

MONARCH CREEK PHASE 2, YOHO NATIONAL PARK, BRITISH COLUMBIA

GEOTECHNICAL ASSESSMENT

MMM Group Limited
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Project no: 151-64288-00 (R715-1830-00)
Revision: 1

Issue Date: February 18, 2016

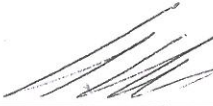
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REVISION HISTORY

CLIENT

REV. NO	ISSUE DATE	DESCRIPTION OF REVISION
1	FEBRUARY 18, 2016	Issued for Client Use

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1 INTRODUCTION

WSP Canada Inc. (WSP), formerly Levelton Consultants Ltd., was retained by MMM Group Limited (MMM) to complete a geotechnical assessment for proposed gabion walls to be constructed along a 40 m long stretch of Monarch Creek within Kicking Horse Campground in Yoho National Park. The approximate project location is illustrated on Figure 1, Appendix B.

Authorization to proceed was provided by Mr. Brian Liu of MMM on October 22, 2015.

The scope of work for the geotechnical assessment was completed in accordance with our proposal dated September 29, 2015 and included the following items:

- Coordination and oversight of a geotechnical field investigation program comprising of three test sites located along the length of the proposed gabion wall and evaluating soil conditions and groundwater conditions encountered;
- Laboratory soil index testing on selected samples comprising of particle size analyses; and
- Preparation of a geotechnical assessment report comprising of the findings of our site review and design recommendations for the proposed gabion wall including cross-sections and associated details for the walls construction.

The use of this report is subject to the Terms of Reference outlined in Appendix A, which form an integral part of this report.

2 SITE AND PROJECT DESCRIPTION

The project site is located within Kicking Horse Campground in Yoho National Park, British Columbia and extends approximately 40 m along the north bank of Monarch Creek. A covered cooking shelter, illustrated in Photo 1, is located near the centre of the 40 m long proposed wall location, approximately 0.5 m north of the north bank of Monarch Creek, as shown on Figure 2, Appendix B.

Photo 1 Covered Cooking Shelter on North Bank of Monarch Creek



A gravel access road is located directly north of the cooking shelter. No other site developments were apparent at the project site during completion of site review.

The following project information was forwarded to WSP by MMM and Parks Canada, and was reviewed during the preparation of this report:

- Topography Survey of Portions of Monarch Creek Within Kicking Horse Campground, prepared by MMM, Job No.: 5215074-000_TOPO, Dwg No.: 5215074-000_TOPO, dated October 16, 2015; and,
- Monarch Creek Culvert Replacements, Sheet No.: C03, prepared by MMM, Project No.: 5214045, dated August 25, 2014.

Based on the information provided as well as measurements taken during fieldwork, the elevation difference from the top of the north bank to bottom of bank of Monarch Creek, within the project site, ranges from approximately 1.3 m on the west end of the site to approximately 1.9 m at the centre of the site near the cooking shelter, to approximately 0.2 m at the east end of the project site. The exterior edges of Monarch Creek were partially frozen and under snow cover during the completion of field work, however, based on visual observations and measurements, the horizontal distance from the active creek channel to the bottom of bank ranges from approximately 3.5 m at the west end of the project site, 7.5 m at the centre of the project site near the cooking shelter, and approximately 2.0 m at the east end of the project site. Based on the information provided, we understand that the north bank is being eroded by Monarch Creek during periods of high flow.

The intent of this geotechnical assessment was to provide geotechnical engineering design input for a proposed gabion wall to support the north bank of the creek within the project site and to mitigate further erosion. WSP did not evaluate the flood or scour potential of Monarch Creek as a part of this assignment. Additionally, determining appropriate flood mitigation measures for Monarch Creek is not part of the scope of this study.

3

INVESTIGATION METHODOLOGY

3.1

GEOTECHNICAL FIELD REVIEW

On November 11, 2015, Adam Burghardt, P.Eng. of WSP attended the project site to complete a site review and to determine the subsurface soil and groundwater conditions along the proposed gabion wall. Three specific locations along the north bank of the creek, identified as TS15-01 through TS15-03, were evaluated in detail during our site review. The test sites were selected based on available project information and accessibility constraints due to the proximity of Monarch Creek. The approximate locations of the three test sites are shown on the Test Site Location Plan included in Appendix B, Figure 1.

Test Site TS15-01, illustrated in Photo 2 and Photo 3, was located approximately 6.0 m west of the west side of the cooking shelter and approximately 6.0 m north of the active channel of Monarch Creek. The exposed soil height from top of bank to bottom of bank was approximately 1.7 m.

Photo 2 Test Site TS15-01



Photo 3 Test Site TS15-01 (Close-Up)



Test Site TS15-02, illustrated in Photo 4 below, was located south of the cooking shelter, near the centre of the project site. Monarch Creek was located approximately 7.0 m to the south of TS15-02. The height from top of bank to bottom of bank at TS15-02 was approximately 1.8 m.

Photo 4 Test Site TS15-02



Test Site TS15-03, illustrated in Photo 5 below, was located approximately 16.0 m east of the east site of the cooking shelter and approximately 3.0 m north of the Monarch Creek. The height from top of bank to bottom of bank was approximately 1.8 m.

Photo 5 Test Site TS15-03



A summary of the exposed soil conditions for each Test Site as well as the field and laboratory test results conducted are shown on the Test Site Records included in Appendix B.

3.2 LABORATORY TESTING

All soil samples obtained were transported to WSP's soil and materials testing laboratory in Calgary for further identification, classification and index testing. The index test program comprised of two particle size analyses (2 tests).

The laboratory test results are discussed within this report, are provided on the Test Site Records in Appendix B, or are attached in Appendix C.

4 SUBSURFACE CONDITIONS

4.1 SUBSURFACE GROUND CONDITIONS

The soil profiles encountered at the discrete test site locations generally consisted of low plastic clay, overlying sand and gravel. The creek bed, encountered at the base of each test site generally comprised of silt or gravel. The Test Site Records present our interpretation of the materials encountered. It is noted that the subsurface stratigraphy may be variable between test site locations. A description of the subsurface soil and groundwater encountered is provided in the following sections.

The detailed subsurface stratigraphy encountered at the project site at the discrete test site locations and the laboratory test results are shown on the Test Site Records included in Appendix B.

4.1.1 CLAY

Low plastic clay was encountered at ground surface in TS15-01 and extended to a depth of approximately 0.1 m. The clay was dark brown to black in colour, moist, and contained trace to some organics, trace sand, and trace gravel.

4.1.2 SAND AND GRAVEL

Sand and gravel to gravel with some sand, trace to some silt and clay was encountered below the clay in TS15-01, and at ground surface in TS15-02 and -03. The sand and gravel extended to the depth of the creek bed in all three test sites, along the north bank of Monarch Creek. The sand and gravel was light brown to dark brown, compact to dense, and moist.

Two particle size analyses were performed on sand and gravel samples. The test results are presented in Table 1.

Table 1 Particle Size Analysis Results

Test Site No.	Sample Depth From – To (mbgs)	Gravel (%)	Sand (%)	Silt/Clay (%)
TS15-01	1.5 – 1.6	51.2	37.1	11.7
TS15-03	0.6 – 0.7	80.1	18.9	1.0

4.1.3 SILT (CREEK BED)

The creek bed at TS15-01 comprised of grey, compact, silt. The silt encountered contained trace clay and was wet. The thickness of the silt layer within the creek bed was not determined.

4.1.4 GRAVEL (CREEK BED)

The creek bed at TS15-02 and TS15-03 comprised of light brown to dark brown, compact, sandy gravel. The sandy gravel encountered contained trace silt, some cobbles and was moist to wet.

4.2 SUBSURFACE GROUNDWATER CONDITIONS

Groundwater was not encountered at the test sites during geotechnical fieldwork, however, due to the close proximity of Monarch Creek and predominantly granular and pervious soils, it is anticipated that groundwater levels at the north bank will closely match those of the creek. In addition, consideration of the Monarch Creek maximum water height during periods of high flow should be taken into account during finalization of the gabion wall design.

5 GEOTECHNICAL COMMENTS AND RECOMMENDATIONS

Based on the results of our assessment, it is our opinion that the construction of the proposed gabion retaining walls is feasible from the geotechnical perspective. This section of the report provides engineering information for the geotechnical design aspects of the gabion walls, based on our interpretation of the site soil condition information from WSP's geotechnical study, review of available information, and on our understanding of the project requirements. The actual design of the gabion walls should be determined based on the assessment of the creek erosion potential along the project area.

The recommendations provided are intended as guidance for planning and design by design engineers and architects. Where comments are made on construction, they are provided to highlight aspects of construction that could affect the design of the project.

