

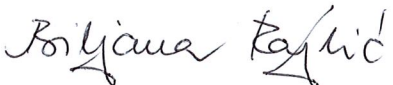


# TECHNICAL MEMO

**To** Linda Riley**From** Biljana Rajlic**Date** July 11, 2012**Project #** 285380**Reference** Tunnel watertightness**Page** 1 of 16**CC**

Revision History					
Revision	Date	Status	Prepared By	Checked By	Reviewed By
A	Nov 29, 2011	For issue to MTO	NMc	AL	BR
B	Mar 6, 2012	For issue to MTO	NMc	AL	BR
C	Mar 13, 2012	For issue to MTO	NMc	AL	BR
D	April 3, 2012	For issue to MTO	NMc	AL	BR
E	July 11, 2012	For issue to MTO	NMc	AL	BR

	Name, Title	Signature	Date
Prepared By	Nancy McGee, Structures Coordinator		July 11, 2012
Reviewed By	Andy Lambert, Structures Coordinator		July 11 2012
Approved By	Biljana Rajlic, Structures Lead		JULY 11 2012



# TECHNICAL MEMO

## Content Summary of REV D

The following document is divided into three main parts:

### **Part 1)**

Rev A Tunnel watertightness Memo issued to PIC/WEMG on November 29, 2012.

This is the original document submitted to HMQ outlining design team's concept and explaining how it meets the intent of the watertight clause in the Project Agreement.

### **Part 2)**

This part is a document issued by the design team in response to HMQ's comments provided in a letter from Trevor Parker (Infrastructure Ontario) to Ignacio Lasa (WEMG) '*RE: Request for Review and Acceptance of Structural Tunnel Watertightness Abutment Details (WEP-WEM-LET-HMQ-0397 and WEP-PIC-LET-HMQ-0192)*' dated January 24, 2012. Part 2 also contains a Variation notification because the RSS abutments are not by definition "watertight".

### **Part 3)**

This part is included as an appendix and contains HMQ's comments to REV A in a letter from Trevor Parker (Infrastructure Ontario) to Ignacio Lasa (WEMG) '*RE: Request for Review and Acceptance of Structural Tunnel Watertightness Abutment Details (WEP-WEM-LET-HMQ-0397 and WEP-PIC-LET-HMQ-0192)*' dated January 24, 2012. It also contains an email from Trevor Parker to Roya Noorbaksh, May 15, 2012, with further technical comments from IO.

## 285380-03-126-0039 Document Revision Summary

**REV A** – Original Tunnel watertightness Memo issued to PIC/WEMG as described above.

**REV B** – This revision was a response memo, addressing comments made in AECOM's response letter to REV A 'Review and comments on WEMG's Request for Review and Acceptance of Structural Tunnel Watertightness Abutment Details' dated Jan 13 2012.

**REV C** – This revision was a compilation of REV A, REV B, and AECOM's response letter 'Review and comments on WEMG's Request for Review and Acceptance of Structural Tunnel Watertightness Abutment Details' dated Jan 13 2012.

**REV D** – This revision was a compilation of REV A, REV B, and HMQ's response letter to WEMG. HMQ requested that WEMG re-issue the memo removing all reference to AECOM's response letter. Instead all references should be made to Infrastructure Ontario letter from Trevor Parker to Ignacio Lasa (WEMG) '*RE: Request for Review and Acceptance of Structural Tunnel Watertightness Abutment Details (WEP-WEM-LET-HMQ-0397 and WEP-PIC-LET-HMQ-0192)*' dated January 24 2012. Some modifications were made to WEMG responses (Part 2 of REV D) in order to address revised wording in the Infrastructure Ontario letter, and due to design progress between revisions B and D.

**REV E** – In this revision, Part 2) has been updated in response to technical comments from IO (emailed by Trevor Parker to Roya Noorbaksh on May 15, 2012, and discussed in the Structures TWG on May 15, 2012). These comments are included in Part 3) as an appendix.

# TECHNICAL MEMO

## **PART 1 – ORIGINAL TUNNEL WATERTIGHTNESS MEMO (REV A)**

### **1. Introduction**

In a design review meeting with MTO/IO Structures on November 1, 2011, the PA (Project Agreement) requirement for tunnels to be watertight was discussed. The design team took away the action to demonstrate how the proposed design addresses the intent of the PA, and to provide information about the water table level and where the drains discharge to.

This memo is to address the above meeting action.

### **2. The PA requirement for tunnels to be watertight**

In relation to waterproofing, the PA requires that tunnels be watertight with no water intrusion (Schedule 15.2, Part 2, 4.2 Design Criteria, (g)(i)), as follows:

#### **(g) Waterproofing**

- (i) The Tunnel structure shall be constructed as a watertight facility with no water intrusion permitted through the structure.**
- (ii) Spray-on materials or bentonite-based boards shall not be used.**
- (iii) Contraction joints shall be equipped with continuous waterstops that are embedded in the concrete structure.**
- (iv) All waterproofing materials shall be resistant to damage from chemicals in the groundwater such as hydrogen sulphide.**

In the meeting on Nov 2, 2011, MTO mentioned that their understanding of 'watertight' is that a watertight item submerged in water will not leak.

The reason for the PA requirement for prevention of water intrusion is not immediately clear, but is likely to be for some or all of the following reasons, especially taking into consideration that the highway may be depressed below existing ground water levels:

- Seepage of water through the abutment could result in surface flows that might freeze on cold days, causing a safety hazard on surfaces;
- Seepage of water through the deck or top of abutments could result in large growths of ice, which could create a safety hazard if they broke off and fell;
- Structures stained by seeping water would be aesthetically undesirable;
- Persistent water seepage through the structure could reduce the design life of the structure.

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### 3. Watertightness of the proposed structure

The design will meet the PA intent, and prevent the above issues from occurring, by waterproofing the tunnel deck and by draining water from behind the abutments such that the water table is permanently lowered to below the abutment walls. This will prevent ingress of water into the tunnels.

