

10 January 2016,
Brett McLennan
McLennan & Associates

Peter Hatton
EGIS Road Services

Dear Peter,

As requested by EGIS Consulting (EGIS), McLennan & Associates (M&A) undertook the December 2015 monthly groundwater survey of existing monitoring bores along the Legacy Way Tunnel. Monitoring of groundwater levels is required as part of the Coordinator Generals conditions for both the design and construct, as well as the operational phase of the Legacy Way Tunnel.

Field work was undertaken on 31 December. All monitoring locations were sampled, with exception of NL2-14 in Birdwood Terrace, due to a vehicle parked over the well for two consecutive days.

BH205 at the ICB appeared to have sediment build-up inside the bore, which continues to have water level less than 10cm (and considered dry for logging purposes) It is recommended that this well is re-developed to clear sediment from the well and filter pack.

Groundwater December 2015

Monthly groundwater monitoring has been conducted in compliance with the Hydrogeology and Groundwater Environmental Management Plan (EMP EN-OP-PP0018). Monitoring locations were previously selected due to their location, geology and accessibility along the Legacy Way Tunnel corridor. The monthly groundwater works included measuring standing water levels along the tunnel alignment and downloading data from *in situ* water level loggers. For the purpose of this study the monitoring wells are targeting bedrock (confined) and alluvial (unconfined) aquifers.

Groundwater Monitoring Locations

The monitoring locations assessed during this month's works are outlined in Table 1 below

TABLE 1- GROUNDWATER LOCATIONS

Locality	ID	Reference	Geology	Monitoring
West	NL2-02	Toowong	Bedrock	Groundwater level
	NL3-05S	Toowong	Alluvium	Groundwater level
	NL3-16	Toowong	Alluvium	Groundwater level
Alignment	BH108	Toowong	Bedrock	Groundwater level
	BH320	Toowong	Bedrock	Groundwater level
	NL5-4	Toowong	Bedrock	Groundwater level
	NL2-12	Toowong	Bedrock	Groundwater level
	NL2-14	Auchenflower	Open Bore – Bedrock and Alluvium	Groundwater level
	BH309	Rosalie	Bedrock	Groundwater level
	BH311	Rosalie	Bedrock	Groundwater level
	BH312	Rosalie	Bedrock	Groundwater level
	BH313	Rosalie	Bedrock	Groundwater level
	BH313 A	Rosalie	Alluvium	Groundwater level
	NL4-HG10	Rosalie	Alluvium	Groundwater level
	NL4-HG6A	Paddington	Alluvium	Groundwater level
	NL4-5	Paddington	Bedrock	Groundwater level
	NL4-A2	Rosalie	Bedrock	Groundwater level
	NL2-06	Red Hill	Bedrock	Groundwater level
	NL2-09	Red Hill	Bedrock	Groundwater level
East	BH205	Inner City Bypass	Bedrock	Groundwater level
	BH221	Kelvin Grove	Bedrock	Groundwater level
	BH222	Inner City Bypass	Bedrock	Groundwater level

The groundwater locations in **Table 2** had previously been decommissioned during the design and construct phase of the project. It is understood that most have been destroyed since the commencement of the project. The quantity of the remaining monitoring locations is deemed sufficient for the purposes of the groundwater monitoring and no additional replacement wells are planned. Monitoring had previously ceased in the Botanic Gardens following handback of the tunnel conveyor to BCC.

TABLE 2 - DECOMMISSIONED GROUNDWATER LOCATIONS

Locality	ID	Reference	Geology	Monitoring
West	BH503	Botanic Gardens	Bedrock	Conveyor Tunnel no longer in use - no further monitoring to be conducted
	BH502	Botanic Gardens	Bedrock	Conveyor Tunnel no longer in use – no further monitoring to be conducted
	BH104D	Botanic Gardens	Bedrock	Destroyed
	BHSC1A	Botanic Gardens	Alluvium	Destroyed
	BHSC1B	Botanic Gardens	Bedrock	Destroyed
Alignment	BH314	Toowong	Bedrock	Not located – Note NL2-14 located nearby this location
	BH310	Rosalie	Alluvium	Replaced by BH313A
	BH307	Red Hill	Bedrock	Decommissioned, due to proximity to the alignment
East	NL4-HG4	Brisbane Grammar	Bedrock	Destroyed
	NL4-HG5	Brisbane Grammar	Bedrock	Destroyed
	BH203	Brisbane Grammar	Bedrock	Destroyed
	BH220	Kelvin Grove	Bedrock	Decommissioned due to damaged casing

