0%		Average DSCR	26353.1%			
Retined earnings	0.0%		Discounted LLCR	195.47			
Dividends rate	100.0%		Discount Rate	6.1%	FIRR		

Table 1:

	PL Statement	1,000
		1,000,000

		WASA-F Own Fund Investmen t	**Charge Revenue**	**Cost of sales**	**O/M**	**Depreciat ion***	**Total Operating Cost**	**Operating Net Profit**	**Non-Operating Net Profit**	**EBIT**	**Interest Payments**	**Income Tax**	**Reserve Fund**	**Not Profit**	**Discounted Net Cashflow**
			a	b	c	d	e	f	g	h=a-e+g	i	j	k	l=h-i-j-k	m
1	2019	186.8								0.0	7.47			-194.3	-183.1
2	2020	198.9								0.0	15.43			-214.3	-190.4
3	2020	526.0								0.0	36.47			-562.5	-470.9
4	2021	992.0								0.0	36.47			-1,028.5	-811.6
5	2021	1,195.7								0.0	76.15			-1,271.8	-945.9
6	2022	679.9								0.0	123.98			-803.9	-563.5
7	2022		2,504.4	0.0	637.0	945	1,581.8	922.6	0.0	922.6	151.17	0.0	0.0	771.4	509.7
8	2023		2,417.1	0.0	630.0	945	1,574.8	842.3	0.0	842.3	144.87	0.0	0.0	697.4	434.3
9	2023		2,329.8	0.0	623.0	945	1,567.8	762.0	0.0	762.0	138.57	0.0	0.0	623.4	365.9
10	2024		2,242.5	0.0	616.0	945	1,560.8	681.7	0.0	681.7	132.28	0.0	0.0	549.4	303.9
11	2024		3,017.3	0.0	608.0	945	1,552.8	1,464.4	0.0	1,464.4	125.98	0.0	0.0	1,338.5	697.8
12	2025		2,895.0	0.0	524.0	945	1,468.8	1,426.2	0.0	1,426.2	119.68	0.0	0.0	1,306.5	642.0
13	2025		2,772.8	0.0	516.0	945	1,460.8	1,312.0	0.0	1,312.0	113.38	0.0	0.0	1,198.6	555.1
14	2026		2,650.6	0.0	508.0	945	1,452.8	1,197.8	0.0	1,197.8	107.08	0.0	0.0	1,090.7	476.1
15	2026		2,528.3	0.0	499.0	945	1,443.8	1,084.5	0.0	1,084.5	100.78	0.0	0.0	983.7	404.7
16	2027		2,406.1	0.0	492.0	945	1,436.8	969.3	0.0	969.3	94.48	0.0	0.0	874.8	339.2
17	2027		2,283.9	0.0	515.0	945	1,459.8	824.1	0.0	824.1	88.18	0.0	0.0	735.9	268.9
18	2028		2,161.7	0.0	504.0	945	1,448.8	712.8	0.0	712.8	81.88	0.0	0.0	630.9	217.3
19	2028		2,039.4	0.0	492.0	945	1,436.8	602.6	0.0	602.6	75.59	0.0	0.0	527.0	171.1
20	2029		1,917.2	0.0	480.0	945	1,424.8	492.4	0.0	492.4	69.29	0.0	0.0	423.1	129.5
21	2029		2,300.6	0.0	458.0	945	1,402.8	897.8	0.0	897.8	62.99	0.0	0.0	834.8	240.8
22	2030		2,300.6	0.0	458.0	945	1,402.8	897.8	0.0	897.8	56.69	0.0	0.0	841.1	228.6
23	2030		2,300.6	0.0	458.0	945	1,402.8	897.8	0.0	897.8	50.39	0.0	0.0	847.4	217.1
24	2031		2,300.6	0.0	458.0	945	1,402.8	897.8	0.0	897.8	44.09	0.0	0.0	853.7	206.1
25	2031		2,300.6	0.0	458.0	945	1,402.8	897.8	0.0	897.8	37.79	0.0	0.0	860.0	195.7
26	2032		2,300.6	0.0	458.0	945	1,402.8	897.8	0.0	897.8	31.49	0.0	0.0	866.3	185.8
27	2032		2,300.6	0.0	458.0		458.0	1,842.6	0.0	1,842.6	25.20	0.0	0.0	1,817.4	367.4
28	2033		2,300.6	0.0	458.0		458.0	1,842.6	0.0	1,842.6	18.90	0.0	0.0	1,823.7	347.5
29	2033		2,300.6	0.0	458.0		458.0	1,842.6	0.0	1,842.6	12.60	0.0	0.0	1,830.0	328.6
30	2034		2,300.6	0.0	458.0		458.0	1,842.6	0.0	1,842.6	6.30	0.0	0.0	1,836.3	310.8
											0.00				
	Total	3,779.3	57,172.4	0.0	12,224.0	18,896.5	31,120.5	26,051.9	0.0	26,051.9	2,185.6	0.0	0.0	20,087.0	4,978.4

APPENDIX FOR CHAPTER C12 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

AC12.1 Environmental Standards in Pakistan

(1) Water Quality

1) National Environmental Quality Standards (NEQS) for Municipal and Liquid Industrial Effluents[1, 2]

(mg/L, unless otherwise defined)

Parameter		Standards		
		Into Inland Waters	Into Sewage Treatment[3]	Into Sea[4]
1	Temperature increase[5]	=<3˚C	=<3˚C	=<3˚C
2	pH	6-9	6-9	6-9
3	Biochemical-Oxygen Demand (BOD)[6]	80	250	80[7]
4	Chemical oxygen demand (COD)	150	400	400
5	Total suspended solids (TSS)	200	400	200
6	Total dissolved solids (TDS)	3,500	3,500	3,500
7	Grease and oil	10	10	10
8	Phenolic compounds (as phenol)	0.1	0.3	0.3
9	Chlorides (as Cl^-)	1,000	1,000	SC[8]
10	Fluorides (as F^-)	10	10	10
11	Cyanide total (as CN^-)	1.0	1.0	1.0
12	Anionic detergents (as MBAS)[9]	20	20	20
13	Sulfates (SO_4)	600	1,000	SC[8]
14	Sulfides (S^-)	1.0	1.0	1.0
15	Ammonia (NH_3)	40	40	40
16	Pesticides[10]	0.15	0.15	0.15
17	Cadmium (Cd)[11]	0.1	0.1	0.1
18	Chromium (trivalent and hexavalent, Cr)	1.0	1.0	1.0
19	Copper (Cu)[4]	1.0	1.0	1.0
20	Lead (Pb)[4]	0.5	0.5	0.5
21	Mercury (Hg)[4]	0.01	0.01	0.01
22	Selenium (Se)[4]	0.5	0.5	0.5
23	Nickel (Ni)[4]	1.0	1.0	1.0
24	Silver (Ag)[4]	1.0	1.0	1.0
25	Total toxic metals	2.0	2.0	2.0
26	Zinc (Zn)	5.0	5.0	5.0
27	Arsenic (As)[4]	1.0	1.0	1.0
28	Barium (Ba)[4]	1.5	1.5	1.5
29	Iron (Fe)	8.0	8.0	8.0
30	Manganese (Mn)	1.5	1.5	1.5
31	Boron (B)[4]	6.0	6.0	6.0
32	Chlorine	1.0	1.0	1.0

1. The dilution of liquid effluents with fresh water to adjust them to within the NEQS limits is not permissible before discharge into the environment.
2. The concentrations of pollutants in water used will be subtracted from the effluent in the calculations of the NEQS limits.
3. Applicable only when and where sewage treatment is operational and BOD = 80 mg/L is achieved by the sewage treatment system.
4. Provided the discharge is not at shore and not within 10 miles of mangrove or other important estuaries.
5. The effluent should not result in a temperature increase of more than 3˚C at the edge of the zone where the initial mixing and dilution take place in the receiving body. If no zone is defined, use 100 m from the point of discharge.
6. Assuming a minimum discharge dilution of 1:10, a lower ratio would invite the determination of progressively more stringent standards by the Federal Environmental Protection Agency. A 1:10 dilution means, for example, that a water body receiving 1 cubic meter of treated effluent would have to contain at least 10 cubic meter of water for dilution of the effluent.
7. The value for industry is 200 mg/L.
8. Discharge concentration at or below sea concentration (SC).
9. Methylene Blue Active Substances: assuming the surfactant is biodegradable.
10. Pesticides include herbicides, fungicides, and insecticides.
11. Provided that the total toxic metals discharge does not exceed the level given at No. 25.

