Southlands Remediation and Development Project

Environmental Assessment
Project Application (MP 06_0191)

Appendix G: Hydrology and Flooding

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1. Introduction

Orica and Goodman jointly propose to develop a high quality industrial estate land known as "Southlands" at Banksmeadow near Botany Bay. The land is located in the lower part of the water catchment of Springvale and Floodvale Drains (Figure 1). The proposal involves a 3 stage development of the Southlands site (Figure 2) and includes in Stage 2 delivery of a new site access road from Botany Road to McPherson Street along with enhanced drainage infrastructure to alleviate long term flooding issues within the general area.

The Southlands site has not previously been developed and therefore suffers with regard to infrastructure availability from being the last parcel of land to be developed in the area. From a flooding perspective, it is burdened with a range of undersized and under performing infrastructure assets.

The proposed development of the Southlands site incorporates a number of warehousing complexes, with some ancillary office area, access roads and carparks. As the proposal has the potential to impact on the drainage patterns in the area, a flood study was commissioned to model and assess a range of possible development options for the site and to then refine a suitable development plan. The clear objective of this work was to determine a development scenario for the site that does not create any adverse flooding impacts on adjoining lands.

Numerical modelling was used to estimate likely flood levels for a range of rainfall events and development plan options and results were assessed to determine the preferred option. Modelling has been undertaken independently of the operation and possible beneficial impacts of the Orica Groundwater Treatment Plant.

1.1 The Southlands Site

The 19 hectare Southlands site is bounded by McPherson Street on its southern boundary, the port railway line on the east and Floodvale Drain on the west. Springvale Drain runs through the site (Figure 1). These "drains" are likely to have been the remnants of previous water courses that have been enlarged over time to assist in draining this previously swampy area.

The Southlands property is the last remaining significant development site on McPherson Street and is the last major development site within its catchment. As a consequence of this, development of the Southlands property is burdened with addressing a flood regime that is a result of all previous development. The result of this is that the Southlands site, to some extent, currently operates as a defacto flood storage area during major flood events, providing flood storage for other developed sites in the catchment.

This report therefore provides a description of the catchment, its existing characteristics and important drainage lines, background flooding issues and previous investigations (Section 2), details of the hydrology modelling (Section 3), hydraulics modelling (Section 4) with discussion of results and recommendations included at Sections 5 and 6.

1.2 Proposed development

The proposed development envisaged for the Southlands site has been determined in association with a team of consultants and the joint proponents. The review of flood issues at the site has been a significant part of this process. The final proposal includes construction of a number of warehouses, ancillary office space, access roads and detention basins as set out in the development plans contained in the Environmental Assessment prepared by URS consultants. The area of the proposed development will occupy flood prone areas of the present site and hence the flood study is required to demonstrate that the design does not have an adverse flooding impact on properties upstream or down stream of the site. In addition, capping of the topsoil will provide additional assurances with respect to encountering residual soil contaminants such as asbestos. Further details are provided in the Remedial

Action Plan (RAP). The high water table and contaminated groundwater also constrain possible regrading of the site.

The proposed development is to be advanced to the Minister for Planning seeking Project Approval under Part 3A of the Environmental Planning and Assessment Act, 1979. The Part 3A Application proposes a redevelopment of the site on a Staged basis, as follows:

- Stage 1 – generally involving the western portion of the site generally between Floodvale and Springvale Drains and interim flood detention in the Stage 2 area;
- Stage 2 – generally involving the south eastern portion of the site, link road and drainage downstream; and
- Stage 3 – generally involving the north eastern portion of the site.

The current Project Application will seek Approval for Stages 1 and 2 of the Project whilst Stage 3 will be the subject of a later approval.

As part of the Application process, Director General's Requirements (DGR's) have been sought on issues to be covered in the Environmental Assessment. The DGR's did not note any specific hydrology and flooding issues but it has been determined by the Proponents that this issue needs to be fully reviewed in respect of the new development. Therefore this report provides an overview of flood issues for the entire site (Stages 1 – 3) and more detailed analysis of flooding issues and mitigation measures to be undertaken in Stages 1 and 2 (the subject of the current application).

Furthermore, detailed investigations will be required on the Stage 2 works prior to a Construction Certificate for that stage of works, however a workable drainage solution is demonstrated in this report.

Future development of the Stage 3 area will be the subject of a future Project Application based on the flooding parameters set out in this report.

This report thus focuses on the flood mitigation issues for the Stages 1 and 2 of the Development.

1.3 Options

Stage 2 of the development involves the introduction of new drainage infrastructure in tandem with the new link road (from Botany Road to McPherson Street) allowing a significant improvement for the drainage of Springvale and Floodvale catchments. However as the new road is not proposed until Stage 2 of the Project, detailed consideration has been given to the options and alternatives for developing the Stage 1 area of the site that will not cause any significant impact on surrounding properties.

A number of options for the proposed Stage 1 development were considered during preliminary design assessment to determine the best approach to developing the site from a flood mitigation perspective. Flood model results for each option were compared with the model results for the existing system to assess the potential impact on flood levels both within the site and in the adjacent properties. The preferred option was then selected as the option that resulted in minimal flood impact within the site and that satisfied the requirement of no adverse flood impacts off the site. This option involves development of the Stage 1 area, limited site regrading works to create interim flood storage in the Stage 2 area on the eastern part of the site with an overflow pathway through the existing Stage 3 area across Nant Street, north of the proposed culvert on Springvale Drain. Flood model results discussed in the following sections focus on this preferred Stage 1 option.

The Stage 2 development will alleviate flooding both on the site and downstream by implementing works to enlarge the currently undersized culverts and channel that impede flow in Springvale Drain. A preliminary hydraulic assessment sizing the culverts and channel section is provided in Section 4.5.

2. Background

2.1 NSW Floodplain Management Manual

The State Government's Flood Policy is directed at providing solutions to existing flooding problems in developed areas and ensuring that new developments are compatible with the flood hazard and do not create additional flooding problems in other areas. Under the Flood Policy the management of flood prone land remains the responsibility of local government with the State Government subsidising flood mitigation works and measures to alleviate existing problems and providing specialist technical support to assist councils to discharge their floodplain management responsibilities.

The NSW Government's Floodplain Development Manual (2005) has been prepared to assist Councils in formulating management plans through the Floodplain Risk Management Process as outlined in Section 2 of the Manual. Appendix C of the Manual outlines the application of the Process as given below:

1. Floodplain Risk Management Committee
2. Data Collection
3. Flood Study
4. Floodplain Risk Management Study
5. Floodplain Risk Management Plan
6. Plan Implementation
7. Review of Plan

The Manual provides a set of guidelines for assessing flooding issues and potential risks associated with proposed developments. While a floodplain risk management plan has not been prepared for the Springvale and Floodvale catchments, the manual notes that development proponents are required to conduct a flood study to define the nature and extent of the flood problem and describe how defined objectives are to be achieved. This investigation is aimed at providing information to inform the decision making process in the absence of a Floodplain Risk Management Study or Plan.

2.2 History of flooding in Springvale/Floodvale Drains

There are limited records of flooding from the Floodvale and Springvale Drains. Sinclair Knight Mertz (SKM) (1992) indicate flooding in Holloway Street and Spring Street as well as flooding throughout the industrial areas while anecdotal information from other sources (cf Botany Bay Council) indicates that flooding remains a wider issue in the catchment. The flooding of industrial areas due to overflow of the open channel sections of Floodvale and Springvale Drains has been significant with reports of inundation over 0.3 m.

2.3 Botany Catchment Management Study (SKM 1992)

A catchment management plan was prepared by Botany Council (Sinclair Knight Merz, 1992) which identified the characteristics of the catchment and the flooding that occurs within the catchment. SKM (1992) identified serious potential flooding of a small number of industrial properties due to overflow from the open channel reaches of both Floodvale and Springvale Drains.

The following key issues and background information were outlined in the SKM report and were recommended to Botany Bay City Council in 1992 as issues that were required to address flooding in the catchment. It is not known if the document was adopted by Council although it is noted that few of the recommendations have been implemented.

2.3.1 Analysis of Existing System (SKM 1992)

Hydraulic modelling was undertaken by SKM (1992) to assess the hydraulic performance of the trunk drainage system. The model was calibrated to the most recently documented event at that time

(February 1990) and was then run for design storm events with average recurrence intervals (ARIs) of 5, 20 and 100 years.

The model results indicate that for the design events the piped reaches surcharge and that overland flow will occur.

The report identified that extensive flooding of industrial areas adjacent to the open channel reaches of the trunk drains would occur in major events. The report estimated that Floodvale Drain and a portion of McPherson Street will overflow to a depth of about 0.8 m in the 5 year ARI event and 1.1 m in the 100 year ARI event. At Springvale Drain, McPherson Street will be overtopped by depths of up to 0.5m.

The report identified large remaining undeveloped industrial sites including the Southlands site and some other areas that have been developed more recently. It was noted that further development within these floodplain sites, in the absence of any drainage amelioration measures, would result in the peak downstream discharges in Floodvale Drain increasing in the order of 10% and peak flood levels increasing by up to 0.1m. Peak discharges in Springvale Drain would increase by up to 25% and peak flood levels would increase by up to 0.2 m.

2.3.2 Proposed Trunk Drainage Improvement Scheme (SKM 1992)

To alleviate flooding problems in the lower reaches of Floodvale and Springvale Drains various options were considered by SKM (1992) and are summarised below. The options largely involved provision of increased channel and culvert capacity for both trunk drains, together with construction of detention basins.

The options included detention basins within the Southlands property and downstream culvert upgrading as follows:

Floodvale Drain

- Construct an additional culvert from Botany Road to Foreshore Road (2.1 m by 1.8 m box culvert)
- Regrade and widen the earth channel downstream of McPherson Street (and new box culvert at McPherson Street)
- Construct detention basin (2 options identified)

Springvale Drain

- Construct new two cell box culvert at Port Botany crossing
- Improve each channel from Sydenham-Botany Railway to SWSOOS No 2
- Construct detention basin (2 options identified)

The SKM report indicated that land acquisition would be required for the construction of the detention basins and the culvert upgrading would require approval of a number of statutory bodies (RTA, NSW Maritime Authority). None of the above works has been completed and, consequently, flooding remains an issue for the existing system and future development within the catchment. No requests for land acquisition for such detention basins have been received by Orica.

In relation to stormwater quality, SKM 1992 noted that, since the catchment of Floodvale and Springvale Drains is highly developed with a large industrial component, the most suitable control options would involve source reduction measures. It was noted that measures that require large surface areas such as wetlands are highly unlikely to be economically feasible in this catchment.

SKM 1992 suggested the most appropriate management program to satisfy future requirements with respect to stormwater quality may include the following elements:

- Sediment controls during the construction stage of developments and vegetation of exposed surfaces.

- Source reduction measures such as on-site infiltration, porous pavements, etc to take advantage of the sandy soils in the catchment (subject to no adverse impacts on groundwater quality).
- Measures to intercept polluted runoff from industrial areas.
- Structures such as trash racks or gross pollutant traps to remove trash and coarse sediment, which might be implemented in conjunction with flood mitigation works such as detention basins (subject to no adverse impacts on flooding).

These issues are considered in this report where relevant.

2.4 Proposed Port Botany Expansion - Hydrologic and Hydraulic Studies (Lawson and Treloar, 2003)

Potential flooding issues associated with the proposed Port Botany expansion of the Brotherson Dock area at the downstream end of Floodvale and Springvale drains was investigated by Lawson and Treloar (1999). The modelling undertaken as part of this investigation has been used to inform the present investigations.

The Expansion of Container Port Facilities in Botany Bay involves the proposed expansion of the existing Brotherson Dock near Penhryn Estuary. Floodvale and Springvale drains discharge into this area and there is potential for ocean backwater effects to increase flood levels in the lower reaches of the drains. A flood study of the area was carried out by Lawson and Treloar (2003) to assess the hydraulic impacts of the proposed Port Botany Expansion. Lawson and Treloar applied the RAFTS catchment runoff model to estimate the likely flood levels associated with extreme rainfall events including the 5%, 2% and 1% Annual Exceedance Probability (AEP) events. They found the critical storm duration for Springvale Drain of 2 hours and the peak flow at the catchment outlet for the 1% AEP event of $34.4 m^3 s^{-1}$.

The SOBEK hydraulic model results indicated that upstream flooding would not worsen as a result of the Port Botany development. The RAFTS model layout developed by Lawson and Treloar (2003) was used for the present study as it provided a consistent approach for the flood modelling. This model was modified near the Southlands site to facilitate modelling effects of the proposed development.

3. Hydrology model

3.1 Overview of drainage system

Floodvale and Springvale Drains form the trunk drainage system for a catchment area of 319 ha, including residential, industrial and open space areas to the north of the site (Figure 3). The drains are comprised predominantly of pipe sections in the upper reaches and of open channel sections with culverts under bridges (refer Appendix B for photographs) in the lower southern reaches through the industrial area. The combined total length of the drains is 6.8 km, with 4.6 km of closed conduit and 2.2 km of open channel. Both drains discharge to Botany Bay through land controlled by NSW Maritime Authority.

During large flood events Springvale and Floodvale drains become hydraulically connected both across the Southlands site and upstream. Both drains share the same tailwater conditions in Botany Bay.

Stormwater runoff in the catchment is conveyed through local drainage networks to Floodvale and Springvale Drains that form the trunk drainage systems for the catchment. The two trunk drains flow in a generally north to south direction and discharge to Botany Bay. The local drainage includes either street drains under the control of Botany Bay Council and private or Crown drains through the large industrial areas.

3.2 Land use

The northern part of the catchment contains mainly residential land use, with some large open space areas such as Jellicoe Park, Mutch Park and part of Bonnie Doon Golf Course. The southern part of the catchment is mainly zoned industrial and contains various large and small scale developments, food processing plants, chemical industries, container areas, and light industry. Botany Golf Course, located between Botany Road and Foreshore Road, is the only significant area zoned as open space in the south.

At present, the residential area is almost fully developed and there is limited scope for further development that could have a significant impact on runoff rates. In the industrial zoned area, development of industrial lands covers a significant part of the lower catchment with various densities and site coverage. Vacant land, such as the Southlands site, have acted as defacto flood storage areas for overflows from the trunk drains in the past, despite the fact that it is zoned for industrial development under the Botany Bay Local Environmental Plan.

3.3 Floodvale Drain

Floodvale Drain commences as a DN375mm pipe drain at Bay Street, in the Botany East residential area. The initial section of drain is largely through private property, crossing Banksia Street, Holloway Street and Gibson Street to Page Street. The drain then follows the road reserves of Page Street and Dudley Street, crosses Spring Street through private property to Ocean Street and Anderson Street.

The drain continues as a closed conduit through major industrial areas with a crossing under the Sydenham-Botany Railway. The drain changes to an earth channel section south of the railway that continues to Botany Road, apart from a small length of closed conduit. There is a three cell box culvert at McPherson Street, and the drain flows under the South Western Sydney Ocean Outfall Sewer (SWSOOS No 2) through an inverted syphon. These drains are presently heavily blocked with silt and debris.

Floodvale Drain reverts to a closed conduit from Botany Road, under Botany Golf Course and Foreshore Drive to the outfall to Botany Bay. This conduit commences as a DN1800mm diameter pipe and transitions to a 2.75 m by 1.9 m box culvert at Foreshore Drive. The total length of Floodvale Drain is 2.9 km, with about 2.1 km of closed conduit and 0.8 km of open channel.

3.4 Springvale Drain

Springvale Drain commences as a DN300mm diameter pipe drain at Wark Avenue in the Pagewood residential area. The initial length of drain traverses through a local park to Murray Road and then along Park Parade, Banks Avenue and Heffron Road.

The drain continues as a pipe section south from Heffron Road through Mutch Park to Wentworth Avenue, and then along Baker Street to Moore Street. The drain then diverts to the east through an industrial area, partly as pipe section and partly as open channel, before returning to the Baker Street road reserve as a 1075mm diameter pipe.

Springvale Drain changes to an earth channel section through the Botany Industrial Park complex south of Anderson Street. There are a total of six road crossings, involving either box culverts or pipe culverts between Anderson Street and the Sydenham-Botany Railway. There are also some elevated pipe and footway crossings of the channel.

The drain flows under the Sydenham-Botany Railway and Council's maintenance track to the south through 900 mm diameter pipe culverts. The channel section in this area is poorly formed and is heavily overgrown. Springvale Drain continues as an open channel due south to McPherson Street where there is a three cell box culvert. Between McPherson Street and the SWSOOS No 2, there is a private road crossing by means of two pipe culverts. The drain flows under SWSOOS No 2 through an inverted syphon. This is also heavily blocked with silt and debris.

The drain is in the form of a two cell box culvert from SWSOOS No 2 through the Discovery Cove development and under Botany Road, then in the form of a rectangular concrete channel to Penrhyn Road, where there is a three cell box culvert. The formal drain construction terminates at the downstream side of Penrhyn Road. The total length of Springvale Drain to this location is about 3.9 km, comprised of 2.5 km of closed conduit and 1.4 km of open channel.

From the outfall at Penrhyn Road there is an open channel of about 200m length to the Penrhyn Estuary of Botany Bay. The land downstream of Penrhyn Road is under the control of NSW Maritime Authority.

3.5 Input data

Information on Floodvale and Springvale Drains was obtained principally from a field survey executed by AAMHatch Pty Ltd, consulting surveyors, prior to the commencement of this study. The survey results were supplemented by a walkover of the drains, information from Council officers, and discussions with major property owners along the drain alignments.

The following attributes were considered in the hydrological analysis of the catchments:

- Sub-catchment characteristics (such as area, slope, overland flow path length)
- Rainfall intensity-frequency-duration (IFD) relationships for the local area
- Land use (pervious and impervious areas), and
- Validation of the hydrologic model and critical flow duration estimation.

Topographic data available includes aerial photographs of eastern Sydney (Nos 179 and 181, Land and Property Information NSW, 2000) and Botany Bay (BPDPOO5A, Sydney Ports Corporation, 2000), the 1:2000 and 1:4000. orthophoto maps (LIC) and the Geological Series Sheet No 9130 (NSW Department of Mineral Resources, 1983). A 5m grid DEM was purchased from the NSW Department of Lands (u1837psdmga56) and utilised for digital confirmation of catchment sizes and levels.

Information on existing drains, (e.g. location, type, and size), for Springvale Drain, Floodvale Drain and the Foreshore Beach drains is available in Willing and Partners (1999), Sinclair Knight and Partners (1992), Sinclair Knight Merz (1996) and Water Research Laboratory (1990).

The average annual rainfall in this area is approximately 1100 mm and the highest rainfall usually occurs in the February — June period (Willing and Partners, 1999). Since the sizes of these catchments are reasonably small, the spatial rainfall distribution is likely to be relatively uniform. Therefore, for both historic and design flood events a uniform rainfall intensity was applied over the whole catchment. No rainfall area reduction factors were applied to the catchment.

3.6 Results

Hydrological conditions have been analysed using the RAFTS 6.5 software package. The model for the Southlands site was adopted from the existing RAFTS models of Springvale and Floodvale drains, prepared previously by Lawson and Treloar (May 2003) and detailed in Appendix I of the Port Botany Expansion Environmental Impact Statement (Volume 4). The Lawson and Treloar model was modified to incorporate more detail in the proposed Southlands development area to accommodate assessment of the impacts on the drainage. The revised sub-catchments include an increase in the area of impervious surface from 0% in the existing situation to 80% in the developed situation. Detention basins were also included to ensure no net increase in the site discharge.

The RAFTS model was run with the same assumptions and input values as used previously by Lawson and Treloar (2003). These values appear appropriate for the catchment, and have been tested by various validation methods outlined in Lawson and Treloar (2003). Use of the same values also allows the results from the two studies to be compared. The model assumptions and input parameter values are outlined in table 3.1.

According to previous studies (WRL, 1990, SKP, 1992 and SMEC, 1992), there are times when no surface runoff may occur from pervious areas if the duration of the storm event is short.

Table 3.1 RAFTS model assumptions and input parameters.

Parameter	Value	Comment
Pervious Surface – Initial Loss	50 mm	This value is higher than many other catchments due to the high hydraulic conductivity of the local botany sands. Using a higher pervious surface loss is conservative in that it will lead to larger detention basins in the proposed development when highly pervious areas are paved.
Pervious Surface – Continuing Loss	15 mm/hr	As above
Pervious Surface – Mannings n	0.025	This is a conservative (with reference to hydrology rather than hydraulics) value, associated with short grass. It is considered appropriate as most pervious areas within the catchments are of an urban nature, being golf courses, gravel roads or grassed areas.
Impervious Surface – Initial Loss	1 mm	Typical of paved areas
Impervious Surface – Continuing Loss	1 mm/hr	Typical of paved areas
Impervious Surface – Mannings n	0.010	This is a conservative (with reference to hydrology rather than hydraulics) value, associated with a piped stormwater system that can convey flows rapidly through the catchment.

The RAFTS model was run for a range of input rainfall events including average return intervals (ARIs) of 1, 2, 10, 20, 50 and 100 years and durations of 15, 20, 45 minutes, 1, 1.5, 2, 3, 6, 9 and 12 hours. The resultant hydrographs are included in Appendix C – RAFTS Hydrological Model Results. Critical durations were assessed from these hydrographs for the 1.5 hour duration events and the storms adopted for hydraulic analysis are shown in Table 3.2. Generally the critical storm for Floodvale drain is a 60 minute event, and the critical storm for Springvale drain is the 90 minute event. However, to simplify analysis and to account for the fact that the volume of water in a 90 minute storm is greater than that of a 60 minute storm, 90 minute duration storms have been adopted for both drains. The difference in peak flows resulting from this assumption is outlined in Table 3.2 below and is considered negligible.

Table 3.2: Peak Flow Values from RAFTS analysis

	Actual RAFTS Results		Adopted RAFTS Results		
	Critical Duration (min)	Peak Flow (m^3/s)	Critical Duration (min)	Peak Flow (m^3/s)	% difference
Floodvale Drain					
1 year	30	8.5	90	8.1	4.11
2 year	60	10.9	90	10.8	0.95
10 year	60	16.9	90	16.7	1.35
20 year	60	19.9	90	19.6	1.39
50 year	60	22.9	90	22.5	1.87
100 year	60	25.9	90	25.5	1.41
Springvale Drain					
1 year	90	10.3	90	10.3	
2 year	90	14.0	90	14.0	
10 year	90	23.9	90	23.9	
20 year	90	29.0	90	29.0	
50 year	90	34.1	90	34.1	
100 year	60	39.3	90	39.3	0.09

Note: The peak flow values presented in this table are taken at the Southlands property boundary at the upstream end of Springvale and Floodvale Drains.

4. Hydraulic modelling

Flooding in the Springvale and Floodvale Drains catchment is a result of the complex interaction of runoff from key storm events coupled with flat terrain, significant development for industrial purposes in the catchment and undersized drainage infrastructure. Development of the Southlands site is further complicated by the relatively high groundwater table (Figure 4) and groundwater contamination under the site, reducing opportunities for extensive site grading works to increase storage capacity and thereby accommodate major flood events. Consequently, numerous development options were reviewed but only the preferred hydraulic options are presented as part of this Project Application.

It is assumed that the existing drains and other structures are clean and function as they were originally designed.

The broad Stages of works in each Stage are therefore proposed as follows:

- Stage 1 - Develop the Stage 1 area for industrial uses and provide interim floodplain storage in the future Stage 2 area (with minor site regrading) and overland flow across the Stage 3 area;
- Stage 2 - Develop the Stage 2 area following construction of the proposed Link Road and enhancements to the Springvale Drain culverts and channel within and downstream of the Southlands site; and
- Stage 3 – (Subject to a future Project Application) - The eventual filling of the total site including Stages 1, 2 and 3 following future assessment of the groundwater contamination issues under the Stage 3 area. Stage 3 filling works will however benefit from the new drainage infrastructure constructed during Stage 2.

The hydraulic assessment of flooding utilised the MIKE 11 hydraulic model to simulate the existing system and proposed Stage 1 development. Hydraulic analysis of the Stage 2 development works used standard analytic equations to provide a preliminary sizing of culverts and drains downstream of the site.

4.1 Description of existing scenario

MIKE 11 (2007) is a one-dimensional hydraulic model, and was selected for its ability to run hydrodynamic simulations under conditions where the flow regime changes from sub to supercritical flow (especially through culverts and weirs, as these are the controlling hydraulic structures affecting stormwater drainage on the Southlands property).

A detailed survey of the Southlands site, including areas downstream of the site expected to act as hydraulic controls on the flow in the drains was carried out by AAMHatch Pty Ltd (2005). The detailed survey was converted to a Triangulated Irregular Network (TIN) surface model for use in the civil design and terrain-modelling package, 12D Model. “Existing” scenario cross section locations for the Mike11 model were then chosen based on the ground surface model and the proposed plans for the site (Figure 5). “Existing” scenario cross sections are presented in Appendix E.

An “Existing” case scenario was established in the model. The “Existing” scenario provided insight into the hydraulic nature of the site. Initial findings can be summarised as:

- Flood levels at the Southlands site are predominantly controlled by the top level of the South Western Sydney Ocean Outfall Sewer (SWSOOS). The SWSOOS runs from west to east, approximately halfway between Botany Road and McPherson Street. It consists of an approximately 3m wide x 2m high rectangular concrete structure (refer photo 5 in Appendix B) that crosses above both Springvale and Floodvale drains.
- The SWSOOS crossing of Floodvale drain creates a short siphon (approximately 10m along the direction of flow), where the drain flows under the concrete sewer. This appears to operate effectively during low flows, however in a 1% AEP event the siphon cannot accommodate the peak flows. The SWSOOS begins to act as a dam wall that is overtopped in the peak event. This results in a backwater effect, with the upstream water surface elevation determined by the

depth of flow over the top of the SWSOOS.

- The SWSOOS crossing of Springvale drain forms the upstream end of a long culvert section and siphon (approximately 200m along the direction of flow). The Discovery Cove Industrial Estate is located immediately downstream of the SWSOOS crossing and is built over Springvale drain. The drain conveys flows through a triple box culvert system under Discovery Cove. It has not been possible to locate work-as-executed drawings of the culverts, however a survey of the culvert entrance shows that each of the culverts appears to be 2.7m wide x 1.55m high. Data from SKM (1992) has also been utilised to build the model. The culverts are currently severely blocked, with sediment buildup that has been consolidated by vegetation growth in the sediment.

The model was then adjusted to incorporate appropriate drainage infrastructure (cleared of obstructions) to simulate the proposed Stage 1 development.

4.2 Summary of design options modelled

Development of the Southlands site is constrained by the flooding issues in the local catchment and a number of on-site issues associated with the contaminated soils and groundwater. The sensitivity of the site to inflows from the catchment and drainage constraints further downstream required careful consideration to find a solution that would satisfy the "no adverse flood impact offsite" criterion. Consequently, numerous development options for the site were investigated using the Mike 11 model. These options involved filling the Stage 1 area with various scenarios for utilising Stage 2 and/or Stage 3 areas for interim flood storage.

The possible creation of floodplain storage to offset the proposed filling within the floodplain in the Southlands site is limited by the following factors:

- Groundwater conditions (contamination and levels)
- Restriction of any cut earthworks in the northeastern portion of the site, due to the presence of DNAPL ((dense non-aqueous phase liquids). Orica has an obligation under the Notice of Cleanup Action (NCUA) to investigate and remediate these to the satisfaction of the NSW DECC.
- Onsite drainage

Site grading and drainage related development options that aimed to mitigate the flood issues within the above constraints were investigated and included:

- Option (1a) – fill Stage 1 area, and remove material from the Stage 2 area to allow its temporary use as floodplain storage.
- Option (1b) - fill Stages 1 and 2 areas and utilise Stage 3 area as floodplain storage
- Option (1c) – fill Stages 1 and 2 areas and partially fill Stage 3 area and provide online floodplain storage within other stages.
- Option (2a) – use Option (1c), but utilise an overland flow path at the south of the site to allow water to flow between Floodvale Drain and Springvale Drain.
- Option (2b) – use Option (1c) but utilise an overland flow path at the north side of the site to allow water to flow between Floodvale Drain and Springvale Drain.
- Option (3a) – widen Springvale drain to provide online storage in combination with cutting material from Stage 3 area.
- Option (3b) – widen Springvale drain at the north of the site to facilitate water flow between Springvale and Floodvale
- Option (4a) – increase the size of the Springvale Drain culverts downstream of the Southlands site
- Option (4b) – increase the size of the Floodvale Drain culverts downstream of the Southlands site.
- Option (4c) – a combination of 4(a) and 4(b).
- Option (5a) – use Option (1a) and utilise Stage 2 area as permanent floodplain storage.
- Option (5b) – use Option (1a) and utilise Stage 2 area as floodplain storage. Raise McPherson

Street to provide additional floodplain storage depth

- Option (5c) – use Option (1a) and utilise Stage 2 area as floodplain storage. Utilise the proposed visual screening bunding along the McPherson Street boundary of the site to provide additional floodplain storage depth.

Due to various constraints involved with the soil and groundwater contamination and the high water table, any significant cutting of the site for storage purposes was deemed impractical and hence excluded from further consideration.

Option (5c) was selected as the preferred option for the Stage 1 development as it satisfies the "no adverse offsite impact criterion"

4.3 Description of Proposed Scenario – Stage 1

A dynamic MIKE11 hydraulic model of the existing Floodvale and Springvale drains was constructed from cross sections extracted from the terrain model, as discussed in Section 4.1. A number of culverts, weirs and siphons were included in the model based on survey data to represent the flow constrictions present. An overflow channel was also added into the model to represent potential overland flows through the site from Springvale Drain to Floodvale Drain as identified from a site visit and confirmed by survey data (Figure 6 and Appendix B). Inflow hydrographs for 1,2,10,20,50 and 100 year Average Recurrence Interval (ARI) event generated in RAFTS (refer Section 3 and Appendix C) were input into the model at the upstream model boundaries of Floodvale and Springvale drains.

The proposed development incorporates filling of areas to the west of Springvale drain that currently provide flood storage and in order to compensate for this loss of flood storage the drainage design required careful consideration of the site geometry. The stage 2 floodplain storage area has been designed to accommodate the flood requirements for the development.

Bulk earth work drawings for the Stage 2 area have been reviewed by JBS Environmental Pty Ltd and compared to historic groundwater levels and considered in the RAP prepared by URS Australia (refer to the Southlands Remediation and Development Environmental Assessment).

For the purposes of this modelling the finished ground surface defined at least 300mm above the October 2004 groundwater levels.

Model runs for the existing system indicated a maximum flood level in Springvale drain of around 4.1m and that about 20,000 m^3 of water flooded over the proposed development area. The southeastern region of the site was identified as potential interim compensatory storage for the Stage 1 development pending development of Stage 2 when the enhancements to Springvale Drain downstream of the site are designed to accommodate reduced flood levels.

A potential storage volume curve for the basin east of Nant St was developed from the digital terrain model. At an elevation of 4.2m AHD some 28,000m^3 of storage is available in the south eastern section of the site. The hydraulic model was restructured to utilise this area and thereby offset the existing floodplain storage lost to the proposed Stage 1 development area.

The existing Stage 2 area comprises a number of mounds, ridges and holes that would be graded to produce a surface with finished ground levels. The Nant St access road has been incorporated as shown in Figure 6. The road is bounded by a vertical retaining wall along Springvale drain and a 1 in 5 batter to the west. The Stage 1 Nant Street crossing over Springvale Drain has been modelled as an 8m long culvert 5.5m wide by 2.0m high with an upstream invert of 2.5m AHD and a downstream invert of 2.45m AHD. A culvert design that has an equivalent rating curve could be used as an alternative to this design.

In other areas the internal access road is built on a 20% (1 in 5) embankment. The road has been designed to serve as an embankment wall for the detention basin, and as such has a minimum level of

4.50m AHD. The basin has a minimum longitudinal slope of 0.5% to allow free drainage. The basin extents do not impact on the easements to the east of Stage 2 area. The basin interface with existing levels has been achieved using a batter slope of 25% (1 in 4). Given the relatively large basin surface area, batter slopes do not have a significant influence on the stage-storage curve of the basin.

A 1.0m high visual-screening embankment is proposed along the McPherson Street boundary. Within the Stage 2 area this embankment also serves as the detention basin (or bund) embankment and as such is designed to a minimum level of 4.50m AHD.

The Stage 3 area would largely remain undeveloped as part of the Stage 1 works, with the exception of the filling of the "Paperwaste Ponds". The existing levels provide an overflow path between Springvale Drain and the interim Stage 2 flood detention area.

The proposed earthworks design was consequently developed to utilise the southeastern quadrant of the site as an interim floodplain storage area thus, the design incorporates the developed Stage 1 area in the western half, a large detention basin in the southeastern area (Stage 2) with the northeastern area (Stage 3) remaining in its existing state.

Terrain models of the proposed Stage 1 area were created, and flood model cross sections for the proposed system extracted to represent the developed ground surface (Figure 7). The new cross sections for the Stage 1 development are presented in Appendix F. The main channel is kept as existing, with the filling of the overbank areas resulting in a reduction in the storage area of the flood plain. This is offset by the grading of the Stage 2 area to form a detention basin.

Input hydrographs for the developed case were the same as the input hydrographs for the existing case, base on the assumption that additional runoff generated by the developed site will be detained/attenuated on site in accordance with the requirements of the construction certificate.
The impact of the proposed Stage 1 development was then assessed by running the MIKE11 model with the revised cross sections and comparing results with the existing terrain results for the same inflow events. The overflow channel between Springvale and Floodvale Drains through the Southlands site was removed from the Stage 1 model, as overflow will no longer be possible due to the filling of the site for the proposed development.

The modelled earthworks plan is shown in Figure 7.

4.4 Mike 11 Results – Stage 1

The 1% AEP flood depths for the existing and developed scenarios are shown in Figure 8 and Figure 9, respectively. Comparing these two figures indicates that flood depths and extents in areas surrounding the Southlands site remain unchanged. Within the site itself the distribution of flood depths

shifts from the proposed Stage 1 development area west of Springvale drain to the Stage 2 area east of the drain.

Maximum flood levels for the modelled existing and developed situations along Springvale and Floodvale Drains for the 1,2,10,20,50 and 100 year events are presented in Appendix D. Results for the 100 year return period events are shown in Figure 10 and Figure 11.

The long channel profiles presented in Figure 10 and Figure 11 indicate that flood levels in Floodvale drain remain unchanged while the Springvale results show the effect of the development within the Southlands site. Note the small effect immediately north of the site in Springvale drain (between chainage 230 and 280 m) has negligible impact on the adjacent property flood levels in the Mobil site as it is contained within the banks of Springvale Drain.

The MIKE 11 model assumes the water flow characteristics are well resolved by the representation of the actual drainage channels on site and the model equations that represent the hydraulics. Given the

survey accuracy (~100 mm), assumptions about the hydraulics and a range of contributing factors the absolute accuracy of the model results is likely to be approximately ±0.5m. This absolute accuracy is typical of flood models where limited data for calibration is available. Relative accuracy is likely to be in the order of several centimetres.

4.5 Description of Proposed Scenario – Stage 2

The Stage 2 development involves construction of the proposed link road joining McPherson Street to Botany Road. This new road requires appropriate drainage design facilitating the opportunity to redress the long term flooding issues in the general area. As discussed previously (SKM, 1992) the hydraulic controls within Springvale Drain at the SWSOOS crossing, bridges within the MCS site and at McPherson St are too small to support the design 1% AEP flood flow and hence the main cause of flooding in the area.

The proposed Stage 2 development aims to alleviate flooding by enlarging the culverts and channel dimensions to contain 1% AEP flood flows within the banks of the refurbished Springvale Drain within and downstream of the Southlands site. A plan view of the proposed Stage 2 Springvale Drain enhancement activities is shown in Figure 12.

The works would include the following:

- Enlarging the Stage 1 culverts under the new Stage 1 access road crossing of Springvale Drain
- New culverts under McPherson Street and the new roundabout;
- Additional culverts running in tandem with the new link road between McPherson Street and the SWSOOS;
- Additional siphon under the SWSOOS;
- New culverts in tandem with the new link road through Discovery Cove to the new intersection at Botany Road;
- A new road crossing for new culverts under Botany Road to connect with the existing open channel at the Caltex property that forms the effective entry to the Penrhyn Estuary (Botany Bay);

As discussed previously (SKM, 1992) the design of these upgrades would allow for detention, trash racks and gross pollutant traps.

The initial design is based on a hydraulic analysis of the Springvale Drain culverts and channel sections assuming a steady flow of 40 m^3s^{-1} that equates to the 1%AEP peak flood flow in Springvale Drain at the northern end of the Southlands site, together with a factor of safety. This discharge is larger than the Lawson and Treloar (2003) estimate of 34.4m^3s^{-1} and hence is deemed to provide a conservative approach to the design. This assessment assumes no interaction between the flow in Floodvale Drain and an enhanced Springvale Drain.

The hydraulic assessment demonstrates that the desired flood mitigation outcomes of containing the 1%AEP flood within the banks of the enhanced Springvale Drain is feasible by enlarging the culverts and channel capacity. Figure 13 shows a schematic long section of Springvale Drain noting the existing culverts and those proposed for the Stage 1 and Stage 2 infrastructure. Detailed design and sizing of the new culverts, channel grades and pipe sizes is to be carried out before the works are undertaken in Stage 2.

The proposed improvements to the hydraulic capacity of Springvale Drain would likely lead to a reduction in the duration of the flood hydrograph and an associated increase in the peak flow rate passing to Botany Bay. An increase in peak flow rate has potential to affect the outlet to Botany Bay and the surrounding Penrhyn Estuary wetlands. Possible issues including scour near the outlet channel and wetland degradation may result without sufficient mitigation measures. Detailed design of the new infrastructure will therefore need to incorporate mitigating design features, prior to construction. These measures will be designed and modelled prior to any Stage 2 works being undertaken, and will ensure an optimal design solution resulting in negligible impact on the wetlands

and Botany Bay.

Detailed design measures to be investigated will therefore include:

- Scour prevention by increased vegetation of the banks immediately downstream of the outlet;
- Upstream detention by the incorporation of additional in-ground detention areas on the Southlands site, where possible;
- Upstream detention in the land adjacent to the section of drain between Foreshore Drive and Penrhyn Road. This could be achieved through excavation of a wider channel, a secondary channel or a detention basin in this area. Approval would need to be sought from the landowner.
- Pollutant removal through measures such as a detention basin or rock weirs in the channel upstream of Penrhyn Road to reduce sediment loading and a trash rack at the inlet to the culvert under Penrhyn Road.

Initial modelling and design resolution confirms that these measures are possible and will reduce flow and scour impacts in the Penrhyn estuary, but detailed design and incorporation of these mitigating items will be required prior to the issuance of a Construction Certificate for the Stage 2 works.

These upgrade works are to a large extent as noted in the SKM (1992) report to Council, as improvements for the local catchment and should be recognised as an issue for all landowners in the area. These works could therefore reasonably be seen as an appropriate S.94 Plan for the area, rather than delivering the burden onto a single land owner. Nevertheless, the upgrade works as proposed in Stage 2 on lands downstream of the Southlands site are proposed as part of the current Project Application.

5. Discussion of results

Hydraulic modelling of the existing and Stage 1 and 2 "Project Works" scenarios has been carried out for a range of inflow events. Simulation of the 1% AEP storm event for the existing situation shows flooding over much of the lower areas of the Southlands site (Figure 8) and adjacent areas both upstream and downstream of the site. As noted by SKM (1992), the site currently acts as a defacto flood storage area during larger storm events for the wider catchment. The proposed development is designed to accommodate the existing flooding characteristics in Stage 1, and subsequently making significant local infrastructure improvements generally as recommended by SKM (1992) in Stage 2 that will provide improved infrastructure downstream, to improve flood conditions for the entire area.

The modelling of various options has demonstrated the sensitivity of the site drainage to the geometry that is typical of low lying flat areas. The potential flooding impacts of any proposed adjustments to the modelled system would therefore need to be carefully considered and possibly remodelled if necessary.

The proposed Stage 1 development has no impact on the Floodvale Drain flood levels. The flooding assessment of the proposed Stage 2 assumed no interaction between Floodvale and Springvale drains and hence under this assumption the Stage 2 works would also have no impact on the Floodvale Drain flood levels.

In Stage 1, the introduction of the access road crossing of Springvale Drain increases the flood levels to the north of the crossing while there is no impact south of the crossing nor in areas downstream of the site. North of the new crossing flood levels increase by about 0.25 m within the Southlands site. Near the upstream boundary of the site (chainage 280 m in Figure 11) this change decreases upstream back to the "existing" flood levels in the adjacent property (chainage 230 in Figure 11). This gradient area is confined within the Springvale channel and has negligible impact on the flood levels in the adjacent property as can be seen by comparing Figure 8 and Figure 9.

Importantly, the modelling work predicts no significant adverse impacts on flood levels either upstream or downstream of the Southlands development site as a result of the Stage 1 works and as an interim measure contains all major flood events within the eastern (Stage 2 and Stage 3) portion of the site. The eastern half of the Southlands site operates effectively as an interim compensatory flood storage area for the Stage 1 development and this flow will be transferred downstream through the increased capacity of Springvale Drain and the culverts following the Stage 2 development. This report has focused on surface water drainage and further mitigation measures may be required in order to manage groundwater interaction with surface flows in the interim stage compensatory flood storage area.

Stage 2 works will serve to significantly increase hydraulic capacity of Springvale Drain through to Botany Bay. The result of adding this new infrastructure will see a significant positive impact on flood levels in the area allowing the subsequent filling of Stages 2 and 3 without any impact on any adjoining properties. Likely changes in flow characteristics of the proposed Stage 2 channel system have been considered and various mitigating measures designed to reduce impacts from increased flows are noted in Section 4.5 of this report. Further detailed design of these measures will be required during the detailed design phase and prior to the issuance of a Construction Certificate for Stage 2 works, with more detailed hydraulic model investigation to ensure the incorporation of appropriate mitigative measures, as required.

5.1 Factors affecting Stage 1 and 2 floor and road levels

Building finished floor levels within the Stage 1 and 2 area are required to be set above the 1% AEP (1 in 100 year ARI) flood event.

The design floor levels for the warehouse areas of the proposed development are subject to a number

of criteria including:

- 1% AEP Flood level plus 300 mm freeboard.
- The ability to drain stormwater from the site.
- Site remediation levels as defined in the preferred remediation strategy documented in URS (2007)

The design floor level needs to be set at the highest of these constraints, which may vary for different locations on the Southlands property and may be reduced as a result of the Stage 2 works, however initial Stage 1 filling works will need to meet current flood conditions as proposed in Stage 1.

For the Stage 1 works flood modelling indicates the 1% AEP flood level on Springvale Drain at the northern end of the Southlands site is 4.6 m AHD. Incorporating 300mm freeboard results in a minimum finished floor level to satisfy flood criteria of 4.9 m AHD at this point.

The 1% AEP flood level on Springvale Drain downstream of the proposed Nant St culverts is 4.1m AHD. Incorporating 300mm freeboard results in a minimum finished floor level to satisfy flood criteria of 4.4m AHD at this point.

The 1% AEP flood level on Floodvale Drain is 4.2m AHD at the northern end of the Southlands site and 4.1 m AHD at McPherson Street. Incorporating 300mm freeboard results in a minimum finished floor level to satisfy flood criteria of 4.5 and 4.4m AHD for the northern and southern points of the site, respectively.

