Table 8.1 TAN15 acceptability criteria 0.1% Annual chance flood event. – Base year 2007, in 50 years 2057 and 100 years 2107

Base year 2007				Scenario - 50 years 2057			Scenario - 100 years 2107		
Development Area	**Flood Free Q100 & T200**	**Maximum depth of flooding (mm)**	**Maximum velocity of floodwaters (m/s)**	**Flood Free Q100 & T200**	**Maximum depth of flooding (mm)**	**Maximum velocity of floodwaters (m/s)**	**Flood Free Q100 & T200**	**Maximum depth of flooding (mm)**	**Maximum velocity of floodwaters (m/s)**
AREA A – Wilkinsons' supermarket &car park	FAIL	<600mm	predominantly < 0.3 localised >0.45	FAIL	>1000	predominantly < 0.3 localised >0.45	FAIL	>1000	predominantly < 0.3 localised >0.45
Residential		FAIL	OK		FAIL	PARTS FAIL		FAIL	PARTS FAIL
Commercial & Retail		FAIL	OK		FAIL	PARTS FAIL		FAIL	PARTS FAIL
Industrial		FAIL	OK		FAIL	PARTS FAIL		FAIL	PARTS FAIL
Emergency Services		FAIL	OK		FAIL	PARTS FAIL		FAIL	PARTS FAIL
General Infrastructure		FAIL	OK		FAIL	PARTS FAIL		FAIL	PARTS FAIL
AREA B - Riverside Quay & A40 Cartlett Road	FAIL	>1000mm	<0.3m/s	FAIL	>1000	predominantly <0.3	FAIL	>1000	predominantly <0.3 some localised 0.45
Residential		FAIL	OK		FAIL	OK		FAIL	PARTS FAIL
Commercial & Retail		FAIL	OK		FAIL	OK		FAIL	PARTS FAIL
Industrial		FAIL	OK		FAIL	OK		FAIL	PARTS FAIL
Emergency Services		FAIL	OK		FAIL	OK		FAIL	PARTS FAIL
General Infrastructure		FAIL	OK		FAIL	OK		FAIL	PARTS FAIL
AREA C - A40 - Cartlett Brook Overland Flood flow	FAIL	predominantly <1000mm	<0.3 to >0.6m/s	FAIL	significant proportion >1000	significant proportion >0.45	FAIL	predominantly >1000	significant proportion >0.45
Residential		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL		FAIL	PARTS FAIL
Commercial & Retail		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL		FAIL	PARTS FAIL
Industrial		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL		FAIL	PARTS FAIL
Emergency Services		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL		FAIL	PARTS FAIL
General Infrastructure		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL		FAIL	PARTS FAIL

Development Area	Base year 2007			Scenario - 50 years 2057			Scenario - 100 years 2107		
	Flood Free Q100 & T200	Maximum depth of flooding (mm)	Maximum velocity of floodwaters (m/s)	Flood Free Q100 & T200	Maximum depth of flooding (mm)	Maximum velocity of floodwaters (m/s)	Flood Free Q100 & T200	Maximum depth of flooding (mm)	Maximum velocity of floodwaters (m/s)
AREA D - Priory & bottom of Union Hill	MAJORITY OK	>1000mm	<0.3	FAIL	>1000 where flooded	predominantly <0.3. parts>0.45	FAIL	>1000 where flooded	significant proportion >0.45
Residential		PARTS FAIL	OK		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL
Commercial & Retail		PARTS FAIL	OK		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL
Industrial		PARTS FAIL	OK		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL
Emergency Services		PARTS FAIL	OK		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL
General Infrastructure		PARTS FAIL	OK		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL
AREA E - Right Bank Quays	MAJORITY FAIL	predominantly <600mm	predominantly <0.3m/s	MAJORITY FAIL	>600 to >1000	predominantly <0.3	MAJORITY FAIL	predominantly >1000	significant proportion >0.45
Residential		OK	OK		FAIL	OK		FAIL	PARTS FAIL
Commercial & Retail		OK	OK		PARTS FAIL	OK		FAIL	PARTS FAIL
Industrial		OK	OK		PARTS FAIL	OK		FAIL	PARTS FAIL
Emergency Services		OK	OK		PARTS FAIL	OK		FAIL	PARTS FAIL
General Infrastructure		OK	OK		PARTS FAIL	OK		FAIL	PARTS FAIL
AREA F - Right Bank between A487 bridge & New Bridge	OK	<600mm	<0.3m/s	OK	<600	<0.3	FAIL	ranges <600 to >1000	<0.3
Residential		OK	OK		OK	OK		PARTS FAIL	OK
Commercial & Retail		OK	OK		OK	OK		PARTS FAIL	OK
Industrial		OK	OK		OK	OK		PARTS FAIL	OK
Emergency Services		OK	OK		OK	OK		PARTS FAIL	OK
General Infrastructure		OK	OK		OK	OK		PARTS FAIL	OK