Groundwater Monitoring Results

Groundwater Level Monitoring

Groundwater levels below ground surface were collected along the tunnel corridor at 22 locations. All locations monitored were equipped with Solinst Leveltrolls (automated water data) loggers, which were calibrated via the static water groundwater level measurements and corrected for barometric pressure. Static groundwater level measurements are detailed in Table 3.

TABLE 3 - GROUNDWATER ELEVATION

Locality	West	Alignment												East	West	Alignment						
Geology	Bedrock	Bedrock												Bedrock	Alluvium	Alluvium						
Location	NL2-02	BH108	BH320	NL5-4	NL2-12	NL2-14	BH309	BH311	BH312	BH313	NL4-5	NL4-A2	NL2-06	NL2-09	BH205	BH221	BH222	NL3-16	NL3-05S	BH313A	NL4-HG10	NL4-HG6A
Units	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD	mAHD
Ground Elevation mAHD	25.78	23.65	47	20.2	26.07	47.7	4.1	4	4.1	3.8	5.6	2.2	63.9	41.4	23.8	29.3	23.9	18.9	25.01	3.8	2.2	5.58
Water Elevation mAHD Dec. 2015	16.57	17.44	18.715	11.51	17.275	NS	-1.14	-1.035	-0.015	-1.545	4.5	0.11	36.08	28.925	18.76	17.84	18.38	15.36	15	-0.045	0.01	2.125

*BH2-14 unable to be sampled (NS-Not Sampled)

Groundwater Level Results

Figure 1 and Figure 2 demonstrate water level variations in the bedrock and alluvium respectively.