The Stage 2 development aims to confine the flood flows within the refurbished Springvale Drain. Downstream of the Southlands site the new Link road will be tied into McPherson St and Botany Road and most likely will include a bridge over the SWSOOS. This component of the project will require negotiations with a number of stakeholders including property owners, council and asset managers to formulate a detailed plan.

5.2 Future Stage 3

As discussed above, Project Approval for Stage 1 and 2 only is sought at this stage. The current modelling work predicts no significant adverse impacts on flood levels either upstream or downstream of the Southlands development site as a result of the Stage 1 and 2 works.

Development of Stage3 will be the subject of future Project Application. Stage 3 will benefit from the major new infrastructure works undertaken in Stage 2 which will essentially allow both Stages 2 and 3 to be filled as required to above 1%AEP levels.

6. Conclusions and recommendations

Flooding of Springvale and Floodvale Drains results from a complex interaction of catchment runoff coupled with flat terrain, historical adjustments to the drainage patterns associated with previous developments in the catchment and undersized drainage infrastructure. The Southlands site, as the last large undeveloped site in the lower catchment, currently operates as a defacto flood storage area for other developed areas despite its current industrial zoning. Development of the Southlands site is further inhibited by groundwater levels and contamination that limit options for developing compensatory floodplain storage.

The proposed Stage 1 Project Application involves filling the site between Springvale and Floodvale drains with on-site flood impacts accommodated as an interim measure within the Stage 2 and 3 areas of the Southlands site. As demonstrated by the extensive flood modelling carried out for this development scenario, there are no major adverse flood impacts on adjoining landholdings as a result of the Stage 1 works.

Stage 2 works involve the introduction of major new infrastructure in tandem with the new entry road that will significantly improve flood conditions for the whole area downstream of the Southlands site and allow the filling of the Stage 2 and 3 areas of the site to 1%AEP levels and allow new industrial development.

Development of the remainder of the site in Stage 3 would rely on a future Project Application but filling of this area will enjoy the benefits of the new infrastructure work in Stage 2.

Filling of the site generally in accordance with the levels proposed in the Stage 1 and 2 of this Application and as included in this report would be acceptable and will not result in any off site flood impacts on surrounding properties.

The Springvale and Floodvale Drain culverts under the SWSOOS should be cleared and maintained to allow maximum flow in Stage 1.

It is recommended that Council consider the preparation of an appropriate Section 94 Plan to deal with the catchment wide flooding issues as outlined in the SKM Report to Botany Bay City Council (1992). This wider approach would facilitate ownership of flooding issues by all affected stakeholders rather than relying on individual landowners to solve catchment wide issues.

7. References

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Institution of Engineers, Australia (1998), *Australian Rainfall and Runoff*

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Sinclair Knight Consulting Engineers (1992), *Catchment Management Study: Floodvale & Springvale Drains* (for Botany Municipal Council).

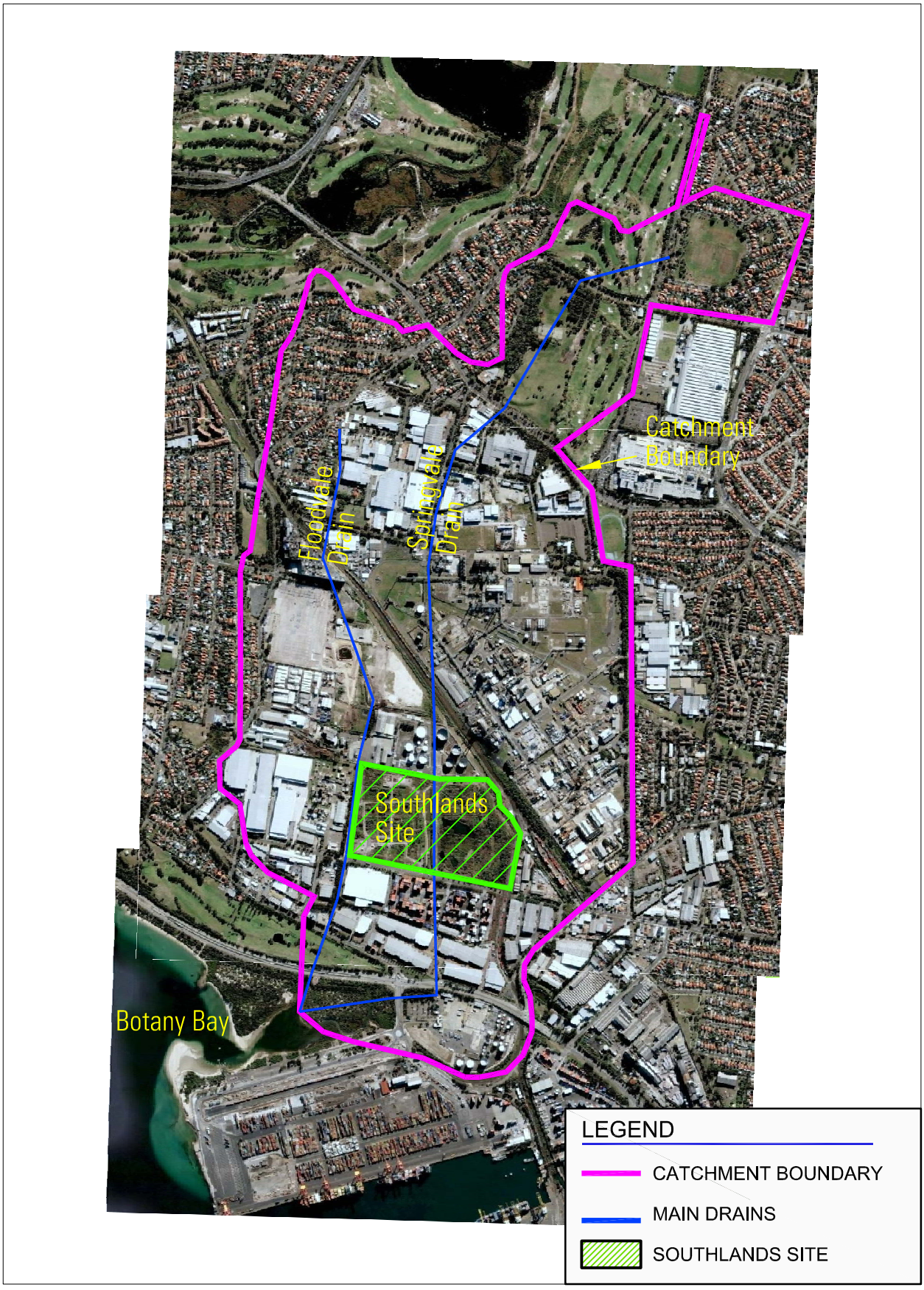
Snowy Mountains Engineering Corporation Limited (1992), *Hydrology and Hydraulic Study, Botany Wetlands*, Prepared for Sydney Water

Willing and Partners (1999), Sinclair Knight and Partners (1992), Sinclair Knight Merz (1996) and Water Research Laboratory (1990).

MIKE 11 (2007) User Manual, Danish Hydraulics Institute

Appendix A

Figures



I:\22202\CAD\Drg\22202-FS-W-003\FIGURE 2 - Site Location and Catchment.dwg

Figure 1

Aerial Photo showing Springvale and Floodvale drains and the catchment boundary

Figure 2

Proposed Development Masterplan - Stages 1 to 3

I:\22202\CAD\Drg\22202-FS-W-003\FIGURE 1 - Proposed Development Masterplan - Stage 1.dwg

N

0 100 200 400m

SCALE 1:10,000

Figure 3

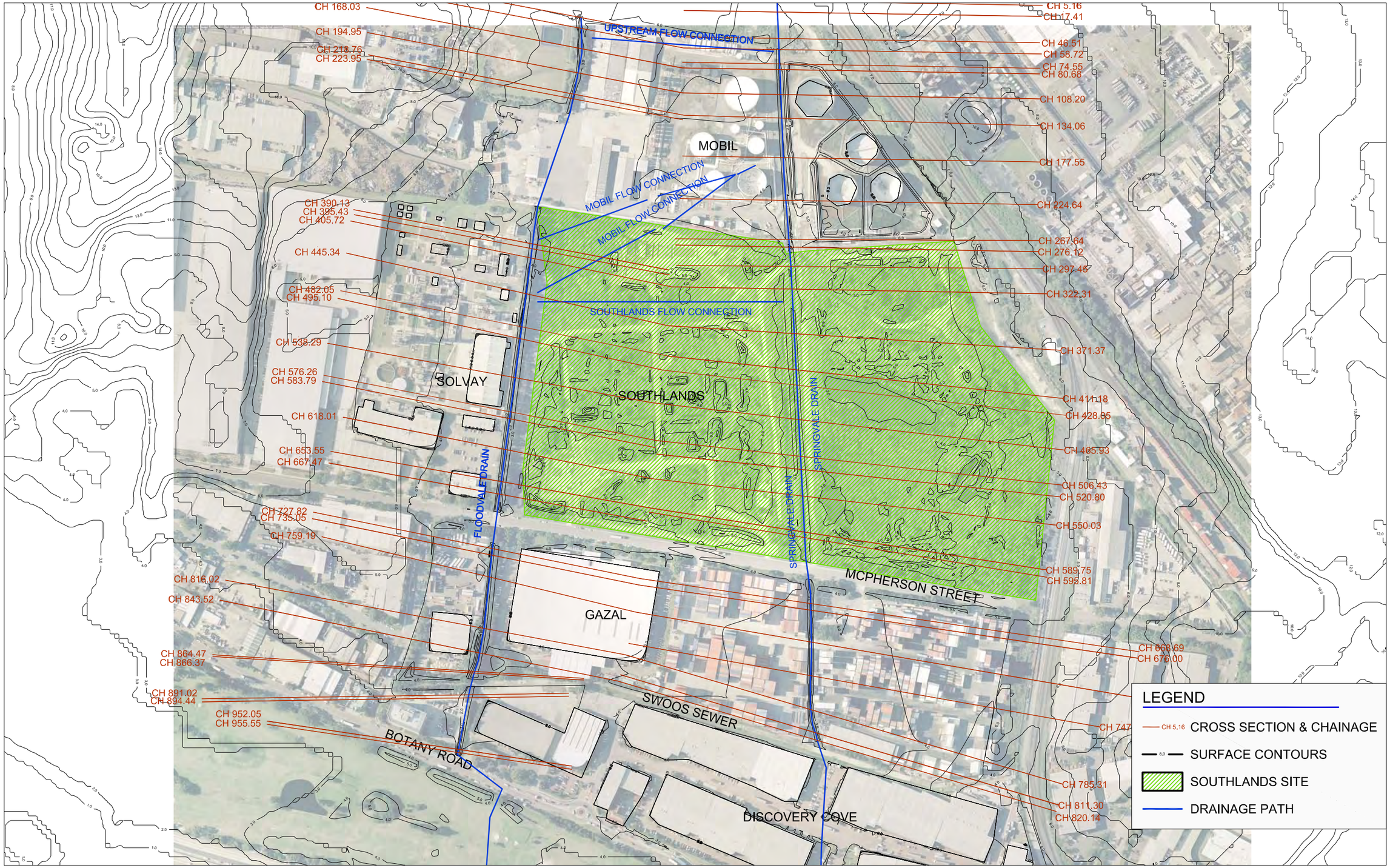
RAFTS Rainfall-Runoff Model Catchments Plan

I:\22202\CAD\Drg\22202-FS-W-003\FIGURE 3 - RAFTS Catchments.dwg

I:\22202\CAD\Drg\22202-FS-W-003\FIGURE 4 - Ex Conts and GW Conts.dwg

Figure 4

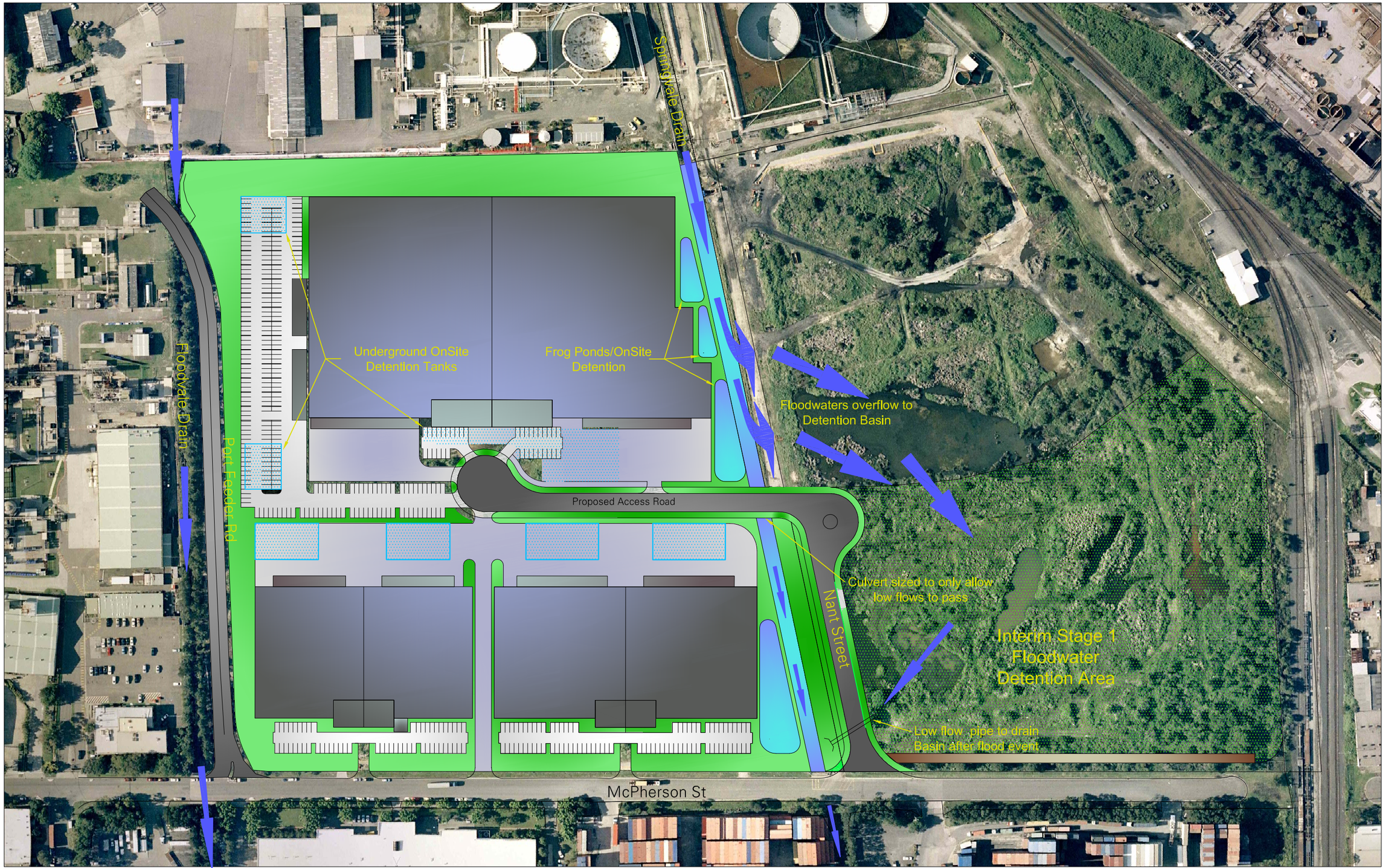
Existing Site Elevation Contours and October 2004
Groundwater Levels Overlaying 2002 Aerial Photo



I:\22202\CAD\Drg\22202-FS-W-003\FIGURE 5 - Ex Conts and M11 XSs.dwg

Figure 5

Existing Contours and "Existing" MIKE11 Model Cross Section Locations



I:\22202\CAD\Drg\22202-FS-W-003\FIGURE 7 - Prop Site Hydraulic Configuration.dwg

Figure 6

Proposed Stage 1 Interim Flood Flow Paths

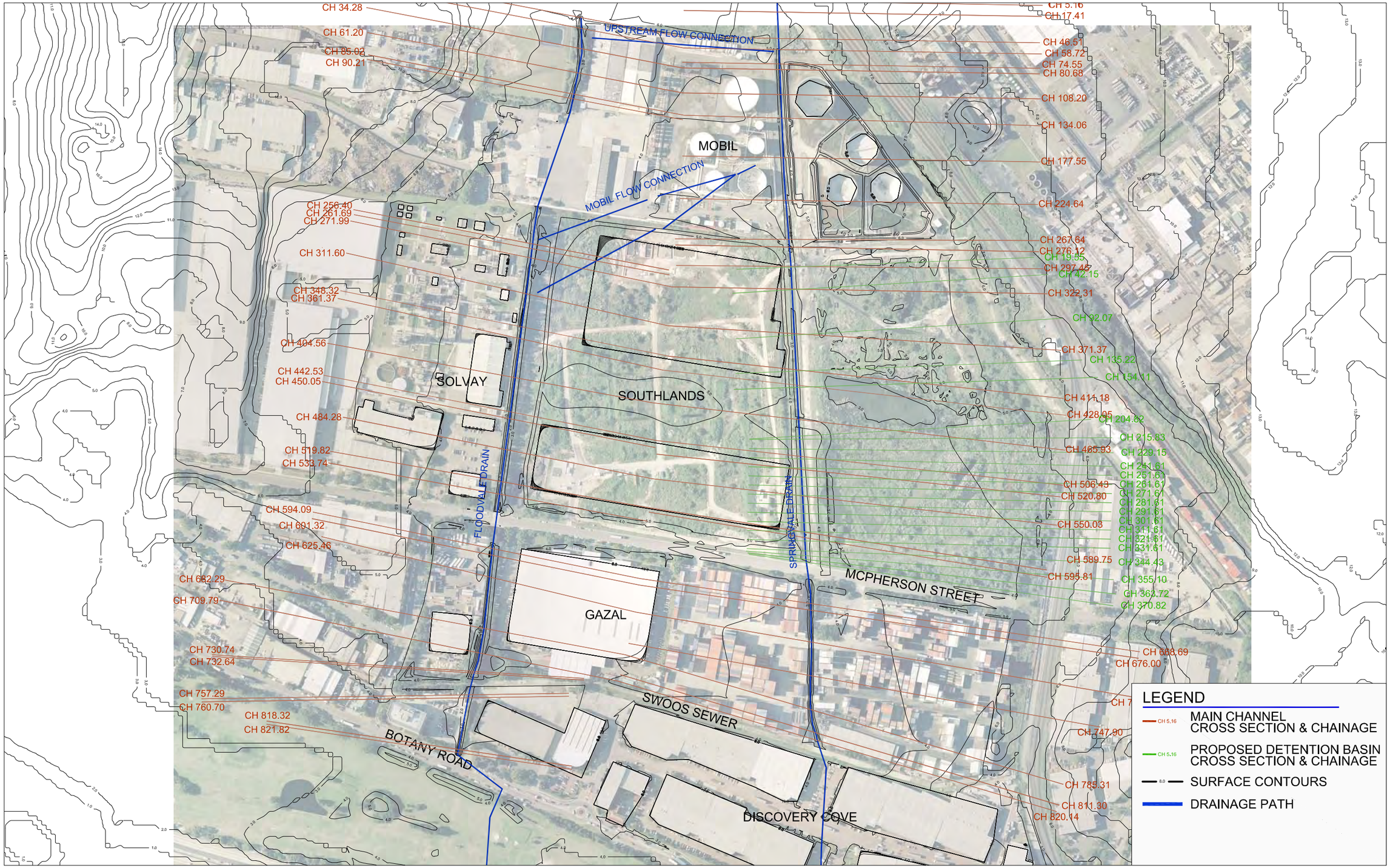
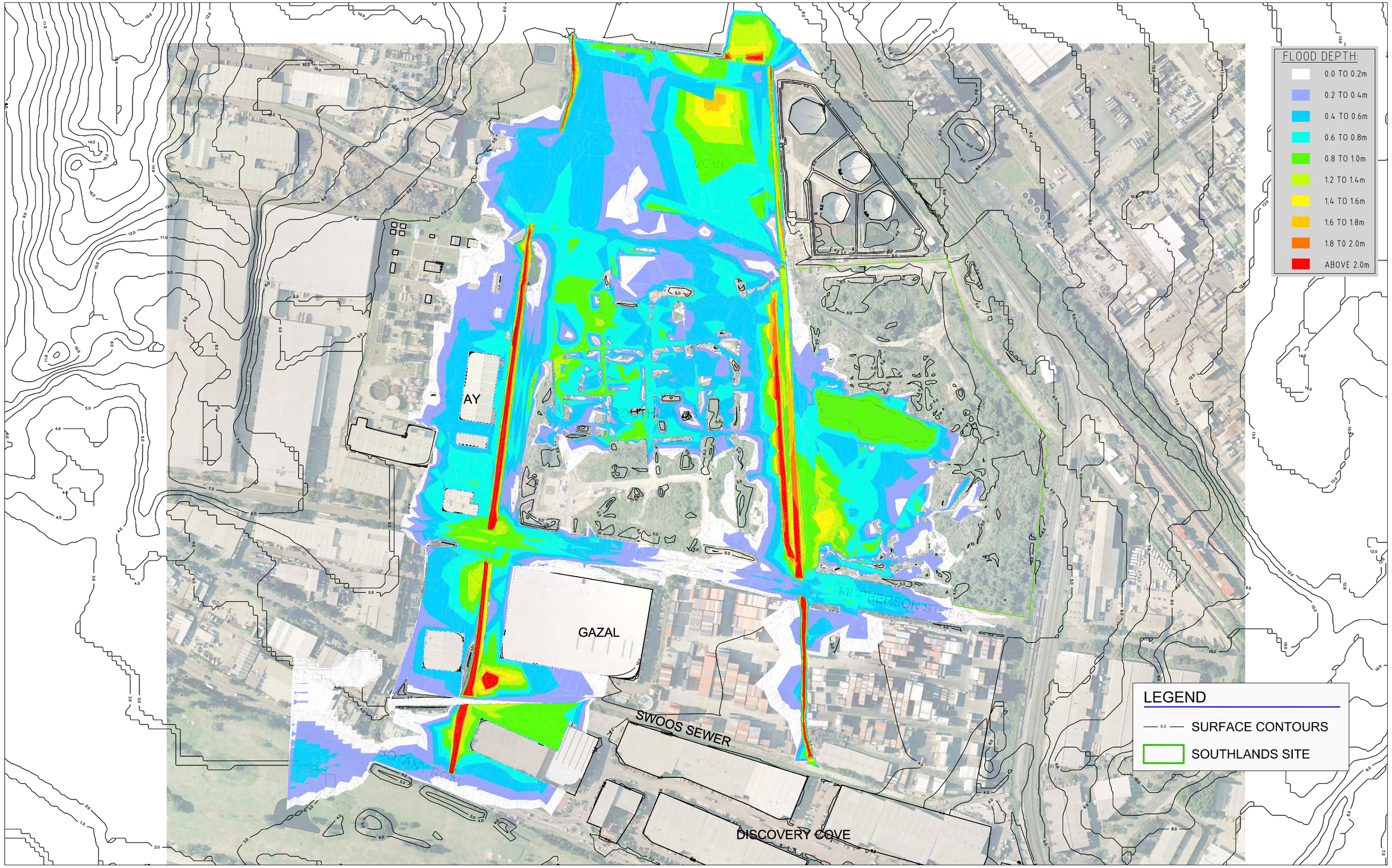


Figure 7

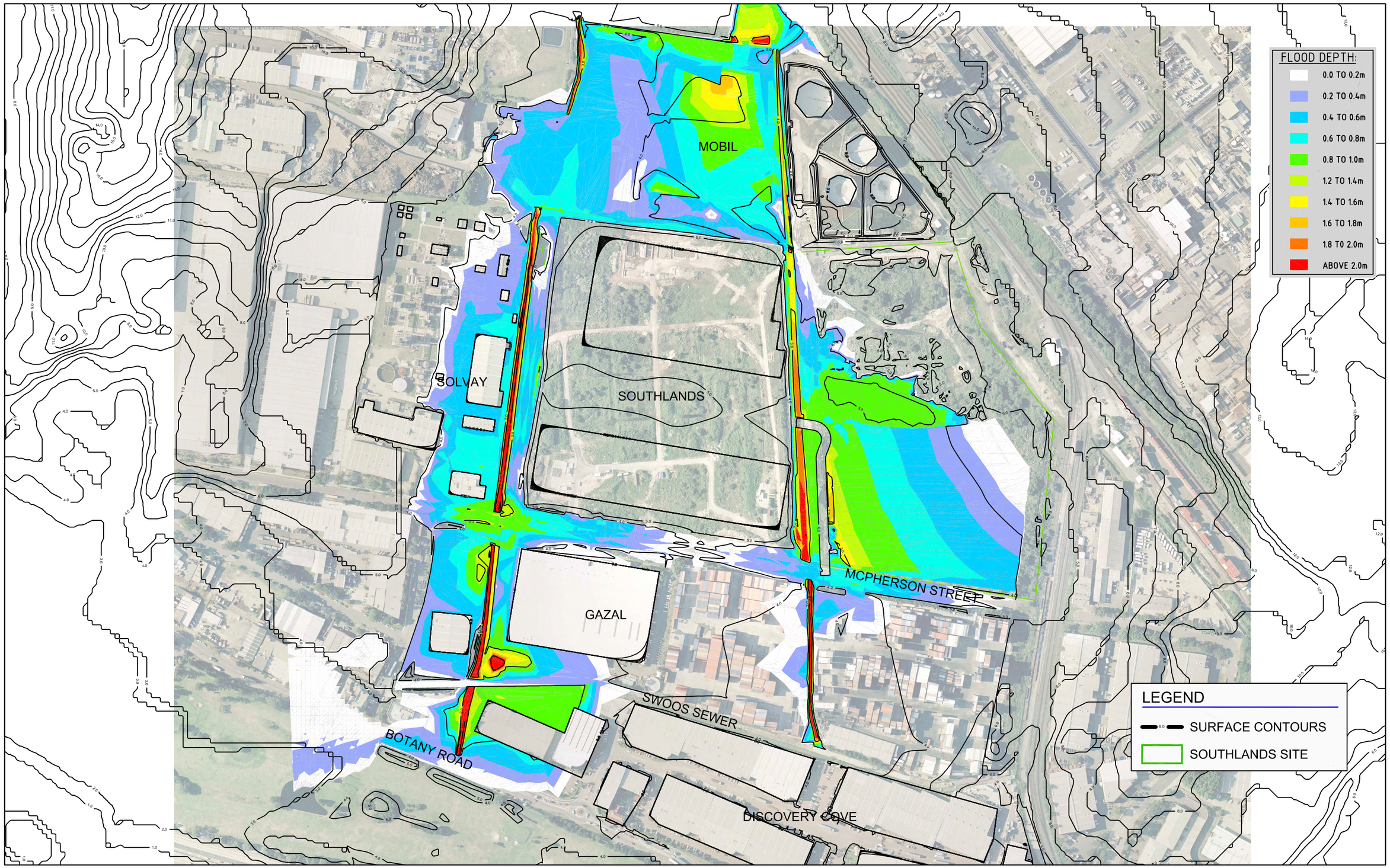
Proposed Elevation Contours Within the Site, Existing and "Proposed" MIKE11 Model Cross Section Locations



I:\22202\CAD\Drg\22202-FS-W-003\FIGURE 8 - Flood Depth Mapping Existing.dwg

Figure 8

Flood Depth Mapping for "Existing" Model at 1% AEP Flows



I:\22202\CAD\Drg\22202-FS-W-003\FIGURE 9 - Flood Depth Mapping Option 5.dwg

Figure 9

Flood Depth Mapping for Proposed Stage 1 Development at 1% AEP Flows

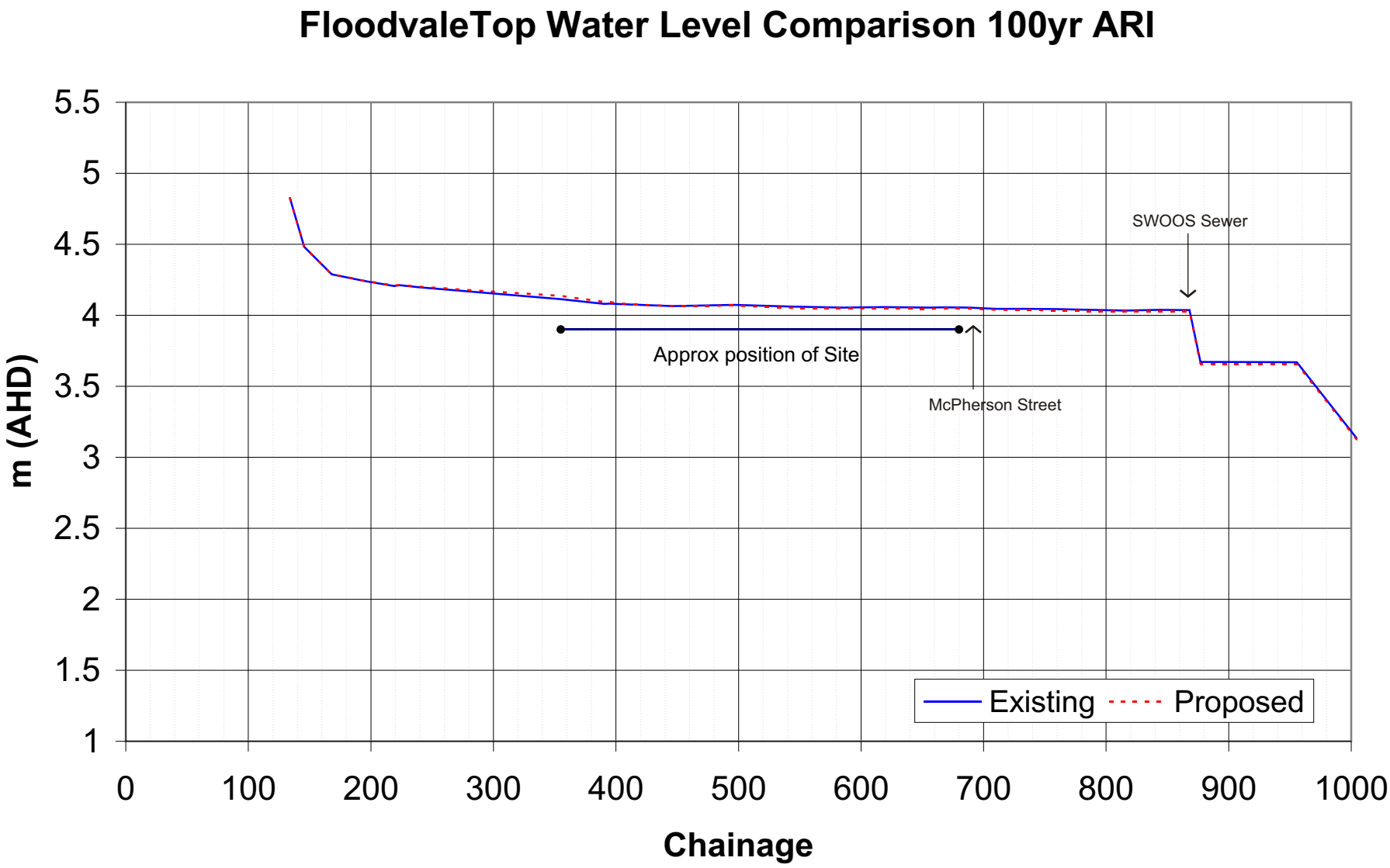


Figure 10

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Floodvale Drain for 1:100 year ARI Event for Existing and Proposed Systems

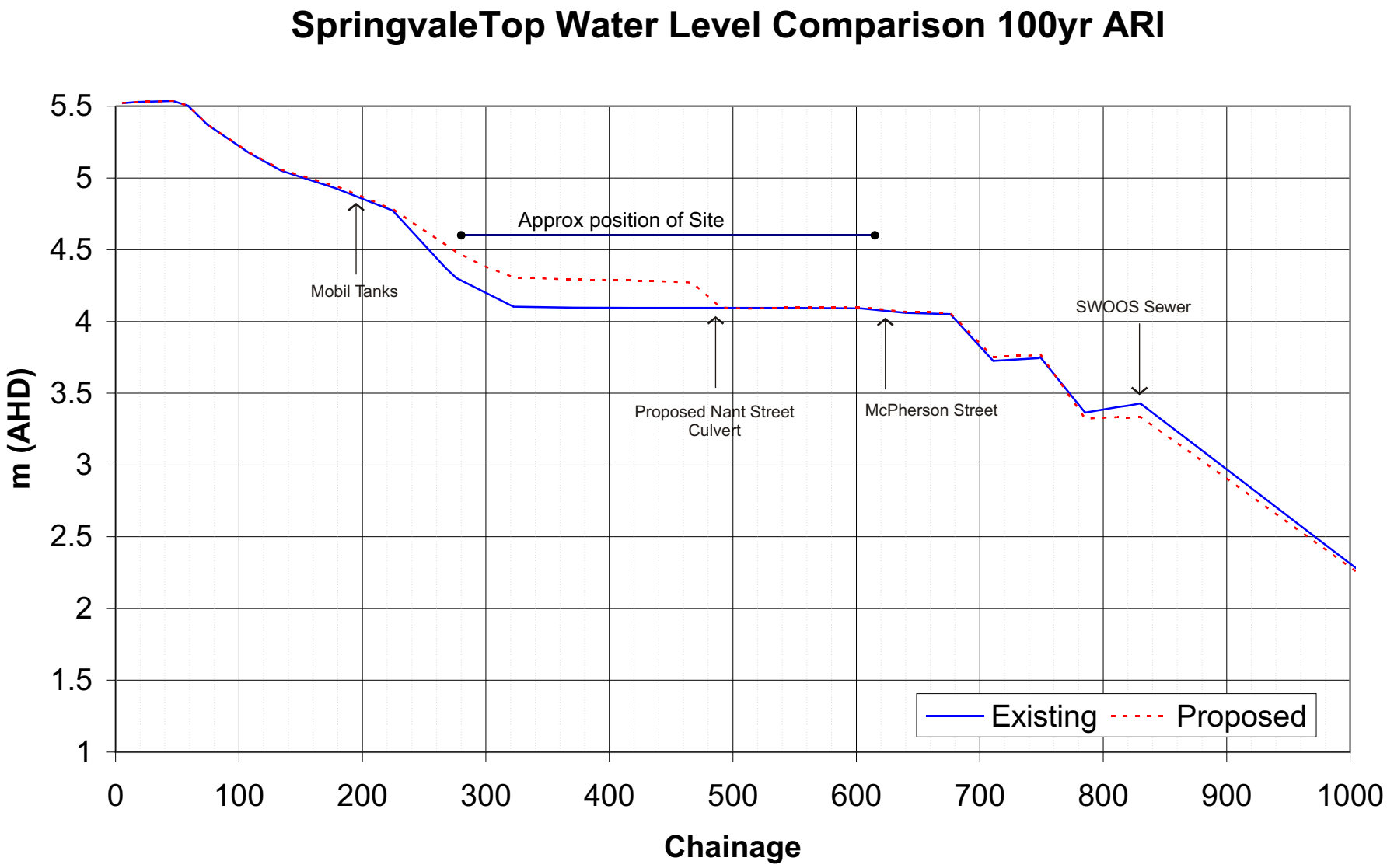


Figure 11

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Springvale Drain for 1:100 year ARI Event for Existing and Proposed Systems

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0 25 50 100m

SCALE 1:2500

I:\22202\CAD\Drg\22202-FS-W-003\FIGURE 10 - Stage 2 Conceptual Hydraulic Design.dwg

Figure 12

Stage 2 Conceptual Hydraulic Design

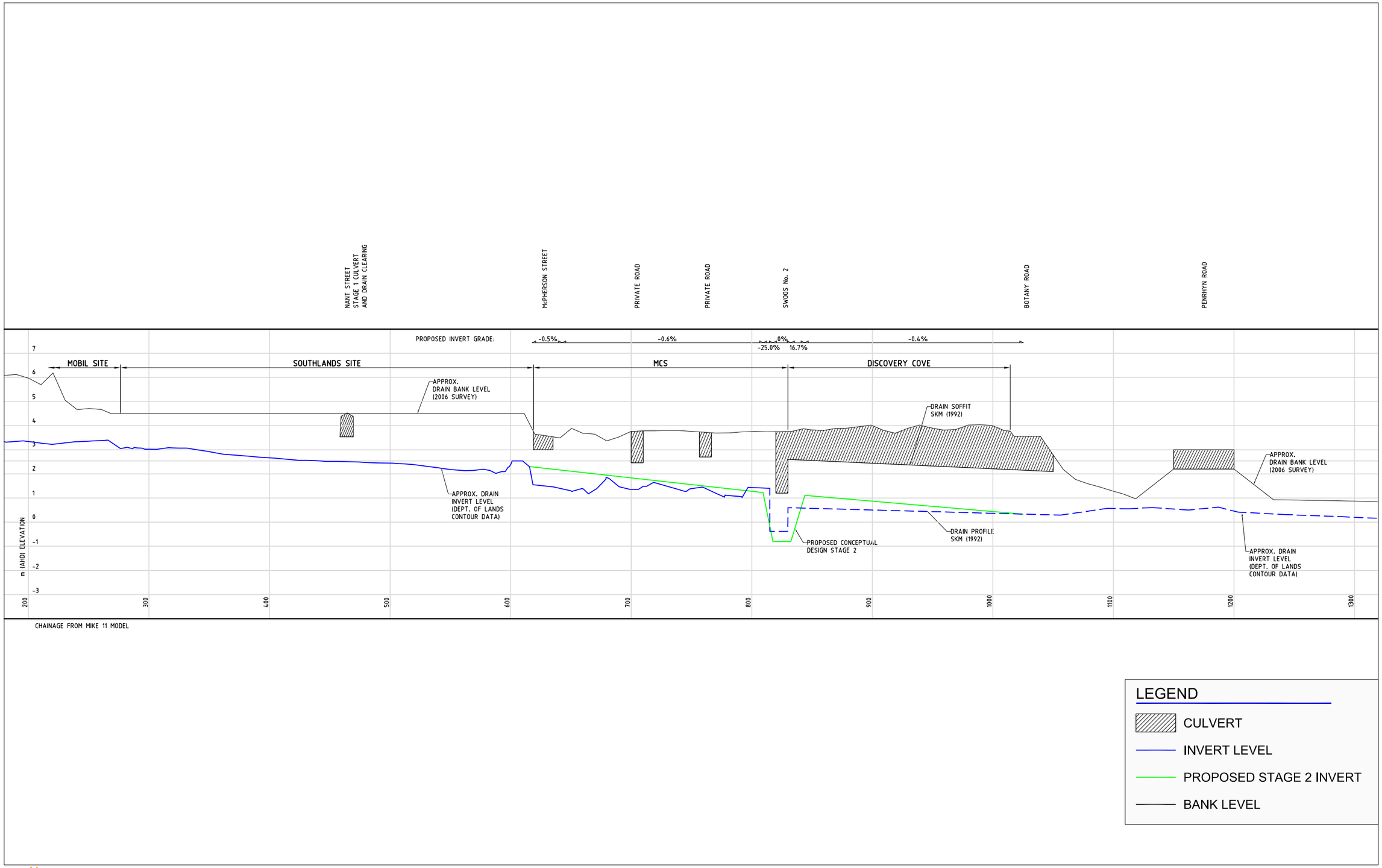

Figure 13

Proposed Stage 1 and Stage 2 Springvale Drain Longitudinal Section

I:\22202\CAD\Drg\22202-FS-W-003\FIGURE 11 - Proposed Drain Longsection.dwg

Appendix B

Site Photos and Hydraulic Structure Survey

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SCALE

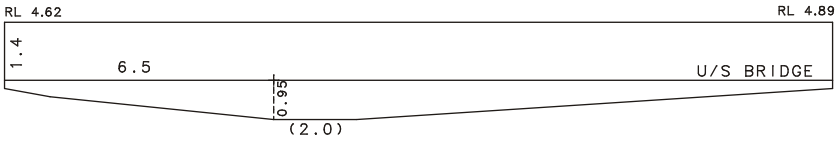
SOUTHLANDS\22202.FS.W.003\30.08.07\RC

Figure B1

Culvert Photo and Survey Location Plan

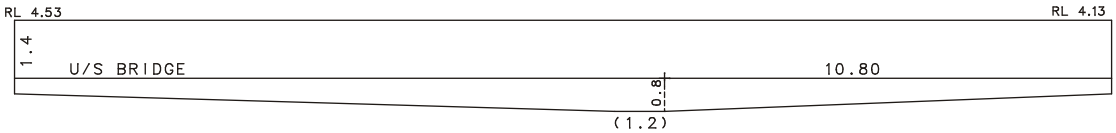
1

'MOBIL' BRIDGE & FLOODVALE
(Looking South)



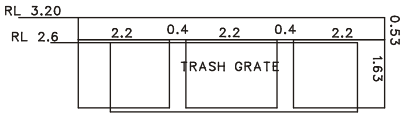
2

'MOBIL' BRIDGE & FLOODVALE
(Looking North)



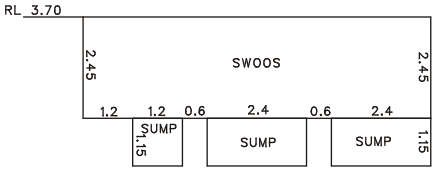
3

McPHERSON OVER FLOODVALE
LOOKING SOUTH



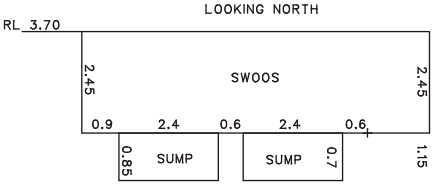
5

SWOOS OVER FLOODVALE
LOOKING SOUTH



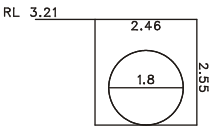
6

SWOOS OVER FLOODVALE
LOOKING NORTH



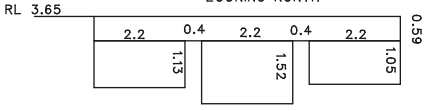
7

BOTANY ROAD OVER FLOODVALE
LOOKING SOUTH



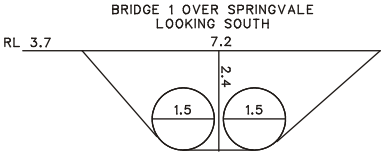
9

McPHERSON OVER SPRINGVALE
LOOKING NORTH



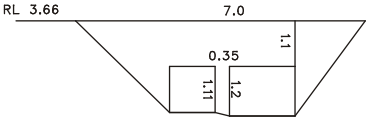
10

BRIDGE 1 OVER SPRINGVALE
LOOKING SOUTH



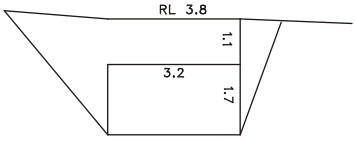
11

BRIDGE 1 OVER SPRINGVALE
LOOKING NORTH



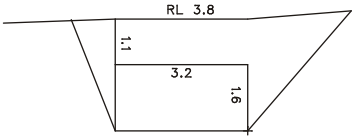
12

BRIDGE 2 OVER SPRINGVALE
LOOKING SOUTH



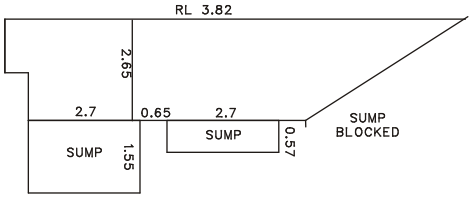
13

BRIDGE 2 OVER SPRINGVALE
LOOKING NORTH



14

SWOOS OVER SPRINGVALE
LOOKING SOUTH



LEGEND
(1) Refers to photos

Figure B2

Source: Goodman (2007)

Culvert Dimensions used in Southland Flood Model

Photo 1: Floodvale drain looking south over Port Feeder Road.