It is not proposed to attempt to make the RSS abutment walls ‘watertight’ as defined by HMQ. To achieve this would be highly complex, if not completely impracticable, due to the differential movements expected after construction. It would be further complicated because any waterproofing layer behind the concrete facing panels would have to be pierced by numerous structural connections between the panels and the steel straps. (It should be also noted that the current design is generally the preferred standard engineering solution for RSS walls. Structurally, it is preferable for retaining structures to be drained rather than watertight, if at all possible.)

### 4. Proposed abutment drainage

The drainage of water from behind the abutments will be achieved by the use of the following drains, as indicated in Figure 1:

- 1) deck drain at the level of the top of the deck, or immediately on top of the deck;
- 2) 150mm subdrain behind the abutment pile cap;
- 3) 150mm subdrain at the toe of the RSS wall, just behind the facing panels;
- 4) 150mm subdrain below and behind the RSS wall (or, as shown in the sketch, at the bottom of the RGM (Reinforced Granular Mat))

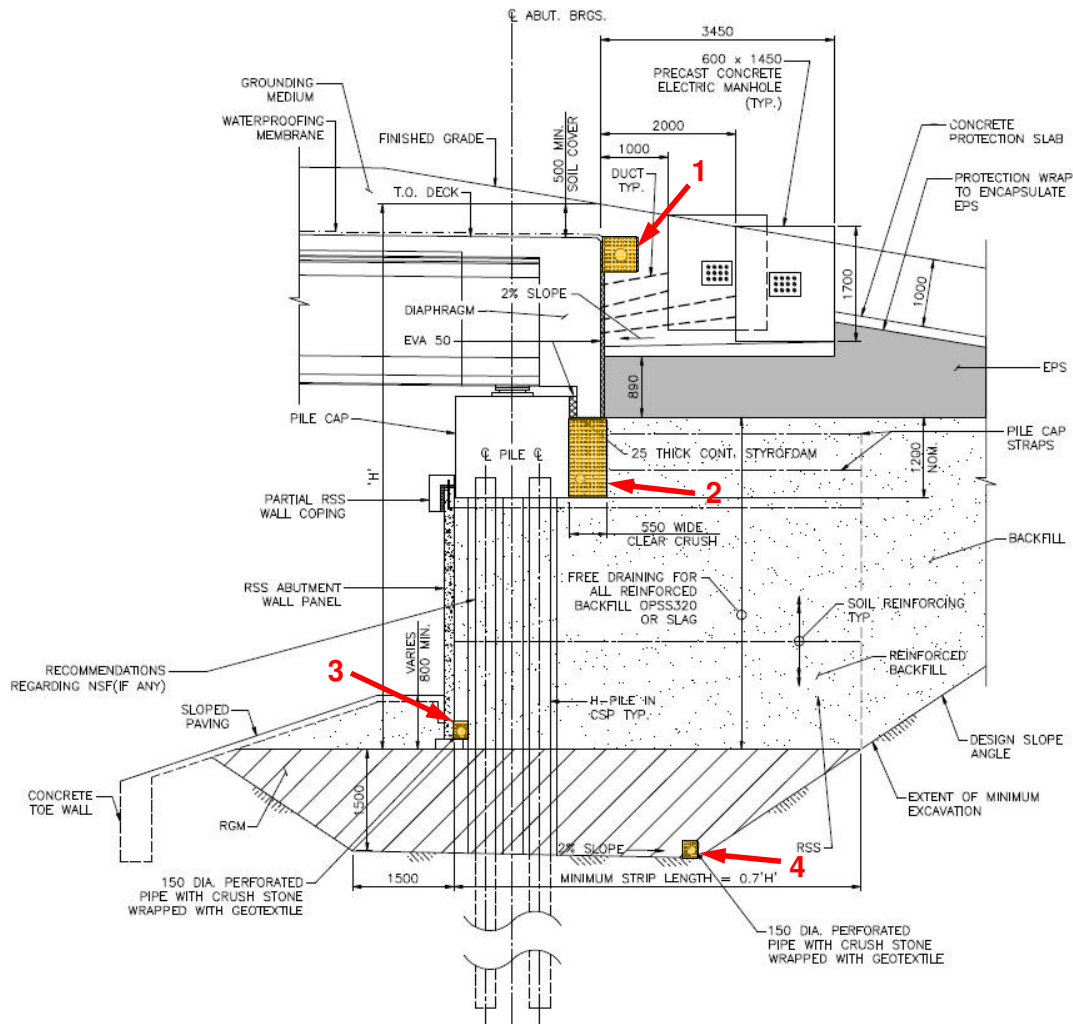
Where necessary, an additional temporary subdrain may also be used at the bottom of the cut slope to lower the water table during construction, but this does not form part of the permanent design.

This is a similar arrangement to the standard detail shown in Figure 3 of the “Semi-Integral Abutment Bridges” MTO manual report no BO-99-03 (see Figure 2 in this memo).

The water table behind the abutment will thus be permanently drawn down to the level of the drainage placed at/below the RSS wall. This will be at least 1m below the finished highway grade in front of the abutments.

The RSS backfill is typically a well-graded material so that migration of fines (which can cause clogging of the subdrains) is not expected. However, by proposing several subdrains the design allows for redundancy in the drainage system should there be a blockage in one of the pipes. Further redundancy is created by the provision of outlets every 60-80m from these subdrains to the roadway drainage system. A plan layout of the drainage system for a typical tunnel is shown in Figure 3 in this memo.

