



CONCEPT DESIGN REPORT

STORMWATER UPGRADES

FOR

RIBBON AVENUE



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REVISION/CHECKING HISTORY					
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1. EXECUTIVE SUMMARY

Douglas Shire Council commissioned a review of the drainage networks in Ribbon Avenue and adjacent streets following significant flooding in early 2017.

This report provides the findings of the concept development phase including options considered to address the flooding risks.

The current stormwater drainage system for Ribbon Avenue is limited to an underground system only as there is no formalised overland flow path. The system capacity was assessed as being less than the capacity required to convey runoff from a rainfall event with a 1-year average recurrence interval, (1-year ARI or Q1).

This indicates that there is a very high risk of localised flooding each year. The absence of any relief flow paths means the consequences are significant on properties in the local area.

From a stormwater control and conveyance perspective, critical site constraints exist at two key locations:

1. At the capture point at the northern end of the earth drain in St Mary's Church land. The lack of capacity at this location and the lack of definition in overland flow paths directly impacts the lots between the drain and Ribbon Avenue.
2. At the end of the Ribbon Avenue cul-de-sac where surface runoff in Ribbon Avenue concentrates without a dedicated overland flow path. Note the runoff in Ribbon Avenue includes flows that have already impacted the western lots backing onto the earth drain.

Six (6) options were assessed to a concept design level to determine the increased level of service able to be provided for each option as well as the shortcomings of each option.

The initial recommendations based on the concept design parameters were in favour of Option 5, (see screen image on following page). Preliminary costings of this concept indicate a project cost inclusive of contingencies and GST will likely be in the order of \$1.5 million, (excluding works on the St Mary's earth drain and the Captain Cook Highway bund which are common for all options).

Option 5 targets a Q50 (2% AEP) level of service. The key features of that Option included:

- Q5 underground pipe network along Endeavour and then St Crispins Avenue;
- Upgrades to the overland flowpath from the open earth drain in St Mary's through to Ribbon Avenue; and
- Construction of an overland flowpath in the easements between Ribbon Avenue and St Crispins Avenue;

The above option sought to improve the existing level of service from approximately a 1-year flood immunity to a 50-year flood immunity level, (2% probability of exceedance in any one year).

However, it is highlighted that some system performance issues would remain and that some key properties remained vulnerable.

The assessments to this point were focused on improving the level of service to the existing properties. Council Officers were concerned that this approach whilst raising the immunity did not fundamentally address the risk of failure of the new system.

Council Officers therefore requested a risk assessment be undertaken on each Option. In the subsequent workshop meeting, a further option, Option 7, was developed.

Option 7 considered continuity and certainty of the overland flow path from the western earth drain through to St Crispins Street.

The key features of this Option included:

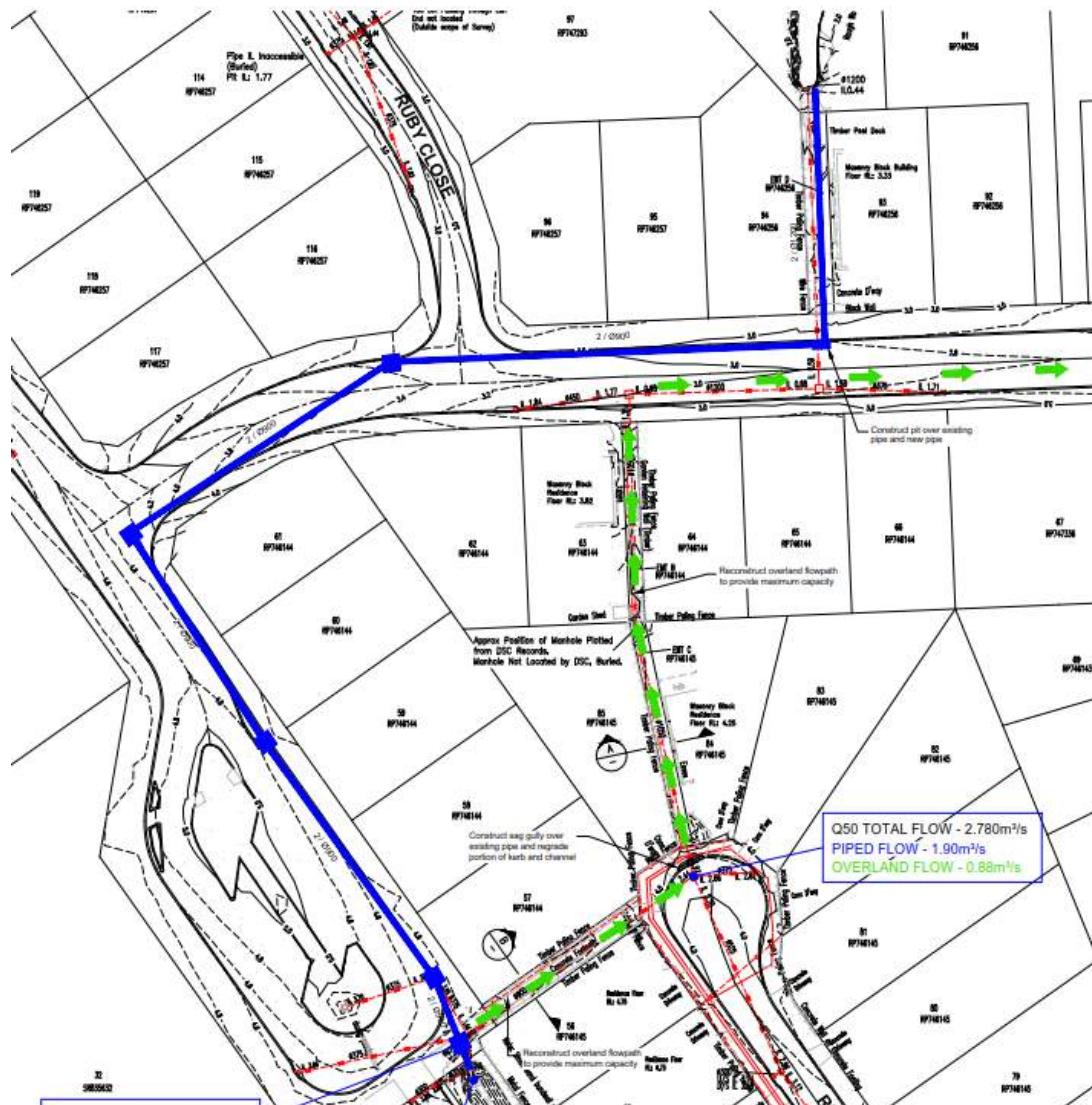
- Property resumptions for three properties to secure land tenure to connect the western earth drain to St Crispins Street;

- Removal of the houses and earthworks (drain excavation) within this corridor footprint to provide a broad flow path for the overland flow capacity on the surface;
- An underground pipe network in a more direct line through the resumed lots with approximate pipe capacity for the 5-year ARI flows (Q5);
- Underground pipe system extending across/along St Crispins Street to connect to the Lake;
- Lowering of the road surface in Ribbon Avenue Cul-de-sac to allow runoff to pass along the corridor at a lower water level to maximise protection to the existing floor levels;

The above option seeks to improve the existing level of service from approximately a 1-year flood immunity to greater than 50-year flood immunity level, (2% probability of exceedance in any one year). In addition, it seeks to provide greater certainty in how the flows are captured, contained and controlled through the proposed drainage flow paths. Option 7 seeks to provide greater certainty in operation with lower reliance on pipe inlet capacity etc.

In addition to construct the proposed works it is recommended that Council work with the Department of Transport and Main Roads to complete a bund along the eastern side of the Captain Cook Highway to divert any external runoff direct to Crees Creek. This represents the easiest, most cost effective and most certain way to contain and convey external runoff west from the School and Church land.

It is expected that flood control fencing/walls will be required along the rear of the lots that back onto the earth drain. Preliminary calculations indicate the drain needs to be reprofiled to contain the required runoff and will run full, with little or no freeboard. Impermeable fencing such as a low masonry wall would be suitable to provide the additional protection and contain the flows to the drainage easement.



2. PURPOSE

Douglas Shire Council commissioned Trinity Engineering and Consulting Pty Ltd (TEC) to review the drainage networks in Ribbon Avenue and adjacent streets. The drainage assessment was required to identify drainage upgrade options available and provide a recommendation to improve the stormwater immunity to the residential properties.

The commission extends only to concept development phase and this report provides Council with information on the options available for further discussion with Councillors and residents before proceeding to detailed design phase.

This report presents the design rationale, constraints and extent identified in the Concept Design Phase. Concept plans are attached in **Appendix A**.

Council subsequently extended the scope of the commission to consider a risk assessment phase and develop further options that address capacity and operational risks for the stormwater drainage system.

1. BACKGROUND

During rainfall runoff events in 2017 the habitable areas of some residential properties located in Ribbon Avenue, Port Douglas were inundated by stormwater runoff. The residents of the Ribbon Avenue properties requested Council investigate drainage options available to provide their properties with the expected stormwater immunity (100-year flood immunity).



Image 1 – Council supplied photo of flooding in Ribbon Avenue from event of 5th February 2017

Council Officers were also concerned that one mechanism for the flooding was from the water levels in the downstream lake. The lake is controlled by a barrage to maintain water levels in the lake area. The lake is north from St Crispin's street and the Ribbon Avenue network discharges into the lake.

A two-dimensional flood model of the lake and downstream barrage was an option in TEC's proposal but was not recommended by TEC in the concept phase and was not adopted by Council.

Trinity Engineering and Consulting Pty Ltd (TEC) undertook an initial review of available information provided in Council's brief with the surface level contours (LiDAR) identifying that St Crispins Avenue is approximately 750mm lower than the Ribbon Avenue cul-de-sac.

Given the depth of flooding through the properties it was considered that the lack of pipe capacity and absence of an overland stormwater flow path connecting between Ribbon Avenue and St Crispins Avenue was the primary cause of flooding and not the downstream Lake influences.

Note that storm tide influences and Crees Creek flooding influences do have an impact on this system but both impose higher tail water levels than the existing barrage and lake. The operation of the lake and barrage was therefore not investigated under this commission.

2. PROJECT INCEPTION AND SITE INSPECTION

A project inception meeting and site inspection was held on Wednesday, 25th October 2017.

The inception meeting included discussions on available options; levels of service (immunity); land tenure; and, available corridors for new infrastructure.

TEC provided a brief overview on stormwater hydrology to assist the discussion on the runoff characteristics and the catchment response to rainfall. The volume of flow and current capacity were discussed to give context to the current stormwater system deficiencies. Based on the hydrology calculations performed by TEC and modelling of the underground system from Council's GIS records, it was determined that the system had a capacity that is less than the annual average recurrence interval (<1-year ARI).



Image 2 - Location of pipe corridor and easement in 17 Ribbon Avenue (Along fence line behind wheelie bins)



Image 3 - Existing easement and underground pipe route viewed from St Crispin's Avenue

Noting that there is no overland flow, the extent and severity of the flooding experienced in 2017 is therefore not surprising considering the above findings.

Identifying the expected volume of flow to be conveyed also enabled the participants at the project inception meeting to discuss required pipe sizes and surface drainage configurations to convey the runoff from rainfall events of varying average recurrence interval (ARI) or annual exceedance probability (AEP).

A number of alignment options were discussed for both underground stormwater and overland relief flow paths. Potential options for land resumption to create overland flow paths were also discussed.

Whilst a number of options and variations of the options were discussed at the project inception meeting, the meeting concluded with six (6) options being agreed for further assessment. These options were further developed to become the options which are listed in the following section.

Following the project inception meeting, a site inspection and walkover of the key corridors was undertaken.

2.1 Site Constraints

Site constraints at the capture point were noted including the lack of freeboard between lots on Ribbon Avenue that back onto the earth drain in St Mary's Church land; Lot 4 on RP739096, (2 Endeavour Street, Port Douglas). This issue also exists for houses on the eastern side of Endeavour Street with a number of the houses having limited or no fall out to the road frontage making them susceptible to flooding in times of high on-road flows.



Image 4 - Lack of containment on eastern side of earth drain in St Marys



Image 5 - Lack of definition in pathway link and overland flow path



Image 6 - Earth drain in St Marys

The lack of inlets (capture points) at the end of the cul-de-sac in Ribbon Avenue was also noted during the site visit and subsequent discussions as the capacity of the existing pipe network may not be optimally utilised if runoff cannot enter the system. This further compounds the system capacity issues.



Image 7 - Lack of freeboard between drain and adjacent lot.

2.2 Council Records

The image below reflects Council's records on the stormwater system as known at the time of the briefing document.

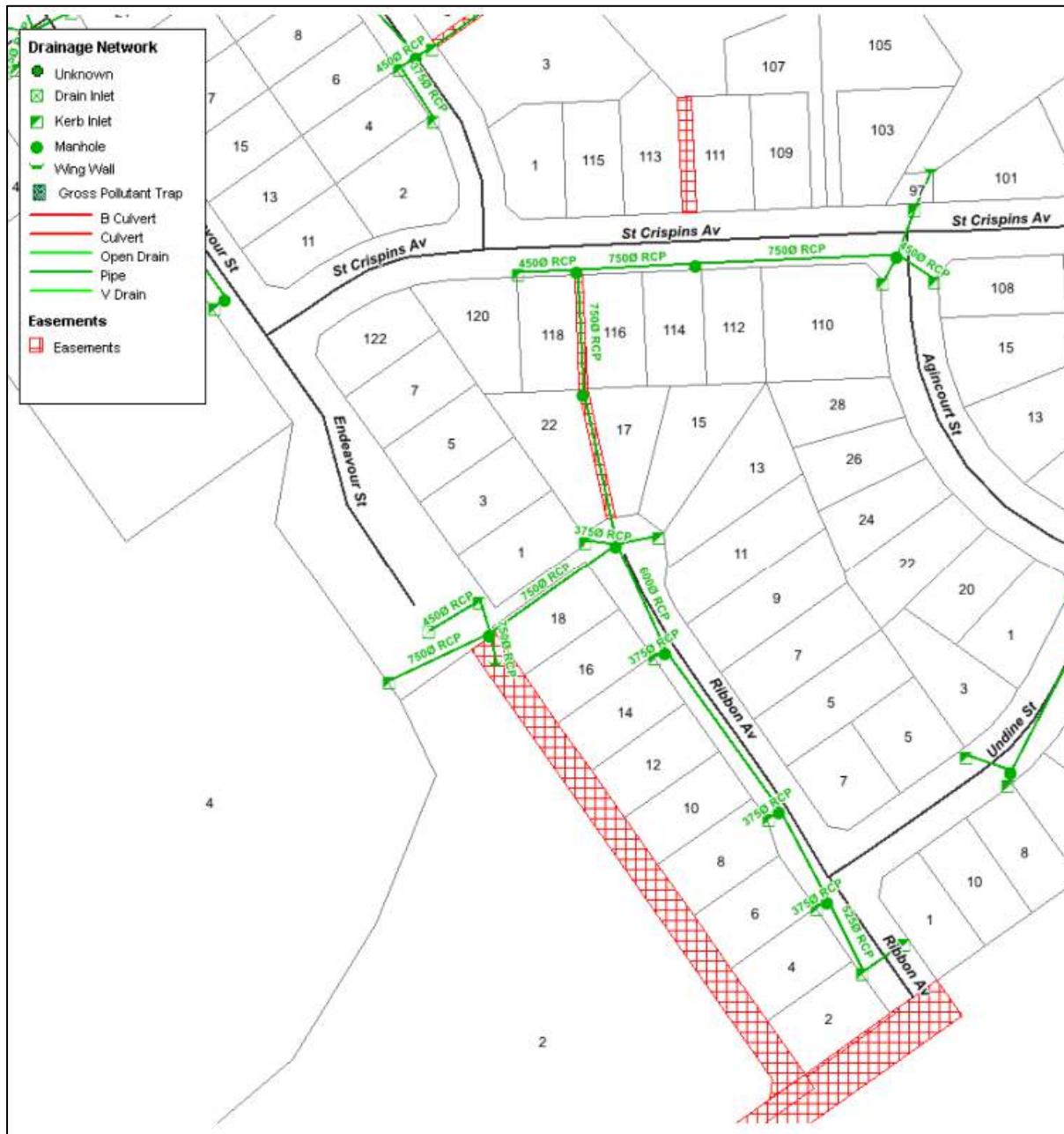


Image 8 – Network information included in Council brief

The image shows that the system was recorded as having 750mm diameter pipes.