Legacy Way - Groundwater Levels - Bedrock

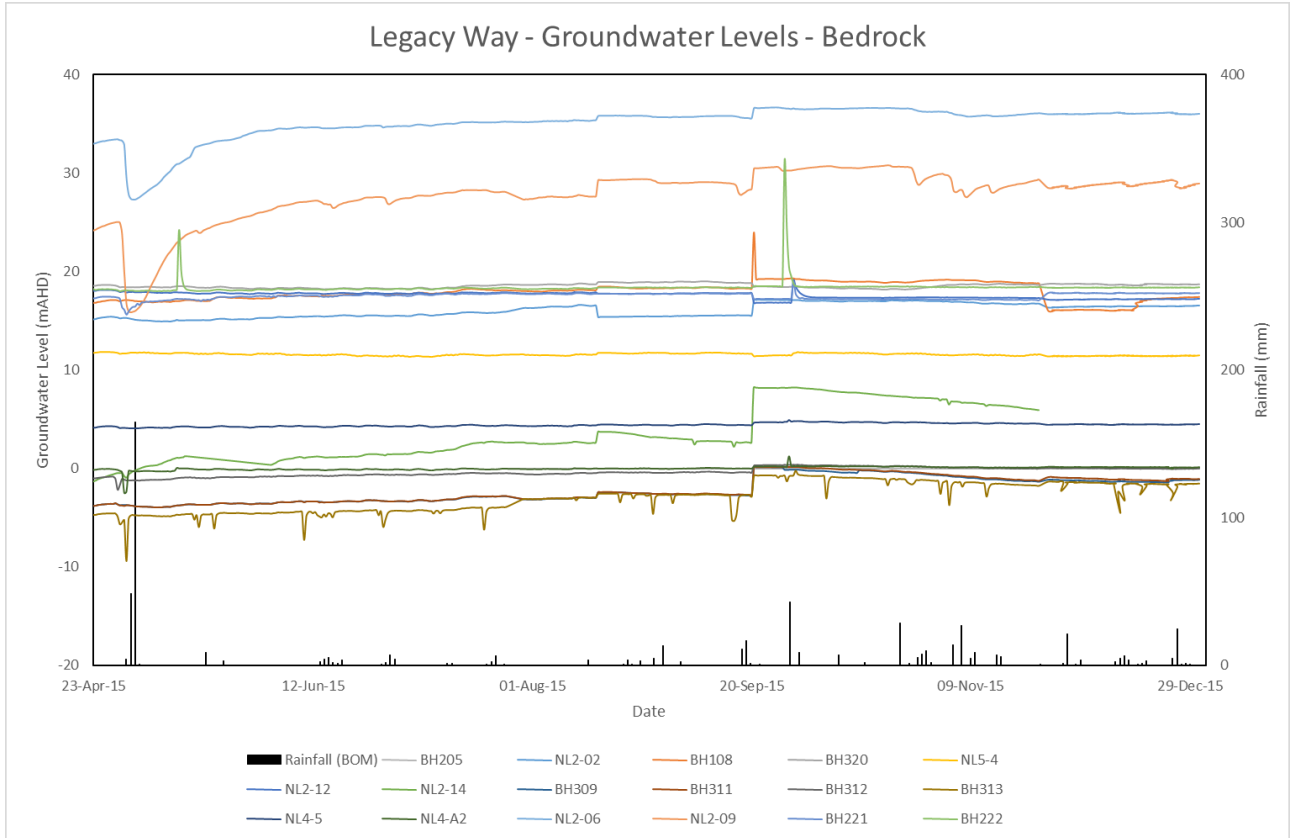


FIGURE 1 - GROUNDWATER LEVELS – BEDROCK

Legacy Way - Groundwater Levels - Alluvium

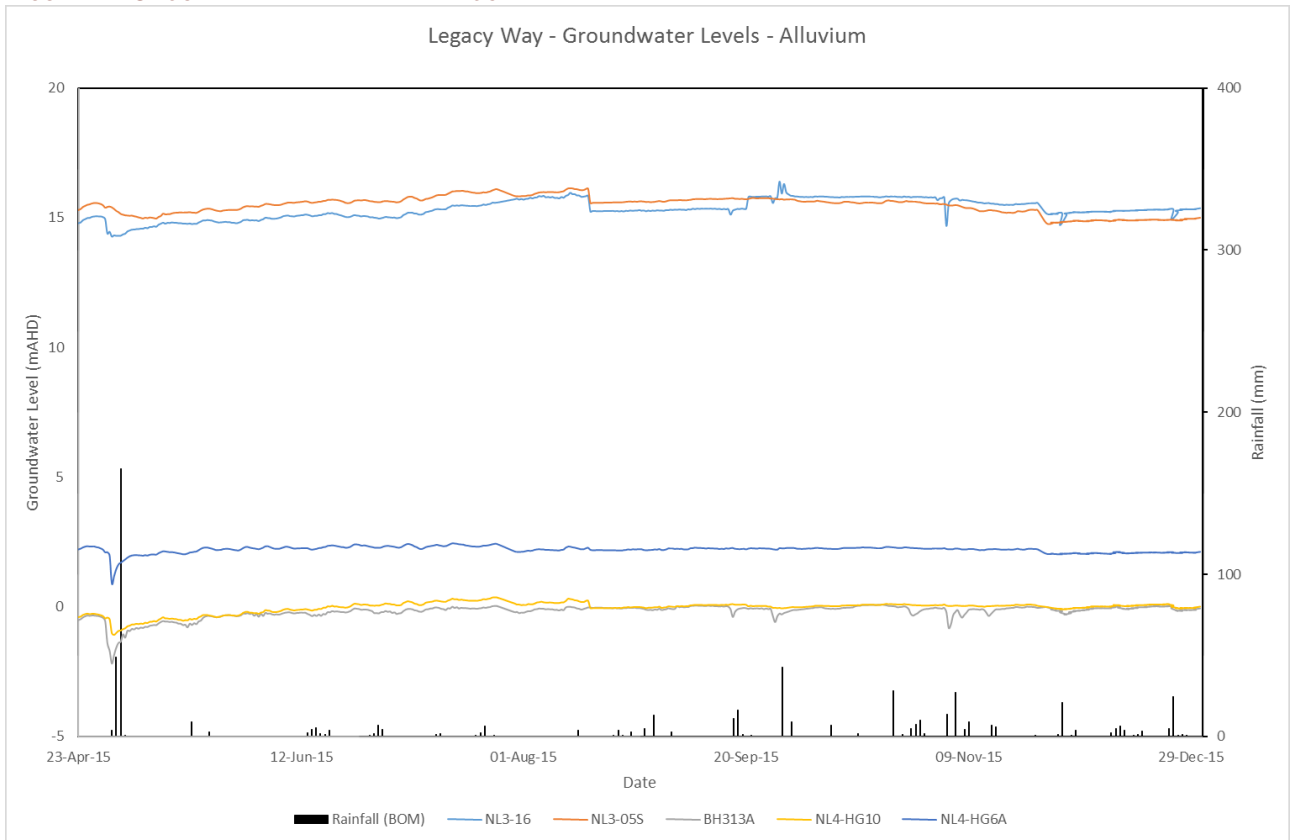


FIGURE 2 - GROUNDWATER LEVELS - ALLUVIUM

The standing water levels generally indicate a continuation of the previous trends displayed during the construction phase i.e. relationship of groundwater fluctuations to rainfall levels, with the following of note:

Groundwater in the Toowong Cemetery and surrounds, the groundwater level in boreholes BH108, BH320, NL5-4, NL2-14 had historically been reported as exceeding the 200% of the natural variation and was associated with the tunneling activities in close proximity to the boreholes. BH108 has slowly decreased since September; however, remains within measured variations. BH320 and NL5-4, indicated static water levels over the previous month. BH 2-14 was unable to be sampled during this monitoring period. The ongoing recovery of the bedrock groundwater level is expected to continue following the wet season recharge.

Along the tunnel alignment in Rosalie and surrounding areas, the groundwater level in boreholes BH309, BH311, BH312, BH313 had previously been reported as historically exceeding the 200% of the natural variation and was associated with tunneling activities in close proximity to the boreholes. These boreholes are assessing water levels in the bedrock, and drawdown from tunneling operations was predicted in this area. Groundwater in BH312 remained static; while BH309, BH311 and BH313 continued to decrease slowly since September.