SOURCE: National Environmental Quality Standards (NEQS), 2000

2) National Standard for Drinking Water Quality (NSDWQ)[1, 2]

(mg/L, unless otherwise defined)

Parameter		Standard Values for Pakistan	WHO Guidelines (2011)	Remarks
Bacterial				
1	E. Coli (Drinking water)	ND/100 ml sample	ND/100 ml sample	Most Asian countries also follow WHO Guidelines
	E. Coli (Treated water entering the distribution system)	ND/100 ml sample	ND/100 ml sample	
	E. Coli (Distribution system)	ND/100 ml sample	ND/100 ml sample	
Physical				
2	Color	≤ 15 TCU	≤ 15 TCU	
3	Taste	Non objectionable/ Acceptable	Non objectionable/ Acceptable	
4	Odor	Non objectionable/ Acceptable	Non objectionable/ Acceptable	
5	Turbidity	< 5 NTU	< 5 NTU	
6	Total hardness as $CaCO_3$	< 500 mg/L	—	
7	Total Dissolved Solids (TDS)	< 1,000 mg/L	—	<1,000 mg/L (WHO guideline value in the year 1984)
8	pH	6.5-8.5	—	6.5-8.5 (the range recommended by WHO for the purpose of corrosion control in pipelines)
Chemical				
	Essential Inorganic	***mg/L***	***mg/L***	
9	Aluminum (Al)	≤ 0.2	0.2	
10	Antimony (Sb)	≤ 0.005(P)	0.02	
11	Arsenic (As)	≤ 0.05(P)	0.01	
12	Barium (Ba)	0.7	0.7	
13	Boron (B)	0.3	2.4	0.5 mg/L (WHO guideline value in the year 2004)
14	Cadmium (Cd)	0.01	0.003	Standard for Pakistan; similar to most Asian developing countries
15	Chloride (Cl)	< 250	—	250 mg/L (the value recommended by WHO for the purpose of taste)
16	Chromium (Cr)	≤ 0.05	0.05	
17	Copper (Cu)	2	2	
	Toxic Inorganic	***mg/L***	***mg/L***	
18	Cyanide (CN)	≤ 0.05	— (0.07, 2004)	Standard for Pakistan; similar to most Asian developing countries
19	Fluoride (F)[1]	≤ 1.5	1.5	
20	Lead (Pb)	≤ 0.05	0.01	Standard for Pakistan; similar to most Asian developing countries
21	Manganese (Mn)	≤ 0.5	— (0.4, 2004)	
22	Mercury (Hg)	≤ 0.001	0.006	0.001 mg/L (WHO guideline value in the year 2004)
23	Nickel (Ni)	≤ 0.02	0.07	0.02 mg/L (WHO guideline value in the year 2004)
24	Nitrate (NO_3)[1]	≤ 50	50	
25	Nitrite (NO_2)[1]	≤ 3(P)	3	
26	Selenium (Se)	0.01(P)	0.01	
27	Residual chlorine	0.2-0.5 at consumer end 0.5-1.5 at source	—	
28	Zinc (Zn)	5.0	— (levels above 3 mg/L may not be acceptable to consumers)	Standard for Pakistan; similar to most Asian developing countries
	Organic			
29	Pesticides mg/L	PSQCA No. 4639-2004, Page No. 4 Table No. 3 Serial No.		Pakistan Standard Specification for Bottled Drinking Water

Parameter		Standard Values for Pakistan	WHO Guidelines (2011)	Remarks
		20- 58 may be consulted. [2]		
30	Phenolic compounds (as Phenols) mg/L		≤ 0.002	
31	Poly-nuclear aromatic hydrocarbons (as PAH) g/L		0.01 (by the GC/MS method)	
	Radioactive	***Bq/L***	***Bq/L***	
32	Alpha emitters	0.1	0.5	
33	Beta emitters	1	1	

1. Indicates priority health-related inorganic constituents that require regular monitoring.
2. PSQCA: Pakistan Standards Quality Control Authority.
3. ND: Not Detected

SOURCE: Pakistan Environmental Protection Agency (EPA)

(2) Air Quality

1) National Environmental Quality Standards (NEQS) for Ambient Air

(μg/m^3)

Pollutants		Time-weighted Average	Concentration in Ambient Air		Method of Measurement
			Effective from 1st July 2010	Effective from 1st January 2013	
1	Sulphur Dioxide (SO_2)	Annual Average[1]	80	80	Ultraviolet Fluorescence Method
		24 hours[2]	120	120	
2	Oxides of Nitrogen as (NO)	Annual Average[1]	40	40	Gas Phase Chemiluminescence
		24 hours[2]	40	40	
3	Oxides of Nitrogen as (NO_2)	Annual Average[1]	40	40	Gas Phase Chemiluminescence
		24 hours[2]	80	80	
4	Ozone (O_3)	1 hour	180	130	Non Dispersive UV Absorption Method
5	Suspended Particle Matter (SPM)	Annual Average[1]	400	360	High Volume Sampling (Average flow rate not less than 1.1m^3/min)
		24 hours[2]	550	500	
6	Respirable Particle Matter (PM_{10})	Annual Average[1]	200	120	β Ray Absorption Method
		24 hours[2]	250	150	
7	Respirable Particle Matter ($PM_{2.5}$)	Annual Average[1]	15	15	β Ray Absorption Method
		24 hours[2]	40	35	
		1 hour	25	15	
8	Lead (Pb)	Annual Average[1]	1.5	1	ASS Method after sampling using EPM2000 or equivalent Filter pater
		24 hours[2]	2.0	1.5	
9	Carbon Monoxide (CO)	8 hours[2]	5	5	Non Dispersive Infra Red (NDIR) Method
		1 hour	10	10	

1. Annual arithmetic mean of minimum 104 measurements in a year taken twice a week hourly at uniform interval.
2. 24 hourly or 8 hourly values should be met 98% of the standard value in a year, 2% of the time. It may exceed but not on two consecutive days.

SOURCE: National Environmental Quality Standards (NEQS) for Ambient Quality, 2010

2) National Environmental Quality Standards (NEQS) for Industrial Gaseous Emission

(mg/Nm^3, unless otherwise defined)

Parameter		Source of Emission	Standards in 1993	Revised Standards in 2000
1	Smoke	Smoke opacity not exceed:	40% or 2 (Renglemann Scale)	40% or 2 (Renglemann Scale) or equivalent smoke number
2	Particulate Matter[1]	(a) Boilers and fumaces:		
		(i) Oil fired	300	300
		(ii) Coal fired	500	500
		(iii) Cement Kilns	200	300
		(b) Grinding, crushing, coolers and related processes, metallurgical processes, convertors, blast fumaces and cupolas.	500	500
3	Hydrogen Chloride[2]	Any	400	400
4	Chlorine[2]	Any	150	150
5	Hydrogen Fluoride[2]	Any	150	150
6	Hydrogen Sulphide[2]	Any	10	10
7	Sulphur Oxides	Sulfuric Acid / Sulfuric Acid plants.	400	5000
		Other plants[3].	400	1700
8	Carbon Monoxide[4]	Any	800	800
9	Lead[2]	Any	50	50
10	Mercury[2]	Any	10	10
11	Cadmium[2]	Any	20	20
12	Arsenic[2]	Any	20	20
13	Copper[2]	Any	50	50
14	Antimony[2]	Any	20	20
15	Zinc[2]	Any	200	200
16	Antimony Zinc Oxides of Nitrogen (NOx)[4]	(i) Nitric Acid manufacturing unit	400	400
		(ii) Gas fired	400	400
		(iii) Oil fired	—	600
		(iv) Coal fired	—	1200

1. Based on the assumption that the size of the particles is 10 microns or more.
2. Any source.
3. Based on 1% sulphure content in fuel oil. Higher content of sulphure will cause standards to be pro-rated.
4. In respect of emissions of sulphure dioxide and nitrogen oxides, the power plants operating on oil or coal as fuel shall, in addition to National Environmental Quality Standards (NEQS) specified above, comply with the following standards.

SOURCE: National Environmental Quality Standards (NEQS) for Industrial Gaseous Emission, 2000

(3) Noise

1) National Environmental Quality Standards (NEQS) for Noise

(Limit in dB (A) Leq[4])

Category of Area/Zone		Effective from 1st July 2010		Effective from 1st July 2012	
		Day time[1]	Night time[2]	Day time[1]	Night time[2]
1	Residential Area (A)	65	50	55	45
2	Commercial Area (B)	70	60	65	55
3	Industrial Area (C)	80	75	75	65
4	Silence Zone[3] (D)	55	45	50	45

1. Day time hours: 6.00 am to 10.00 pm
2. Night time hours: 10.00 pm to 6.00 am
3. Silence zone: Zones which are declared as such competent authority. An area comprising mot less than 100 meters around hospitals, edictional institutions and courts.
4. dB (A) Leq: Time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

Source: National Environmental Quality Standards (NEQS) for Noise, 2010

AC12.2 Photos of Water Environment in Faisalabad

Wastewater in town
Overflow of domestic wastewater.

Wastewater in town
Roads are inundated due to lack of drainage.

Wastewater in Suburb
Untreated industrial effluent is discharged to the environment

Wastewater used for Irrigation
Raw wastewater is used as source of irrigation water for agriculture.

Drainage Channel
Storm water drainage channels are used as wastewater drains receiving domestic wastewater.

Drainage Channel
The storm water is discharged by pump.

Drainage Channel
New drainage channels are ineffective to collect storm water.

Drainage Channel
Solid waste disposal to the drainage channel.

Industrial Wastewater
Industrial effluent is discharged to the environment

Industrial Wastewater
Untreated colored wastewater is drained to WASA sewer at the factory.

Industrial Wastewater
Large amount of industrial effluent is discharged from pumping station (PS-38).

Industrial Wastewater
Extensive use of blackish groundwater and industrial discharge without any treatment.