5.1 SITE PREPARATION

Any existing fill material, vegetation, organic material, topsoil and other deleterious material, where encountered, should be removed from beneath the proposed gabion wall structure and where engineered fill is needed to bring the project site to final grade. Additionally, it is recommended that the silt material encountered, such as the creek bed material at TS15-01, be over excavated and replaced with suitable granular fill to allow for a relatively uniform subgrade comprising of granular material. The exposed subgrade should be reviewed by WSP geotechnical engineering staff prior to placement of any new fill.

It is recommended that engineered fill, necessary to bring the subject site to design grade consist of 75 mm minus, well-graded sand and gravel containing less than 5% fines (material passing the 0.075 mm sieve) by weight, such as pit run sand and gravel. It is our opinion that the onsite native sand and gravel may be suitable for re-use as engineered fill provided is from oversized rocks, organics, roots, debris, and other deleterious materials and it is placed and compacted within +/- 2% of optimum moisture content.

New fill material must not be placed on frozen soil. Fill should be placed in lifts not exceeding 200 mm thickness (loose measure), at a moisture content of +/-2% of its optimum moisture content for compaction purposes. Each lift should be compacted to at least 98% Standard Proctor Maximum Dry Density (SPMDD). Moisture conditioning may be required during compaction to achieve the required density.

We recommend that the Geotechnical Engineer be provided with the opportunity to review and approve candidate engineered fill materials prior to their use at the site. A Geotechnical Engineer should conduct in-place soil density testing on all engineered fills as they are being placed to confirm that adequate compaction is achieved.

5.2 GEOTECHNICAL ENGINEERING RECOMMENDATIONS FOR GABION WALL DESIGN AND CONSTRUCTION

The preliminary design of the proposed gabion wall structure was conducted using Maccaferri Gawacwin software. Geotechnical engineering data including subsurface soil and groundwater conditions encountered during the geotechnical site review was provided to Maccaferri and was incorporated in the design. In the Maccaferri design, the native soils were defined as retained soil and gravel at creek bed elevation was defined as foundation soil. Additionally, wall backfill was assumed to consist of either native sand and gravel or imported granular material.

The following geotechnical soil parameters provided in Table 2, were utilized in the preliminary gabion wall design:

Table 2 Geotechnical Soil Parameters

Soil Material	In-situ Unit Weight γ (kN/m ³)	Submerged Unit Weight γ' (kN/m ³)	Effective Cohesion (kPa)	Angle of Internal Friction – Drained (°)
Granular Backfill	21	12	0	35
Retained Soil	20	11	0	30
Foundation Soil	20	11	0	30

Three preliminary gabion wall design options have been selected as potentially feasible for the project site based on the subsurface soil conditions encountered and the observed condition of the creek bank at the time of the site review. These options utilize galvanized, or galvanized and PVC coated gabion baskets, as described in the Technical Data Sheet provided in Appendix G. The optional PVC coating is generally applied to the baskets in active streams, polluted, contaminated, or aggressive environments where additional protection is required. It should be noted that Maccaferri recommends the use of galvanized and PVC coated gabion baskets in order to mitigate the risk of damages to the gabion baskets due to sediment transport in the creek as well as contact with granular material during flooding events. The gabion baskets should be filled with gabion stone comprising of clean, hard, durable, angular to round, 100 (min) to 200 mm (max) rock and shall conform to ASTM 6711-01.

A cross section of the first preliminary gabion wall design (Option 1) is provided in Appendix D. The intent of Option 1 is to replace the existing creek bank with a gabion wall structure. Option 1 assumes a minimal or non-existent scour depth. As a result, the gabion wall proposed for Option 1 has a total height of approximately 2.5 m and is founded a minimum of 0.4 m into suitable foundation soil. Option 1 may not be feasible and should be evaluated based on scour considerations by others.

A cross section of the second preliminary gabion wall design option (Option 2) is provided in Appendix E. As indicated in the cross section, Option 2 requires that the gabion wall be founded below the anticipated scour depth of the Monarch Creek to avoid undermining the foundation of the wall. For the purposes of creating a preliminary cross section, a gabion wall height of 4.0 m was arbitrarily selected, which assumes that the maximum scour depth will be approximately 1.5 to 2.0 m. It is reiterated that the gabion wall height of 4.0 m has been selected arbitrarily and that the actual gabion wall height should be selected based on scour depth considerations by others. Backfill behind the gabion wall should comprise of free draining granular material and should be compacted to a minimum of 95% SPMDD. It is recommended that a non-woven geotextile (such as MacTex MX-225)

be placed between the gabion wall and the granular backfill material. A perforated drainage tile installed within the backfill material and connected to a positive outlet is shown on the cross section drawings. Since the gabion wall should allow water collected in the granular backfill material to drain freely, the intent of the optional perforated drainage tile is to prevent the buildup of hydrostatic forces behind the gabion wall in the case that the non-woven geotextile becomes clogged with fines and water is no longer able to drain freely.

A cross section for the third preliminary gabion wall design (Option 3) is provided in Appendix F. Option 3 includes an apron installed outward from the base of the wall to protect against undermining of the wall foundation due to scour. The length of the apron should be approximately 1.5 to 2.0 times the depth of the maximum scour anticipated. The scour depth and the resulting apron length should be determined by others. Since an apron is utilized in Option 3, deep foundations are not required resulting in a gabion wall height approximately equal to the current height of the Monarch Creek north bank. Backfill material recommendations and perforated drainage tile recommendations for Option 3 match those provided above for Option 2.

Site grading for the region above and adjacent to the proposed gabion walls should at all times direct water flow away from the gabion wall structure. Railing should be constructed along the top of the wall as per civil engineering consultant's recommendations. Additional preliminary construction notes as well as a product installation guide are provided in Appendices H and I, respectively.

6 CLOSURE

This geotechnical report has been prepared by WSP Canada Inc. exclusively for MMM Group Limited and their appointed agents. The report reflects our judgment in light of the information provided to us at the time it was prepared. Any use of the report by third parties, or any reliance on or decisions made based on it, are the responsibility of such third parties. WSP Canada Inc. does not accept responsibility for damages suffered, if any, by a third party as a result of their use of this report.

The soil logs attached to this report provide description of the soil and groundwater conditions encountered at discrete test locations. Actual soil conditions in areas remote from test locations may vary across the site. Contractors should make their own interpretation of the soil logs and the site conditions for the purposes of bidding and performing work at the site.

We trust that the information contained in this report meets your present requirements. Should you require any inspection services or further information regarding the geotechnical aspects of this project, please contact the authors of the report.

Appendix A

TERMS OF REFERENCE

TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS ISSUED BY WSP CANADA INC.

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The terms of reference for geotechnical reports issued by WSP (the "Terms of Reference") contained in the present document provide additional information and caution related to standard of care and the use of the Report. The Client should read and familiarize itself with these Terms of Reference.

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All documents, records, drawings, correspondence, data, files and deliverables, whether hard copy, electronic or otherwise, generated as part of the services for the Client are inherent components of the Report and, collectively, form the instruments of professional services (the "Instruments of Professional Services"). The Report is of a summary nature and is not intended to stand alone without reference to the instructions given to WSP by the Client, the communications between WSP and the Client, and to any other reports, writings, proposals or documents prepared by WSP for the Client relative to the specific site described in the Report, all of which constitute the Report.

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WSP prepared the Report for the Client for the specific site, development, building, design or building assessment objectives and purpose that the Client described to WSP. The applicability and reliability of any of the information, observations, findings, suggestions, recommendations and opinions contained in the Report are only valid to the extent that there was no material alteration to or variation from any of the said descriptions provided by the Client to WSP unless the Client specifically requested WSP to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information, observations, findings, suggestions, recommendations and opinions contained in the Report, or any component forming the Report, are for the sole use and benefit of the Client and the team of consultants selected by the Client for the specific project that the Report was provided. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION OR COMPONENT WITHOUT THE WRITTEN CONSENT OF WSP. WSP will consent to any reasonable request by the Client to approve the use of this Report by other parties designated by the Client as the "Approved Users". As a condition for the consent of WSP to approve the use of the Report by an Approved User, the Client must provide a copy of these Terms of Reference to that Approved User and the Client must obtain written confirmation from that Approved User that the Approved User will comply with these Terms of Reference, such written confirmation to be provided separately by each Approved User prior to beginning use of the Report. The Client will provide WSP with a copy of the written confirmation from an Approved User when it becomes available to the Client, and in any case, within two weeks of the Client receiving such written confirmation.

