Chutes Part 3: Grass-lined

DRAINAGE CONTROL TECHNIQUE

Low Gradient		Velocity Control		Short Term	✓
Steep Gradient	✓	Channel Lining		Medium-Long Term	✓
Outlet Control	[1]	Soil Treatment		Permanent	[2]

[1] Chutes can act as stable outlet structures for *Catch Drains* and *Flow Diversion Banks*.

[2] The design of permanent chutes may require consideration of issues not discussed here.

Symbol → CH →

Photo 11 – Grass-lined chute (showing incorrect placement of turf)

Photo 12 – Correct placement of turf (flow is from top of photo to bottom)

Key Principles

1. The critical design components of a chute are the flow entry into the chute, the maximum allowable flow velocity down the face of the chute, and the dissipation of energy at the base of the chute.
2. The critical operational issues are ensuring unrestricted flow entry into the chute, ensuring flow does not undermine or spill out of the chute, and ensuring soil erosion is controlled at the base of the chute.
3. Most chutes fail as a result of water failing to enter the chutes properly. It is critical to control potential leaks and flow bypassing, especially at the chute entrance.

Design Information

The material contained within this fact sheet has been supplied for use by persons experienced in hydraulic design.

The following information must be read in association with the general information presented in *Part 1 – General information*.

Part 3 of this fact sheet addresses design issues associated with turf and grass-lined chutes.

The design procedure outlined within this fact sheet has been developed to provide a simplified approach suitable only for those involved in the regular design of temporary drainage chutes. The procedure is just **one** example of how chutes can be designed.

Typical Manning's (n) roughness values for grass 50–150mm blade length are presented in Table 19. It should be noted that significant variations could occur in the channel roughness depending on the type, health and density of grass.

Maximum allowable flow velocities are presented in Table 20 for various soil types, channel gradients and percentage grass cover.

Table 19 – Manning's roughness for grassed channels (50–150mm blade length) [1]

Hydraulic radius (m)	Chute slope (%)					
	10	15	20	25	33.3	50
0.05	0.119	0.092	0.080	0.072	0.064	0.056
0.10	0.049	0.044	0.042	0.040	0.037	0.035
0.15	0.038	0.036	0.034	0.033	0.031	0.029
0.20	0.034	0.032	0.030	0.030	0.028	0.028
0.25	0.031	0.030	0.028	0.028	0.028	0.028
0.30	0.030	0.028	0.028	0.028	0.028	0.028
0.35	0.028	0.028	0.028	0.028	0.028	0.028
0.40	0.028	0.028	0.028	0.028	0.028	0.028

[1] Values are presented to three significant figures for convenience, but this should not imply the values are accurate to three significant figures.

In addition to Table 19, the following equations can be used for 50-150mm grass:

Findlay & Ellul (1976)

$$n = 0.027 + \frac{0.00534}{(V.R)^{0.75}} \qquad \text{(Eqn 1)}$$

Witheridge (2007)

$$n = \frac{R^{0.167}}{5124 + 20.77\log(R^{1.4}.S^{0.4})} \qquad \text{(Eqn 2)}$$

Table 20 – Maximum allowable velocities for bare earth and grassed channels [1]

Channel gradient (%)	Percentage of stable vegetal cover			
	0	50	70	100
Erosion resistant soils:				
2 (50:1)	0.6	1.4	1.8	2.5
3 (33:1)	0.5	1.3	1.7	2.4
4 (25:1)		1.3	1.6	2.3
5 (20:1)		1.2	1.6	2.2
6 (17:1)			1.5	2.1
8 (13:1)			1.5	2.0
10 (10:1)			1.4	1.9
15 (6.7:1)			1.3	1.8
20 (5:1)			1.3	1.7
Easily eroded soils:				
2 (50:1)	0.5	1.1	1.4	1.9
3 (33:1)	0.4	1.0	1.3	1.8
4 (25:1)		1.0	1.2	1.7
5 (20:1)		0.9	1.2	1.6
6 (17:1)			1.1	1.6
8 (13:1)			1.1	1.5
10 (10:1)			1.1	1.5
15 (6.7:1)			1.0	1.4
20 (5:1)			0.9	1.3

[1] Adapted from Qld Natural Resources & Mines (2004)

Recommended maximum channel bank slopes of 3:1(H:V) for non-mowable banks, and 4:1(H:V) for mowable banks.