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**Figure 1: Drains in a typical WEP tunnel abutment**

# TECHNICAL MEMO

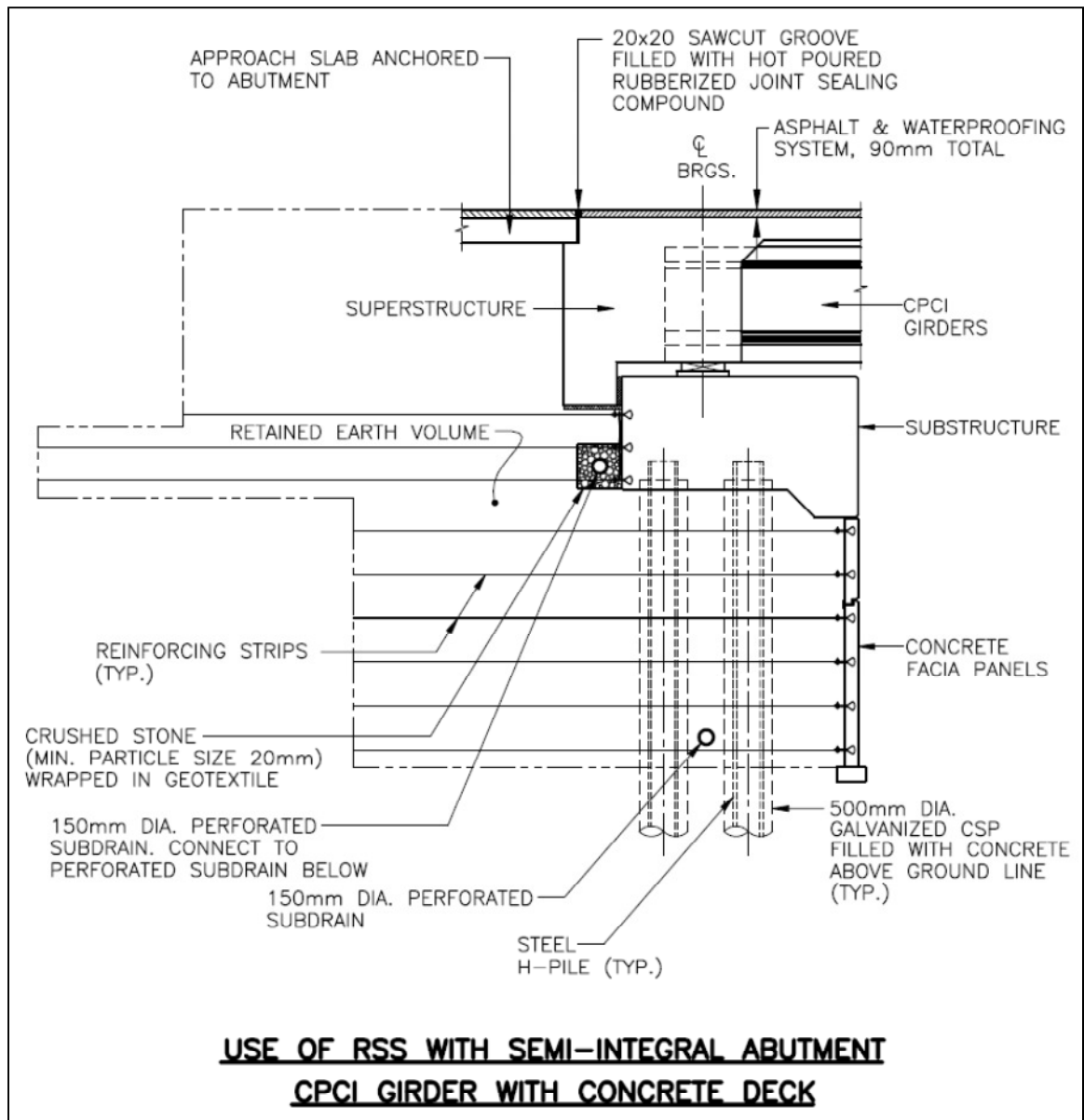


Figure 2: Standard detail as shown in figure 3 of “Semi-Integral Abutment Bridges” MTO manual report no BO-99-03, Figure 3



