21 February 2022

Groundwater Drawdown Model and Detailed Settlement Analysis – 114-120 Cary Street, 1,2,3,5 Bath Street and 3 Arnott Avenue Toronto

Toronto Investments No1 Pty Ltd

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1 INTRODUCTION

CMW Geosciences Pty Ltd (CMW) was engaged by Toronto Investments No1 Pty Ltd (Toronto) to undertake an assessment of groundwater dewatering and associated settlement for the development located at 118 Cary St Toronto, NSW. **Figure 1** shows the site location.

1.1 Site development

We understand that the building development will comprise a multi-storey building and will include a two-level tanked basement with secant-piled walls. Based on the architectural plans provided, the two basements will occupy vertical depth of ~5.6 m, and it is understood that excavation will be required to approximately 6 metres below ground level (mBGL). Because this will be below the watertable elevation, dewatering will be required.

Previous work undertaken at the site included:

1. Chameleon Geosciences Pty Ltd (2020). Geotechnical Investigation Report. Prepared for Toronto Investments No.1 Pty Ltd, dated 22 December 2020.
2. Chameleon Geosciences Pty Ltd (2021). Response to amended statement of facts and contentions. Letter report in response to the Land and Environment Court. Dated 18 June 2021.
3. JK Geotechnics (2016). Geotechnical Assessment Report. Ref. 29644S Brpt, dated 13 October 2016.
4. Coffey Geosciences (2005). Preliminary Geotechnical Assessment. Ref. N09456/01-AB, dated 22 March 2005.

Only references 1) and 2) above were available for review for this study.

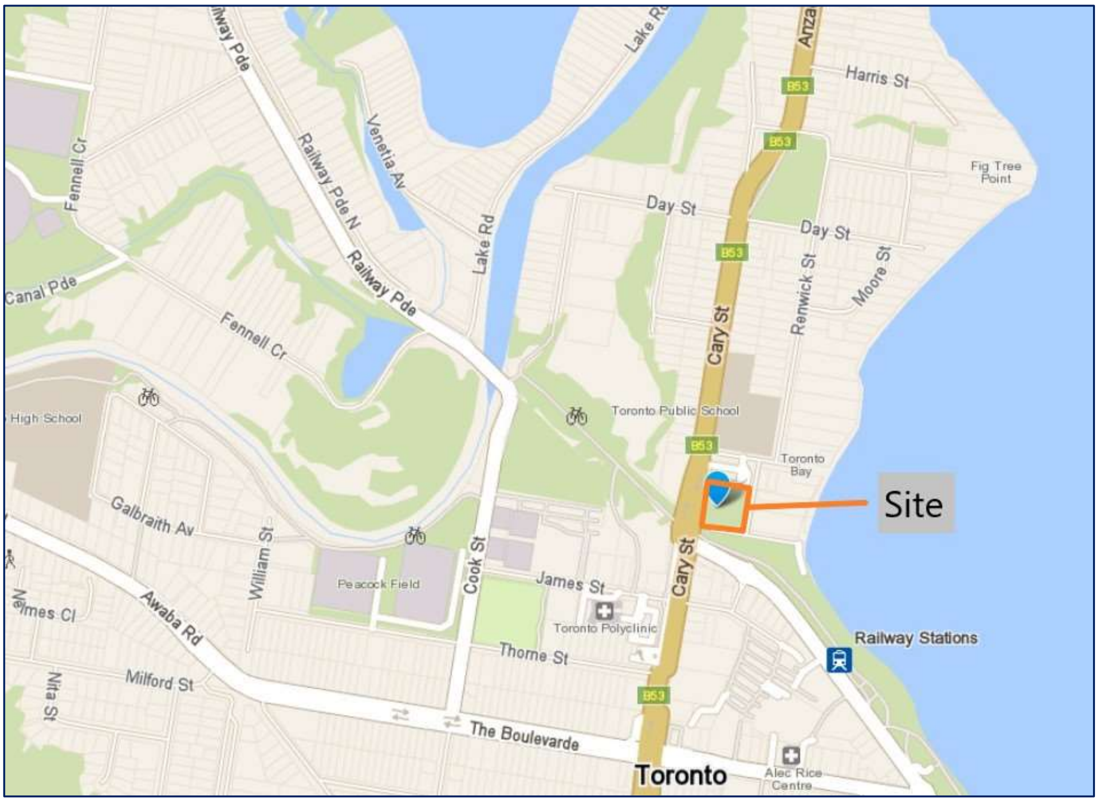

Figure 1 Site plan and investigation locations

1.2 Scope of Work

The following work scope was carried out:

- Review of the site situation and previous work,
- Numerical groundwater modelling to predict groundwater drawdown, and
- Geotechnical settlement analysis, informed by the groundwater model drawdown predictions, to demonstrate potential off-site impacts.

Field investigations were not included in the scope, which relied on previous investigations and generally available information.

2 EXISTING ENVIRONMENT

The site is located approximately 100 m west of Toronto Bay, and is bound to the west by Cary St and to the east by Arnott St. A vacant grassed area and Victory Parade are located to the south of the site (Chameleon, 2020).

The ground surface at the site is approximately 3 to 4 mAHD (metres Above Australian Height Datum).

2.1 Climate

Mean annual rainfall near the site is 1,090 mm/year with a range from 605 to 1,745 mm/year based on the record for nearby Bolton Point (BOM station 61133) which holds data from 1962 to 2021.

The rainfall pattern is distributed throughout the year, with higher average rainfall experienced from the months January to April.

2.2 Geology

The Gosford-Lake Macquarie 1:100,000 map sheet indicates the site is underlain by Newcastle Coal Measures, comprising conglomerate, tuff, siltstone, claystone and coal (Chameleon, 2020). Residual soils and fill overly the conglomeratic bedrock. The generalised ground conditions inferred from the site investigations (9 boreholes) are summarised in **Table 1**.

Table 1: Summary of lithology (after Chameleon, 2020)

Description	Depth mBGL	
	minimum	maximum
Silty sandy CLAY, medium plasticity, soft, moist.	0	1.0
Silty CLAY, with fine gravel, medium to high plasticity, moist, stiff to very stiff.	0.4	3.8
Silty CLAY, fine to medium gravel, medium to high plasticity, moist, very stiff to hard.	1.0	14.0
Gravelly silty CLAY, medium to high plasticity, wet, soft. (BH7 and BH8 only)	0.4	2.7
CLAY, with fine gravel, high plasticity, with silty clay, with fine to medium gravel, moist, very stiff to hard. (BH7, BH8 and BH9 only)	1.0	14.5
CONGLOMERATE, variable sized clasts with traces of sand.	13.4	17.0

2.3 Hydrogeology

The surficial groundwater system comprises an unconfined aquifer hosted within the weathered residual sequence.

Based on bore logs, the upper part of the aquifer comprises stratified sandy and gravelly clay, with conglomerate rock indicated at depth.

2.3.1 Groundwater levels

Based on the previous geotechnical investigation (Chameleon, 2020) groundwater was encountered in all boreholes drilled. Boreholes BH1, BH3, BH5, BH7 and BH9 were constructed as groundwater monitoring wells. Groundwater levels were monitored in these wells from January 2020 to August 2021 and summarised in Table 2. A review of the data indicated a general seasonal fluctuation in groundwater SWL up to 0.8 m (Chameleon, October 2021).

Mean groundwater levels at BH1 to BH9 ranged from 0.66 to 1.23 mAHD. Groundwater levels at the site will vary due to seasonal fluctuation in the groundwater table, and also due to local influences and response to rainfall events at the cleared site.

Monitoring wells BH101 to 103 were installed and measured at a later date than the BH1 to BH9, and a further two wells (Well 1 and Well 2) are located off-site at 97 Cary Street, and only limited time-series monitoring data are available for these wells. It is also noted that BH101 to 103 are constructed at shallower depths than BH1 to BH5 and the slightly higher groundwater RLs at these locations may indicate a downward vertical hydraulic gradient typical of active recharge processes at the site.