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TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS ISSUED BY WSP CANADA INC. (continued)

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- a. **Nature and Exactness of Descriptions:** The classification and identification of soils, rocks and geological units, as well as engineering assessments and estimates have been based on investigations performed in accordance with the standards set out in Paragraph 1 above. The classification and identification of these items are judgmental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations or assessments utilizing the standards of Paragraph 1 involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions are subject to changes over time and the parties making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or when the Client has special considerations or requirements, the Client must disclose them to WSP so that additional or special investigations may be undertaken, which would not otherwise be within the scope of investigations made by WSP or the purposes of the Report.
- b. **Reliance on information:** The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site investigation and field review and on the basis of information provided to WSP. WSP has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, WSP cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the report as a result of misstatements, omissions, misrepresentations or fraudulent acts of persons providing information.
- c. **Additional Involvement by WSP:** To avoid misunderstandings, WSP should be retained to assist other professionals to explain relevant engineering findings and to review the geotechnical aspects of the plans, drawings and specifications of other professionals relative to the engineering issues pertaining to the geotechnical consulting services provided by WSP. To ensure compliance and consistency with the applicable building codes, legislation, regulations, guidelines and generally-accepted practices, WSP should also be retained to provide field review services during the performance of any related work. Where applicable, it is understood that such field review services must meet or exceed the minimum necessary requirements to ascertain that the work being carried out is in general conformity with the recommendations made by WSP. Any reduction from the level of services recommended by WSP will result in WSP providing qualified opinions regarding adequacy of the work.

6. ALTERNATE REPORT FORMAT

When WSP submits both electronic and hard copy versions of the Instruments of Professional Services, the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding upon WSP. The hard copy versions submitted by WSP shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancy, the hard copy versions shall govern over the electronic versions; furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed and sealed versions of the Instruments of Professional Services maintained or retained, or both, by WSP shall be deemed to be the overall originals for the Project.

The Client agrees that the electronic file and hard copy versions of Instruments of Professional Services shall not, under any circumstances, no matter who owns or uses them, be altered by any party except WSP. The Client warrants that the Instruments of Professional Services will be used only and exactly as submitted by WSP.

The Client recognizes and agrees that WSP prepared and submitted electronic files using specific software or hardware systems, or both. WSP makes no representation about the compatibility of these files with the current or future software and hardware systems of the Client, the Approved Users or any other party. The Client further agrees that WSP is under no obligation, unless otherwise expressly specified, to provide the Client, the Approved Users and any other party, or any or all of them, with specific software and hardware systems that are compatible with any electronic submitted by WSP. The Client further agrees that should the Client, an Approved User or a third party require WSP to provide specific software or hardware systems, or both, compatible with the electronic files prepared and submitted by WSP, for any reason whatsoever included but not restricted to an order from a court, then the Client will pay WSP for all reasonable costs related to the provision of the specific software or hardware systems, or both. The Client further agrees to indemnify and hold harmless WSP, its officers, directors, employees, agents, representative or sub-consultant, or any or all of them, against any claim or any nature whatsoever brought against WSP, whether in contract or in tort, arising or related to the provision or use of any specific software or hardware provided by WSP.

Appendix B

PROJECT LOCATION PLAN
TEST SITE LOCATION PLAN
TEST SITE RECORDS



SOURCE: GOOGLE EARTH IMAGE, CIRCA 2004



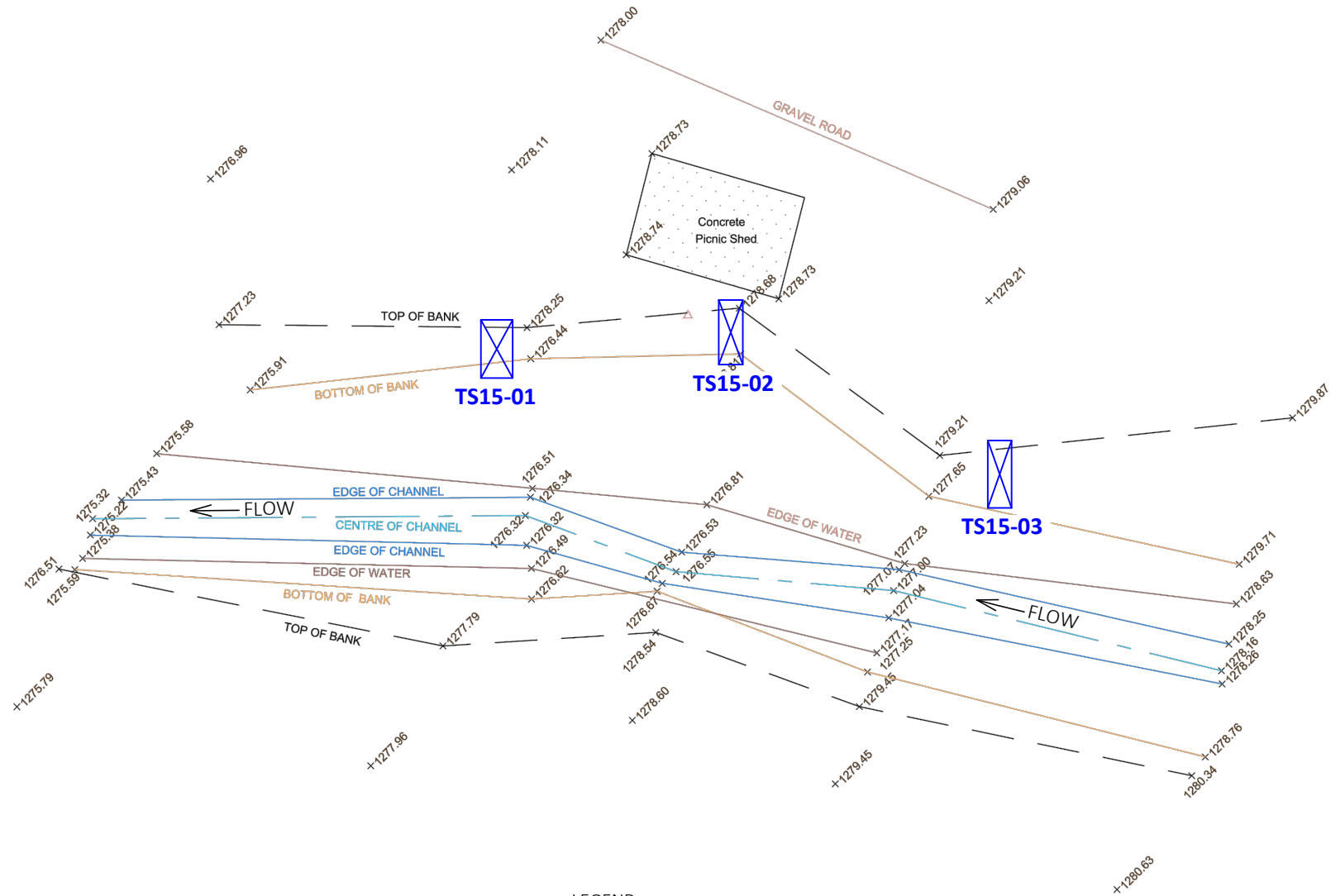
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TITLE:
PROJECT:

CLIENT:

Project Location Plan
Monarch Creek Gabion Walls
Yoho National Park
British Columbia
MMM Group Limited

DES.	AB	DR.	LCH
CH.	AB	SCALE	NTS
APP.	AB	DATE	Feb. 17/16
PROJECT NO.		151-64288-00	
FIGURE NO.		1	



LEGEND
 APPROXIMATE TEST SITE LOCATION

0 5 10 15m
 Scale 1:300

SOURCE: MMM GEOMATICS ALBERTA LIMITED



WSP GROUP
 203 - 6919 32nd Avenue NW Tel: 403 247-1813
 Calgary, AB T3B 0K6 Fax: 403 247-1814

TITLE:

PROJECT:

CLIENT:

Test Site Location Plan
 Monarch Creek Gabion Walls
 Yoho National Park
 British Columbia
 MMM Group Limited

DES.	AB	DR.	LCH
CH.	AB	SCALE	NTS
APP.	AB	DATE	Feb. 17/16
PROJECT NO.	151-64288-00		
FIGURE NO.	2		



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Test Site Exposed Soil Log
Monarch Creek Phase 2
Yoho National Park, Alberta

Depth (m) (ft)	Description	C	N	Type	Water Level	10	20	30	40	50	60	70	80	90
Elev. 1275.30 m (Approx.)														
2	Dark brown to black, firm to stiff, low plastic CLAY , trace to some organics, trace sand, trace gravel, moist to wet													
4	Light brown, dense, SAND and GRAVEL , trace silt, trace clay, moist From 0.85 m: compact			G										
6	Grey, compact, SILT , trace clay, wet (Creek Bed)			G										
8	Test location approximately 1.8 m in height. Creek bed material encountered at approximately 1.7 m. Depth of silt not determined. Groundwater seepage not encountered.													
10														
12														
14														
16														
18														
20														
22														
24														
26														
28														
30														
32														

