TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

Installation Damage Testing of Xgrid PET PVC 60/30 IT and Xgrid PET PVC 30/30 IT MD & XD

January, 2006

Submitted to:

TEMA Technologies and Materials
Via dell'Industria, 21
31029 VITTORIO VENETO (TV)
ITALY

Attn: Dr. Graziano Peterle
graziano.peterle@temacorporation.com

Submitted by:

TRI/Environmental, Inc.
9063 Bee Caves Rd.
Austin, Texas 78733

C. Joel Sprague
Project Manager

January 3, 2006

Dr. Graziano Peterle
TEMA Technologies and Materials
Via dell'Industria, 21
31029 VITTORIO VENETO (TV)
ITALY

graziano.peterle@temacorporation.com

SUBJECT: Installation Damage Testing of Xgrid PET PVC 60/30 IT and 30/30 IT MD & XD

Dear Dr. Peterle:

TRI/Environmental, Inc. (TRI) is pleased to present this final report for installation damage testing of reinforcing geosynthetics. TEMA Technologies and Materials' submitted Xgrid PET PVC 60/30 IT, Xgrid PET PVC 30/30 IT MD (machine direction), and Xgrid PET PVC 30/30 IT XD (cross-machine direction) for exposure to coarse gravel (Type 1) and sand (Type 3).

Technical Approach

There is currently no standard laboratory simulation of installation damage. Thus, TRI adopted a convenient method for applying installation damage to geogrids that allows for exhumation of the test samples while avoiding unintended damage. The method was developed by Watts and Brady of the Transport Research Laboratory (TRL) in the United Kingdom and documented as TRL's "Procedure for Installation Damage Test for BBA Assessments" (CERC.SOIL.TM028, Jan. 1997). TRI used this procedure as modified to generally conform to ASTM D 5818 requirements. A short review is provided below.

Exposure Procedure

Since compaction typically occurs parallel to the face of retaining walls and the contour lines of slopes, TRI placed the machine direction perpendicular to the running direction of the compaction equipment. To initiate the exposure procedure, four steel plates each measuring 42-inches x 52-inches (1.07 m x 1.32 m), equipped with lifting chains, were placed on a flat clean surface of hardened limestone rock. The longer side of the plates is parallel to the running direction of the compaction equipment. A layer of soil/aggregate was then placed over the adjacent plates and compacted to a thickness of not less than 8 inches (0.20 m). Next, each of four coupons of the tested geosynthetic sample were placed on the compacted soil over an area corresponding to an underlying steel plate. To complete the installation, the second layer of soil was compacted over the coupons. To guide and contain the compaction process, braced railroad

ties defined the long (208+ in. / 5.28 m) edges of the installation. The target cover compacted lift thickness and degree of compaction were 8 in. (0.2 m) and 90% modified Proctor, respectively, unless otherwise requested.

Compaction was accomplished using a 4550 kg ride-on steel-wheeled roller with vibratory capability. All compaction and exhumation procedures, as well as laboratory soil classification and field thickness measurements, were performed under the supervision of TRI's Lead Geotechnical Technician. Density measurements were made by a qualified geotechnical technician (Fugro-McClelland of Austin, Texas).

The following construction quality control measures were followed during exposure.

- Proctor and sieve analyses were performed on each soil/aggregate, when possible. (Proctors could not be performed on Gradations 1 and 2.)
- Lift thickness measurements were made after soil/aggregate compaction.
- When possible, moisture and density measurements were made on each lift using a nuclear density gage to confirm that densities >90% of modified Proctor (per ASTM D 1557) were being achieved.

In addition to the above, the number of compaction equipment loadings (i.e. passes) was recorded for each exposure and corresponding soil compaction effort.

To exhume the geosynthetic, railroad ties were removed and one end of each plate was raised with lifting chains. After raising the plate to about 45°, soil located near the bottom of the leaning plate was removed and, if necessary, the plate was struck with a sledgehammer to loosen the fill. The covering soil/aggregate was then carefully removed from the surface while "rolling" the geosynthetic away from the underlying soil/aggregate. This procedure assured a minimum of exhumation stress.

Photographs representative of the procedures are included in the Appendix of this report.

Gradation of backfill material

Each geosynthetic was exposed to soils/aggregates chosen by the client from a range of available stockpiles having different gradations. The soil/aggregate used in this testing was coarse gravel (Type 1) and sand (Type3). Soil gradation curves may be found in the Appendix of this report.