Development Area	Base year 2007			Scenario - 50 years 2057			Scenario - 100 years 2107		
	Flood Free Q100 & T200	Maximum depth of flooding (mm)	Maximum velocity of floodwaters (m/s)	Flood Free Q100 & T200	Maximum depth of flooding (mm)	Maximum velocity of floodwaters (m/s)	Flood Free Q100 & T200	Maximum depth of flooding (mm)	Maximum velocity of floodwaters (m/s)
AREA G - Morrison's & other retail	OK	Flood free	Flood free	OK	Flood free	Flood free	OK	Flood free	Flood free
Residential		OK	OK		OK	OK		OK	OK
Commercial & Retail		OK	OK		OK	OK		OK	OK
Industrial		OK	OK		OK	OK		OK	OK
Emergency Services		OK	OK		OK	OK		OK	OK
General Infrastructure		OK	OK		OK	OK		OK	OK
AREA H - Cattle Mart area & Football Ground	PARTS FAIL	<600 to >2000	<0.30 to >0.45	PARTS FAIL	<600 to >1000	<0.3 to parts>0.45	PARTS FAIL	<600 to >1000	<0.15 to parts>0.45
Residential		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL
Commercial & Retail		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL
Industrial		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL
Emergency Services		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL
General Infrastructure		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL		PARTS FAIL	PARTS FAIL

8.3 Sensitivity to Blockage of Structures

Each of the structures along the study reaches of the Western Cleddau and the Cartlett Brook have been assessed for their potential to block.

8.3.1 Assessment of structures

Cartlett Brook

The culvert entrance and trash screen at Cartlett Road has been assessed as likely to block under flood conditions, particularly given the wooded area immediately upstream providing trash material. As a sensitivity test, the inlet to the section of culvert from the A40 roundabout under County Hall was also assumed to block. Both Sections of culvert have, therefore, been blocked by 50% of the inlet area to test the impact on flooding for the 1% and 0.1% annual chance events.

Western Cleddau

The A487 bridge is a single span and has been assessed as unlikely to block significantly.

The following three bridges downstream of the A487 bridge are likely to suffer some degree of blockage. It is likely that the main source of trash would be from upstream of A487.

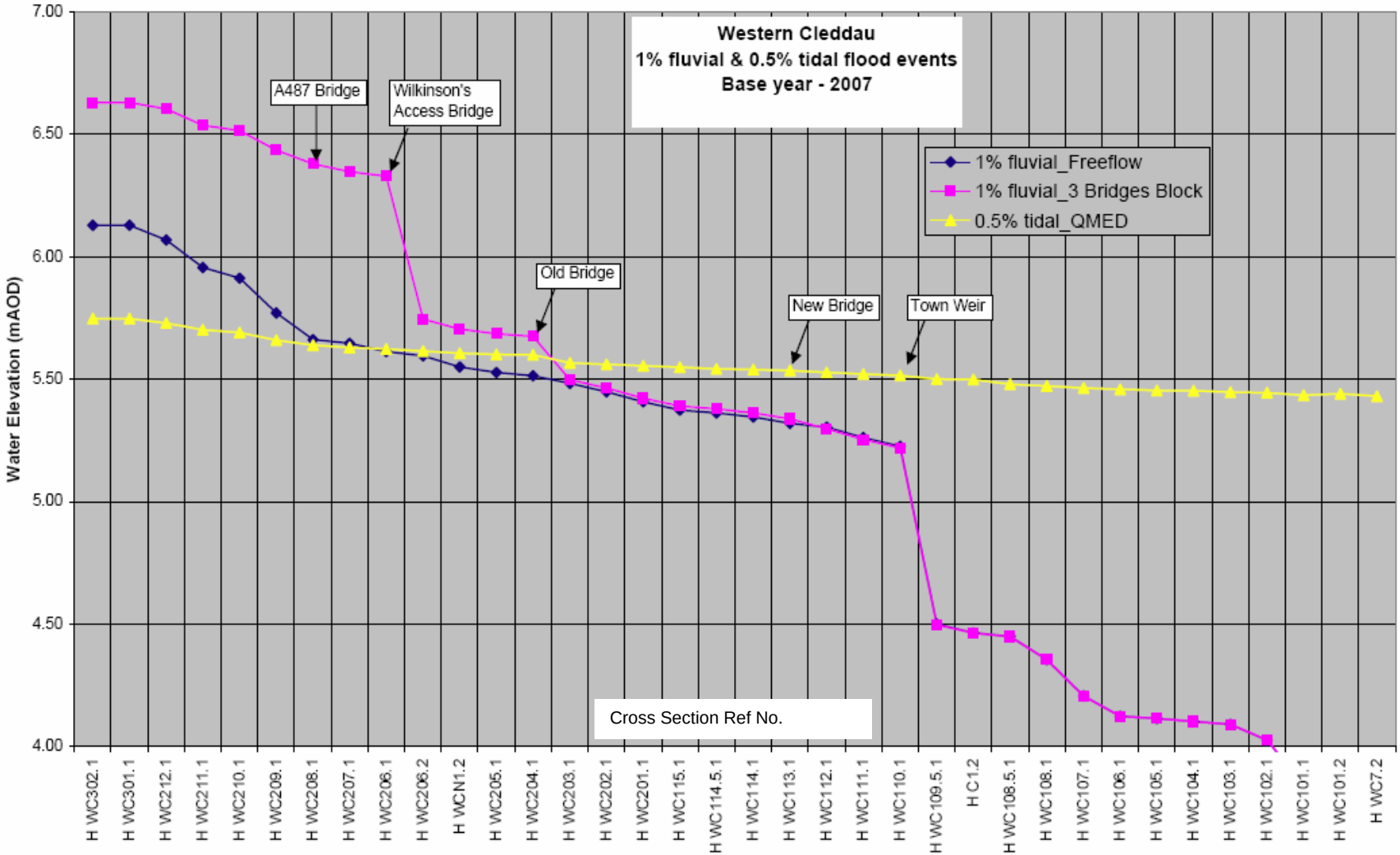
- Wilkinson's Access Bridge
- Old Bridge
- New Bridge (Victoria Place)