C: Condition of SampleGood ☒Disturbed ☐No Recovery ☐**Type: Type of Sampler**

SPT : 2 in. standard

ST : Shelby

FP : Fixed Piston

G : Grab

CORE

N: Number of Blows

WH : Weight of Hammer

WR : Weight of Rod

Standard Penetration Test : ASTM D1586

Hammer Type:

● Moisture Content %

▼ Plastic Limit %

▲ Liquid Limit %

▼ Ground Water Level

⊗ Shear strength in kPa (Torvane or Penetrometer)

✕ Shear strength in kPa (Unconfined)

⊗ Shear strength in kPa (field vane)

⊗ Remolded strength in kPa

■ Percent Passing # 200 sieve

Drill Method:

Date Drilled: 06/11/2015

By: AB

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Test Site Exposed Soil Log
Monarch Creek Phase 2
Yoho National Park, Alberta

Depth (m) (ft)	Description	C	N	Type	Water Level	10	20	30	40	50	60	70	80	90
Elev. 1278.70 m (Approx.)														
2	Dark brown, compact, SAND and GRAVEL , some organics, trace silt, trace clay, cobbles, moist to wet From 0.1 m: dense, cobbles, moist													
4	From 0.7 m: light brown, compact													
6				G										
2	Light brown, compact, sandy GRAVEL , trace silt, cobbles, moist to wet (Creek Bed)			G										
8	Test location approximately 1.9 m in height. Creek bed material encountered at approximately 1.8 m. Groundwater seepage not encountered.													
10														
12														
14														
16														
18														
20														
22														
24														
26														
28														
30														
32														

C: Condition of SampleGood ☒Disturbed ☐No Recovery ☐**Type: Type of Sampler**

SPT : 2 in. standard

ST : Shelby

FP : Fixed Piston

G : Grab

CORE

N: Number of Blows

WH : Weight of Hammer

WR : Weight of Rod

Standard Penetration Test : ASTM D1586

Hammer Type:

● Moisture Content %

● Plastic Limit %

● Liquid Limit %

● Ground Water Level

⊗ Shear strength in kPa (Torvane or Penetrometer)

⊗ Shear strength in kPa (Unconfined)

⊗ Shear strength in kPa (field vane)

⊗ Remolded strength in kPa

■ Percent Passing # 200 sieve

Drill Method:

Date Drilled: 06/11/2015

By: AB

THIS LOG IS FOR GEOTECHNICAL PURPOSES ONLY
 THIS LOG IS THE SOLE PROPERTY OF WSP CANADA INC.
 AND CANNOT BE USED OR DUPLICATED IN
 ANY WAY WITHOUT EXPRESS WRITTEN PERMISSION.



WSP Canada Inc.
#203 - 6919 32nd Avenue NW
Calgary, AB T3B 0K6
Tel: +1 403-247-1813
Fax: +1 403-247-1814
www.wspgroup.com

Test Site Exposed Soil Log
Monarch Creek Phase 2
Yoho National Park, Alberta

Depth (m) (ft)	Description	C	N	Type	Water Level	10	20	30	40	50	60	70	80	90
Elev. 1279.20 m (Approx.)														
2	Dark brown, compact, SAND and GRAVEL , some organics, trace silt, trace clay, moist to wet From 0.1 m: dense, cobbles, moist													
4	From 0.6 m: some sand			G										
6	From 1.2 m: light brown, compact			G										
2	Dark brown, compact, sandy GRAVEL , trace silt, cobbles, moist to wet (Creek Bed)			G										
8	Test location approximately 1.9 m in height. Creek bed material encountered at approximately 1.8 m. Groundwater seepage not encountered.													
10														
12														
14														
16														
18														
20														
22														
24														
26														
28														
30														
32														

C: Condition of SampleGood ☒Disturbed ☐No Recovery ☐**Type: Type of Sampler**

SPT : 2 in. standard

ST : Shelby

FP : Fixed Piston

G : Grab

CORE

N: Number of Blows

WH : Weight of Hammer

WR : Weight of Rod

Standard Penetration Test : ASTM D1586

Hammer Type:

● Moisture Content %

● Plastic Limit %

● Liquid Limit %

● Ground Water Level

⊗ Shear strength in kPa (Torvane or

Penetrometer)

✕ Shear strength in kPa (Unconfined)

⊗ Shear strength in kPa (field vane)

⊗ Remolded strength in kPa

■ Percent Passing # 200 sieve

Drill Method:

Date Drilled: 06/11/2015

By: AB

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Appendix C

LABORATORY TEST RESULTS

**WSP Canada Inc.**

6919 32nd Avenue N.W., Calgary, AB
Tel. No. (403) 247-1813, FAX No. (403) 247-1814

To: MMM Group Limited

Project: Monarch Creek Phase 2 Yoho National Park

Sieve Analysis

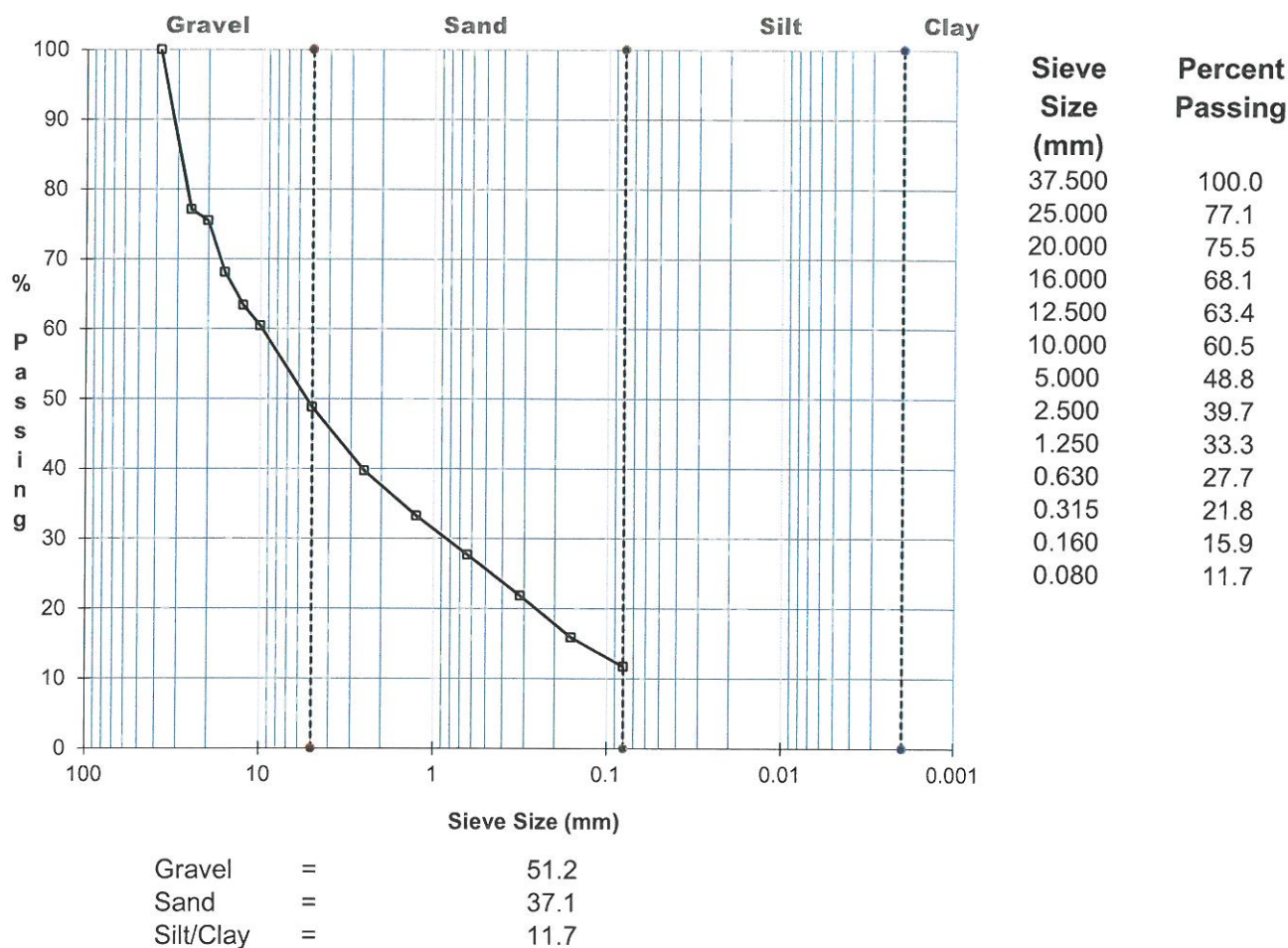
Report Date: Nov. 19, 2015
Project Number: R715-1830-00
TRN: 446