AC12.3 Photos of Surroundings of Proposed Wastewater Treatment Plants

Chokera WWTP (West)
Diagram of current treatment system

Chokera WWTP (West)
Satellite image of surroundings

Chokera WWTP (West)
Facultative pond

Chokera WWTP (West)
Experimentation of floating wetland

Chokera WWTP (West)
Accumulated sodium alkylbenzene sulfonate (ABS)

Chokera WWTP (West)
Treated wastewater discharged to agricultural lands

New West WWTP candidate site
Satellite image of surroundings

New West WWTP candidate site

New West WWTP candidate site

New West WWTP candidate site

New East WWTP candidate site
Satellite image of surroundings

New East WWTP candidate site

New East WWTP candidate site

New East WWTP candidate site

Final Disposal Site

Final Disposal Site

Final Disposal Site

Final Disposal Site

AC12.4 Stakeholder Meeting Report

(1) Proceedings of 1st Stakeholder Meeting (SHM-1)

Initial Environmental Examination (IEE) process forms a part of the JICA-WASA M/P Project. Under this component, the first stakeholder meeting (SHM) was organized by JICA Mission Team (JMT). The date, venue, objectives the meeting are as under:

Date : 28th September, 2017
Venue : Conference Room, WASA Faisalabad.
List of participants: Attached as **Annex-1**.

The objectives of the SHM are:
- To provide key stakeholders with information regarding the findings of the study and proposed long-term plan of water supply and sewerage in Faisalabad under the project.
- To provide an overview of the environmental and social assessment and Public Participation Process (PPP) being followed for the proposed project.
- To provide an opportunity for key stakeholders to seek clarity and provide input into the project.
- To record comments raised and include them in the Interim Report of the project.

Agenda of the meeting including presentations made are as under:
- Overview/ Scope of M/P
- Environmental and Social Considerations
- Discussion
- way forward

1) Summary of Presentation in SHM-1
An overview of M/P for formulating a strategy for the development/improvement of water supply services and sewerage/drainage system in Faisalabad was presented in the meeting. The information provided is summarized as under:

Water Supply
Water supply sources comprise of ground water and surface water in Faisalabad. The sources of ground water are government owned tube wells/ private wells and river water (Chenab River/RBC, JBC and GBC). WASA-F is responsible for delivery, maintenance and management of water supply system. The current water supply situation is highlighted below:

- Actual Water Supply in 2017 : 247000 m3 /day
- Total Water Demand in 2015 : 287000 m3 /day
- Current Water supply service: 6 hours or less from
- Insufficient water quantity with low pressure

Issues
- Over/illegal pumping from tube wells causes groundwater depletion
- Mostly pipes do not have water meters
- Water containing high salinity content
- Low operation rate of water treatment plants (JKWTP-empty filters)
- Intermittent low operation of pumps (6hr/day) at terminal reservoir & pumping station along with Inability of manage water distribution

Targets Proposed in M/P
- Total Water Demand estimated in 2038: 1252000 m3/day
- Water supply service/operation : 24/7

- Sufficient water pressure : 12m
- Sufficient water quantity: 145litres/capita/day
- Safe water quality: WHO guidelines by establishing water quality system in WASA
- Step-wise development (groundwater + surface water) based on the future demand

Considering the above planning, two scenarios were studied for the development of water sources to achieve the future demand & other targets in the M/P. Scenario-1 mostly provides for short and medium terms proposals which mainly aims at development of well fields and canals (JBC, RBC, GBC), whilst Scenario-2 apart from taking intake from canal water on short term basis, primarily focuses on development of well field, of Chenab River. In financial terms Scenario-1 is cost effective, whereas Scenario-2 involves huge investment.

Environmental & Social Considerations

- Environmental Impacts
  - Water usage or water right
  - Depletion of groundwater
  - Generation of sludge & wastewater from WTPs
- Social Impacts
  - Land acquisition for the TR & OHR/GR sites
  - Evacuation & demolition during construction stage
- Other considerations
  - Traffic congestion during construction stage
  - Noise & vibration
  - Air pollution

Sewerage & Drainage

The vast majority of industrial effluent is discharged "raw" without any treatment into two main drains that are Paharang drain to the North West and Madhuana drain to the South East. Paharang Drain eventually discharges to the Chenab River and Madhuana Drain to the Ravi River; both drains are managed by the Irrigation Department.

In order to assess the quality of water being discharged into Main Drains and to estimate the results of planned sewerage system on reduction of pollution loads, a survey along Main Drains within target area of the project and that of Chenab & Ravi Rivers is conducted. Sampling method and flow rate measurement to estimate the pollution loads is summarized as under:

- Water Quality Analysis on Main Drains
  - Sampling points: Madhuana Drain 4, Paharang Drain 10
  - Parameters: Temp, pH, SS, BOD, COD, SS, NO2-, NO3-, NH4+, T-N, T-P, Oil, SO4-, CN-, Phenol, Cu, Zn, As, Cr, Pb, Cr, Hg, Ni, Coliform (total 24)
- Water Quality Analysis on Main Rivers
  - Sampling points: Chenab River 2, Ravi River 2
  - Parameters: Temp, pH, EC, SS, DO, BOD, COD, SS, NH4+, Coliform (total 8)
- Flow rate Measuring (to estimate the pollution loads)
  - Velocity & Section area at drains and rivers
  - Pumping operation at pump stations

Major Conclusions of the survey:

- Water quality of Main drains as well as that of rivers exceeds NEQS/WHO guidelines.
- Drain and river water is heavily polluted with domestic & industrial waste water.

Planning Proposed for Domestic Waste Water in M/P

- Basic Planning

- Expansion of sanitary sewer network
- On-site sanitation facilities for the low populated areas

- Sewers & Pumping Stations
  - Increase of the capacity of sewers
  - Installation of sewer pipes collecting WW instead of open drainage channels
- Wastewater Treatment Plants (WWTP)
  - Renovation of Chokera WWTP
  - Preparation of appropriate sites for new WWTPs
  - Treated WW shall be used for agricultural purposes

Planning Proposed for Industrial Waste Water in M/P

- Main issues
  - Acceptance of industrial WW to sewerage system of WASA-F
  - Installation/operation of pre-treatment facilities in factories
- Regulation to control the IWW quality
  - Strengthening regulations & observing compliance
  - COD, TDS & toxics shall be reduced by pre-treatment
  - Dedicating penalty for violation
- Monitoring of IWW
  - Data collection for enhanced registration & inspection system
  - Improvement of WASA-F lab to analyze key parameters
  - Establishment of sustainable monitoring system

Environmental & Social Considerations

- Environmental Impacts
  - Hydrological situation/water quality (to be improved)
  - Generation of sludge from WWTPs
- Social Impacts
  - Land acquisition for the WWTP sites
  - Evacuation & demolition during construction stage
- Other considerations
  - Traffic congestion during construction stage
  - Noise & vibration
  - Air pollution

2) Discussion/ Minutes of SHM-1

Questions & Answer including observations/clarifications made in the meeting are summarized as under:

Mr. Rohan Javed (DDT), WASA

Mr. Rohan shared his opinion on the two scenarios discussed in the presentation. According to him, for Scenario-1 (JBC, RBC, GB), the proposal has to be first discussed with the Irrigation department because the rights of canal water belongs to them. Also, Scenario-1 will solve the problem of water supply for only 20 years. Whereas, the cost of Scenario-2 is much higher than the Scenario-1 as it provides one-time investment and long-term solution catching the need of the Faisalabad for 50 years. Also, the water from the Chenab River can be supplied in accordance to the demand and volume can be increased with the increase in requirement. So, in the light of explanation provided by him, he supported the Scenario-2 to be opted.

MD, WASA, responded that the Scenario-2 is very costly as the investment required for long term to solve the water issue. However, the final decision will depend upon the availability of finances for this project. He also mentioned that east zone of the Faisalabad city possesses more pollution as compared to the west zone and there is more need to establish waste water treatment plant in east zone as compared to west zone. He requested JICA Study Team to verify their results in east and west zone.

JICA Study Team Member, Ms. Takamizawa, however informed that Scenario-1 is better because of low cost as compared to Scenario-2. Also, the feasibility of Scenario-2 depends upon the construction of Chiniot dam. She said that the JICA Study Team will further examine the Scenario-2 in detail after verifying the feasibility of Chiniot dam.

Rana Kashif Ali, S.D.O, Irrigation Department
Irrigation department highlighted their concerns about the installation of Water Pumping Radar (WPR) on the canals as proposal would require the redesigning of that part of the canal where WPR are to be installed. He was of the view that installation of WPR equipment should be undertaken under a separate project.
MD, WASA, said that in order to resolve this issue, detailed discussion would need to be held with Irrigation department.

Gul Hafeez, SIDS, The Urban Unit, Govt. of Punjab
Mr. Gul highlighted the issue regarding the institutional capacity building of WASA and suggested that the JICA Study Team should consider it while finalizing their proposal/ recommendation in the report.
JICA Study Team ensured that the strengthening of WASA is included in the scope of work of M/P.
Mr. Hafeez further states that the capacity of water supply system is proposed to be raised from 63 MGD in 2015 to 275 MGD in 2038. WASA would not be able to handle this capacity. JICA Study Team clarified that the water supply system of Faisalabad would be upgraded/ developed to cope with the augmentation of the capacity.
For the industrial waste disposal and the environmental issues, WASA should setup their Non-Environmental Cell.
Mr. Shahid Iqbal from FINITE highlighted that firstly priority projects under Master Plan would be identified, then the requirement to mitigate the environmental issues would be incorporated in the IEE/ EIA reports to be submitted for the approval of EPA which supervises/ oversees every environmental issue.
When the Master Plan will be completed, then EIA and IEE reports will be prepared and will be submitted to EPA for their approval.