Table 2: Summary of groundwater levels (after Chameleon, 2020)

Well ID	Depth (mBGL)	Surface RL (mAHD)	SWL Range (mBGL)	Mean SWL (mBGL)	Mean Groundwater RL (mAHD)
BH1/GW1	13.0	5.5	4.1 to 4.9	4.62	0.88
BH3/GW2	13.5	4.14	3.3 to 3.6	3.43	0.71
BH5/GW3	9.5	3.85	2.6 to 3.0	2.78	1.07
BH7/GW4	13.0	3.80	2.1 to 2.9	2.57	1.23
BH9/GW5	13.0	2.55	1.6 to 2.3	1.89	0.66
BH101	6.0	3.6		1.19	2.41
BH102	6.5	4.1		1.79	2.31
BH103	6.0	3.2		0.66	2.54
Well 1*	4.0	2.46	-	2.0	0.46
Well 2*	4.0	2.60	-	2.1	0.5

* Wells located at 97 Cary Street.

2.3.2 Hydraulic conductivity

Slug tests (Chameleon, October 2021) provided K values for three boreholes BH101, 102 and 103 of 0.0029, 0.0015 and 0.0042 m/day respectively The geometric mean value of these results is 0.0026 m/day. Chameleon (September 2021) also provided K values for other wells of 0.3 m/day, considered more representative of the underlying formations.

2.4 Surface water

Lake Macquarie is located 100 m east of the site and Fennel Bay, part of Lake Macquarie, is located approximately 700 m to the north-west. Stony Creek discharges to Fennel Bay, and is located approximately 350 m to the west.

A westerly trending canal is located between Cary St and the creek, entering the creek just north of the Cook St bridge. Surveyed elevations of key surface water features are provided in Table 3 and used to inform boundary conditions for the model.

Table 3: Surveyed surface water elevations (mAHD)

Feature	High tide	Low tide	Mean
Lake Macquarie	0.11	0.07	0.09
Wetland	0.54	0.56	0.55
Canal	0.41	0.46	0.43
Stony Creek	0.13	0.09	0.11

3 GROUNDWATER MODELLING

Numerical modelling was conducted to simulate excavation dewatering.

A layered 3D numerical model was implemented, with model design undertaken using the Groundwater Vistas modelling environment. The numerical modelling code utilised for the simulations was USGS Modflow 2005, an industry standard finite-difference groundwater flow model.

3.1 Model setup

3.1.1 Discretisation

A four-layer model was setup, with 20 m row and column grid-spacing, refined to 10 m grid-spacing in the site area to improve resolution (Figure 2). The model base was assigned at -20 mAHD. Elevation top surfaces were assigned at:

- Layer 2: RL -3
- Layer 3: RL -5
- Layer 4: RL -10

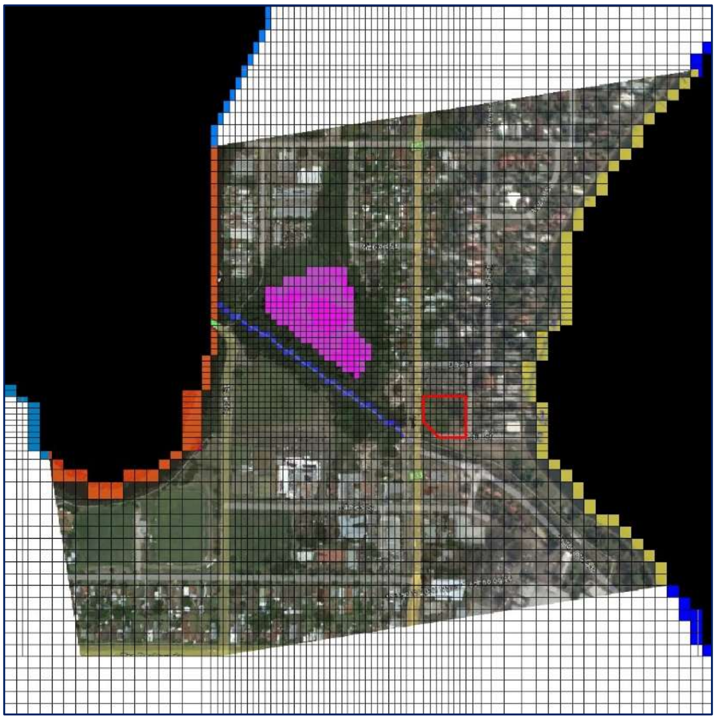

Figure 2 Model grid

3.1.2 Parameters

Based on the results of aquifer testing (refer Section 2.3) the horizontal hydraulic conductivity (K_h) adopted for the clay dominated upper formation was 0.0026 m/day (model layer 1). The horizontal hydraulic conductivity adopted for the underlying model layers was 0.3 m/day. Vertical hydraulic conductivity (K_v) was assigned an order of magnitude lower than K_h in all layers.

A specific yield (S_y) of 0.05 was assumed, representing relatively low effective porosity, typical of lithology with high fines content.

3.1.3 Boundary conditions

Constant-head boundaries were applied to the model edges to represent Lake Macquarie to the east, and Stony Creek and feeding Fennel Bay to the west (refer Figure 2) with head values assigned based on the mean surveyed levels (refer Section 2.4). No-flow cells were applied beyond these areas.

Modflow River cells were used to represent the wetland and the canal. This method provides a more realistic representation of such features compared with drain or constant-head cells. The wetland water level was assigned a value of 0.55 RL, and the canal water level was assigned a value of 0.43 mAHD.

Cut-off walls (secant piles)

The excavation area at the site was modelled to have an area approximately equivalent to the proposed basement. Secant pile cut-off walls are incorporated into the model using the Modflow HFB (horizontal flow boundary) package. The hydraulic parameters adopted have equivalent characteristics of 0.5 m thick walls with $1x10^{-5}$ m/day hydraulic conductivity and therefore are modelled as effectively impermeable. The toe level of the cut-off wall is simulated at -5 mAHD (9 mBGL)

Excavation drainage

Excavation drainage was simulated using the Modflow Drains package. The drain cell locations are located within the excavation perimeter, and assigned a drainage head (dewatering level) of -2 mAHD, representative of dewatering to 6 mBGL. The model drain cells have a conductance of 100 m^2/d.

3.2 Simulations and Results

The modelling included a baseline steady-state simulation, and transient simulation to estimate inflow and drawdown under drainage.

In addition, a steady-state simulation was made to represent the likely changes to groundwater head and flow direction post-construction.

3.2.1 Baseline condition

A baseline model was initially simulated with recharge across the model adjusted to establish an initial head condition at the site area that is within the range of the observed groundwater levels.

Figure 3 shows the baseline steady-state groundwater surface, using the adopted model parameters. The baseline assumes no dewatering, and provides a starting surface for the subsequent dewatering simulations.