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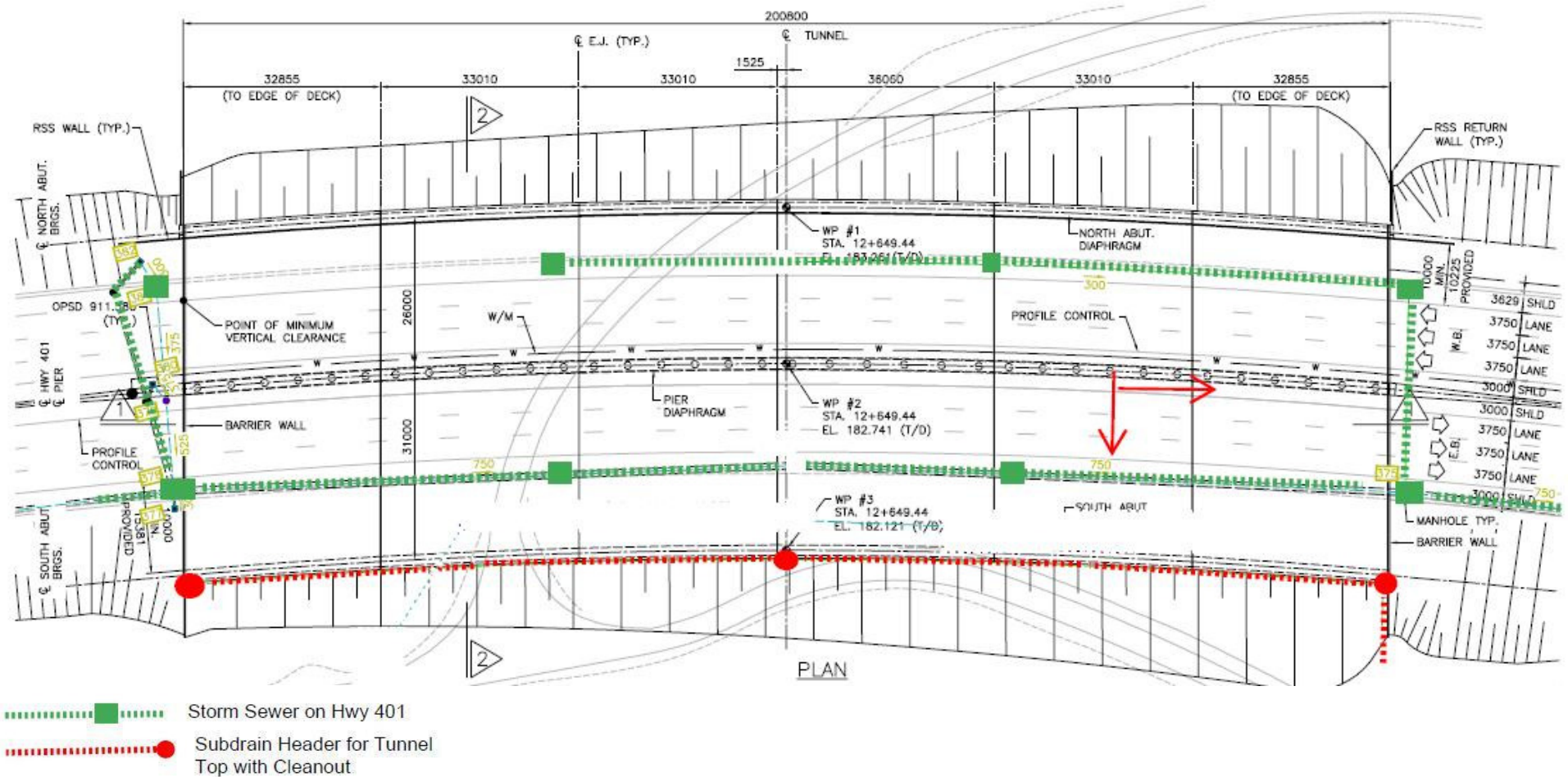
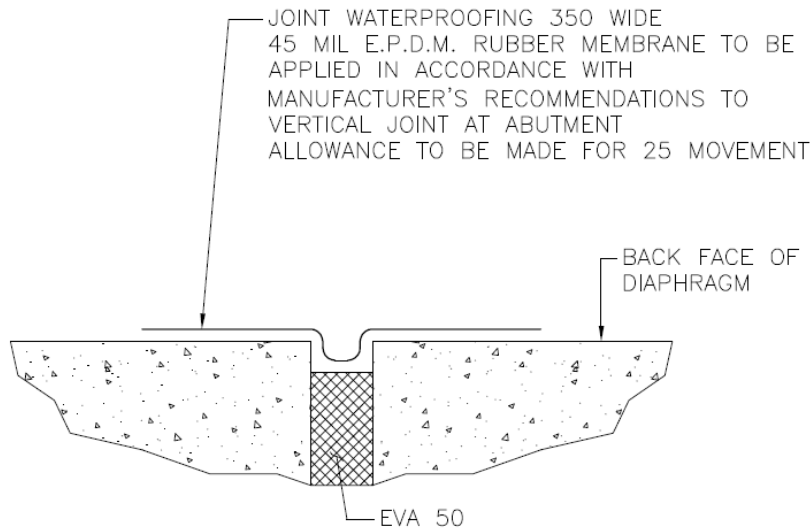


Figure 3: Layout of drains in a typical tunnel. Abutment drains have outlets to the storm sewer catchbasins, which are indicated here as green squares.

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## 5. Seals for abutment joints

Along the length of tunnel abutments there may be a number of expansion joints (also referred to as expansion-contraction joints). These joints will be made watertight by use of a seal. The proposed seal is shown in Figure 4 below.



**Figure 4: Plan on detail of seal at abutment expansion joint**

## 6. Conclusion

As explained in this memo, the design fully complies with the intent of the PA.

With controlled drainage behind abutments there will be no ingress of water through the RSS wall or abutment into the tunnel. This is the design team's understanding of the PA clause that requires the tunnels to be watertight.



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## PART 2 – RESPONSE TO HMQ COMMENTS

(INFRASTRUCTURE ONTARIO LETTER AND EMAIL ARE ATTACHED AS PART 3 FOR REFERENCE)

### **1. Introduction**

WEMG requested that HMQ review the proposed design details for tunnel RSS abutments in relation to PA Schedule 15-2, Part 2, Article 4.2 (g) (i) which requires that all Tunnel structures be constructed as watertight facilities with no water intrusion permitted through the structure (ref WEP-PIC-LET-WEM-0192, dated December 6, 2011).

HMQ reviewed this letter, and responded with comments for consideration (reference '*RE: Request for Review and Acceptance of Structural Tunnel Watertightness Abutment Details (WEP-WEM-LET-HMQ-0397 and WEP-PIC-LET-HMQ-0192)*' dated January 24 2012).

This portion of the memo is in response to HMQ's comments, and is also a Variation Notification because the RSS abutments are not by definition "watertight".

### **2. HMQ comment #1**

HMQ comment: "HMQ would consider the four (4) lines of subdrains identified in Section 4 of PIE's memo (enclosed with PIC's letter) on their own to be non-compliant as the EPS could act as an impervious layer thus causing water to build up behind the abutment."

Since the issue of revision A of this memo, the precast concrete manholes have been removed from this location. The removal of the electrical manholes means that there is no longer the potential for water to be trapped in the lowered portion of EPS, as was shown in Figure 1 of revision A.

Ground Improvement drawings showing subdrain locations for T10B are provided in Figures 6, 7, and 8. This subdrain arrangement is typical for all WEP tunnels. At T10B the deck drains towards the north abutment. Water draining off of the back edge of the north abutment diaphragm is captured in the trench formed by an impermeable membrane attached to the waterproofing and protection board, and drains into a 200mm diameter subdrain header pipe. The details of this header pipe are shown in the Highway New Construction Drawings and are provided again in Figure 5. Water collected by the header pipe is drained to the Highway 401 storm sewer network.