Asif Kiyani (EPA)
Mr. Asif Kiyani supports the Scenario-2 and appreciates Mr. Rohan observations on both scenarios. He raised a question about how to control pollution including solid waste.
JICA Study Team states that existing solid waste management is not included in their scope of work. But they will give comments and provide guidance to manage it. They also emphasize to educate the citizens about solid waste management.

Ms. Takamizawa (JICA Study Team)
Ms. Takamizawa mentioned the stakeholders to whom she wants to discuss the details of the Master Plan Project. MD, WASA assisted her on that question.

Closing Remarks from Mr. Irfan (Vice Chairman, WASA)
Mr. Irfan pays his tribute to JICA, Government of Japan for conducting this Master Plan Project and for looking after the needs of Faisalabad city and regards their spirit. He emphasized on the importance of the Faisalabad city as one of the major Industrial city of Pakistan. He also mentioned another Tender for up gradation of Terminal Reservoir in Faisalabad City, worth 1.6 billion Pak Rupees. He discussed the installation of new public stations and lines in the city. After the construction of 2nd Treatment Plant, WASA will be able to provide 100% potable water to the local people of the city. Mr. Irfan also emphasize on the installation of waste water treatment plant on both east and west side of the city.

Way Forward
- Finalization of Interim Report

- Planning & design of priority project
- Cost estimation of M/P & priority project
- Financial evaluation
- IEE level survey of priority project
- Stakeholder & public consultation
- Completion of Draft Final Report

(2) Proceedings of Workshop/ 2nd Stakeholder Meeting (WS/SHM-2)

JICA Mission Team (JMT) in consultation with all the concerned departments and stakeholders involved in the formulation of Master Plan has prepared an Interim Report in November 2017. The Interim Report provided an overall overview of M/P and divulged upon priority projects for planned development and improvement of water supply, sewerage and drainage facilities in the city.
In order to update all the concerned departments, one day workshop together with second SHM was organized by WASA-F/JMT.

Date : 20th December, 2017
Venue : Serena Hotel Faisalabad.
List of participants: Attached as **Annex-2**.

The objectives of the Workshop/ SHM are:
- To provide information regarding findings of M/P & proposed long term plan of water supply, sewerage and drainage in Faisalabad.
- To provide an overview of the environmental and social assessment and public participation process for proposed projects.
- To provide clarification to queries of participants & seek their contribution for the improvement of Master Plan.
- To record comments raised & incorporate them in the draft Final Report of M/P project.

Agenda of the meeting including presentations made are as under:
- Overview/Scope of M/P relating to
  - Water Supply
  - Sewerage & drainage
- Environmental and Social Considerations
- Discussion

(1) Summary of Presentation in the WS/SHM-2

Master Plan including ensuing strategy for the development/improvement of water supply services and sewerage/drainage system in Faisalabad presented in the first SHM already was also discussed in the workshop/second SHM (herein after called as second meeting). Besides the information regarding existing situation, planned proposals in M/P etc.as provided above in para 6.1, following additional details have been divulged in the second meeting.

Direction of Water Supply planning
- Securing Water Resources
  - Step-wise development (ground & water) considering the future demand
- Improvement of Water Supply Services
  - Supply zones, transmission & distribution network, distribution centers
  - Method for improvement of service level, from vicious to virtuous cycle

- Proposed Priority Project to be initiated in three areas; Sitara Sapna city, Sarfaraz colony and Medina Town. This includes:
  - Old Jhal Khaluana WTP Renewal (10 MGD) with New DCs Construction
  - New Transmission and Distribution Network with Water Meter Procurement
  - Stepwise Development: Phase 1 (5 MGD) and Phase 2 (5 MGD)

Planned Water Supply Service (2038)

Current (2015) Target (2038)

- Served Population (domestic): 4,146,000
- Connection (domestic): 572,000
- Water Demand: 275 MGD
- Production Capacity: 277 MGD
- Coverage Area: 2 360 km2
- Use of Groundwater: 16%

Key Features:

- Step-wised development of new water sources based on short term plan for 2023, midterm plan for 2023-2028/2033 & long term plan for 2028/33-2038
- Service area divided into seven (7) supply zones with respect to water source. This includes :
  - 4 Zones from Terminal Reservoirs (TRs):
  - 1 existing TR & 3 new TRs
  - 1 Zone from RBC
  - 1 Zone from New JK WTP
  - 1 Zone from Old JK WTP
- 56 water distribution centers (WDC) are proposed to be established serving respective Administrative Zones (including 20 on private land) with OHR of 25m height & capacity=2000m^3
- Utilization of ground water would be substantially reduced from present 85% to 16% in 2038
- Components of priority projects proposed in above three areas include WDC, Water Treatment Plant, Distribution & Transmission Main Lines, & Meters

Direction of Sewerage/Drainage planning

Domestic WW Management

Basic Planning Policy

- Domestic wastewater to be collected by sewer pipes and conveyed to
- WWTP not discharged to the open drainage channels.
- Installation of interceptor sewers to maximize the capacity of sewerage network

Improvement of Sewer Network & Pumping Stations

- Increase of the capacity of sewer network
- Minimizing the number of pumping stations by deeper pipe installations
- Use of existing disposal pumps as storm-water pumps where possible

Wastewater Treatment Plants (WWTP)

- Renovation of Chokera WWTP
- Preparation of appropriate sites for new WWTPs
- Industrial WW to be treated separately

Planned Sewerage/Drainage Service (2038)

Domestic

Served Population:	4,292,000 (Including FDA City, Sadar & Khurrianwala)
Wastewater Flow:	130 MGD
Pollution Load:	242 ton/d-BOD

Industrial

Wastewater Flow:	646 MGD
Pollution Load:	584 – 659 ton/d-BOD

Design Sewer Flow: 190 MGD
Capacity of WWTP: 190 MGD
Water Quality (BOD): 80 mg/l
Coverage Area: 2 379 km2

Key Features:

- Industrial Wastewater Volume to be accepted by the WASA-F Sewerage System:
  - About 20% of Total Design Ave. Daily Flow in 2038

Industrial WW Management

Acceptance of Industrial WW to WASA-F Sewerage System

- Current ratio of Total volume of Industrial WW to non-industrial WW is 1:3 in WASA area.
- Installation/operation of pre-treatment facilities in factories

Regulations to Control Industrial WW Quality

- Strengthening regulations & observing compliance
- COD, TDS & toxics shall be reduced by pre-treatment
- Enforcement of penalty for violation

Monitoring of Industrial WW

- Data collection for enhanced registration & inspection system
- Improvement of WASA-F lab to analyze key parameters
- Establishment of sustainable monitoring system

Recommendations for Industrial WW management

- Industrial WW is harmful to biological WW treatment process. It is very difficult for WASA-F Sewerage System to accept all amount of industrial WW. It is therefore recommended:
- Separate Industrial WWTP for Khurrianwala
- Shifting of major Industrial Estates to M3 in future
- Large sized factories should treat their own Industrial WW in compliance with NEQS
- WASA-f may accept industrial WW once their effluent quality is complied with quality agreed to by the WASA-F.
- To establish the **Industrial Wastewater Management Unit in WASA-F-** responsible for application, monitoring and inspection of industrial units served by WASA-F sewerage under **the Sewerage and Drainage Faisalabad Regulation (2015).**

Environmental & Social Considerations

In addition to the impacts described in the above section (first SHM proceedings), it is worthwhile to state that land would be required for Construction of:

- OHRs proposed on public/private land with area of one Centre amounts to 1500m^2
- TR near Narwala Road Bypass Satiana Road with area of one reservoir of 10000m^2
- Gugera WTP &TR & Jhang WTP with area for one WTP of 10acre
- Chokera WWTP with 550 acres & Mew West WWTP with 710 acres
- Eastern WWTP with required area of 1100 acres

It is also imperative to carry out effective coordination with stakeholders for

- Identification of Project Affected Persons (PAPs)
- Public consultation and compensation where necessary
- Permissions regarding road & transport, canal, environment
- Arrangement of construction waste & sludge disposal
- Technical assistance from universities
- Scarcity of water resources in Faisalabad
- Importance of water saving
- Proper disposal of waste no to sewerage or drainage
- Enforcement of regulations and observation of compliance

Discussion/ Minutes of Work-Shop & SHM-2

A gist of discussions in the form of Questions & Answers including observations/clarifications made as well as input provided by the participants in the workshop is presented below:

Q.1
Whether or not any study has been undertaken to assess/examine the extent of contamination both in surface water (S/W), & underground water (U/G) because of presence of lot of Silt, toxic industrial effluent, particularly Arsenic particles. If not, it would be more appropriate to carry out a detailed study before the installation of Water Treatment Plant (WTP).
Answer
Mostly the U/G water was found to be contaminated with chemical including Arsenic particles. It is planned to provide WTP for S/W while WTP has not been considered to be installed for U/G water. It is, however, agreed to incorporate the proposal to conduct a detailed study before installation of WTP, in the Master Plan (M/P).