Photo 2: Floodvale drain looking north over Port Feeder Road.

Figure B3

Site Photos

Source: Goodman (2007)

Photo 3: Floodvale drain at McPherson Street culvert looking south.

Photo 3a: Floodvale drain at McPherson Street culvert looking south behind the trash rack.

Figure B4

Source: Goodman (2007)

Site Photos

Photo 3b: Springvale drain at McPherson street culvert V notch weir looking south.

Photo 5: Floodvale drain at SWOOS crossing looking south.

Figure B5

Source: Goodman (2007)

Site Photos

Photo 6: Floodvale drain at SWOOS crossing looking north.

Photo 7: Floodvale drain at Botany Road looking south.

Figure B6

Source: Goodman (2007)

Site Photos

Figure B7

Site Photos

Source: Goodman (2007)

Photo 10: Springvale drain at Bridge 1 looking south.

Photo 11: Springvale drain at Bridge 1 looking north.

Figure B8

Site Photos

Source: Goodman (2007)

Photo 12: Springvale drain at Bridge 2 looking south.

Photo 13: Springvale drain at Bridge 2 looking north.

Figure B9

Source: Goodman (2007)

Site Photos

Photo 14: Springvale drain SWOOS crossing looking south.

Figure B10

Site Photos

Source: Goodman (2007)

Figure B1

Culvert Photo and Survey Location Plan

Appendix C

RAFTS Hydrological Model Results

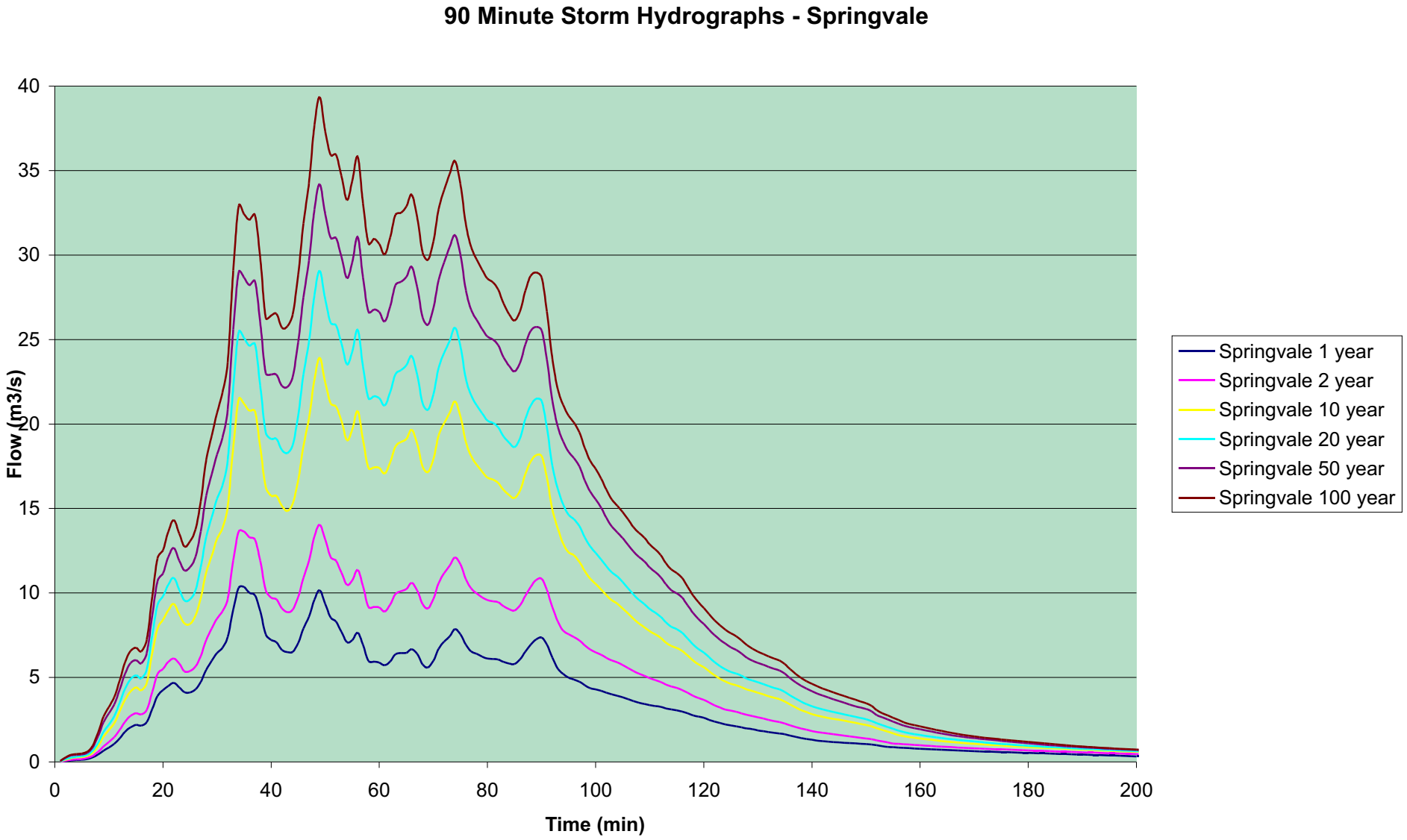


Figure C1

Source: RAFTS

Springvale Drain Discharge Hydrographs at Different Recurrence Intervals for 90 Minute Rainfall Event

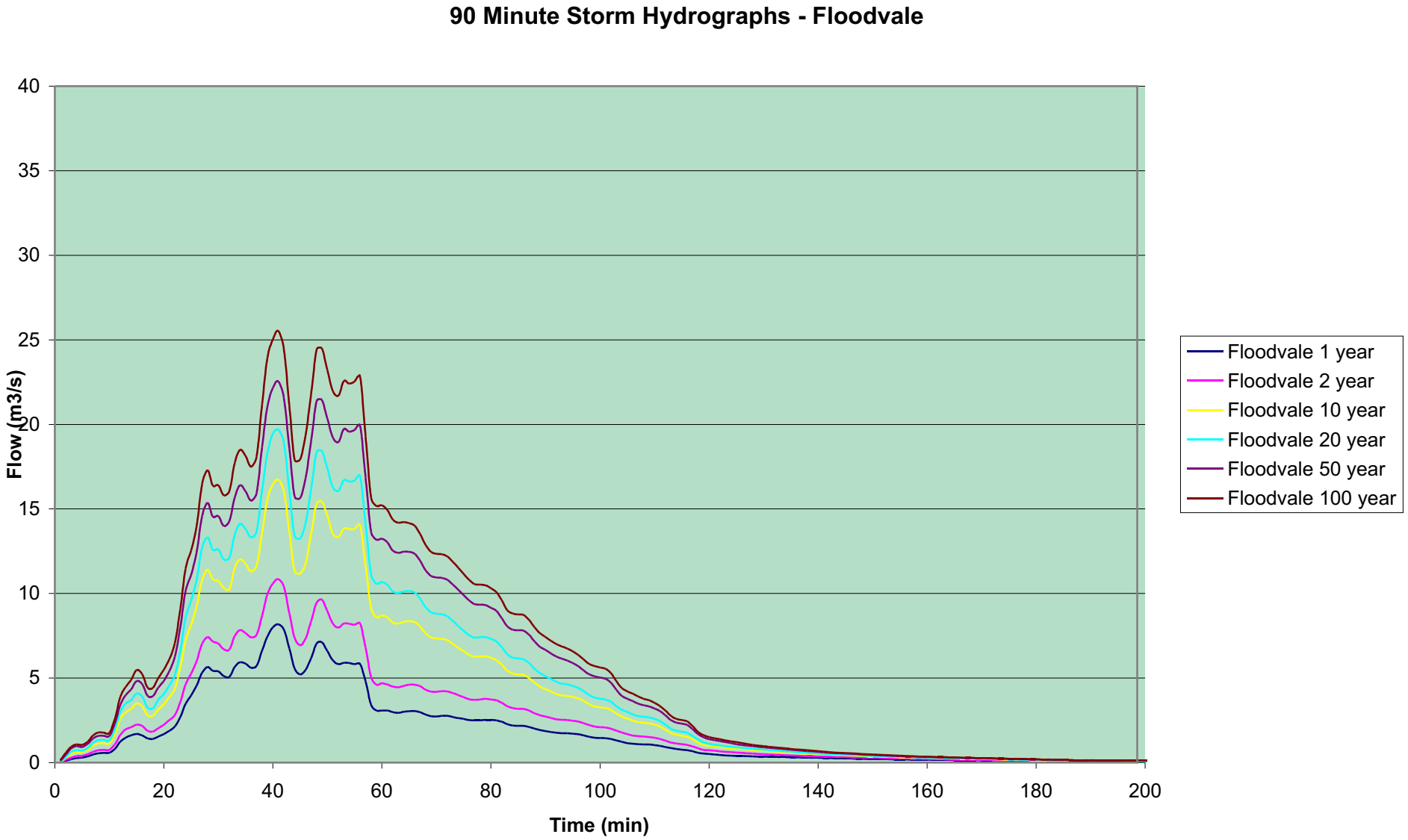


Figure C2

Source: RAFTS

Floodvale Drain Discharge Hydrographs at Different Recurrence Intervals for 90 Minute Rainfall Event

Appendix D

MIKE 11 Hydraulic Model Results

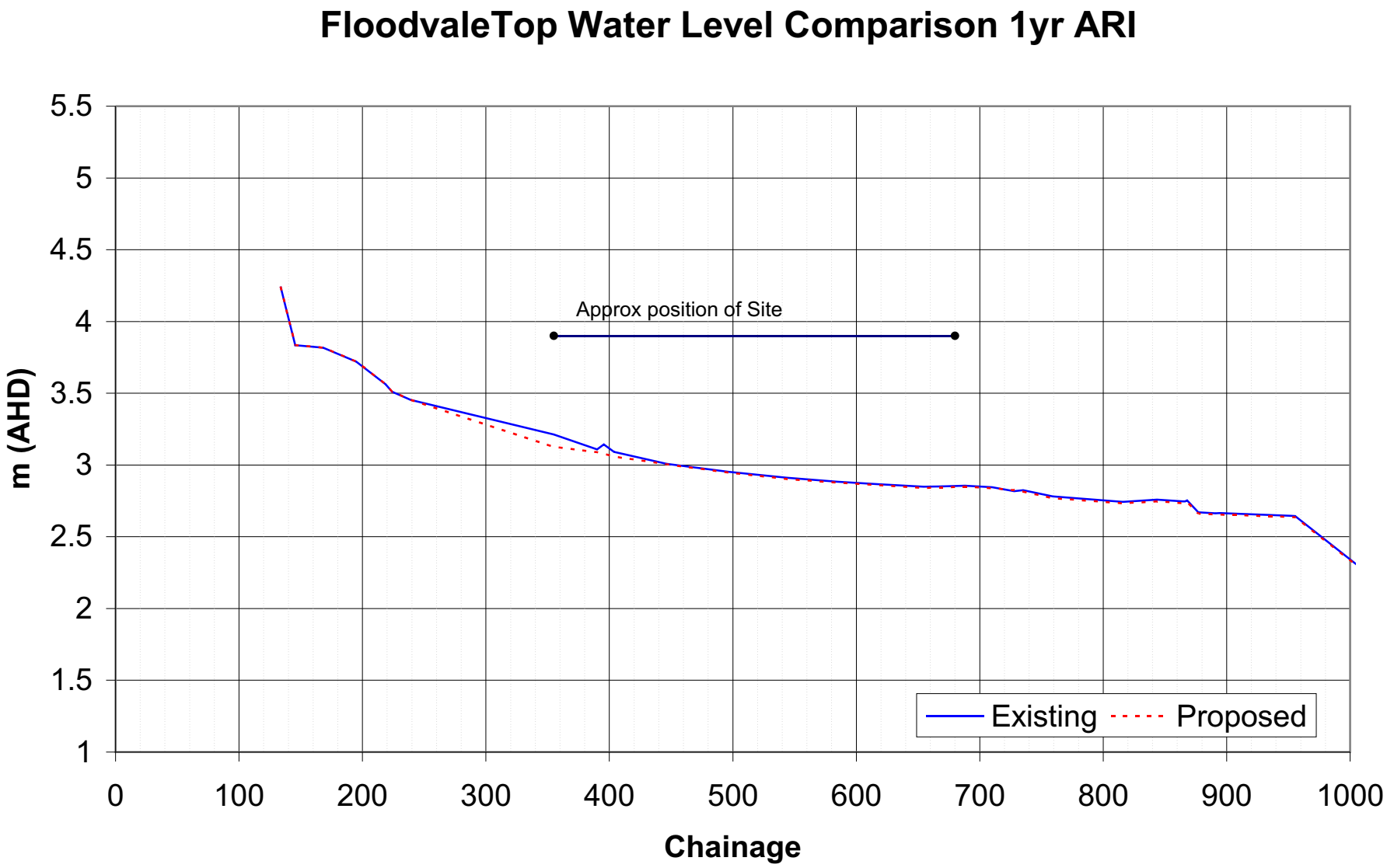


Figure D1

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Floodvale Drain for 1:1 year ARI Event for Existing and Proposed Systems

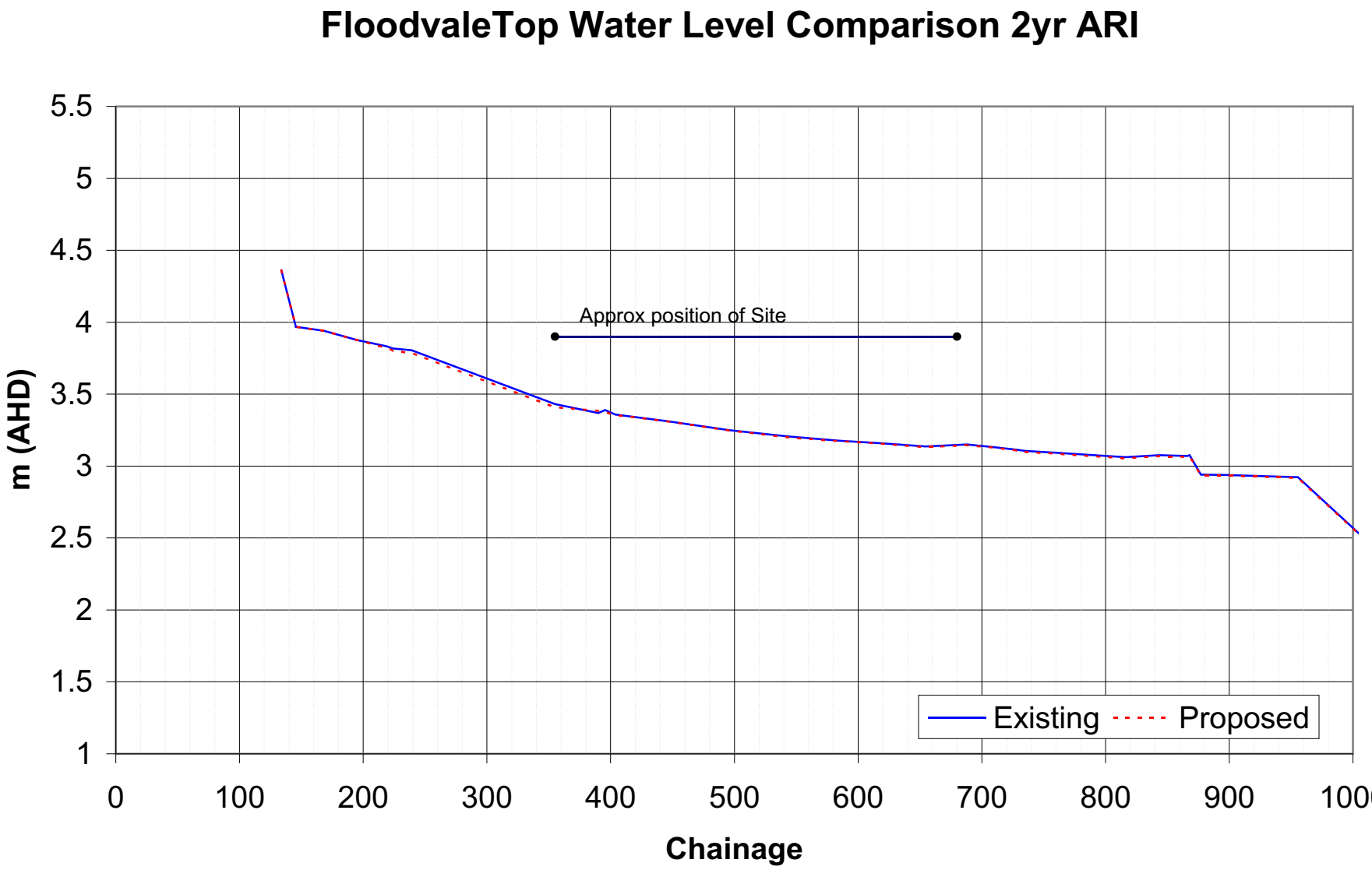


Figure D2

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Floodvale Drain for 1:2 year ARI Event for Existing and Proposed Systems

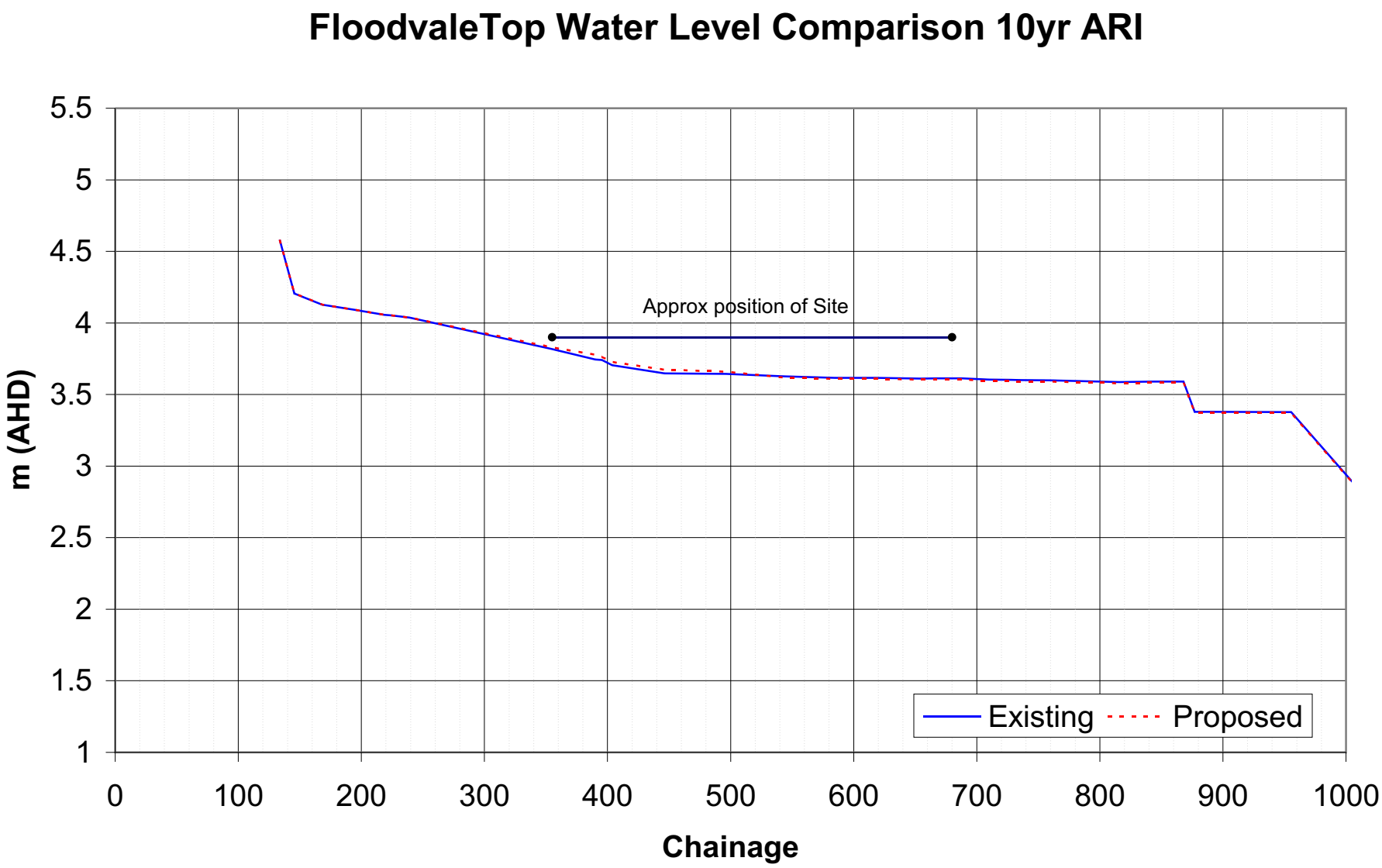


Figure D3

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Floodvale Drain for 1:10 year ARI Event for Existing and Proposed Systems

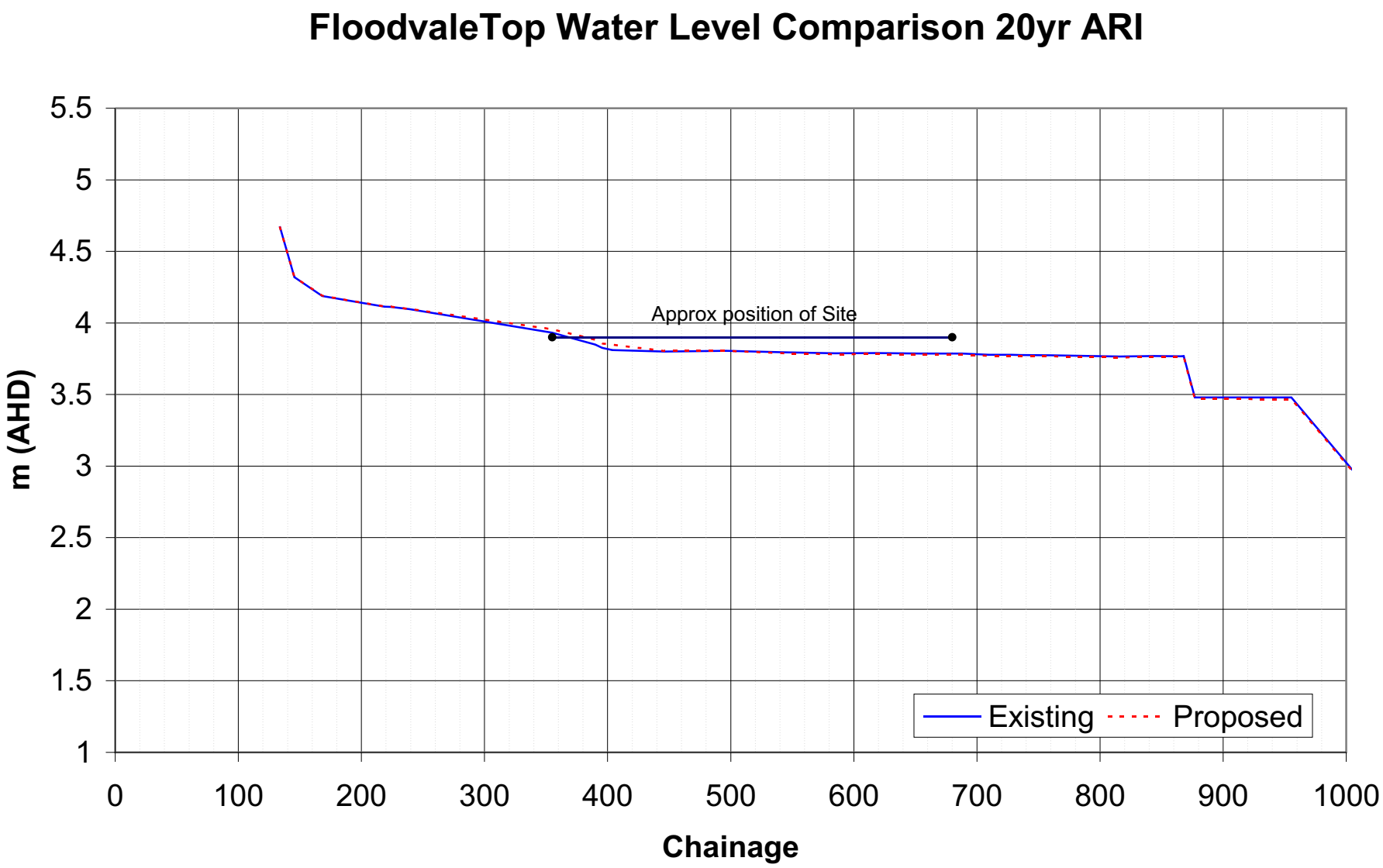


Figure D4

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Floodvale Drain for 1:20 year ARI Event for Existing and Proposed Systems

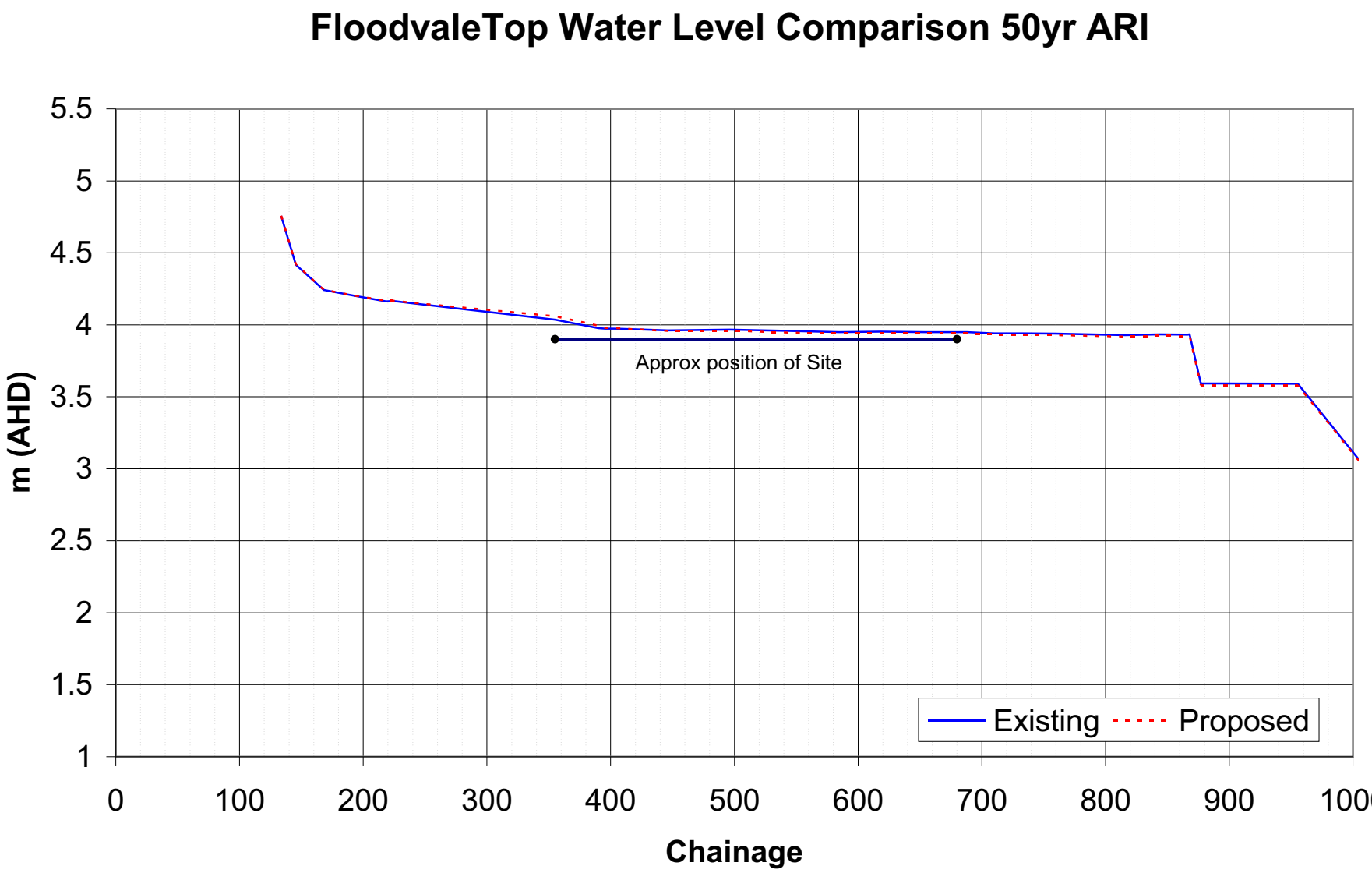


Figure D5

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Floodvale Drain for 1:50 year ARI Event for Existing and Proposed Systems

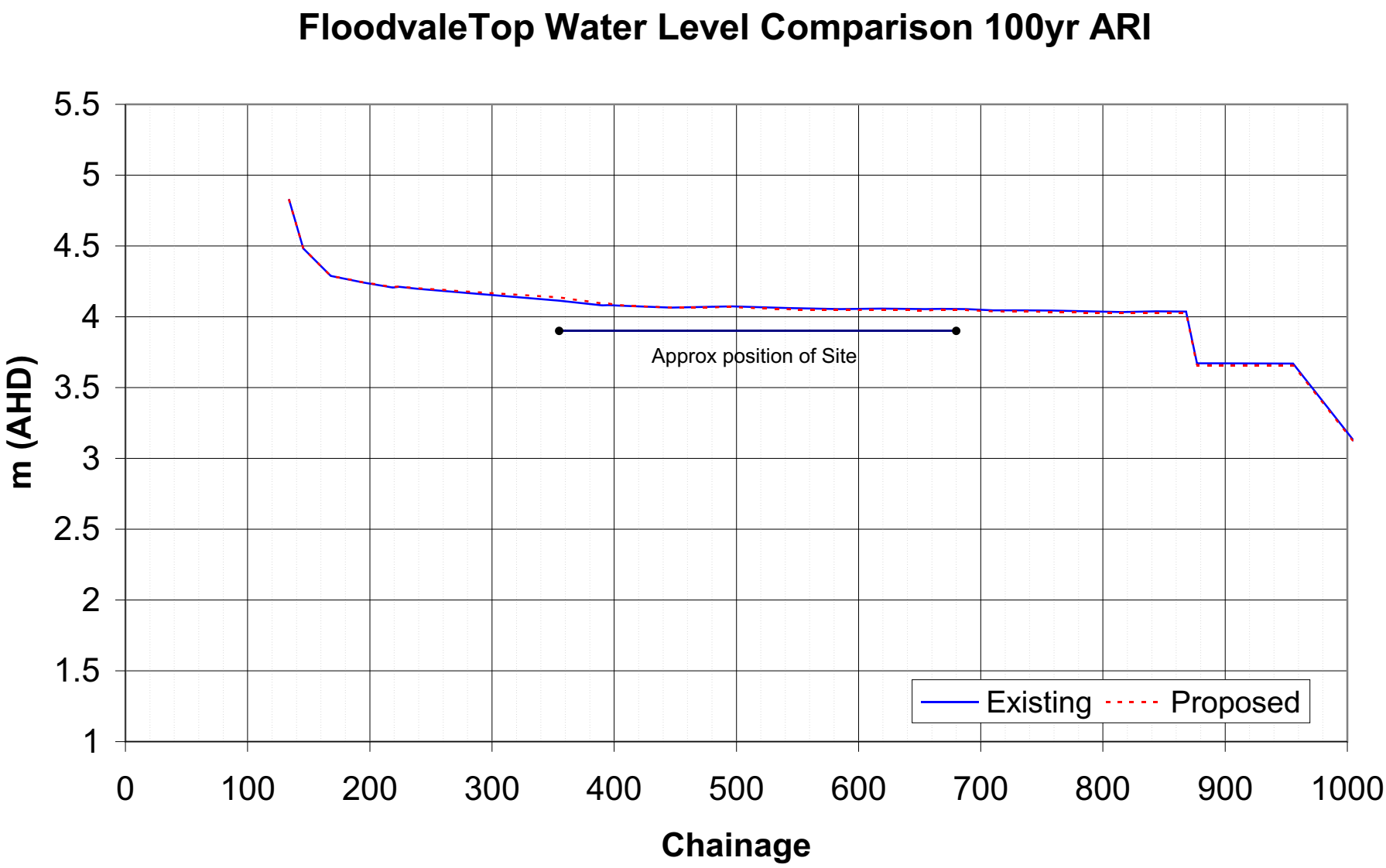


Figure D6

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Floodvale Drain for 1:100 year ARI Event for Existing and Proposed Systems

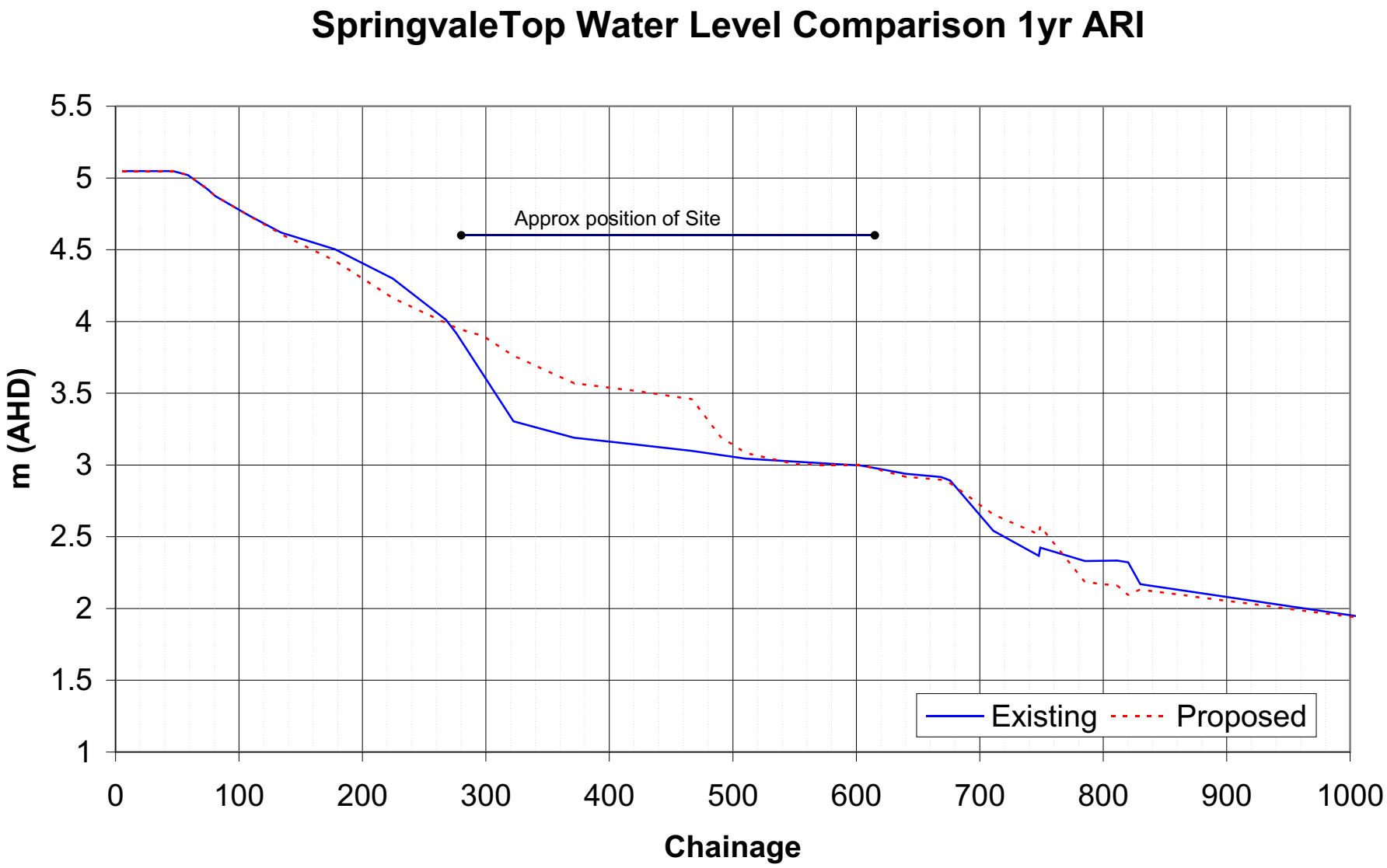


Figure D7

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Springvale Drain for 1:1 year ARI Event for Existing and Proposed Systems

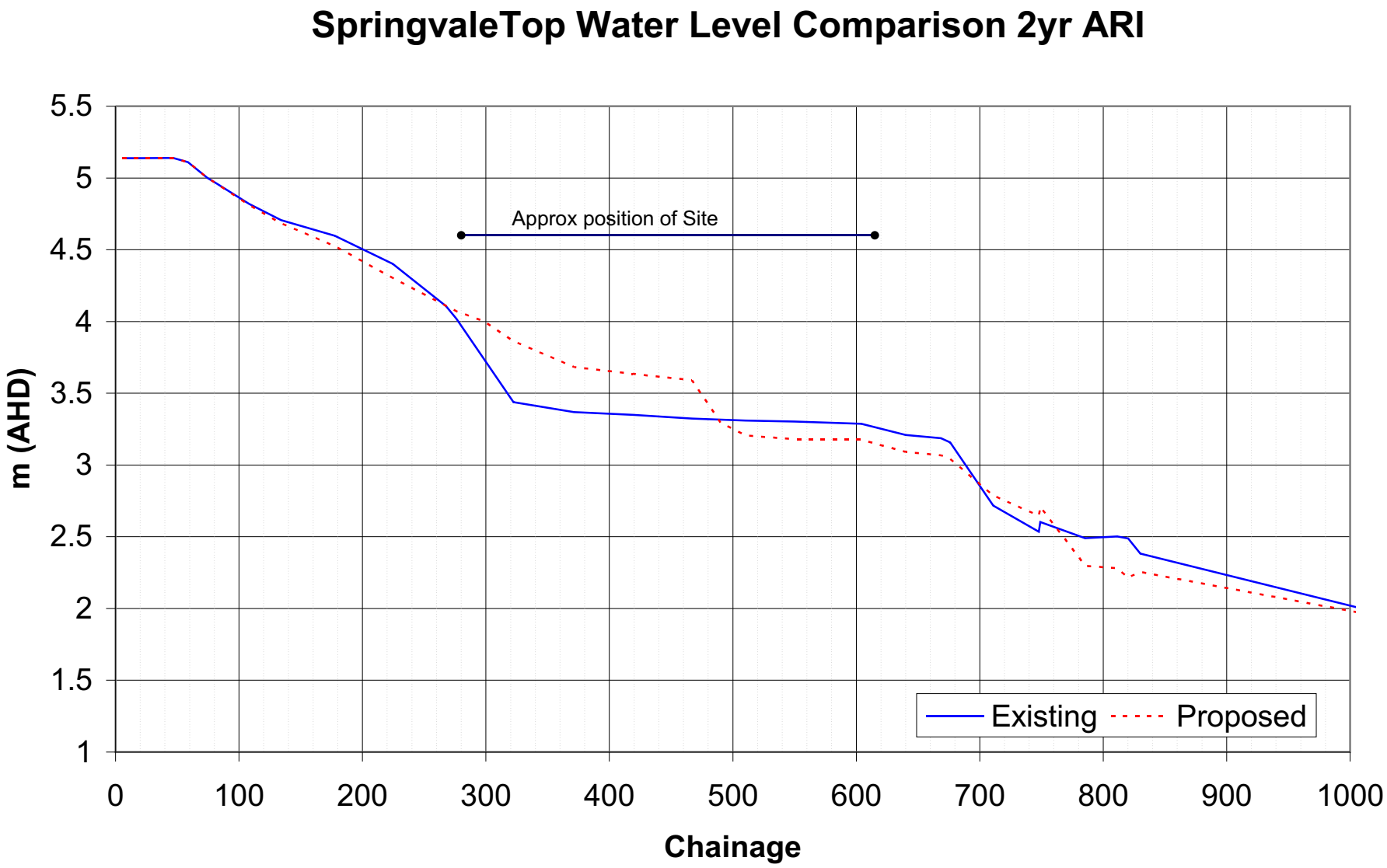


Figure D8

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Springvale Drain for 1:2 year ARI Event for Existing and Proposed Systems

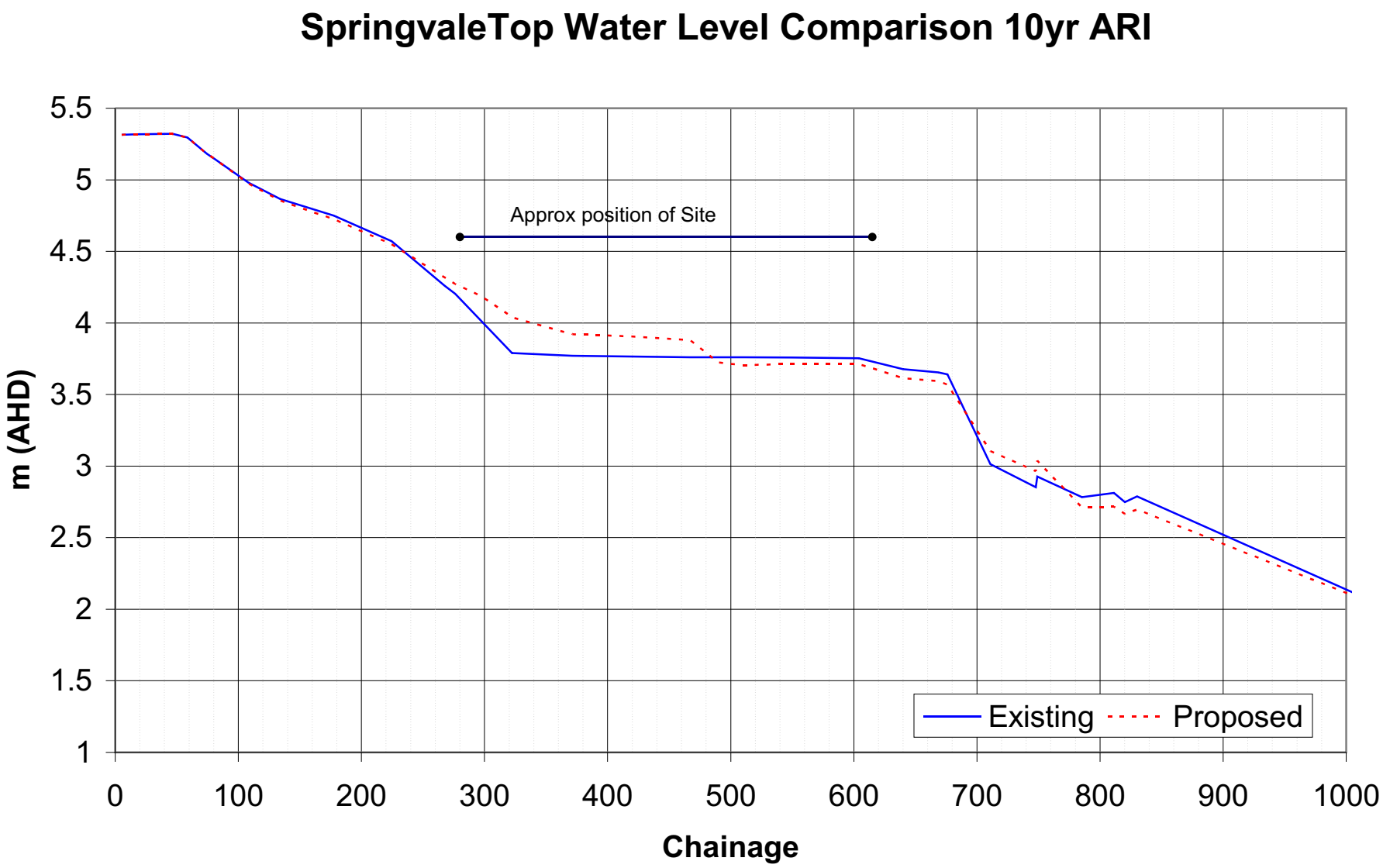


Figure D9

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Springvale Drain for 1:10 year ARI Event for Existing and Proposed Systems