In circumstances where flows are likely down the chute immediately after placement of the turf, then the turf should be anchored with wooden pegs; alternatively, pre-grown reinforced grass could be used.

All turf should be suitably placed an anchored within the chute. If high-velocity flows are likely down the chute immediately after placement of the turf, then the turf should be placed in a 'stretcher bond' layout as shown in Photo 12 and Figure 9. The placement of turf in such a manner reduced the risk of flows passing along the joins between the turf causing erosion (partial failure of the turf can be seen in Photo 11).

It is important to ensure that wherever water is required to enter a turfed area, flow conditions are suitably detailed to **prevent** the water being diverted by the up-slope edge of the turf (Photo 13), thus avoiding rill erosion as shown in Photo 14.

Photo 13 – Example of up-slope edge of turf that can redirect water flow

Photo 14 – Undesirable rilling along edge of turf caused by lateral inflows

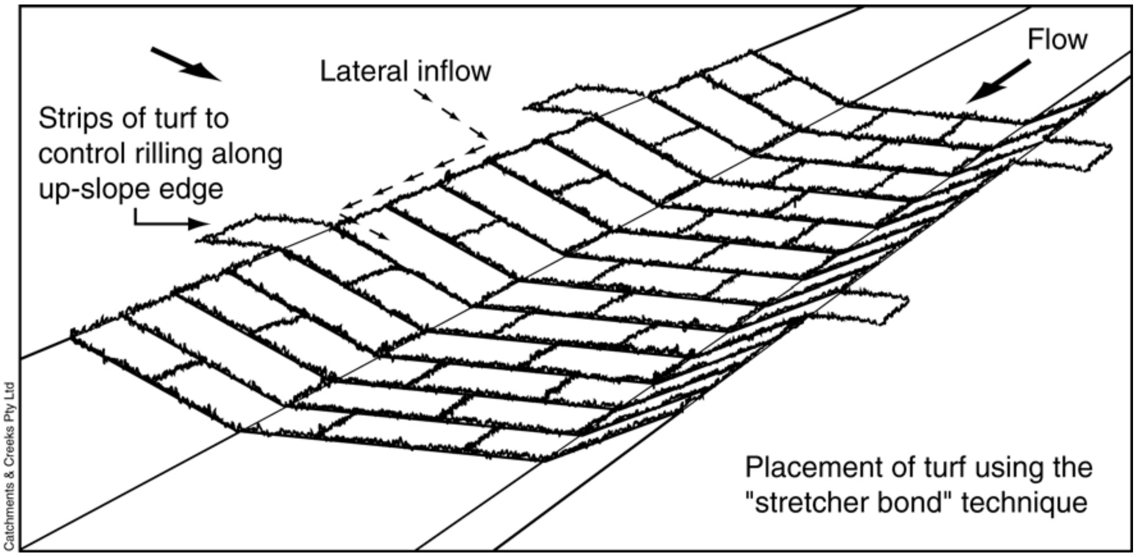

Figure 9 – Placement of turf in chutes

Permanent grass-lined chutes must be formed in a manner and profile that allows all necessary ongoing maintenance, including mowing (where necessary).

Terminology used in Equations 1 and 2:

n = Manning's roughness value [dimensionless]
V = average flow velocity [m/s]
R = hydraulic radius (R = A/P) [m]
S = slope [m/m]

Hydraulic design of grass-lined chutes:

Step 1 Determine the design discharge (Q) for the chute.

Step 2 Define the surface conditions of the chute that are appropriate for the design discharge. A typical design condition being grass of 50–150mm length.

Step 3 Determine the slope (S) of the chute from the site geometry. The chute should be straight, with no bends or curves, from the crest to the base of the chute.

Step 4 Determine the allowable flow velocity (V_{allow}) for the grass surface. The allowable flow velocities for various grass conditions are presented in Table 20.

Step 5 Nominate the chute profile: e.g. rectangular, trapezoidal or parabolic.

Parabolic profiles are typically only used for minor, temporary drainage chutes.

Step 6 Determine the maximum allowable approach flow depth, ‘H’ (relative to the inlet crest) upstream of the chute’s inlet for the nominated design discharge.