Q.2
Treatment of surface water containing Industrial Waste/toxic material is a major problem which has become very severe in intensity in the city. The presentation made by DD WASA-F does not indicate as to how many treatment plants are required. Is there any plan for a specified number of treatment plants proposed to be installed in M/P for Faisalabad?
Answer
It was informed that M/P has proposed stage-wise development schemes under Scenario-1 including priority projects for the rehabilitation & improvement of existing old WTP and the installation of new WTP. Under Scenario-1, the water Supply Service system is proposed to the developed through integration of canal water while the system under Scenario-II is based on the use of Chenab river water. The Scenario-I, being cost effective, is proposed in the development of water supply service system as under:

Water Source/Development Project	Design Capacity (MGD)	Name of Water Sources	Term	Target Year
Surface Water				
Renewal of Old JKWTP	10	RBC	Short Term	2023
New JKWTP	05	RBC	Short Term	2020/ 2023
Jhang WTP-1	20	JBC(upper)	Mid Term	2028
Jhang WTP-2	40	JBC (upper)	Long Term	2038
Gugera WTP-1	25	GBC(lower)	Mid Term	2023
Gugera WTP-2	25	GBC(lower)	Mid Term	2028
Gugera WTP-3	25	GBC (Lower)	Long Term	2033
Ground Water				
JBC new well	10	JBC (Upper)	Mid Term	2028
JBC exp-well	10	JBC (Upper)	Mid Term	2033
Gugera-1-well	05	GBC (Lower)	Mid Term	2023
Gugera-2-well	05	GBC(Lower)	Mid Term	2028

Under the priority projects, the existing old JKWTP constructed in 1935 with slow sand filtration plant having original capacity of 3.5 MGD, is proposed to be rehabilitated /renewed through installation of rapid sand filtration system. This would augment the capacity from 3.5 MGDE to 10 MGD, to cater for the consumer demand which has been growing rapidly manifold since then.

Q.3
Water of Gugera Branch Canal (GBC) is highly contaminated. What measures are being proposed to resolve this problem?
Answer
Both surface water and ground water have been proposed to be purified through rapid sand filtration system. A total of three (3) WTP for surface water and two WTP for ground water are proposed to be constructed at GBC (Lower), as evident from the above table.

Q.4
Water supply gets affected or suspended during the closure of canals. How the demand would be met during this period. What proposals are being made to ensure sustainable operations of the water treatment plant during the closing period of canals? Haphazard
Answer
Irrigation Canal is an important source of surface water. Being a direct source of irrigation water, the maintenance of canals is considered imperative. Three (3) branches of canal water, (JBC-upper, RBC & GBC-lower) are affected due to the closure of LCC feeder and lower channel canals respectively. Considering the standard closing period, the effect of canal closure can be minimized through construction of water supply network so as to complement each other for the closure period of few days. To ensure the stability in the flow of surface water and to meet the required demand during the canal closure period, the option is to develop surface water source by constructing new water treatment plants facilities by acquiring direct intake water from an irrigation canal. However, the direct intake solution may involve constraints like incurring high cost and taking long time to negotiate with the Irrigation Department. Furthermore, the duration of standard closing period is at least 18 days which has increased to almost one month in recent years. This period needs to be reduced to minimum of 15-18 days. It was informed that adjustment needs to be made to avoid overlapping of the closing periods of two canals JBC & GBC, which can be made by shifting/staggering the closing period of JBC and GBC.
It may be proposed to Irrigation Department that more water can be withdrawn from canals like JBC during the closing period of other canals such as GBC. The negotiation for procuring direct intake of water of 25 MGD from GBC and 20 MGD from others with the Irrigation Department is in progress. It was further pointed out that reuse of waste water after treatment is also under consideration. An agreement with Government of Denmark has been signed for carrying out a feasibility study in this regard.

Comment
There is no procedure/method that can be followed medically for extracting Arsenic from the human body if water containing Arsenic is used. It would be more appropriate to eliminate Arsenic contents in the drinkable underground or surface water.
Answer
As compared to Lahore, no such problem exists in Faisalabad. The Arsenic contents amount to 10 microgram/liter in the water in Faisalabad city which is below than the WHO standard.
Installation of RO plants is under way to overcome this problem in Lahore.

Comment/Question 5
Competition seems to be observed between Agriculture and Water Irrigation sectors in Punjab/Pakistan. With the increase in population this competition also increased while the quality of drinking water is continued deteriorating which is of major concern for the public/water users. The question is to what extent the treatment should be carried out for the improvement of quality of the canal water.
Answer
Regarding the quality of the surface water through canals, it was clarified that water treatment is being carried out following the WHO standards which are being used all over the world and provide robust criteria for checking the quality of water taken from the surface water sources i.e. canals, rivers etc. It was further divulged that treated canal water is being used for both drinking and irrigation purpose. An example of Vietnam was quoted, where treatment is performed for drinking water only. Regarding contamination in water being used for household purposes, efforts are being made to supply clean/treated

water on regular basis. The performance of WASA-F in this regard is being improved on sustainable basis and day by day.

Comments
In the use of water resources, preference/priority seems to be given to the surface water sources, which are estimated to be gradually depleting. The sustainability of water supply sources especially that of surface water, is considered to be a real challenge. The Irrigation Department had not been able to supply water for drinking and even for irrigation purposes on sustainable basis. Whether any Risk Analysis has been undertaken in the M/P, to ensure sustainability?
Answer
Team leader of JICA study team responded that there was a scarcity of water resources in Pakistan including Punjab/Faisalabad as compared to the other countries like Thailand, Laos etc. where rivers are large and water is abundantly available. In Pakistan the availability of water on sustainable basis is a critical issue and poses big challenge. The Risk Analysis is a theoretical matter; however, the M/P underscores the need of backup support for the sustainable water supply from the surface water sources especially the canal water. Referring to planned water intake from canals, about 160MGD of treated water has been proposed to be taken from three branches of canals (Jhang BC, Rakh BC & Gugera BC), which amount to 5% of total canal water in 20 years. It was further brought out that an agreement with Irrigating Department was reached to supply 20 MGD waste water after treatment.

Q.6
Weather, WASA-F possesses, their own water distribution centers (WDC) if so, how many are owned by WASA in Faisalabad.
Answer
A water distribution center consists of Overhead Reservoir (OHR) + Ground Reservoir (GR). Currently Seven (7) WDCs are functioning at following sites in the Faisalabad city:

Abdullah pur	:	1
Medina Town	:	2
People's Colony	:	3
Head water works	:	1
Total	:	7

A total 56 WDCs are planned to be established with each OHR is 25 m in height. Of these, 20 WDCs (OHR/GR) are proposed to set up on private land, while the rest would be constructed on public land. Explaining the water supply facilities, WASA-F apprised the participants, with the aim of producing portable water to each and every home situated within its operational area. WASA-F has been suffering from the budgetary constraints for implementing the water source development projects for drinking purpose. The network has been developed whose O& M cost is on high side but the revenue fell short of the cost because of low/poor recovery of outstanding dues. At present, the water requirement of Faisalabad City stands at 130 gallons per person per day and WASA-F has not been able to meet this demand. Nor is WASA-F now maintaining 24/7 water supply in the city. This can only be accomplished with the cooperation of water users who would be willingly paying water charges on regular basis.

Q.7
Is the saline/waste water acceptable after treatment for drinking?
Answer
It was explained that after proper treatment through water treatment plant as well as following RO method for eliminating Chemical/toxic elements, the water can be used for drinking, other household activities and irrigation purposes.

Q.8
Water contamination issue exists due to mixing of water supply and drainage/ sewerage pipe lines. The reason among others is that two pipelines are laid very close to each other and that too on one side of the streets. This issue needs to be resolved on priority basis.

Answer
It was responded that both water supply lines and sewerage pipes are very old and laid very close to each other. Due to lack of maintenance and wear & tear, the condition of pipe lines has deteriorated with the passage of time, consequently the contents of the pipes got intermingled with each other. WASA-F is striving hard to get rid of this problem and it is expected to resolve this issue in a period of six months.

Comments/Question 9
It appeared from the presentation that M/P has emphasized to follow projects with proper engineering design/techniques for the provision of clean water to the city. No mention regarding Water Quality Index seems to be made in the M/P. Water Quality Index, being an important issue especially in view of the fact that quality of water is changed on hourly basis, needs to be addressed in the M/P.
Answer
It was clarified that water Quality Index depends upon a number of items. WASA-F has already been affiliated with American Association regarding clean water supply system. In this regard WASA-F is following the parameters presented by the American Association and shares information with them. However, considering the importance attached to assessment of water quality, it was agreed to incorporate the Water Quality index in the final report of M/P.

Q.10
There are many industries situated in and around Faisalabad. How many industries have installed the treatment plants for processing the industrial effluent/waste water?
Answer
It was elaborated that the issue regarding availability of treatment plant and its operation in the industries has been studied in detail and included in the Interim Report of M/P. Majority of the industries (about 70%) have been shifted to Industrial Estate and few (i.e. 30%) are still working in and around city. Most of the Industries have their own treatment plants, which are not operating most of the time. No proper monitoring system has been established so far to judge the performance of treatment plants owned by the industries.
It was informed that WASA-F (Government of Punjab) have signed an agreement with Government of Denmark to undertake a Feasibility study of processing / treatment of industrial waste water and its disposal through drainage. The study is estimated to cost Rs 15 billion, of which 35% would be provided as a grant and remaining 65% loan by the Danish Government.

Comment
In order to derive the desired benefits from the project for providing water supply, sewerage & drainage system in Faisalabad as identified in M/P, it is imperative to ensure implementation of projects & recommendations as planned both for long term and short-term solutions.