Borehole No. : TS15-01
Sample I.D.: #1
Sample Depth: 1.5 - 1.6 m
Sampled By: AB
Tested By LF

Nov. 06, 2015

Nov. 18, 2015

Nov. 06, 2015



Sample Description: Gravel and Sand, trace silt, trace clay

Remarks:

Per: 

**WSP Canada Inc.**

6919 32nd Avenue N.W., Calgary, AB
Tel. No. (403) 247-1813, FAX No. (403) 247-1814

Sieve Analysis

Report Date: Nov. 19, 2015
Project Number: R715-1830-00

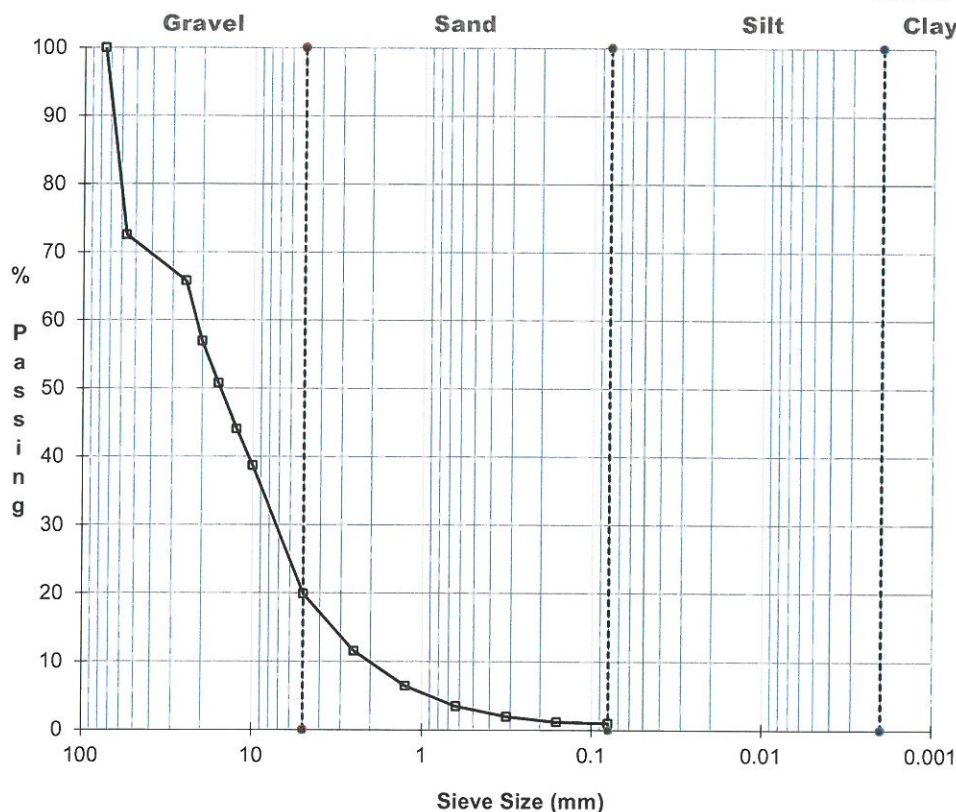
TRN: 446

To: MMM Group Limited

Borehole No.: TS15-03
Sample I.D.: #2
Sample Depth: 0.6 - 0.7 m
Sampled By: AB
Tested By: LF

Project: Monarch Creek Phase 2 Yoho National Park

Nov. 06, 2015



Sieve Size (mm)	Percent Passing
75.000	100.0
56.000	72.5
25.000	65.8
20.000	56.9
16.000	50.8
12.500	44.0
10.000	38.7
5.000	19.9
2.500	11.6
1.250	6.4
0.630	3.5
0.315	1.9
0.160	1.2
0.080	1.0

Gravel = 80.1
Sand = 18.9
Silt/Clay = 1.0

Sample Description: Gravel, some sand, trace silt, trace clay
Remarks:

Per: _____

Appendix D

PRELIMINARY GABION WALL
DESIGN OPTION 1

-
- Top of the existing bank
- Temporary excavation to be reviewed by geotechnical engineer
- Free Draining Granular Material
Min. 95% SPMD
- Retained soil
- Optional Perforated Drainage Tile
(to positive outlet)
- Maccaferri Geotextile
MacTex MX-225
- Structure must be founded on approved competent soil.
(Applied load 65kPa)
- Maccaferri PVC coated gabion
- 1m
- 0.5m
- 2.5m
- 9.5
- 2m
- Embedment > expected scour
Min 0.4m
- River bed
- 6.0 TRAFFIC SURCHARGE LOADING
- 7.0 WATER LEVEL IS ASSUMED AS IN
- 8.0 READ DETAIL IN CONJUNCTION WITH THE NOTES FOR THE MACCAFERRI GABION DRAWING.
- 9.0 FOUNDATION IS TO BE REVIEWED BY A GEOTECHNICAL ENGINEER
- 10.0 GABION BASKETS TO BE GALVANIZED



TITLE:

PROJECT:

CLIENT:

DES.	AB	DR.	LCH
CH.	DJ	SCALE	1:75
APP.	AB	DATE	Feb. 17/16
PROJECT NO.		151-64288-00	
FIGURE NO.		3	

Appendix E

PRELIMINARY GABION WALL
DESIGN OPTION 2

-
- MINIMUM FACTOR OF SAFETY FOR**
- 4.2 GLOBAL STABILITY IS THE RESPONSIBILITY OF THE DESIGNER.
 - 5.0 SEISMIC DESIGN
HORIZONTAL ACCELERATION COEFFICIENT = 0.1g
 - 6.0 TRAFFIC SURCHARGE LOADING = 5kPa
 - 7.0 WATER LEVEL IS ASSUMED AS INDICATED ON DRAWING.
 - 8.0 READ DETAIL IN CONJUNCTION WITH THE NOTES FOR THE MACCAFFERRI GABION WALL DRAWING.
 - 9.0 FOUNDATION IS TO BE REVIEWED BY THE GEOTECHNICAL ENGINEER
 - 10.0 GABION BASKETS TO BE GALVANIZED, AND INSTALLATION OF GABION BASKETS SHALL BE IN ACCORDANCE WITH THE NOTES FOR THE MACCAFFERRI GABION WALL DRAWING.
- Top of the existing bank**
- Temporary excavation to be reviewed by geotechnical engineer**
- Free Draining Granular Material Min. 96% SPMDD**
- Retained soil**
- Optional Perforated Drainage Tile (to positive outlet)**
- Maccafferri Geotextile MacTex MX-225**
- Maccafferri PVC coated gabion**
- Typ. 4m**
- Δz (exp. scour)**
- $\Delta h > \Delta z$**
- River bed**
- Backfill excavated river bed material as required and compact to minimum 95% SPMD**
- Structure must be founded on approved competent soil. (Applied load 65kPa)**
- Dimensions:** 1m, 0.5m, 9.5, 2.5m
- Ratio:** 4/3

TYPICAL RIVERBANK CROSS-SECTION
GABION WALL WITH DEEP FOUNDATION H=4.0m



TITLE:

PROJECT:

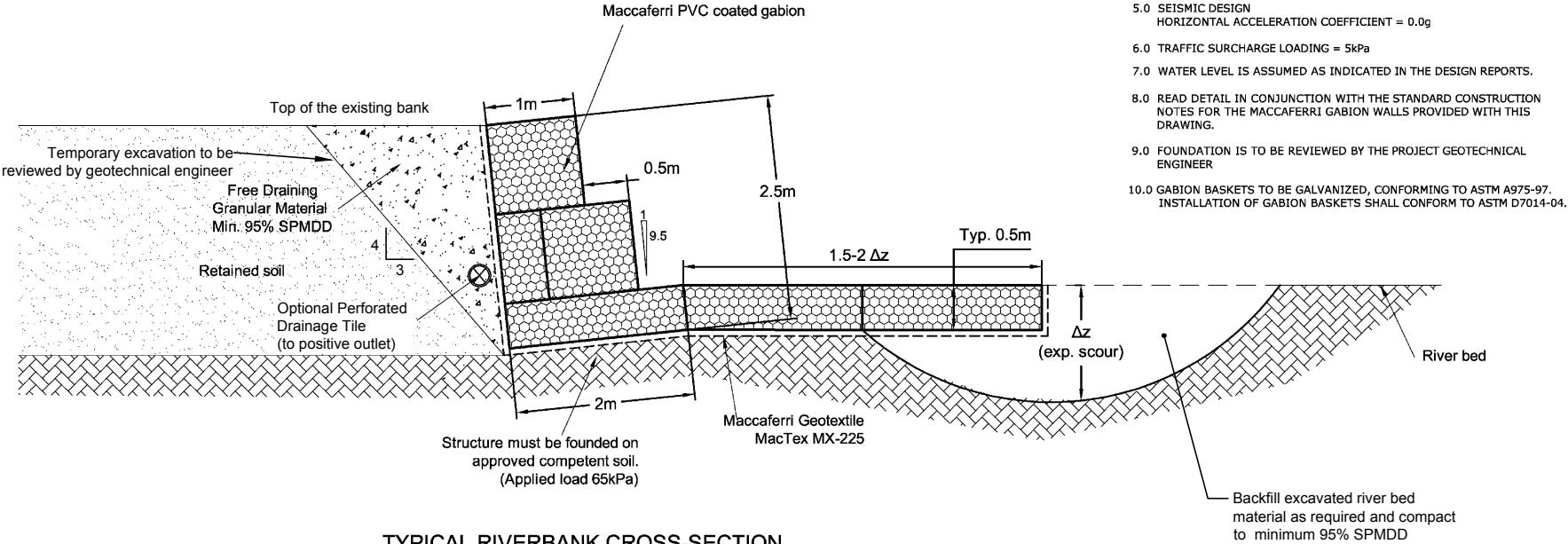
CLIENT:

Option 2
Monarch Creek Gabion Walls Phase 2
Yoho National Park
British Columbia
MMM Group Limited

DES.	AB	DR.	LCH
CH.	DJ	SCALE	1:75
APP.	AB	DATE	Feb. 17/16
PROJECT NO.		151-64288-00	
FIGURE NO.		4	

Appendix F

PRELIMINARY GABION WALL
DESIGN OPTION 3



SOURCE: MACCAFERRI CANADA LTD.

Appendix G

TECHNICAL DATA SHEET

GABION GALVANIZED & PVC COATED

Product Description

Gabions are baskets manufactured from 8x10 double twisted hexagonal woven steel wire mesh, as per ASTM A975 (Fig. 1 and 2). Gabions are filled with stones at the project site to form flexible, permeable, monolithic structures such as retaining walls, channel linings, and weirs for erosion control projects.

The steel wire used in the manufacture of the gabion is heavily zinc coated soft temper steel. A PVC coating is then applied to provide additional protection for use in polluted, contaminated or aggressive environments: in salt, fresh water, acid soil or wherever the risk of corrosion is present. The PVC coating has a nominal thickness of 0.50 mm. The standard specifications of the mesh-wire are shown in Table 2.

The gabion is divided into cells by diaphragms positioned at approximately 1 m centers (Fig. 1).

To reinforce the structure, all mesh panel edges are selvedged with a wire having a greater diameter (Table 3). Dimensions and sizes of PVC coated gabions are shown in Table 1.

Gabions shall be manufactured and shipped with all components mechanically connected at the production facility.

Wire

All tests on wire must be performed prior to manufacturing the mesh. All wire should comply with ASTM A975, style 3 coating, galvanized and PVC coated steel wire. Wire used for the manufacture of gabions and the lacing wire, shall have a maximum tensile strength of 515 MPa as per ASTM A641/A641M soft temper steel.

Woven Wire Mesh Type 8x10

The mesh and wire characteristics shall be in accordance with ASTM A975 Table 1, Mesh type 8x10 and PVC coated. The nominal mesh opening, $D = 83$ mm as per Fig. 2.

The minimum mesh properties for strength and flexibility should be in accordance with the following:

- **Mesh Tensile Strength** shall be a minimum of 42.3 kN/m when tested in accordance with ASTM A975 section 13.1.1.
- **Punch Test** resistance shall be a minimum of 23.6 kN when tested in compliance with ASTM A975 section 13.1.4.
- **Connection to Selvedges** shall be 17.5 kN/m when tested in accordance with ASTM A975.

P.V.C. (Polyvinyl Chloride) Coating

The technical characteristics and the resistance of the PVC to aging should meet the relevant standards. The main values for the PVC material are as follows:

- The initial property of the PVC coating shall be in compliance with ASTM A975 section 8.2.
- Prior to UV and abrasion degradation, the PVC polymer coating shall have a projected minimum durability of 60 years when tested in accordance with *UL 746B Polymeric Material—Long Term Property Evaluation* for heat aging test.

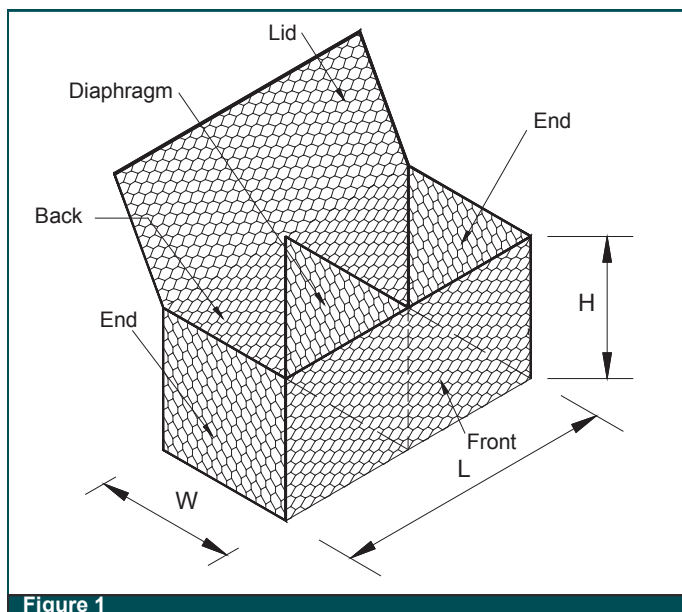


Figure 1

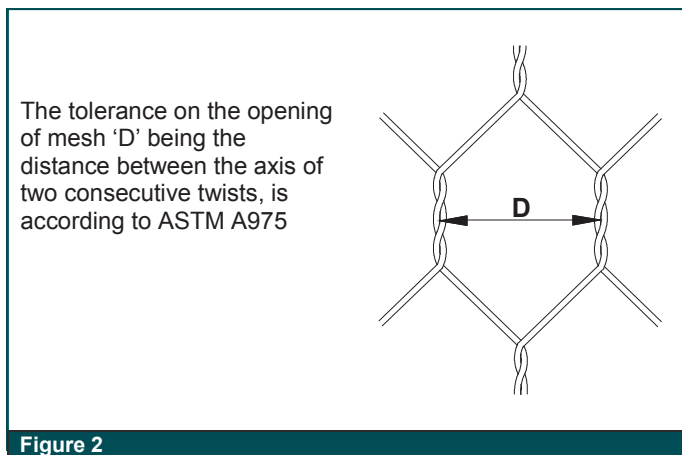


Figure 2

Lacing, Assembly and Installation

Gabion units are assembled and connected to one another using lacing wire specified in Table 3 and described in Fig. 3. Lacing wire is to be used as internal connecting wires when a structure requires more than one layer of gabions to be stacked on top of each other. Internal connecting wires with lacing wire shall connect the exposed face of a cell to the opposite side of the cell. An exposed face is any side of a gabion cell that will be exposed or unsupported after the structure is completed.

Stainless steel ring fasteners can be used instead of, or to complement, the lacing wire (Fig. 4 and Fig. 5).

Table 1—Sizes for gabions

L=Length m	W=Width m	H=Height m	# of cells
2	1	0.3	2
3	1	0.3	3
4	1	0.3	4
2	1	0.5	2
3	1	0.5	3
4	1	0.5	4
2	1	1	2
3	1	1	3
4	1	1	4

All sizes and dimensions are nominal. Tolerances of $\pm 5\%$ of the width, and length height, of the gabions shall be permitted.

Stainless steel rings for PVC coated gabions shall be in accordance with ASTM A975 section 6.3. Spacing of the rings shall be in accordance with ASTM A975 Table 2, Panel to Panel connection, Pull-Apart Resistance. In any case, ring fasteners spacing shall not exceed 150 mm (Fig. 3). The rings can be installed using pneumatic tools (Fig. 5). The average maximum resistance of the fasteners from the field shall not be lower than 90% of the resistance provided in the certification.

For full details, please see the Gabion Product Installation Guide.