Where necessary, design and specify appropriate *Flow Diversion Banks* or the like to appropriately control the approach flow and prevent any water bypassing the chute.

Step 7 Determine the required inlet geometry of the chute using an appropriate weir equation.

If the approach channel (the channel immediately upstream of the chute’s crest) is short, then the relationship between the upstream water level (H) and discharge (Q) can be determined from one of the weir equations presented in Table 1 (*Part 1 – General information*). Tables 2 and 3 (Part 1) provides specific H–Q information for parabolic chutes ($T = 3.3(Y)^{0.5}$), and trapezoidal chutes with 2:1 (H:V) side slopes.

If the approach channel is long, and friction loss within this channel is likely to be significant, then an appropriate backwater analysis may be required.

Step 8 Ensure the entrance to the chute is suitably designed to allow the free flow of water into the chute (i.e. flow is not diverted along the up-slope edge of the turf).

Where necessary, detail appropriate measures to control scour at the entrance to the chute (see Part 1 of this fact sheet, including Figure 3).

Step 9 Determine the Manning’s (n) roughness for the grassed surface either from Table 19, or Equations 1 and 2 as appropriate.

Always check the values obtained from Equations 1 and 2 with the values presented in Table 19 to confirm that a reasonable Manning’s roughness has been obtained.

Step 10 Using Manning’s equation, or Tables 21 to 26 (if appropriate), determine the uniform flow depth (y) and maximum flow velocity (V) down the chute.

Manning’s equation: $Q = A.V = (1/n)\, A \,.\, R^{2/3}.\, S^{1/2}$

Check that the maximum flow velocity (V) does not exceed the allowable flow velocity of the grass lining (determined in Step 3). If the flow velocity exceeds the allowable velocity, then redesign the chute (e.g. increase the bed width).

Step 11 Specify the required depth of the chute, being the greater of:

(i) 300mm (unless a lower depth is supported by expected flow conditions);

(ii) 0.67(H) plus minimum freeboard of 150mm; (‘H’ determined from Step 6)

(iii) the uniform flow depth (y) plus a minimum freeboard of 150mm, or the equivalent of the flow depth, whichever is smaller.

Step 12 Design the required outlet energy dissipation structure at the base of the chute.

Refer to Part 1 of this fact sheet or the fact sheet on *Outlet Structures*.

Design example: grass-lined chute

Design a grass-lined chute on erosion-resistant soils for a discharge of 250L/s, the batter slope is 6:1, and the maximum allowable water level upstream of the inlet (H) is 200mm during the design discharge.

Step 1 Design discharge given as 250L/s or 0.25m^3/s.

Step 2 Assume 50–150mm length grass cover achieved through the placement of turf.

Step 3 The chute slope is given as, S = 16.7% (6:1).

Step 4 Given the stable soil, choose an allowable flow velocity of 1.8m/s from Table 20. This assumes 100% grass cover is achieved and maintained.

For permanent chutes, it may be more appropriate to assume 70% cover to account for the fact that most grassed areas go through some degree of stress during periods of drought. This, of course, may not be the case if the chute is contained in a well-maintained area such as a golf course.

Step 5 Try a trapezoidal profile for the chute.

Step 6 The maximum allowable approach flow depth is given as, H = 0.2m

Step 7 Table 2 (Part 1) indicates that a bed width, b = 1.5m is required to allow the design discharge of 250L/s to enter a trapezoidal chute with side slopes of 2:1.

Step 8 To control water movement and erosion at the chute entrance, specify on the plans that after the initial laying of the turf down the chute, an erosion control blanket is to be placed immediately upstream of the turf to ensure the free entry of water into the chute. Also, flow diversion banks will be constructed each side of the chute entrance to direct water into the chute. The minimum height of the flow diversion banks will be H + 0.3m = 0.2 + 0.3 = 0.5m

Step 9 For this example, there will be no need to choose a Manning's roughness for the grass chute because Tables 21 to 26 can be used to design the chute.

Step 10 Given the chute slope of 6:1, and an allowable flow velocity of 1.8m/s, Table 22 indicates that a bed width, b = 1.0m will carry a flow of 260L/s, which exceed the design discharge of 250L/s.

However, in Step 7, a bed width of 1.5m was required to allow the design discharge to enter the chute while maintaining a maximum upstream flow depth of 0.2m.