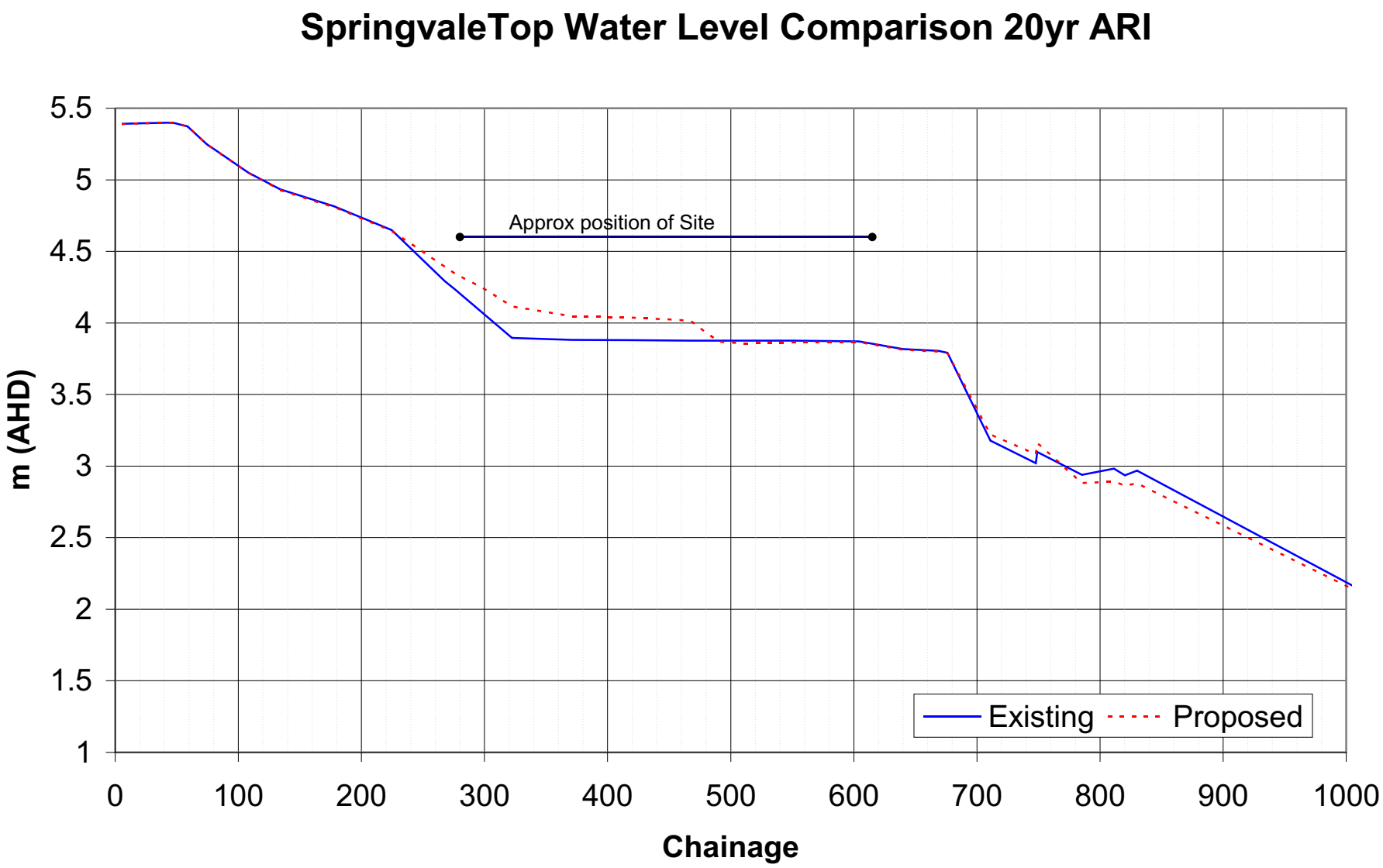


Figure D10

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Springvale Drain for 1:20 year ARI Event for Existing and Proposed Systems

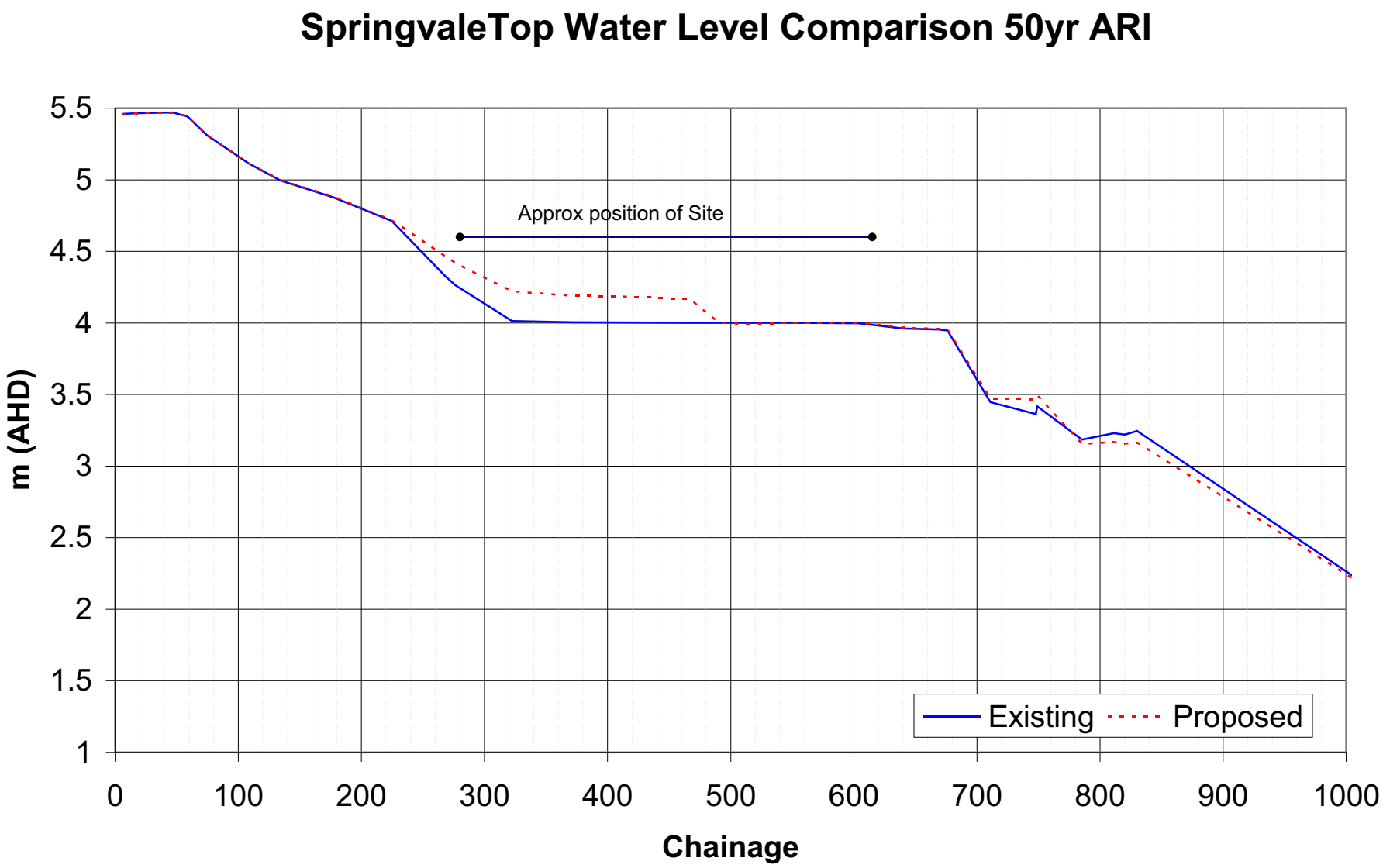


Figure D11

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Springvale Drain for 1:50 year ARI Event for Existing and Proposed Systems

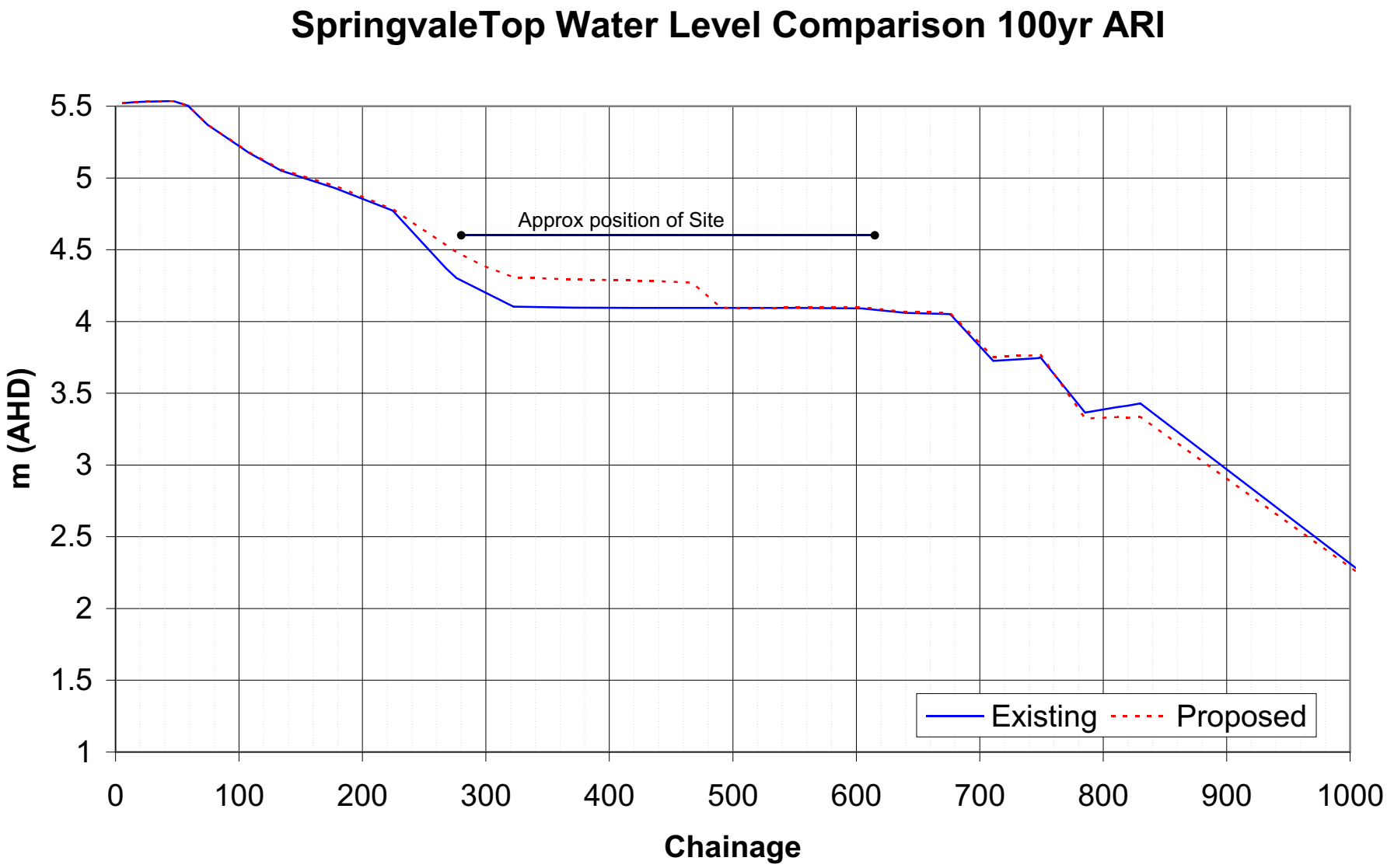


Figure D12

Note: Chainage from upstream model boundary

Source: Mike II Model

Flood Levels along Springvale Drain for 1:100 year ARI Event for Existing and Proposed Systems