The impact of the blockage of the three bridges together was assessed, which may be considered to most closely approach the most likely blockage scenario. The cross Section area of each bridge was reduced by approximately 50%.

8.3.2 Mechanisms and results of flooding under blockage scenario

The levels in the Western Cleddau river for a 1% chance fluvial flow are compared to the unblocked situation as presented in Figure 8.10. This highlights the significant increase in river levels upstream, which result from the blockage of Wilkinson's access bridge. The resulting increase in overtopping and overland flow reduces flow passing downstream to Old Bridge where the increased afflux is less marked.

Figure 8.10 Change in Water Surface elevation along channel of Western Cleddau -1% fluvial, 0.5% tidal & 1% fluvial event with 3 bridges blocked 50%



For a 0.1% chance fluvial event, under existing conditions in the base year 2007, assuming 50% block of the 3 bridges named above and the culvert inlets on the Cartlett Brook, the following mechanisms of flooding occur.

The flood mechanisms are similar to those occurring in an unblocked situation, albeit with increased severity of flooding. The following additional mechanisms are worthy of note.

The Cartlett Brook spills out of the open channel Section immediately upstream of the culvert inlet and from the short open channel Section in the middle of the A40 roundabout, causing flood depths in excess of 1.0m on the A40 access from the east of the town and along its route to the north.