Thus, choose a bed width, b = 1.5m

From Table 23 it can be seen that a flow velocity slightly greater than 1.5m/s will occur at a flow rate of 250L/s on a 6:1 slope.

Step 11 From Table 23 the uniform flow depth is expected to be 0.097m, however the expected flow turbulence is likely to result in a significant variation in this depth.

The required depth of the chute should be the greater of:

(i) 300mm;

(ii) 0.67(H) plus freeboard of 150mm = 0.67(200) + 150 = 284mm;

(iii) y + 150mm = 97 + 150 = 247mm.

Thus, choose a total chute depth, Y = 300mm.

Step 12 Design of outlet structure as per Part 1 – 'General Information':

Given that the flow approaching the outlet structure is less than 100mm in depth, and the velocity is less than 2m/s, Table 5 (Part 1) indicates a rock size of 100mm.

Table 6 (Part 1) indicates a length of rock protection, L = 1.3m.

Table 7 (Part 1) indicates a dissipation basin recess depth, Z = 0.14m

The flow top width at the base of the chute = b + 2my = 1.5 + 2(2)0.097 = 1.89m

From Figure 6 (Part 1), W_1 = 1.89 + 0.6 = 2.49m, and W_2 = 1.89 + 0.4(1.3) = 2.41m

Let W_1 = W_2 = 2.5m

Alternatively, use an equivalent area of reinforced grass.

Table 21 – Maximum allowable discharge and corresponding uniform flow depth

Trapezoidal Chute – grass lined (50–150mm)										
Manning's n = variable				Bed width = 0.5 metres				Side slopes 2:1 (H:V)		
Chute slope (H:1)	Allowable flow velocity down Chute									
	1.0 m/s		1.2 m/s		1.5 m/s		1.8 m/s		2.0 m/s	
	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)
20:1	152	0.178	224	0.205	377	0.251	594	0.300	784	0.335
10:1	88	0.119	125	0.135	199	0.161	299	0.189	384	0.209
6:1	60	0.089	84	0.100	129	0.117	189	0.136	238	0.149
5:1	54	0.081	73	0.090	112	0.105	162	0.121	204	0.133
4:1	46	0.072	63	0.080	94	0.092	136	0.106	168	0.115
3:1	38	0.062	52	0.068	77	0.079	109	0.089	134	0.097
2.5:1	34	0.056	46	0.062	68	0.071	95	0.080	116	0.087
2:1	30	0.050	40	0.055	59	0.063	81	0.071	99	0.076
1.75:1	28	0.047	37	0.052	54	0.059	74	0.066	90	0.071
1.67:1	27	0.046	36	0.050	52	0.057	72	0.064	87	0.069
1.5:1	26	0.044	34	0.048	49	0.054	67	0.060	81	0.065
1.25:1	23	0.040	31	0.044	44	0.049	60	0.055	72	0.058
1:1	21	0.036	27	0.039	38	0.044	52	0.048	62	0.052

Table 22 – Maximum allowable discharge and corresponding uniform flow depth

Trapezoidal Chute – grass lined (50–150mm)										
Manning's n = variable				Bed width = 1.0 metres				Side slopes 2:1 (H:V)		
Chute slope (H:1)	Allowable flow velocity down Chute									
	1.0 m/s		1.2 m/s		1.5 m/s		1.8 m/s		2.0 m/s	
	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)
20:1	197	0.151	281	0.174	450	0.211	686	0.253	891	0.284
10:1	124	0.103	171	0.116	262	0.137	380	0.160	479	0.177
6:1	91	0.079	123	0.088	184	0.102	260	0.117	322	0.128
5:1	82	0.072	111	0.080	163	0.092	229	0.105	280	0.114
4:1	72	0.064	97	0.071	141	0.081	196	0.092	240	0.100
3:1	62	0.056	82	0.061	119	0.070	163	0.079	198	0.085
2.5:1	56	0.051	75	0.056	107	0.063	146	0.071	176	0.077
2:1	50	0.046	66	0.050	94	0.057	128	0.063	153	0.068
1.75:1	47	0.043	62	0.047	88	0.053	119	0.059	142	0.063
1.67:1	46	0.042	60	0.046	85	0.052	115	0.058	138	0.061
1.5:1	44	0.040	57	0.044	81	0.049	108	0.054	129	0.058
1.25:1	40	0.037	52	0.040	73	0.045	98	0.050	117	0.053
1:1	36	0.034	47	0.036	65	0.040	87	0.044	103	0.047