Specimen Preparation and Wide Width Tensile Testing

Upon removal from the exposure site, exposure coupons were allowed to dry. Coupons were then cleaned by removing surface soil via light hand sweeping. Soil trapped within the geosynthetic structure was not removed by washing or otherwise stressing the geosynthetic. No additional cleaning was performed and specimens were cut and tested in their soiled condition.

The evaluation of RF_{ID} was based on the results of wide width tensile tests per ASTM D 6637, *Standard Test Method for Determining Tensile Properties of Geogrids by the Single orMulti-Rib Tensile Method*. The specimens were tested using an Instron Model 5583 tension/compression machine equipped with Series IX "Merlin" data acquisition software. Strain was monitored using an Epsilon extensometer mounted on the specimen via prongs. Pretest slack removal around the roller grips was limited to application of a 50 lb (223 N) preload immediately prior to testing each specimen. After exposure was complete, all baseline and exposed wide width tensile tests were performed during the same testing period.

Sampling and Specimen Selection

Each set of tensile tests of an exposed style of geosynthetic were compared with tensile tests of the same style of the geosynthetic in an unexposed, or "baseline" condition. It should be noted that tensile specimens were not representative of the roll width, but instead were specific to a defined region within the roll width. This approach was accomplished by cutting five coupons (four for exposure and one for baseline) measuring approximately 42 inches x 52 inches (1.07 m x 1.32 m) in sequence along the length of the geosynthetic. This technique captured common yarns and/or ribs in the tested specimens to minimize variation.

Tensile tests of the product before exposure to installation conditions: The specific sampling procedure as described above was followed to assure that individual baseline specimen populations were developed from the same region of the roll width as those specimens dedicated to installation damage exposure.

Tensile tests of specimens taken from the damaged material after installation: The coupons and candidate specimens to be exposed to installation stresses were selected prior to exposure and installed in accordance with a defined sampling plan (via ASTM D 5818). Exposure coupons were laid within the exposure lane in consecutive order, each representing five specimens. Thus, the exposure lane was constructed with specimens 1 through 20 as shown below.

Exposure Coupon 1					Exposure Coupon 2					Exposure Coupon 3					Exposure Coupon 4				
1	2	3	4	5	11	12	13	14	15	6	7	8	9	10	16	17	18	19	20

Upon exhumation of the exposed coupons, specimens were cut and tested in numerical order. A minimum of nine exposed specimens from each testing condition was systematically selected for testing from the twenty candidate specimens. The test results were averaged and compared to the average of the baseline specimens.

Tensile test results for both virgin (i.e. baseline) and damaged (i.e. exhumed) specimens: All tensile test results have been tabularized and may be found in the Appendix of this report.

Test Results

Retained strengths for each of the tested geosynthetic styles are presented in Table 1.

Table 1. Retained Strength for Tested Geosynthetics

Style	Type 1 (Coarse gravel)		Type 3 (Sand)	
	% Retained	RF_{ID}	% Retained	RF_{ID}
Xgrid PET PVC 60/30 IT	92.8	1.08	96.1	1.04
Xgrid PET PVC 30/30 IT MD	94.3	1.06	99.3	1.01
Xgrid PET PVC 30/30 IT XD	88.1	1.14	94.8	1.06

Conclusion

TRI is very pleased to present this report for installation damage testing of soil reinforcing geosynthetics. If you have any questions or require any additional information, please call me at 1-864-242-2220.

Sincerely,

C. Joel Sprague, P.E.
Senior Engineer

cc: Sam Allen
Jarrett Nelson

APPENDIX OF TEST RESULTS

Installation Damage Results

Soil / Aggregate Gradations

Construction Quality Control Summary

Representative Pictures

9063 Bee Caves Road ▪ Austin, TX 78733-6201 ▪ (512) 263-2101 ▪ FAX 263-2558 ▪ 1-800-880-TEST

INSTALLATION DAMAGE TEST RESULTS

Xgrid PET PVC 60/30 IT
Xgrid PET PVC 30/30 IT MD
Xgrid PET PVC 30/30 IT XD

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TEMA
INSTALLATION DAMAGE TESTING - WIDE WIDTH TENSILE (ASTM D 6637)
Xgrid PET PVC 60/30 IT