The quantity of water above the EPS at the higher side of the deck (for T10B, the south side) will be much smaller than at the lower side, and, in terms of drainage design, subdrains are not necessary above the EPS at the higher side. If any water is trapped on top of the reinforced concrete slab above the EPS, it will simply drain around the EPS block to the 3 available subdrains below. The top of the concrete slab will be graded at a minimum of 0.35% away from the abutment to facilitate the drainage of water to the subdrains.

Diagram illustrating the cross-section of a drainage system, showing the following components and dimensions:

- TERRADRAIN 600 (SHEET DRAIN)**
- EARTH FILL**
- GEOTEXTILE**
- 19mm CLEAR STONE**
- 300** (Horizontal dimension for stone layer)
- 300** (Horizontal dimension for geotextile layer)
- 300 MIN.** (Vertical dimension for stone layer)
- 50 MIN.** (Vertical dimension for geotextile layer)
- 450 MIN.** (Horizontal dimension for stone layer)
- 50 MIN.** (Vertical dimension for geotextile layer)
- WATERPROOFING**
- ABUTMENT DIAPHRAGM**
- 500mm OVERLAP OF MEMBRANE**
- IMPERMEABLE MEMBRANE (HDPE 20 MIL. GEOMEMBRANE)**
- 200mm PERFORATED SUBDRAIN**

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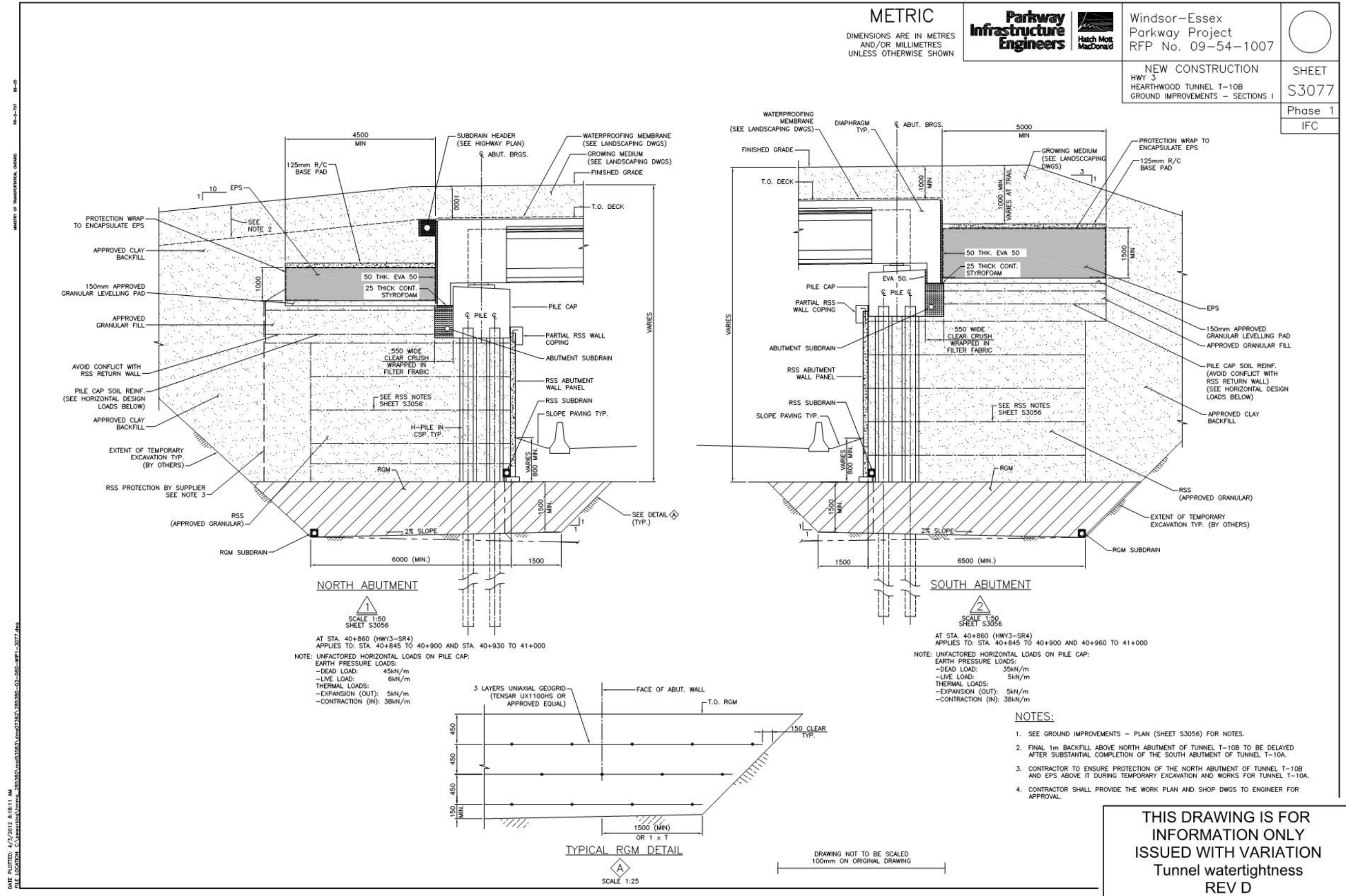