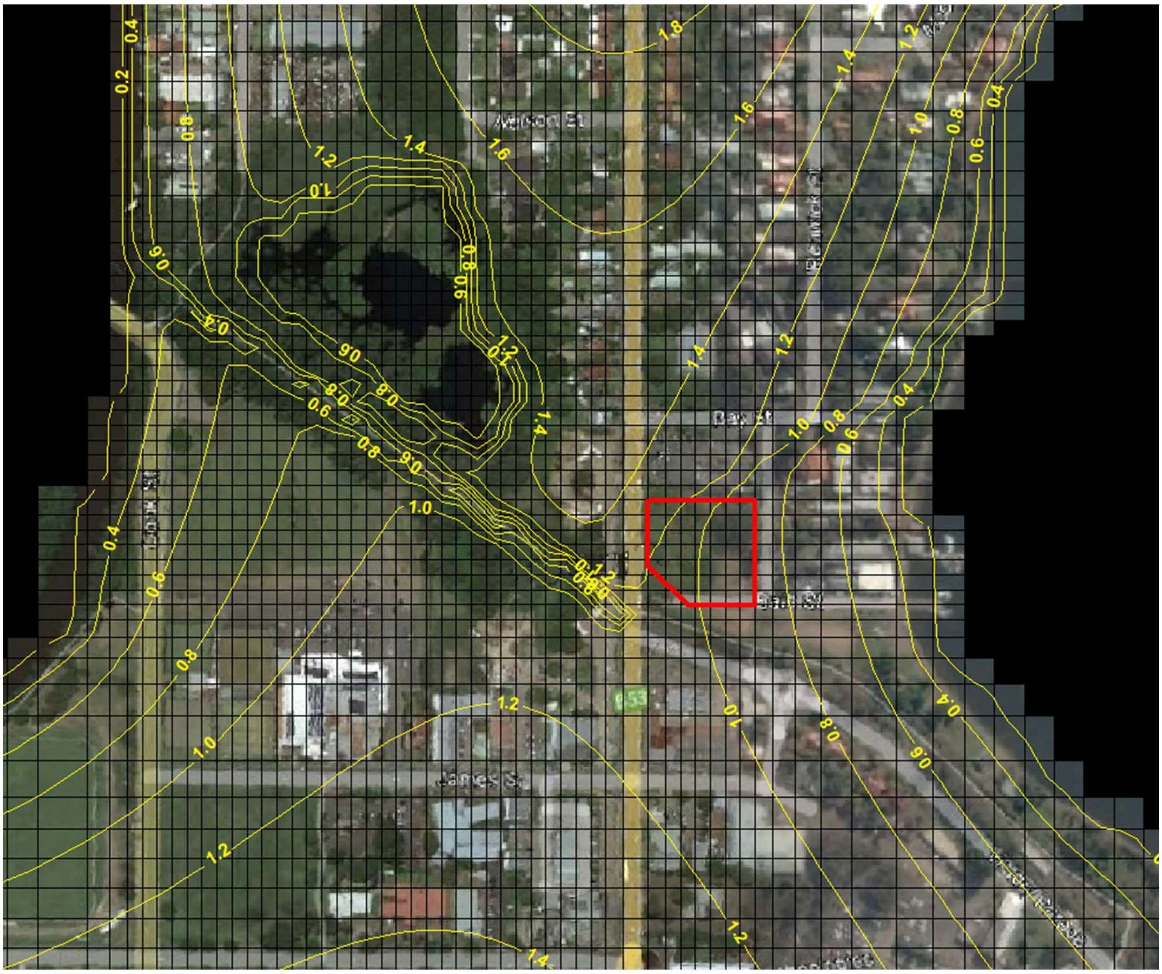

Figure 3 Groundwater baseline – no dewatering

The calibrated rainfall recharge rates in the model were:

- Northern model zone (north of the canal) 0.0001 m/day, equivalent to approximately 3.5% of rainfall.
- Southern model zone (south of the canal) 0.00025 m/day, equivalent to approximately 8% of rainfall.

3.2.2 Transient dewatering simulation

Figure 4 to **Figure 8** show transient drawdown for this scenario at 30, 60, 120, 180 and 360 days. Drawdown will be relative to the starting groundwater level at the time of commencement. Under this scenario, the model mass balance reports groundwater inflows as indicated in **Table 3**.

Table 4: Dewatering inflows

Time (days)	Inflow (m^3/day)	Inflow (L/sec)
7	20.4	0.24
30	20.3	0.23
60	20.1	0.23
120	19.8	0.23
180	19.6	0.23
360	19.3	0.22

The model indicates a maximum off-site extent of groundwater drawdown (0.2 m contour) of ~120 m to the north and south after 360 days of dewatering. The extent to the east/north-east toward the wetland is reduced due to the wetland boundary supporting the groundwater level locally. After 360 days dewatering, within approximately 30 m of the site boundary, a maximum drawdown of approximately 0.5 m is indicated.