Answer
WASA-F Authorities ensured that with the support of government, other organizations, public representatives and academic institutions, every effort would be made to arrange and provide finances required for the implementation of projects recommended in the M/P.
Moreover, WASA-F invited the participants of workshop particularly the professionals from the Agricultural University, WWF, etc., to share information regarding studies (to be carried out or already completed). The case in point is the provision of comprehensive treatment plant for Kurianwala city, for which concept paper is required to be shared with the WASA-F for review/examination.
It was also revealed that the Geo-Tag study regarding sewerage system for Faisalabad has been prepared by the Agricultural University of Faisalabad. WASA-F while appreciating the technical input being made for the sewerage/drainage development in the city, requested the concerned organization to share a copy of this study with JICA study team as the very objective of this meeting is to share views and, disseminate knowledge for the improvement and development of water supply, sewerage in Faisalabad.

Regarding the participation of public Representation in the workshop, it was explained that Vice Chairman WASA-F is a public representative and attending the workshop. In this regard it was informed that design of Dhoriwala Nula has been remodeled to overcome the problem of choking of sewerage system in the area during monsoon. Similarly, the sewerage system of Khannawala which becomes choked during monsoon has been planned to be improved on priority basis to overcome the problem.

FINDINGS OF SHM'S/ WORKSHOPS

- The most important stakeholders are mainly governmental Departments, such as WASA-F, Irrigation Department, CDGF/District Offices, FDA, EPD, Concerned Provincial Departments/Punjab EPA etc. Many have been deeply involved in the planning process and contributed towards the formulation of M/P. The stakeholders include the sectors that would influence the implementation of M/P. For example, EPD/Punjab EPA would evaluate the environmental management of the projects although it did not participate in the planning process, and FDA would review the management of land use of the M/P project. In nutshell, it is preempted that all of these stakeholders would be able to greatly gain from the meetings/ workshop.
- Feedback received from the stakeholders/ participants would largely contribute towards the better improvement and development of M/P in the planning process/stage. The suggestions/proposals made by the stakeholders especially professionals/ professors from WASA-F, Irrigation Department and Faisalabad Agricultural university would not only help formulating the practical approach for implementation of M/P recommendations but also provide short/medium term plans to meet the ever-growing water demand.
- In conclusion, the SHM/ workshop has provided good opportunity to integrate the opinions of the stakeholders into decision making.

Water Sources Development Plan, two alternative scenarios of water source development plan were examined: Scenario-1) development of well field and canals (JBC, RBC, GBC), and Scenario-2) development of well field, canal and Chenab River.

ANNEX-1 List of Participants SHM-1

Stakeholder Meeting on Master Plan of WASA Faisalabad
JICA Master Plan Study Team
28 September 2017
Conference Room, WASA - F

Sr. No	Name	Designation & Department
1	Faqir Muhammad Ch.	MD - WASA
2	Khalid Javed	Municipal Officer (Infrastructures)
3	Dr. Haroon Rashid	Lecturer Dept of Struct & Env. Engg Uni of Agri. Fsd.
4	M. Naeem	MSE Specialist (The Urban Unit)
5	Gul Hafeez	SIDS The Urban Unit
6	Rana Kashif Ali	S.D.O Irrigation Dept
7	Asif Gillani	Environment Specialist (The Urban Unit, FSD)
8	Shaukat Hayat	DD EPA FSD
9	Waseem Ahmad Hashmi	DMD (S) WASA
10	Muhmmad Khalid	DMD € Wasa
11	Adnan Nisar	Director P&D Wasa
12	Shoaib Rashid	Director RMO 1
13	Zahid Pervez	Director (Admin.)
14	Ejaz Latif	Dir (ODM) W
15	Ryunan Matsue	JICA Mission Team
16	Harutoshi UCHIDA	JICA Mission Team
17	Kiyoko Takamizawa	JICA Mission Team
18	Naoto Takatoi	JICA Mission Team
19	Kaora Suzuki	JICA Mission Team
20	Itsuro Matsubara	JICA Mission Team
21	Yasuhiro Matsuoka	JICA Mission Team
22	Akira Kohara	JICA Mission Team
23	Dr. Shahid Nasir	Finite Engineering
24	Hafiz M. Awais	Asst. Director
25	Roohan	DD (Tech)/ W. R
26	Asad Ali	Deputy Director (FFP)
27	Sultan Azam	JMT
28	Kamran Raza	(O&M) E
29	Syed Shujja Haider	Project Coordinator JMT
30	Shahid Iqbal	Finite Engineering
31	Irfan Mannan	V. Chairman WASA
32	Ishtiaq Ahmad Khan	IRC Specialist (The Urban Unit)

ANNEX-2 List of Participants WS/SHM-2

2nd Workshop/ Stakeholder Meeting on Master Plan of WASA
JICA Master Plan Study Team
12/20/2017
Conference Hall, Serena Hotel Faisalabad

Sr. No.	Name	Designation & Department
1	Muhammad Shabbir Afzal	Deputy Director Agriculture (Ext) Faisalabad
2	Prof Dr. M Arshad	Chairman Department of Irrigation & Drainage University of Agriculture FSD (UAF)
3	Dr. R Naiz Ahmed	Director, Water Management UAF
4	Dr. Lubna Anjum	Lecturer, Dept. of Irrigation & Drainage Agri. Engg. UAF
5	Engr. Wajeeha Qamer	Assistant Professor, Civil Engineering Dept. NFC IEFR FSD
6	Engr. Abubaker Ijaz	Duty Director (Tech), Energy Management Cell Water Resources, WASA FSD
7	Abul Ghaffar Naveed	Deputy Director, WASA, FSD
8	Aamer Aziz	Additional DG FDA
9	Dr. Muhammad Asif Shazad	District Health Officer, Preventive Services, FSD
10	Muhammad Saleem Bhathi	SE LCC East Irrigation, FSD
11	Dr. Shaid Nasir	Director Finite Engineering, (Pvt) ltd.
12	Ms Kiyoko Akamizawa	JICA M/P Mission Team
13	Shujjaa Haider	Project Coordinator, JICA Mission Team
14	Sultan Azam	JICA M/P Team
15	Ghulam Murtaze	SELCC West Irrigation, FSD
16	Syed Faisal Hassan	Engr. Operation & Maintenance SNGPL
17	Kamran Raza	WASA (O&M), FSD
18	M Farhan Akram	DD WASA, FSD
19	M Abdullah	Project Coordinator, WWF
20	Ali Shan Arif Makhdum	Environmental Officer, WWF
21	Mubasher Ahmad Cheema	Technical Skills Training Specialist (check department/ Address)
22	Zia Mustafa	Water Specialist, Aljagdi Academy, Urban Unit (Check Aljagdi)
23	Ejaz Latif	Director (O&M) WASA, FSD
24	Muhammad Ali	Deputy Director (Tech), P&D Department
25	G. Mustafa	Psychologist (Check designation & department)
26	Faqir Hussain Babar	Director, PHS, WASA FSD
27	Shahbaz latif	DDR (I&C), WASA FSD
28	Zahid Pervaiz	Director Rev (IDL), WASA FSD
29	Burira Anam (check name)	AD (GIS), WASA, FSD
30	Samreen Ashraf	AD (GIS), WASA, FSD
31	Farhat Adibbia (check name)	SRO, WASA, FSD
32	Shahida Rehman	AD, WASA, FSD
33	Muhammad Shaukat Ali	Ex DMD, WASA, FSD
34	Shoaib Rashid	Director Rev (Domestic), WASA FSD
35	Haroon Rasheed	Director Admin, WASA FSD
36	Muhammad Khalid	DMD, WASA, FSD
37	Waseem Ahmed Hashmi	DMD.D.(S) WASA, FSD
38	Adnan Nisar Khan	Director, WASA, FSD

Sr. No.	Name	Designation & Department
39	Rana Asif Muhmood	Chief Engineer, Irrigation Dept. FSD ZONE
40	Faqir Muhammad CH	MD-WASA, FSD
41	Irfan Mannan	Vice Chairman - WASA, FSD
42	Hoshino Takashi	Team Leader, JICA Mission Team
43	M.Riaz Kamoka	U-C Chairman
44	Gul Hafeez	SIDS - Urban Unit
45	Hafiz M.Awais Jamal	Asst. Director (Project), WASA, FSD
46	Saqib Raza	WASA, FSD
47	Usman Latif	WASA, FSD
48	M.Maqsood Ahmed	WASA, FSD
49	Atiq-ur-Rehman	WASA, FSD
50	Abdul Raouf Butt	WASA, FSD
51	Muhammad Ashraf	Resident Engineer
52	Muhammad Nouman Noor	Assistant Director (Tech), water Resources Directorate, WASA FSD
53	M.Farhan ali	Deputy Director, I.T, WASA, FSD
54	M.Fasial Mirza	Research Associate
55	Azhar Azeez	PRO, WASA, FSD
56	Laiba Tanveer	Survey-Assistant, JICA Mission team
57	Asad Ali	Deputy director, (FFP), WASA Faisalabad
58	Ghulam Shabbir	Deputy Director (P&D)
59	Umar Iftikhar Khan	DD (Admin) WASA, FSD
60	Shahid Iqbal	Consultant, Finite Engg. (pvt.) Ltd, Islamabad

APPENDIX CS EXAMPLE OF SEWERAGE PLAN IN CHAK JHUMRA TOWN

The wastewater management in Chak Jhumra Town is proposed to be done by sanitation facilities up to 2038 in the M/P. It is recommended that the sanitation facilities are improved with the technical and financial assistance of universities and NGOs. The PHED is responsible for instructing the private and public owners and the contractors for the improvement of sanitation facilities and the proper maintenance of sanitation facilities such as regular desludging and the sludge disposal.