Appendix E

MIKE 11 Model Cross Sections for Existing System

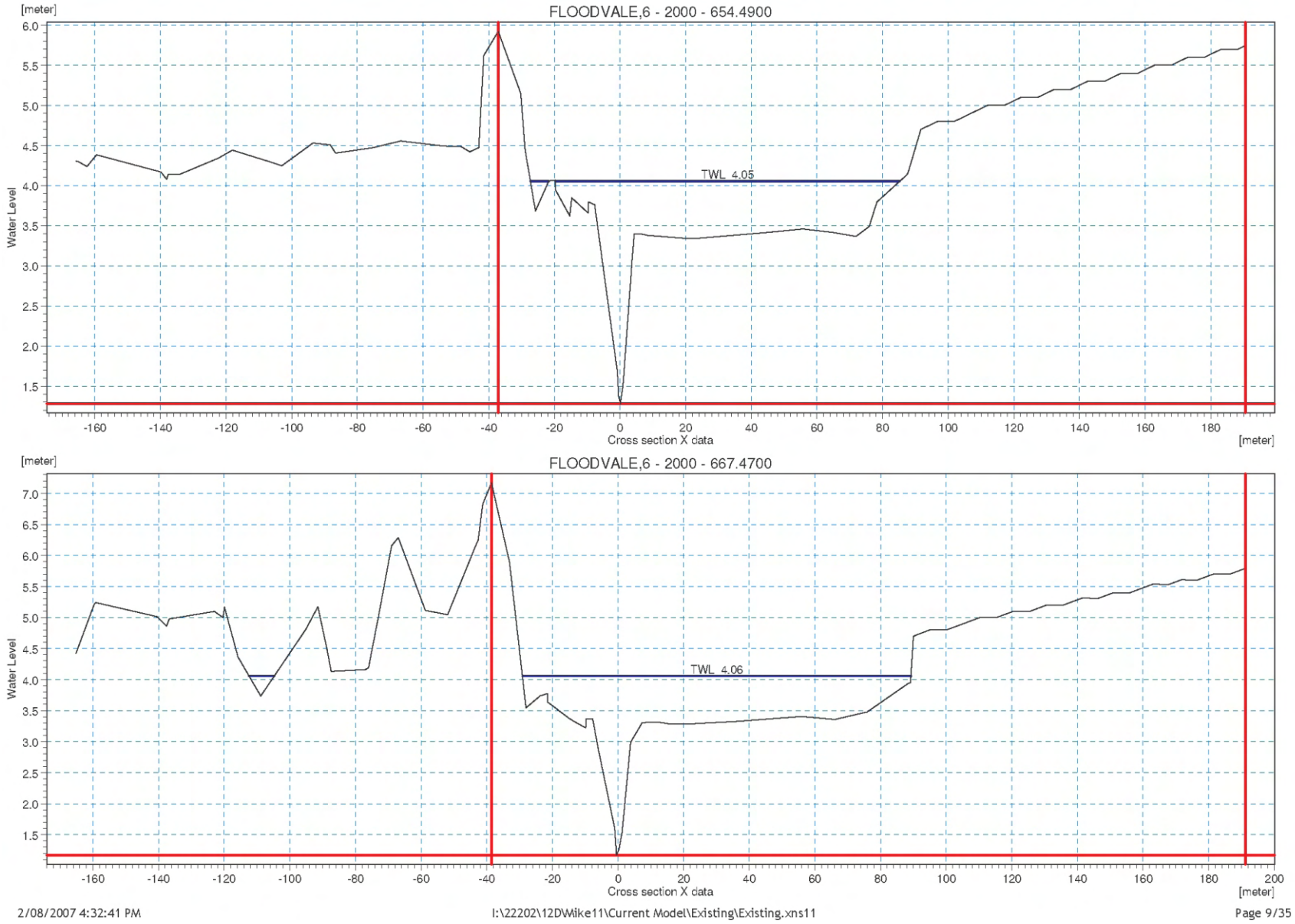


Figure E1

Note: Chainage from upstream model boundary

Source: Mike II Model

Existing Floodvale Drain Cross Sections at Chainage 133.74 and 145.63

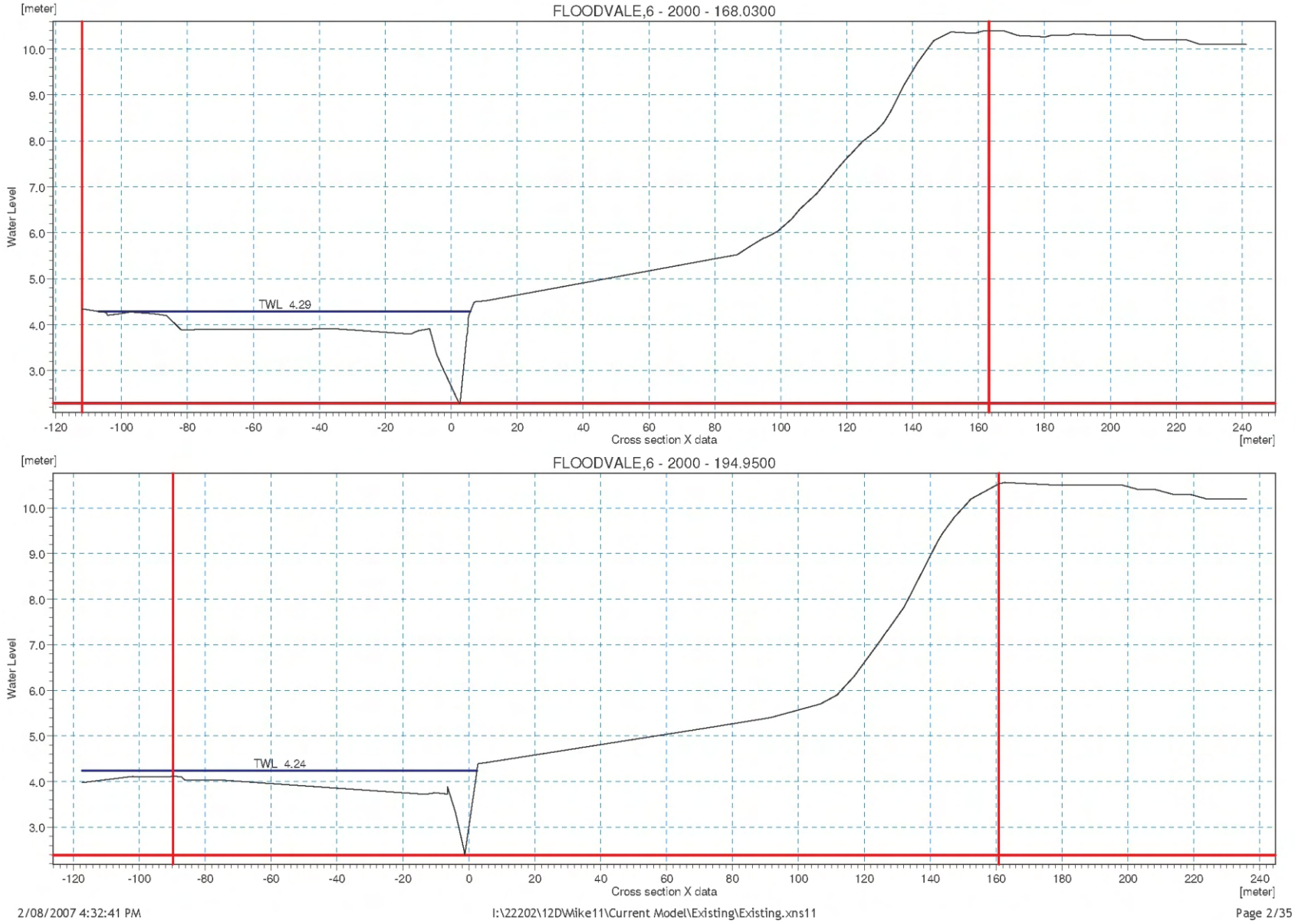


Figure E2

Note: Chainage from upstream model boundary

Source: Mike II Model

Existing Floodvale Drain Cross Sections at Chainage 168.03 and 194.95

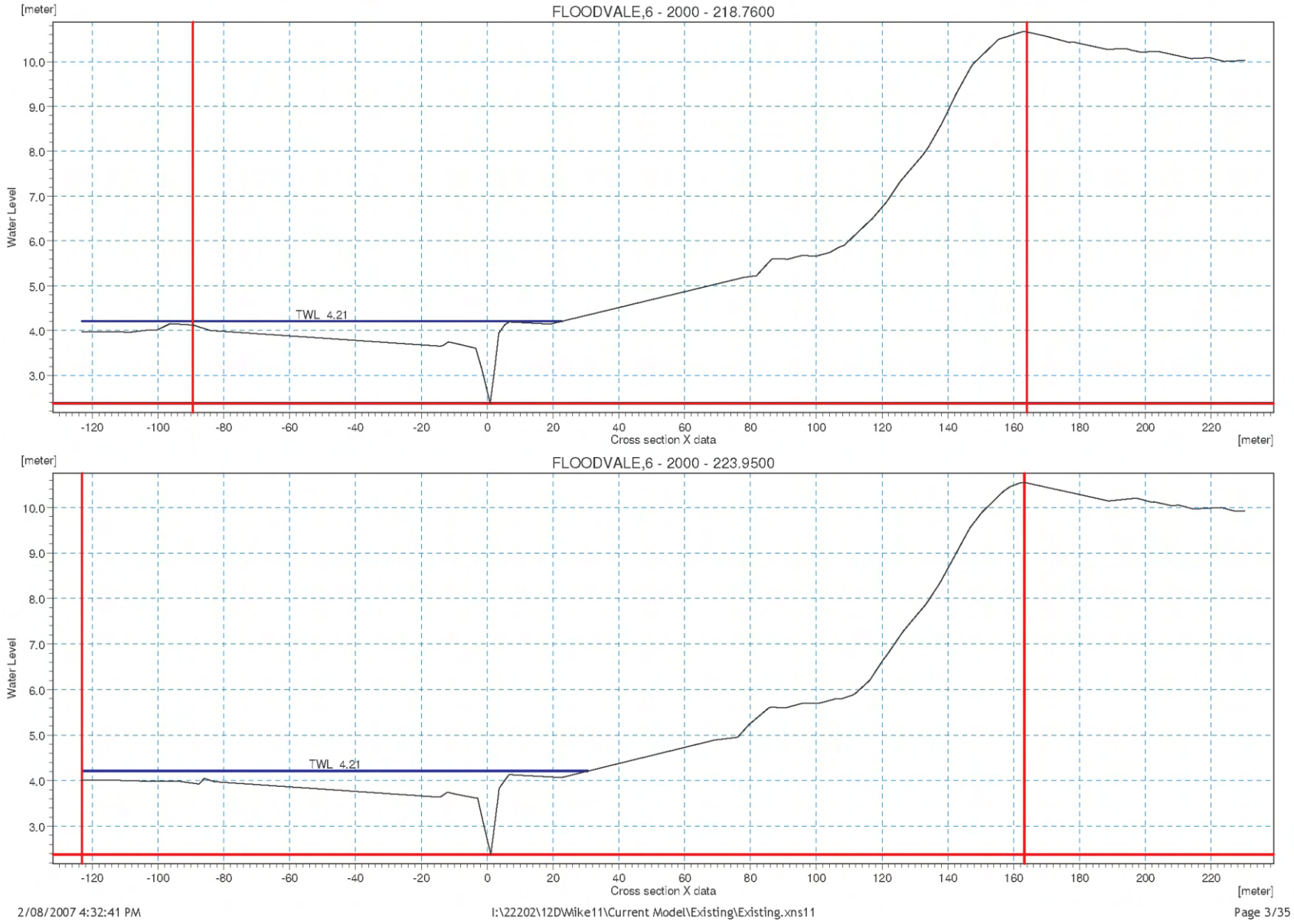


Figure E3

Existing Floodvale Drain Cross Sections at Chainage 218.76 and 223.93

Note: Chainage from upstream model boundary

Source: Mike II Model

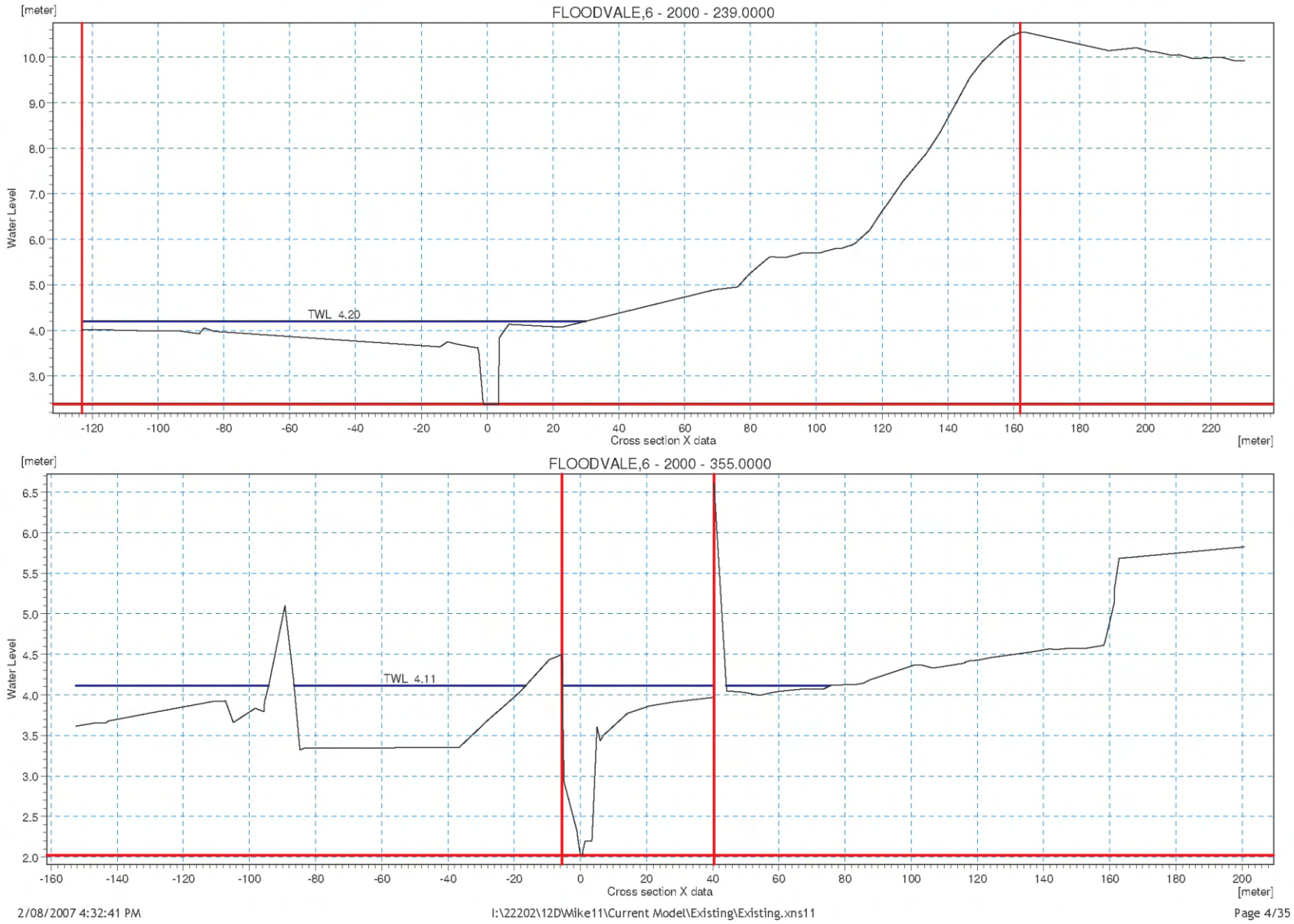


Figure E4

Existing Floodvale Drain Cross Sections at Chainage 239.00 and 355.00

Note: Chainage from upstream model boundary

Source: Mike II Model

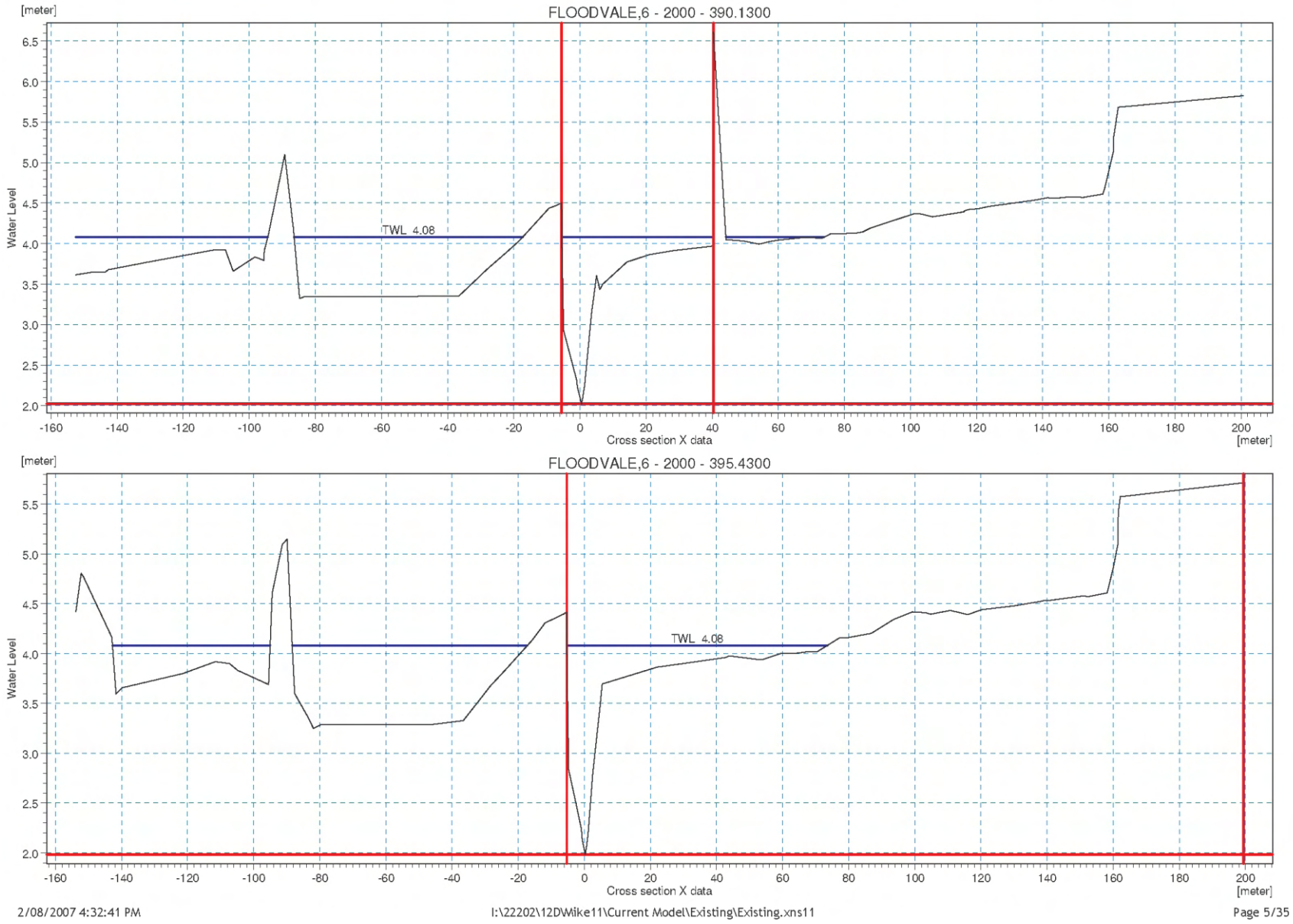


Figure E5

Existing Floodvale Drain Cross Sections at Chainage 390.13 and 395.43

Note: Chainage from upstream model boundary

Source: Mike II Model

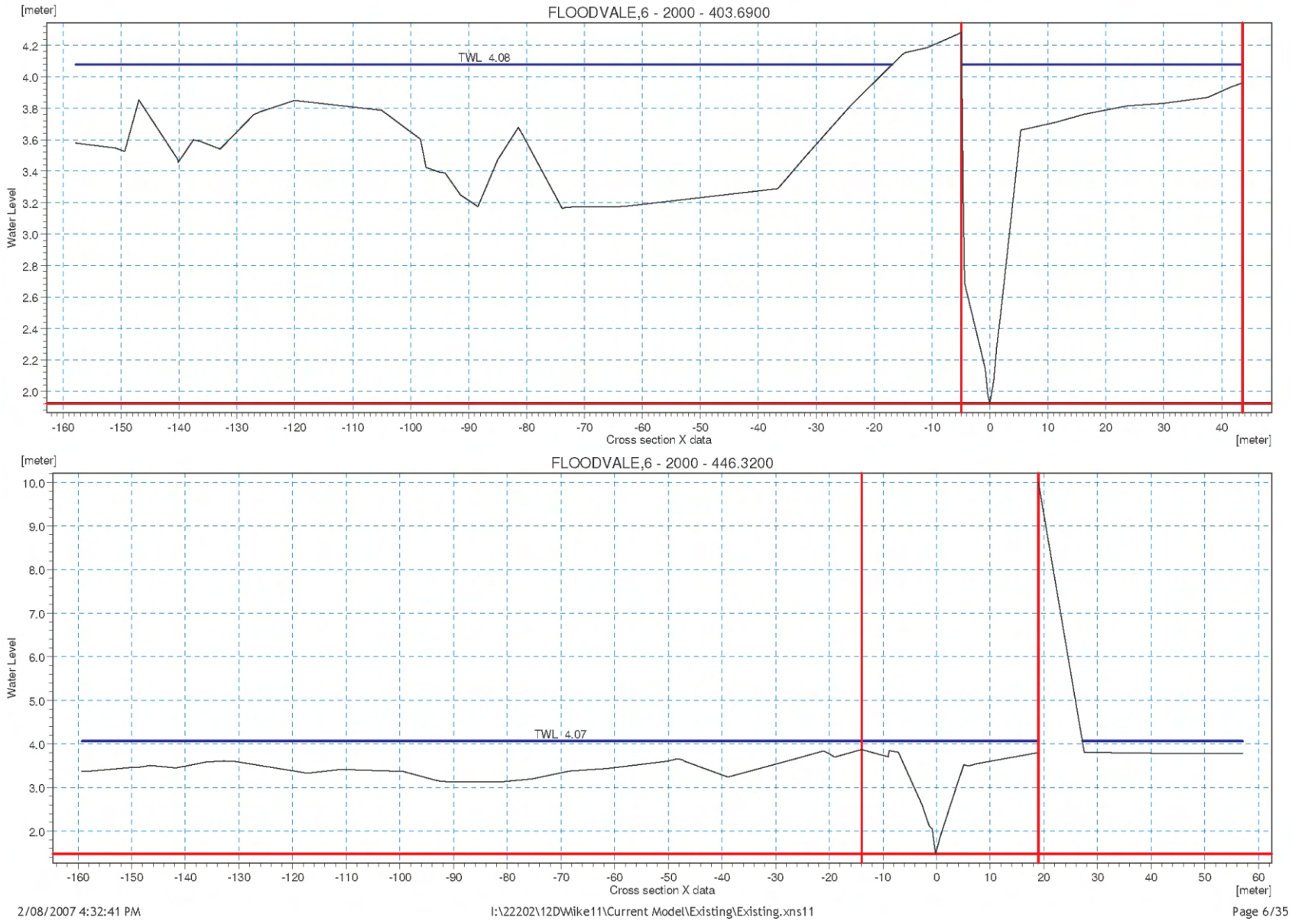


Figure E6

Existing Floodvale Drain Cross Sections at Chainage 403.69 and 446.32

Note: Chainage from upstream model boundary

Source: Mike II Model

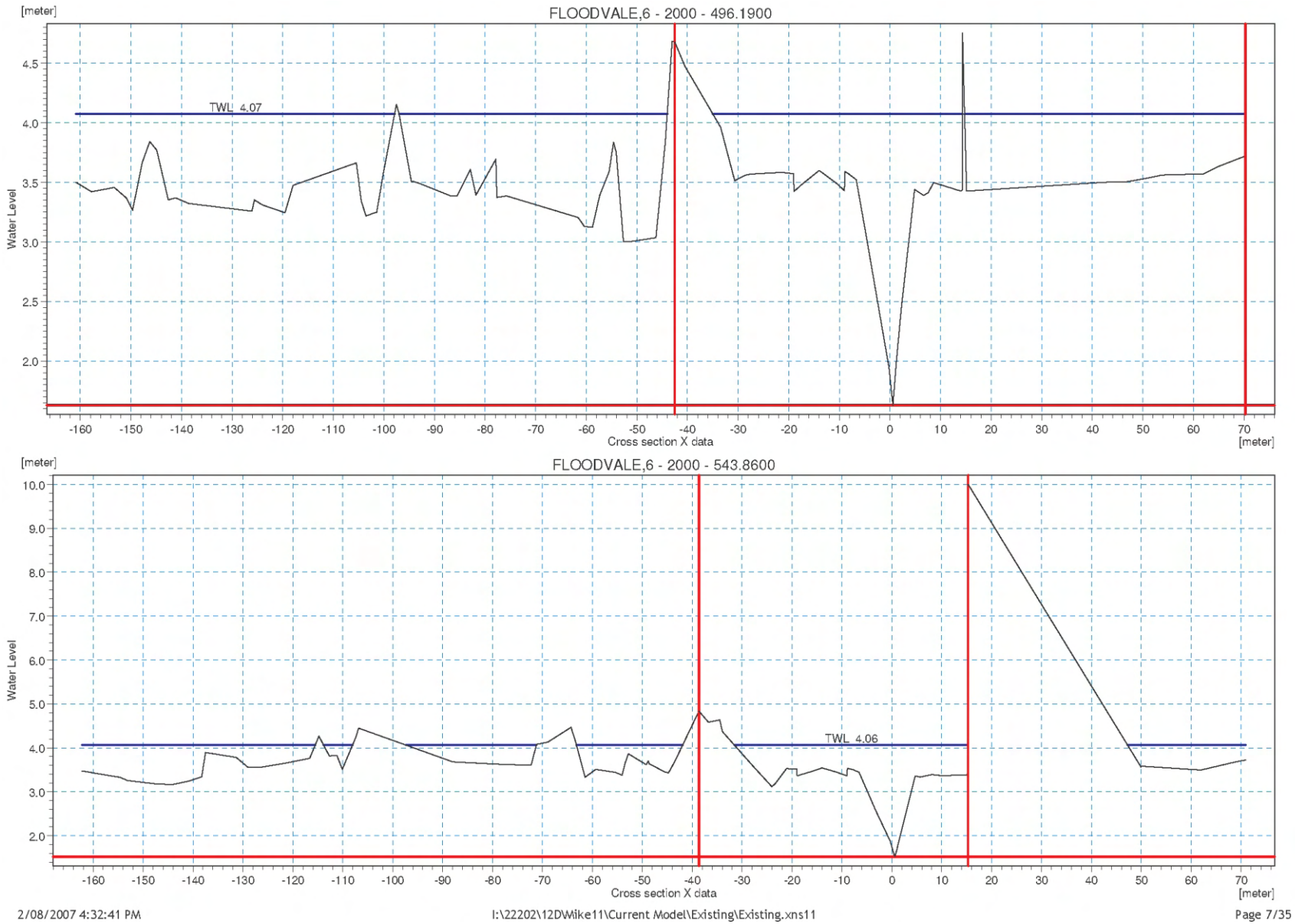


Figure E7

Note: Chainage from upstream model boundary

Source: Mike II Model

Existing Floodvale Drain Cross Sections at Chainage 496.19 and 543.86

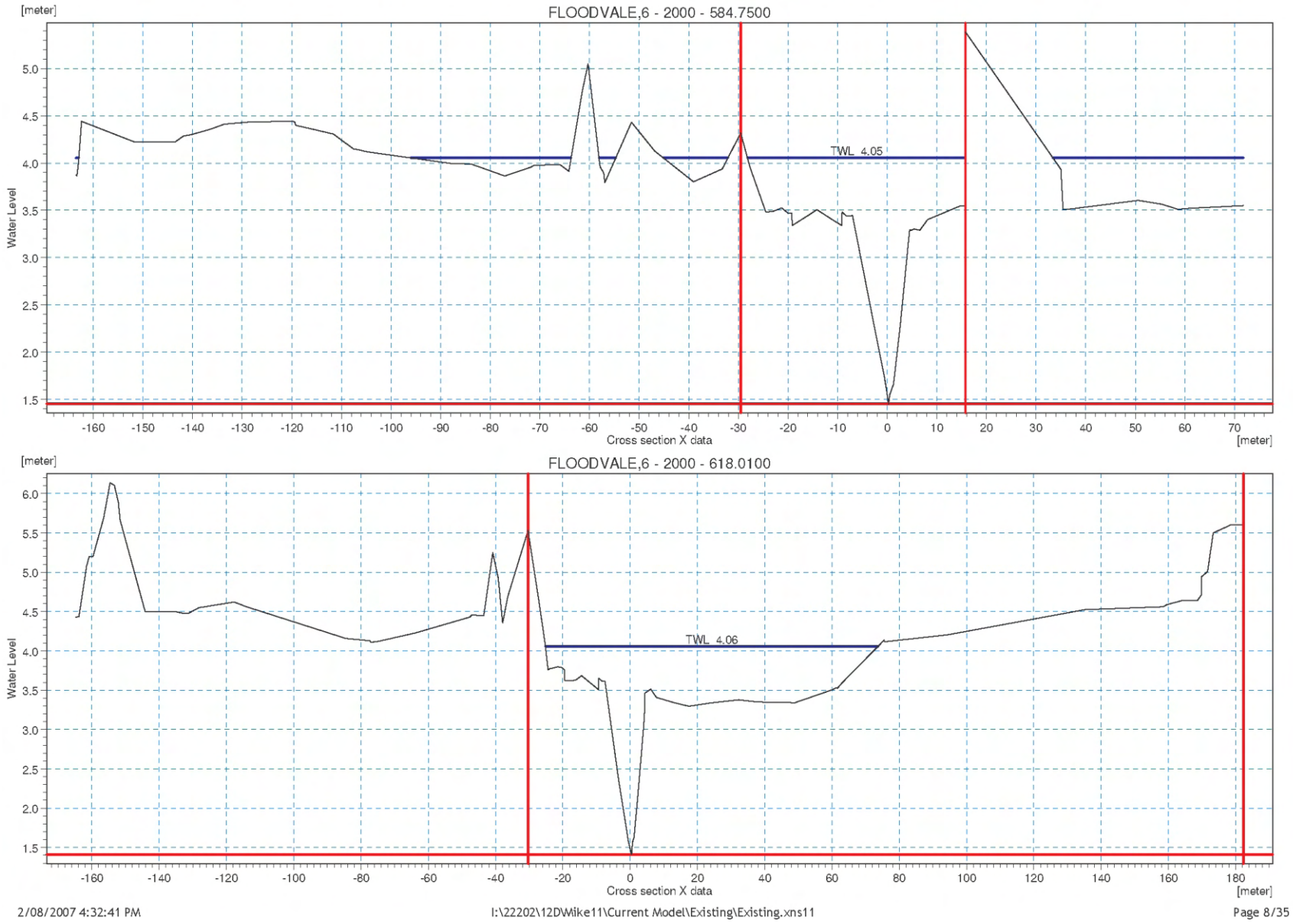


Figure E8

Note: Chainage from upstream model boundary

Source: Mike II Model

Existing Floodvale Drain Cross Sections at Chainage 584.75 and 618.01

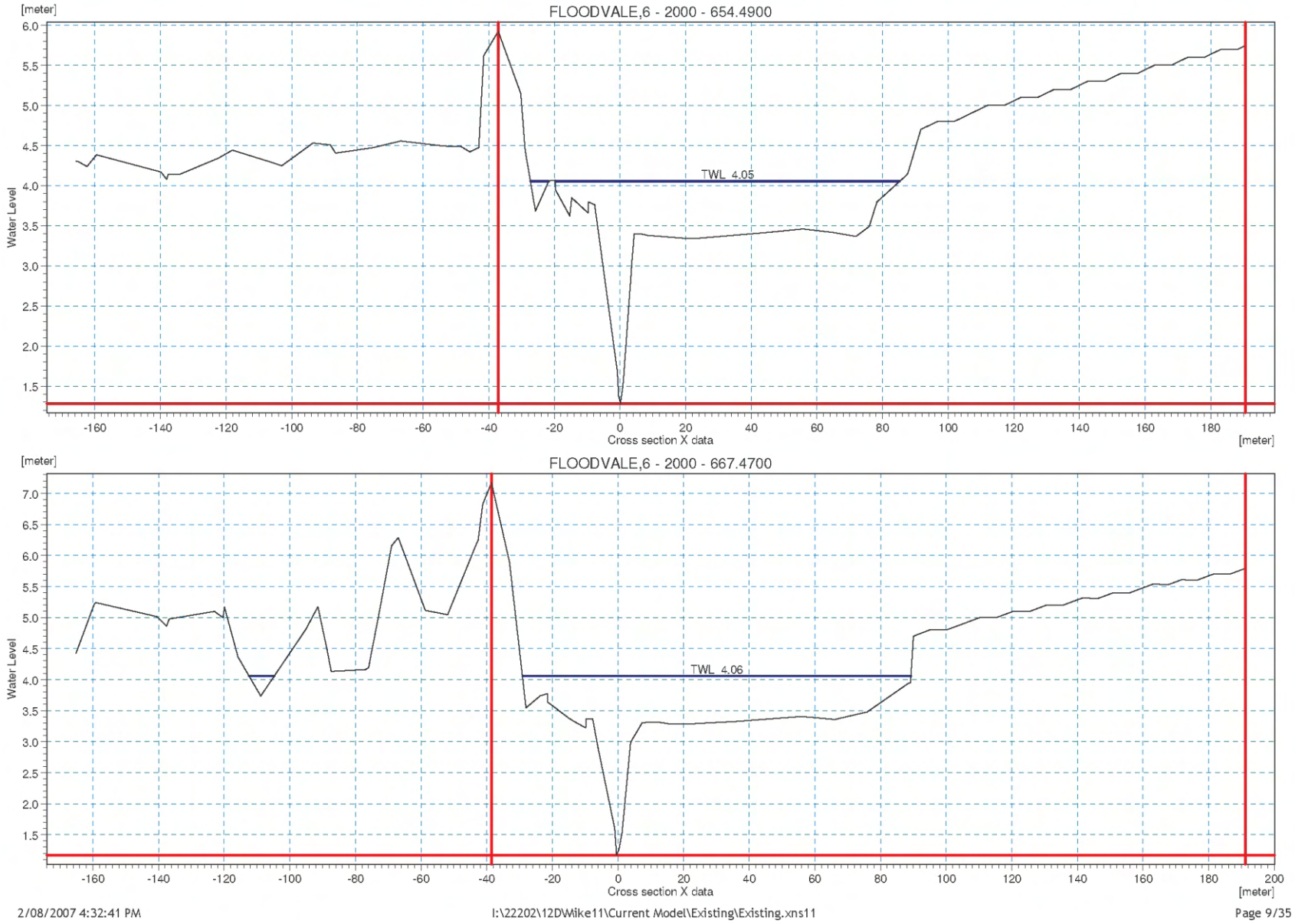


Figure E9

Note: Chainage from upstream model boundary

Source: Mike II Model

Existing Floodvale Drain Cross Sections at Chainage 654.49 and 667.47

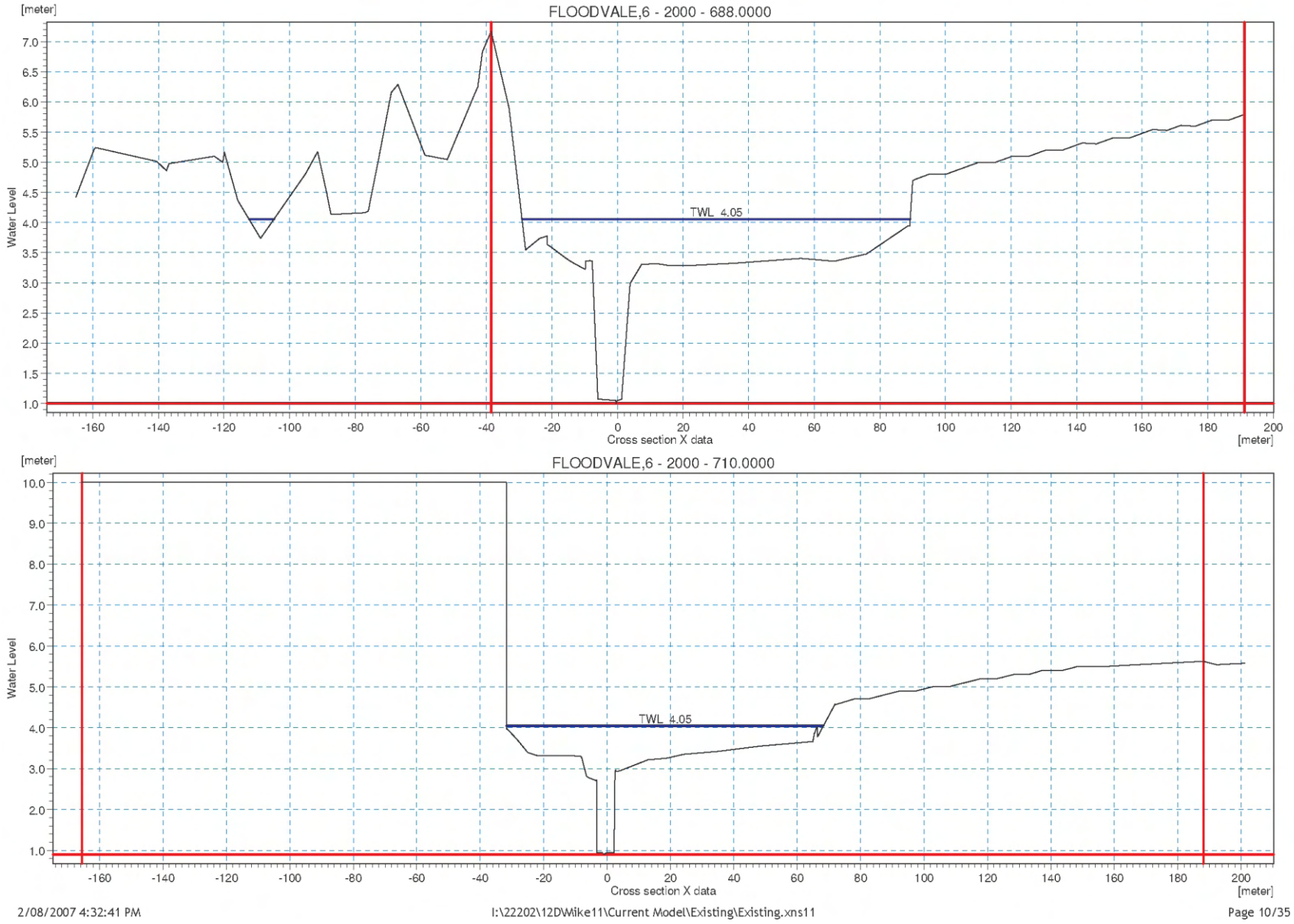


Figure E10

Note: Chainage from upstream model boundary

Source: Mike II Model

Existing Floodvale Drain Cross Sections at Chainage 688.00 and 710.00

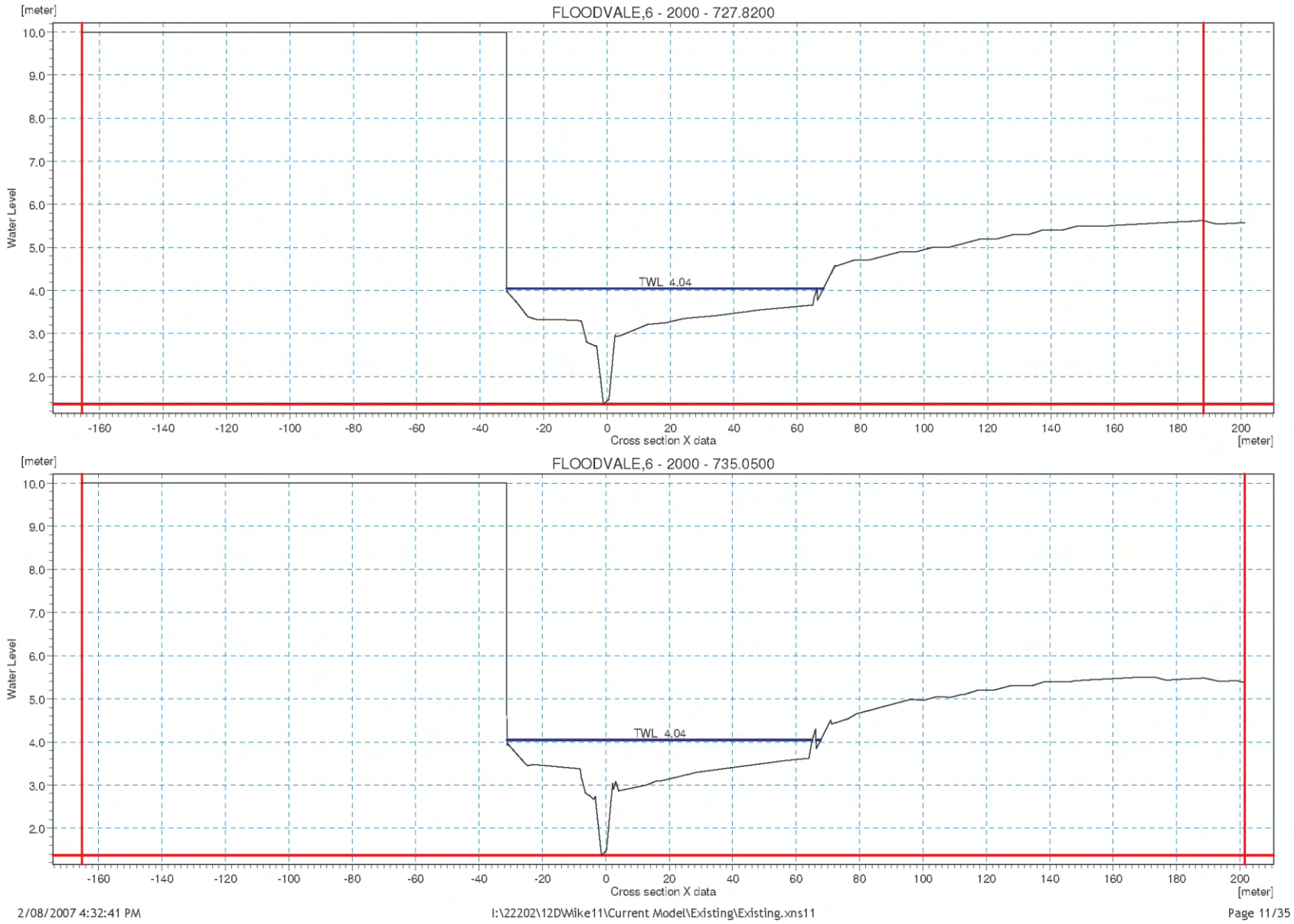


Figure E11

Existing Floodvale Drain Cross Sections at Chainage 727.82 and 735.05

Note: Chainage from upstream model boundary

Source: Mike II Model

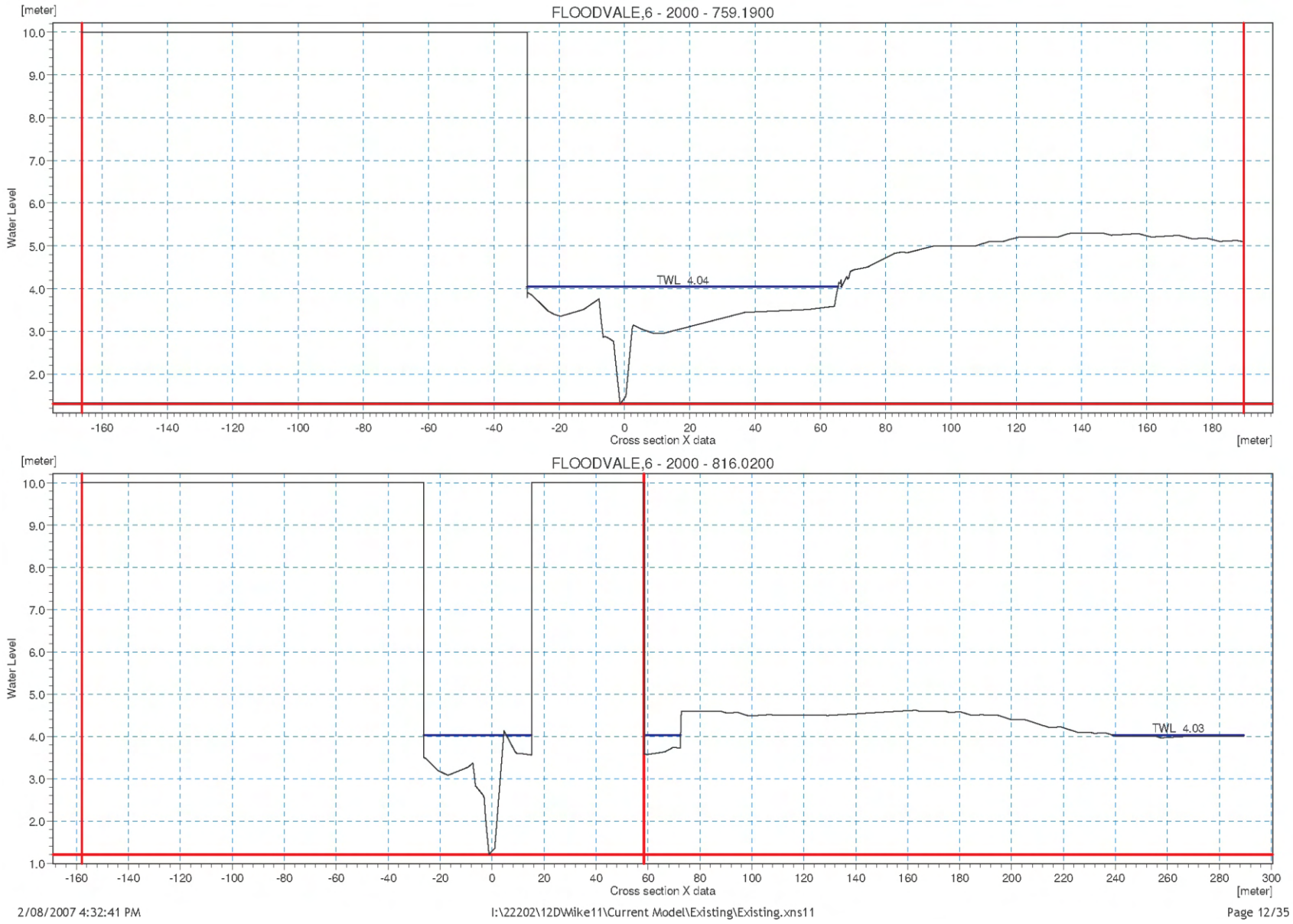


Figure E12

Existing Floodvale Drain Cross Sections at Chainage 759.19 and 816.02

Note: Chainage from upstream model boundary

Source: Mike II Model

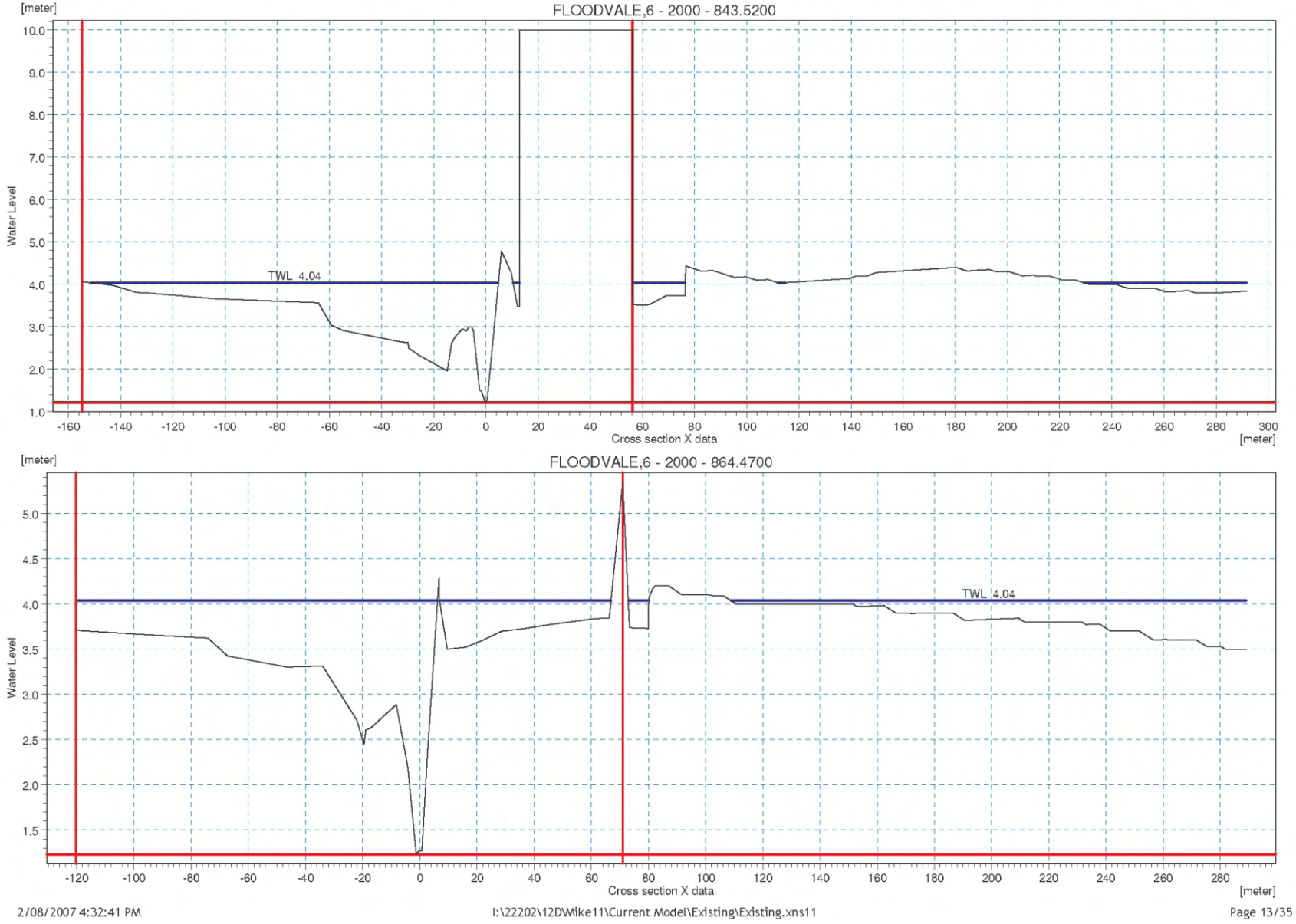


Figure E13

Existing Floodvale Drain Cross Sections at Chainage 843.52 and 864.47

Note: Chainage from upstream model boundary

Source: Mike II Model

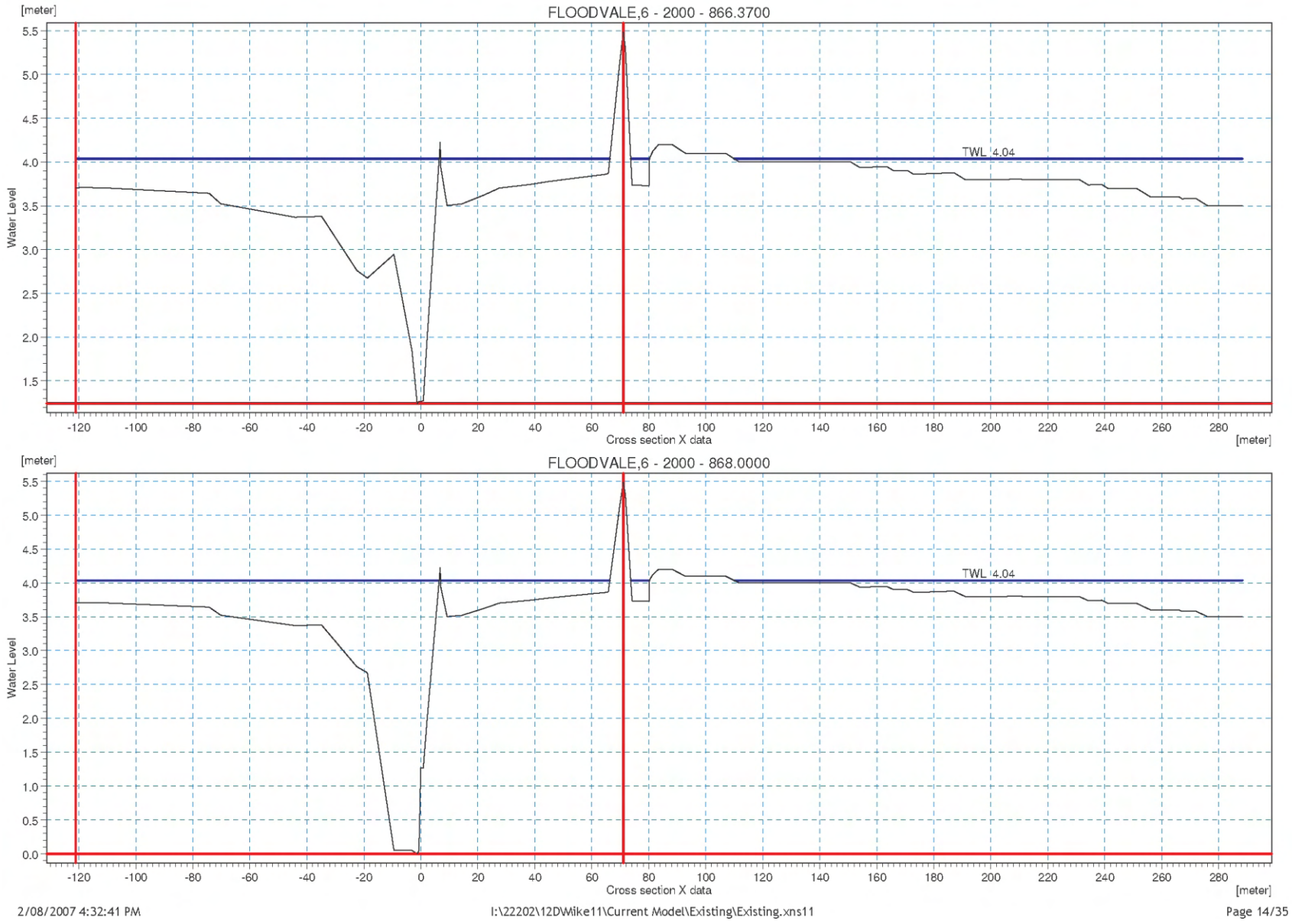


Figure E14

Note: Chainage from upstream model boundary

Source: Mike II Model

Existing Floodvale Drain Cross Sections at Chainage 866.37 and 868.00

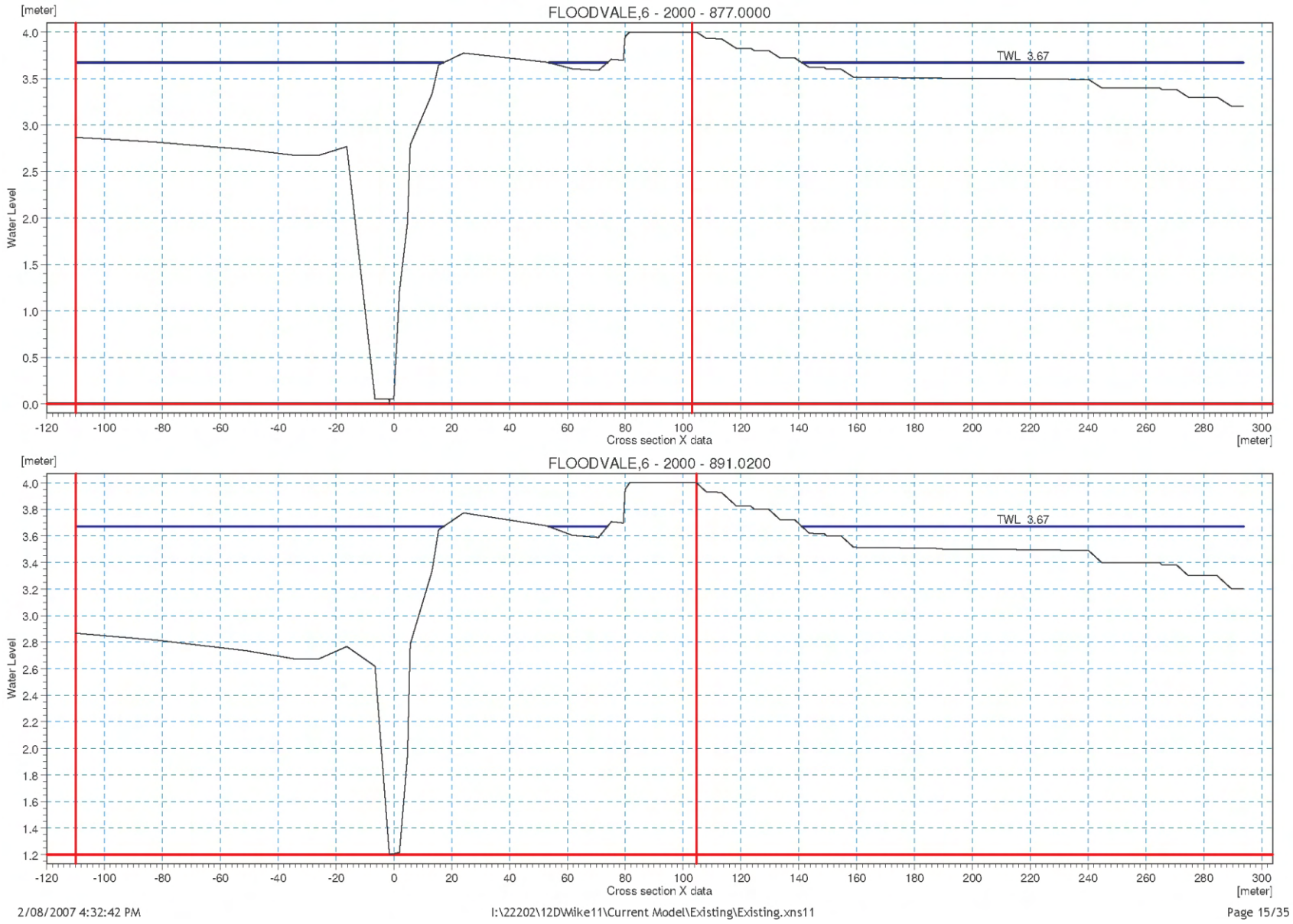


Figure E15

Existing Floodvale Drain Cross Sections at Chainage 877.00 and 891.02

Note: Chainage from upstream model boundary

Source: Mike II Model

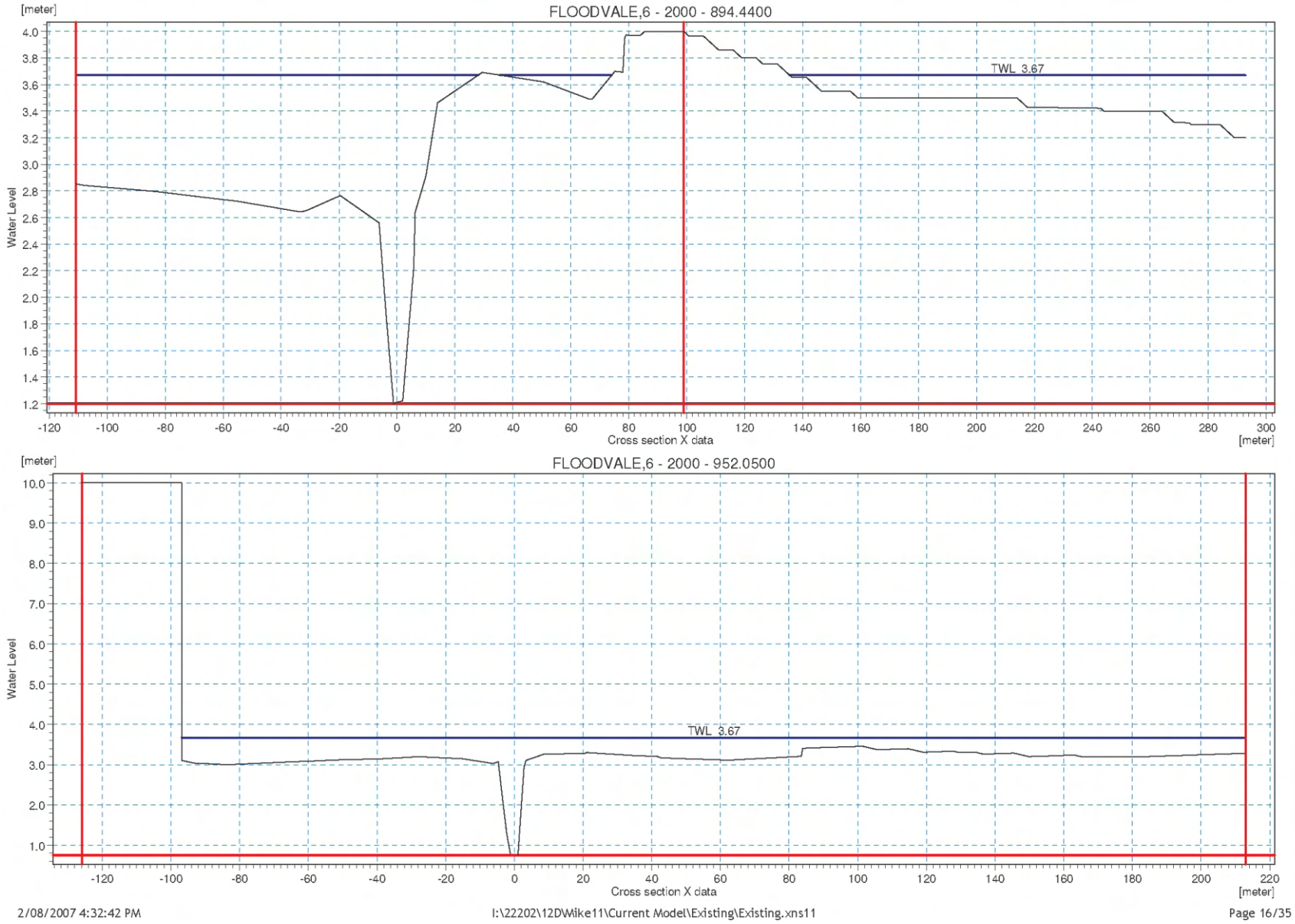


Figure E16

Existing Floodvale Drain Cross Sections at Chainage 894.44 and 952.05

Note: Chainage from upstream model boundary

Source: Mike II Model

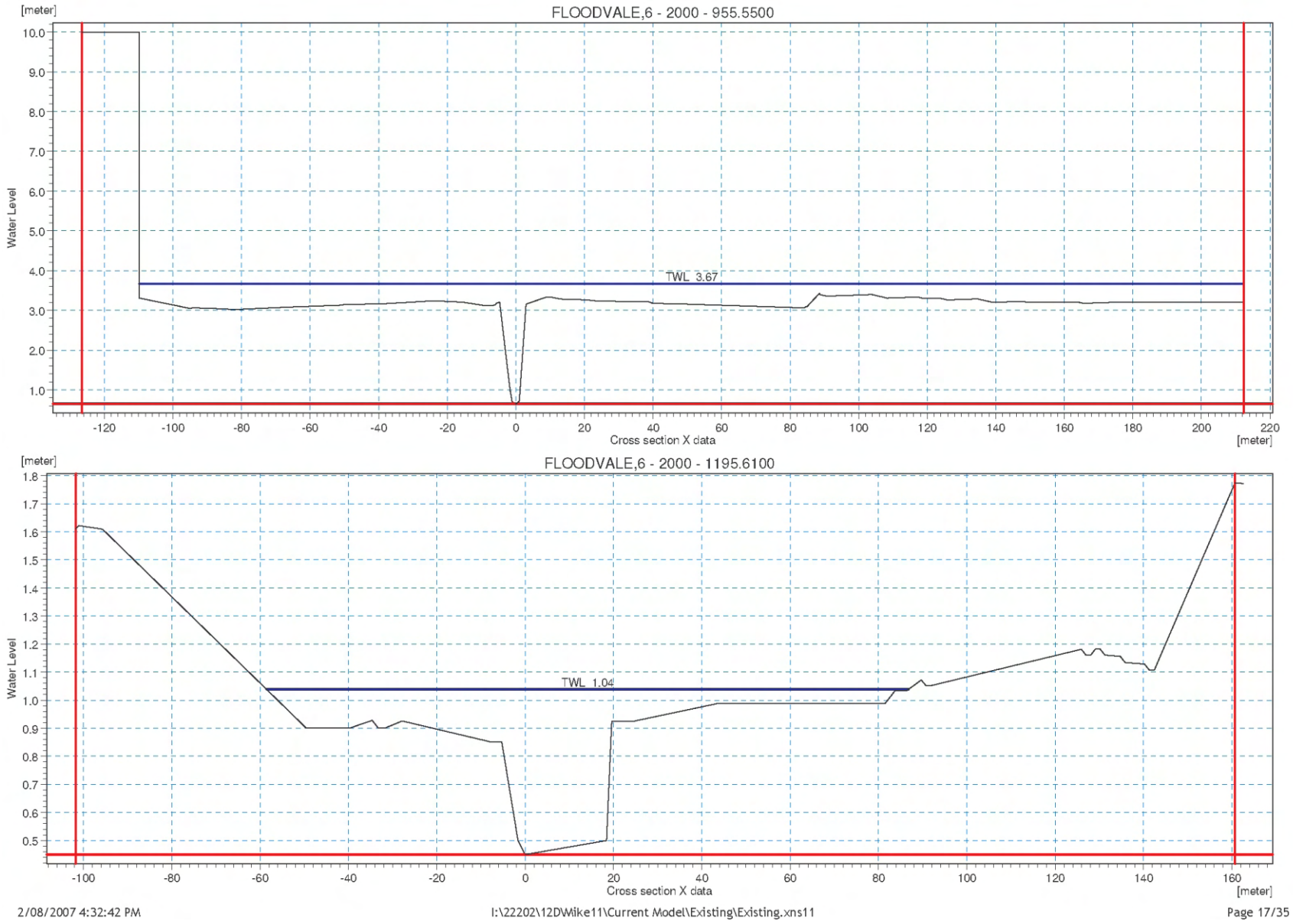


Figure E17

Existing Floodvale Drain Cross Sections at Chainage 955.55 and 1196.61

Note: Chainage from upstream model boundary

Source: Mike II Model

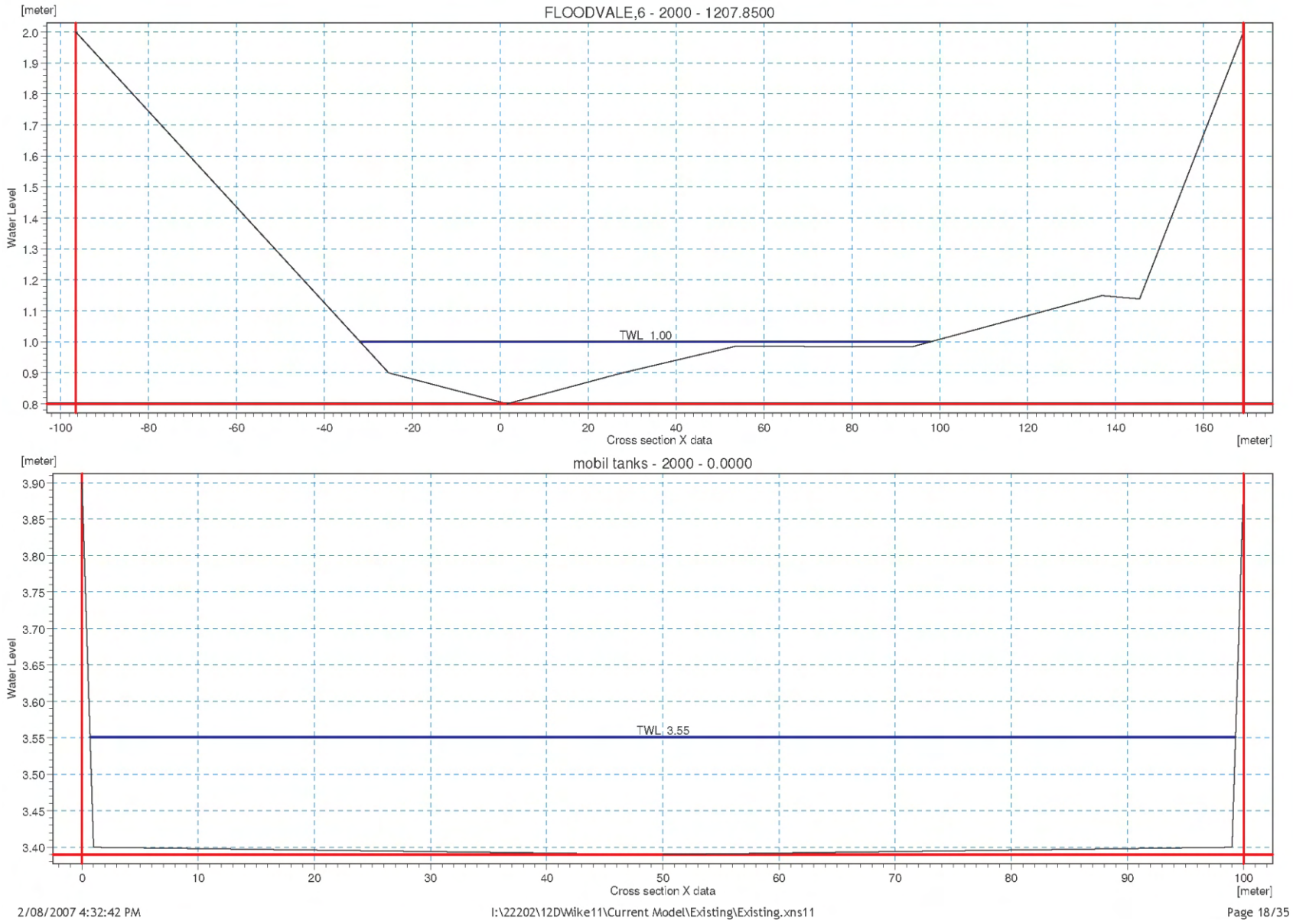


Figure E18

Existing Floodvale Drain Cross Sections at Chainage 1207.85 and Mobil Tanks Link 0

Note: Chainage from upstream model boundary

Source: Mike II Model

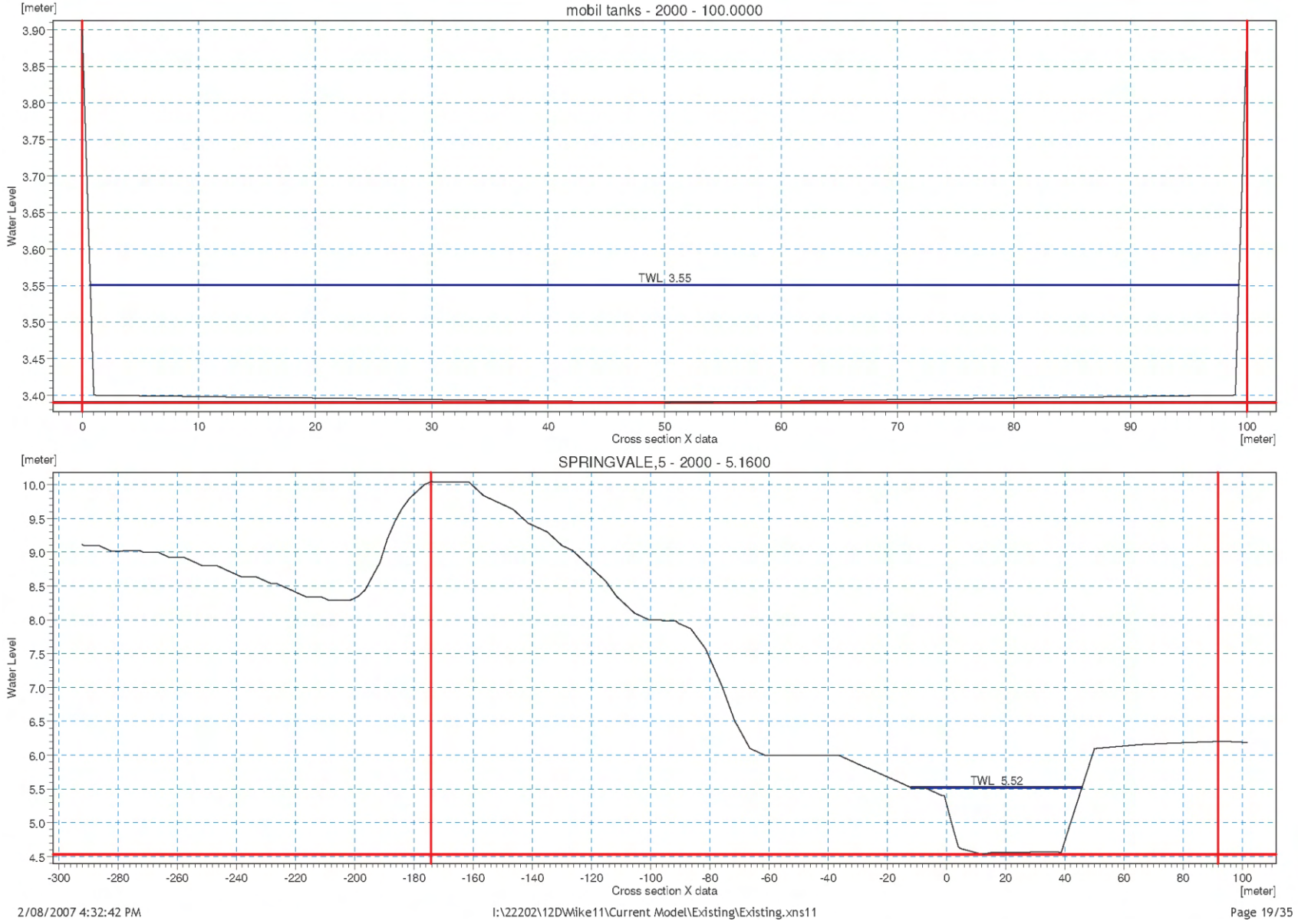


Figure E19

Existing Mobil Tanks Link 100 and Springvale Drain Cross Section at Chainage 5.16

