#### S.R. Stapel, 2023 RAINFALL-RUNOFF MODELLING TO ASSESS FLOOD HAZARS ON SINT-EUSTATIUS, CARIBBEAN NETHERLANDS

# APPENDIX 1

# Field measurements and photo impression

Map with locations of field measurements	1
Field observations and measurements	2
Map with minimum infiltration rates	5
Map with observed preferential flow indicators	6
Map with observed soil classes	7
Map with photo locations	8
Photo 1 – Remote view of the study area	9
Photo 2 – Soil profile at a recently excavated construction site	10
Photo 3 – Tall grass field	11
Photo 4 – Unpaved road damaged by repeated rill erosion	12
Photo 5 – Weg naar White Wall $\times$ Ground Dove Road intersection	13
Photo 6 – Weg naar White Wall covered with sediment after a moderate rainfall event	14
Photo 7 - Coastal cliffs exposing the Quill's youngest ash and scoria deposits	15
Photo 8 – Typical unpaved road in the subdivision	16
Photo 9 – Steep unpaved road with an infiltration pit to the side	17
Photo 10 – Dense shrub vegetation north of the subdivision	18
Photo 11 –Gully control dam from the colonial era	19
Photo 12 – Inactive gully with rounded side walls and deep litter layer	20
Photo 13 – Dense forest	21
Photo 14 - Section of Weg naar White Wall prone to flooding due to lack of drainage paths	22
Photo 15 - Soil, rocks and plant litter on Weg naar White Wall after a major rainfall event	23
Photo 16 – Weg naar White Wall × Active gully intersections	24
Photo 17 – Weg naar White Wall × Active gully intersections after major flooding	25
Photo $18 - Gully 1 \times Weg$ naar White Wall culvert	26
Photo 19 – Open forest	27
Photo 20 - Presumed outcrop of White Wall - Sugar Loaf succession in a gully sidewall	28
Photo 21 – Tree damaged by a recent debris flow	29
Photo 22 - Gully incision in volcanic conglomerates and sandstones of the White Wall - Sugar Loaf succession	30
Photo 24 – Active gully with steep and active side walls	31
Photo 25 - Reactivated gully after a debris flow	32
Photo 26 – Debris flow end lobe	33
Photo 27 – Sparse vegetation and plant litter cover	34
Photo 28 - Limestone outcrop of White Wall - Sugar Loaf succession	35
Photo 29 – White Wall and Sugar Loaf formations	36
Photo 30 - Sediment-laden discharge from active gullies into the Caribbean Sea	37