Machine Direction — Specimen Width (in): 6.30

Sample Identification	Specimen Number	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% (lbs)	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% (lbs)	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% (lbs)	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
Xgrid PET PVC 60/30 IT Baseline	1	3109	5922	86.5	18.3	405	771	11.3	643	1224	17.9	1086	2068	30.2
	2	3116	5935	86.6	18.1	433	826	12.1	655	1247	18.2	1130	2152	31.4
	3	2836	5402	78.9	15.5	451	859	12.5	672	1279	18.7	1363	2596	37.9
	4	3138	5977	87.3	17.2	482	918	13.4	688	1310	19.1	1342	2555	37.3
	5	3119	5941	86.7	16.8	478	911	13.3	681	1297	18.9	1421	2706	39.5
Average		3064	5835.4	85.2	17.2	450.0	857.1	12.5	667.6	1271.6	18.6	1268.2	2415.6	35.3
Standard Deviation		114.3	217.7	3.2	1.0	28.7	54.8	0.8	16.6	31.7	0.5	134.2	255.7	3.7
% COV		3.7	3.7	3.7	6.0	6.4	6.4	6.4	2.5	2.5	2.5	10.6	10.6	10.6

Machine Direction — Specimen Width (in): 6.30

Sample Identification	Specimen Number	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% (lbs)	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% (lbs)	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% (lbs)	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
Xgrid PET PVC 60/30 IT installed in Gradation 1 (Coarse Gravel)	1	2871	5468	79.8	16.7	383	729	10.6	643	1224	17.9	1141	2173	31.7
	2	2853	5435	79.3	17.9	412	785	11.5	645	1228	17.9	1000	1904	27.8
	3	2724	5189	75.8	18.0	380	724	10.6	611	1164	17.0	921	1755	25.6
	4	2903	5530	80.7	17.8	433	824	12.0	653	1244	18.2	1013	1930	28.2
	5	2716	5173	75.5	17.0	422	804	11.7	648	1235	18.0	1006	1917	28.0
	6	2793	5320	77.7	18.7	441	840	12.3	634	1208	17.6	933	1778	26.0
	7	2819	5370	78.4	19.3	375	714	10.4	591	1126	16.4	818	1558	22.7
	8	3049	5807	84.8	19.0	439	835	12.2	641	1221	17.8	941	1792	26.2
	9	2654	5054	73.8	17.0	423	806	11.8	642	1223	17.9	961	1831	26.7
	10	3037	5784	84.4	17.7	472	900	13.1	679	1292	18.9	1092	2080	30.4
Average		2842	5413	79.0	17.9	417.9	796	11.6	638.7	1217	17.8	983	1872	27
Standard Deviation		123.9	236.1	3.4	0.8	29.5	56.3	0.8	22.4	42.7	0.6	86.2	164.1	2.4
% COV		4.4	4.4	4.4	4.6	7.1	7.1	7.1	3.5	3.5	3.5	8.8	8.8	8.8

Percent Retained	92.8	92.8	92.8	104.3	92.9	92.9	92.9	95.7	95.7	95.7	77.5	77.5	77.5
RFid	**1.08**	**1.08**	**1.08**										

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TEMA
INSTALLATION DAMAGE TESTING - WIDE WIDTH TENSILE (ASTM D 6637)
Xgrid PET PVC 60/30 IT

Machine Direction — Specimen Width (in): 6.30

Sample Identification	Specimen Number	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% (lbs)	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% (lbs)	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% (lbs)	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
Xgrid PET PVC 60/30 IT Baseline	1	3087	5879	85.8	15.8	466	888	13.0	676	1288	18.8	1358	2587	37.8
	2	3094	5894	86.1	16.7	455	866	12.6	660	1258	18.4	1188	2263	33.0
	3	3095	5896	86.1	16.7	436	831	12.1	649	1237	18.1	1097	2089	30.5
	4	3063	5833	85.2	16.2	476	906	13.2	670	1275	18.6	1248	2377	34.7
	5	3126	5954	86.9	15.8	440	839	12.2	657	1251	18.3	1169	2227	32.5
Average		3093	5891.3	86.0	16.2	454.6	866.0	12.6	662.5	1261.8	18.4	1212.1	2308.7	33.7
Standard Deviation		20.2	38.5	0.6	0.4	15.1	28.7	0.4	9.4	17.9	0.3	87.5	166.7	2.4
% COV		0.7	0.7	0.7	2.6	3.3	3.3	3.3	1.4	1.4	1.4	7.2	7.2	7.2