Note: Chainage from upstream model boundary

Source: Mike II Model

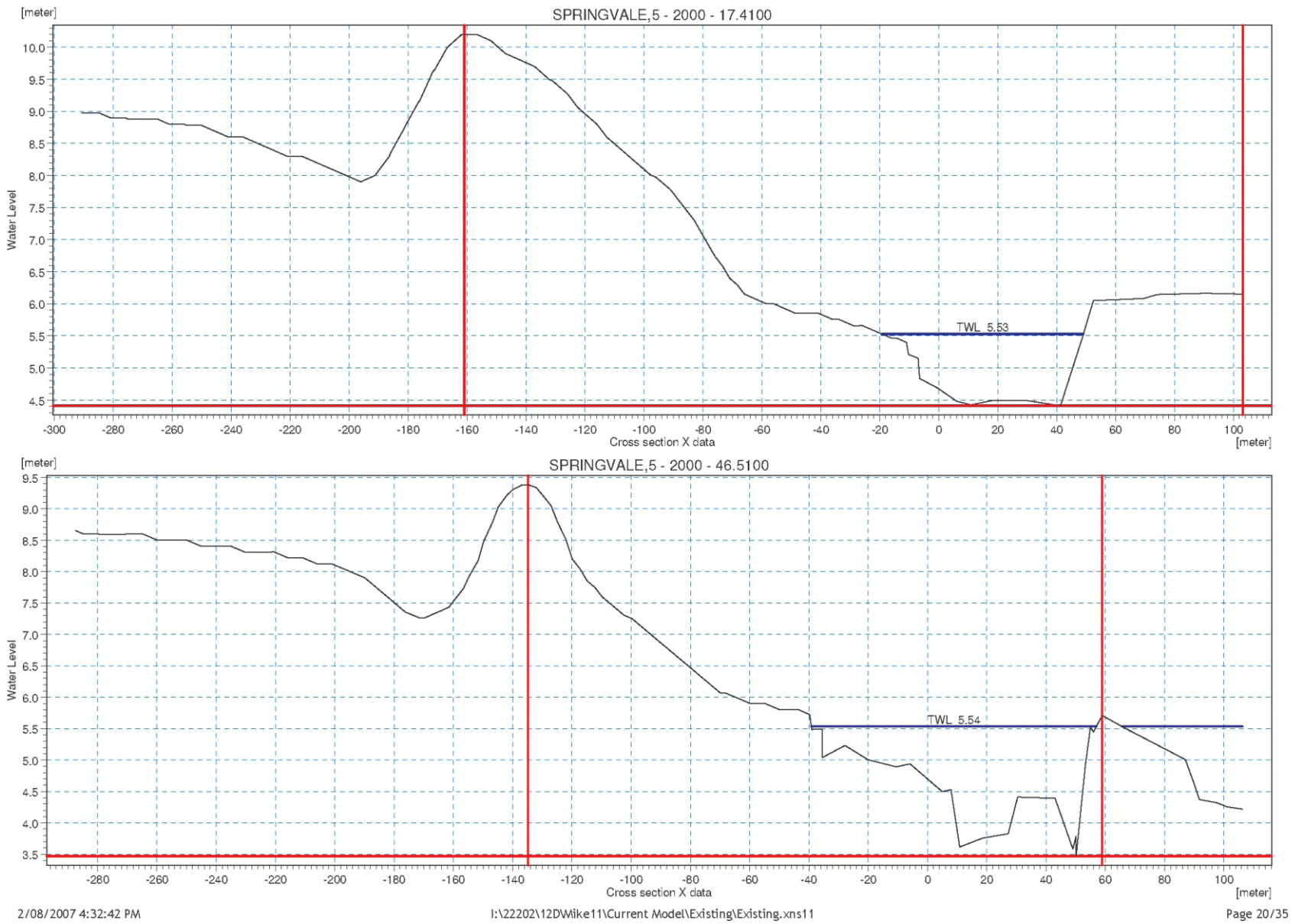


Figure E20

Existing Floodvale Drain Cross Sections at Chainage 17.41 and 46.51

Note: Chainage from upstream model boundary

Source: Mike II Model

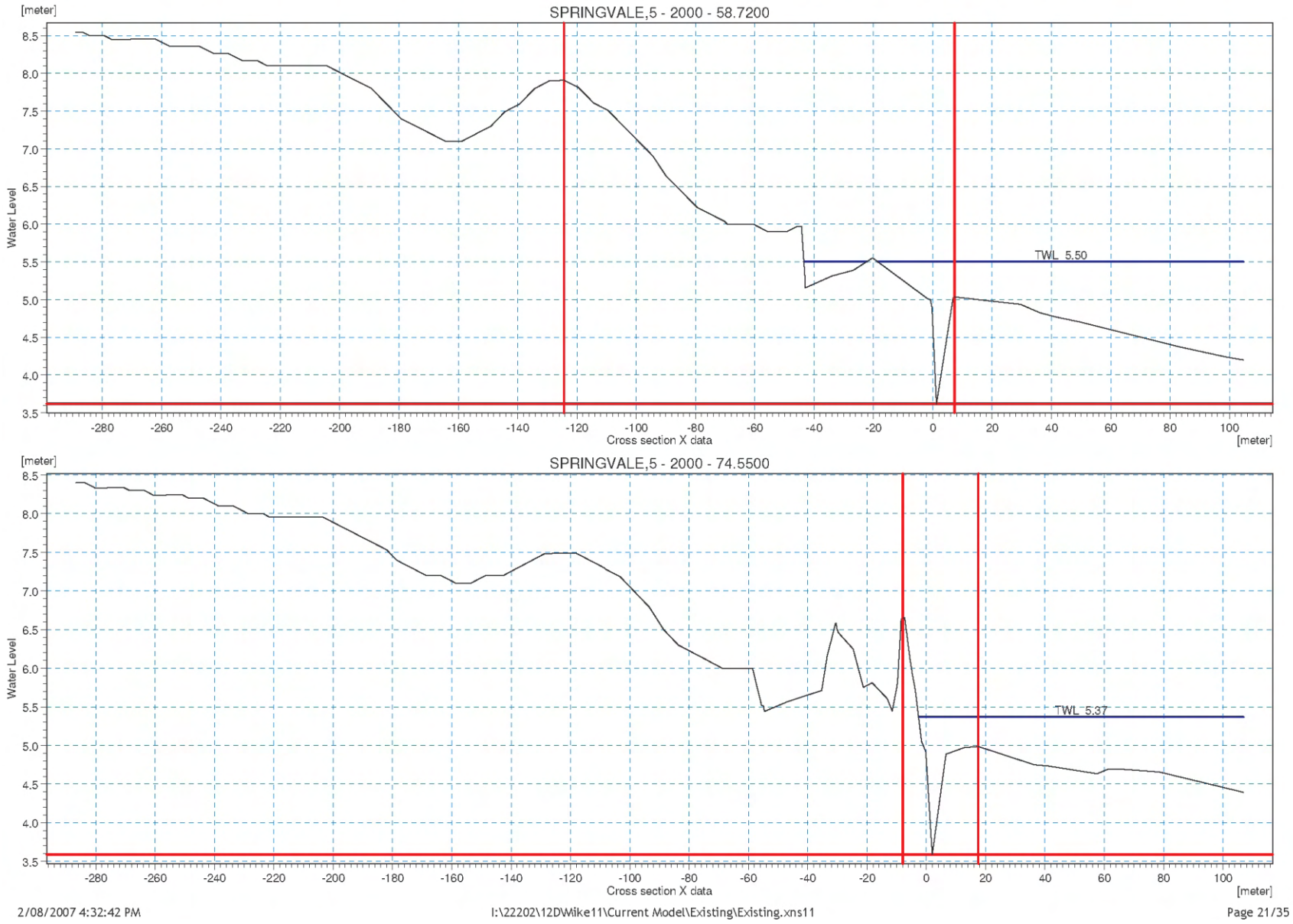


Figure E21

Note: Chainage from upstream model boundary

Source: Mike II Model

Existing Floodvale Drain Cross Sections at Chainage 58.72 and 74.55

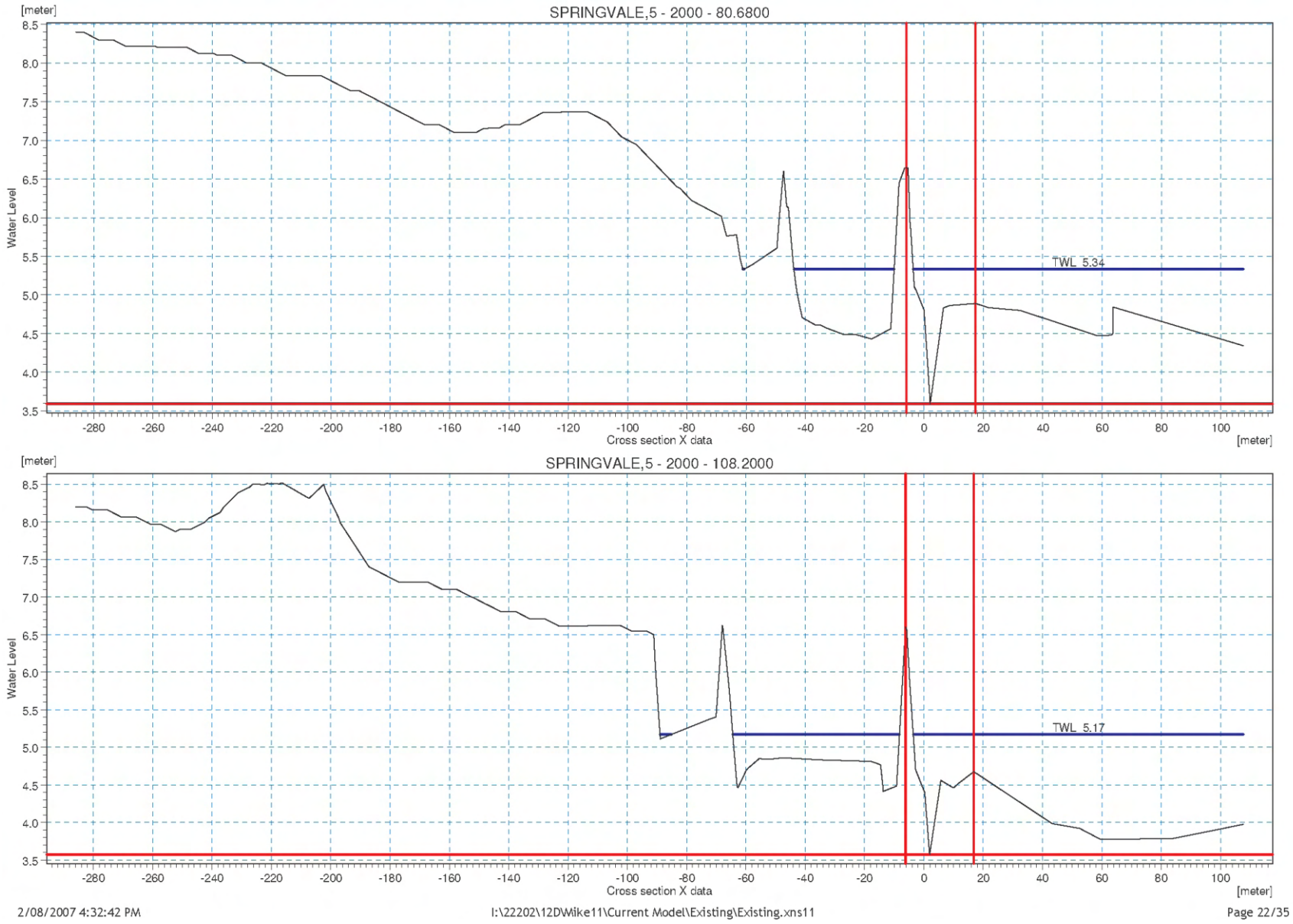


Figure E22

Existing Floodvale Drain Cross Sections at Chainage 80.68 and 108.20

Note: Chainage from upstream model boundary

Source: Mike II Model

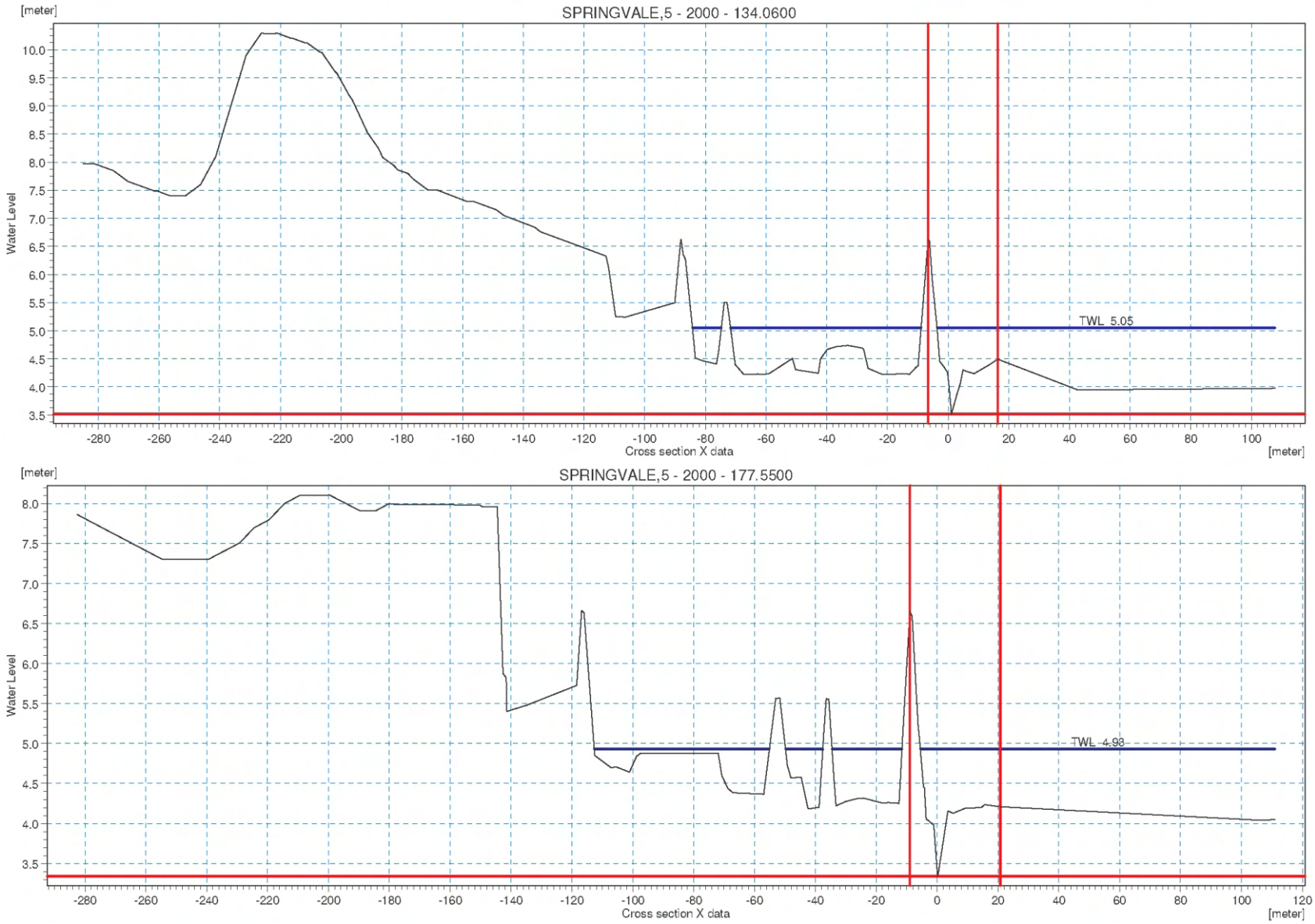


Figure E23

Note: Chainage from upstream model boundary

Source: Mike II Model

Existing Floodvale Drain Cross Sections at Chainage 134.06 and 177.55

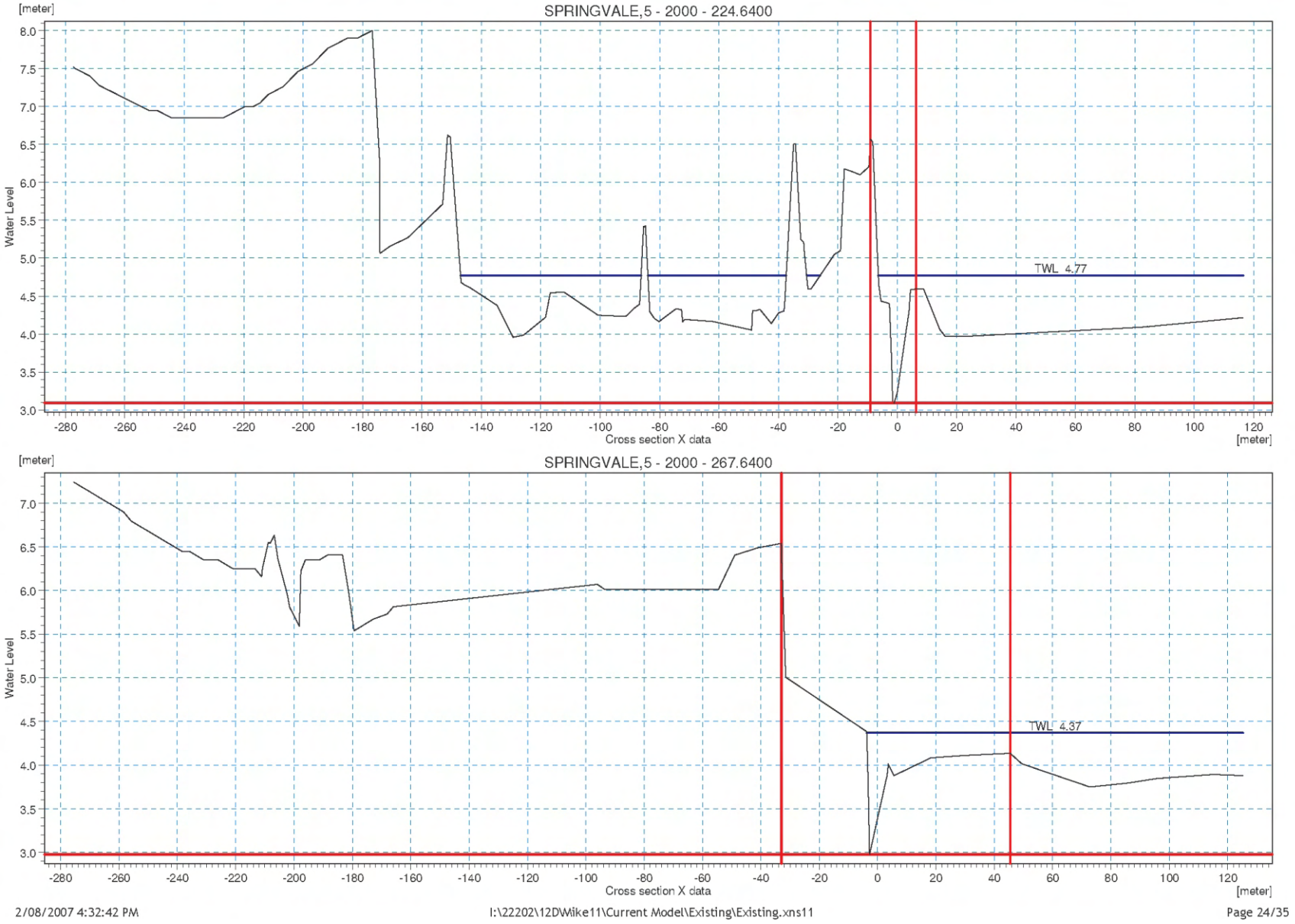


Figure E24

Existing Floodvale Drain Cross Sections at Chainage 224.54 and 267.64

Note: Chainage from upstream model boundary

Source: Mike II Model

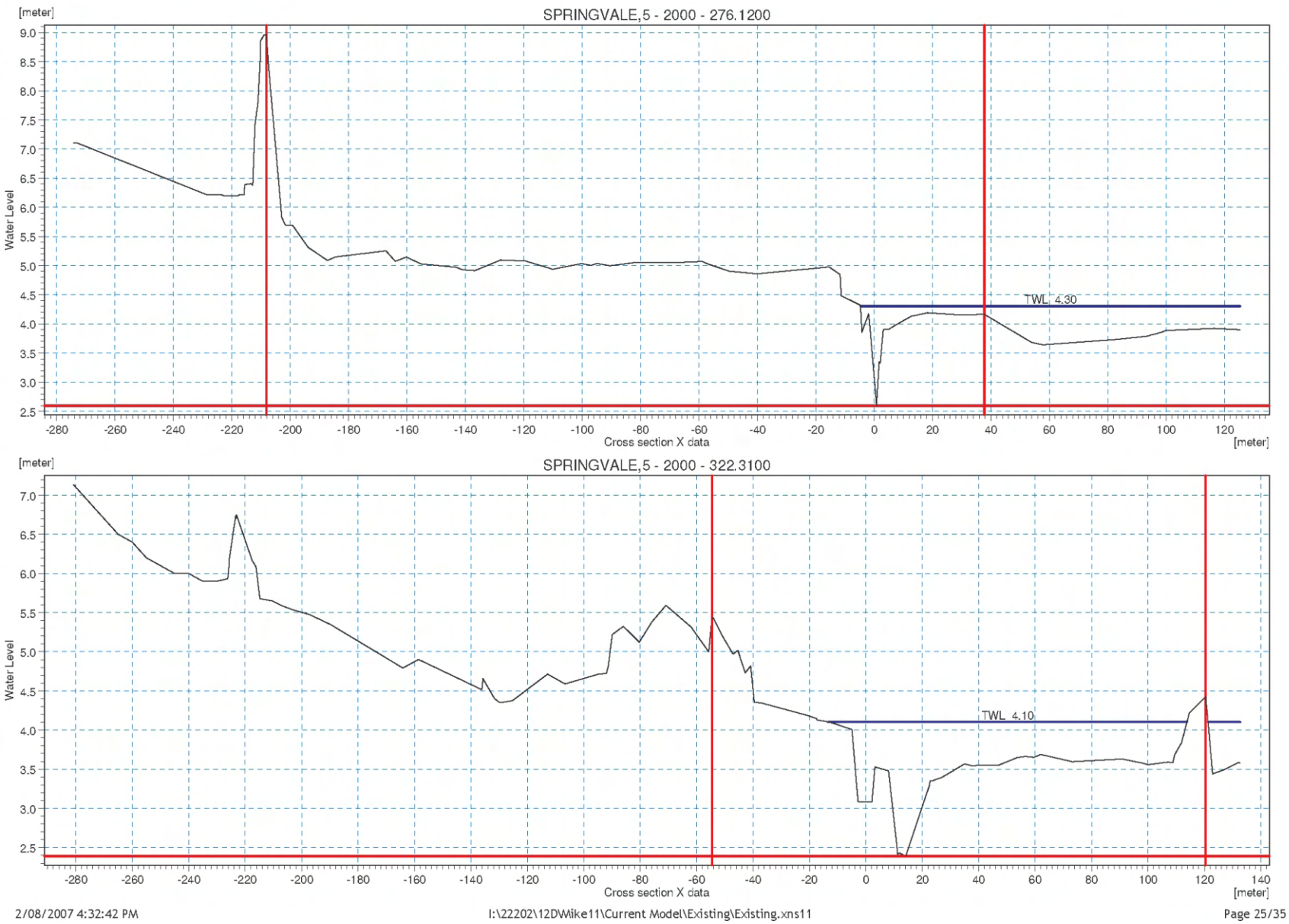


Figure E25

Existing Floodvale Drain Cross Sections at Chainage 276.12 and 322.31

Note: Chainage from upstream model boundary

Source: Mike II Model

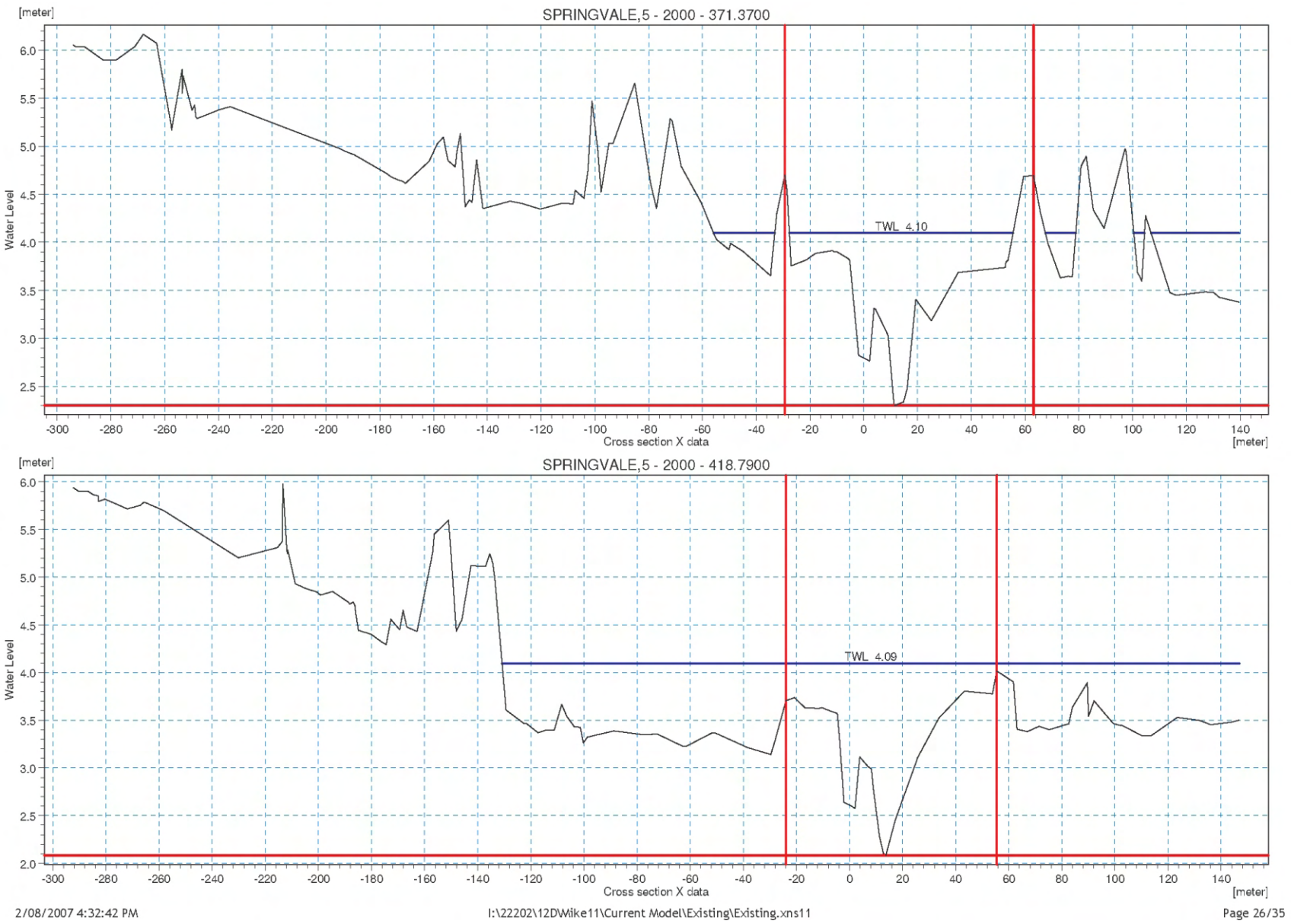


Figure E26

Existing Floodvale Drain Cross Sections at Chainage 371.37 and 418.74

Note: Chainage from upstream model boundary

Source: Mike II Model

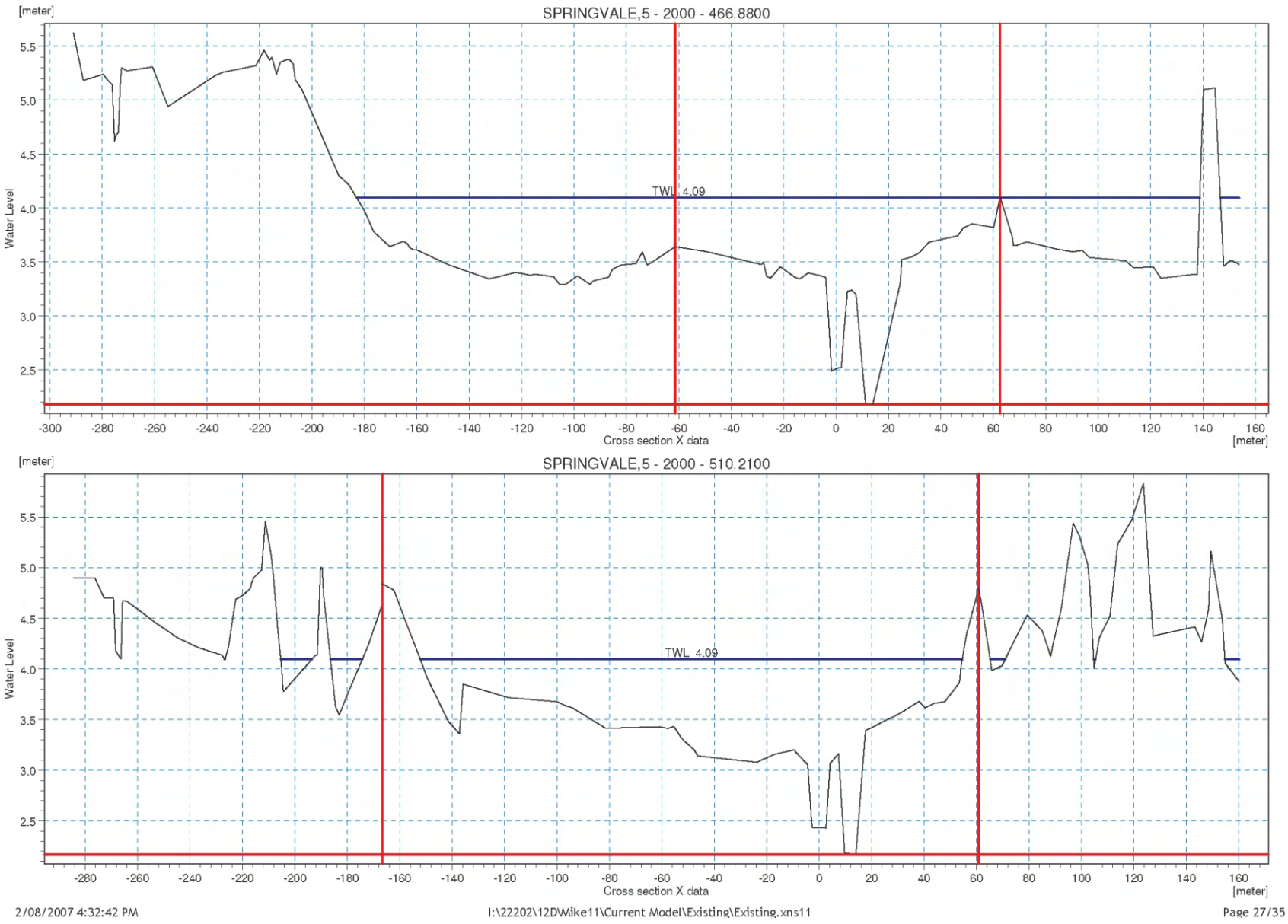


Figure E27

Existing Floodvale Drain Cross Sections at Chainage 466.88 and 510.21

Note: Chainage from upstream model boundary

Source: Mike II Model

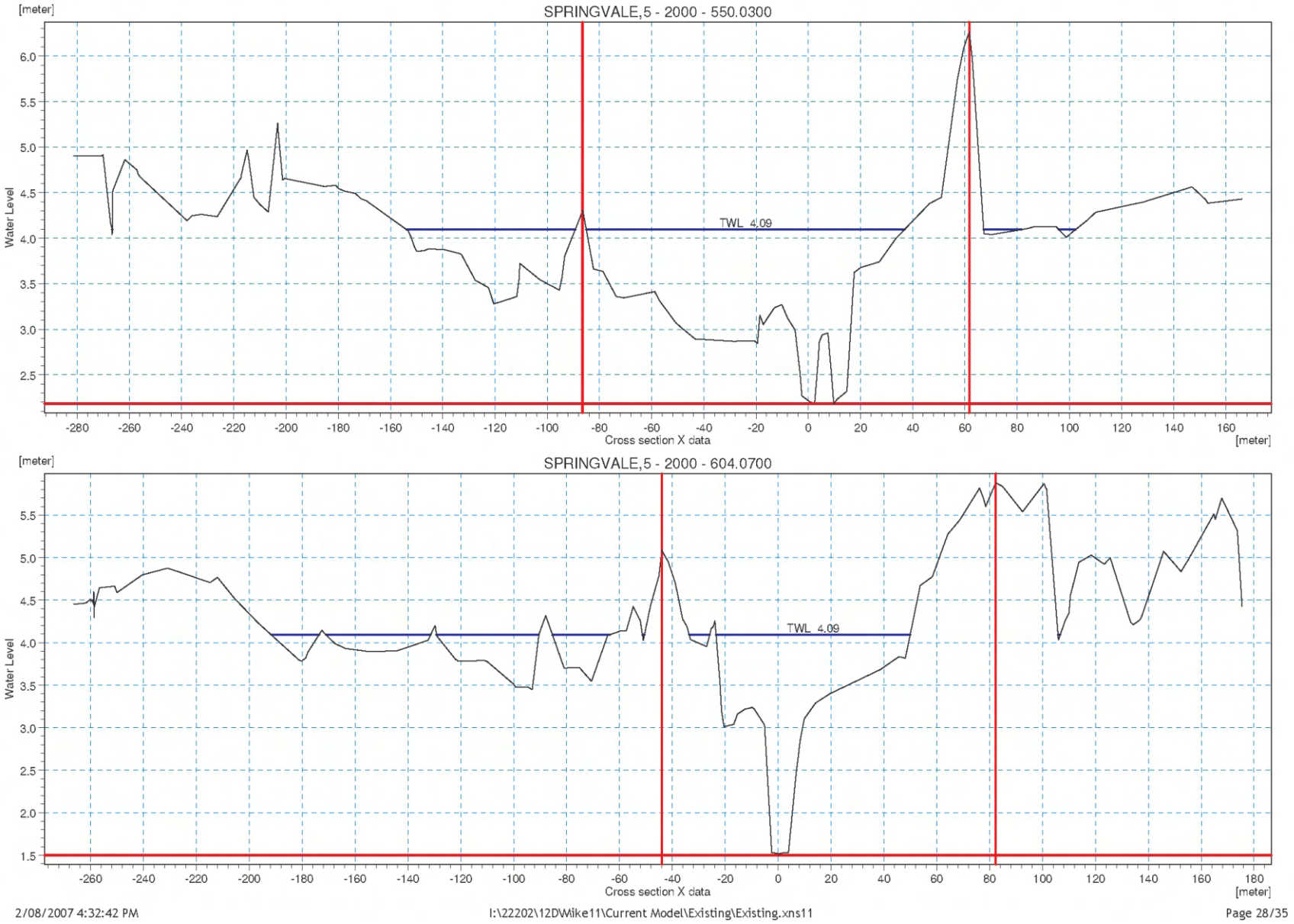


Figure E28

Existing Floodvale Drain Cross Sections at Chainage 550.03 and 604.07

Note: Chainage from upstream model boundary

Source: Mike II Model

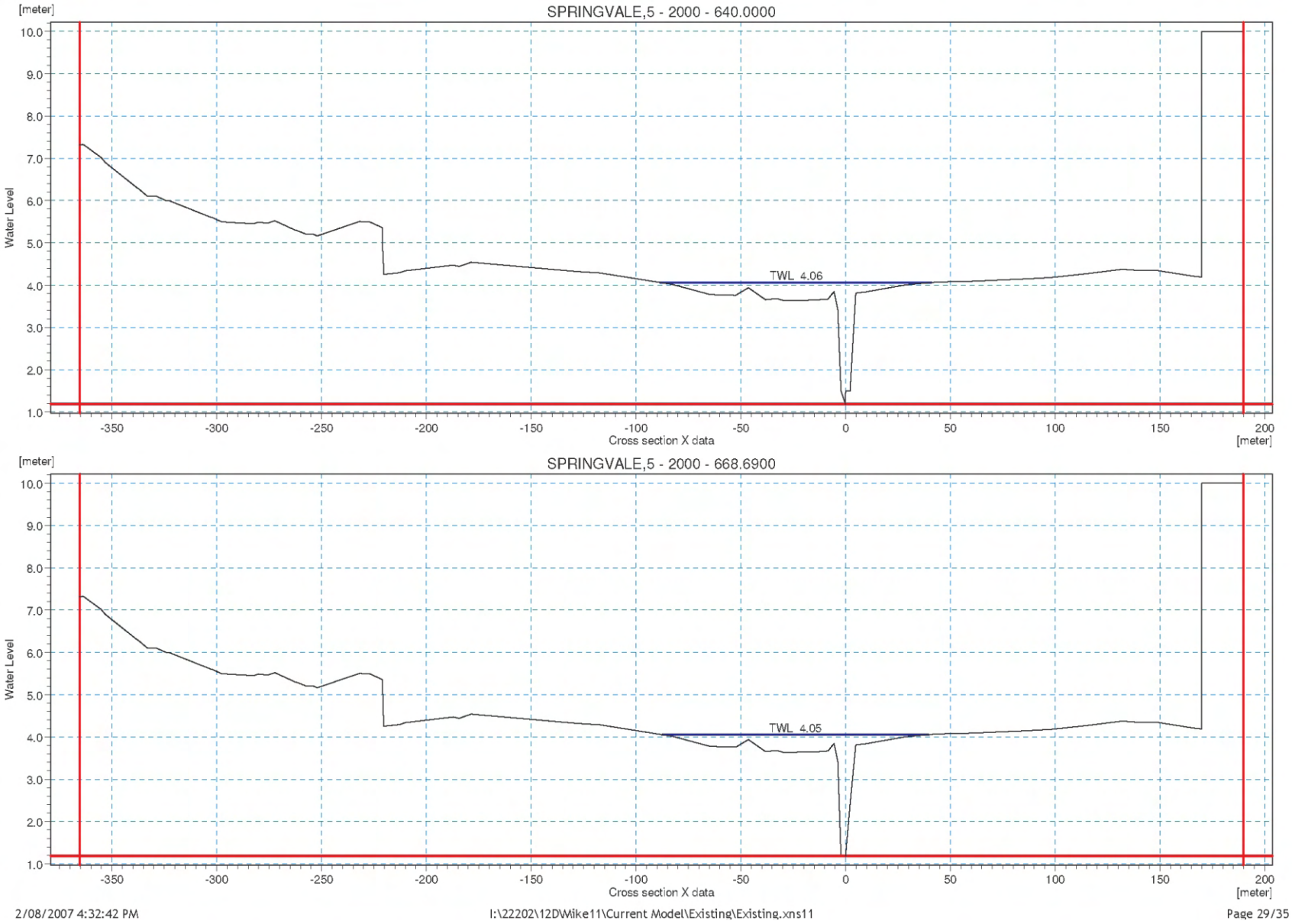


Figure E29