Figure 7: Ground Improvements Sections I, T10B

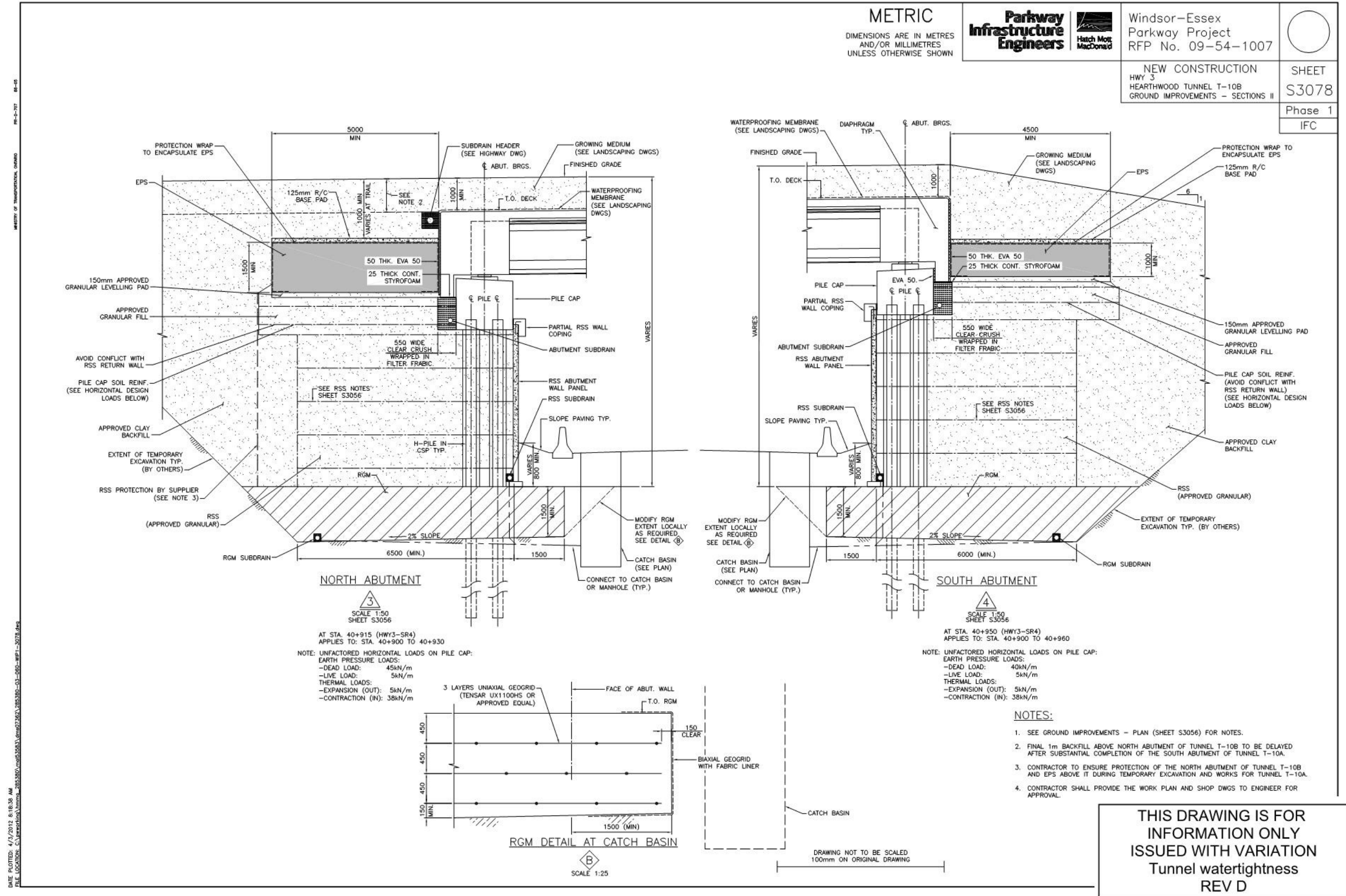


Figure 8 - Ground Improvements Sections II, T10B



# TECHNICAL MEMO

### 3. HMQ comment #2: confirmation of water table draw-down

HMQ comment: "...the claim that the water table will be '...permanently drawn down...' should be confirmed for each site by a qualified hydrogeologist...Hydrogeological information will also be required in determining the size of subdrains and outlet pipes...."

The design team has undertaken hydrogeological modelling to determine the construction and permanent dewatering requirements for the project. The modelling has demonstrated that negligible inflows will occur from groundwater discharges into the subgrade portion of the WEP from groundwater flow through the subgrade. Total groundwater inflows for the subgrade are estimated to be less than 400m<sup>3</sup>/day for the whole project. The reason for the low inflows is simply that the cut is through low-permeability material.

The permanent drawdown will be to the elevation of the subdrain system.

The hydrogeological modelling output shows that the maximum quantity of water to be drained from behind an abutment will be approximately 20 litres per day per metre of abutment. The subdrain system proposed provides a much greater drainage capacity. For example, one single 150mm diameter perforated subdrain laid to only 0.5% slope would have a capacity in the order of 100 times greater than this.

Further information is provided in Geotechnical Investigation and Design Reports for Permanent Cuts and Tunnels, and in the Hydrogeological Assessment for Construction Dewatering and Permanent Dewatering (ref WEP-WEM-LET-HMQ-0820, issued to HMQ for information on May 22, 2012).

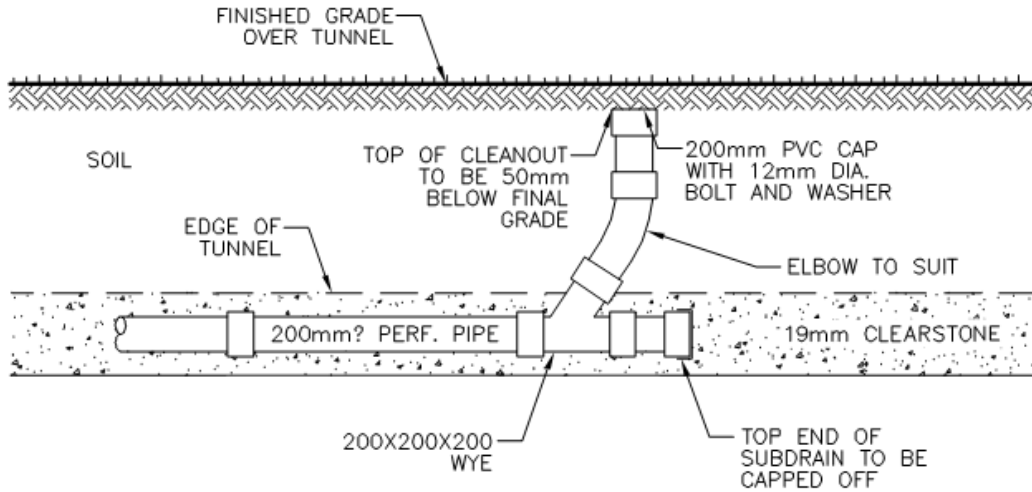
### 4. HMQ comment #3: monitoring subdrain system