If the sewerage facilities were planned to introduce by the provincial government with appropriate budget arrangement, the sewerage facilities would be managed, operated and maintained by the municipality with financial and technical assistance of the PHED. In the following sections, a design of sewerage system is presented as an example.

ACS.1 Sewerage Planning Basis

Based on the planning bases of the water supply plan for the Chak Jhumra Town, the design influent flow rates and the design influent quality in terms of BOD concentration are set as shown in Table ACS.1.1. The effluent BOD concentration is set at 80 mg/L to comply the Pakistan's NEQS.

Table ACS.1.1 Planning Bases of the Sewerage System for Chak Jhumura

1) Design Influent Flow Rate (m3/d)			
Population served	**53,000**	person	
Per capita wastewater generation	96	lpcd	=120x0.80
Domestic wastewater	5,088	m3/d	=53000x0.96
Commercial wastewater (15% of Total wastewater generation)	898	m3/d	
Total wastewater	5,986	m3/d	
Rounded designe wastewater flow			
Domestic wastewater	5,090	m3/d	
Commercial wastewater	900	m3/d	
Total design wastewater flow rate	5,990	m3/d	
I/I of groundwater (5% of Total Flow)	300	m3/d	
Design Influent flow rate	6,290	m3/d	
Rounded	**6,300**	m3/d	
2) Influent Design Quality (BOD)			
Populaton served	53,000	person	
Unit BOD load generation rate	40	gBOD/d･person	
BOD load of domestic wastewater	2,120	kg/d	
Commercial wastewater flow	900	m3/d	
Typical BOD conc. in the commercial wastewater	200	mg/L	
BOD load of commercial wastewater	180	kg/d	
Total BOD load	2,300	kg/d	
Total design influent flow rate	6,300	m3/d	
Influent BOD concentration	**365**	mg/L	
Effluent BOD concentration	**80**	mg/L	

ACS.2 Sewer Plan

ACS.2.1 Sewer Design

Table ACS.2.1 presents the sewer design sheet.

Table ACS2.1 Sewer Capacity Calculation Sheet for the New Sewers in the Chak Jhumra (Example)

Population ($x10^{3}$)	Peaking Factor	Population ($x10^{3}$)	Peaking Factor
Up to 5	4.5	From 25 to 50	3.0
From 5 to 10	4.0	From 50 to 100	2.5
From 10 to 25	3.5	More than 100	2.0

Sewer No.	Incoming Sewer	Sewerage Area (ha) Increment	Sewerage Area (ha) Cumurative Total	Sewer Length (m)	Domestic Wastewater Flow: Unit Generation Rate (LPCD) 96 — Population (thousand) Increment Total	Service Population (thousand) Increment Total	Peak Factor	Domestic WW Flow (m^3/sec)	Point Souce: Industrial WW Flow (m^3/sec)	Commercial WW Flow (m^3/sec)	I/I of Ground water Flow (m^3/sec)	Design Max. Flow (m^3/sec)	Sewer Line Design: Dia. (mm)	Slope (‰)	Velocity (m/sec)	Capacity (m^3/sec)	Remarks	Ratio of Design Flow against Capacity
C1		30.00	30.00	473.00	3.686	3.686	4.5	0.018	0.000	0.001	0.000	0.019	○ 300	2.00	0.61	0.043		0.45
			To C4		3.686	3.686												
C2		64.00	64.00	1133.00	7.863	7.863	4.0	0.035	0.000	0.002	0.001	0.038	○ 375	1.50	0.62	0.068		0.56
			To C4		7.863	7.863												
C3		32.00	32.00	884.00	3.931	3.931	4.5	0.020	0.000	0.001	0.000	0.021	○ 300	2.00	0.61	0.043		0.48
C4	C1, C2	0.00	126.00	103.00	0.000	0.000	3.5	0.060	0.000	0.003	0.001	0.065	○ 500	1.00	0.61	0.119		0.54
			To C6		15.480	15.480												
C5		55.00	55.00	1,097.00	9.361	9.361	4.0	0.042	0.000	0.002	0.001	0.045	○ 375	1.50	0.62	0.068		0.66
C6	C4	139.00	320.00	1,008.00	23.659	23.659	3.0	0.162	0.000	0.010	0.003	0.175	○ 750	0.60	0.62	0.272		0.64
			To C8		48.500	48.500												
C7		73.00	73.00	1,009.00	4.500	4.500	4.5	0.023	0.000	0.000	0.000	0.023	○ 300	2.00	0.61	0.043		0.52
C8	C6	0.00	393.00	3,200.00	0.000	0.000	2.5	0.147	0.000	0.010	0.003	0.161	○ 750	0.60	0.62	0.272		0.59
		To WWTP			53.000	53.000												

ACS.2.2 General Plan of Sewer

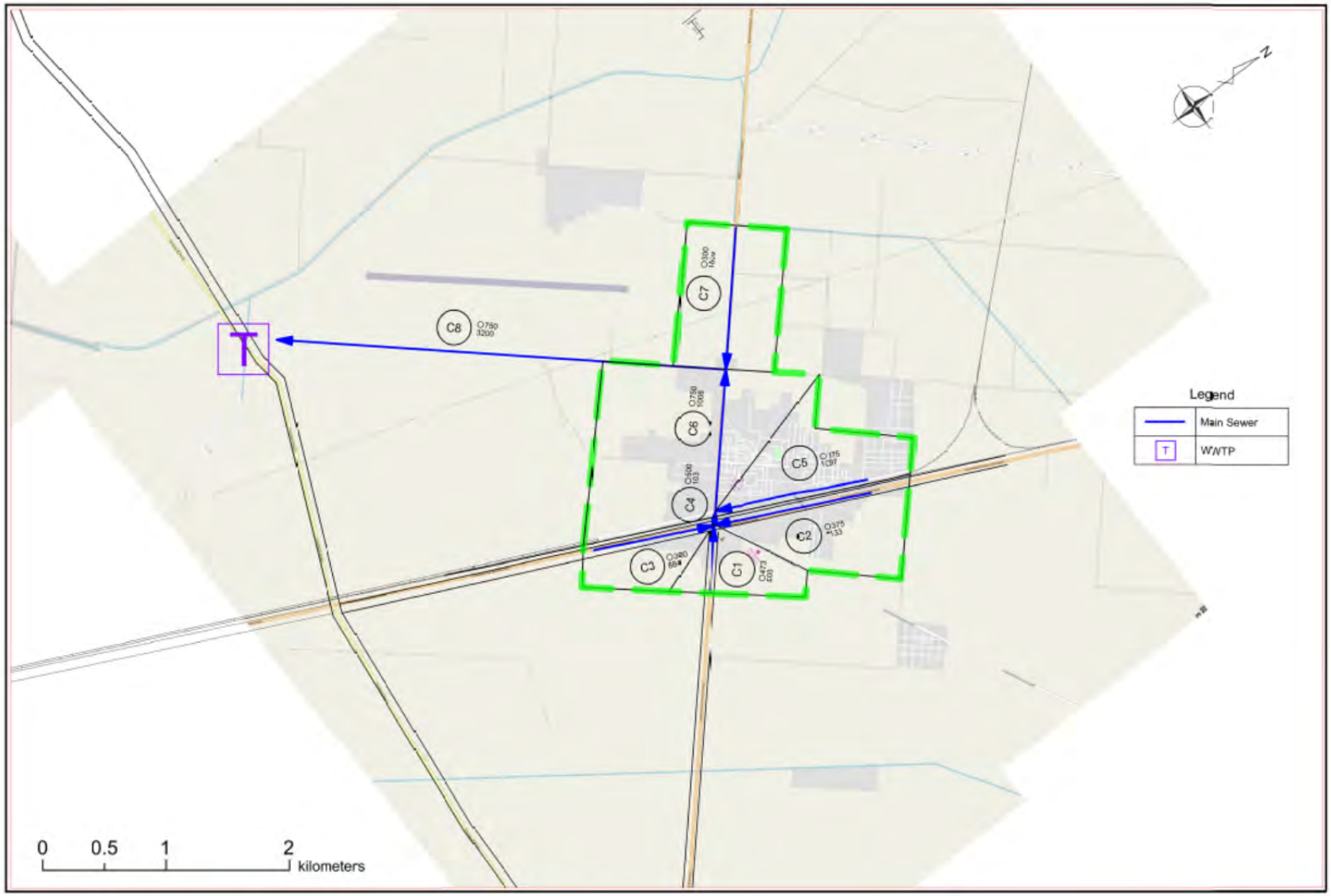


Figure ACS2.2 General Plan of Sewer

ACS.3 Plan of Wastewater Treatment Plant

ACS.3.1 Design Conditions

The design conditions are set based on the sewerage planning bases in the previous section.

- Average influent flow: 6,300 m^3/d,
- Design Influent BOD concentration: 365 mg/L, Design Effluent BOD concentration: 80 mg/L, and Design Air Temperature is 17.5℃

ACS3.2 Design calculation of Wastewater Treatment Process

The stabilization pond system (Anaerobic ponds + Facultative ponds) is selected as the most appropriate wastewater treatment processes for Chak Jhumra WWTP. Because the wastewater treatment process is most suitable because of easiness in O&M and low cost in construction and operation and maintenance. The detailed studies on selection of wastewater treatment process have been presented in the Chapter C9 of the Main Report.

In the followings, the preliminary design of stabilization ponds system are presented under the above design conditions.

(1) Anaerobic ponds anaerobic pond

Facility design based on the concept of Duncan Mara.