#### Map with locations of field measurements



# Field observations and measurements

part 1/3

		Prefe in	erentia ndicato	l flow ors	Soil [NEN	class 5104]		Timin [m:ss	ng 5]	Input [mL/min]											Runoff [mL/min]											
Site	Date	Roots	Crust	SWR	Texture	Humus	$\Delta \mathbf{t}$	tp	tr	W1	<b>W</b> 2	<b>W</b> 3	<b>W</b> 4	<b>W</b> 5	W6	W7 V	W8 W	<b>Σw</b>	<b>q</b> 1	q2	2 <b>q</b> 3	<b>q</b> 4	q5	<b>q</b> 6	<b>q</b> 7	<b>q</b> 8	q9	qend	Σq	Σf	fave	f <sub>min</sub>
1	27-2-2023				ZS1	0	3			375	375	400						1150											5	1145	254	
2	27-2-2023				ZS2	1	3			375	400	400						1175											636	539	120	
3	27-2-2023				ZS2	1	3			350	400	400						1150											112	1038	231	
4	27-2-2023				ZS2	2	3			375	375	400						1150											441	709	158	
5	27-2-2023				LZ3	0	3			425	400	375						1200											193	1007	224	
6	28-2-2023	2	0	1	ZS4	2	3	0:35	0:45	350	375	375						1100											488	612	136	
7	28-2-2023	1	1	0	LZ3	2	3	0:35	1:20	400	375	375						1150	_										65	1085	241	
8	28-2-2023	3	0	1	LZ3	2	3	0:40	0:50	375	450	400						1225											700	525	117	
9	28-2-2023	1	1	0	LZ3	1	3	0:20	0:40	450	500	500						1450											370	1080	240	
10	28-2-2023	1	1	0	LZ3	1	3	0:25	0:50	400	400	425						1225											94	1131	251	
11	28-2-2023	1	1	0	LZ3	1	3	0:05	0:15	400	400	400						1200											460	740	164	
12	1-3-2023	0	0	0	ZSI	0		#N/A	#N/A	500	250	250						500											0	500	333	
13	1-3-2023	1	0	0	ZS3	1	3	0:30	1:10	350	350	350						1050											122	928	206	
14	1-3-2023	1	1	0	ZS2	0	3	0:25	0:50	400	350	3/5						1125											262	863	192	
15	1-3-2023	3	0	1	ZS4	0	3	0:40	1:00	400	325	325						1050											485	365	126	
10	1-3-2023	1	0	0	ZS2	0	2	0:25 #NI/A	0.45	425	275	3/5						1150	_										215	025	196	
1/	1-3-2023	0	0	0	Z54	3	2	#IN/A	0:45 #NI/A	3/3	575	400						1150											315	833	244	
10	1-3-2023	3	0	0	ZS1 7S2	0	3	#IN/A	#IN/A	400	400	400						1350											170	1080	240	
20	1 3 2023	0	0	0	ZS2 7S4	0	3	#IN/A	1.10	430	375	400						1230											242	058	240	
20	1-3-2023	1	0	0	L 73	0	3	0.35	1.10	423	400	400						1200											112	1088	213	
21	1-3-2023	1	0	0	LZ3	0	3	0.50	1.20	400	400	375						1175	-										450	725	161	
23	1-3-2023	1	0	0	LZ3	0	3	0.30	0.50	375	375	375						1175											315	810	180	
24	2-3-2023	1	0	1	ZS4	2	3	0.30	0.30	375	375	350						1100											402	698	155	
25	2-3-2023	3	0	1	ZS4	3	2	#N/A	0:30	375	350	375						1100											540	560	187	
26	2-3-2023	0	1	0	ZS2	0	3	0:20	1:05	475	475							950											70	880	196	
27	2-3-2023	2	0	0	ZS4	2	3	1:15	1:35	375	375	375						1125											185	940	209	
28	2-3-2023	2	0	1	LZ3	3	3	#N/A	0:30	375	375	375						1125											590	535	119	
29	2-3-2023	1	0	0	LZ1	0	3	1:25	2:00	400	375	375						1150											96	1054	234	
30	2-3-2023	1	1	0	LZ3	0	3	0:15	0:35	400	375	400						1175											198	977	217	
31	2-3-2023	2	0	1	LZ1	0	3	0:50	1:10	350	400	400						1150											420	730	162	
32	2-3-2023	1	1	0	LZ3	0	3	#N/A	1:35	475	375	425						1275											300	975	217	
33	2-3-2023	2	0	0	LZ3	0	3	0:30	0:45	475	375	375						1225											444	781	174	
34	2-3-2023	2	0	1	LZ3	2	3	1:15	1:30	375	400	375						1150											338	812	180	
35	2-3-2023	1	1	0	LZ3	2	3	0:45	1:15	375	375	400						1150											304	846	188	
36	3-3-2023	1	0	0	ZS4	1	3	0:50	1:30	375	325	350						1050	0	20	)							90	110	940	209	220
37	3-3-2023	2	1	0	ZS4	3	3	0:30	0:40	375	375	375						1125	13	153	3							254	420	705	157	148
38	3-3-2023	2	0	0	ZS3	2	3	#N/A	0:50	425	300	375						1100	1	12	1							228	350	750	167	164
39	3-3-2023	2	0	0	ZS3	2	3	0:25	0:30	400	375	400						1175	32	144	4							218	394	781	174	165
40	3-3-2023	2	0	0	ZS4	2	3	0:40	0:50	375	375	375						1125	8	128	8							224	360	765	170	165
41	3-3-2023	2	0	0	LZ3	3	3	0:30	0:40	400	400	375						1175	15	15	1							242	408	767	170	160
42	3-3-2023	1	0	0	ZS4	2	3	0:35	0:40	375	375	400						1150	15	16.	3							342	520	630	140	147
43	3-3-2023	1	0	0	ZS4	2	3	0:05	0:10	400	350	400						1150	74	240	6							258	578	572	127	92
44	3-3-2023	2	0	0	ZS4	2	3	0:05	0:15	400	400	425						1225	100	200	0							278	578	647	144	139
45	3-3-2023	2	0	0	LZ3	3	3	0:20	0:30	400	400	400						1200	68	240	0							362	670	530	118	107