HMQ comment: "...As each of the 5 lines of subdrains has a specific purpose for the drainage of a specific area of the structure, the subdrain system may not provide sufficient redundancy in the event that one or more pipes become blocked. WEMG should propose a means of monitoring the performance of the subdrain system and removing any plugs. Further detail should also be provided for the "Cleanouts" shown in Figure 3."

WEMG is of the opinion that the subdrain system will provide sufficient redundancy in the event that one or more pipes become blocked. The system is to be installed according to the requirements of OPSS 405, including wrapping the subdrains with a knitted sock geotextile, and the subdrains will have sufficient slope for the water to drain properly.

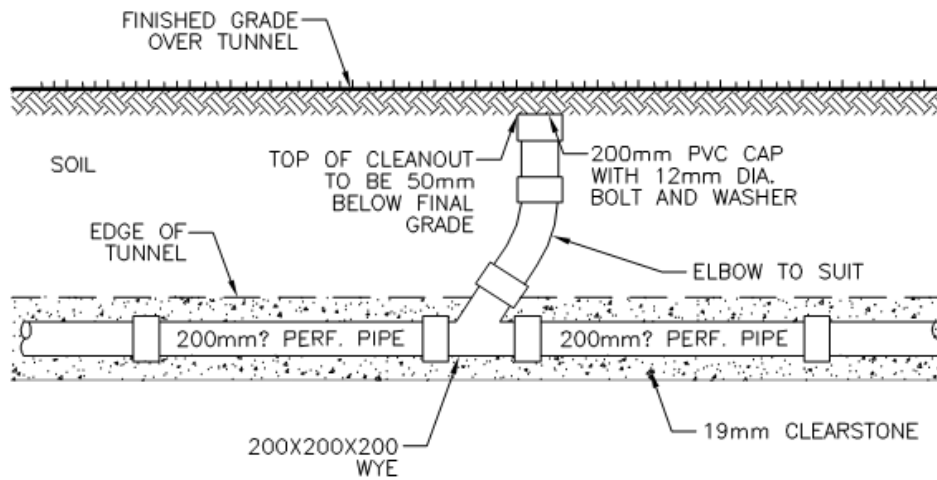
Inspection of the subdrain outlets will be part of the detailed structures inspection that is specified to happen every year.

Further detail for the "Cleanouts" has now been provided in the Highways design submissions. Typical details are shown in Figure 9.



## **SUBDRAIN HEADER – TOP END CLEANOUT**

N.T.S.



## **SUBDRAIN HEADER – IN LINE CLEANOUT**

N.T.S.

**Figure 9: Typical cleanout details** (extract from Highways design submission)

## 5. HMQ comment #4: sealing of abutment joints

HMQ comment: "...the edges of the rubber membrane should be sealed to prevent the ingress of water between the concrete and the membrane."

WEMG fully agrees with this comment, and Tunnel drawings will specify that the rubber membrane be fully sealed to the concrete surface with an appropriate adhesive system around all edges, as shown in Figure 10.

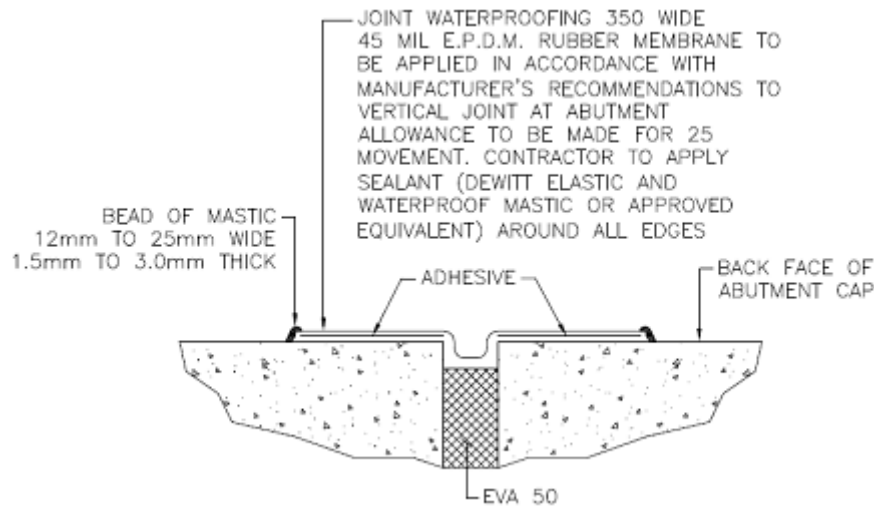


Figure 10: Plan on abutment joint seal (extract from Structures design submission)

## 6. Conclusion

WEMG requests that HMQ grant a Variation from PA Schedule 15-2, Part 2, Article 4.2 (g) (i), which requires that all Tunnel structures be constructed as watertight facilities. Although the tunnel abutments will not be by definition "watertight", they will be drained to prevent water intrusion through the RSS structure.

## PART 3 – HMQ'S COMMENTS ON REV A

(LETTER AND EMAIL IN APPENDIX THAT FOLLOWS)

- Trevor Parker (Infrastructure Ontario) to Ignacio Lasa (WEMG) '*RE: Request for Review and Acceptance of Structural Tunnel Watertightness Abutment Details (WEP-WEM-LET-HMQ-0397 and WEP-PIC-LET-HMQ-0192)*' dated January 24, 2012.
- Email from Trevor Parker (Infrastructure Ontario) to Laith Sadik and Roya Noorbakhsh (WEMG) '*WEP VE details in response to VN-18 (RSS Walls not watertight)*', dated May 15, 2012.