Figure 4 Groundwater drawdown – 30 days

Figure 5 Groundwater drawdown – 60 days

Figure 6 Groundwater drawdown – 120 days

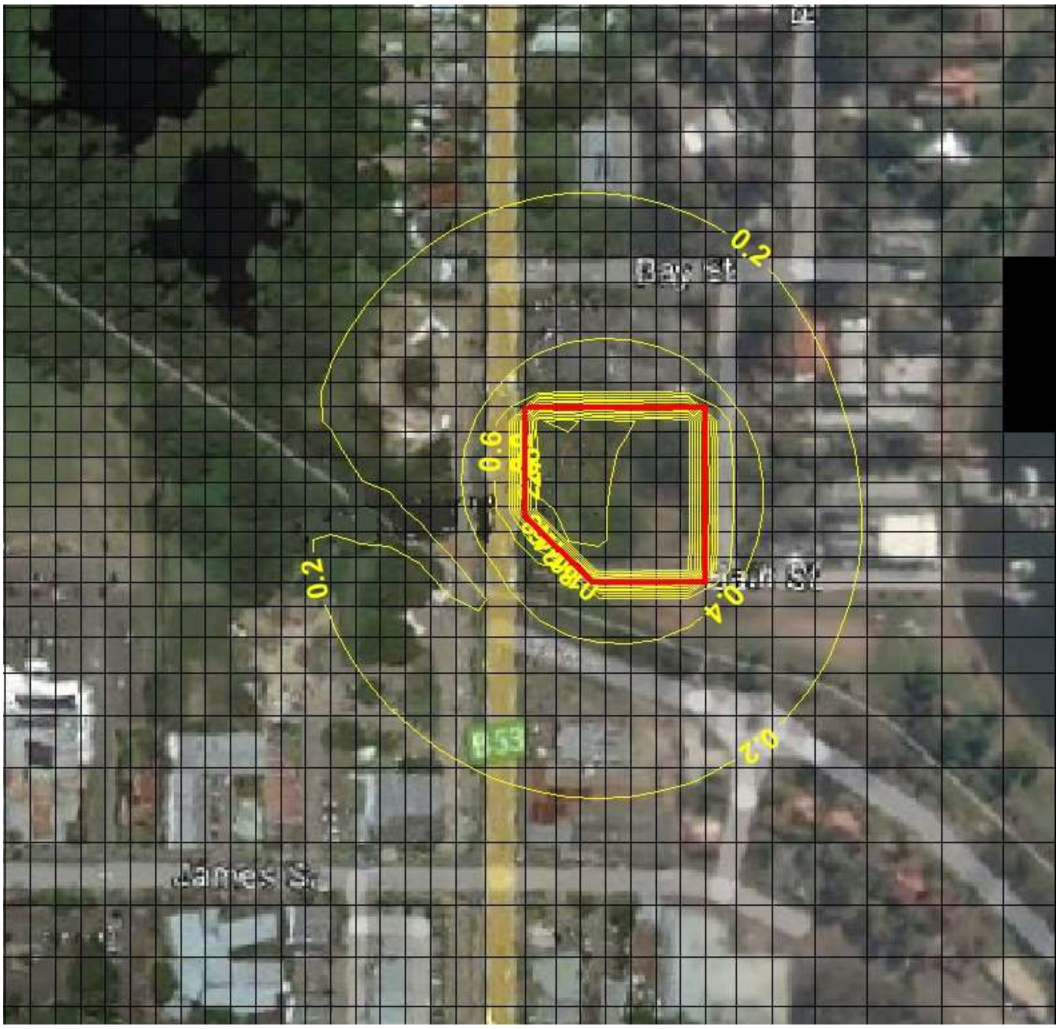

Figure 7 Groundwater drawdown – 180 days

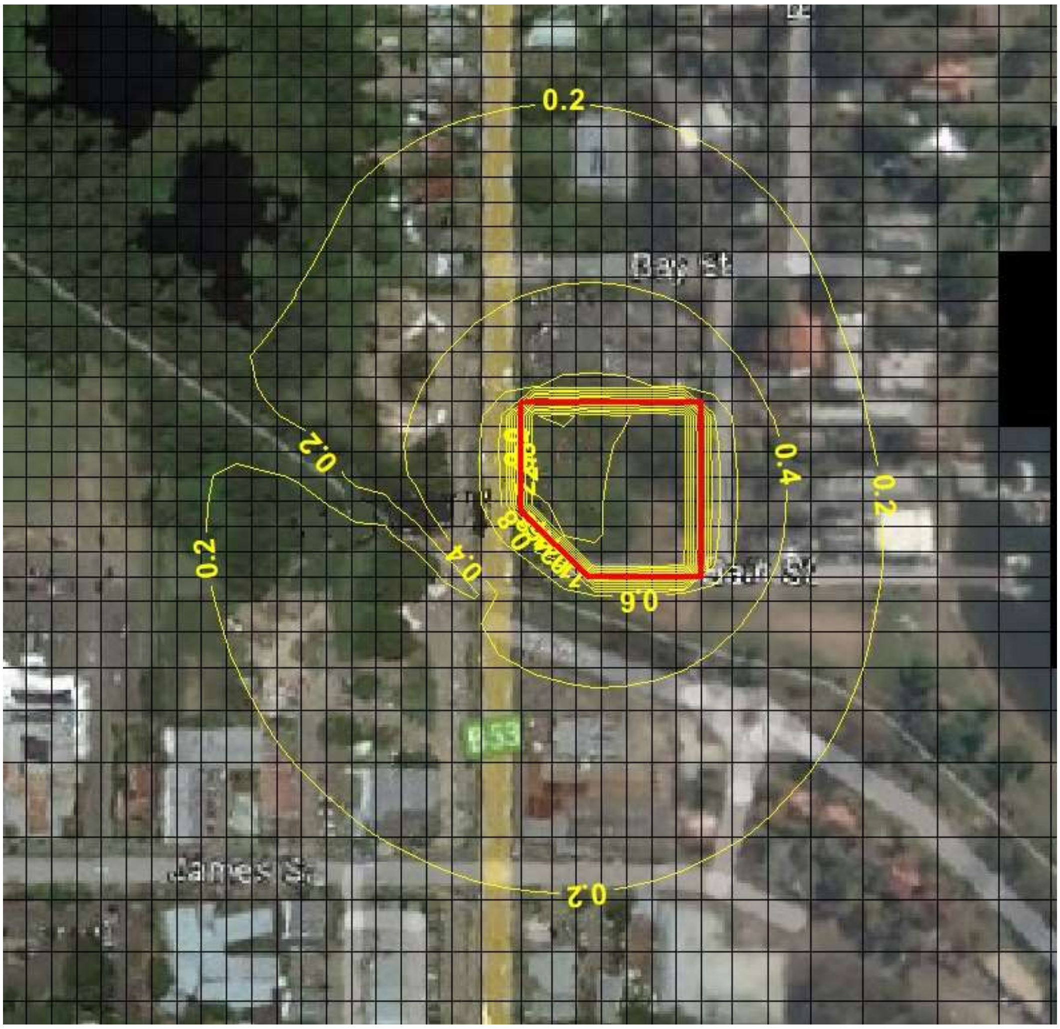

Figure 8 Groundwater drawdown – 360 days

Impact to wetland water balance

Based on model simulated groundwater inflow to the wetland with and without excavation dewatering, a summary of groundwater inflow and wetland impact is provided in Table 5, together with the estimated water level change.

Assuming a wetland area of 1.7 ha the water level change is indicated to be less than 9 mm by 180 days, and approximately 21 mm after 360 days dewatering.

It is noted that the wetland area varies according to water level, and has been reported up to 2.45 ha (GIS measurements undertaken by Dr Daniel McDonald on 25 January 2022). Assuming a wetland area of 2.45 ha the water level change is reduced by ~70% to less than 6 mm by 180 days, and less than 15 mm after 360 days dewatering (Table 5).

Table 5: Wetland Impacts			
Time (days)	**Cumulative wetland inflow* (m^3)**	**Difference (m^3/d)**	**Cumulative water level change at wetland (mm)**

	without dewatering	**with dewatering**		wetland surface area of ~1.7 ha	wetland surface area of ~2.45 ha
30	257.8	241.1	16.6	0.98	0.68
60	515.6	478.3	37.3	2.2	1.5
90	773.3	712.8	60.6	3.6	2.5
120	1031.1	944.9	86.2	5.1	3.5
180	1546.8	1401.9	144.9	8.5	5.9
360	3093.7	2734.6	359.1	21.1	14.7
* inflow data from transient model reported mass balance data					

3.2.3 Post-construction groundwater simulation

To simulate the effects of the development, the cells in the model representing the basement were assigned a very low hydraulic conductivity value to simulate a zone with no effective permeability.

Figure 9 shows steady-state groundwater head and flow vector arrows for the baseline groundwater surface, which represents the pre-development groundwater system simulation (i.e. no dewatering), and **Figure 10** shows steady-state groundwater head and flow vector arrows for the post-construction groundwater surface.

The simulation indicates that:

- The model predicted changes in groundwater head and flow direction in the site vicinity are considered materially insignificant.
- No material change is indicated to groundwater discharge area locations or discharge rate.