# Field observations and measurements

Part 2/3

		Prefe in	erenti ndicat	al flow ors	Soil [NEN	class 5104]		Timir [m:ss	ng 5]	Input [mL/min]											Runoff [mL/min]											Infiltration [mm/hr]			
Site	Date	Roots	Crus	st SWR	Texture	Humus	Δt	tp	tr	<b>W</b> 1	<b>W</b> 2	<b>W</b> 3	W4	<b>W</b> 5	W6	<b>W</b> 7	<b>W</b> 8	<b>W</b> 9	$\Sigma w$	<b>q</b> 1	<b>q</b> 2	Q3	q4	q5	<b>q</b> 6	<b>q</b> 7	<b>q</b> 8	q9	qend	Σq	Σf	fave	fmin		
46	6-3-2023	2	0	1	LZ3	3	3	0:10	0:35	400	375	375							1150	53	267								390	710	440	98	78		
47	6-3-2023	1	0	1	LZ3	1	3	0:15	0:40	375	400	375							1150	52	183								285	520	630	140	134		
48	6-3-2023	2	0	0	LZ3	2	3	0:35	1:30	375	375	375							1125	0	46								159	205	920	204	219		
49	6-3-2023	1	0	0	ZS4	2	3	1:40	1:55	400	400	475							1275	0	5								180	185	1090	242	280		
50	6-3-2023	3	0	1	VZ3	#N/A	3	0:15	0:40	400	425	400							1225	57	258								340	655	570	127	100		
51	6-3-2023	3	0	0	ZS4	2	3	1:00	1:25	425	425	400							1250	0	80								170	250	1000	222	224		
52	6-3-2023	3	0	1	VZ3	#N/A	3	0:15	0:25	400	400	425							1225	162	304								370	836	389	86	70		
53	6-3-2023	2	0	1	ZS4	3	3	0:15	0:30	325	375	400							1100	160	318								402	880	220	49	32		
54	6-3-2023	2	0	0	LZ3	2	3	0:55	1:15	3/5	400	375							1150	0	158								270	428	1112	160	150		
55	6 2 2022	2	0	1		2	2	0.15	2:10	400	275	400							11/5	0	100								02	03	505	122	200		
57	7 3 2023	3	0	0	LZ3	2	3	0:15	1:55	375	350	375							1100	0	100	118							287	124	076	217	150		
58	7 3 2023	3	0	1	LZ3	2	3	0.33	0.45	375	375	375							1100		103	157							3/	208	802	178	140		
59	7-3-2023	2	0	1	LZ3	1	3	0.20	0.45	400	375	450							1225	2	173	278							46	298 499	726	161	87		
60	7-3-2023	3	0	1	VZ1	#N/A	3	0.15	0:45	400	400	400							1223	110	253	270							65	718	482	107	73		
61	7-3-2023	2	0	0	VZ1	#N/A	3	0.10	0.15	375	400	400							1175	50	223	290							62	617	558	124	73		
62	7-3-2023	2	0	1	LZ3	2	3	0:30	0:50	400	375	400							1175	34	201	302							88	625	550	122	60		
63	7-3-2023	3	0	0	LZ3	2	3	1:15	2:10	400	400	400							1200	0	0	42							9	51	1149	255	239		
64	7-3-2023	3	0	0	LZ3	2	3	2:00	2:15	425	375	425							1225	0	0	51							17	68	1157	257	238		
65	7-3-2023	2	0	0	LZ3	2	3	0:55	1:20	375	400	400							1175	0	29	60							10	99	1076	239	221		
66	7-3-2023	2	0	0	LZ3	2	3	0:20	0:30	375	400	400							1175	82	152	88							11	333	842	187	160		