Existing Floodvale Drain Cross Sections at Chainage 640.00 and 668.69

Note: Chainage from upstream model boundary

Source: Mike II Model

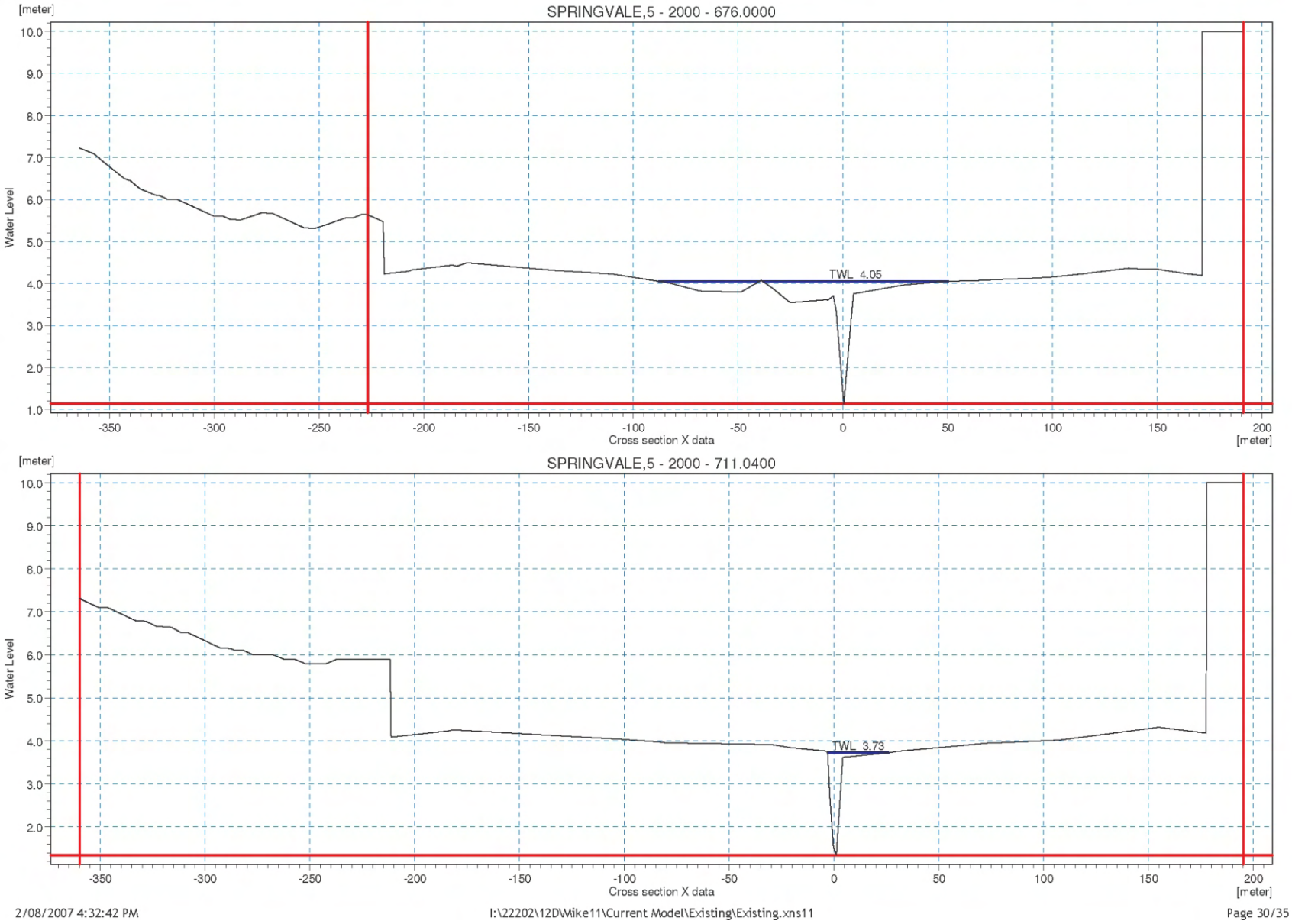


Figure E30

Existing Floodvale Drain Cross Sections at Chainage 676.00 and 711.04

Note: Chainage from upstream model boundary

Source: Mike II Model

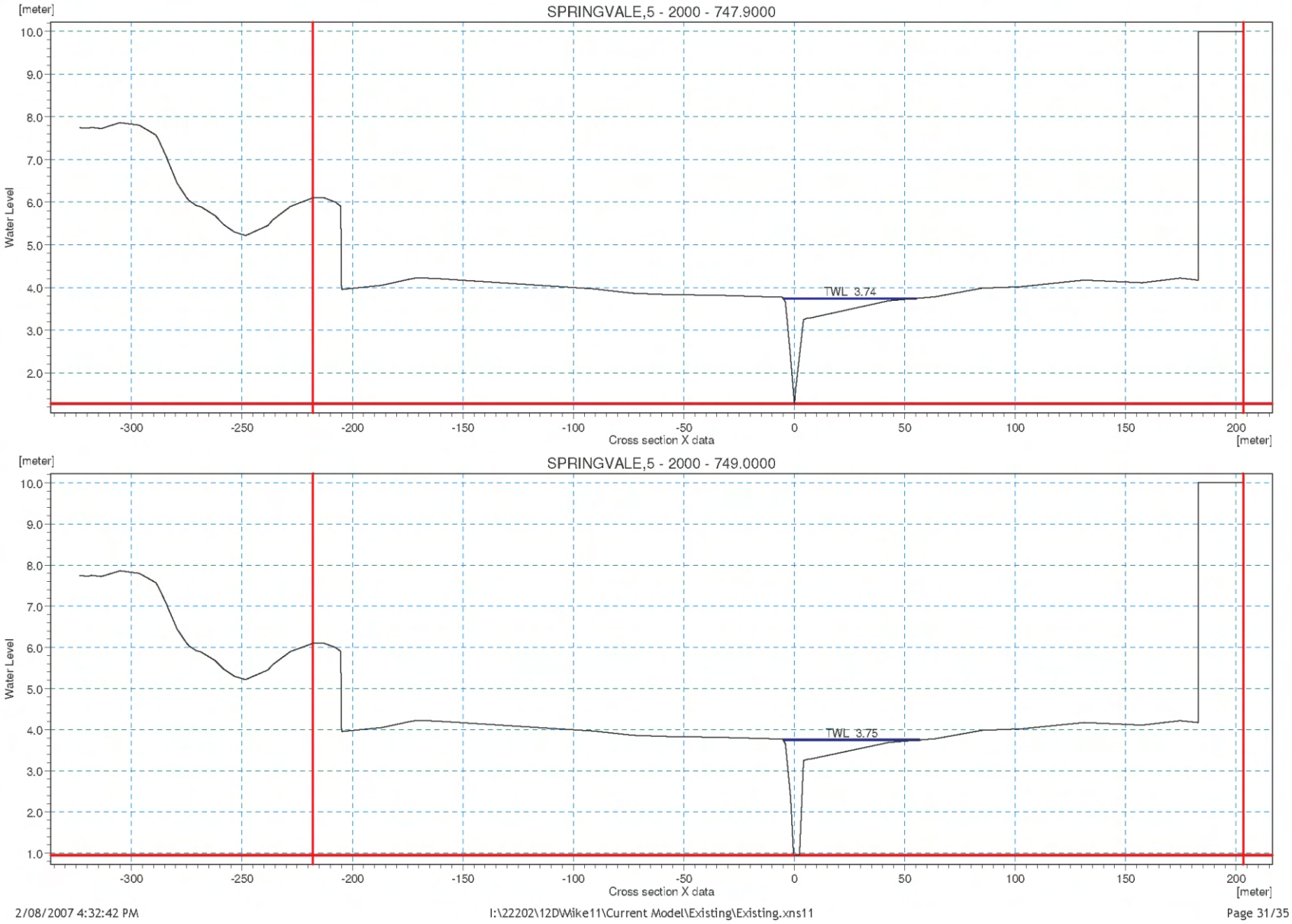


Figure E31

Note: Chainage from upstream model boundary

Source: Mike II Model

Existing Floodvale Drain Cross Sections at Chainage 747.9 and 749.00

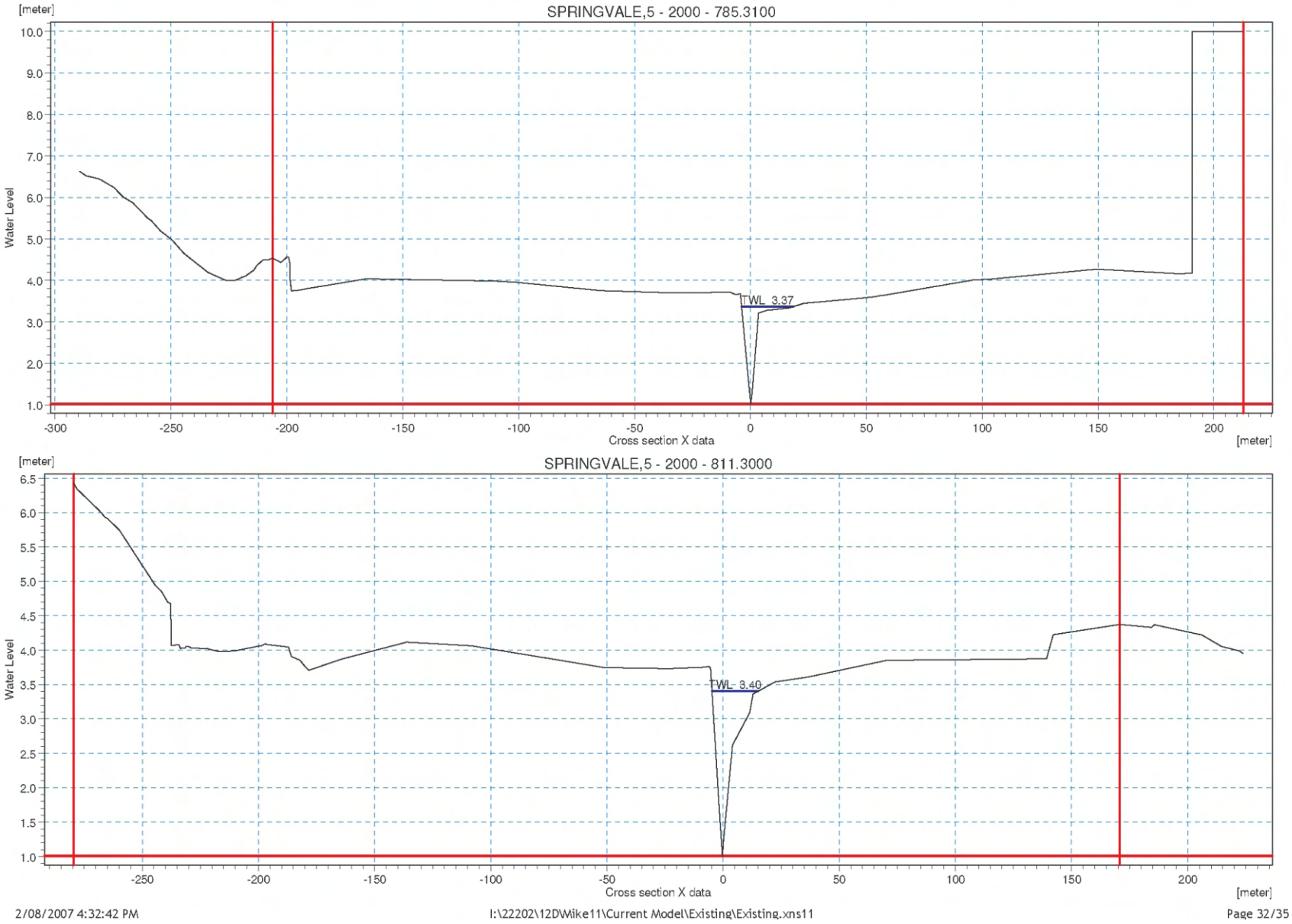


Figure E32

Note: Chainage from upstream model boundary

Source: Mike II Model

Existing Floodvale Drain Cross Sections at Chainage 785.31 and 811.30

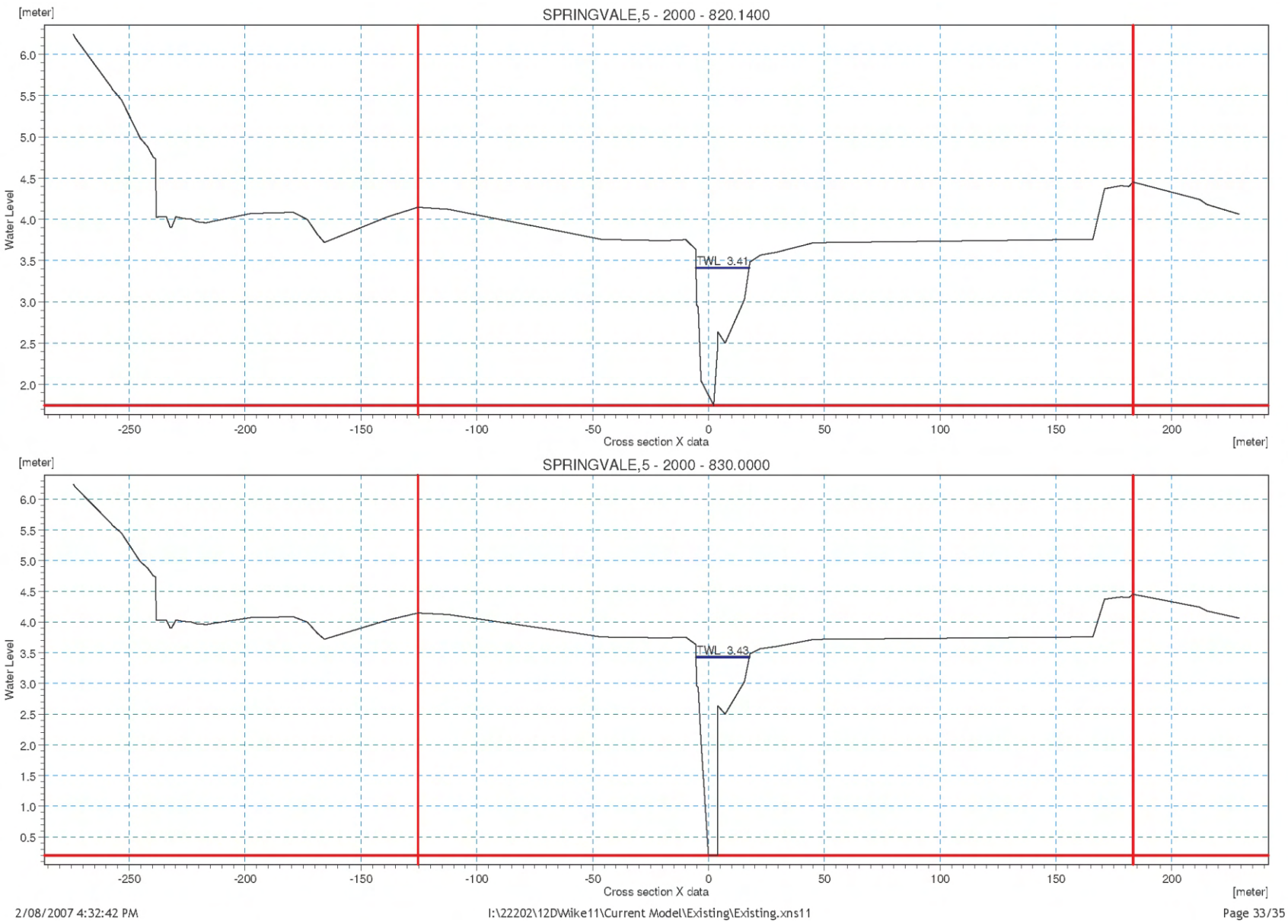


Figure E33

Existing Floodvale Drain Cross Sections at Chainage 820.14 and 830.00

Note: Chainage from upstream model boundary

Source: Mike II Model

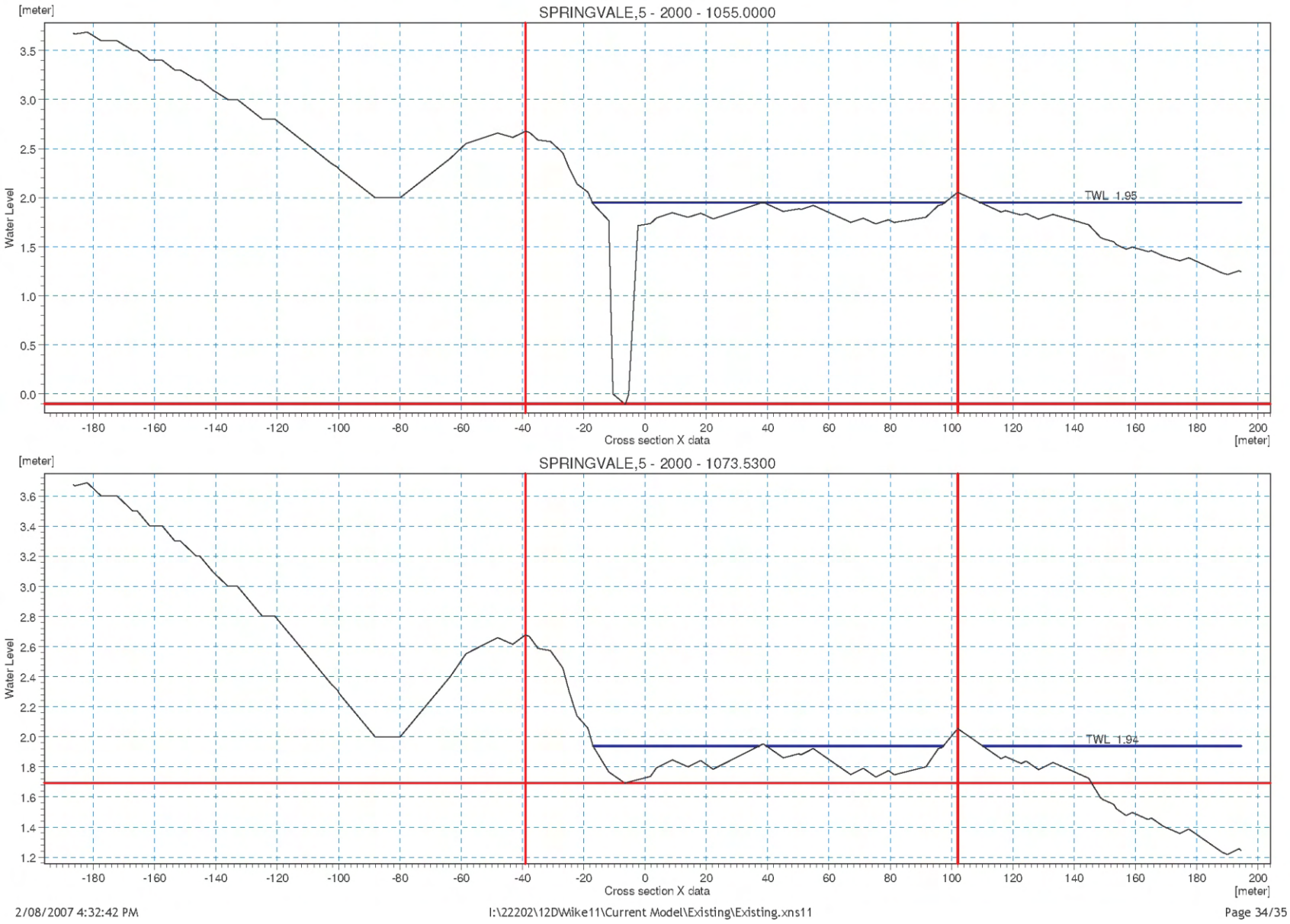


Figure E34

Note: Chainage from upstream model boundary

Source: Mike II Model

Existing Floodvale Drain Cross Sections at Chainage 1055.00 and 1073.53

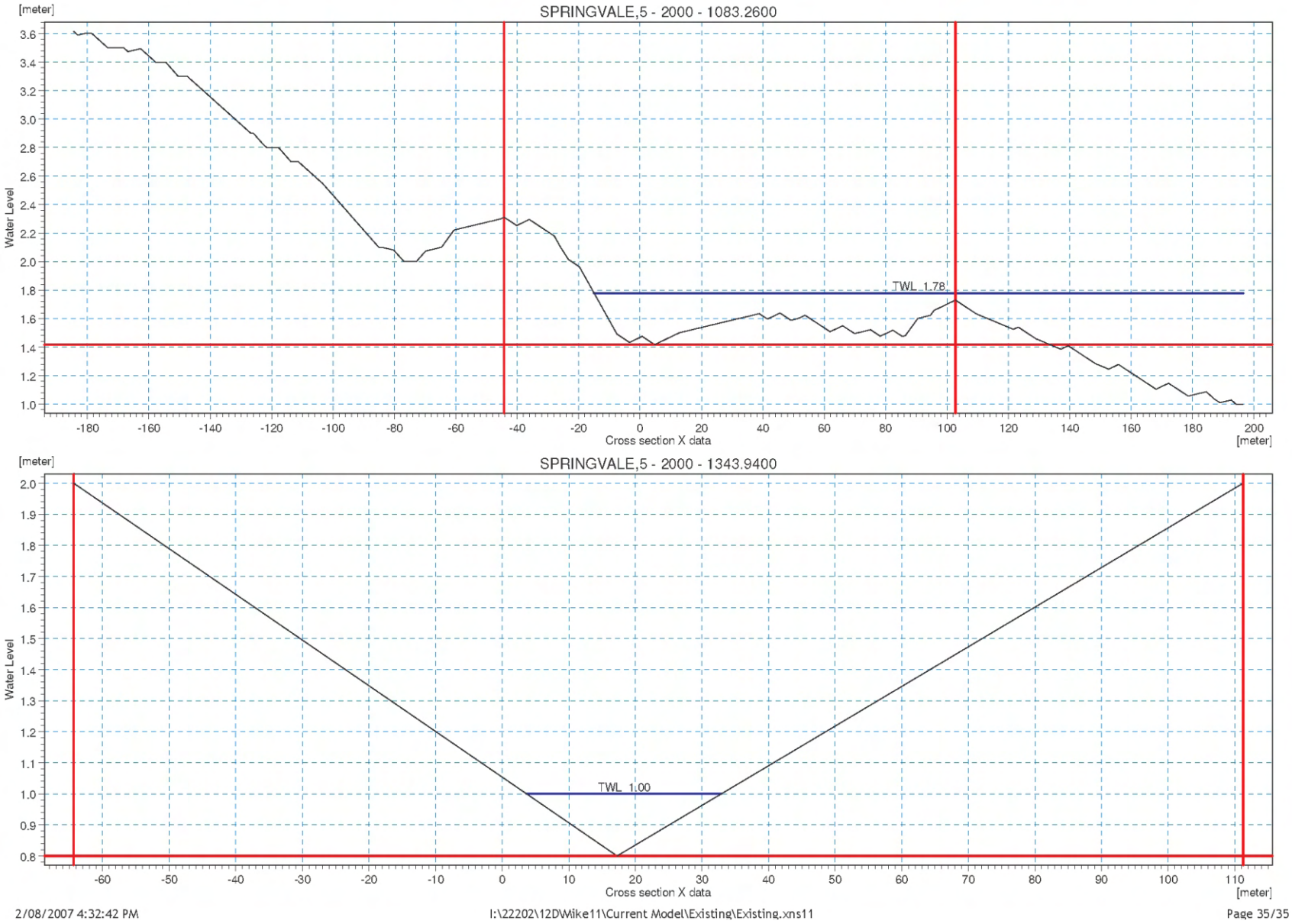


Figure E35

Existing Floodvale Drain Cross Sections at Chainage 1083.26 and 1343.94

Note: Chainage from upstream model boundary

Source: Mike II Model

Appendix F

MIKE 11 Model Cross Sections for Proposed Stage 1 System

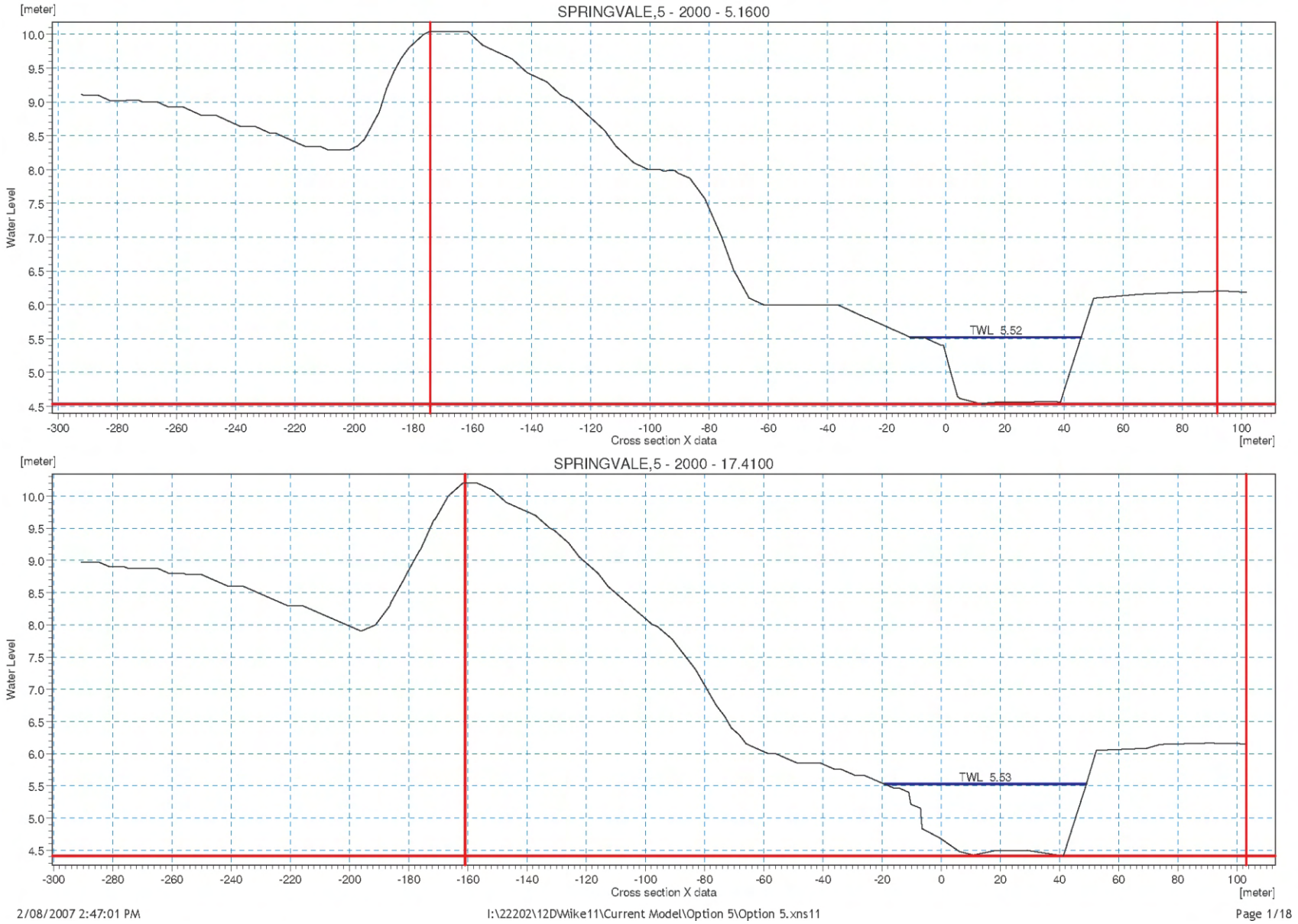


Figure F1

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 5.16 and 17.41

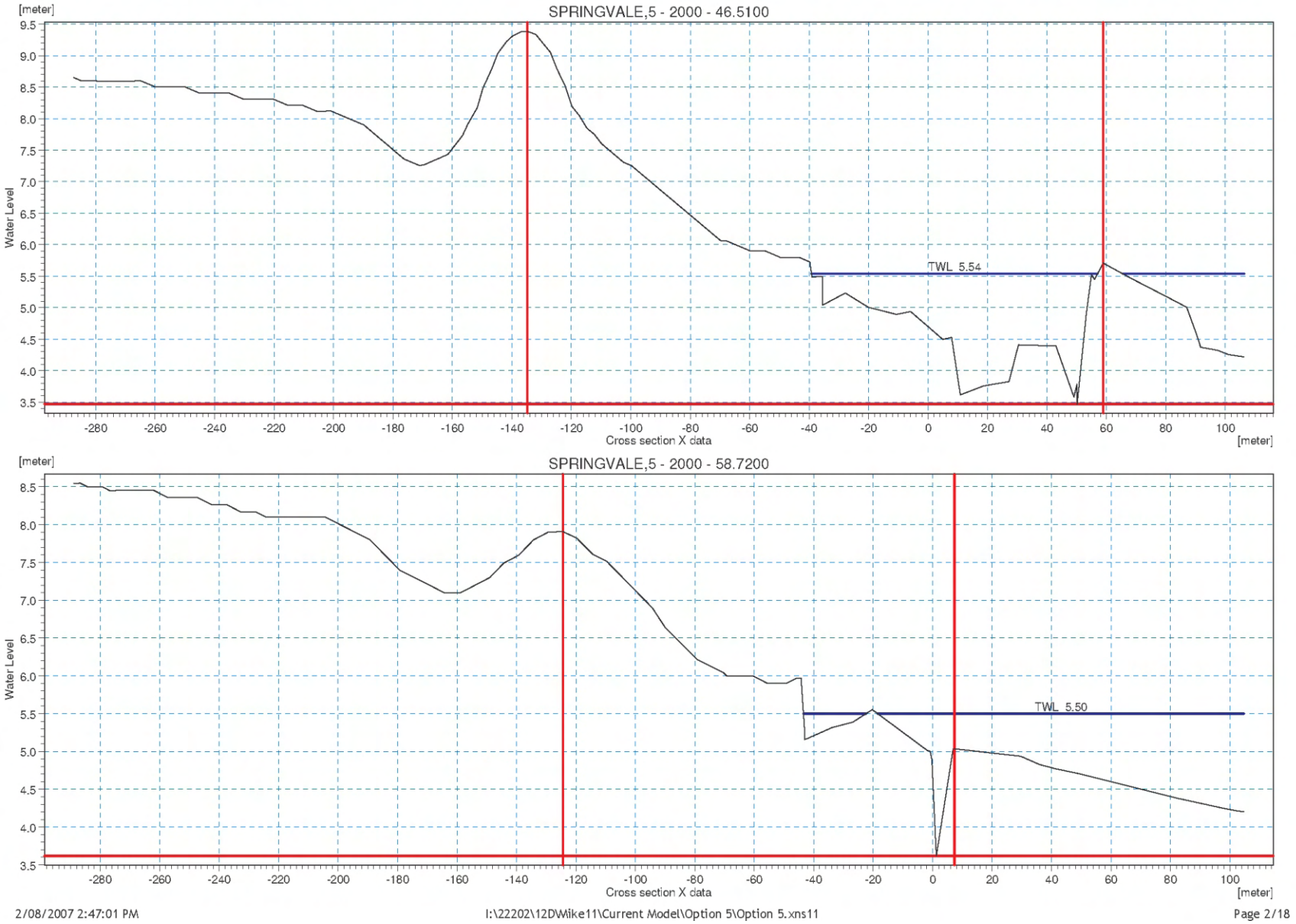


Figure F2

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 46.51 and 58.72

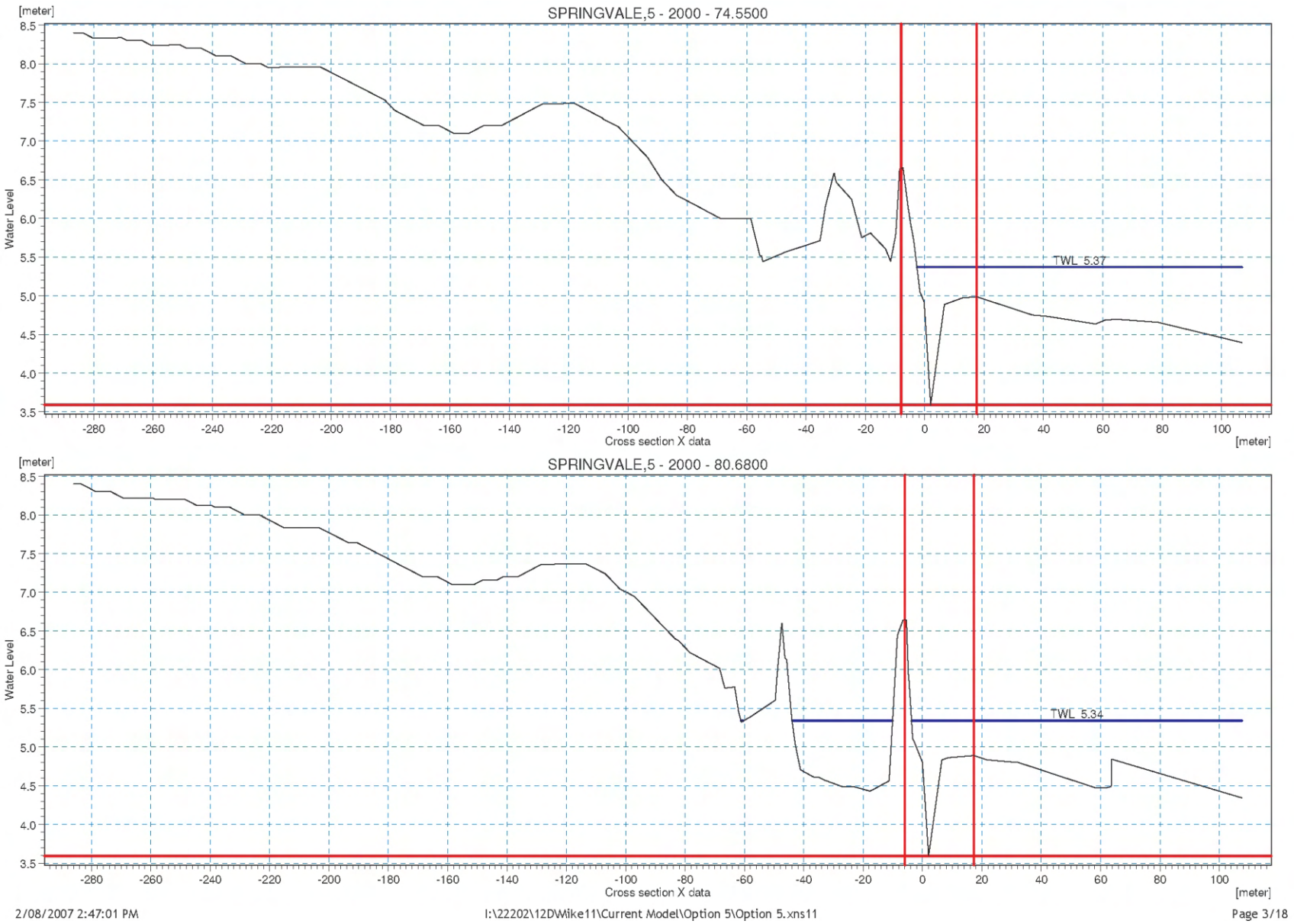


Figure F3

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 74.55 and 80.68

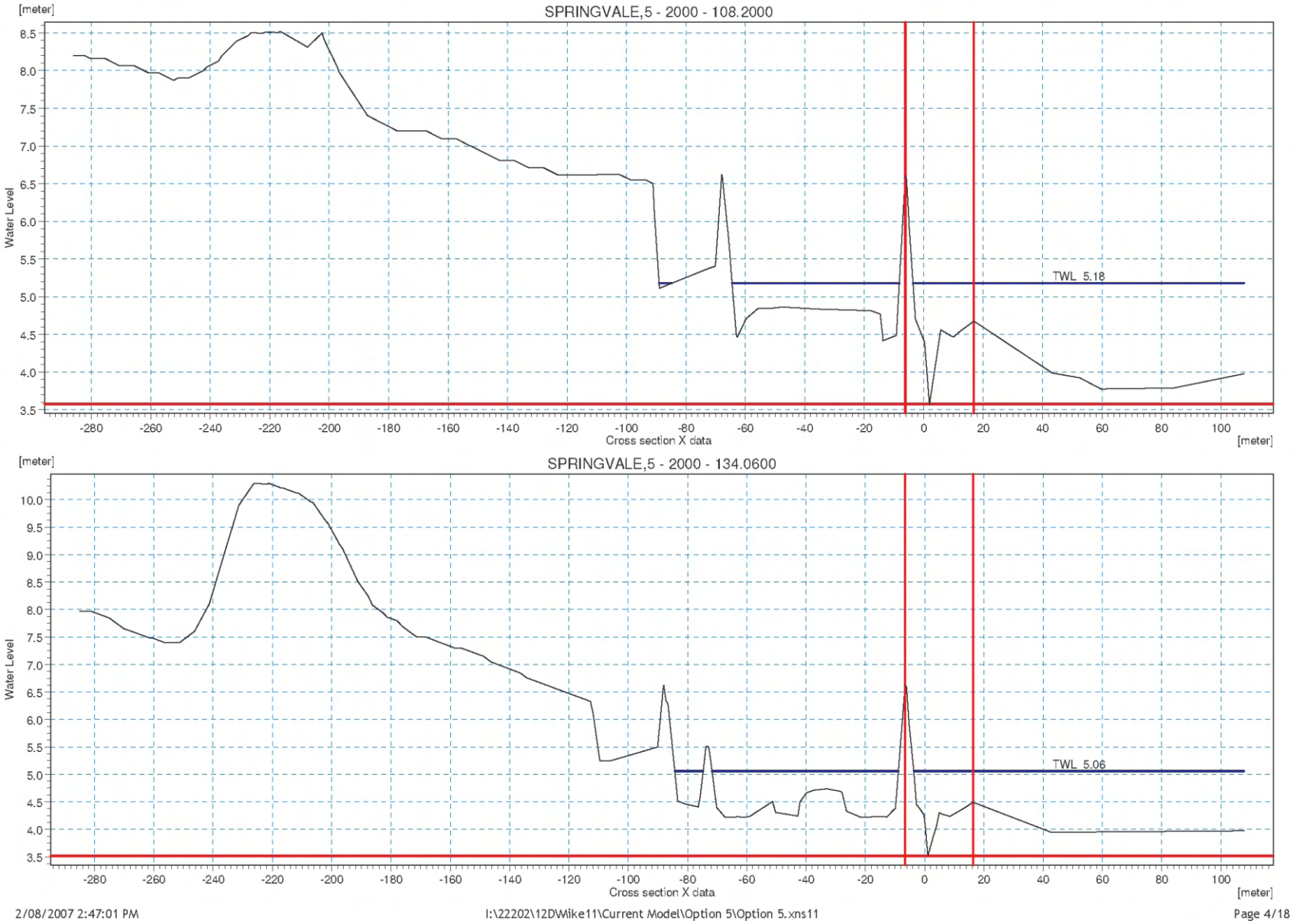


Figure F4

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 108.20 and 134.06