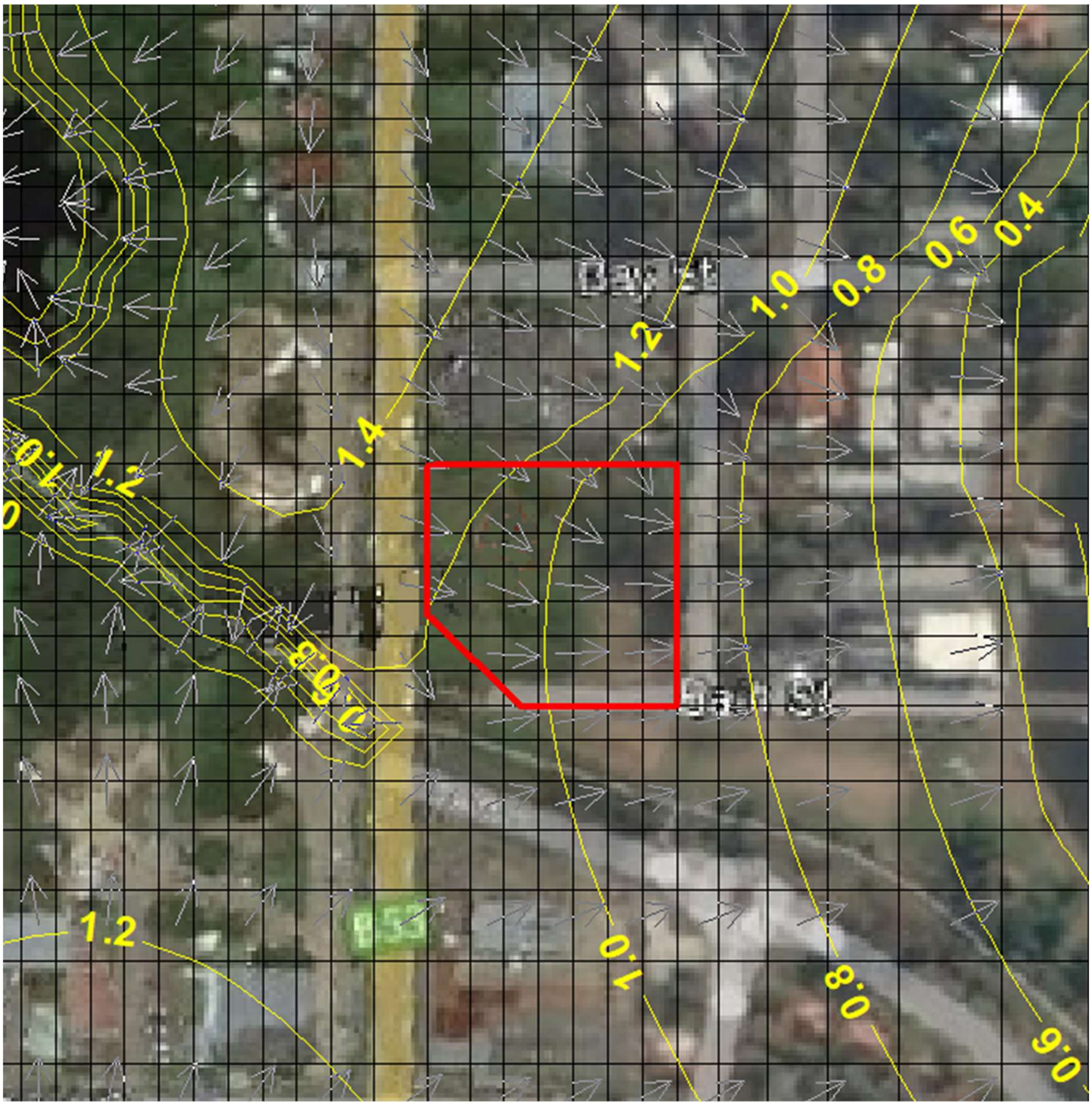

Figure 9 Groundwater head and flow vector arrows – pre-development

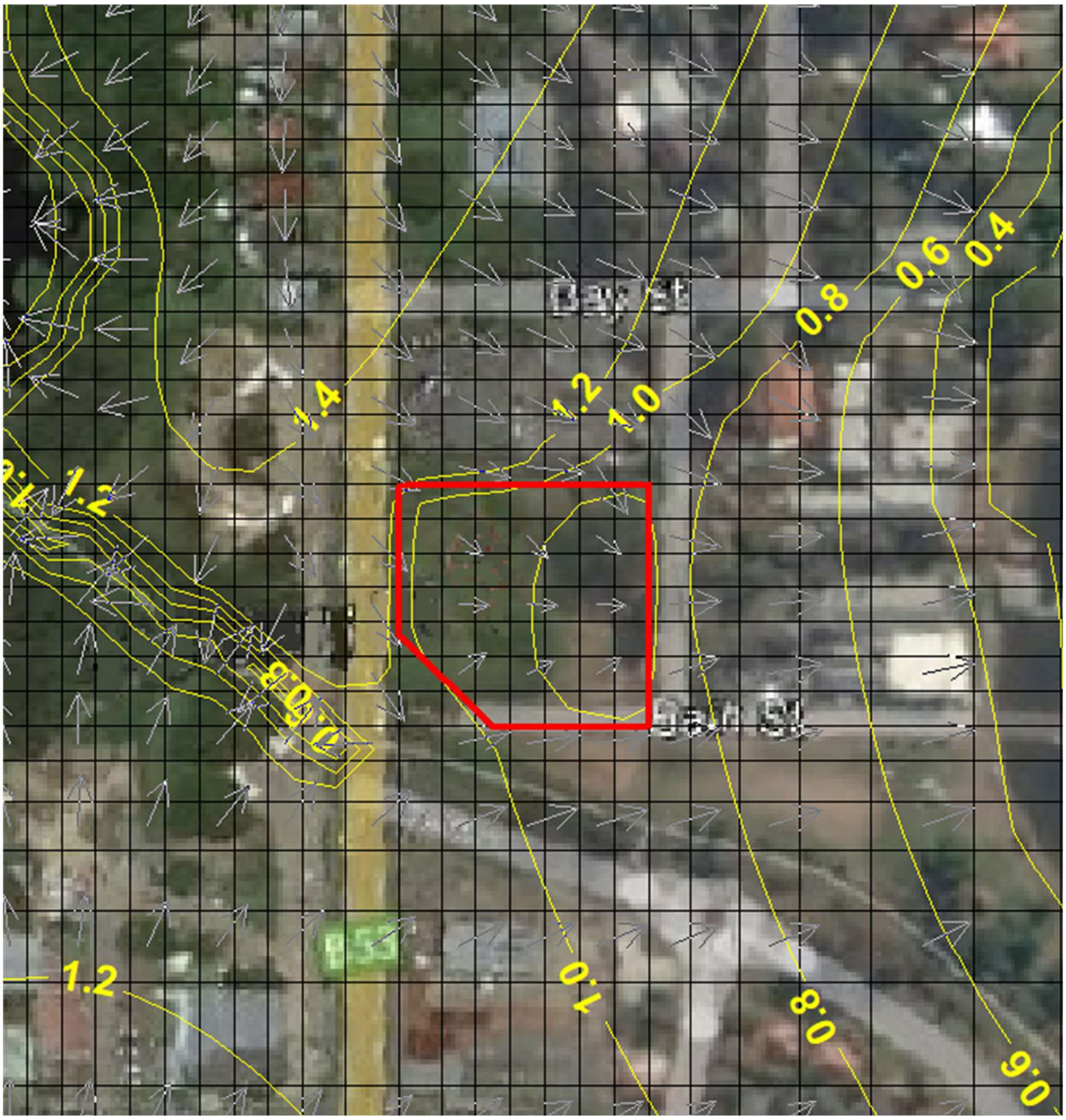

Figure 10 Groundwater head and flow vector arrows – post-development

3.2.4 Sensitivity analysis

The following simulations were undertaken to help understand model sensitivity to parameters (sensitivity analysis):

- Case 1 - Layer 1 vertical hydraulic conductivity increased to equal the horizontal hydraulic conductivity;
- Case 2 - Layer 1 horizontal hydraulic conductivity increased by a factor of two.
- Case 3 - Layer 1 horizontal hydraulic conductivity decreased by a factor of two.
- Case 4 - Layer 1 specific yield reduced from 5% to 2.5%.

The model predicted outputs are presented in Appendix B for 30, 120 and 360 days, together with tabulated excavation inflow and a comparison of wetland impacts (water level change at wetland) for the sensitivity simulations (also for 30, 120 and 360 days) compared with the transient simulation presented in Section 3.2.2.

For each of the sensitivity cases, only the parameter of interest is changed, for the purpose of evaluating how model predictions might be affected by different values. Hence, these models are effectively decalibrated, and should not be considered reliable for predictions. For example, increasing K by a factor of two doubles the transmissivity of the upper model layer, which would normally require a significant increase to model recharge and/or an adjustment to specific yield, in order to rematch the model to observed groundwater levels.

The results show that the model is sensitive to hydraulic conductivity, as summarised below:

- Case 1 - Increasing model vertical hydraulic conductivity (K_v=K_h) results in ~20% increase in groundwater dewatering rates. A slightly increased extent of drawdown is observed that slightly increases the impact to the wetland. The maximum cumulative additional impact is <1.2 mm.
- Case 2 - Increasing model K results in ~17% increase in groundwater dewatering rates. An increased extent of drawdown is observed that increases the impact to the wetland. The maximum cumulative additional impact is ~55 mm, noting that in a calibrated model this would be reduced by a higher rate of recharge.
- Case 3 - Reducing model K results in ~23% decrease in groundwater dewatering rates. A significantly decreased extent of drawdown is observed that reduces the impact to the wetland.
- Case 4 - Reducing model specific yield (S_y) results in ~1.5% decrease in groundwater dewatering rates. A slightly increased extent of drawdown is observed that slightly increases the impact to the wetland. The maximum cumulative additional impact is <4 mm.

4 DISCUSSION

The dewatering simulations provide inflow values and drawdown that are valid for the hydrogeological conditions as modelled. Model simulated inflow rates are indicated to be below 1 L/sec, and assume that the cut-off wall installation is satisfactory – refer to Section 3.2.

The model indicates a maximum off-site extent of groundwater drawdown (0.2 m contour) of ~120 m to the north and south after 360 days of dewatering. The extent to the east/north-east toward the wetland is reduced due to the wetland boundary supporting the groundwater level locally.

After 360 days dewatering, within approximately 30 m of the site boundary, a maximum drawdown of approximately 0.5 m is indicated.

The hydraulic impact to the wetland is low, with a cumulative water level change due to reduced groundwater inflow, indicated to be less than 9 mm by 180 days, and approximately 21 mm after 360 days dewatering.

4.1 Dewatering method

The model simulations assumed dewatering within the excavated areas using the Modflow Drain package. Dewatering using wells may require slightly higher flow rates and/or longer dewatering lead times to achieve target drawdown, depending on the number and location of wells and/or sumps.

In practice, wells/sumps should be located inside the sheet piled areas. Dewatering from outside the sheet-piling will be ineffective and lead to higher inflow rates and drawdown.

4.2 General comments

Estimated extents of drawdown and inflows will be sensitive to the bulk field value for hydraulic conductivity and specific yield. We note that the modelling is based on a parameter set that is informed by limited site-specific investigation (slug tests) and actual hydraulic parameters may vary from those adopted. Pumping tests, and boreholes to characterise the deeper lithology, have not been undertaken, and accordingly, the dewatering system design should incorporate flexibility to increase or otherwise manage dewatering rates, should such be necessary if higher inflows are incurred, for example due to hydraulic parameter variation from modelled.

The dewatering system should be installed and operated by an experienced contractor, and should incorporate sufficient redundancy to ensure that failure of any element of the depressurisation system does not compromise the safety of the excavation.

4.3 Margin of safety

The construction contractor should ensure the basement designer/engineer’s advice and recommendations are taken in relation to the margin of safety, and at what point during construction the dewatering/depressurisation system can be safely decommissioned.

We advise that the groundwater modelling conducted neither evaluates nor implies a margin of safety, nor that risk of heave or slope failure is not present. The results should be interpreted by a suitably qualified engineer.

4.4 Uncertainty

All groundwater models are subject to uncertainty, which arises due to parameter uncertainty and conceptual uncertainty.

Conceptual uncertainty in the model arises because of the limitations necessary in simplifying complex hydrogeology for the purpose of constructing a practical model. Parameter uncertainty arises because the modelling adopts physical and hydraulic parameters which have not been fully tested in the field.

The approach undertaken for this project was deterministic, and actual parameters may vary from those adopted. Based on the geological and hydrogeological information available at the time of reporting, the model parameters adopted are considered reasonable, but do not necessarily represent a unique solution. Other interpretations are possible. Accordingly, the modelling results and predictions made in this report should be considered as indicative, and subject to interpretation.