67	7-3-2023	2	0	0	LZ3	2	3	1:15	1:50	400	375	375							1150	0	13	103							18	134	1016	226	187		
68	9-3-2023	1	0	0	LZ3	1	3	0:50	1:55	375	375	375							1125	0	1	68							4	73	1052	234	205		
69	9-3-2023	3	0	1	VZ3	#N/A	3	0:15	0:30	375	350	375							1100	80	292	330							112	814	286	64	24		
70	9-3-2023	2	0	0	LZ3	1	3	0:50	1:50	375	375	350							1100	0	0	46							4	50	1050	233	214		
71	9-3-2023	1	0	0	LZ3	1	3	0:15	0:50	400	375	400							1175	10	180	230							48	468	707	157	108		
72	9-3-2023	1	0	0	LZ3	1	3	0:55	1:30	425	375	375							1175	0	32	140							22	194	981	218	168		
73	9-3-2023	1	0	0	LZ3	1	3	1:15	1:40	400	400	375							1175	0	11	103							12	126	1049	233	192		
74	9-3-2023	1	0	0	LZ3	1	3	1:50	2:30	400	400	400							1200	0	0	21							10	31	1169	260	253		
75	9-3-2023	1	0	1	LZ3	1	3	0:40	1:05	350	375	375							1100	0	105	175							25	305	795	177	128		
76	9-3-2023	1	0	1	LZ3	1	3	0:15	0:35	425	400	425							1250	22	113	213							32	380	870	193	136		
77	9-3-2023	1	0	1	LZ3	1	3	0:10	0:30	400	400	400							1200	40	180	260							28	508	692	154	93		
78	9-3-2023	1	0	0	LZ3	1	5	1:40	3:30	350	375	375	375	375					1850	0	0	0	19	61					8	88	1762	235	204		
79	9-3-2023	3	0	1	LZ3	2	3	0:15	1:15	375	375	375							1125	0	44	92							20	156	969	215	189		
80	10-3-2023	3	0	1	LZ3	2	3	0:10	0:25	350	375	375							1100	150	290	303							77	820	280	62	42		
81	10-3-2023	3	0	1	LZ3	2	3	0:05	0:20	375	375	375							1125	134	302	318							102	856	269	60	38		
82	10-3-2023	3	0	0	LZ3	2	3	0:10	0:30	375	375	375							1125	136	300	310							128	874	251	56	43		
83	10-3-2023	3	0	0	LZ3	2	3	0:10	0:25	375	375	375							1125	122	310	318							118	868	257	57	38		
84	10-3-2023	3	0	0	LZ3	2	3	0:10	0:30	375	375	400							1150	114	254	290							94	752	398	88	62		
85	10-3-2023	3	0	0	LZ3	2	3	0:30	0:50	375	375	375							1125	5	110	212							52	379	746	166	109		
86	10-3-2023	4	0	1	LZ3	3	3	0:05	0:20	3/5	3/5	5/5							1125	128	298	318							115	859	266	59	58		
8/	10-3-2023	2	0	1	LZ3	2 #NT/A	5	0:05	0:15	3/3	3/3	5/5							1125	103	207	268							62 76	/60	303	81 104	/1		
88	10-3-2023	3	0	1	VZ3	#IN/A	3	0:10	0:20	3/3	3/3	3/3							1125	100	245	230							/0	00/ 001	408	104 92	8/		
89	10-3-2023	3	0	1	VZ3	#IN/A	3	0:05	0:15	400	375	400							11/5	134	254	295							118	750	2/4	03	04 54		
90	10-3-2023	5	0	0	VZ3	#IN/A	5	0:05	0:25	350	5/5	5/5							1100	92	260	280							122	159	541	/6	54		