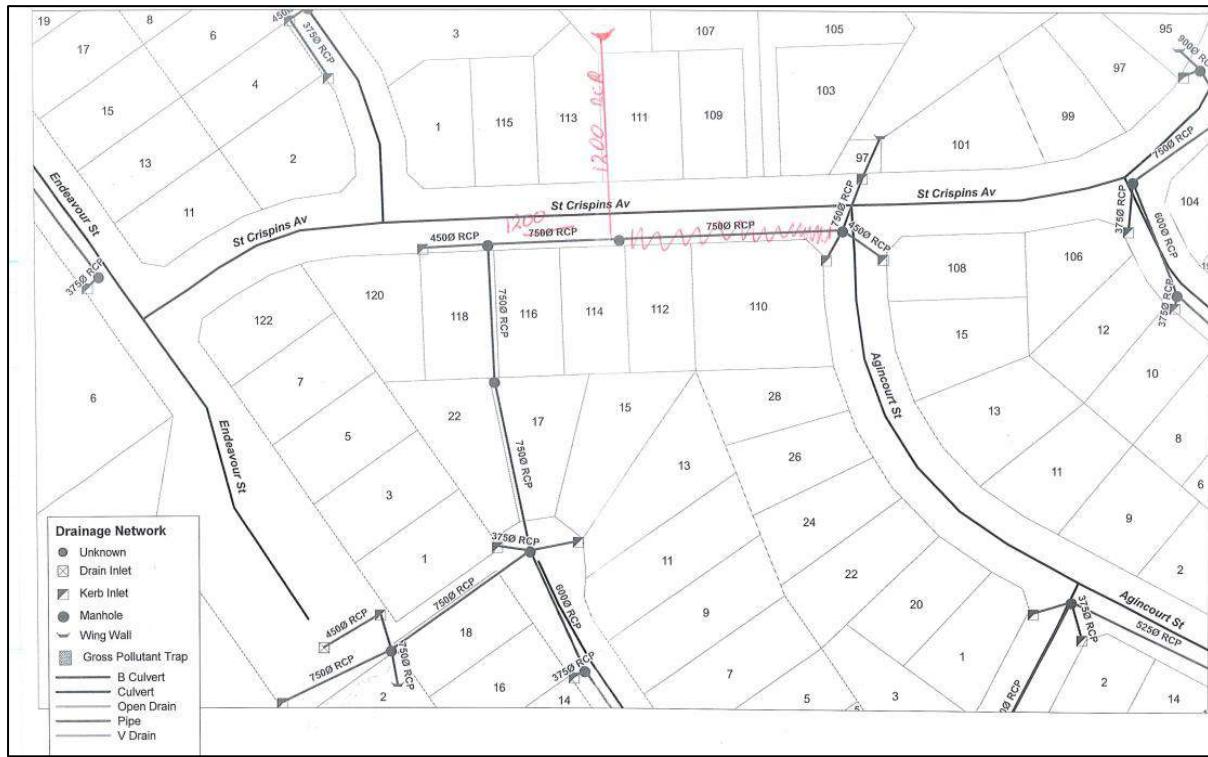


Image 9 – Updated information from Council

Council officers advised that the downstream pipe network size and alignment was different to that shown on its system. Image 9 shows the annotated system within this.

Note: detailed survey later confirmed that the pipes from Ribbon Avenue to St Crispins Avenue are 1050mm diameter pipes. A 900mm diameter pipe connects to the open drain in St Mary's Church land.

Updated modelling of the existing system with the above pipe sizes indicates a capacity of approximately 1-year ARI (Q1) flows.

3. UPGRADE OPTIONS

The following six (6) options were developed from the options discussed at the project inception meeting.

Option	Brief description
Base Case – Existing Scenario	Assessed as less than 1-year ARI (Q1) capacity
Option 1	Q5 underground pipe network in Endeavour Street and construct overland flow path in easements from Ribbon Avenue to St Crispins Avenue
Option 2	Q5 underground pipe network in Endeavour Street and provide an overland flow path by reconstructing Endeavour Street through to St Crispins Avenue
Option 3	Q100 underground pipe network in Endeavour Street with no overland flow paths
Option 4	Q10 underground pipe network in Endeavour Street and provide overland flow path by reconstructing Endeavour Street through to St Crispins Avenue

Option	Brief description
Option 5	Q5 underground pipe network in Endeavour Street and Construct overland flow path by reconstructing pathway link from Endeavour Street to Ribbon Avenue plus constructing surface drainage in easements from Ribbon Avenue to St Crispins Avenue
Option 6	Resumptions of Lots on Ribbon Avenue and St Crispins Avenue to provide flow corridor for overland flows out of Cul-de-sac

The above options were further assessed to determine what constraints exist and if the desired level of service and immunity could be achieved.

Discussion of each option is provided in the sections below and summarised in the Table in **Appendix B**.

3.1 Option 1

Option 1 seeks to provide an underground pipe network in Endeavour Street with capacity to convey runoff from a 5-year ARI rainfall event, (Q5 capacity). Overland flows out of Ribbon Avenue would be improved by constructing a 3m wide surface drain for the overland flow path in the easements from Ribbon Avenue to St Crispins Avenue (this drain would impact 17 Ribbon Avenue and 118 St Crispins Avenue).

Twin 900mm diameter pipes are required along Endeavour Street and down St Crispins Avenue until the new pipes intersect with the existing Ribbon Avenue drainage crossing at 111 St Crispins Avenue. The existing pipe size and depth prevents the new pipe network from continuing east. Initially an outlet to the lake opposite Agincourt Street was envisaged, however, that would require further system reconstruction due to the existing pipe crossing at 111 St Crispins Avenue.

The option of continuing east to Agincourt street is also constrained by the Ergon pad mount transformer and the Sewage pump station locations.



Image 10 – Existing infrastructure at the Agincourt/St Crispins intersection

Noting the constructability issues with an Agincourt Street discharge point for a twin pipe stormwater upgrade and need to re-route the existing stormwater, the outlet through 111 St Crispins Avenue easement was preferred utilizing the existing diameter 1200mm pipe and augmenting with a further parallel pipe.

An alternative outlet exists by directing the new pipework along Ruby Close and through the currently vacant lot at 7 Ruby Close. Council would need to resolve land tenure issues (easement or acquisition of property). This option remains and can be considered a variation to Option 1.

System performance issues identified with Option 1 are:

- Depth within the easement drain out of Ribbon Avenue is likely to exceed recommended flow depth limits (>300mm);
- Lack of connectivity from western earth drain (in St Mary's) to Ribbon Avenue due to constructed levels of pathway; and
- Does not address freeboard issues at the western drain.

3.2 Option 2

Option 2 provides the same underground system as Option 1 above, (Q5 capacity). Option 2 seeks to provide an alternative overland flow path along Endeavour Street.

Significant disturbances would take place to construct the pipe system and may facilitate the option to lower the kerb line and allow runoff from the St Mary's open earth drain to be conveyed along the road.

The issue with this overland flow option is that the drain levels in St Mary's and the road levels at the southern end of Endeavour Street are too low to make this option work without full reconstruction of Endeavour Street (including relaying all services, footpaths and kerbs etc. and reconstructing driveways into each house).

A one-way crossfall was trialed to seek to minimize the impact on the western side, however, this does not appear feasible due to the required steep road crossfall, and particularly noting this is a school zone. In addition, the capacity of the road as a one-way crossfall does not allow the required volume of runoff to be conveyed.

System performance issues identified with Option 2 are:

- Excessive scope is likely to trigger service relocations and full reconstruction of Endeavour Street through to St Crispins Avenue;
- Depth within the one-way crossfall road will exceed recommended flow depth limits (>300mm);
- Lack of freeboard to properties backing onto the western earth drain (in St Mary's); and
- Lack of freeboard/protection for 1 Endeavour Street (north from Pathway link) due to existing lot level.

3.3 Option 3

Option 3 seeks to address the capacity issue by piping all of the runoff for the 100-year ARI rainfall event (Q100). Theoretically this option provides the required capacity and immunity, however advice from Council Officers across various North Queensland Councils is that blockages can, and do occur, and the lack of overland flow relief paths is seen as a deficiency with this option.

Note the Queensland Urban Drainage Manual (QUDM) also raises this issue and recommends against such solutions that do not have relief overland flow paths.

In the concept sketches for this option, the pipe sizes are all increased from earlier options reflecting the need to convey more flow underground. This creates a further issue where the corridor goes through the easement in 111 St Crispins Avenue as the existing 200mm diameter pipe would most likely need to be removed so that two larger pipes could be installed (twin 1350mm diameter pipes).

The option to utilise Ruby Close and exit through currently vacant 7 Ruby Close may assist; however, as discussed earlier, land tenure issues would need to be resolved with potential acquisition costs to be considered.

A further design challenge would be capturing all of the flow into the system given the limited freeboard and flat grades that are involved. In particular, the capture point required at the end of the open earth drain in the St Mary's site west from Ribbon Avenue properties.

System performance issues identified with Option 3 are:

- Vulnerability to blockage and no overland flow paths;
- Difficulty in containing and capturing all of the flow;
- Lack of freeboard to properties backing onto the western earth drain in St Mary's (associated with the capture and containment of flows at the inlet); and
- Construction issues with the larger pipe sizes through 111 St Crispins Avenue easement.

3.4 Option 4

Option 4 is essentially Option 2 with increased capacity provided in the underground pipe system, (Q10 pipes).

This option was initially considered to seek to overcome the potential capacity issues with the overland flow path in Endeavour Street,

Ultimately, the construction issues to achieve the levels and fall north away from the turnaround at the southern end of Endeavour Street are considered too great for Options 2 and 4 to be feasible.

System performance issues identified with Option 4 are as per Option 2.

3.5 Option 5

Option 5 is similar to Option 1 and resulted from discussions with Council Officers and seeking to refine the options to overcome some of the system performance issues.

A further element reviewed in developing Option 5 was to review the flood mapping for the area to seek to determine when external factors will influence the outcomes regardless of the current upgrades.

Council's flood mapping appears to indicate that the local area including Ribbon Avenue, Endeavour Street and St Crispins Avenue will be impacted in events with an average recurrence interval of 50 years (or a 2% chance of flooding in any year).

Whilst the local system pipework will cater for events of different duration than the wider area flooding, it is important to note that achieving greater than a 50-year immunity level does not appear to be possible.

Option 5 therefore considered this slightly lower immunity level with associated slightly lower flows required to be conveyed.

Option 5 maintains the proposed new underground pipe system along Endeavour Street with a capacity sized to convey the runoff from a 5-year ARI rainfall event (Q5 capacity).

Option 5 also seeks to address the localised flooding risk at the interface between the open earth drain in St Mary's and the southern end of Endeavour Street. The proposal includes removing the current pathway link and reconstructing a lowered pathway that aims to control water surface levels at this confluence point.

As with Option 1, overland flows out of Ribbon Avenue in Option 5 are proposed to be managed by constructing a 3m wide surface drain in the easements from Ribbon Avenue to St Crispins Avenue. The formation of the drain is proposed to be similar to FNQROC Standard Drawing S1035 with full concrete lining and vertical sides for maximum capacity.

There is limited ability to soften this engineering solution and there will be amenity impacts on 17 Ribbon Avenue and 118 St Crispins Avenue.

System performance issues identified with Option 5:

- Reduced immunity level of Q50 or 2% AEP (consistent with flood mapping for local area);
- Depth in overland flow paths will be at the maximum recommended flow depth limits (>300mm);
- Lack of freeboard to properties backing onto the western earth drain (in St Mary's) is not addressed by the infrastructure due to differential levels, (property owners will need to build solid fencing to address this freeboard issue); and
- Probable issue remaining in higher flow events with lack of freeboard/protection for 1 Endeavour Street (north from Pathway link) due to existing lot levels.

3.6 Option 6

Option 6 involves resuming lots to create an overland flow path between Ribbon Avenue and St Crispins Avenue. Costs for resumption, demolition of houses and earthworks to reprofile the overland flow path would be needed.

Council may also need to consider if access controls are needed for vehicular and pedestrian connectivity.

System performance issues identified with Option 6 are:

- No additional underground capacity;
- Does not address the issues at the interface of the open earth drain in St Mary's and the pathway link though to Ribbon Avenue, (although this could be addressed as a variation to this option);
- Does not address the lack of freeboard to properties backing onto the western earth drain in St Mary's, (property owners will need to build solid fencing to address this freeboard issue); and
- Probable issue remaining in higher flow events with lack of freeboard/protection for 1 Endeavour Street (north from Pathway link) due to existing lot levels.

3.7 Undine Street

This option was initially discussed at the project inception meeting with Council Officers requesting consideration of an alternative utilising the Undine Street corridor as Officers identified that Council owns a vacant lot that would allow connectivity between Undine Street and catchment areas to the west.

Additional surface levels were picked up by the surveying sub-consultant to enable this option to be assessed further.

The option potentially allows for a large portion of the south western catchment to be diverted away from the two critical system points at the Ribbon Avenue cul-de-sac and at the northern end of the open earth drain in St Marys, (southern end of Endeavour Street). options may include overland flow and piped flow.

The Undine Street corridor does afford additional connectivity, however, a portion of the external catchment to the west would not be captured. Hence, part of the piped and overland flow solutions discussed in the above options would still be required to address the remainder of the catchment.

The concept design team also reviewed the option to regrade the existing St Mary's earth drain south, back to the vacant lot west from Undine Street. However, concerns with the levels at the rear of properties significantly constrain the ability to achieve this regrading and/or achieve the hydraulic grade to convey the flows south along the drain. Accordingly, it was assessed that a capture point at Undine Street would not collect all of the catchment flows.

Piping the external catchment captured south from this point would alleviate the pressure on the downstream system. However, while this option is technically feasible the current review discounted a further pipe route along the Undine Street / Agincourt Street corridor as this would necessitate removal and replacement of that existing system for the increased capacity required. Also, because the further upgrades in Endeavour Street cannot be eliminated, this option would essentially result in a duplication of disturbance and restoration as well as additional infrastructure costs (pits/pipes/outlets etc.).

Use of the Undine street corridor for overland flows was also not considered further due to the levels at the Undine Street/Ribbon Avenue intersection. The existing pavement and kerb levels are too high to allow the drain to outlet into the street. Therefore, reconstruction of part of these two streets would be required.

Capacity issues on Agincourt Street were also identified with the very flat road grades making any further increase in surface runoff undesirable.

Noting the above constraints, the Undine Street option was not considered further at this stage.

4. RISK OF SYSTEM NOT SUCCEEDING

Notwithstanding the demonstrated improvements to flooding mitigation and increased immunity with all options, Council Officers were concerned with the limitations of each option.

With each option there were system performance issues that would remain, and key properties remained vulnerable.

The assessments to this point were focused on improving the level of service to the existing properties. Council Officers were concerned that whilst this approach sought to improve the immunity it did not fundamentally address the risk of failure of the new system.

Council requested that the risk of the new system “not succeeding” be assessed for each option.

A further workshop was held to discuss the merits and potential risks for each option and through this process a further option, Option 7, was developed.

Option 7 was developed with consideration to the key risk of failure at the capture point at the northern end of the earth drain in the St Marys Church land. The option considered the benefits achieved if 18 Ribbon Avenue was vacant and able to be reshaped to accommodate continuity of the surface flows from the earth drain. This has the potential to address a number of the shortcomings that all options have at this critical point.

Similar to Option 6, the land resumptions to create a corridor between Ribbon Avenue and St Crispins Street are part of this new Option 7.

However, the pipe network in Option 7 is routed through the proposed resumed properties in a direct connection from the earth drain to St Crispins Street. The pipe alignment is the most direct and avoids the costly work in roads with associated disruption to traffic in this important school precinct.

It will need to be confirmed during detailed design; however, the shorter route and lack of road traffic may enable a larger and shallower pipe to be constructed. This should enable a single pipe construction rather than the twin pipes envisaged with other options. Construction costs for the pipe component will be lower if this is the case.

However, the greatest benefit will be the increased ability to manage the overland flow transition from the earth drain and though the proposed resumed lots.

It is expected that this option will require lowering and regrading of the cul-de-sac head to enable the surface flows to pass along the proposed flow corridor. The aim being to create continuity and certainty of the overland flow path from the western earth drain through to St Crispins Street.

The key features of this option included:

- Property resumptions for three (3) properties to secure land tenure to connect the western earth drain to St Crispins Street;
- Removal of the houses and earthworks (drain excavation) within this corridor footprint to provide a broad flow path for the overland flow capacity on the surface;
- An underground pipe network in a more direct line through the resumed lots with approximate pipe capacity for the 5-year ARI flows (Q5);
- Underground pipe system extending across/along St Crispins Street to connect to the Lake;
- Lowering of the road surface in Ribbon Avenue Cul-de-sac to allow runoff to pass along the corridor at a lower water level to maximise protection to the existing floor levels;

Option 7 seeks to provide greater certainty in operation with limited consequence if there are blockages at the uppermost pipe inlet due to the common alignment in the underground and overland footpaths.

A further risk reduction measure is to ensure that the catchment extents are minimised to limit to flows required to be conveyed through this constrained flow path. In this respect, it is recommended that Council work with the Department of Transport and Main Roads (TMR) to complete a bund along the eastern side of the Captain Cook Highway to divert any external runoff direct to Crees Creek. This represents the easiest, most cost effective and most certain way to contain and convey any runoff west from the School and Church land.

Land on the western side of Ribbon Avenue (eastern side of the earth drain) is potentially vulnerable due to the limited hydraulic capacity of the drain. This potentially affects 8 lots (2 to 16 Ribbon Avenue).

It is expected that suitable impermeable fencing/walls that will serve as flood control will be required along the rear of the lots that back onto the earth drain. Preliminary calculations indicate the drain needs to be reprofiled to contain the required runoff. Even the upgraded drain will run full or near full, with little or no freeboard. Impermeable fencing such as a low masonry wall would be suitable to provide the additional protection and contain the flows to the drainage easement.

Assessment of the freeboard to the church building should also be undertaken during detailed design if this option is adopted.

5. SUMMARY AND CONCLUSIONS

Six (6) initial upgrade options were considered and documented in the concept phase report. All options are able to provide a significant improvement to the current capacity and would greatly reduce the localised flooding.

Option 3 – “Q100 piped solution” will theoretically provide the flow capacity but is not recommended due to concerns with system operation in the event of pipe or inlet blockages.