5 GROUND SETTLEMENT ASSESSMENT

The groundwater drawdown due to the dewatering can result in the ground settlement of the surrounding area. The soil below the groundwater table is experiencing the effective stress which is less than the overburden stress. When the groundwater level is lowered, the effective stress on soil body increases proportionally to the pore pressure reduction. This leads to compression of the soil body and subsequent settlement on the ground surface.

The coefficient of volume compressibility (m_v) is defined as the volume change per unit volume per unit increase in effective stress. The coefficient of volume compressibility is measured in the laboratory consolidation test as follows.

$$m_v = \frac{1}{H_0}\left(\frac{\Delta H_i}{\Delta \acute{\sigma}}\right)$$

Where,

H_0 – initial thickness of the soil

ΔH_i – change in soil layer thickness

$\Delta \acute{\sigma}$ – change if effective stress

According to this relationship, the settlement of a soil layer due to the effective stress increase can be expressed as,

$$\Delta H_i = m_v H_0 \Delta \acute{\sigma}$$

For 'n' number of soil layers below the groundwater table, the total settlement of the ground is estimated by,

$$\Delta H = \sum_{i=1}^{n} m_{vi} H_i \Delta \acute{\sigma}$$

Where,

H_i – initial thickness of the i^{th} soil layer

m_{vi} - coefficient of volume compressibility of i^{th} soil layer

ΔH – total settlement

5.1 Geotechnical Parameters

The coefficient of volume compressibility is measured in laboratory from the oedometer test. The parameter is not a constant and depends on the stress level. As the coefficient of volume compressibility of materials are not known, CMW has taken conservative approach to approximate the coefficient of volume compressibility, assuming the reciprocal of 3/4 of the modulus of elasticity of the soil. Table 5 shows the average soil unit thicknesses and adopted modulus of elasticity values for the soil units by Chameleon Geosciences with approximate coefficients of compressibility adopted in this assessment. Ground model and modulus of elasticity as presented in Geotechnical investigation report by Chameleon Geosciences.

Table 5 – Geotechnical parameters of soil units

Unit	Top of unit (m)	Unit thickness (m)	Modulus of Elasticity (MPa)	Coefficient of compressibility (m2/MN)
Fill	0	0.5	6	0.22
Stiff to Very Stiff Residual Soil (Clay)	0.5	2.5	15	0.09
Very Stiff to Hard Residual Soil (Clay)	3.0	11.5	25	0.05
Conglomerate	14.0	-		

The groundwater level monitored over time in the same report indicates the groundwater levels are at around 3.0m below ground level. Hence the effective stress increase due to the dewatering is applied only to the very stiff to hard clay layer. The compressibility of the bedrock is assumed negligible.

5.2 Results and Discussion

The groundwater drawdowns predicted in Section 3.2 were used to calculate the ground settlement. For the predicted drawdowns, the expected ground settlements are presented in Table 6. The settlement contours for dewatering 180 days are presented in **Figure 11**. The settlement contours for other dewatering scenarios are attached in **Appendix A**.

Table 6 – Predicted Ground Settlements

Drawdown (m)	Change in Effective Stress (kPa)	Predicted Settlement (mm)
1.00	10.0	7
0.80	8.0	6
0.60	6.0	4
0.40	4.0	3
0.20	2.0	1

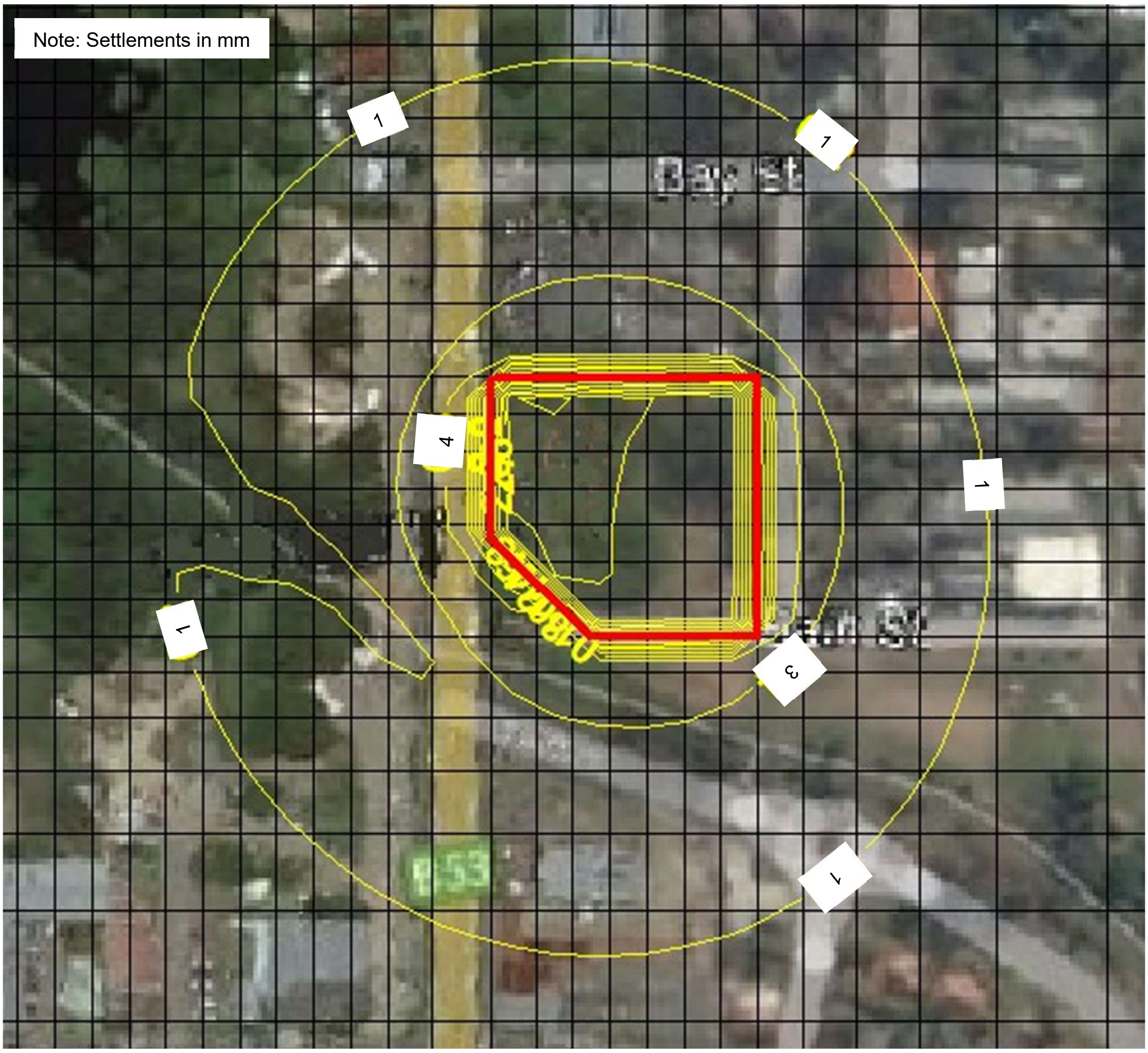

Figure 11 Ground surface settlement contours for dewatering for 180 days

6 CLOSURE

The findings contained within this report are the result of limited discrete investigations conducted in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, can it be considered that these findings represent the actual state of the ground conditions away from our investigation locations.

If the ground conditions encountered during construction are significantly different from those described in this report and on which the conclusions and recommendations were based, then we must be notified immediately.

This report has been prepared for use by Toronto Investments No1 Pty Ltd in relation to the Mixed Use Development at 114-120 Cary Street, 1,2,3,5 Bath Street and 3 Arnott Avenue, Toronto project in accordance with generally accepted consulting practice. No other warranty, expressed or implied, is made as to the professional advice included in this report. Use of this report by parties other than Toronto Investments No1 Pty Ltd and their respective consultants and contractors is at their risk as it may not contain sufficient information for any other purposes.