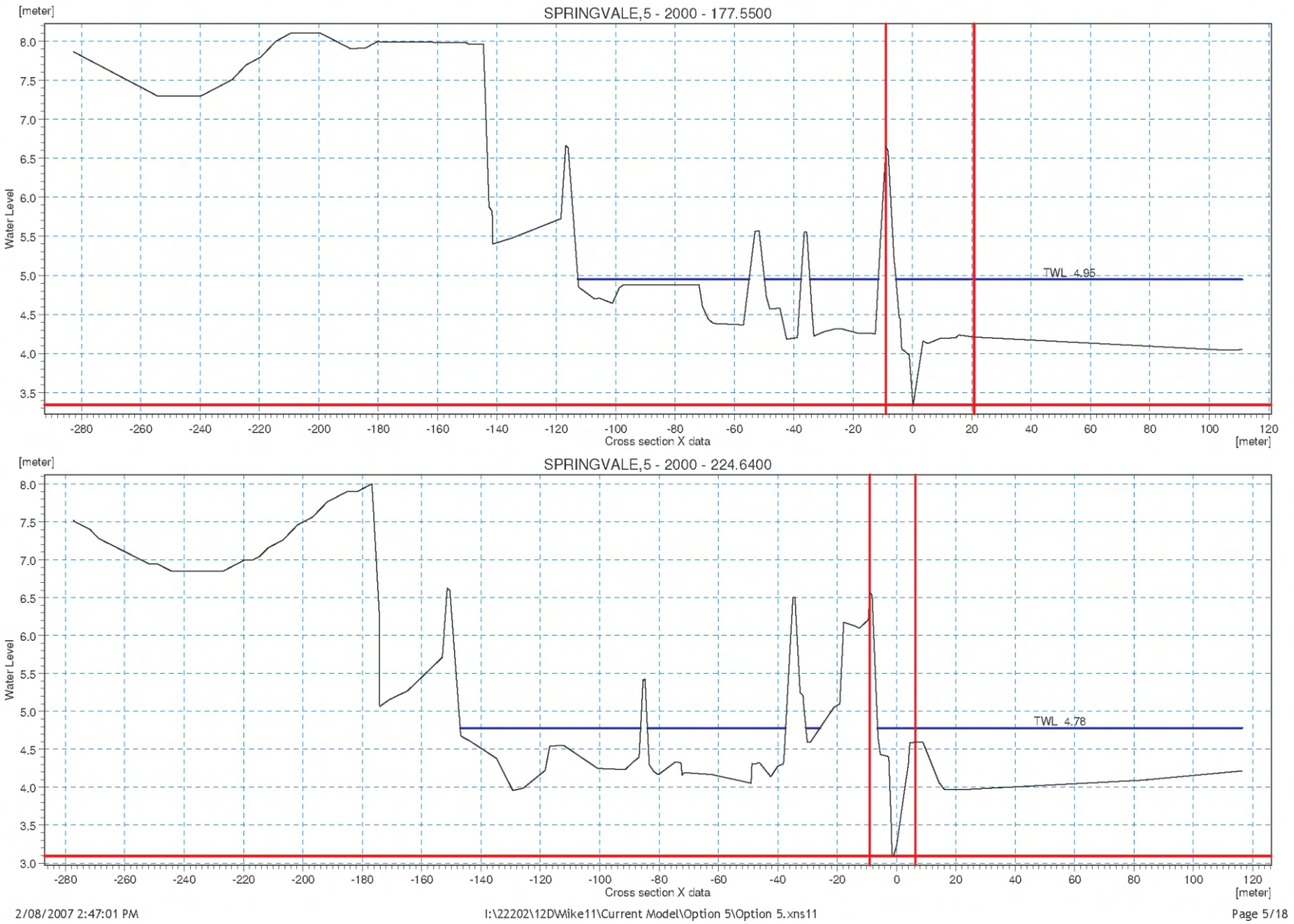


Figure F5

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 177.55 and 224.64

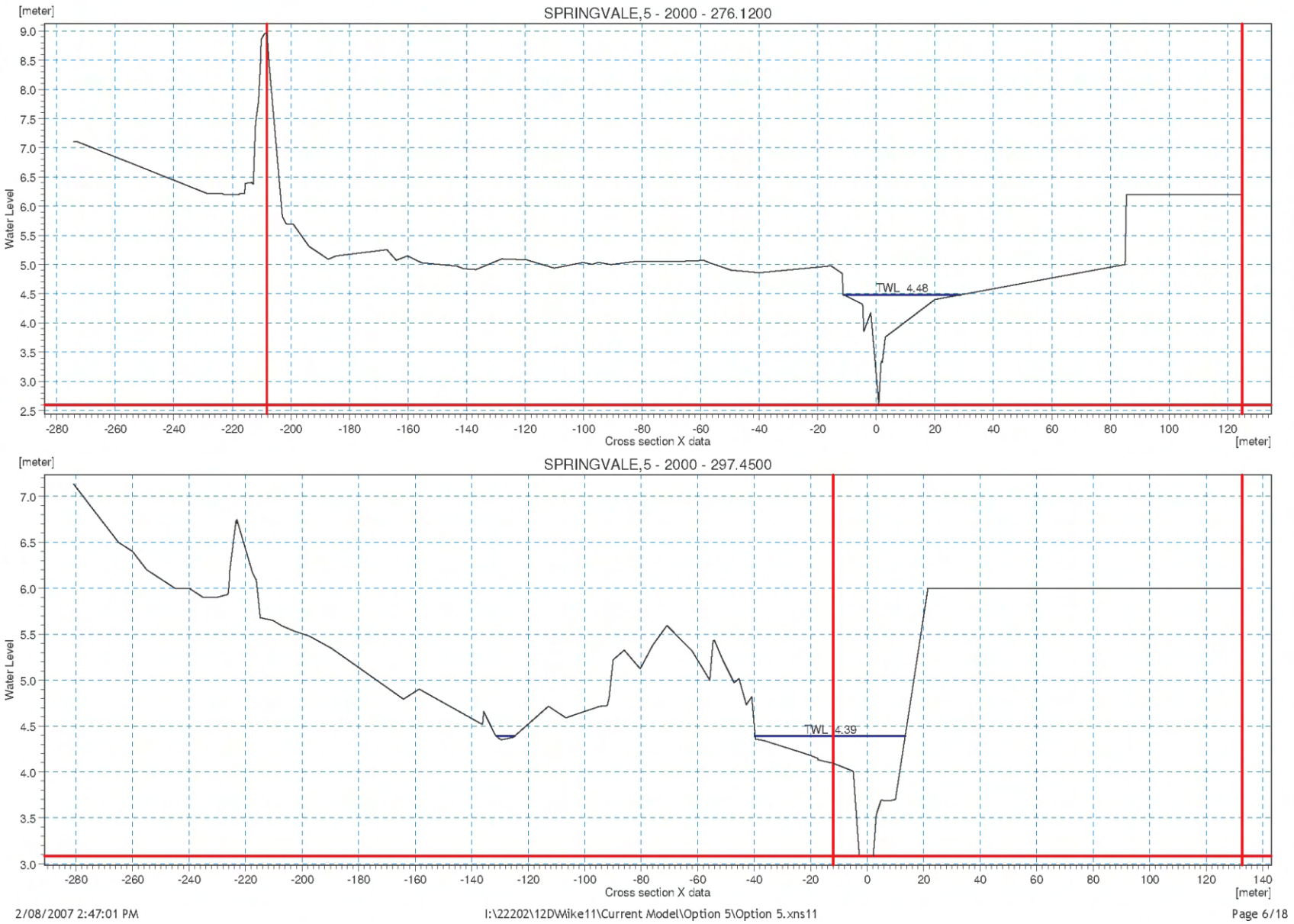


Figure F6

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 276.12 and 297.45

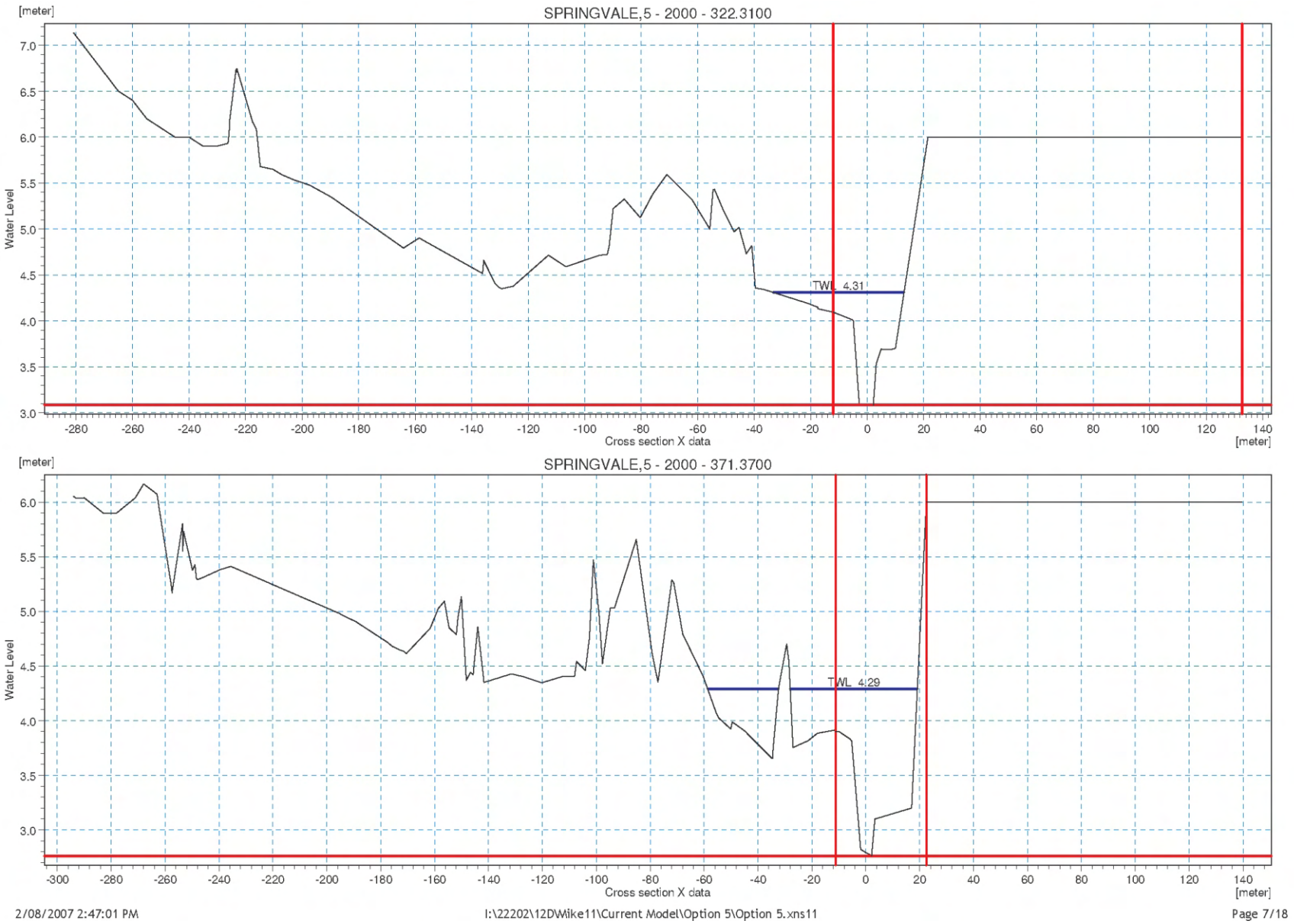


Figure F7

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 322.31 and 371.37

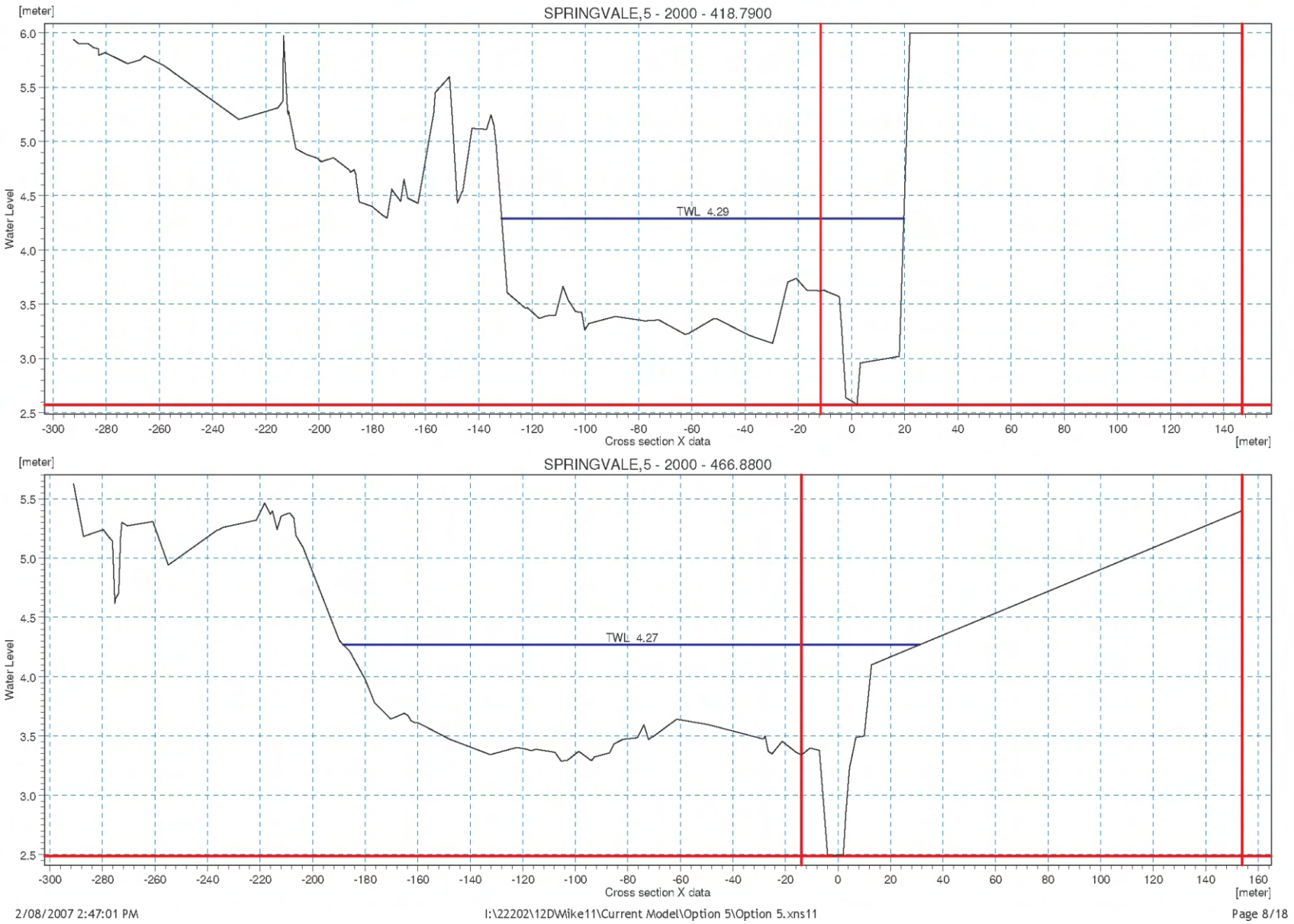


Figure F8

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 418.79 and 466.88

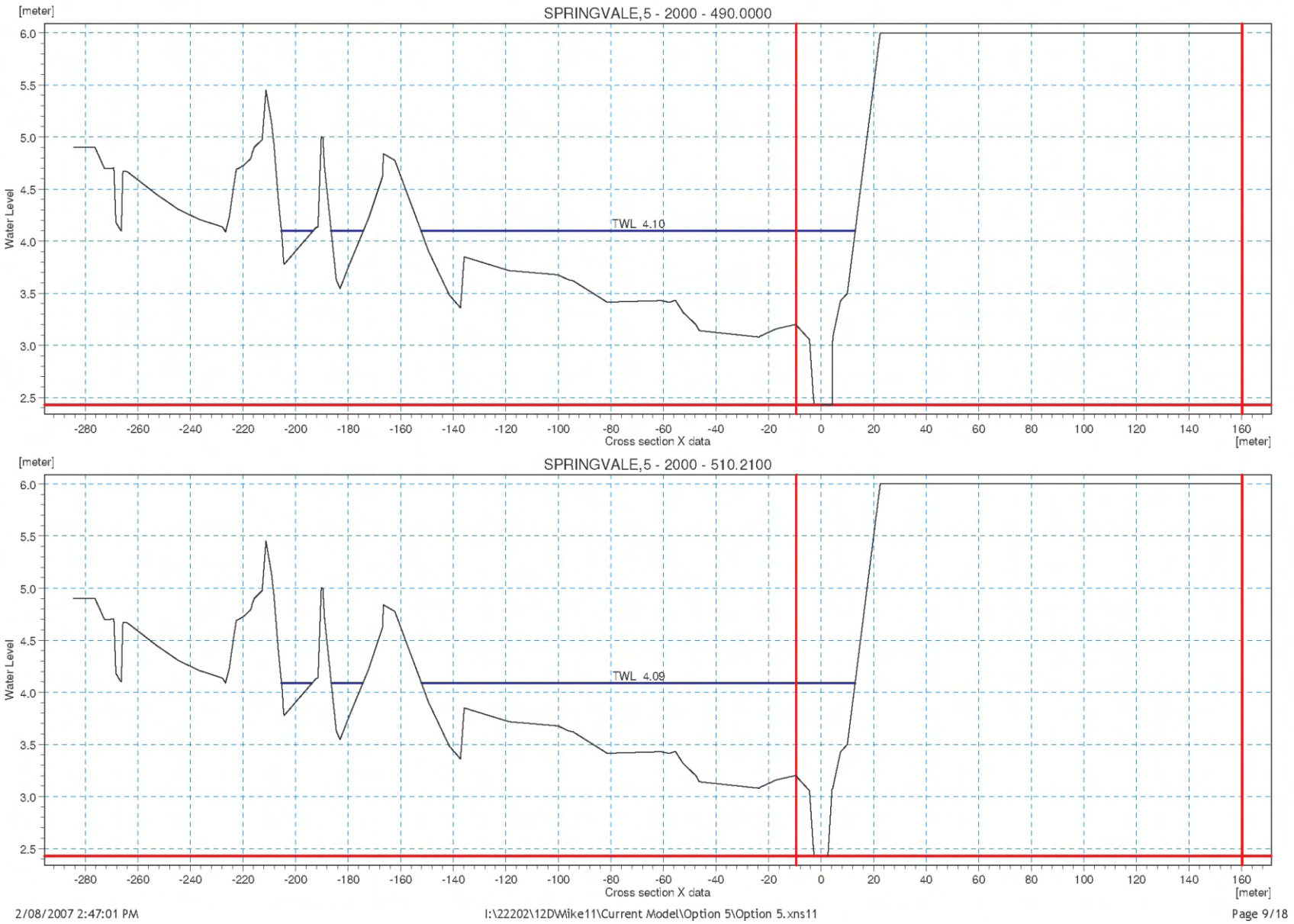


Figure F9

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 490.00 and 510.21

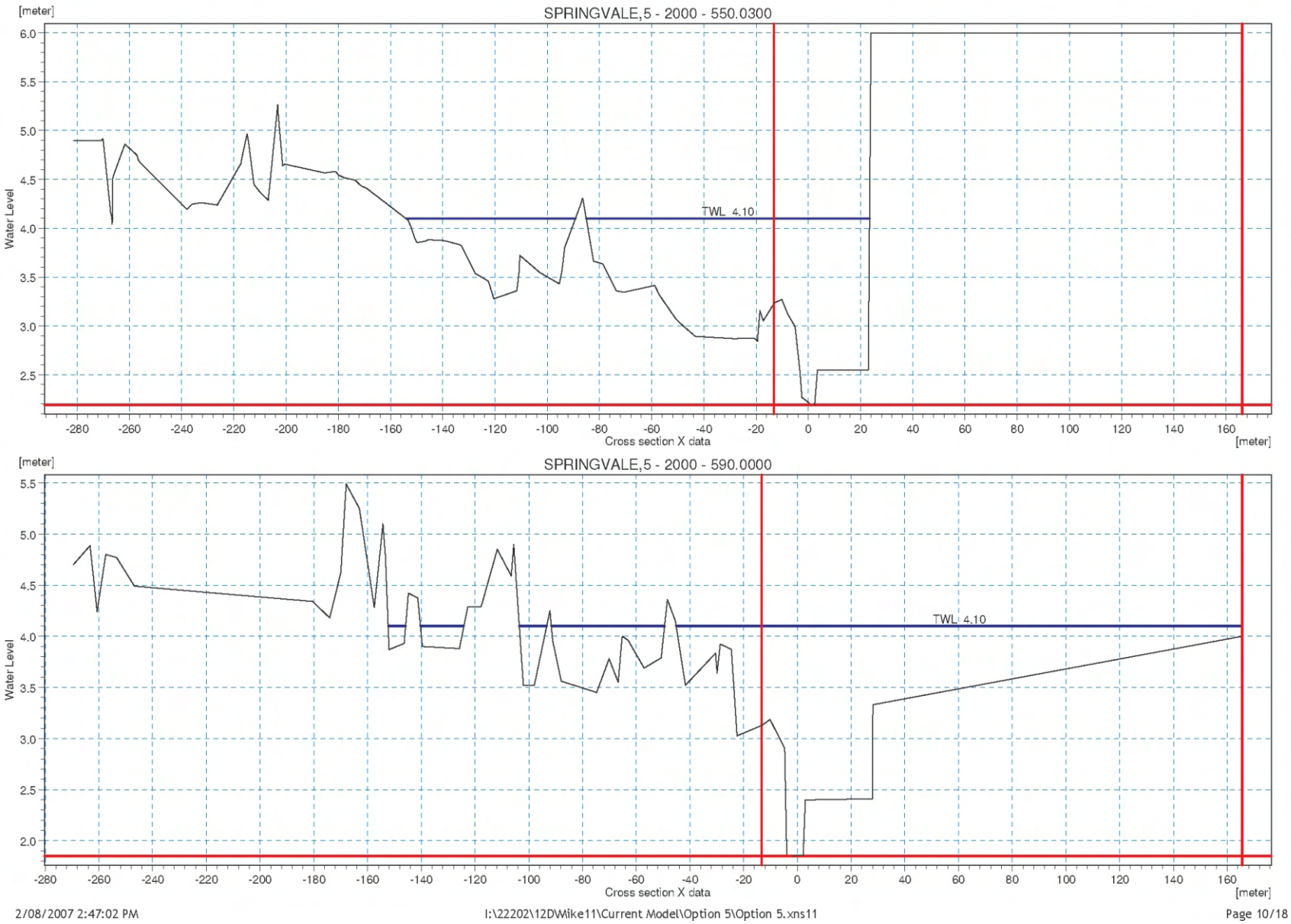


Figure F10

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 550.03 and 590.00

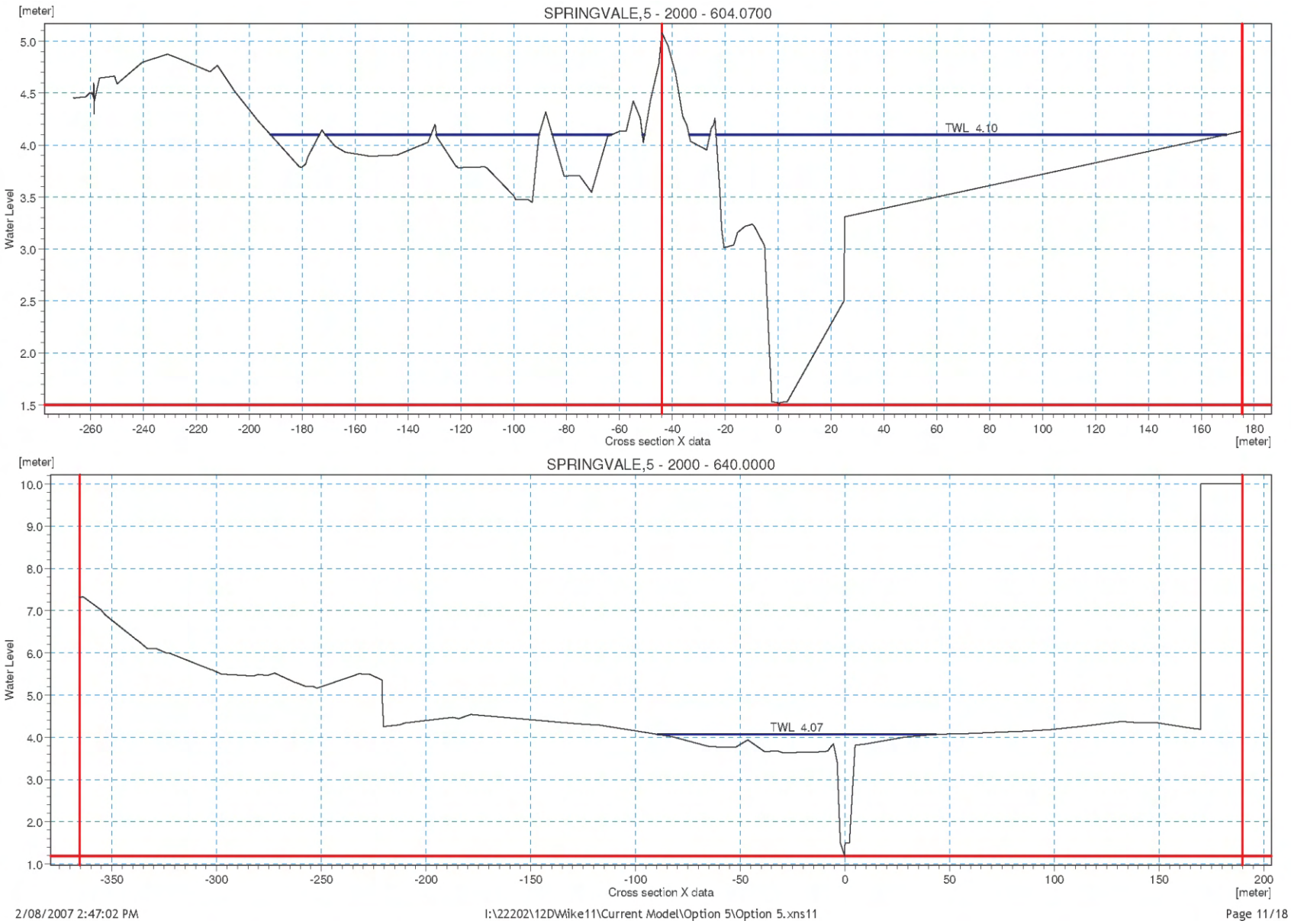


Figure F11

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 604.07 and 640.00

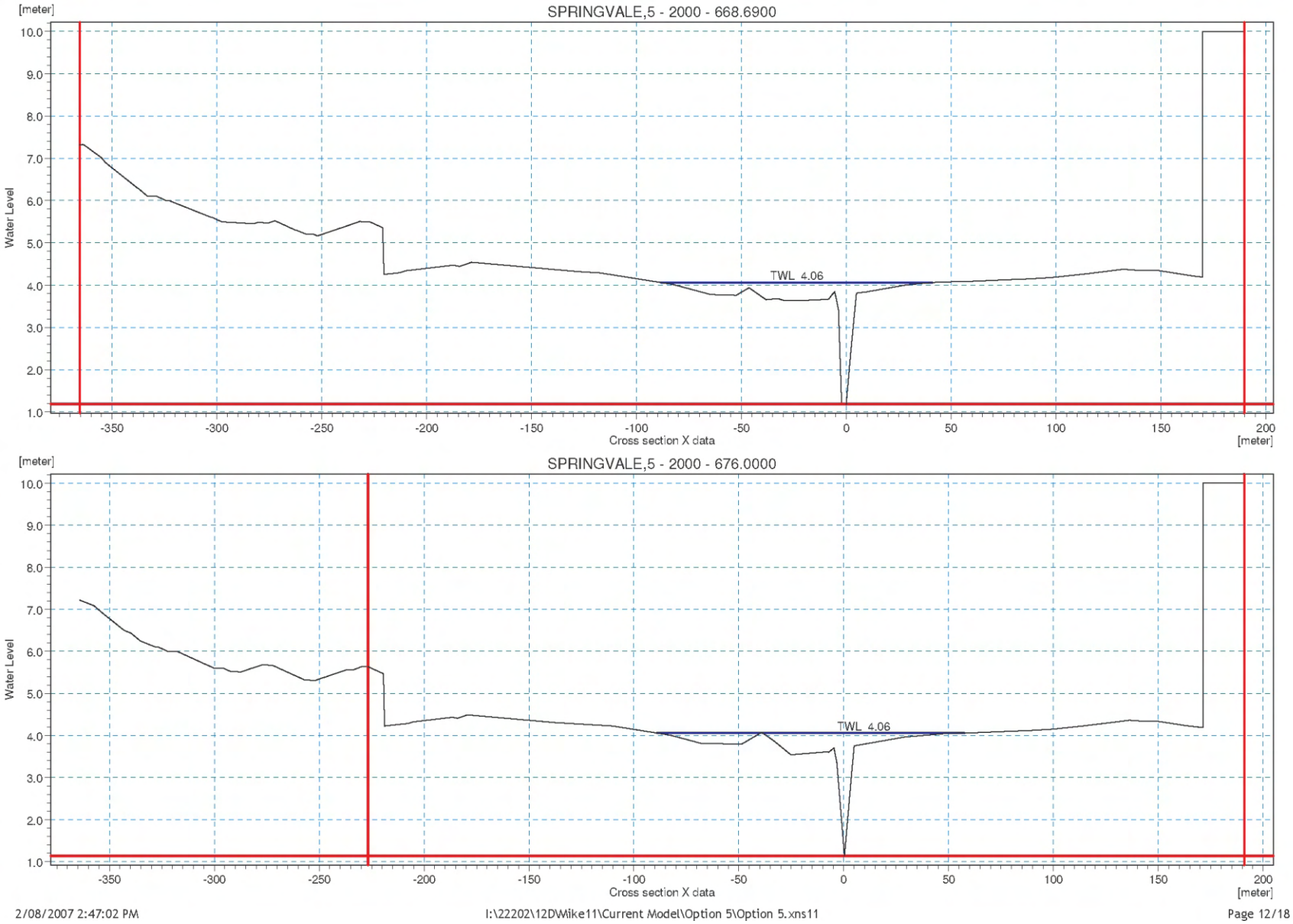


Figure F12

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 668.69 and 676.00

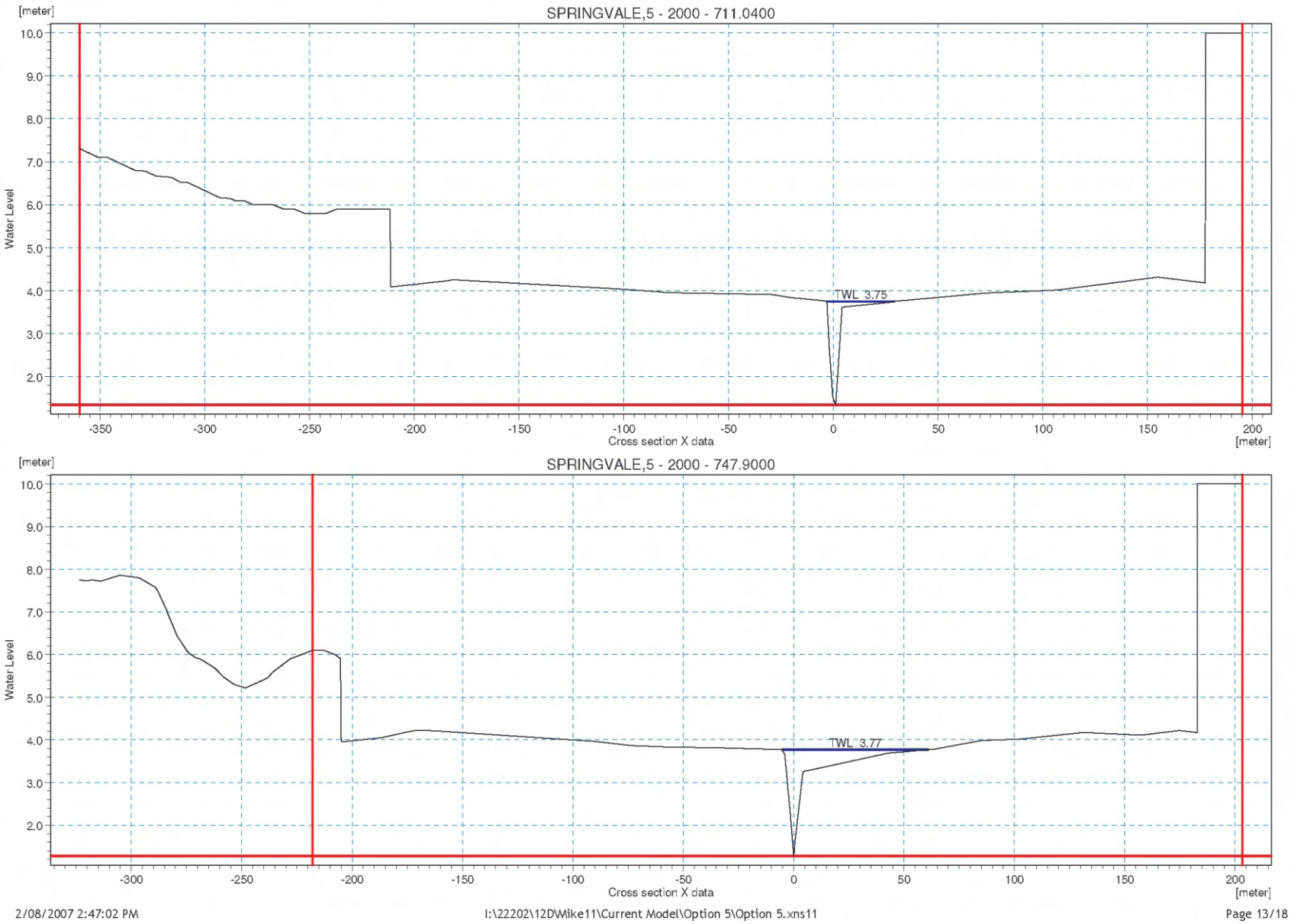


Figure F13

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 711.04 and 747.90

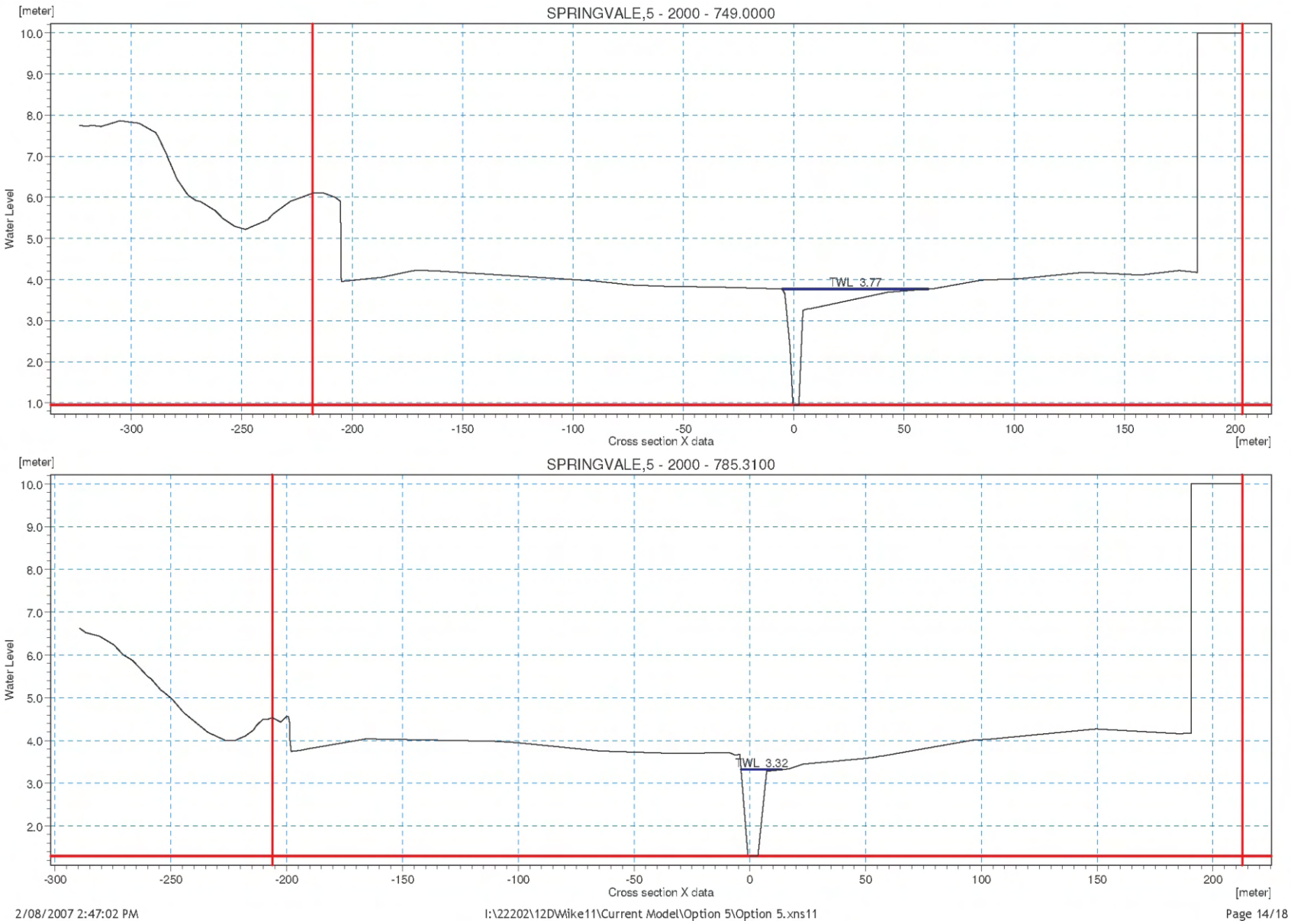


Figure F14

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 749.00 and 785.31

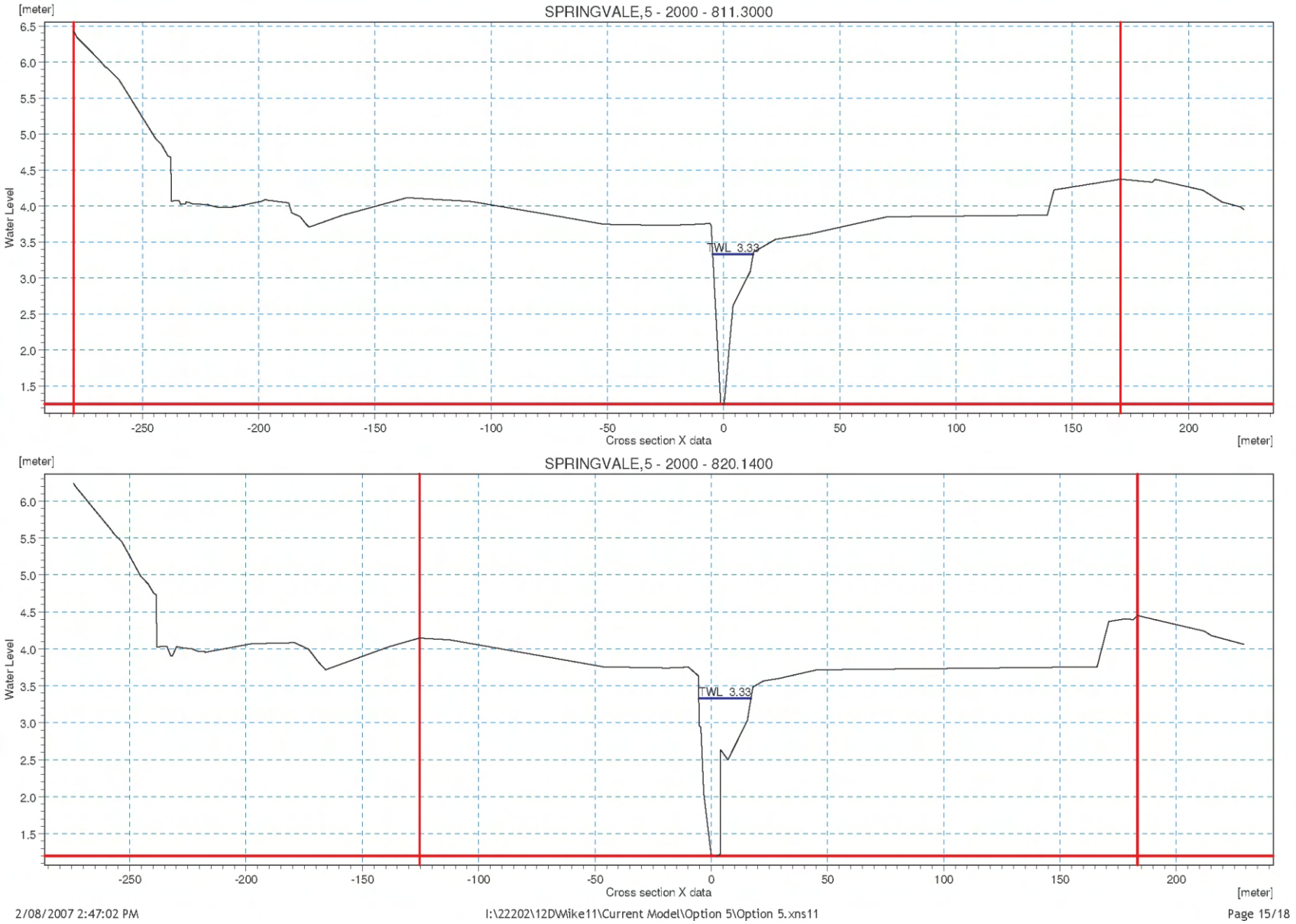


Figure F15

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 811.30 and 820.14

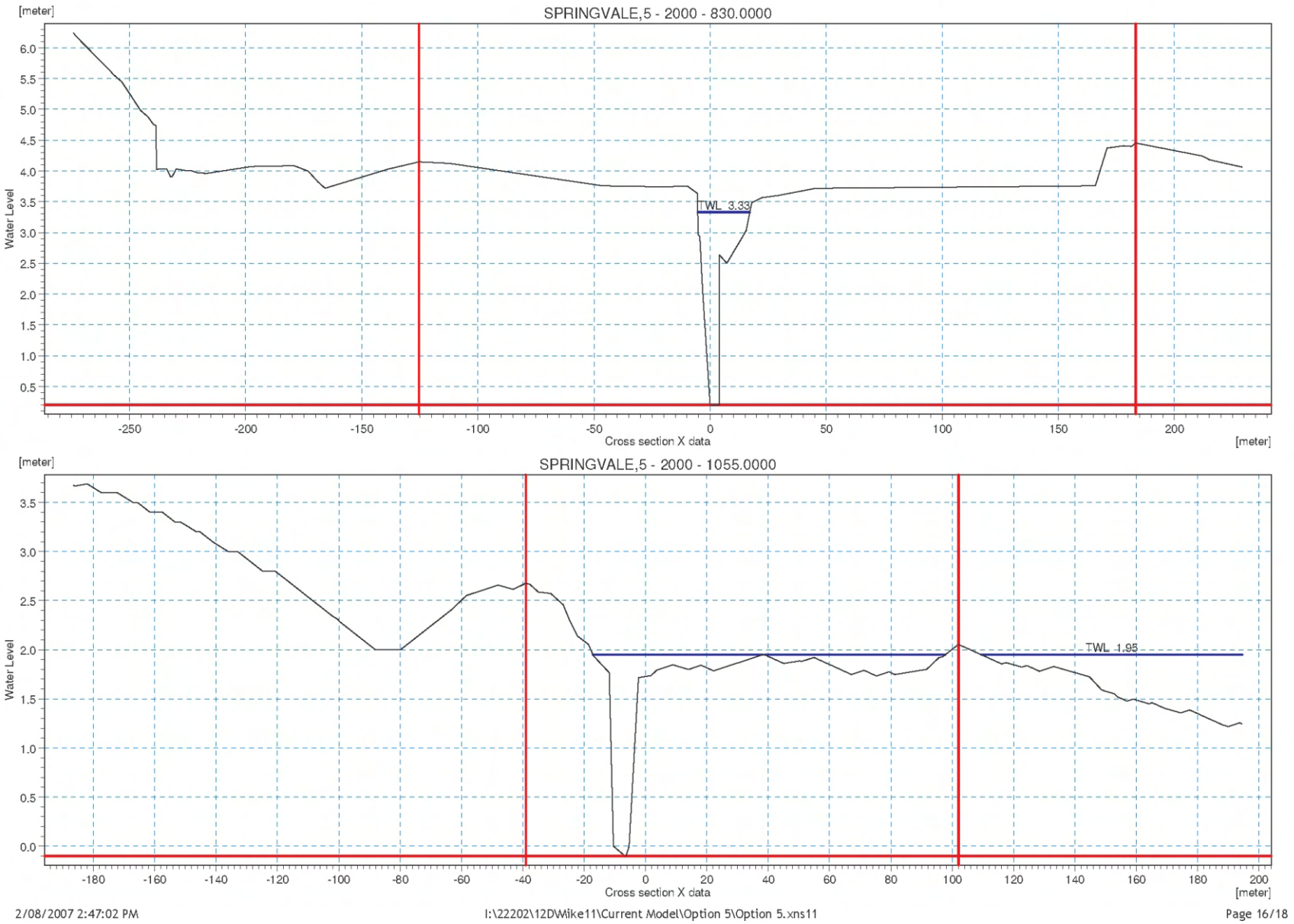


Figure F16

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 830.00 and 1055.00

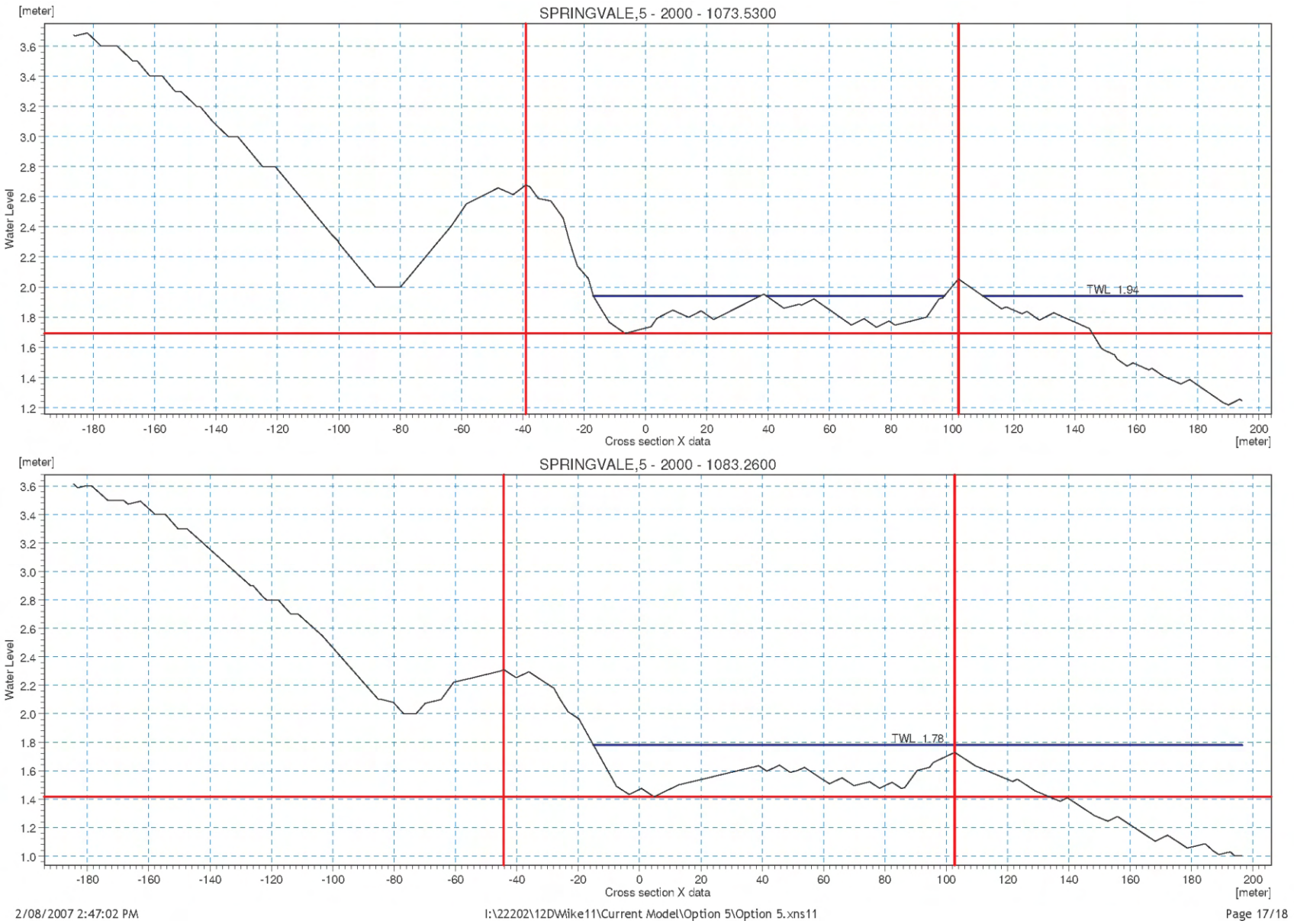


Figure F17

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 1073.53 and 1083.26

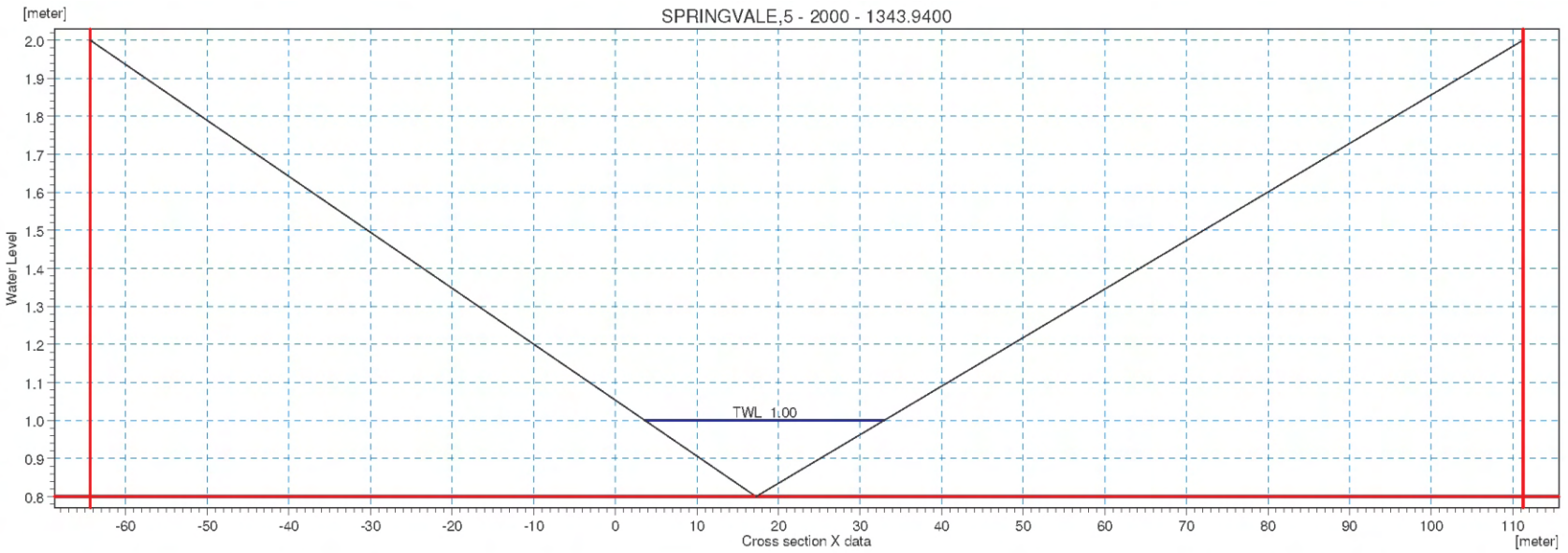


Figure F18

Source: UBD Digital Street Mapping-Australian Cities

Springvale Drain Cross Sections for Proposed Development at Chainage 1343.94