Option 6 – “resumption” will theoretically provide overland flow capacity between Ribbon Avenue and St Crispins Avenue. However, land resumption is required, and no additional capacity is provided upstream and downstream from this link. Flooding of the lots on the western side of Ribbon Avenue is not addressed and no additional pipes are proposed with this option.

Of the original six (6) options, Option 5 appears to provide the best improvements to the local drainage and seeks to match the immunity level of the system with that achieved in the wider flood mapping for the area.

However, none of the 6 initial options identified was able to provide the capacity or desired operating environment for a conventional stormwater system. In addition, the assessment identified risks and/or vulnerabilities with each option that were not considered acceptable to Council.

Following further meetings with Council an additional option, Option 7 was developed to seek to overcome the risk of system failure with particular focus on the vulnerable point at the interface with the western earth drain.

The key features of Option 7 are:

- Property resumptions for three (3) properties to provide a direct link from western earth drain to St Crispins Street;
- Shallow drain excavation within this corridor footprint to provide a broad flow path for the overland flow capacity on the surface;
- An underground pipe network through the resumed lots with approximate pipe capacity for the 5-year ARI flows (Q5);
- Underground pipe system extending across/along St Crispins Street to connect to the lake;
- Lowering of the road surface in Ribbon Avenue Cul-de-sac to allow runoff to pass along the corridor at a lower water level to maximise protection to the existing floor levels;

Option 7 seeks to provide greater certainty in operation with limited consequence if there are blockages at the uppermost pipe inlet due to the common alignment in the underground and overland footpaths.

Additional measures to maximise system performance include:

- A bund on the eastern side of the Captain Cook Highway to prevent runoff entering from external catchments;
- Reshaping, widening and possibly lowering the western earth drain in St Mary's to maximise capacity of this element; and
- Construction of flood control fencing at the rear of properties backing onto the earth drain to prevent runoff tipping through these properties;

Note, this commission did not assess the capacity or operation of St Crispins Avenue on-road flows as the stormwater currently arrives at this point prior to these works and the increased pipe capacity recommended will have a significant positive impact in reducing the pre-upgrade surface flows.

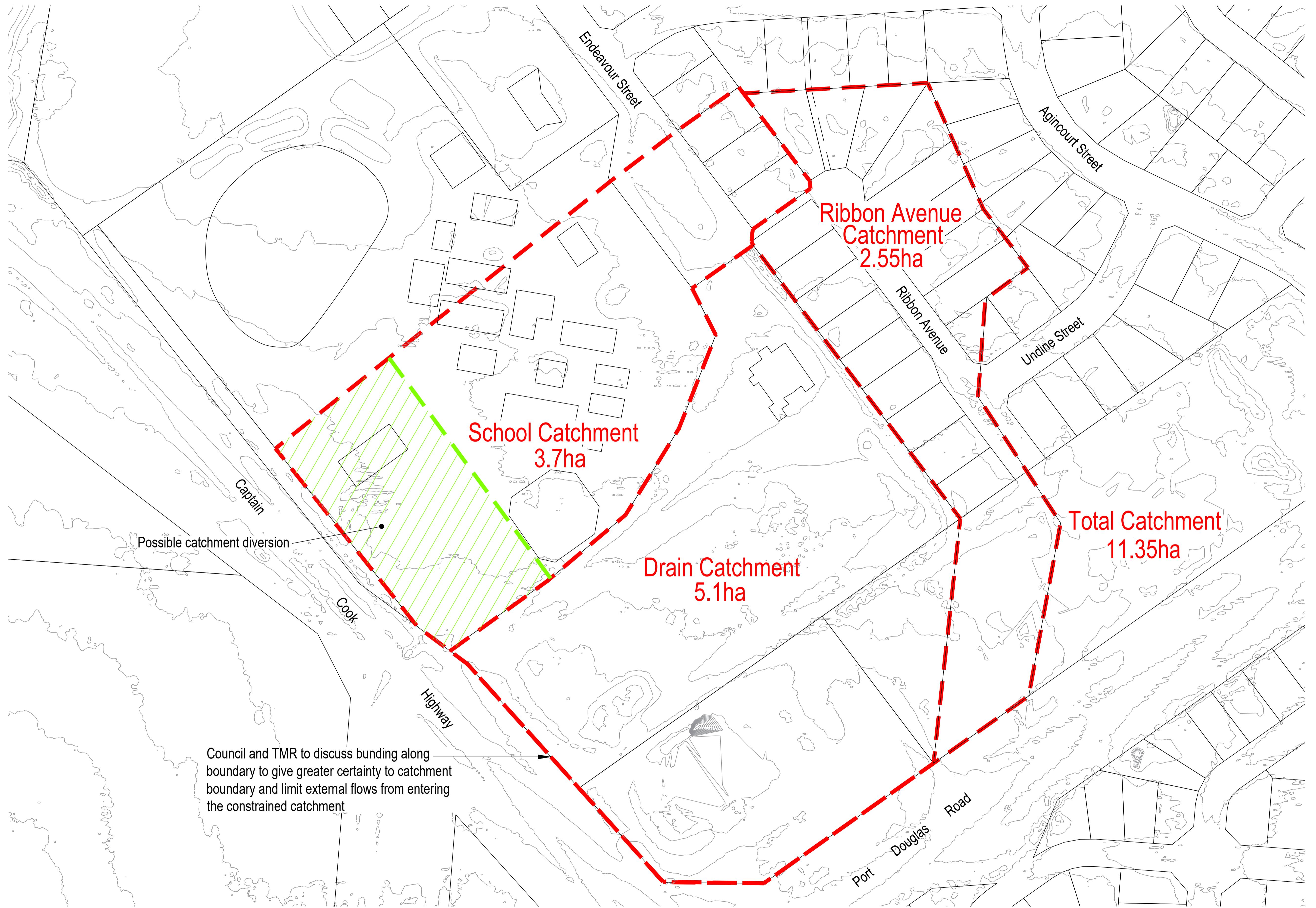
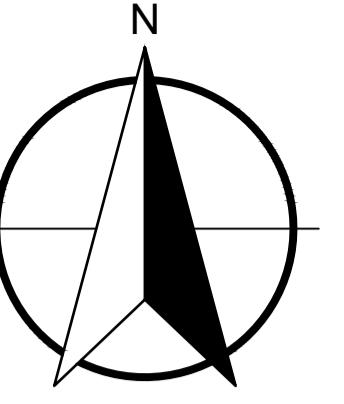
6. RECOMMENDATION

It is recommended that Council:

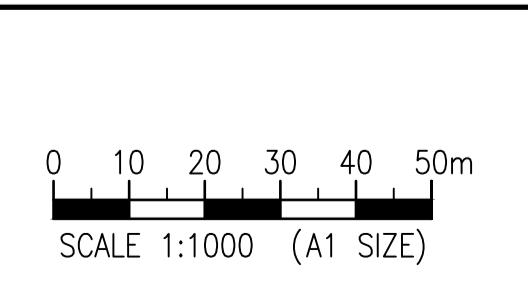
1. Accept this report for the purpose of discussions with Councillors and stakeholders;
2. Confirms that 2%AEP immunity level (Q50) is acceptable; and
3. Commences the preliminary and detailed design work required to prove up the preferred option.

Appendix A

Stormwater Catchment Plan

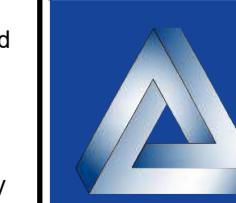


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Client	DOUGLAS SHIRE COUNCIL		
Project	RIBBON AVENUE DRAINAGE INVESTIGATION		
Title	CATCHMENT PLAN		
JOB No.	1184	Scale (A1 size) 1:1000	Date 10 APRIL 2018

Revision B

Appendix B

Table of Upgrade Options

	Description	Underground system	Overland flow path	Capacity	Immunity Achieved	Equivalent Flow	Risk (to successful system operation)	Pros/Cons	Comments
Existing Scenario		900 dia from pit adjacent open drain through to 1050 dia out of Ribbon Avenue through easement	None - localised flooding experienced	< Q1	<Q1	5.55m³/s	Ongoing risk due to lack of capacity and flowpaths		Localised Flooding is experienced at the lower end of Ribbon Avenue. "Do Nothing" is not considered acceptable to the community
Option 1	Construct Q5 pipe network and easement modifications for overland flow path.	2 / 750 dia RCP's from open drain, increase to 2 / 900 dia to collect school catchment. Continue along Endeavour Street and St Crispins Avenue to align with the easement adjacent No. 111 St Crispins Avenue. Construct new pit over existing 1200 dia main and connect original system. Additional 1200mm dia to be constructed adjacent existing 1200 dia pipe in the easement through to the lake.	Reconstruct overland flow path in Ribbon Avenue only to provide maximum capacity.	Q5 in pipes, Q100 - Q5 as overland flow	Q50	2.89m³/s piped Flow, 1.66m³/s overland at 300mm deep therefore 1.184m³/s not catered for.	<ul style="list-style-type: none"> Capacity and bank levels of earth drain in St Mary's - do flows arrive at inlet? (conveyance capacity). Flooding risk remains for Ribbon Avenue lots backing onto the western earth drain. Pipes are Q5 only - fixed capacity (events greater than design not readily accommodated). Inlet performance (capture) is critical to system performance and blockage risks is high; Safety of inlet must reflect school area - conflict with desire for "open" inlet for capture Flow control from Ribbon Avenue into proposed easement drain (low point does not align with easement). Risk of concentrated flows at outlet from easement drain across verge onto St Crispins Avenue. Possible pit surcharge (St Crispins Avenue). Downstream tailwater influence on storm surge/cross creek flooding. 	Pros: <ul style="list-style-type: none"> Provides increased capacity Q5 pipes and inlet upgrade. Increased certainty of flow path (Ribbon Avenue to St Crispins Avenue). Cons: <ul style="list-style-type: none"> Does not address capacity of existing earth drain. Does not address how flows get from western drain and/or Endeavour Street to Ribbon Avenue. Concentrated flow out of easement drain onto St Crispins Av Disturbance to road/school area. Unknown ground conditions for construction. Additional pipe in 111 St Crispins Avenue (impact on resident). May negate 'detention' effects/downstream issues. 	Depth in Easement is 430mm and therefore exceeds the QUDM requirement of 300mm maximum in Q100 event, which is not considered good engineering practice. This Option does not provide the required stormwater and flooding outcome
Option 2	Construct Q5 pipe network and reconstruct Endeavour Road.	As above	Provision of some capacity by reconstructing road and lowering kerb along Endeavour St kerb following pipe trenching through this corridor.	Q5 in pipes, Q100 - Q5 as overland flow			<ul style="list-style-type: none"> Capacity and bank levels of earth drain in St Mary's - do flows arrive at inlet? (conveyance capacity). Flooding risk remains for Ribbon Avenue lots backing onto the western earth drain. Provides a notional overland flow path from drain but existing road levels limit the grade, depth and capacity of the flowpath; Concern with capacity of on-road flowpath - provides only half road flow (Endeavour St) and at minimal grade may not alleviate flooding as water levels build up anyway; Pipes are Q5 only - fixed capacity (events greater than design not readily accommodated). Inlet performance (capture) is critical to system performance and blockage risks is high; Safety of inlet must reflect school area - conflict with desire for "open" inlet for capture Ribbon Avenue relies on piped only solution, flood risk in cul-de-sac remains; Downstream tailwater influence on storm surge/cross creek flooding. 	Pros: <ul style="list-style-type: none"> Provides increased capacity Q5 pipes and inlet upgrade. Limited capacity flow path (Endeavour to St Crispins). Cons: <ul style="list-style-type: none"> Does not address capacity of existing earth drain. Does not address Endeavour Street starting surface/water levels. Major disturbance to road/school area. Unknown ground conditions for construction. Additional pipe in 111 St Crispins Avenue (impact on resident). May negate 'detention' effects/downstream issues. 	Access into allotment 61 on Endeavour Avenue has crossfall of 16.9% This Option does not provide the required stormwater and flooding outcome
Option 3	Construct Q100 pipe network	2 / 1050 dia RCP's from open drain, increase to 2/1200 dia along Endeavour Street and St Crispins Avenue to align with the easement adjacent No. 111 St Crispins Avenue. Construct new pit over existing 1200 dia main and connect original system. Existing 1200mm dia RCP to be removed and replaced with 2 / 1350 dia in the easement through to the lake.	None provided	Q100 in pipes	Q100	5.55m³/s piped Flow, 0m³/s Overland. Emergency overland relief not provided	<ul style="list-style-type: none"> Capacity and bank levels of earth drain in St Mary's - do flows arrive at inlet? (conveyance capacity). Flooding risk remains for Ribbon Avenue lots backing onto the western earth drain. Pipes are Q100 - fixed capacity (events greater than design not readily accommodated). Inlet performance (capture) is critical to system performance and blockage risks is high; Safety of inlet must reflect school area - conflict with desire for "open" inlet for capture <p>If overflow occurs (inlet blockage) as per current performance issues:-</p> <ul style="list-style-type: none"> No flow control. Potentially less overland flow due to Increase in pipe capacity (if some flow gets into inlet). Possible pit surcharge (St Crispins). Downstream tailwater influence on storm surge/cross creek flooding. 	Pros: <ul style="list-style-type: none"> Provides significant increased capacity Q100 pipes and inlet upgrade. Cons: <ul style="list-style-type: none"> Does not address capacity of existing earth drain. Disturbance to road/school area. Unknown ground condition for construction. Additional pipe in 111 St Crispins Avenue (impact on resident). Does not provide overland flow in Endeavour or Ribbon Avenue in event of any failures in underground system. 	Lack of overland flow path is not consistent with good engineering practice Due to concerns with Blockages, this Option does not provide the required stormwater and flooding outcome
Option 4	Construct Q10 pipe network and reconstruct Endeavour Road.	2 / 750 dia to be replaced with 2 / 900 dia Pipes, remainder to be constructed as per Option 2 above.	Provision of some on-road capacity per Option 2.	Q10 in pipes, Q100 - Q10 as overland flow		4.44m³/s piped Flow,	As per option 2 except slightly larger pipes (Q10 instead of Q5)	As per option 2 except slightly larger pipes (Q10 instead of Q5)	This Option does not provide the required stormwater and flooding outcome
Option 5	Construct Q5 pipe network, Q50 - Q5 via upgraded pathway link and easement modifications. Increased capture in Ribbon Av to maximise existing diam 1050mm pipe.	2 / 900 dia to collect school catchment. Continue along Endeavour Street and St Crispins Avenue to align with the easement adjacent No. 111 St Crispins Avenue. Construct new pit over existing 1200 dia main and connect original system. Additional 1200mm dia to be constructed adjacent existing 1200 dia pipe in the easement through to the lake. Construct Kerb Inlet pit over existing 1050dia main at cul de sac head in Ribbon Avenue	Reconstruct overland flow paths from Drain to Ribbon Avenue and Ribbon Avenue to Saint Crispins Avenue to provide maximum capacity.	Q5 in pipes, Q50-Q5 as overland flow		2.89m³/s piped Flow at Endeavour Street, additional 1.90m³/s capture at Ribbon Avenue leaving overland flow of 0.88m³/s.	<ul style="list-style-type: none"> As per Option 1, except that this option provides an overland flow path from earth drain through to Ribbon Avenue. No flow control from Ribbon Avenue into proposed easement drain (low point does not align with easement). Upgraded pathway link offers some relief from earth drain to Ribbon Ave. However risk remains with water levels at the northern end of open earth drain (western end of pathway link) Risk at end of drain (inlet, overland flow path). These have to work with limited levels. 	Pros: <ul style="list-style-type: none"> Provides increased capacity Q5 pipes and inlet upgrade. Provides overland flow at end of drain. Increased certainty of flow path (Ribbon Avenue to St Crispins Avenue). Upgraded pathway link offers some relief. Additional inlet in Ribbon Avenue and upgrade Ribbon Avenue cul-de-sac. Cons: <ul style="list-style-type: none"> Uncertainty in operation (water levels) for these 3 improvements. 	This Option does not provide the required stormwater and flooding outcome
Option 6	Resume 2 x houses between Ribbon Av and St Crispins Street to allow for construction of overland flowpath	No additional underground capacity.	Demolish and remove two houses and reprofile the surface of those lots to provide overland flow path. Lower and upgrade pathway link. (freeboard protection to rear of lots abutting drain recommended).	< Q1 underground, Q100-Q1 accommodated in new overland flowpath at Ribbon Avenue		Approx. 4.5 m³/s	<ul style="list-style-type: none"> Capacity and bank levels of earth drain in St Mary's - do flows arrive at inlet? (conveyance capacity). No overland flow path from earth drain through to Ribbon Avenue. Flooding risk remains for Ribbon Avenue lots backing onto the western earth drain. "On -road" water levels in Ribbon Ave still build up due to capacity to outlet into resumed lot (Regrade of cul-de-sac offers path for runoff out of Ribbon Avenue into resumed lots and to St Crispins Avenue). Does not address upstream of Ribbon Avenue or downstream of St Crispins Avenue. And hence does not provide any additional capacity outside the 2-lot footprint. 	Pros: <ul style="list-style-type: none"> Provides opportunity/path for runoff to be conveyed from Ribbon Avenue to St Crispins Avenue. Opportunity to reprofile verge in Ribbon Ave to control and outlet the surface flows into the resumed lot. Should allow flooding of cul-de-sac to be addressed. Cons: <ul style="list-style-type: none"> Does not address upstream Ribbon Avenue or downstream St Crispins Avenue. And hence does not provide any additional capacity outside the 2-lot footprint. 	Overland flow adjacent the drain will continue to cause problems for the adjacent allotments as no work is being carried out in this area. Flooding at the end of Ribbon Avenue will be alleviated. This Option does not provide the required stormwater and flooding outcome
Option 8 (Modified from Options 7A and 7B)	Resume 3 x houses between Western Earth Drain, Ribbon Av and St Crispins Street to allow for construction of overland flowpath from western catchment through to St Crispins Ave. Provide piped capacity from Earth Drain through to Lake Proposed flood fence/wall to protect Ribbon Avenue lots backing onto earth drain;	Diameter 1200mm minimum pipe from Earth Drain through to Lake	Demolish and remove three houses and reprofile the surface of those lots to provide overland flow path from Western drain through to St Crispins Ave; Reprofile (lower) the cul-de-sac head in Ribbon Avenue to provide continuity of the flow path; Construct new inlet and pipe in resumed lot to convey minimum Q5 from western Earth Drain to Lake. Construct flood fence/wall on eastern side of St Mary's earth drain to provide immunity to existing houses in Ribbon Avenue	Seeks to provide Q50 capacity and may provide higher subject to downstream conditions (Cannot provide further capacity if Crees Creek is flooding and/or storm tide occurs)	Q50	4.5 m³/s (and potentially greater subject to downstream conditions)	<ul style="list-style-type: none"> proposed flood fence/wall required added to address risk with lots between drain and Ribbon Avenue (u/s from 18 Ribbon Avenue). Upgrade existing earth drain to ensure flows arrive at inlet? (conveyance capacity is appropriate). Significant regrade of cul-de-sac required to offer path for runoff out of Ribbon Avenue into resumed lots and to St Crispins Avenue. Land resumption alone does not address downstream St Crispins (needs significant pipe capacity through to lake). No formation of St Crispins overflow at Agincourt. - (needs further works) <p>Detailed design needs to focus on the system elements as follows:</p> <ol style="list-style-type: none"> at earth drain into 18 Ribbon Avenue. in Ribbon Avenue cul-de-sac. in 15/16 Ribbon Avenue. in 116/112 St Crispins. Overall hydraulic grade. 	Pros: <ul style="list-style-type: none"> Provides opportunity for overland flow from earth drain to Ribbon Ave through resumed lot 18 Ribbon Avenue. Provides overland flow opportunity at Ribbon Avenue to St Crispins Avenue (but requires regrade of cul-de-sac). Provides piped flow capacity from earth drain for minor flows with the pipes aligned with the overland flow path through to St Crispins Avenue; Piped capacity downstream from St Crispins Avenue to lake aligns with roadway and provides connectivity to existing systems; Cons: <ul style="list-style-type: none"> Ribbon Avenue cul-de-sac regrade required to allow runoff to pass. External works required in St Mary's. External works required at back of Ribbon Avenue lots (barrier/wall). Construction issues with major pipe corridor at pump station/ERGON padmount on route to Lake. 	Higher certainty in control of flows and water levels at western extent. Needs work on western drain and properties backing onto drain. This Option provides the best opportunity to achieved the required stormwater and flooding outcome