Table 23 – Maximum allowable discharge and corresponding uniform flow depth

Trapezoidal Chute – grass lined (50–150mm)										
Manning's n = variable				Bed width = 1.5 metres				Side slopes 2:1 (H:V)		
Chute slope (H:1)	Allowable flow velocity down Chute									
	1.0 m/s		1.2 m/s		1.5 m/s		1.8 m/s		2.0 m/s	
	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)
20:1	249	0.140	349	0.160	549	0.194	820	0.232	1045	0.259
10:1	164	0.097	225	0.109	337	0.128	478	0.148	595	0.163
6:1	124	0.075	165	0.083	244	0.096	341	0.110	416	0.120
5:1	112	0.069	150	0.076	218	0.087	303	0.099	367	0.107
4:1	100	0.062	132	0.068	191	0.077	264	0.088	319	0.095
3:1	86	0.054	114	0.059	163	0.067	223	0.075	267	0.081
2.5:1	79	0.050	104	0.054	148	0.061	200	0.068	240	0.073
2:1	71	0.045	93	0.049	132	0.055	177	0.061	210	0.065
1.75:1	67	0.042	87	0.046	123	0.051	165	0.057	195	0.060
1.67:1	65	0.041	85	0.045	119	0.050	160	0.055	191	0.059
1.5:1	62	0.039	81	0.043	113	0.047	151	0.052	180	0.056
1.25:1	57	0.036	74	0.039	104	0.044	138	0.048	163	0.051
1:1	51	0.033	67	0.035	92	0.039	123	0.043	145	0.046

Table 24 – Maximum allowable discharge and corresponding uniform flow depth

Trapezoidal Chute – grass lined (50–150mm)										
Manning's n = variable				Bed width = 2.0 metres				Side slopes 2:1 (H:V)		
Chute slope (H:1)	Allowable flow velocity down Chute									
	1.0 m/s		1.2 m/s		1.5 m/s		1.8 m/s		2.0 m/s	
	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)	Flow (L/s)	Depth (m)
20:1	306	0.135	427	0.154	658	0.185	958	0.219	1214	0.244
10:1	206	0.094	278	0.105	414	0.123	584	0.142	721	0.156
6:1	157	0.073	209	0.081	305	0.093	422	0.106	513	0.115
5:1	143	0.067	189	0.074	275	0.085	379	0.096	457	0.104
4:1	127	0.060	169	0.066	242	0.075	332	0.085	399	0.092
3:1	111	0.053	146	0.058	208	0.065	282	0.073	339	0.079
2.5:1	102	0.049	133	0.053	189	0.060	255	0.067	304	0.071
2:1	91	0.044	119	0.048	169	0.054	226	0.059	269	0.063
1.75:1	86	0.041	112	0.045	157	0.050	211	0.056	250	0.059
1.67:1	84	0.041	110	0.044	154	0.049	205	0.054	244	0.058
1.5:1	80	0.039	105	0.042	146	0.047	194	0.051	230	0.055
1.25:1	74	0.036	96	0.039	134	0.043	177	0.047	210	0.050
1:1	67	0.033	86	0.035	120	0.039	158	0.042	187	0.045

Table 25 – Maximum allowable discharge and corresponding uniform flow depth

Trapezoidal Chute – grass lined (50–150mm)										
Manning's n = variable				Bed width = 3.0 metres				Side slopes 2:1 (H:V)		
Chute slope (H:1)	**Allowable flow velocity down Chute**									
	1.0 m/s		**1.2 m/s**		**1.5 m/s**		**1.8 m/s**		**2.0 m/s**	
	Flow (L/s)	**Depth (m)**	**Flow (L/s)**	**Depth (m)**	**Flow (L/s)**	**Depth (m)**	**Flow (L/s)**	**Depth (m)**	**Flow (L/s)**	**Depth (m)**
20:1	420	0.129	577	0.146	879	0.175	1265	0.206	1584	0.229
10:1	290	0.091	388	0.101	573	0.118	801	0.136	983	0.149
6:1	223	0.071	297	0.079	429	0.090	588	0.102	715	0.111
5:1	203	0.065	272	0.072	389	0.082	530	0.093	640	0.100
4:1	184	0.059	242	0.065	344	0.073	470	0.083	562	0.089
3:1	160	0.052	211	0.057	298	0.064	402	0.071	479	0.076
2.5:1	147	0.048	193	0.052	271	0.058	365	0.065	435	0.069
2:1	133	0.043	174	0.047	243	0.052	325	0.058	386	0.062
1.75:1	125	0.041	163	0.044	228	0.049	303	0.054	360	0.058
1.67:1	122	0.040	159	0.043	223	0.048	296	0.053	352	0.057
1.5:1	117	0.038	152	0.041	212	0.046	282	0.051	332	0.054
1.25:1	107	0.035	140	0.038	194	0.042	258	0.046	304	0.049
1:1	98	0.032	127	0.035	175	0.038	230	0.042	272	0.044