**Infrastructure Ontario**

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January 24, 2012

Mr. Ignacio Lasa  
Windsor Essex Mobility Group  
2187 Huron Church Rd., Suite 210  
Windsor, ON M9C 2L8

**RE: Request for Review and Acceptance of Structural Tunnel Watertightness  
Abutment Details (WEP-WEM-LET-HMQ-0397 and WEP-PIC-LET-HMQ-0192)**

Dear Mr. Lasa:

With reference to the above letter HMQ comments as follows:

HMQ considers the proposed solution to be compliant in principle with PA Schedule 15-2, Part 2, Section 4.2(g)(i) provided the following comments are addressed to HMQ's satisfaction:

1. HMQ would consider the four (4) lines of subdrains identified in Section 4 of PIE's memo (enclosed with PIC's letter) on their own to be non-compliant as the EPS could act as an impervious layer thus causing water to build up behind the abutment. Please propose a solution to address this issue.
2. With respect to the 4th paragraph in Section 4 of PIE's memo, the claim that the water table will be "...permanently drawn down..." must be confirmed for each site by a qualified hydrogeologist, as there is no information provided on the volume of groundwater which must be handled. Hydrogeological input will also be required in determining the size of the subdrains and outlet pipes. In addition, the ability to effectively convey the water collected in the tunnel's subdrain system into the highway storm drainage system must be confirmed for each site.
3. With respect to the 5th paragraph in Section 4 of PIE's memo, the term 'well-graded material' infers some percentage of fines, which can clog the subdrains. As each of the 5 lines of subdrains has a specific purpose for the drainage of a specific area of the structure, the subdrain system may not provide sufficient redundancy in the event that one or more pipes become blocked. WEMG must propose a means of monitoring the performance of the subdrain system and removing any plugs. Further detail should also be provided for the "Cleanouts" shown in Figure 3 of the memo.
4. The proposed details at abutment joints referenced in Section 5 of PIE's memo are in general conformance with OPSD 3950.100, November 2005. The only comment to be directed to WEMG with respect to the abutment joints is that the edges of the rubber membrane should be sealed to prevent the ingress of water between the concrete and the membrane.

If you have any questions, please contact me directly at 416.314.5488 or [trevor.parker@infrastructureontario.ca](mailto:trevor.parker@infrastructureontario.ca)

Sincerely,

A handwritten signature in blue ink, appearing to read "Trevor Parker".

Trevor Parker

Project Coordinator, Infrastructure Ontario

cc: Roger Hanmer, Infrastructure Ontario  
Fay Marzuq, Infrastructure Ontario  
Garfield Dales, MTO  
Rick Luebbers, CH2M HILL  
Michael Hatchell, PIC



**From:** [Rajlic, Biljana](#)  
**To:** [Lambert, Andrew](#); [McGee, Nancy](#)  
**Cc:** [Yu, Matthias](#)  
**Subject:** FW: WEP VE details in response to VN-18 (RSS Walls not watertight)  
**Date:** Tuesday, May 15, 2012 9:30:18 AM

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-----Original Message-----

**From:** Parker, Trevor [[Trevor.Parker@infrastructureontario.ca](mailto:Trevor.Parker@infrastructureontario.ca)]  
**Sent:** Tuesday, May 15, 2012 09:27 AM Eastern Standard Time  
**To:** Roya Noorbakhsh ([rnoorbakhsh@wemg.ca](mailto:rnoorbakhsh@wemg.ca))  
**Cc:** Rajlic, Biljana; Simon Ng ([Simon.Ng@aecom.com](mailto:Simon.Ng@aecom.com)); 'Werner.Volkmann@ch2m.com'; Chirico, Joey (MTO); 'Linda Riley'  
**Subject:** FW: WEP VE details in response to VN-18 (RSS Walls not watertight)

Roya,

For your convenience, here is the email with the technical comments. HMQ is amenable to WEMG's approach to water tightness from a philosophical perspective, but we have some technical comments.

Trevor

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**From:** Parker, Trevor  
**Sent:** Friday, May 11, 2012 5:17 PM  
**To:** Laith Sadik ([laith.sadik@wemg.ca](mailto:laith.sadik@wemg.ca)); Roya Noorbakhsh ([rnoorbakhsh@wemg.ca](mailto:rnoorbakhsh@wemg.ca))  
**Subject:** WEP VE details in response to VN-18 (RSS Walls not watertight)

Laith/Roya,

Here are some additional technical comments that your designers will find useful. Please pass these along.

- 1) HMQ does not agree that the water settled above the flat EPS will simply drain around the EPS. This would require some sort of hydraulic pressure or gradient to push it away. How does PIC intend to achieve this?
- 2) Subdrains are to be wrapped with a knitted sock geotextile per OPSS 405.
- 3) Hydrogeology findings are subject to reviews of the Dewatering report when provided.
- 4) Maintenance procedures regarding the cleanouts is vague and needs to be documented and detailed. We understand cleanouts will be present but how will WEMG determine that the subdrains are clogged? When will inspections happen and what will determine that flushing will be needed? This is critical to ensure the subdrains will operate continuously.
- 5) We have concerns with the expansion/contraction joint detail and revisions to the proposed design are required. Some concerns include the possibility the EPDM being torn due to movement and the likelihood for deleterious material to migrate between the E.P.D.M and EVA due to the presence of a gap.
- 6) In Figure 5 there is a lack of detail to address the prevention of water from getting beneath

the membrane and avoiding the sub drain altogether. Detail needs to be provided for the planon (dimpled drainage board).

Thank you,  
Trevor

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