# Field observations and measurements

Part 3/3

		Prefe in	erentia Idicato	l flow ors	Soil [NEN	Timing [m:ss]			Input [mL/min]										Runoff [mL/min]												Infiltration [mm/hr]		
Site	Date	Roots	Crust	t SWR	Texture	Humus	Δt	tp	tr	<b>W</b> 1	W2	<b>W</b> 3	W4	<b>W</b> 5	W6	<b>W</b> 7	<b>W</b> 8	W9	Σw	<b>q</b> 1	<b>q</b> 2	Q3	q4	q5	<b>q</b> 6	<b>q</b> 7	<b>q</b> 8	q9	Qend	Σq	Σf	fave	f <sub>min</sub>
91	13-3-2023	2	0	1	LZ3	2	3	0:10	0:30	375	375	375							1125	112	284	280							82	758	367	82	61
92	13-3-2023	2	0	1	LZ3	2	3	0:10	0:30	375	375	375							1125	105	250	282							70	707	418	93	62
93	13-3-2023	2	0	0	LZ3	1	3	6:30	6:50	325	425	400							1150	14	125	170							2	311	839	186	142
94	13-3-2023	2	0	1	LZ3	1	3	0:10	0:30	400	400	400							1200	80	230	268							62	640	560	124	88
95	13-3-2023	1	0	1	LZ3	1	3	0:15	1:30	375	400	400							1175	0	25	88							20	133	1042	232	202
96	14-3-2023	1	0	0	LZ3	1	3	0:10	0:55	375	350	375							1100	5	168	270							26	469	631	140	64
97	14-3-2023	1	0	0	LZ3	1	3	0:30	0:55	375	375	375							1125	3	102	195							38	338	787	175	120
98	14-3-2023	0	0	0	ZS4	0	5	1:50	3:20	375	400	400	400	400					1975	0	0	0	38	70					8	116	1859	248	214
99	14-3-2023	1	0	0	LZ3	1	5	2:10	2:40	400	400	400	400	400					2000	0	0	7	101	84					58	250	1750	233	199
100	14-3-2023	0	0	0	LZ3	1	5	1:20	2:05	375	375	375	400	375					1900	0	0	48	110	35					14	207	1693	226	177
101	14-3-2023	1	0	0	LZ3	1	3	0:30	0:50	375	375	400							1150	21	236	294							67	618	532	118	60
102	14-3-2023	1	0	0	LZ3	0	5	1:45	2:40	375	400	400	400	400					1975	0	0	13	66	101					11	191	1784	238	194
103	14-3-2023	0	0	0	LZ3	0	1	0:15	0:40	375									375											#N/A	#N/A	#N/A	#N/A
104	14-3-2023	1	0	0	LZ3	1	5	2:40	3:15	375	375	375	375	375					1875	0	0	0	41	96					11	148	1727	230	124
105	15-3-2023	1	0	0	LZ3	1	3	0:15	0:25	375	350	375							1100	146	285	320							105	856	244	54	21
106	15-3-2023	1	0	0	LZ3	1	3	1:15	1:40	400	400	400							1200	0	50	170							21	241	959	213	102
107	15-3-2023	1	0	0	LZ3	1	4	0:50	1:55	375	400	375	425						1150	0	0	23	91						23	137	1013	169	130
108	15-3-2023	2	0	1	LZ3	1	3	0:10	0:25	400	400	400	250	200	250	250	225	200	1200	150	325	330	100	100	100	100	100	100	75	880	320	71	31
109	15-3-2023	2	0	1	LZ3	1	8	0:20	0:30	250	200	250	250	200	250	250	225	200	2075	78	180	184	196	190	188	190	190	192	55	1643	432	36	17
110	15-3-2023	2	0	0	LZ3	1	4	0:30	1:10	400	375	375	400						1150	0	220	146	163						0	364	786	131	98
111	17-3-2023	3	0	1	LZ3	2	3	0:05	0:15	400	350	3/5							1125	162	270	310							124	866	259	58	29
112	17-2-2023	3	0	1	LZ3	2	2	#IN/A	0:20	325	250	3/3							1050	150	2/3	200							/U	/93 561	257	5/ 100	22
113	17-3-2023	3	0	1		2	2	0:10 #NI/A	U:25	275	250	250							1050	113	190	200							30 70	201 752	489	109	0/
114	17-2-2023	2	0	1		2	2	#IN/A	#IN/A	275	250	250							10/5	120	242	320							/0	/32 502	323	107	1/ 52
115	17-3-2023	3	0	0		2	2	0:30	0:40	3/3	250	250							10/5	21	176	238							91 40	393	482	107	56