Table 26 – Maximum allowable discharge and corresponding uniform flow depth

Trapezoidal Chute – grass lined (50–150mm)										
Manning's n = variable				Bed width = 5.0 metres				Side slopes 2:1 (H:V)		
Chute slope (H:1)	**Allowable flow velocity down Chute**									
	1.0 m/s		**1.2 m/s**		**1.5 m/s**		**1.8 m/s**		**2.0 m/s**	
	Flow (L/s)	**Depth (m)**	**Flow (L/s)**	**Depth (m)**	**Flow (L/s)**	**Depth (m)**	**Flow (L/s)**	**Depth (m)**	**Flow (L/s)**	**Depth (m)**
20:1	651	0.124	887	0.140	1336	0.167	1892	0.195	2335	0.215
10:1	455	0.088	611	0.098	894	0.114	1241	0.131	1512	0.143
6:1	357	0.070	473	0.077	679	0.088	926	0.099	1116	0.107
5:1	328	0.064	432	0.070	619	0.080	839	0.090	1008	0.097
4:1	294	0.058	388	0.063	552	0.072	748	0.081	895	0.087
3:1	259	0.051	340	0.056	480	0.063	643	0.070	767	0.075
2.5:1	239	0.047	312	0.051	437	0.057	586	0.064	696	0.068
2:1	216	0.043	281	0.046	394	0.052	525	0.057	623	0.061
1.75:1	203	0.040	266	0.044	371	0.049	492	0.054	581	0.057
1.67:1	199	0.039	259	0.043	361	0.047	480	0.052	567	0.056
1.5:1	190	0.038	247	0.041	344	0.045	454	0.050	539	0.053
1.25:1	176	0.035	228	0.038	316	0.042	417	0.046	491	0.048
1:1	160	0.032	207	0.034	285	0.038	375	0.041	443	0.044

Common Problems

Rill erosion can occur along the upper edge of the turf if it is not properly laid.

Early failure of a channel can result if the grass or turf is established directly on a dispersive soil.

Turf strips can be displacement by high velocity flows if such flows occur within the first few weeks after placement.

Severe rilling along the sides of the chute can be caused by splash or lateral inflows being deflected by the edge of the chute.

Erosion at the base of the chute caused by inadequate energy dissipation.

Special Requirements

A uniform and complete grass cover is usually required to control soil erosion.

May require diversion of flows while grass is being established (grass seeding).

Requires placement of a suitable topsoil layer prior to seeding or laying turf.

Turf is normally placed transversely on ripped subsoils that have been covered with a 75mm layer of topsoil.

Turf usually cannot be placed directly over a dispersive soil. A minimum 75mm layer of non-dispersible topsoil should placed over the dispersive soil prior to placement of the turf.

Site Inspection

A minimum grass strand length of 50mm should be maintained in areas of medium to high velocity flow.

Check flow entry conditions to ensure no bypassing, undermining, sedimentation or erosion.

Ensure the chute is straight.

Check for erosion around the edges of the chute (top and sides).

Ensure the outlet is appropriately stabilised.