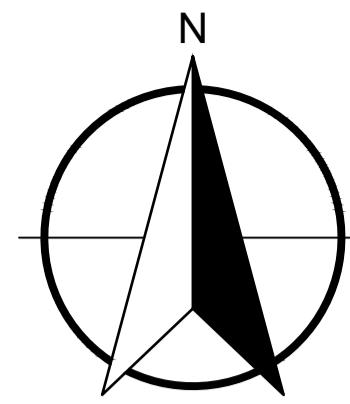
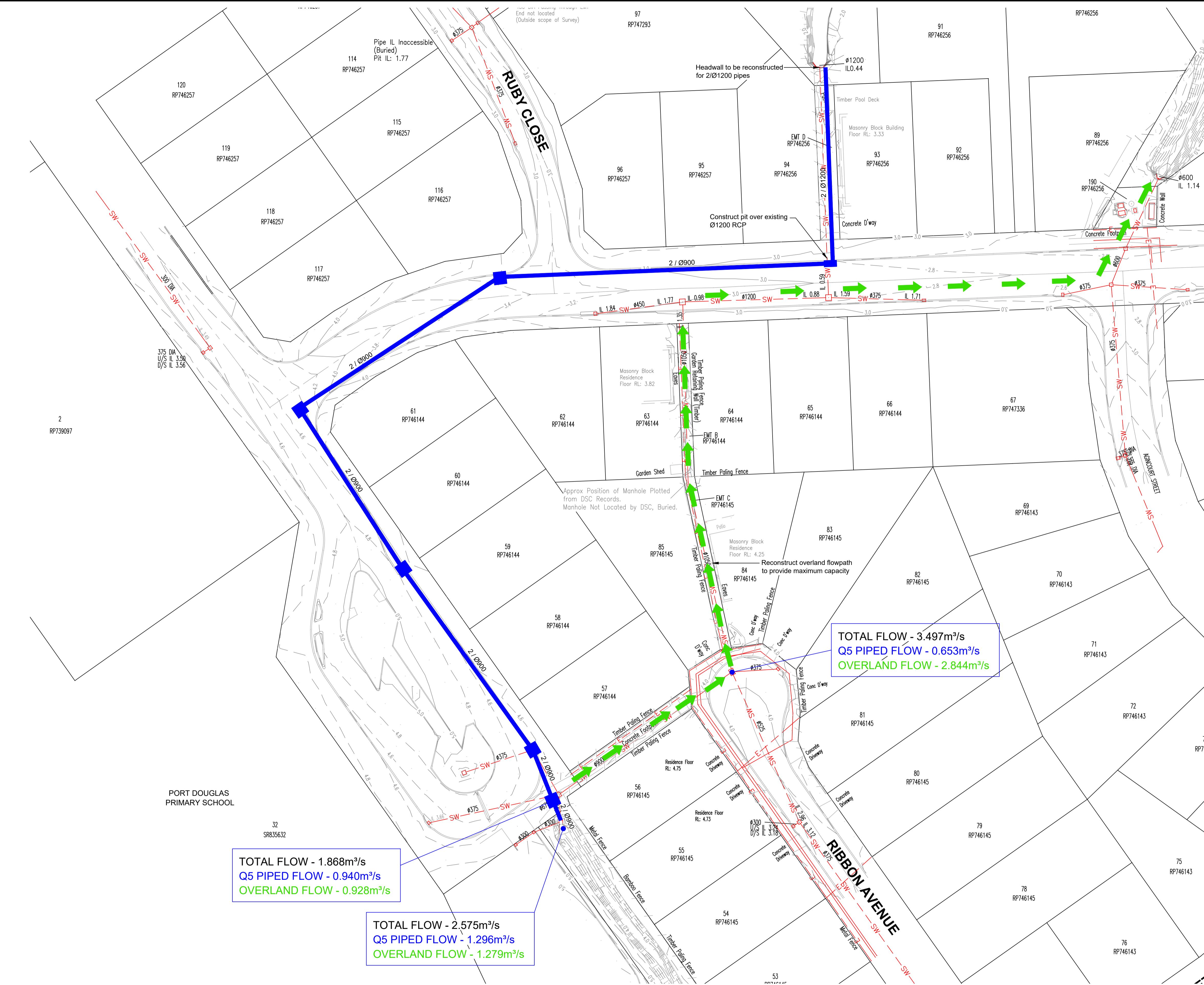
IMPORTANT NOTE:
The above are preliminary indication of costs only, prepared to assist in determining whether to proceed to have the project costed by a quantity surveyor. These costs cannot be used for any other purpose including, without limitation, determining to proceed with the project, to obtain finance or for sale purposes.
It has been prepared based on certain assumptions. We have not independently verified the assumptions made in the Preliminary Costs Schedule nor have we verified the completeness or accuracy of the information provided to us by you or other parties.

It is intended for use only by the client under the agreed Terms of Engagement and may not be relied on by any other person.

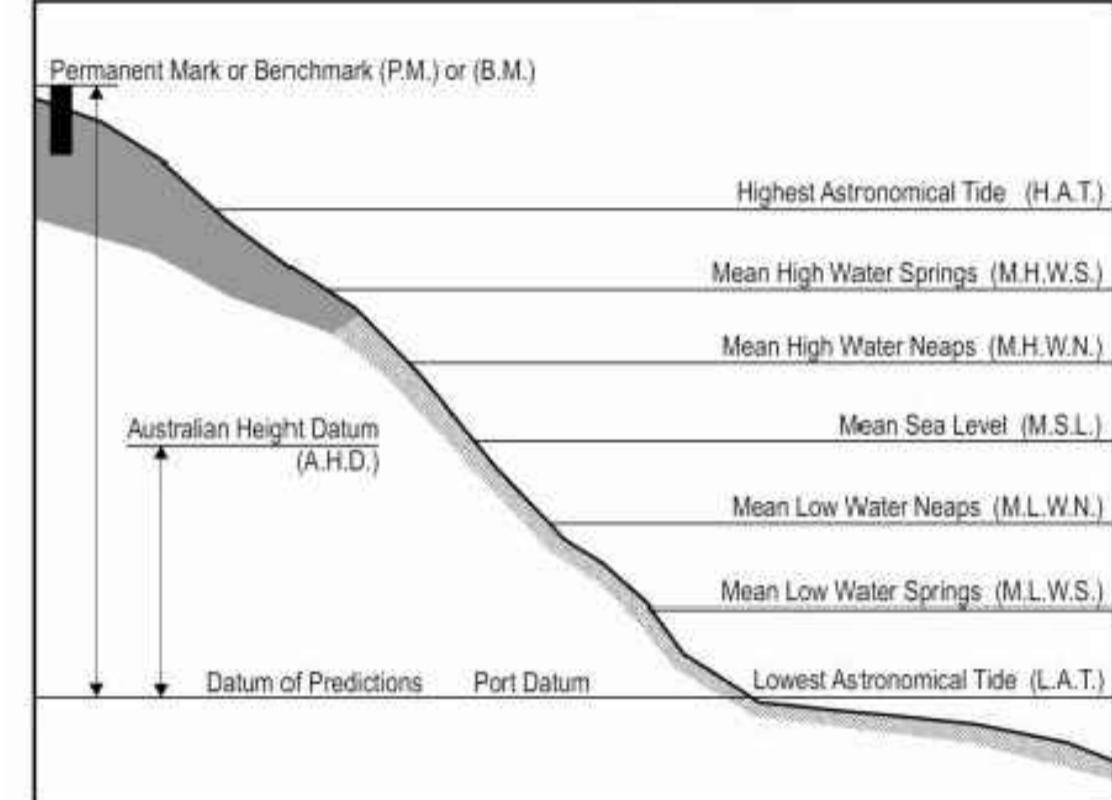
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Appendix C

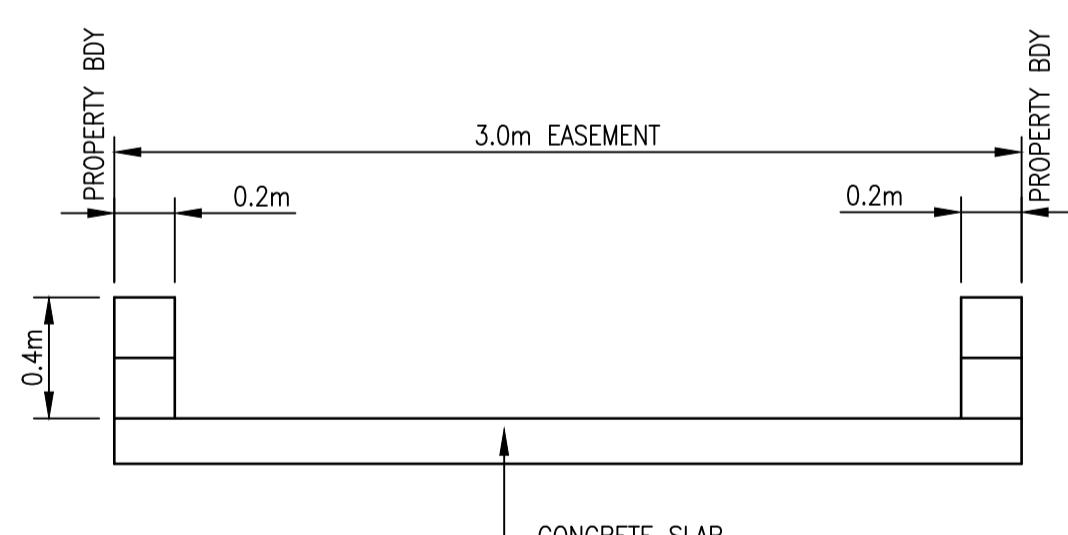
Concept Options

**LEGEND**

OVERLAND FLOW DIRECTION
 Q5 PIPE SYSTEM

Guide to Semidiurnal Tidal Planes

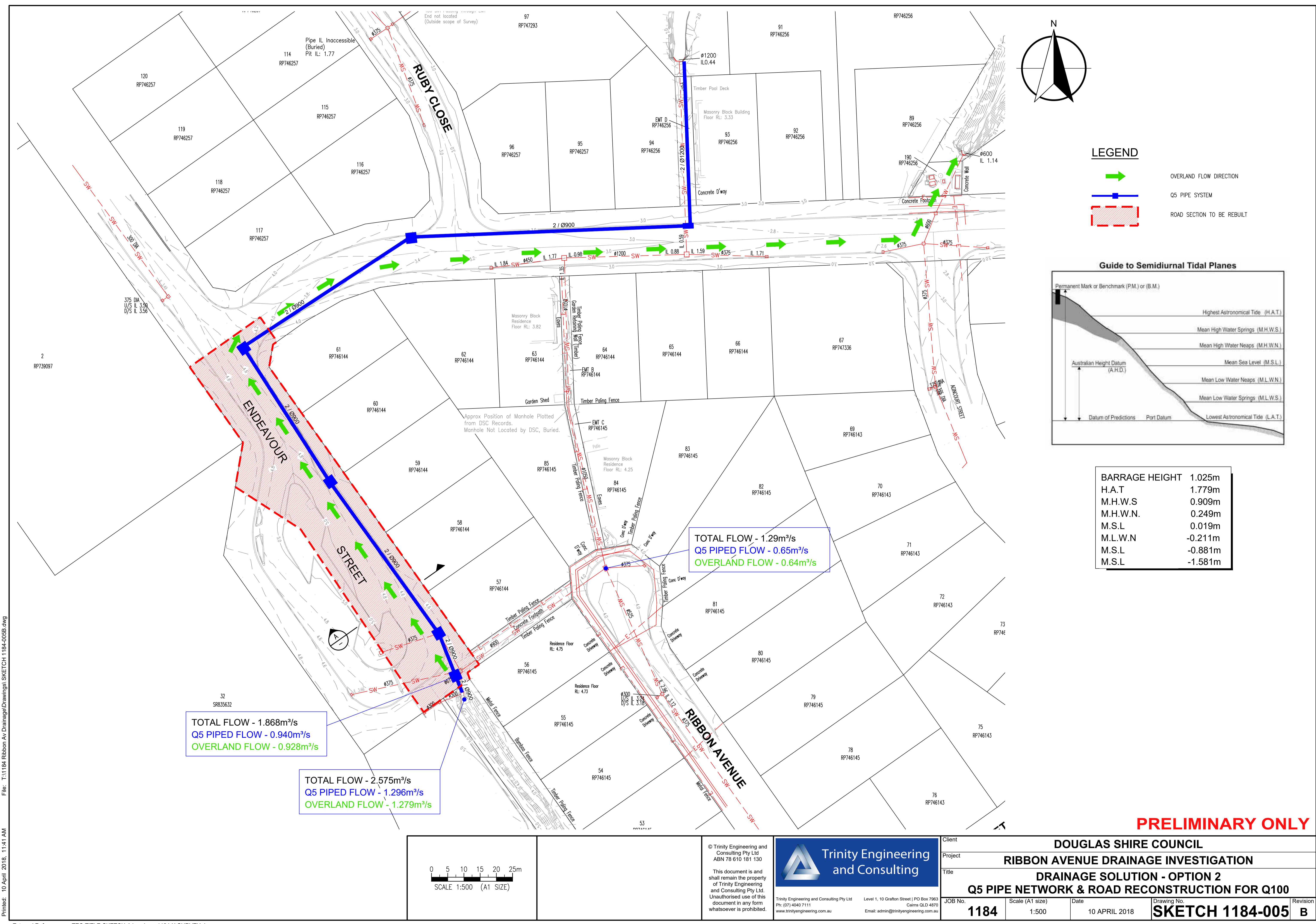
BARRAGE HEIGHT	1.025m
H.A.T	1.779m
M.H.W.S	0.909m
M.H.W.N.	0.249m
M.S.L	0.019m
M.L.W.N	-0.211m
M.S.L	-0.881m
M.S.L	-1.581m