Machine Direction — Specimen Width (in): 6.30

Sample Identification	Specimen Number	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% (lbs)	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% (lbs)	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% (lbs)	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
Xgrid PET PVC 60/30 IT installed in Gradation 3 (Sand)	1	3039	5789	84.5	19.9	343	653	9.5	574	1093	16.0	790	1505	22.0
	2	2792	5318	77.6	16.0	404	769	11.2	646	1230	18.0	1135	2162	31.6
	3	2810	5353	78.1	15.7	457	871	12.7	681	1297	18.9	1235	2352	34.3
	4	2991	5698	83.2	16.7	459	873	12.8	665	1267	18.5	1257	2394	35.0
	5	3027	5766	84.2	17.4	401	764	11.1	647	1233	18.0	1112	2118	30.9
	6	3042	5794	84.6	20.1	395	752	11.0	629	1199	17.5	900	1713	25.0
	7	3071	5849	85.4	19.6	383	730	10.7	625	1190	17.4	883	1682	24.6
	8	2847	5423	79.2	18.1	381	726	10.6	614	1170	17.1	977	1861	27.2
	9	3070	5848	85.4	19.0	429	816	11.9	651	1241	18.1	968	1844	26.9
	10	3020	5753	84.0	18.8	373	710	10.4	616	1173	17.1	862	1643	24.0
Average		2971	5659	83	18	402	766	11	635	1209	18	1012	1928	28
Standard Deviation		104.3	198.6	2.9	1.5	34.8	66.3	1.0	28.7	54.6	0.8	154.6	294.5	4.3
% COV		3.5	3.5	3.5	8.4	8.6	8.6	8.6	4.5	4.5	4.5	15.3	15.3	15.3

Percent Retained	96.1	96.1	96.1	111.6	88.5	88.5	88.5	95.8	95.8	95.8	83.5	83.5	83.5
RFid	**1.04**	**1.04**	**1.04**										

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TEMA
INSTALLATION DAMAGE TESTING - WIDE WIDTH TENSILE (ASTM D 6637)
Xgrid PET PVC 30/30 IT

Machine Direction — Specimen Width (in): 6.30

Sample Identification	Specimen Number	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% (lbs)	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% (lbs)	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% (lbs)	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
Xgrid PET PVC 30/30 IT Baseline	1	1538	2930	42.8	16.8	294	559	8.2	391	744	10.9	650	1238	18.1
	2	1469	2798	40.9	17.0	282	536	7.8	380	724	10.6	606	1153	16.8
	3	1564	2979	43.5	17.4	284	541	7.9	381	725	10.6	612	1165	17.0
	4	1559	2969	43.3	16.4	301	573	8.4	399	760	11.1	704	1340	19.6
	5	1556	2964	43.3	16.1	300	571	8.3	399	759	11.1	725	1382	20.2
Average		1537	2928	43	17	292	556	8	390	742	11	659	1256	18
Standard Deviation		35.2	67.0	1.0	0.5	8.0	15.2	0.2	8.2	15.6	0.2	48.1	91.6	1.3
% COV		2.3	2.3	2.3	2.8	2.7	2.7	2.7	2.1	2.1	2.1	7.3	7.3	7.3

Machine Direction — Specimen Width (in): 6.30

Sample Identification	Specimen Number	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% (lbs)	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% (lbs)	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% (lbs)	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
Xgrid PET PVC 30/30 IT installed in Gradation 1 (Coarse Gravel)	1	1473	2805	41.0	18.1	273	520	7.6	364	693	10.1	567	1080	15.8
	2	1483	2825	41.2	17.3	275	524	7.6	367	700	10.2	584	1111	16.2
	3	1493	2844	41.5	18.1	280	533	7.8	370	705	10.3	581	1106	16.2
	4	1451	2764	40.4	17.2	280	534	7.8	378	720	10.5	592	1128	16.5
	5	1461	2784	40.6	17.8	280	533	7.8	375	714	10.4	579	1103	16.1
	6	1442	2748	40.1	16.6	274	522	7.6	374	713	10.4	605	1152	16.8
	7	1462	2785	40.7	17.0	282	538	7.9	376	717	10.5	602	1146	16.7
	8	1341	2555	37.3	16.2	277	527	7.7	374	712	10.4	569	1083	15.8
	9	1492	2841	41.5	16.9	285	544	7.9	380	723	10.6	606	1154	16.9
	10	1398	2663	38.9	17.6	280	533	7.8	376	715	10.4	626	1192	17.4
Average		1450	2761	40.3	17.3	278.7	530.8	7.8	373.3	711.1	10.4	590.9	1125.5	16.4
Standard Deviation		44.8	85.3	1.2	0.6	3.7	7.0	0.1	4.6	8.8	0.1	17.7	33.6	0.5
% COV		3.1	3.1	3.1	3.5	1.3	1.3	1.3	1.2	1.2	1.2	3.0	3.0	3.0