Installation (chute formation)

1. Refer to approved plans for location and construction details. If there are questions or problems with the location or method of installation, contact the engineer or responsible on-site officer for assistance.
2. Ensure all necessary soil testing (e.g. soil pH, nutrient levels) and analysis has been completed, and required soil adjustments performed prior to planting.
3. Clear the location for the chute clearing only what is needed to provide access for personnel and equipment for installation.
4. Remove roots, stumps, and other debris and dispose of them properly.
5. Construct the subgrade to the elevations shown on the plans. Remove all unsuitable material and replace with stable material to achieve the desired foundations.
6. If the chute is temporary, then compact the subgrade to a firm consistency. If the chute is intended to be permanent, then compact and finish the subgrade as specified within the design plans.
7. Avoid compacting the subgrade to a condition that would prevent the turf from bonding with the subgrade.
8. Ensure the sides of the chute are no steeper than a 1.5:1 (H:V) slope.
9. Ensure the completed chute has sufficient deep along its full length.
10. Ensure the chute is straight from its crest to the toe of the chute.
11. On fill slopes, ensure that the soil is adequately compacted for a width of at least 1m each side of the chute to minimise the risk of soil erosion, otherwise protect the soil with suitable scour protection measures such as turf or erosion control mats.
12. Place and secure the turf as directed.
13. Install an appropriate outlet structure (energy dissipater) at the base of the chute (refer to separate specifications).
14. Ensure water leaving the chute and the outlet structure will flow freely without causing undesirable ponding or scour.
15. Appropriately stabilise all disturbed areas immediately after construction.

Additional requirements when laying turf within a chute:

1. Turf should be used within 12-hours of delivery, otherwise ensure the turf is stored in conditions appropriate for the weather conditions.
2. Moistening the turf after it is unrolled will help maintain its viability.
3. Turf should be laid on a minimum 75mm bed of adequately fertilised topsoil. Rake the soil surface to break the crust just before laying the turf.
4. During the warmer months, lightly irrigate the soil immediately before laying the turf.
5. Ensure the turf is not laid on gravel, heavily compacted soils, or soils that have been recently treated with herbicides.
6. Lay the first row of turf in a straight line diagonal to the direction of flow. Stagger subsequent rows in a brick-like (stretcher bond) pattern. The turf should not be stretched or overlapped. Use a knife or sharp spade to trim and fit irregularly shaped areas.
7. Ensure the turf extends up the sides of the channel at least 100mm above the elevation of the channel bed, or at least to a sufficient elevation to fully contain the expected channel flow that is considered likely to occur within the first month after placement.
8. On chute gradients of 3:1(H:V) or steeper, or wherever erosion may be a problem, or in situations where high flow velocities (i.e. velocity >1.5m/s) are likely within the first 2-weeks following placement, secure the individual turf strips with wooden or plastic pegs.
9. Ensure that intimate contact is achieved and maintained between the turf and the soil such that seepage flow beneath the turf is avoided.
10. Where practicable, once fixed in place, the turf should be rolled with a roller weighing 60 to 90kg/m width, then watered.
11. After rolling, lightly spread screened topsoil to replace topsoil lost from the turf and to fill any gaps between the rows.
12. Water until the soil is wet 100mm below the turf. Thereafter, watering should be sufficient to maintain and promote healthy growth.

Maintenance

1. During the construction period, inspect all chutes prior to forecast rainfall, daily during extended periods of rainfall, after significant runoff producing storm events, or otherwise on a weekly basis. Make repairs as necessary.
2. Maintain a healthy and vigorous grass condition whenever and wherever possible, including watering and fertilising as needed.
3. Ensure a minimum grass leaf blade length of 50mm is maintained in areas subject to medium to high flow velocities, and 20 to 50mm in low velocity areas.
4. Mowing should not be attempted until the turf is firmly rooted, usually 2 to 3 weeks after laying.
5. Check for movement of, or damage to, the turf lining.
6. Check for soil scour adjacent the chute. Investigate the cause of any scour, and repair as necessary.
7. Ensure sediment is not partially blocking flow entry into the chute. Where necessary, remove any deposited material to allow free drainage.
8. Dispose of any sediment in a manner that will not create an erosion or pollution hazard.
9. When making repairs, always restore the chute to its original configuration unless an amended layout is required.

Removal

1. When the soil disturbance above the chute is finished and the area is stabilised, the chute and any associated flow diversion banks should be removed, unless it is to remain as a permanent drainage feature.
2. Dispose of any materials, sediment or earth in a manner that will not create an erosion or pollution hazard.
3. Grade the area in preparation for stabilisation, then stabilise the area as specified in the approved plan.