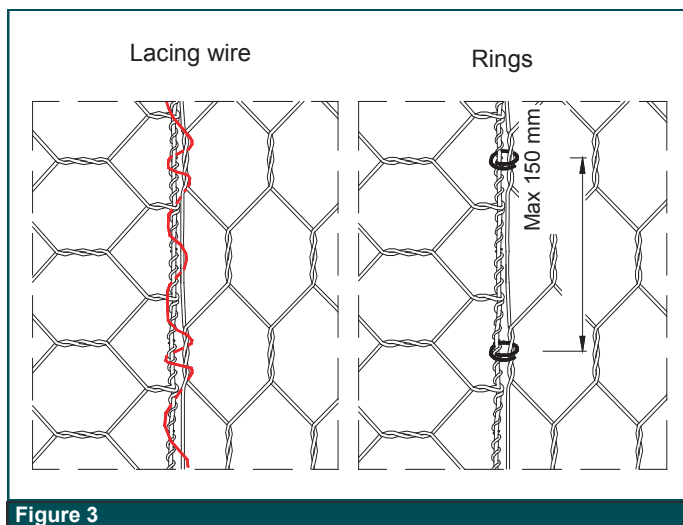


Figure 3

Table 2—Standard mesh-wire

Type	D mm (in.)	Tolerance	Internal Wire Dia mm (in.)	External Wire Dia mm (in.)
8x10/ ZN+PVC	83	$\pm 10\%$	2.70	3.70

Table 3—Standard wire diameters

	Lacing Wire	Mesh Wire	Selvage Wire / Preformed Stiffeners
PVC Mesh Diameter mm	2.2/3.2	2.7/3.7	3.4/4.4
Wire Tolerance mm	0.10	0.10	0.10
Minimum Quantity/Zinc g/m ²	214	244	259
Wire + PVC diameter mm	3.20	3.70	4.40

Quantity Request

When requesting a quotation, please specify:

- number of units,
- size of units (length x width x height, see Table 1),
- type of mesh,
- type of coating.

EXAMPLE: No. 100 gabions 2x1x1 m - Mesh type 8x10 - Wire diam. 2.7/3.7 mm - Galvanized + PVC coated.

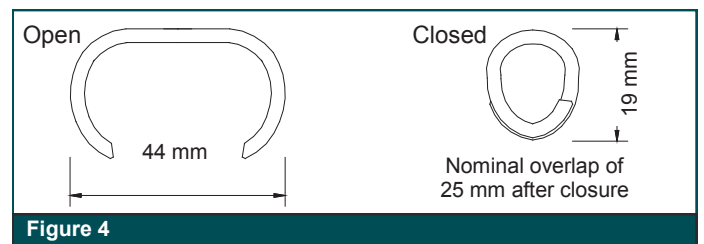


Figure 4

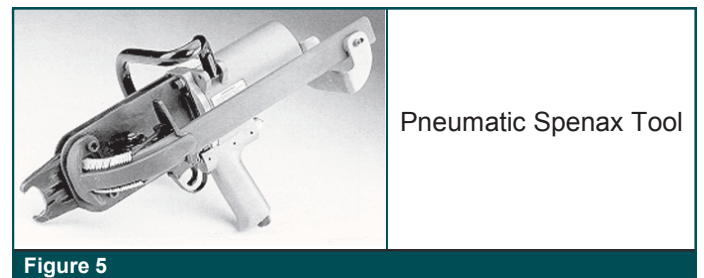


Figure 5

400 Collier MacMillan Drive, Unit B
Cambridge, ON N1R 7H7
Tel: 519-623-9990
Fax: 519-623-1309

MACCAFERRI CANADA LTD.

email: info@maccaferri.ca
website: www.maccaferri.ca

Halifax, NS tel: 902-468-8615
Montréal, QC tel: 450-420-1845
Edmonton, AB tel: 780-447-2719
Calgary, AB tel: 403-244-6556
Vancouver, BC tel: 604-683-4824

Appendix H

PRELIMINARY CONSTRUCTION
NOTES FOR GABION WALLS

CONSTRUCTION NOTES FOR GABION WALLS

1.0 MATERIALS

- 1.1 GABION BASKETS SHALL BE GALVANIZED 8x10 HEXAGONAL DOUBLE TWIST WIRE MESH TYPE AS PER ASTM A975-97, AS OUTLINED IN SECTION 2.1 OF THE PRODUCT STANDARD SPECIFICATIONS.
- 1.2 GABION STONE SHALL BE CLEAN, HARD, ANGULAR TO ROUND, 100mm(MINIMUM) TO 200mm (MAXIMUM) ROCK AS SPECIFIED IN SECTION 2.5 OF THE PRODUCT STANDARD SPECIFICATIONS. GABION STONE SHALL CONFORM TO ASTM D6711-01
- 1.3 BACKFILL SHALL MEET THE STRENGTH REQUIREMENTS AS DEFINED ON THE CROSS SECTION PROVIDED.
- 1.4 BACKFILL MATERIAL SHALL BE ON SITE SOILS OR SELECT FREE DRAINING BACKFILL AND MUST BE APPROVED BY THE OWNER OR THE OWNER'S REPRESENTATIVE.
- 1.5 BACKFILL MATERIAL SHALL BE FREE OF EXCESS MOISTURE, ROOTS, MUCK, SOD, SNOW, FROZEN LUMPS, ORGANIC MATERIAL OR OTHER DELETERIOUS MATERIALS.

2.0 DRAINAGE

- 2.1 SITE GRADING SHALL AT ALL TIMES DIRECT WATER FLOW AWAY FROM THE RETAINING WALL STRUCTURE.
- 2.2 THIS DESIGN IS BASED ON THE ASSUMPTION THAT THE BACKFILL MATERIAL SHALL BE FREE OF SUBSURFACE DRAINAGE OF WATER (SEEPAGE). PERMANENT SUBSURFACE WATER COLLECTION AND DIVERSION SHALL BE THE RESPONSIBILITY OF THE OWNER OR THE OWNER'S REPRESENTATIVE.
- 2.3 AT THE END OF EACH WORKDAY, BACKFILL SURFACE SHALL BE GRADED A MINIMUM OF 2% AWAY FROM THE WALL FACE AND COMPACTED WITH A SMOOTH WHEEL ROLLER TO MINIMIZE PONDING.
- 2.4 THE ENGINEERING, ANALYSIS, DESIGN AND MITIGATION OF SURFACE DRAINAGE AND SEEPAGE OF GROUND WATER IS THE RESPONSIBILITY OF THE OWNER OR THE OWNER'S REPRESENTATIVE.

3.0 TECHNICAL REQUIREMENTS

- 3.1 PRIOR TO CONSTRUCTION THE CONTRACTOR SHALL CLEAR AND GRADE THE BACKFILL AREA, REMOVING TOP SOIL, BRUSH, SOD AND OTHER ORGANIC DELETERIOUS MATERIALS. ANY UNSUITABLE SOILS SHALL BE OVER EXCAVATED AND REPLACED AND COMPACTED WITH BACKFILL MATERIAL TO PROJECT SPECIFICATIONS OR AS OTHERWISE DIRECTED BY THE OWNER OR THE OWNER'S REPRESENTATIVE.
- 3.2 INSTALLATION OF GABION BASKETS SHALL BE IN ACCORDANCE WITH ASTM D7014-04 AND MANUFACTURER'S SPECIFICATIONS.
- 3.3 GABIONS SHALL BE INSTALLED USING THE CORRECT BATTER ANGLE AS SHOWN ON THE DRAWING(S).
- 3.4 GABIONS SHALL BE CONSTRUCTED AND MAINTAINED DURING CONSTRUCTION TO SLOPE AS SHOWN ON DRAWING(S). INDIVIDUAL GABION DEFORMATION SHALL BE LIMITED TO 64mm AT THE TOP AND A BULGE OF 51mm MEASURED FROM THE BASE OF THE GABION. THE CONTRACTOR SHALL PROVIDE ALIGNMENT CONTROL FOR EACH COURSE OF GABIONS AND MAKE ALIGNMENT CORRECTIONS AS NECESSARY.
- 3.5 INSTALL GEOTEXTILE FABRIC AS SPECIFIED ON CROSS SECTION BEHIND THE GABION BASKETS PRIOR TO PLACEMENT OF BACKFILL MATERIAL.