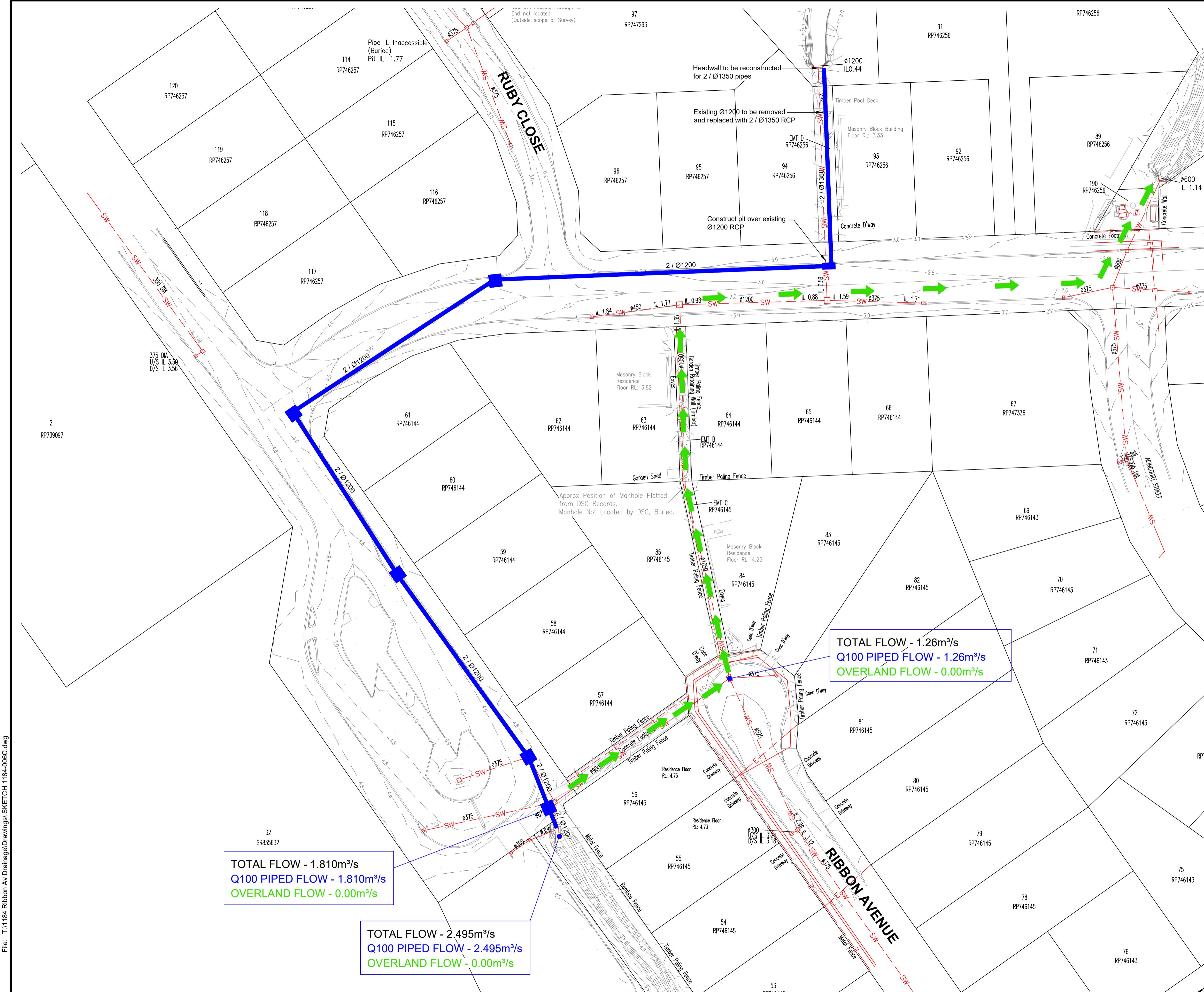
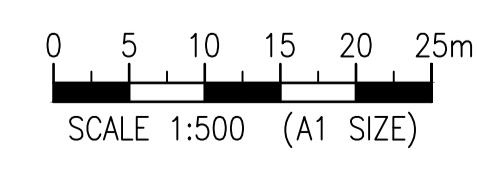
**OVERLAND FLOWPATH**
SCALE 1:25**PRELIMINARY ONLY**

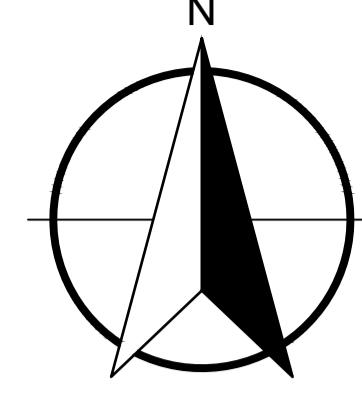
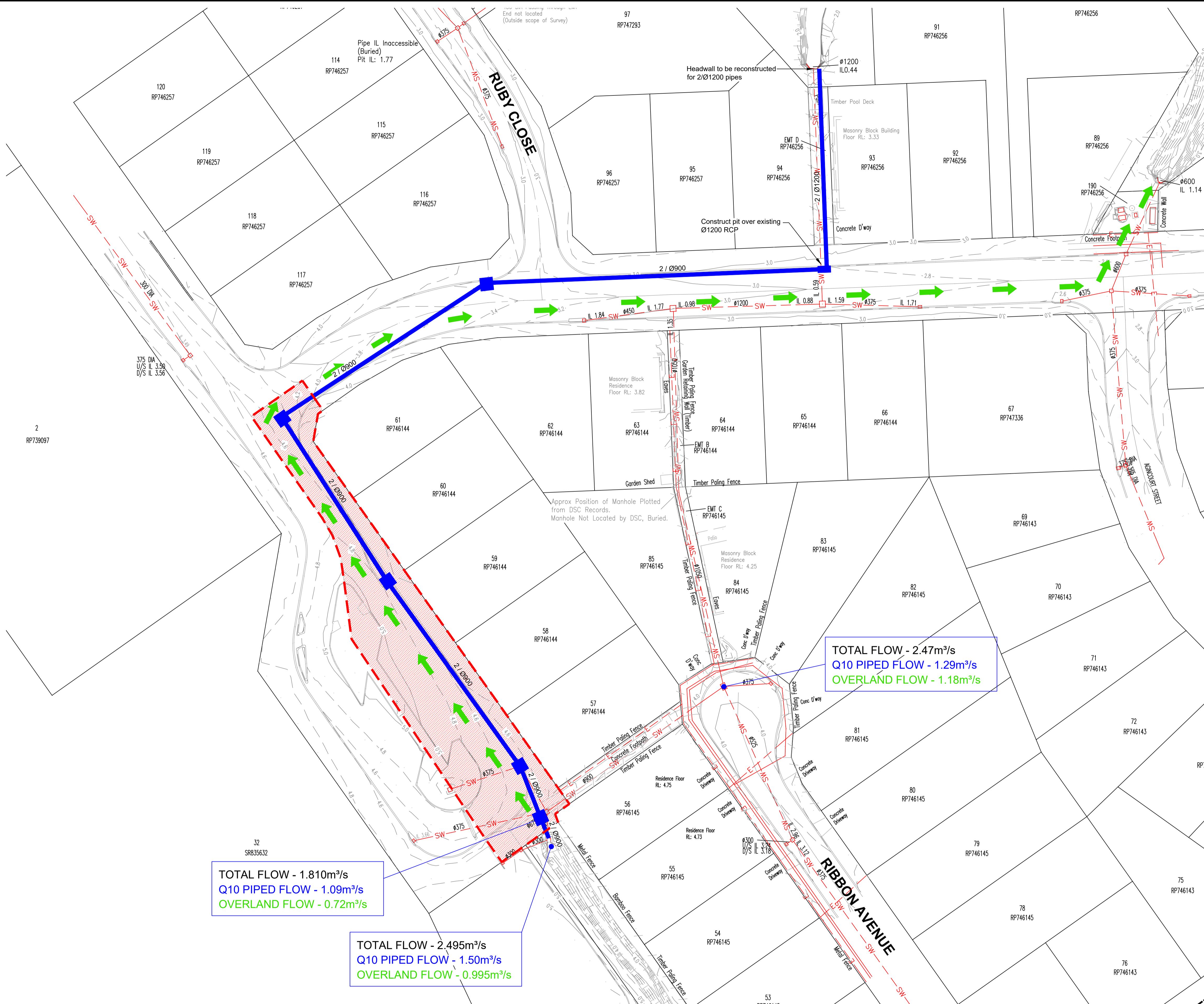
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Client	DOUGLAS SHIRE COUNCIL		
Project	RIBBON AVENUE DRAINAGE INVESTIGATION		
Title	DRAINAGE SOLUTION - OPTION 1		
Q5 PIPE NETWORK & EASEMENT MODIFICATIONS FOR Q100			
JOB No.	Scale (A1 size)	Date	Drawing No.
1184	1:500	10 APRIL 2018	SKETCH 1184-004 C



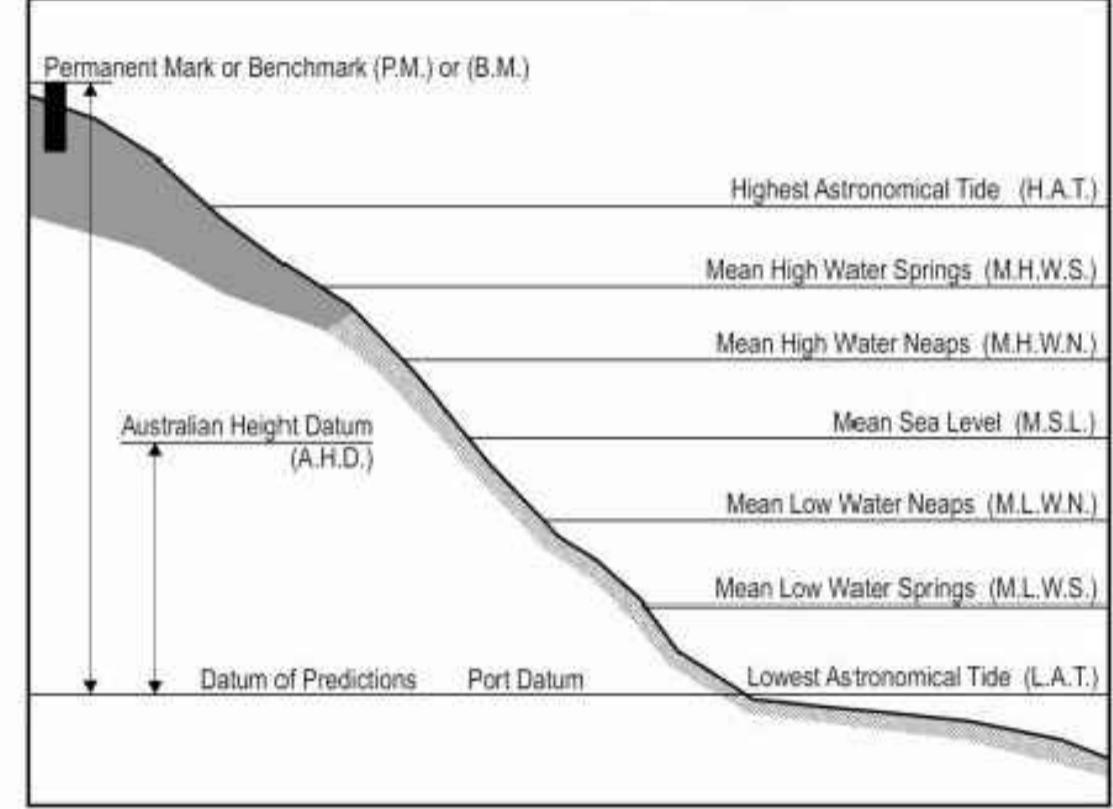
**PRELIMINARY ONLY**



LEGEND

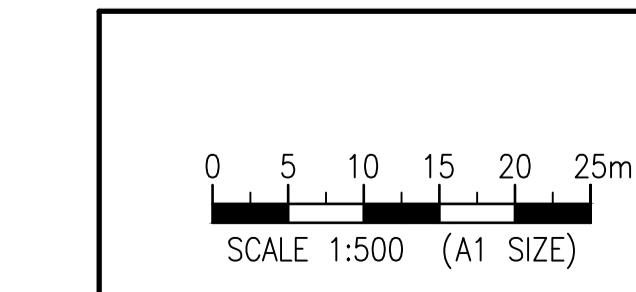
- OVERLAND FLOW DIRECTION
- Q5 PIPE SYSTEM
- ROAD SECTION TO BE REBUILT

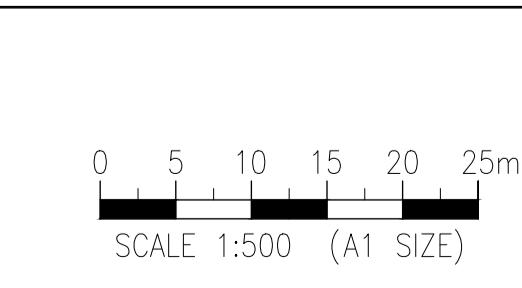
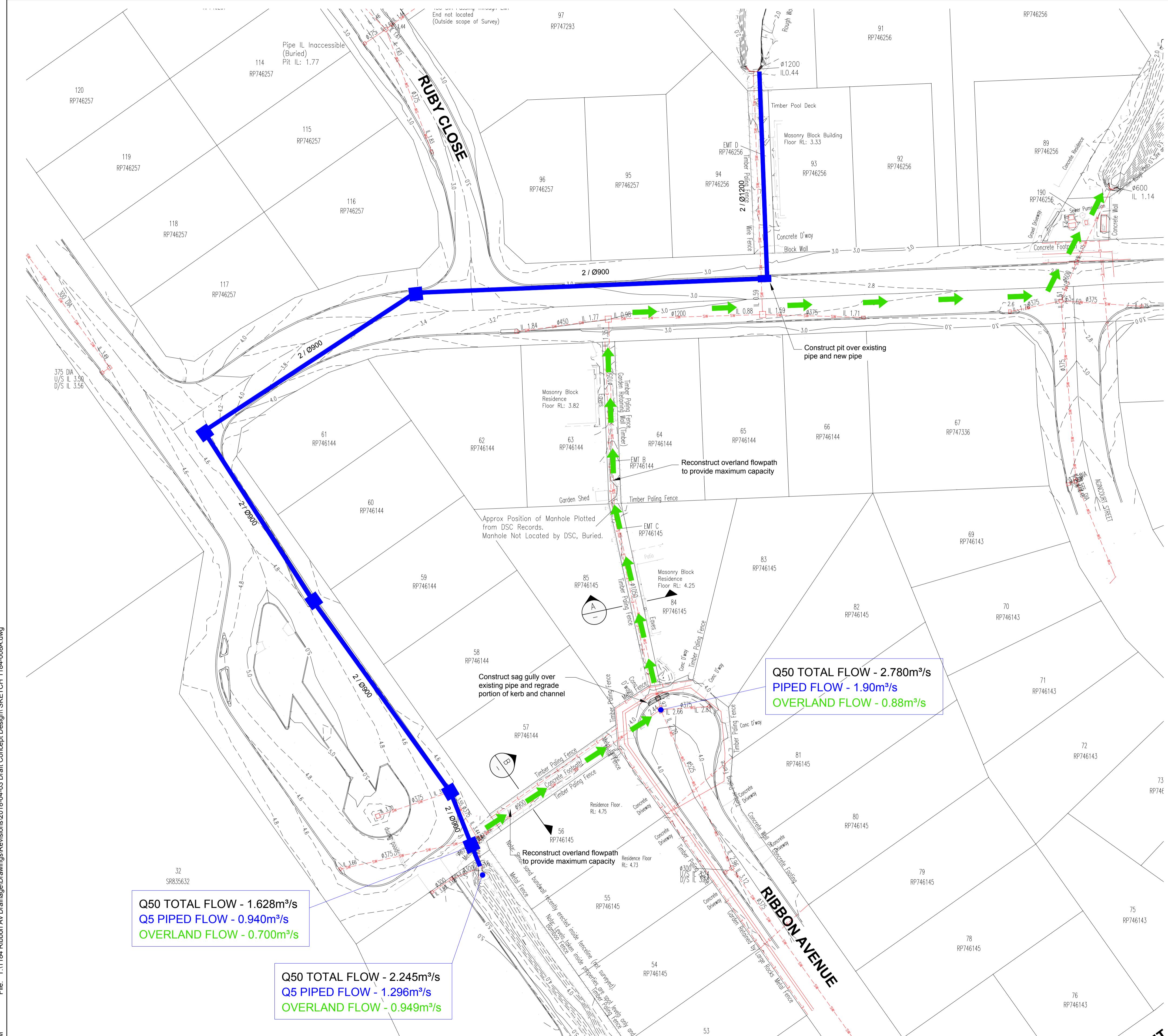
Guide to Semidiurnal Tidal Planes



BARRAGE HEIGHT	1.025m
H.A.T	1.779m
M.H.W.S	0.909m
M.H.W.N.	0.249m
M.S.L	0.019m
M.L.W.N	-0.211m
M.S.L	-0.881m
M.S.L	-1.581m