For and on behalf of CMW Geosciences

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Distribution: 1 electronic copy to Toronto Investments No1 Pty Ltd via email
Original held at CMW Geosciences

Appendix A - Ground Settlement Contours

Appendix B – Sensitivity Analysis

Sensitivity Analysis Simulations

The following additional simulations were undertaken for the purpose of sensitivity analysis:

- Case 1 - Layer 1 vertical hydraulic conductivity equal to horizontal hydraulic conductivity ($K_v = K_h$);
- Case 2 - Layer 1 horizontal hydraulic conductivity increased by a factor of two (K_h x 2).
- Case 3 - Layer 1 horizontal hydraulic conductivity decreased by a factor of two ($K_h \div 2$).
- Case 4 - Layer 1 specific yield (S_y) reduced to 2.5%.

The sensitivity simulations are uncalibrated model versions, provided for reference only, and not for design. They are intended to provide insight into numerical effects within the model due to a single parameter alteration. As discussed in Section 3.2.4 the results are provided for the purpose of evaluating how model predictions might be affected by different values, and these models are effectively decalibrated.

Case 1

Figures B1 to B3 show transient drawdown for Case 1 (Layer 1 $K_v = K_h$) at 30, 120 and 360 days. Under this scenario, the model mass balance reports groundwater dewatering inflow as indicated in **Table B1**, and wetland impacts as detailed in **Table B2.**

Table B1: Dewatering inflows – Case 1

Time (days)	Inflow (m^3/day)	Inflow (L/sec)
30	24.4	0.282
120	23.7	0.274
360	23.0	0.266

Table B2: Wetland Impacts – Case 1

Time (days)	Cumulative wetland inflow* (m^3)		Difference (m^3/d)	Cumulative water level change** at wetland (mm)	Comparison with transient case (Table 5) (mm)
	No dewatering	Case 1 dewatering			
30	257.81	244.9	12.9	0.76	-0.24
120	1031.1	952.1	79.1	4.7	-0.45
360	3093.7	2714.3	379.4	22.3	1.22

* inflow data from transient model reported mass balance data
** water level change calculation assumes a wetland surface area of ~1.7 ha, for 2.45 ha the impacts will be reduced by ~70%.

Figure B1 Case 1 - Groundwater drawdown – 30 days

Figure B2 Case 1 - Groundwater drawdown – 120 days

Figure B3 Case 1 - Groundwater drawdown – 360 days

Case 2

Figures B4 to B6 show transient drawdown for Case 2 (Layer 1 K_h x 2) at 30, 120 and 360 days. Under this scenario, the model mass balance reports groundwater dewatering inflow as indicated in **Table B3**, and wetland impacts as detailed in **Table B4.**

Table B3: Dewatering inflows – Case 2		
Time (days)	**Inflow (m^3/day)**	**Inflow (L/sec)**
30	23.9	0.277
120	23.1	0.267
360	22.3	0.258

Table B4: Wetland Impacts – Case 2					
Time (days)	**Cumulative wetland inflow* (m^3)**		**Difference (m^3/d)**	**Cumulative water level change** at wetland (mm)**	**Comparison with transient case (Table 5) (mm)**
	No dewatering	**Case 2 dewatering**			

30	257.81	192.8	-69.05	3.83	2.8
120	1031.1	706.4	-324.7	19.1	14.0
360	3093.7	1802.2	-1291.5	76.0	54.9
* inflow data from transient model reported mass balance data ** water level change calculation assumes a wetland surface area of ~1.7 ha, for 2.45 ha the impacts will be reduced by ~70%.					

Figure B4 Case 2 - Groundwater drawdown – 30 days

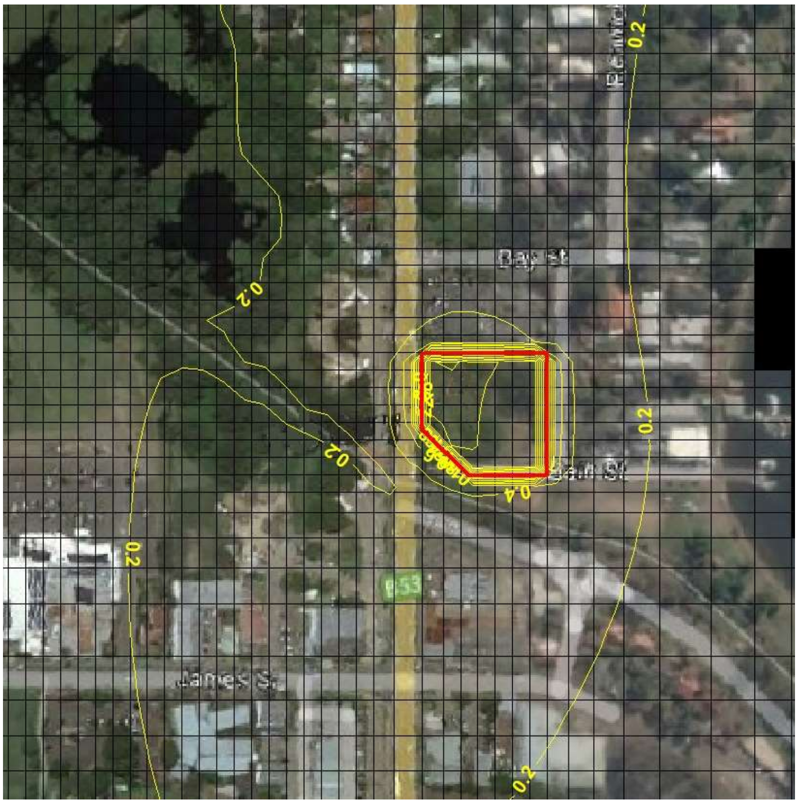

Figure B5 Case 2 - Groundwater drawdown – 120 days

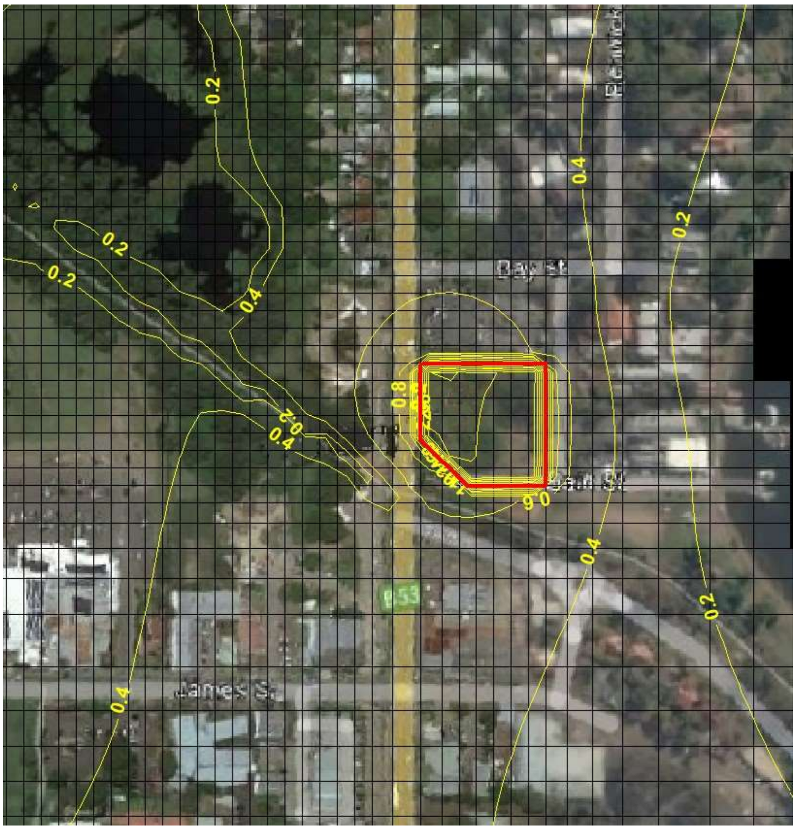

Figure B6 Case 2 - Groundwater drawdown – 360 days

Case 3

Figures B7 to B9 show transient drawdown for Case 3 (Layer 1 K_h ÷ 2) at 30, 120 and 360 days. Under this scenario, the model mass balance reports groundwater dewatering inflow as indicated in **Table B5**, and wetland impacts as detailed in **Table B6.**

Table B5: Dewatering inflows – Case 3

Time (days)	Inflow (m^3/day)	Inflow (L/sec)
30	15.6	0.181
120	15.3	0.177
360	15.2	0.176

Table B6: Wetland Impacts – Case 3

Time (days)	Cumulative wetland inflow* (m^3)		Difference (m^3/d)	Cumulative water level change** at wetland (mm)	Comparison with transient case (Table 5) (mm)
	No dewatering	Case 3 dewatering			
30	257.81	264.57	+6.77	-0.4	-1.4
120	1031.1	1084.1	+52.97	-3.12	-8.2
360	3093.7	3428.5	+334.8	-19.7	-40.1

* inflow data from transient model reported mass balance data
** water level change calculation assumes a wetland surface area of ~1.7 ha, for 2.45 ha the impacts will be reduced by ~70%.