Borehole locations NL4-HG10 and NL4-HG6A (monitoring the alluvium north and south of the tunnel alignment respectively) continues to remain static since the September monitoring round. NL4-5 and NL4-A2 (monitoring the bedrock north and south of the tunnel alignment respectively) remained static without any marked changes. Stabilisation and recovery of these locations is underway since the cross passage works in the vicinity were completed; however, it will be dependent on recharge rates. Recovery of bedrock groundwater levels continues to be recorded in this area via the automated data logger information and correlated with static water level measurements in the area. Assessment of the groundwater levels at these locations will continue.

Groundwater monitoring of the Eastern Portal area continued, with slow recovery noted in the bores. BH205 has continued to have less than 10 cm of water and is considered “dry” for automatic logging. This is most likely to be associated with the dewatering of the Eastern Portal. BH221 continued to increase since the September rainfall event, but appears to be stabilizing.

At the Western portal, NL2-02 indicated a slight increase in the water level since November, and appears to be stabilizing. This location has been noted to be potentially influenced from external activities (i.e. Mt Coot-Tha Quarry and the botanic garden ponds). This will continue to be assessed to determine if the bedrock in this area continues to recover. Groundwater in the alluvial bore NL3-16 slightly decreased and remained within the winter variation. This well has been noted to be influenced by moderate rainfall events; however, it recovers within several days. NL3-05 continued to remained steady.

It should be noted that at this stage Egis does not propose any mitigation strategies in regards to fluctuations in groundwater levels. However, ongoing monitoring will be undertaken to assess any impacts and stabilisation of water levels.



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