Percent Retained	94.3	94.3	94.3	103.3	95.5	95.5	95.5	95.8	95.8	95.8	89.6	89.6	89.6
RFid	**1.06**	**1.06**	**1.06**										

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TEMA
INSTALLATION DAMAGE TESTING - WIDE WIDTH TENSILE (ASTM D 6637)
Xgrid PET PVC 30/30 IT

Machine Direction — Specimen Width (in): 6.30

Sample Identification	Specimen Number	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% (lbs)	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% (lbs)	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% (lbs)	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
Xgrid PET PVC 30/30 IT Baseline	1	1551	2953	43.1	15.7	296	564	8.2	389	741	10.8	678	1291	18.9
	2	1561	2974	43.4	18.0	274	522	7.6	377	718	10.5	607	1156	16.9
	3	1550	2951	43.1	17.3	277	528	7.7	377	718	10.5	597	1137	16.6
	4	1536	2926	42.7	17.2	275	524	7.6	379	722	10.5	666	1269	18.5
	5	1576	3001	43.8	18.1	259	493	7.2	369	703	10.3	574	1093	16.0
Average		1555	2961.1	43.2	17.3	276.2	526.1	7.7	378.2	720.4	10.5	624.4	1189.3	17.4
Standard Deviation		13.2	25.1	0.4	0.9	11.8	22.5	0.3	6.4	12.2	0.2	40.5	77.1	1.1
% COV		0.8	0.8	0.8	4.9	4.3	4.3	4.3	1.7	1.7	1.7	6.5	6.5	6.5

Machine Direction — Specimen Width (in): 6.30

Sample Identification	Specimen Number	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% (lbs)	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% (lbs)	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% (lbs)	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
Xgrid PET PVC 30/30 IT installed in Gradation 3 (Sand)	1	1560	2971	43.4	18.1	275	524	7.6	374	713	10.4	584	1113	16.2
	2	1508	2872	41.9	17.6	270	514	7.5	374	713	10.4	580	1105	16.1
	3	1572	2995	43.7	18.8	268	510	7.5	372	709	10.4	566	1077	15.7
	4	1566	2982	43.5	17.7	272	518	7.6	374	713	10.4	583	1110	16.2
	5	1528	2911	42.5	17.2	264	503	7.3	373	710	10.4	599	1141	16.7
	6	1535	2925	42.7	18.4	237	451	6.6	348	662	9.7	522	994	14.5
	7	1520	2895	42.3	17.0	285	543	7.9	383	730	10.7	641	1220	17.8
	8	1544	2941	42.9	17.1	275	524	7.6	376	717	10.5	621	1182	17.3
	9	1535	2923	42.7	17.0	274	522	7.6	376	716	10.4	602	1146	16.7
	10	1566	2983	43.5	16.8	286	545	8.0	383	729	10.6	627	1194	17.4
Average		1543	2940	43	18	271	515	8	373	711	10	592	1128	16
Standard Deviation		20.7	39.5	0.6	0.6	12.9	24.7	0.4	9.3	17.7	0.3	32.4	61.7	0.9
% COV		1.3	1.3	1.3	3.6	4.8	4.8	4.8	2.5	2.5	2.5	5.5	5.5	5.5

Percent Retained	99.3	99.3	99.3	101.7	98.0	98.0	98.0	98.7	98.7	98.7	94.9	94.9	94.9
RFid	**1.01**	**1.01**	**1.01**										

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TEMA
INSTALLATION DAMAGE TESTING - WIDE WIDTH TENSILE (ASTM D 6637)
Xgrid PET PVC 30/30 IT