Figure B7 Case 3 - Groundwater drawdown – 30 days

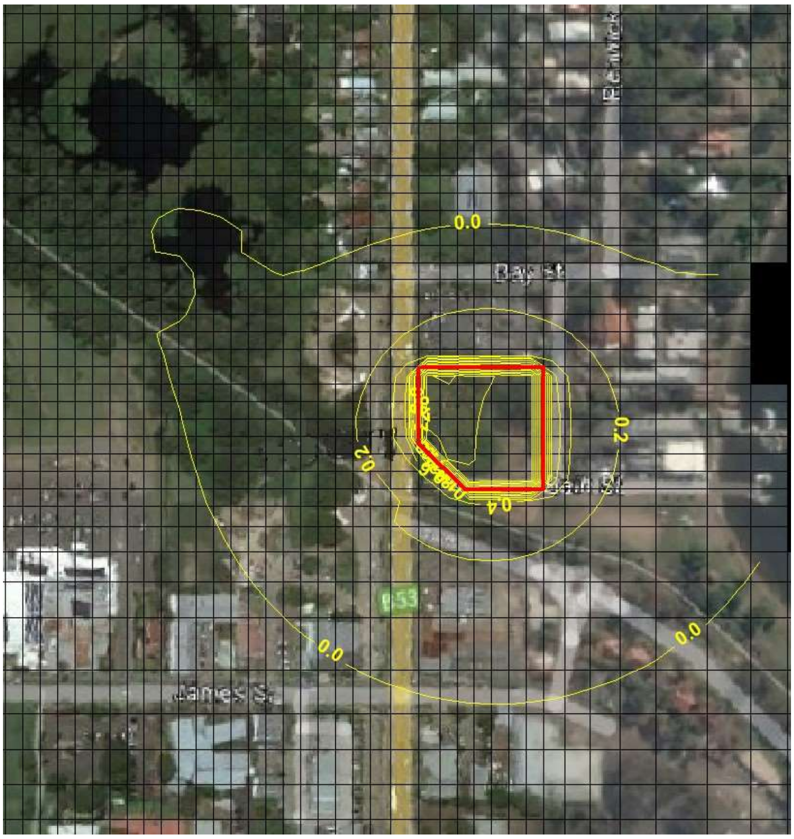

Figure B8 Case 3 - Groundwater drawdown – 120 days

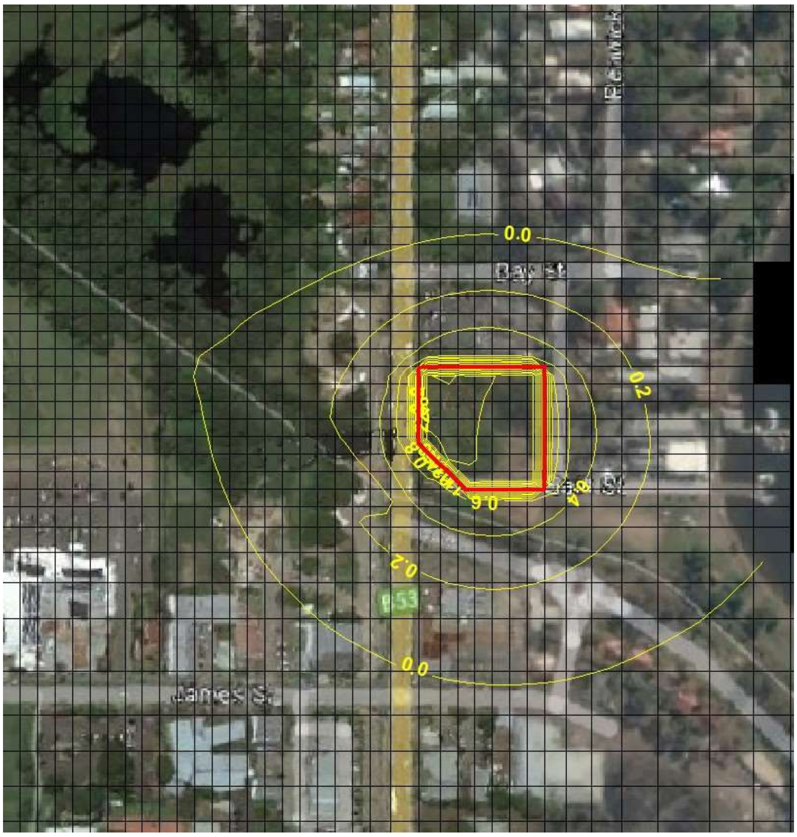

Figure B9 Case 3 - Groundwater drawdown – 360 days

Case 4

Figures B10 to B13 show transient drawdown for Case 4 (Layer 1 S_y = 2.5%) at 30, 120 and 360 days. Under this scenario, the model mass balance reports groundwater dewatering inflow as indicated in **Table B7**, and wetland impacts as detailed in **Table B8.**

Table B7: Dewatering inflows – Case 4		
Time (days)	**Inflow (m^3/day)**	**Inflow (L/sec)**
30	20.1	0.233
120	19.5	0.226
360	19.1	0.221

Table B8: Wetland Impacts – Case 4					
Time (days)	**Cumulative wetland inflow* (m^3)**		**Difference (m^3/d)**	**Cumulative water level change** at wetland (mm)**	**Comparison with transient case (Table 5) (mm)**
	No dewatering	**Case 4 dewatering**			

30	257.81	238.8	-19.0	1.12	+0.12
120	1031.1	925.9	-105.25	6.19	+1.09
360	3093.7	2669.8	-423.9	24.9	+3.84
* inflow data from transient model reported mass balance data ** water level change calculation assumes a wetland surface area of ~1.7 ha, for 2.45 ha the impacts will be reduced by ~70%.					

Figure B10 Case 4 - Groundwater drawdown – 30 days

Figure B11 Case 4 - Groundwater drawdown – 120 days

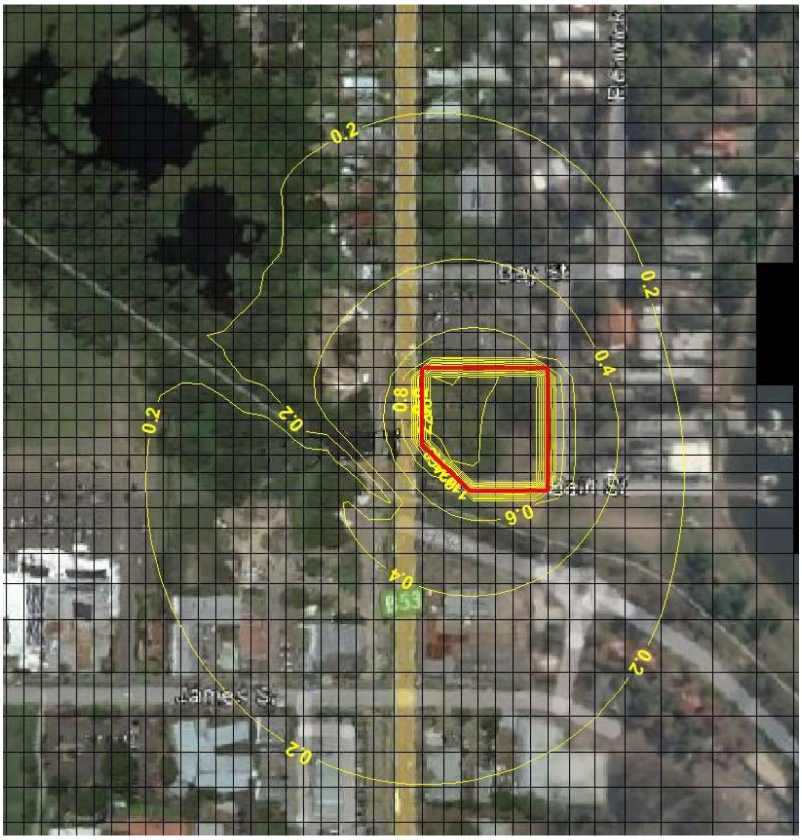

Figure B12 Case 4 - Groundwater drawdown – 360 days