PRELIMINARY ONLY



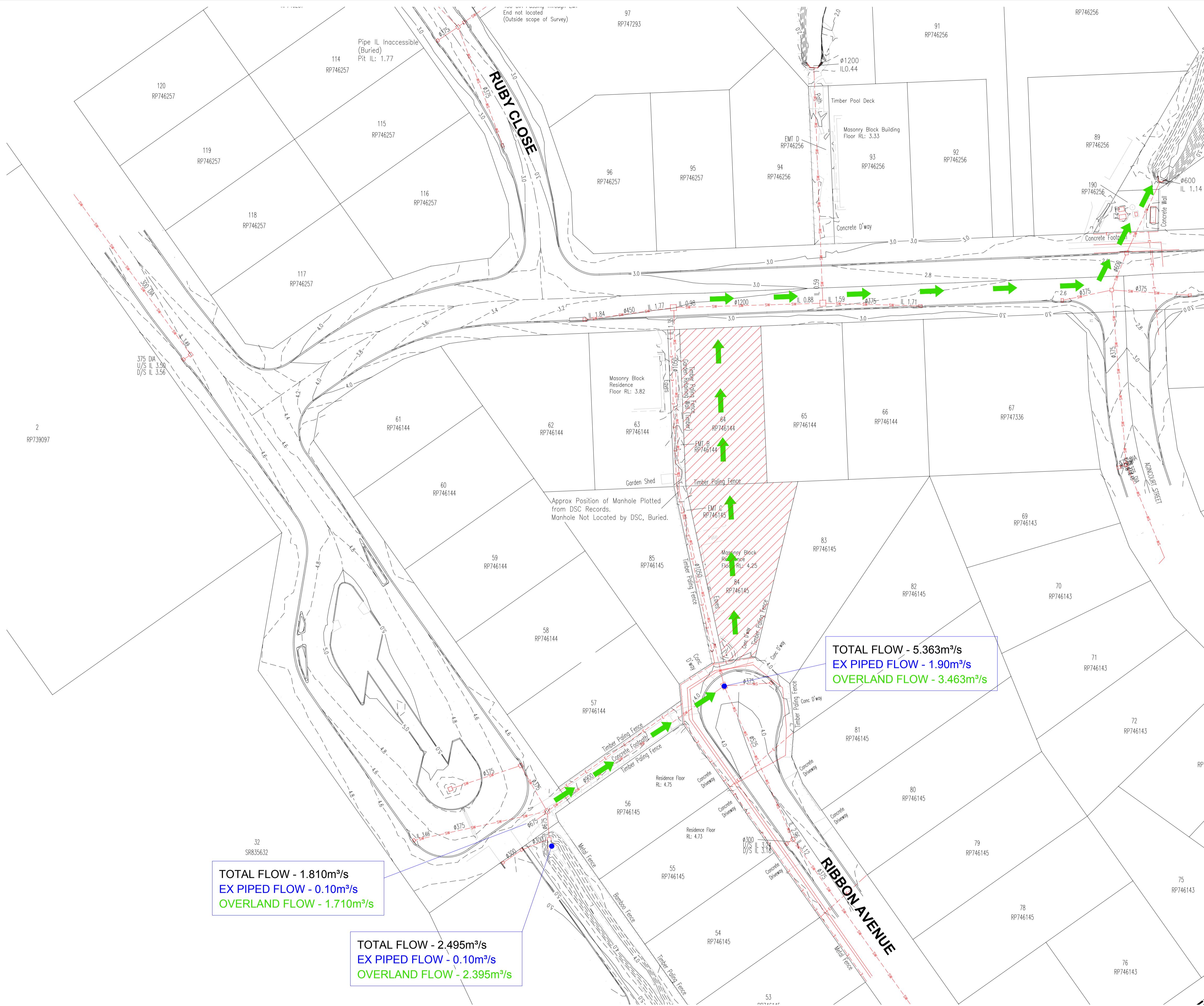
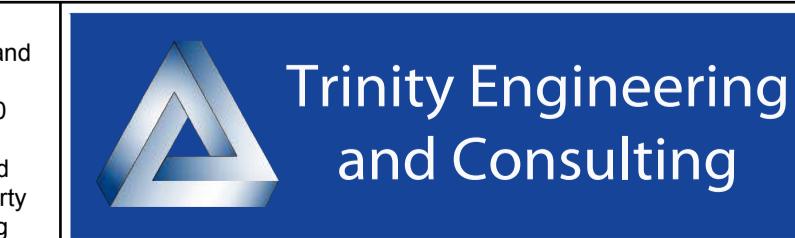


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Client	DOUGLAS SHIRE COUNCIL		
Project	RIBBON AVENUE DRAINAGE INVESTIGATION		
Title	DRAINAGE SOLUTION - OPTION 5		
	Q5 PIPE NETWORK & PATHWAY RECONSTRUCTION FOR Q100		
JOB No.	Scale (A1 size)	Date	Drawing No.
1184	1:500	1 MARCH 2018	SKETCH 1184-008 A

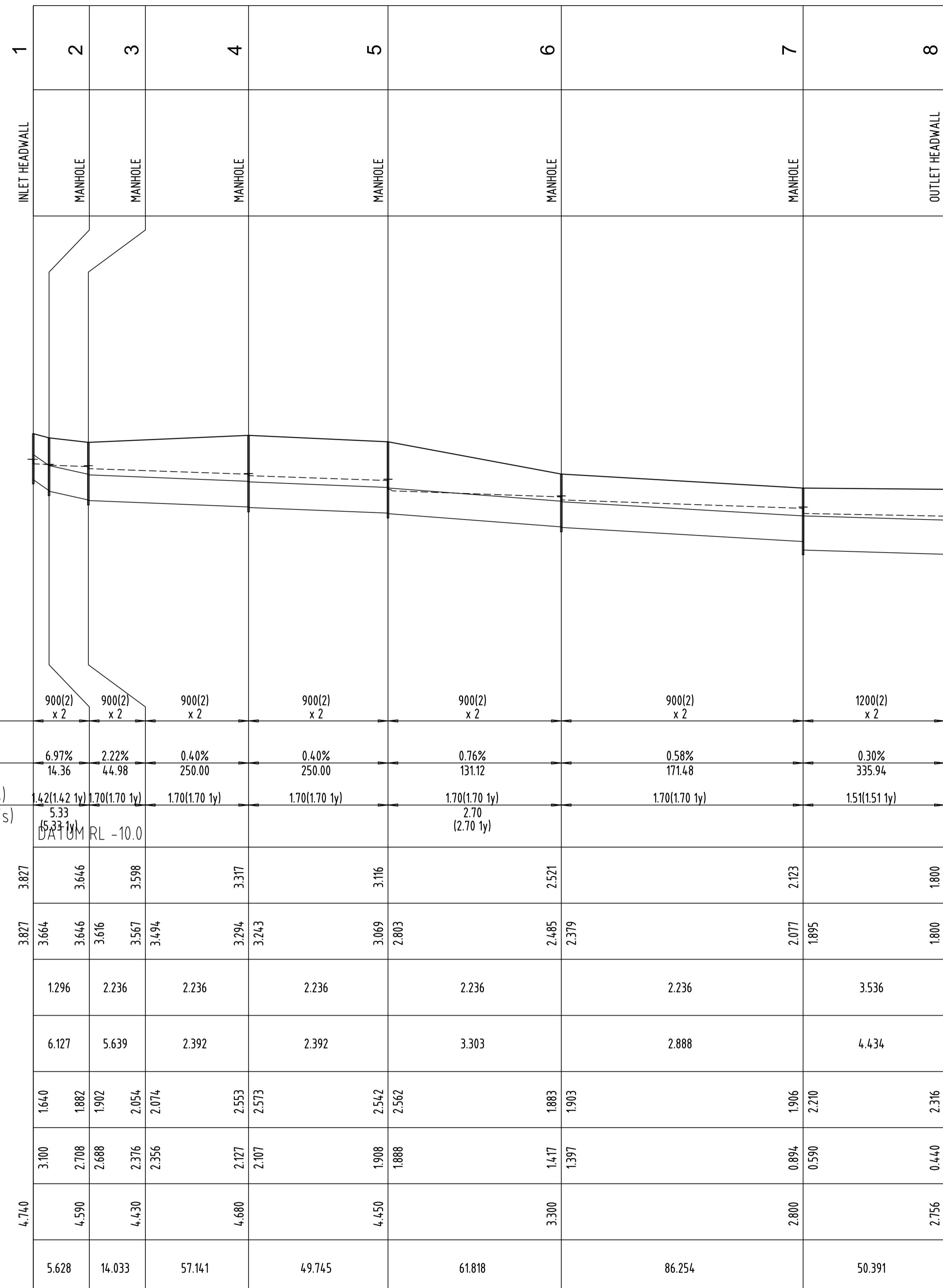
**PRELIMINARY ONLY****DOUGLAS SHIRE COUNCIL****RIBBON AVENUE DRAINAGE INVESTIGATION****DRAINAGE SOLUTION - OPTION 6****RESUMPTION OF LOT 84 ON RP746145 & LOT 64 ON RP746144**

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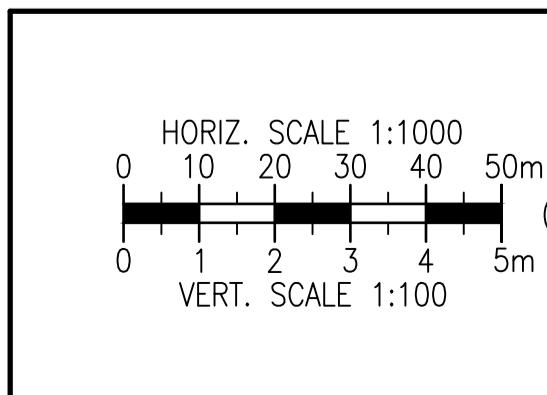
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Client			
Project			
Title			
JOB No.	Scale (A1 size)	Date	Drawing No.
1184	1:500	1 MARCH 2018	SKETCH 1184-009 A

STRUCTURE NAME	
STRUCTURE DESCRIPTION	
PIPE SIZEmm (Class)	
PIPE GRADE %	
PIPE SLOPE 1 in X	
FULL PIPE FLOW VELO	
PART FULL FLOW VEL	
WATER LEVEL IN STRUCTURE	
HYDRAULIC GRADE LEVEL	
PIPE FLOW (Cumecs)	
PIPE CAPACITY AT GRADE (Cumecs)	
DEPTH TO INVERT	
INVERT LEVEL OF DRAIN	
DESIGN SURFACE LEVEL	
PIPE LENGTH	

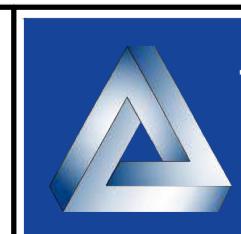


Q5 DRAINAGE PIPE



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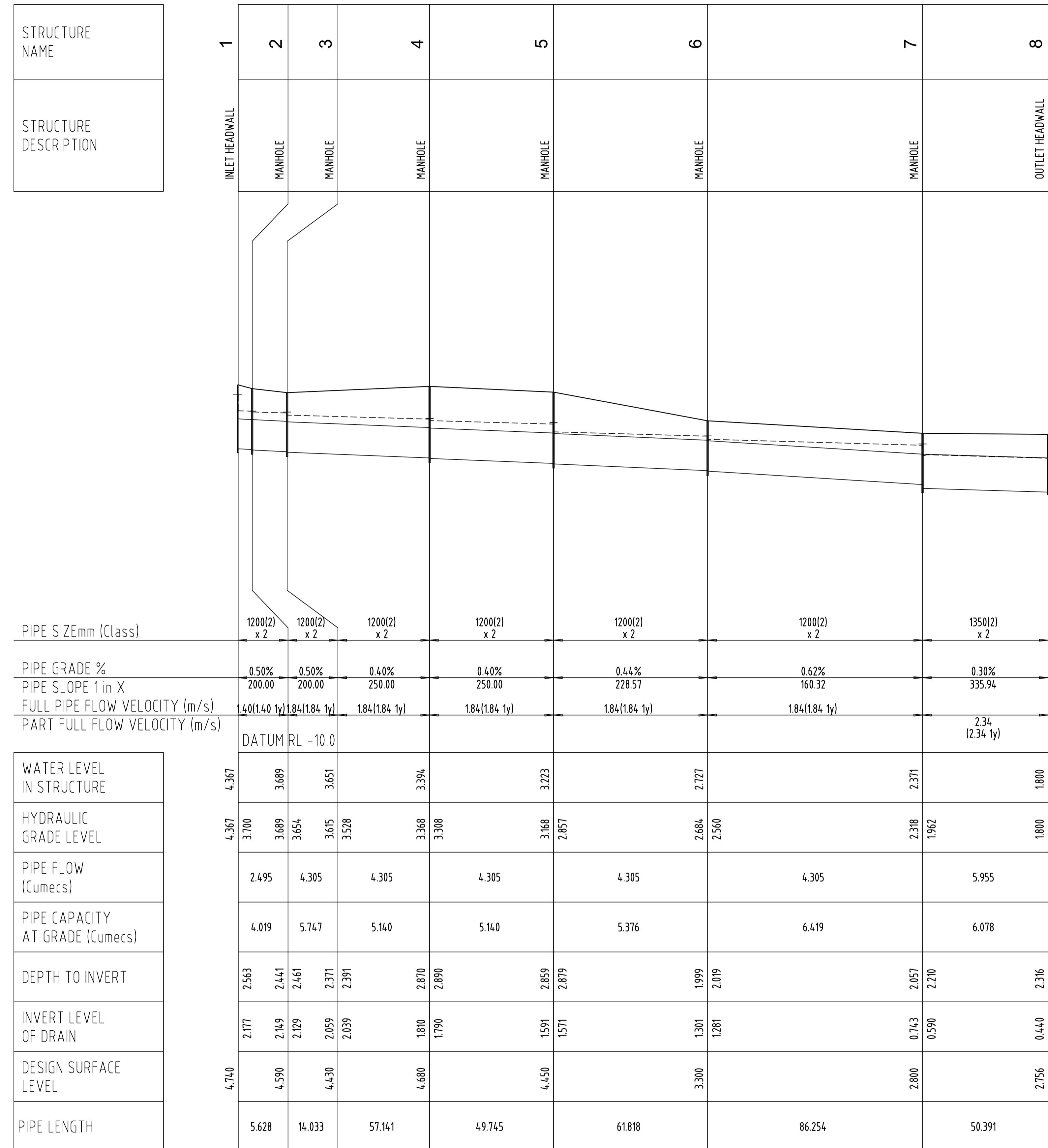
DOUGLAS SHIRE COUNCIL

RIBBON AVENUE DRAINAGE INVESTIGATION

DRAINAGE SOLUTION - OPTION 2

Q5 STORMWATER LONGITUDINAL SECTIONS

PRELIMINARY ONLY



HORIZ. SCALE 1:1000
0 10 20 30 40 50m
(A1)
0 1 2 3 4 5m
VERT. SCALE 1:100

Q100 DRAINAGE PIPE
SCALE 1:1000 HOR 1:100 VERT

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Client	DOUGLAS SHIRE COUNCIL		
Project	RIBBON AVENUE DRAINAGE INVESTIGATION		
Title	DRAINAGE SOLUTION - OPTION 3		
	Q100 STORMWATER LONGITUDINAL SECTIONS		
JOB No.	Scale (A1 size)	Date	Drawing No.
1184	AS SHOWN	10 APRIL 2018	SKETCH 1184-011 B

PRELIMINARY ONLY

STRUCTURE NAME
STRUCTURE DESCRIPTION

PIPE SIZEmm (Class)

PIPE GRADE %

PIPE SLOPE 1 in X

FULL PIPE FLOW VELOCITY (m/s)

PART FULL FLOW VELOCITY (m/s)

WATER LEVEL IN STRUCTURE

HYDRAULIC GRADE LEVEL

PIPE FLOW (Cumecs)

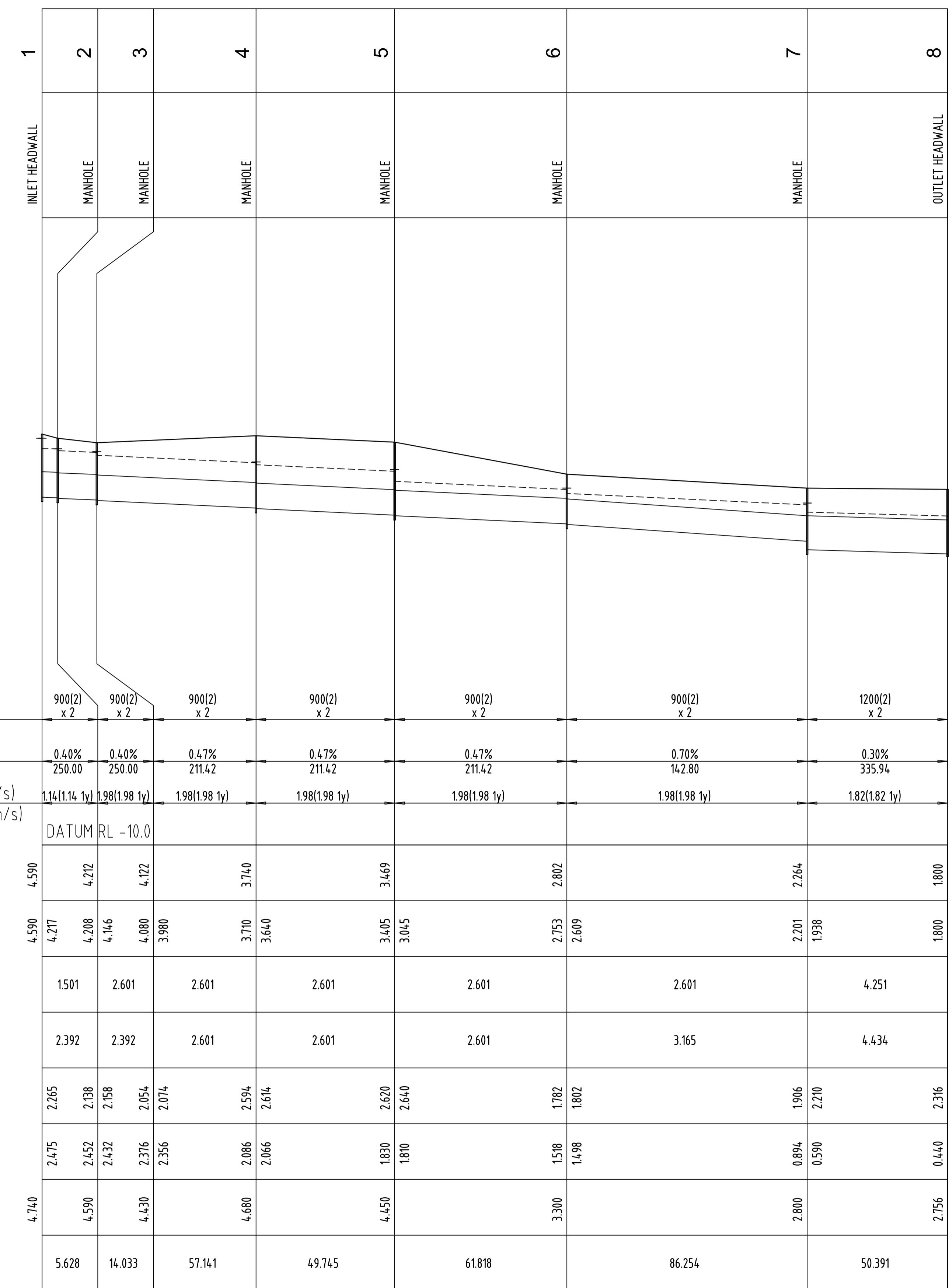
PIPE CAPACITY AT GRADE (Cumecs)