#### Map with minimum infiltration rates

in mm/h



#### Map with observed preferential flow indicators



# Map with observed soil classes NEN 5104



# Map with photo locations



# Photo 1 – Remote view of the study area

8-3-2023



# **Photo 2 – Soil profile at a recently excavated construction site** *3-1-2023*







# **Photo 4 – Unpaved road damaged by repeated rill erosion** 23-2-2023



## **Photo 5 – Weg naar White Wall × Ground Dove Road intersection** 14-3-2023



## **Photo 6 – Weg naar White Wall covered with sediment after a moderate rainfall event** 18-3-2023



# **Photo 7 – Coastal cliffs exposing the Quill's youngest ash and scoria deposits** 26-12-2022



# **Photo 8 – Typical unpaved road in the subdivision** 14-3-2023



# **Photo 9 – Steep unpaved road with an infiltration pit to the side** 14-3-2023



**Photo 10 – Dense shrub vegetation north of the subdivision** 13-3-2023



#### **Photo 11 – Gully control dam from the colonial era** 7-3-2023

# **Photo 12 – Inactive gully with rounded side walls and deep litter layer** 4-2-2023



# **Photo 13 – Dense forest** 15-1-2023



# **Photo 14 – Section of Weg naar White Wall prone to flooding due to lack of drainage paths** 26-12-2023



# Photo 15 – Soil, rocks and plant litter on Weg naar White Wall after a major rainfall event 18-1-2023



# **Photo 16 – Weg naar White Wall × Active gully intersections** 26-12-2023



### **Photo 17 – Weg naar White Wall × Active gully intersections after major flooding** 7-1-2023



## **Photo 18 – Gully 1 × Weg naar White Wall culvert** 26-1-2023

![](_page_26_Picture_4.jpeg)

![](_page_27_Figure_3.jpeg)

![](_page_27_Picture_4.jpeg)

![](_page_28_Figure_3.jpeg)

![](_page_28_Picture_4.jpeg)

# **Photo 21 – Tree damaged by a recent debris flow** *3-3-2023*

![](_page_29_Picture_4.jpeg)

### Photo 22 – Gully incision in volcanic conglomerates and sandstones of the White Wall – Sugar Loaf succession 4-1-2023

![](_page_30_Picture_4.jpeg)

#### **Photo 24 – Active gully with steep and active side walls** 4-1-2023

![](_page_31_Picture_4.jpeg)

# **Photo 25 – Reactivated gully after a debris flow** 2-3-2023

![](_page_32_Picture_4.jpeg)

# Photo 26 – Debris flow end lobe 2-3-2023

![](_page_33_Picture_4.jpeg)

#### **Photo 27 – Sparse vegetation and plant litter cover** 4-1-2023

![](_page_34_Picture_4.jpeg)

### **Photo 28 – Limestone outcrop of White Wall – Sugar Loaf succession** 4-1-2023

![](_page_35_Picture_4.jpeg)

# **Photo 29 – White Wall and Sugar Loaf formations** 26-1-2023

![](_page_36_Picture_4.jpeg)

### **Photo 30 – Sediment-laden discharge from active gullies into the Caribbean Sea** 7-1-2023

![](_page_37_Picture_4.jpeg)