Cross-Machine Direction — Specimen Width (in): 6.70

Sample Identification	Specimen Number	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% (lbs)	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% (lbs)	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% (lbs)	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
Xgrid PET PVC 30/30 IT Baseline	1	1563	2800	40.9	13.5	313	561	8.2	401	719	10.5	885	1584	23.1
	2	1556	2787	40.7	14.2	304	544	7.9	386	692	10.1	800	1432	20.9
	3	1541	2760	40.3	13.1	312	559	8.2	402	719	10.5	914	1637	23.9
	4	1531	2742	40.0	13.6	297	532	7.8	382	684	10.0	778	1394	20.4
	5	1546	2769	40.4	14.7	281	503	7.3	367	657	9.6	690	1236	18.0
Average		1548	2772	40	14	301	540	8	388	694	10	813	1457	21
Standard Deviation		11.3	20.3	0.3	0.6	11.7	21.0	0.3	13.1	23.5	0.3	79.9	143.1	2.1
% COV		0.7	0.7	0.7	4.1	3.9	3.9	3.9	3.4	3.4	3.4	9.8	9.8	9.8

Cross-Machine Direction — Specimen Width (in): 6.70

Sample Identification	Specimen Number	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% (lbs)	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% (lbs)	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% (lbs)	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
Xgrid PET PVC 30/30 IT installed in Gradation 1 (Coarse Gravel)	1	1322	2367	34.6	14.1	293	526	7.7	373	668	9.7	656	1174	17.1
	2	1361	2438	35.6	14.1	296	531	7.7	373	667	9.7	661	1184	17.3
	3	1448	2594	37.9	14.5	293	524	7.7	369	661	9.7	674	1207	17.6
	4	1477	2645	38.6	15.4	288	516	7.5	367	658	9.6	609	1091	15.9
	5	1329	2379	34.7	15.1	287	515	7.5	364	652	9.5	596	1068	15.6
	6	1403	2513	36.7	15.3	289	517	7.6	365	653	9.5	624	1118	16.3
	7	1329	2381	34.8	15.1	289	517	7.6	364	651	9.5	620	1111	16.2
	8	1317	2359	34.4	14.8	294	527	7.7	370	663	9.7	637	1141	16.7
	9	1336	2392	34.9	14.5	293	525	7.7	368	659	9.6	636	1139	16.6
	10	1311	2348	34.3	14.9	294	526	7.7	371	665	9.7	632	1132	16.5
Average		1363	2442	35.6	14.8	291.7	522.4	7.6	368.4	659.9	9.6	634.5	1136.4	16.6
Standard Deviation		56.0	100.4	1.5	0.5	2.9	5.2	0.1	3.3	5.9	0.1	22.6	40.6	0.6
% COV		4.1	4.1	4.1	3.1	1.0	1.0	1.0	0.9	0.9	0.9	3.6	3.6	3.6

Percent Retained	88.1	88.1	88.1	107.0	96.8	96.8	96.8	95.0	95.0	95.0	78.0	78.0	78.0
RFid	**1.14**	**1.14**	**1.14**										