DEPTH TO INVERT

INVERT LEVEL OF DRAIN

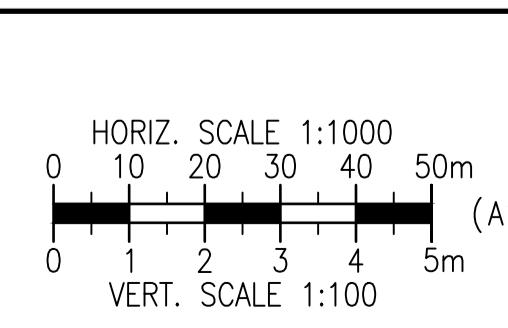
DESIGN SURFACE LEVEL

RUNNING CHAINAGE



Q10 DRAINAGE PIPE

SCALE 1:1000 HOR 1:100 VERT



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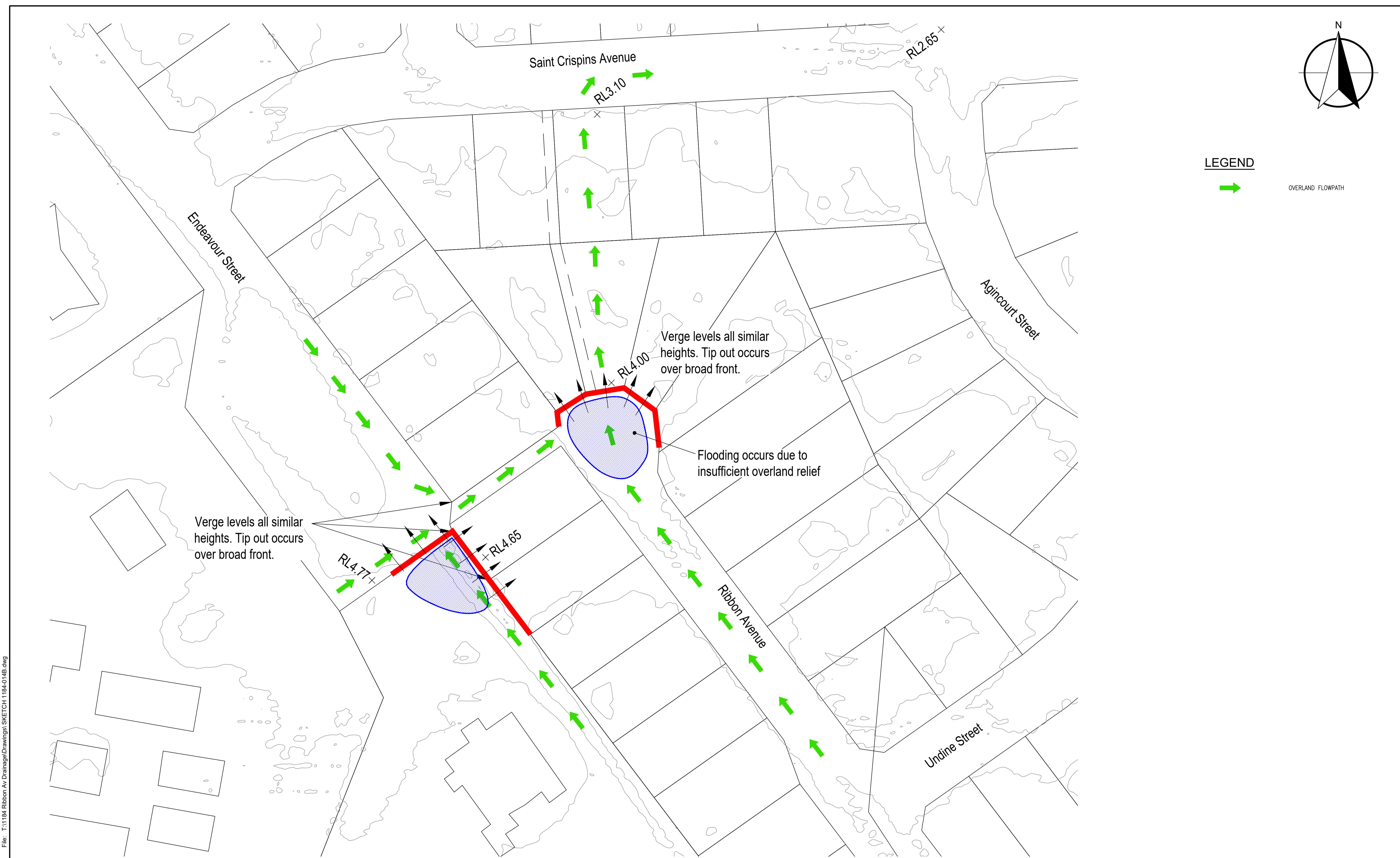
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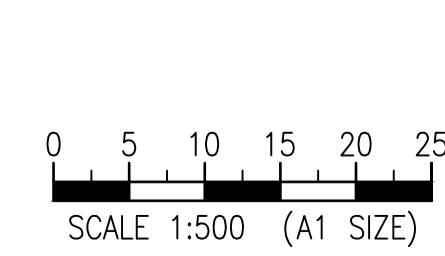
PRELIMINARY ONLY**DOUGLAS SHIRE COUNCIL****RIBBON AVENUE DRAINAGE INVESTIGATION****DRAINAGE SOLUTION - OPTION 4
Q10 STORMWATER LONGITUDINAL SECTIONS**

Client			
Project			
Title			
JOB No.	Scale (A1 size)	Date	Drawing No.
1184	AS SHOWN	10 APRIL 2018	SKETCH 1184-012
Revision			B



PRELIMINARY ONLY

DOUGLAS SHIRE COUNCIL			
RIBBON AVENUE DRAINAGE INVESTIGATION			
CURRENT FLOODING OBSERVATIONS			
Client	Project	Title	Revision
JOB No.	Scale (A1 size)	Date	Drawing No.
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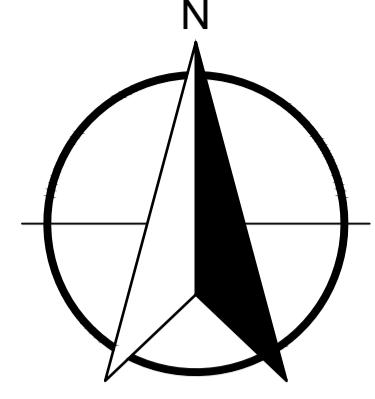
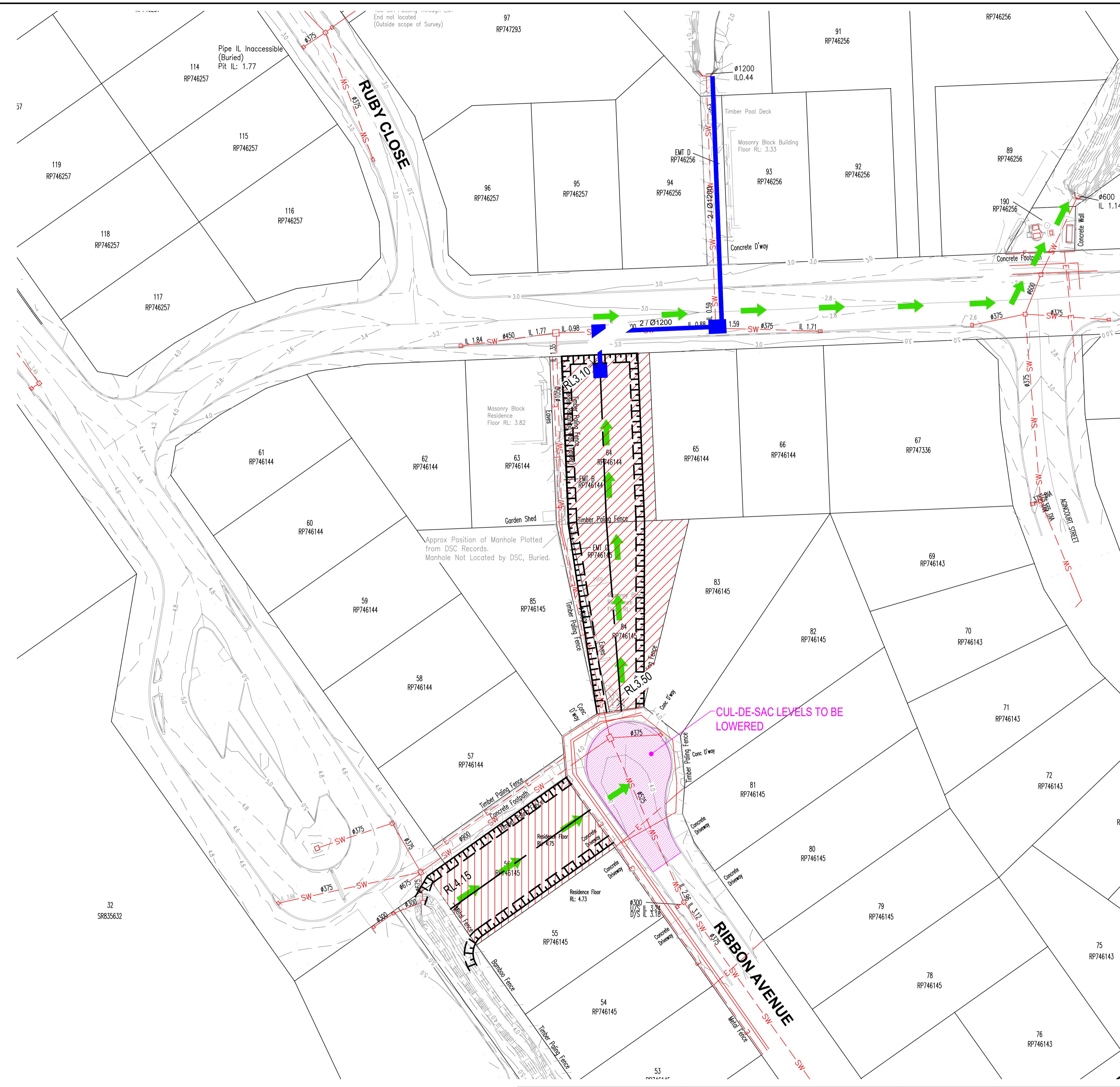


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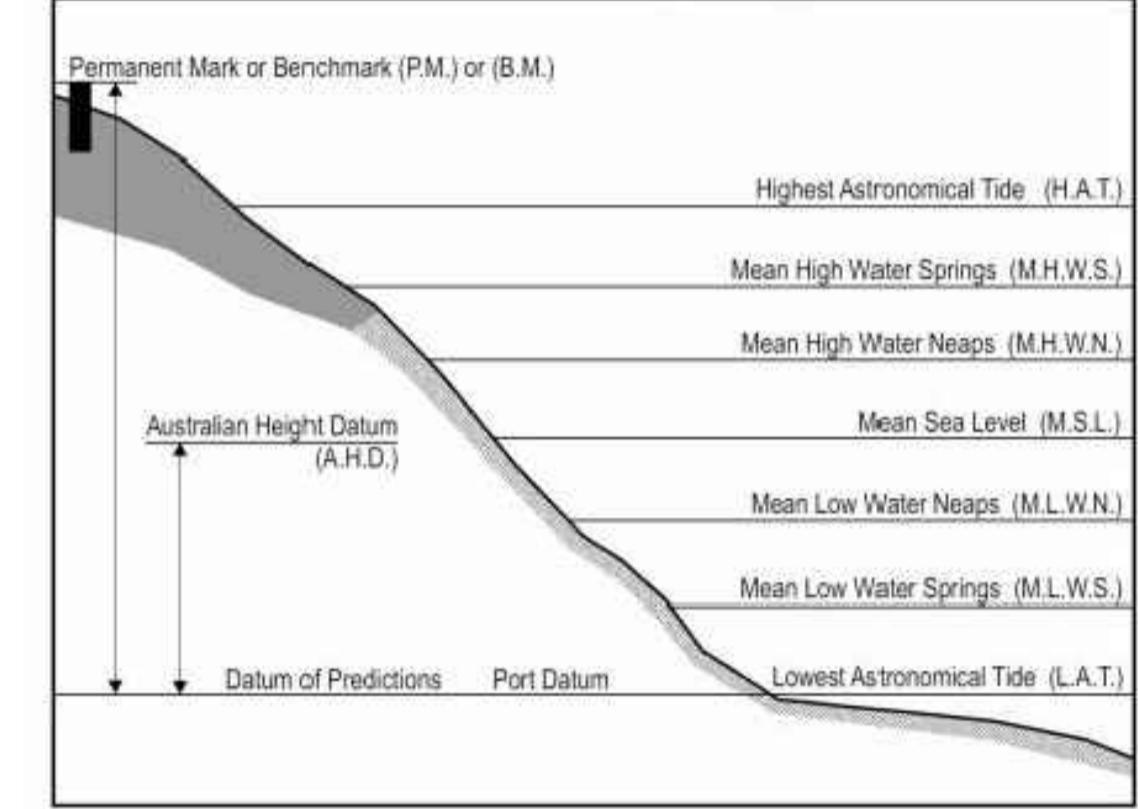
LEGEND

OVERLAND FLOW DIRECTION

RESUMPTION

PIPE SYSTEM

Guide to Semidiurnal Tidal Planes



BARRAGE HEIGHT	1.025m
H.A.T	1.779m
M.H.W.S	0.909m
M.H.W.N.	0.249m
M.S.L	0.019m
M.L.W.N	-0.211m
M.S.L	-0.881m
M.S.L	-1.581m

SECTION

TYPICAL OVERLAND FLOWPATH

SCALE 1:100

PRELIMINARY ONLY





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DOUGLAS SHIRE COUNCIL

RIBBON AVENUE DRAINAGE INVESTIGATION

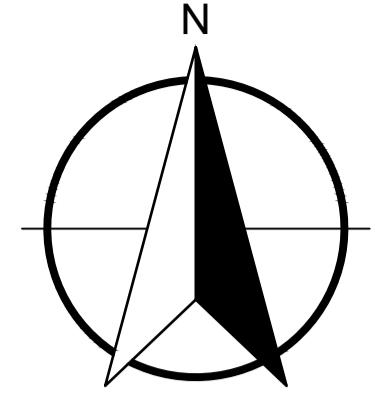
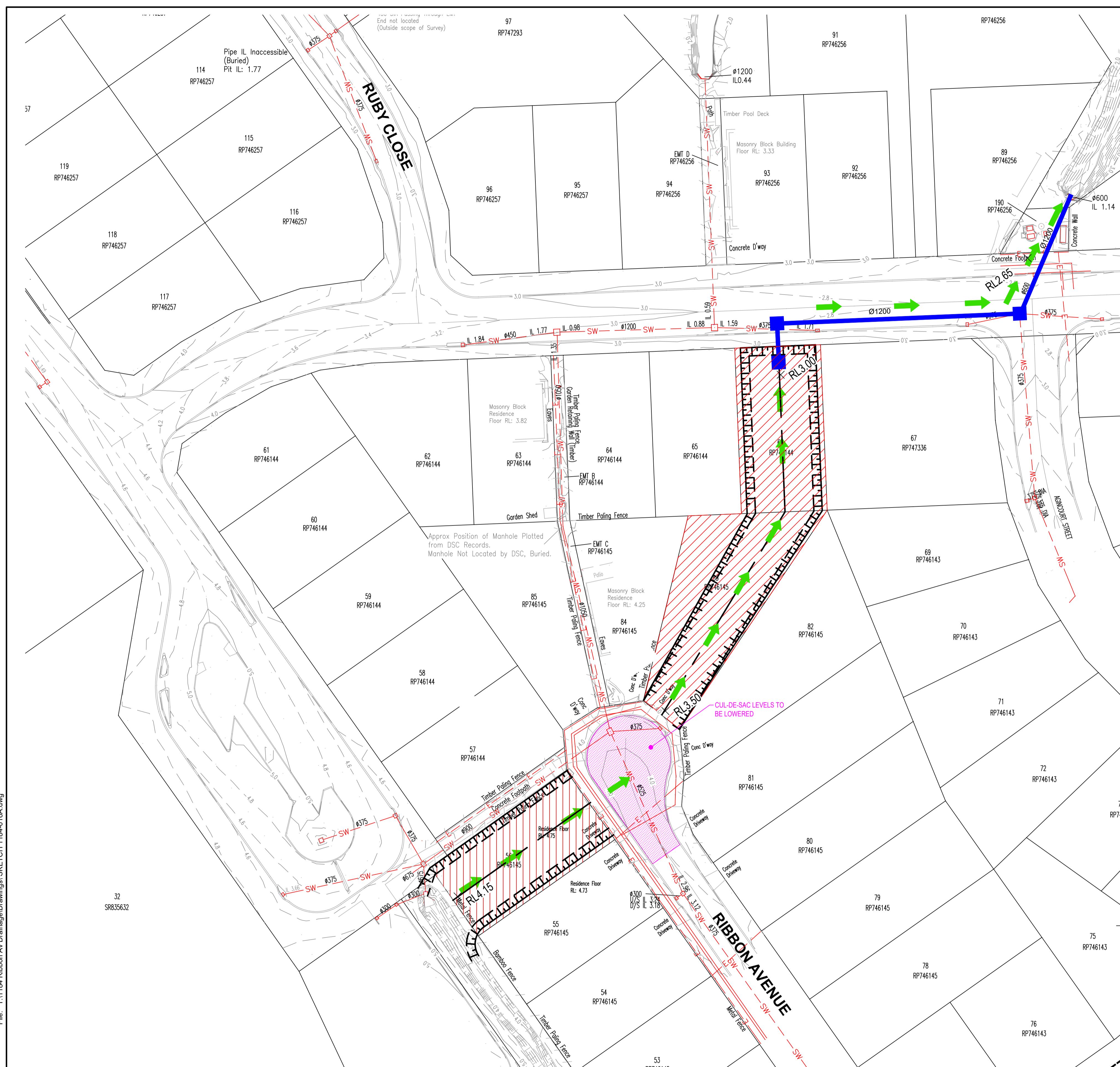
DRAINAGE SOLUTION - OPTION 7A