4.0 SPECIAL PROVISIONS

- 4.1 ANY REVISIONS TO THE DESIGN PARAMETERS STATED ON THE CROSS SECTION PROVIDED OR STRUCTURE GEOMETRY SHALL REQUIRE DESIGN MODIFICATIONS PRIOR TO CONSTRUCTION. THE CONTRACTOR SHALL CHECK AND VERIFY ALL DIMENSIONS ON THE STRUCTURAL DRAWINGS WITH SITE DRAWINGS PRIOR TO COMMENCEMENT OF CONSTRUCTION AND NOTIFY THE ENGINEER IMMEDIATELY OF ANY DISCREPANCIES
- 4.1 THE ACCOMPANYING DRAWING(S) SHALL BE READ IN CONJUNCTION WITH ALL OTHER CONTRACT DOCUMENTS.
- 4.2 THESE CONSTRUCTION NOTES MUST BE READ IN CONJUNCTION WITH PRODUCT SPECIFICATIONS AND PRODUCT INSTALLATION GUIDE FOR GABIONS.
- 4.3 THIS DESIGN IS VALID ONLY FOR THE PROPOSED GABION WALL AS SHOWN HEREIN.
- 4.4 THE DESIGN PROVIDED HEREIN IS PRELIMINARY IN NATURE AND MUST BE VERIFIED BY A CONSULTING ENGINEER PRIOR TO COMMENCEMENT OF CONSTRUCTION.

SOURCE: MACCAFERRI CANADA LTD.

TITLE:

PROJECT:

CLIENT:

Construction Notes
Monarch Creek Gabion Walls Phase 2
Yoho National Park
British Columbia
MMM Group Limited

DES.	AB	DR.	LCH
CH.	AB	SCALE	NTS
APP.	AB	DATE	Feb. 11/16
PROJECT NO.	151-64288-00		
FIGURE NO.	6		

Appendix I

PRODUCT INSTALLATION GUIDE

PRODUCT INSTALLATION GUIDE

Gabions

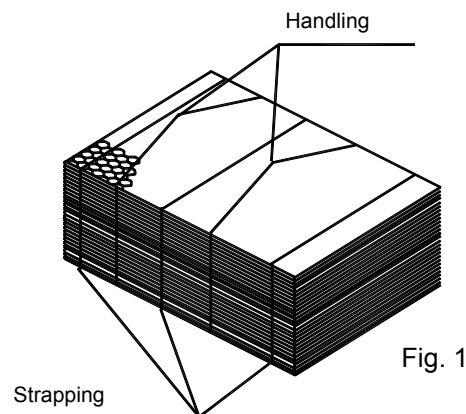


Fig. 1

Maccaferri gabions are delivered to the job site in bundles. They are compressed and strapped in the factory for easier shipping and handling.

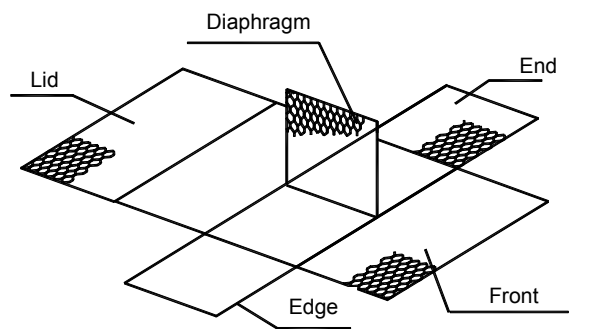


Fig. 2

1. Open and unfold the gabions one by one on a flat, hard surface. Eliminate all folds due to the packaging.

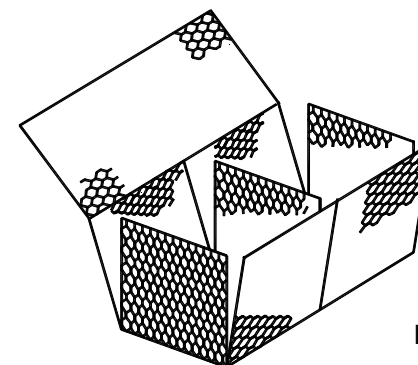


Fig. 3

2. Pull up the sides and the diaphragms to form an open box. Be sure the top of face and side panels are at the same level.

3. Fold by hand the end of the reinforcing wire of the main unit and the diaphragms allowing the gabion to stand by itself.

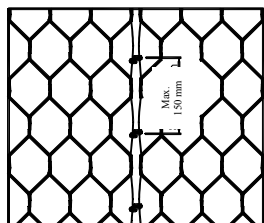


Fig. 4

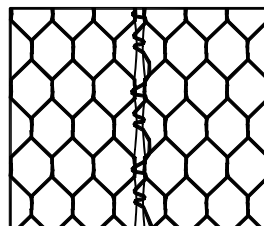


Fig. 5

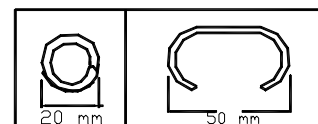


Fig. 6

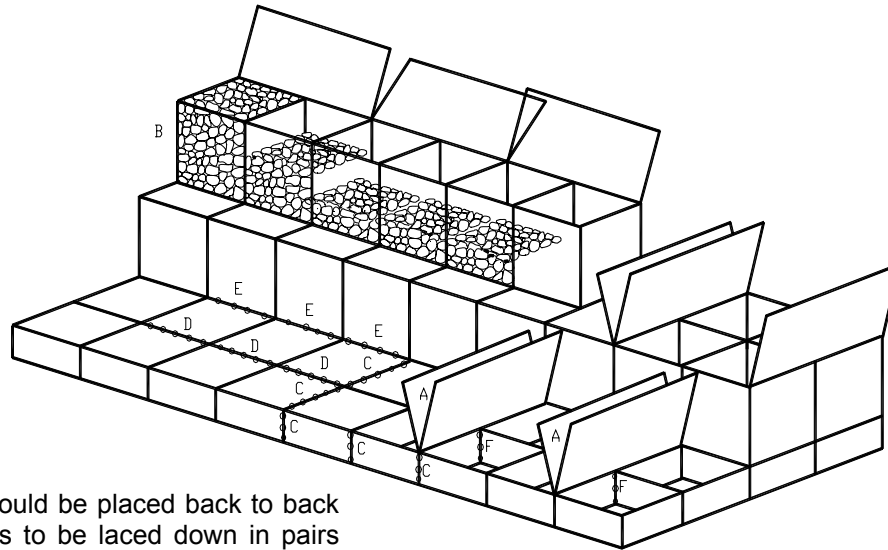
The fasteners have a diameter of 50 mm open and 20 mm closed.

4. Edges are joined together, using the appropriate lacing techniques.

MANUAL: continuous wire looped tightly around every other mesh opening, alternating single and double loops (Fig. 5). Galvanized lacing wire is used for galvanized gabions and PVC coated lacing wire is used for PVC coated gabions.

MECHANICAL: using a pneumatic tool and "C" shaped fasteners (galvanized fasteners for galvanized gabions and stainless steel fasteners for PVC gabions). For continuity and strength, the recommended spacing is every mesh opening, and not to exceed 150mm (Fig. 4).

Fig. 7



A – Units should be placed back to back to enable lids to be laced down in pairs and also to facilitate dumping of the stone.

B – Unit after fill-up

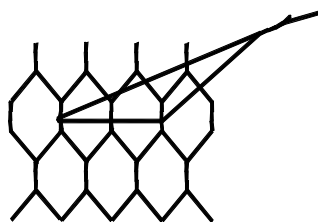
C – Lacing together of the units.

D – Lacing the lids to the diaphragms.

E – Lacing the upper gabion to the lower gabion.

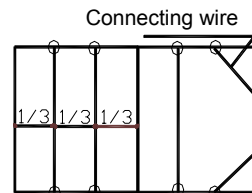
F – Lacing the diaphragms together.

Fig. 10



The connecting wire must grip at least two mesh openings.

Fig. 9



At the extremities, extra connecting wire should be installed at 45 degrees to the adjacent faces.

5. Install a few gabions empty at the proper location, placing them side by side and back to back. Connect the gabions together tightly at the contact edges. The rows above, below and beside should be laced together at the edges. Prior to filling the row of gabion baskets, the gabions shall be stretched and maintained in tension.

6. While maintaining tension, fill the gabions in 0.3m lifts of rock fill. The rock fill in exposed vertical faces shall be hand placed to reduce voids on the outer face. Sufficient hand manipulation of the rock fill shall be performed to minimize voids and achieve a maximum den-

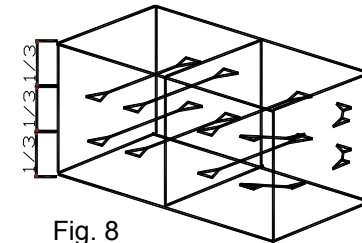


Fig. 8

7. The connecting wires are placed at the 1/3 and 2/3 levels for the gabions 1.00m high and half-height for the gabions 0.50m high.

8. Lace the lids two by two, attaching the edges to the gabion's selvage wire. A crow bar or a steel bar can be used to facilitate lid closure.

MACCAFERRI

Website : www.maccaferri-canada.com

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Halifax, NS: (902) 468-8615