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1/3/2006

TEMA
INSTALLATION DAMAGE TESTING - WIDE WIDTH TENSILE (ASTM D 6637)
Xgrid PET PVC 30 30 IT

Cross-Machine Direction — Specimen Width (in): 6.70

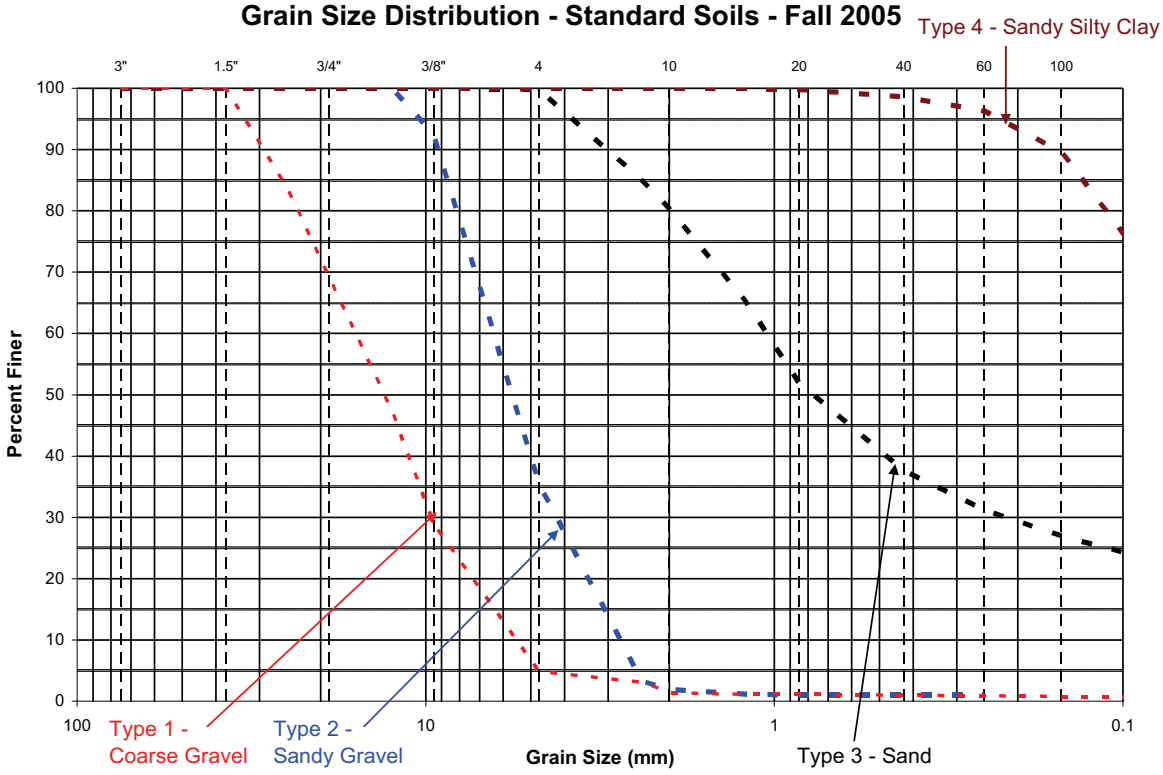
Sample Identification	Specimen Number	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% (lbs)	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% (lbs)	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% (lbs)	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
Xgrid PET PVC 30/30 IT Baseline	1	1550	2777	40.5	14.6	290	520	7.6	378	677	9.9	745	1335	19.5
	2	1540	2759	40.3	14.4	300	538	7.8	385	689	10.1	770	1379	20.1
	3	1513	2709	39.6	13.4	302	540	7.9	387	693	10.1	838	1501	21.9
	4	1548	2773	40.5	13.8	295	529	7.7	384	687	10.0	843	1510	22.0
	5	1585	2840	41.5	15.0	293	526	7.7	378	677	9.9	730	1308	19.1
Average		1547	2771.6	40.5	14.2	296.1	530.4	7.7	382.3	684.8	10.0	785.4	1406.7	20.5
Standard Deviation		23.2	41.6	0.6	0.6	4.2	7.6	0.1	3.6	6.4	0.1	46.8	83.8	1.2
% COV		1.5	1.5	1.5	3.9	1.4	1.4	1.4	0.9	0.9	0.9	6.0	6.0	6.0

Cross-Machine Direction — Specimen Width (in): 6.70

Sample Identification	Specimen Number	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% (lbs)	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% (lbs)	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% (lbs)	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
Xgrid PET PVC 30/30 IT installed in Gradation 3 (Sand)	1	1507	2699	39.4	13.5	301	540	7.9	391	700	10.2	867	1553	22.7
	2	1451	2599	38.0	13.4	295	529	7.7	382	684	10.0	826	1479	21.6
	3	1529	2739	40.0	15.3	294	527	7.7	375	672	9.8	685	1227	17.9
	4	1450	2597	37.9	13.6	304	544	7.9	387	694	10.1	760	1362	19.9
	5	1409	2523	36.8	13.5	297	532	7.8	383	686	10.0	785	1406	20.5
	6	1515	2713	39.6	15.9	185	331	4.8	363	650	9.5	631	1130	16.5
	7	1340	2399	35.0	12.6	304	545	8.0	387	693	10.1	767	1374	20.1
	8	1433	2567	37.5	15.2	248	444	6.5	357	639	9.3	643	1152	16.8
	9	1486	2662	38.9	14.6	301	540	7.9	383	686	10.0	750	1343	19.6
	10	1544	2766	40.4	15.0	296	530	7.7	378	676	9.9	737	1320	19.3
Average		1467	2627	38	14	283	506	7	379	678	10	745	1335	19
Standard Deviation		59.6	106.7	1.6	1.0	36.1	64.6	0.9	10.4	18.5	0.3	71.3	127.7	1.9
% COV		4.1	4.1	4.1	7.1	12.8	12.8	12.8	2.7	2.7	2.7	9.6	9.6	9.6