UMPTION OF LOTS 56&84 ON RP746145 & LOT 64 ON RP746144

בְּנֵי יִשְׂרָאֵל וְבְנֵי עֲמָקָם

Printed: 17 April 2018, 2:41 PM

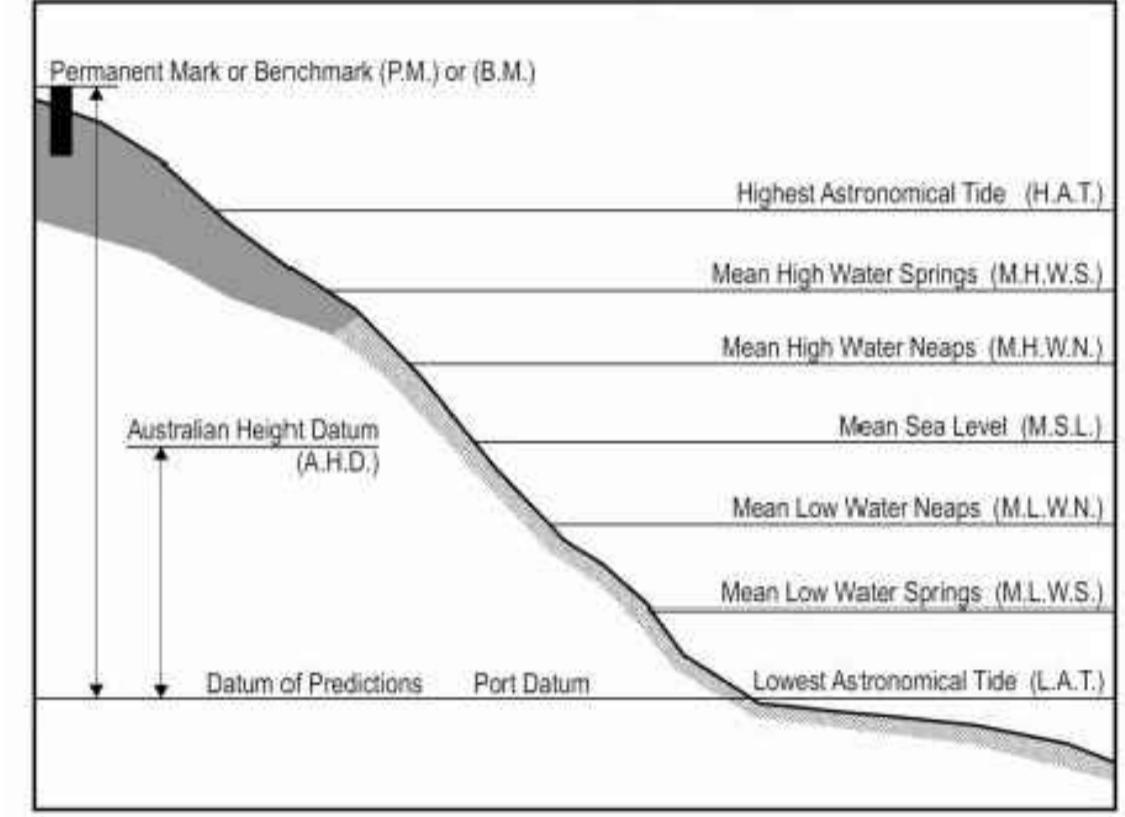
External References: TEC-TITLE-SKETCH-A1_a.dwg ; 1184-X-SURVEY.dwg



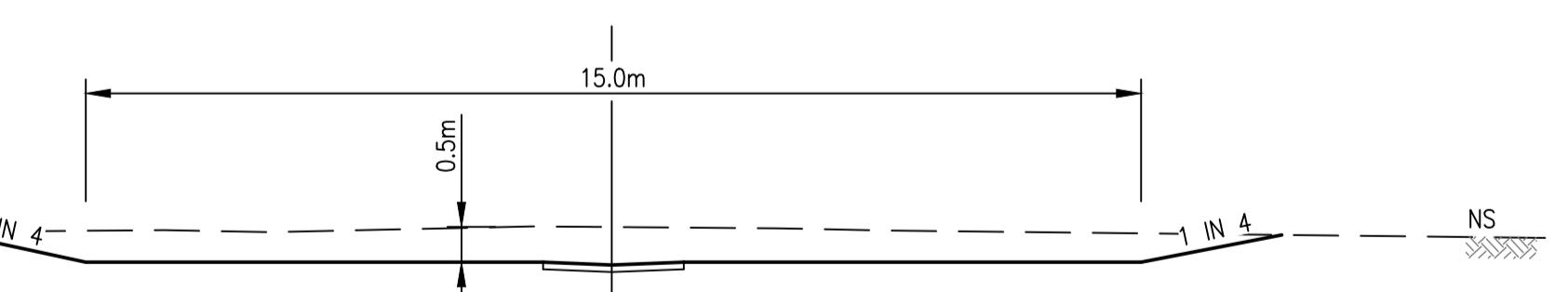
LEGEND

- OVERLAND FLOW DIRECTION
- RESUMPTION
- PIPE SYSTEM

Guide to Semidiurnal Tidal Planes



BARRAGE HEIGHT	1.025m
H.A.T	1.779m
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M.S.L	0.019m
M.L.W.N	-0.211m
M.S.L	-0.881m
M.S.L	-1.581m



SECTION

TYPICAL OVERLAND FLOWPATH

SCALE 1:100

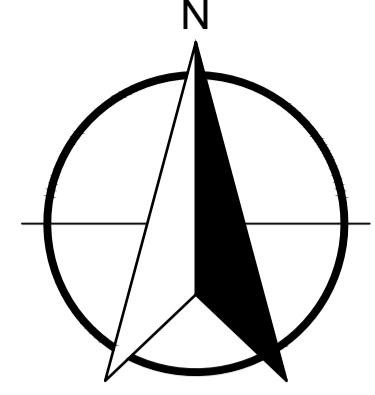
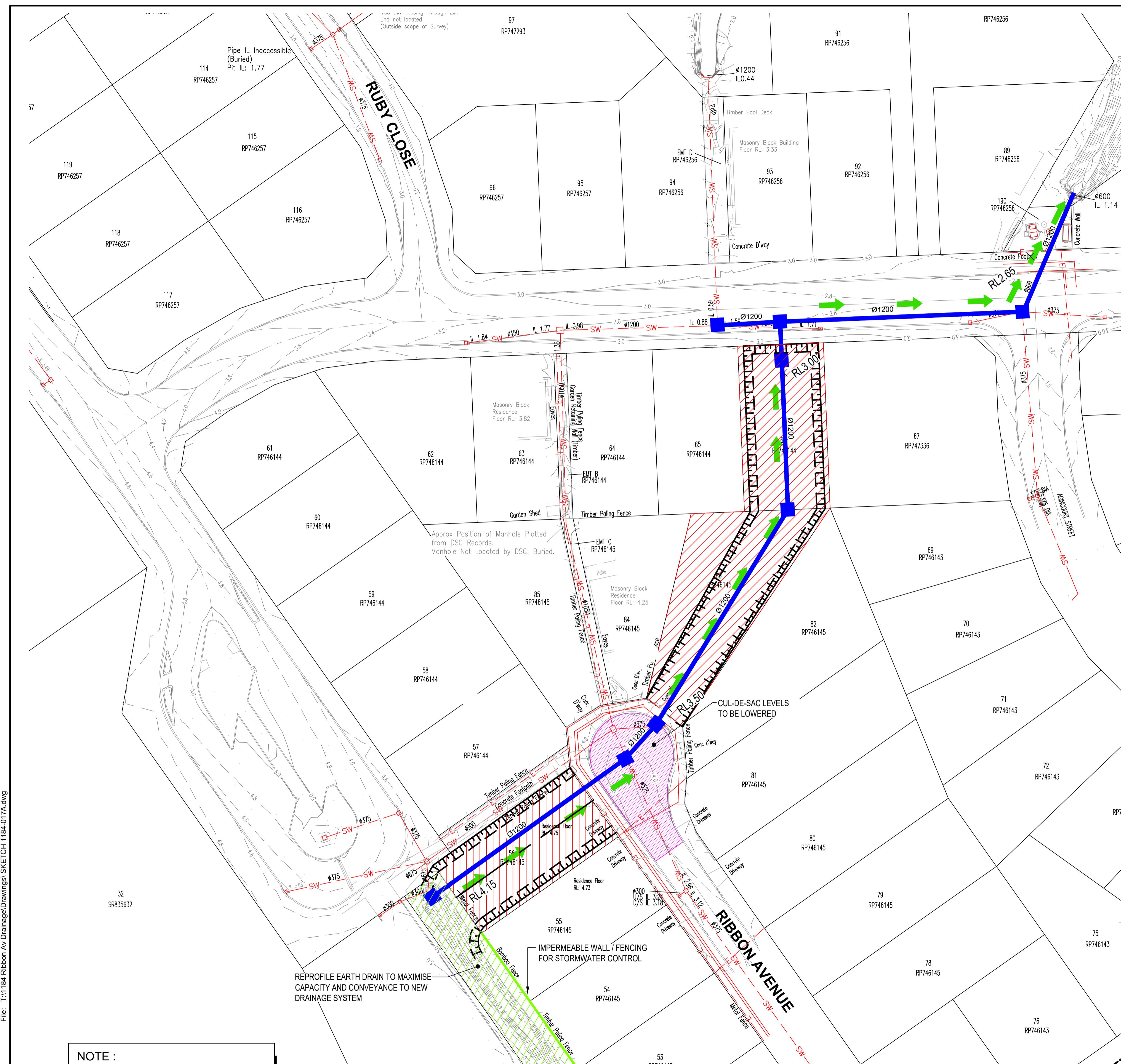
PRELIMINARY ONLY

0 5 10 15 20 25m
SCALE 1:500 (A1 SIZE)

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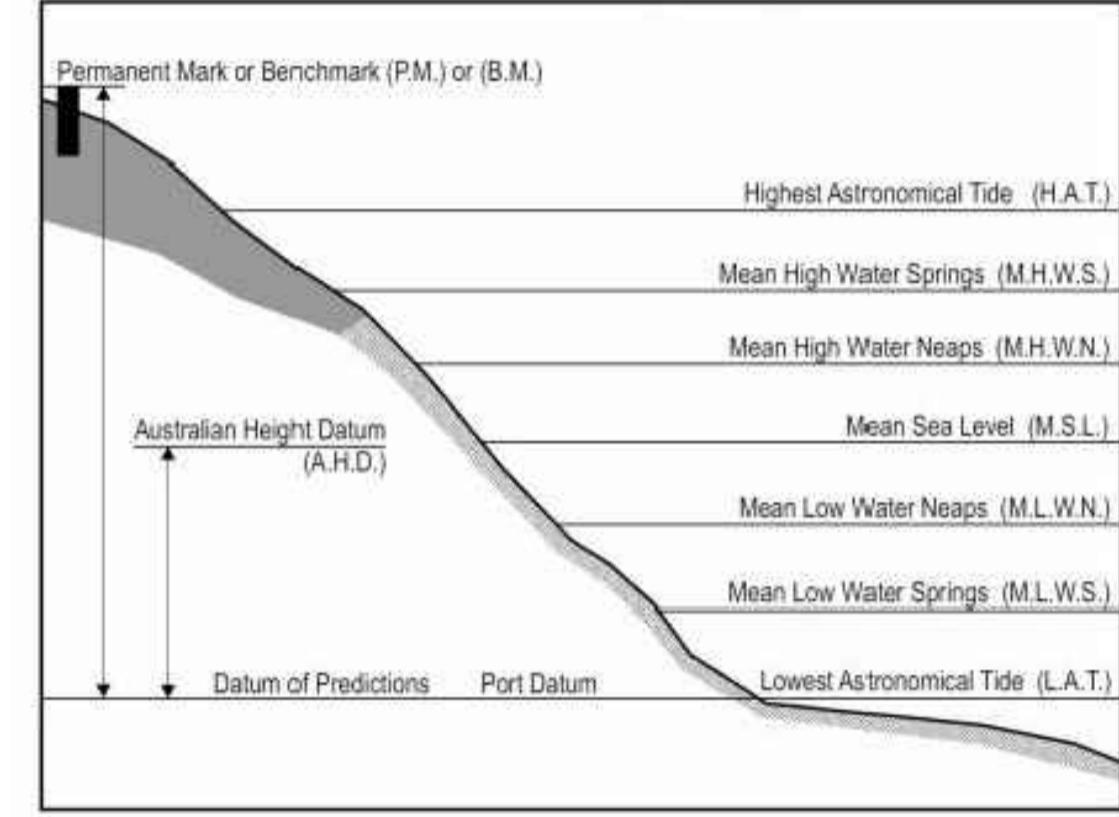
Client	DOUGLAS SHIRE COUNCIL		
Project	RIBBON AVENUE DRAINAGE INVESTIGATION		
Title	DRAINAGE SOLUTION - OPTION 7B		
RESUMPTION OF LOT 56&83 ON RP746145 & LOT 66 ON RP746144			
JOB No.	Scale (A1 size)	Date	Drawing No.
1184	1:500	17 APRIL 2018	SKETCH 1184-016 A



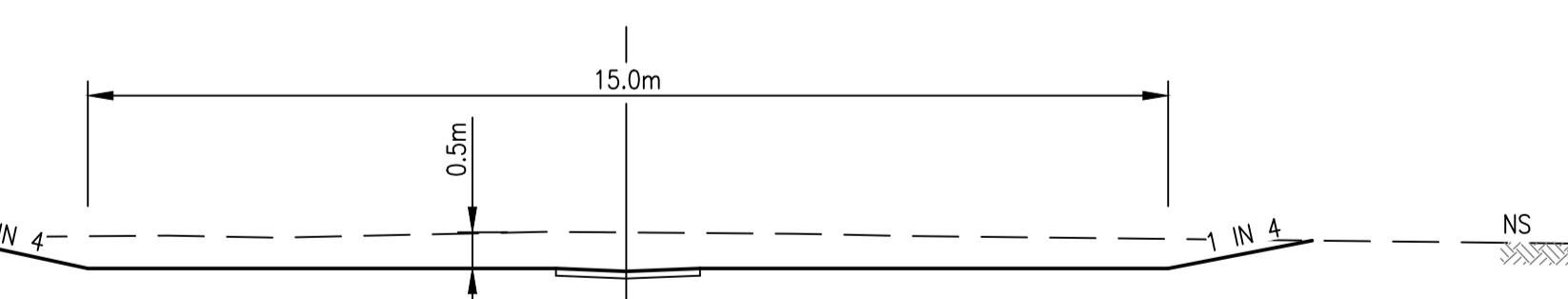
LEGEND

- OVERLAND FLOW DIRECTION
- RESUMPTION
- PIPE SYSTEM

Guide to Semidiurnal Tidal Planes



BARRAGE HEIGHT	1.025m
H.A.T	1.779m
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M.S.L	-0.881m
M.S.L	-1.581m



SECTION

TYPICAL OVERLAND FLOWPATH

SCALE 1:100

PRELIMINARY ONLY

Client	DOUGLAS SHIRE COUNCIL		
Project	RIBBON AVENUE DRAINAGE INVESTIGATION		
Title	DRAINAGE SOLUTION - OPTION 8		
	RESUMPTION OF LOT 56&83 ON RP746145 & LOT 66 ON RP746144		
JOB No.	1184	Scale (A1 size)	1:500
Date	27 APRIL 2018	Drawing No.	SKETCH 1184-017 A

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