Anaerobic pond volume is derived by the following equation:

$V_a = L_i \cdot Q / \lambda_v$

where,

V_a=anaerobic ponds volume, m^3

L_i=influent wastewater BOD, mg/L;

Q=influent wastewater average flow, m^3/d;

λ_v = volumetric design loading, g/m^3d

From Table ACS.3.1 the design loading(λ_v) for17.5℃ is 250 g BOD/m^3 /day.

Table ACS.3.1 Variation of design volumetric BOD loading and BOD removal in anaerobic ponds

Temperature (℃)	Design loading (g/m^3 d): λ_v	BOD removal (%)
<10	100	40
10-20	20*T-100	2*T+20
20-25	10*T+100	2*T+20
>25	350	70

*T=temperature,℃

Thus the anaerobic pond volume (V_a) :

$V_a = L_i \cdot Q / \lambda_v = 365*6{,}300/250 = 9{,}98$ m^3

for Check:

The anaerobic pond retention time(θ a, d)is then calculated from:
subject to a practical minimum value for θ_a of 1day

θ a= V_a/Q=9,198/6,300=1.46 d As θ_a > 1 day…….Ok

Assuming a depth of 4 m, the anaerobic pond area is 2,450 m^2 or 0.3 ha or 0.6 acre

Noted that the depth is normally in the range 2 to 5 m. Ideally the deeper the better.

At 17.5℃ the BOD removal (Table ACS3.1) is 55%, so the BOD of the anaerobic pond effluent is (0.45 × 365), i.e. 164.0 mg/L.

(2) Facultative Pond

Facultative Pond are designed on the basis of surface BOD loading (λs, kg/ha d), given by Mara's equation.

At 17.5℃ the BOD removal (Table ACS3.1) is 55%＝ (2*17.5) +20, so the BOD of the anaerobic pond effluent is (0.45 × 365), i.e.164.0 mg/L.

λ_s= 350 (1.107－0.002T)$^{T-25}$= 350 (1.107－0.002*17.5)$^{-7.5}$= 208 kg/ha d
where, T=mean air temperature of the coldest month,17.5℃

The pond area (A_f, m^2) is given by:

$A_f=10L_i \cdot Q/\lambda_s$=(10*164.0*6,300)/208=49,673 m^2=4.97 ha=12.3 acre

Where, Q=influent wastewater average flow, m^3/d;
Li=influent BOD, 164.0mg/L（the anaerobic pond effluent）

Pond depth varies from 1 to 2m, with 1.5m being typical. Taking the depth as 1.5m=D_f

The pond retention time(θ_f,d) is given by:

$\theta_f=2A_fD_f/(2Q_i-0.001eA_f)$=2*49,673*1.5/（2*6,300－0.001*5*49,673）
＝12.1 d
subject to practical minimum value for θ_f of 4days

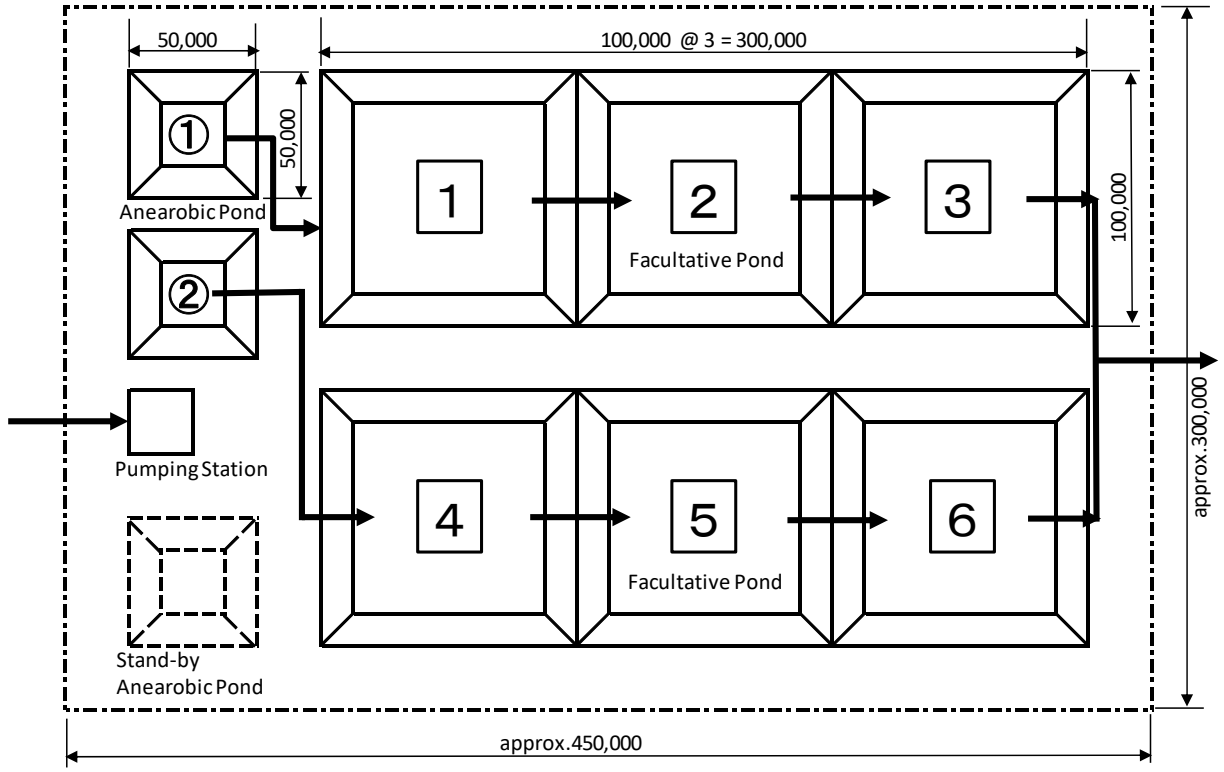
where D_f=facultative pond depth, m:1.5m
Qi=influent wastewater flow, m^3/d; 6,300 m^3/d
e= the net evaporation rate, mm/day; 5mm/day.

The BOD removal is 80%, so the facultative pond effluent is (0.20 ×365), i.e73.0 mg/L

＜References：Design manual for waste stabilization ponds in India/Duncan Mara.>

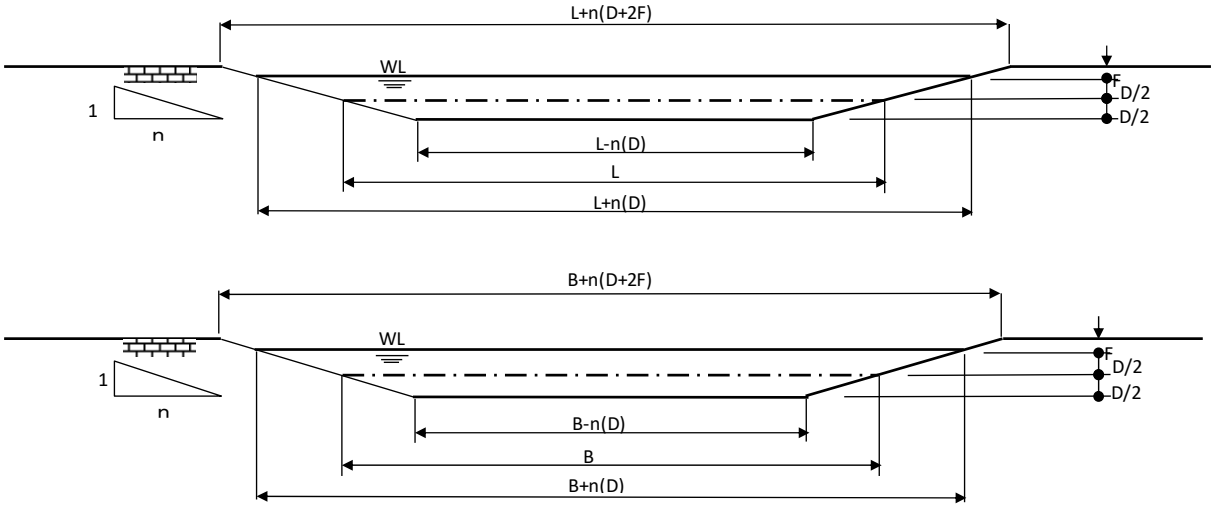
ACS3.3 Layout Plan and Section of Wastewater Treatment Facilities

An example of the layout plan and the section of wastewater treatment facilities for Chak Jhumra WWTP is presented in Figure ACS.3.1 and Figure ACS.3.2.



Note: Required land area: 13.5ha/33.4acre, Unit of length: mm
Source: JICA Mission Team

Figure ACS.3.1 Layout Plan of Chak Jhumra WWTP (Example)



Anaerobic

		TYPE.1
top side a ; L−n(D)	m	23.0
top side b ; B−n(D)	m	23.0
top side A ; L+n(D)	m	47.0
top side B ; B+n(D)	m	47.0
hight h ; D	m	4.0
Volume	m^3	5,092
Unit		2
Total volume	m^3	10,184 > 9,198….OK

Where

F: free board	m	0.5
n: side slope(1:n)		3
Embank ment	m	illustration [(L+(D+2F) or B+(D+2F)]

Facultative

		TYPE.1
L	m	92.5
B	m	92.5
Area	m^2	8,556
Unit		6
Total Area	m^2	51,336 > 49,673….OK

Source: JICA Mission Team

Figure ACS.3.2 Cross Sections of Ponds at Chak Jhumra WWTP (Example)