Percent Retained	94.8	94.8	94.8	100.2	95.4	95.4	95.4	99.0	99.0	99.0	94.9	94.9	94.9
RFid	**1.06**	**1.06**	**1.06**										

SOIL/AGGREGATE GRADATIONS



INSTALLATION DAMAGE SOILS

US Sieve No.	Sieve Size (mm)	Percent Passing			
		Type 1 (Coarse Gravel)	Type 2 (Sandy Gravel)	Type 3 (Silty Sand)	Type 4 (Sandy Silt)
3	75.000	100	100.0	100.0	100.0
2	50.000	100	100.0	100.0	100.0
1.5	37.500	100	100.0	100.0	100.0
1	25.000	83.8	100.0	100.0	100.0
1/2	12.500	47.3	100.0	100.0	100.0
3/8	9.500	29	92.4	100.0	100.0
#4	4.750	4.9	35.6	99.8	100.0
#8	2.400	3.1	3.2	85.0	100.0
#10	2.000	1.4	1.9	80.4	100.0
#16	1.200	1.1	1.1	65.0	99.9
#20	0.850	1.1	1.1	51.9	99.8
#40	0.425	1.0	1.0	37.6	98.6
#60	0.250	0.9	1.0	31.2	96.3
#100	0.150	0.8		26.9	89.6
#200	0.075	0.67		22.3	67.0
D50, mm		14	6	0.8	0.03
Liquid Limit, %					
Plasticity Index, %					
USCS Classification		GP	GM	SW	SM
		Poorly Graded Gravel	Poorly Graded Gravel with Sand	Well Graded Sand	Sandy Silty Clay

CONSTRUCTION QUALITY CONTROL DURING INSTALLATION DAMAGE EXPOSURE

SUMMARY OF OBSERVATIONS AND MEASUREMENTS

TRI/Environmental, Inc.
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1/3/2006

				SOUTH				NORTH			
DATE	**COMPANY**	**PRODUCT(S)**	**TYPE**	**LOCATION**	**DENSITY**	**MOISTURE**	**# PASSES**	**LOCATION**	**DENSITY**	**MOISTURE**	**# PASSES**
06-Dec-05	TEMA	Xgrid PET PVC 30/30 IT Machine Direction	1	NA NA	NA NA	NA NA	4	NA NA	NA NA	NA NA	4
06-Dec-05	TEMA	Xgrid PET PVC 30/30 IT Transverse Direction	1	NA NA	NA NA	NA NA	4	NA NA	NA NA	NA NA	4
07-Dec-05	TEMA	Xgrid PET PVC 60/30 IT Machine Direction	1	NA NA	NA NA	NA NA	4	NA NA	NA NA	NA NA	4
09-Dec-05	TEMA	Xgrid PET PVC 30/30 IT Machine Direction	3	E W	94.2 93.0	4.0 5.5	8	E W	94.4 94.7	8.3 8.0	8
09-Dec-05	TEMA	Xgrid PET PVC 30/30 IT Transverse Direction	3	E W	95.5 95.5	6.2 6.1	8	E W	92.3 91.7	6.5 5.5	8
09-Dec-05	TEMA	Xgrid PET PVC 60/30 IT Machine Direction	3	E W	98.4 94.4	7.8 7.4	8	E W	92.8 94.7	7.3 7.2	8

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REPRESENTATIVE PICTURES OF EXPOSURE PROCEDURE

LIFTING PLATES POSITIONED BETWEEN TIES AND COVERED WITH FIRST LIFT OF COMPACTED SOIL/AGGREGATE

GRID POSITIONED OVER COMPACTED BASE AND COVERED

COVER SOIL/AGGREGATE IS UNIFORMLY SPREAD AND
COMPACTED USING FIELD-SCALE EQUIPMENT AND PROCEDURES

THE DENSITY OF COMPACTED SOIL IS MEASURED

THE STEEL PLATES ARE TILTED TO FACILITATE EXHUMATION