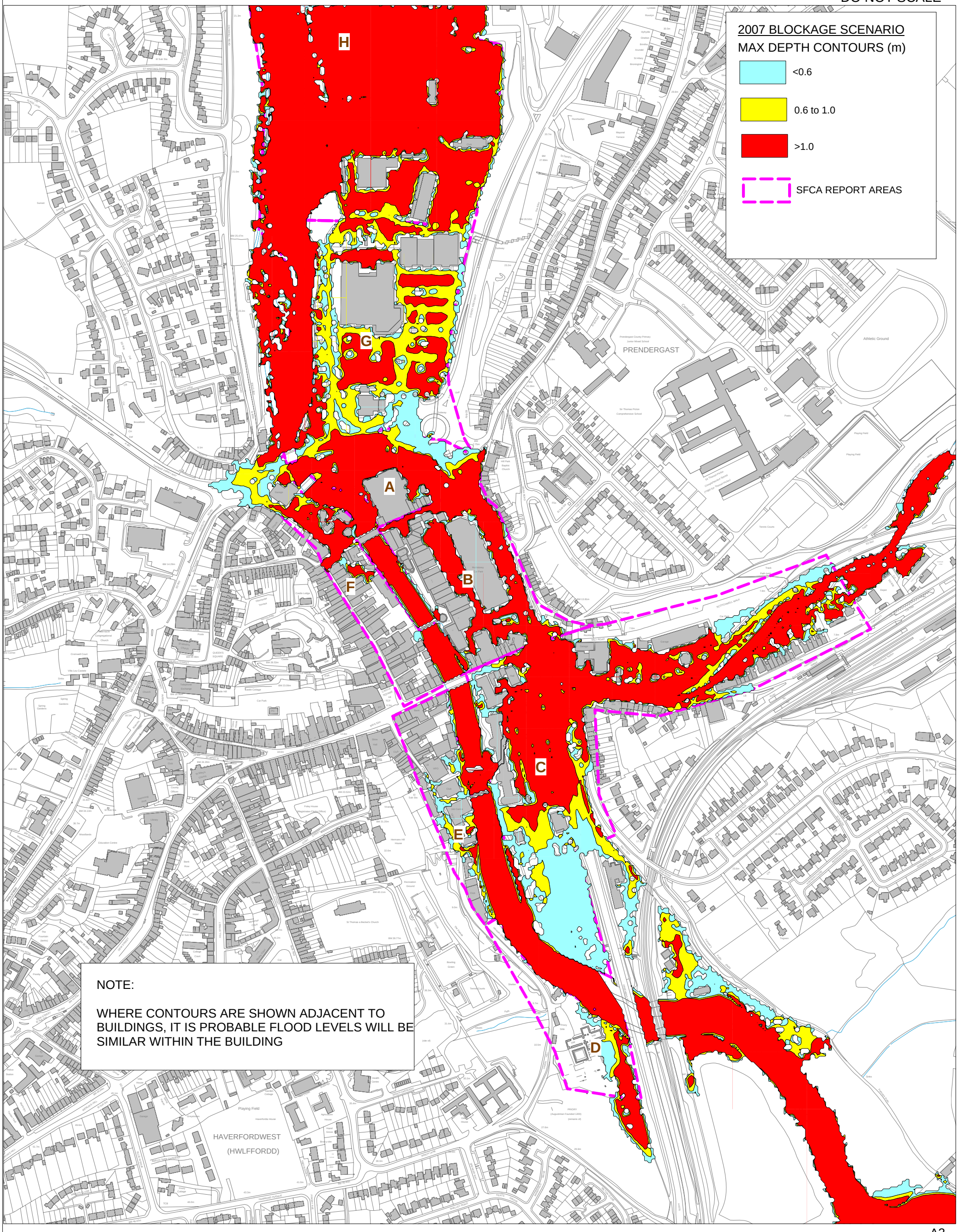
As in the free flow situation, the left bank of the Western Cleddau is overtopped upstream and downstream of Wilkinson's access bridge into Area A. However, river levels rise sufficiently to also overtop the right bank upstream of Old Bridge, into Area F, which is flood free under unblocked conditions.

The A487 road is overtopped, from upstream either side of the bridge such that flood depths exceed 0.6m.

Area G , which is flood free for the 0.1% flood event under the unblocked situation, is inundated both from direct overtopping of the left bank immediately upstream of the A487 and as a result of overland flow paths from Area H to the north.

Generally, the severity of flooding resulting from the blockage scenario is such that large parts of the town will experience depths of flooding in excess of 1.0m. All crossings of the river are likely to become impassable as a result. This is situation is clear on the flood depths contours presented on Figure 8.11.

DO NOT SCALE



A3

ATKINS

EXISTING SITUATION (BASE YEAR 2007)
3 BRIDGES & CULVERT BLOCKED
0.1% CHANCE FLOOD EVENTS - FLUVIAL & TIDAL
MAXIMUM DEPTH CONTOURS

FIGURE 8.11

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8.4 Summary comments - TAN 15 indicative guidance by area

The compliance of each of the areas with TAN15 has previously been documented for ease of reference in Table 8.1, Section 8.2.2. Additional comments are provided below for each area to clarify the situation with respect to flood risk over both 50 year and 100 year development lifetimes. The blockage scenario is also commented on. Possible mitigation options are discussed in Section 9.

Area A Wilkinsons' Supermarket and car parking area

Under the existing situation flood depths during a 0.1% event exceed 1.0m over a large part of the central and eastern end of this area, including the vehicular access onto the A40. Flow velocities will remain below 0.3m/s over the majority of the site, except in the area of direct overtopping from the Western Cleddau, between the A487 bridge and the access bridge. Locally here velocities exceed 0.45m/s. The area fails the TAN15 criteria for any development based on the flood depths, under the existing situation.

Over a 50 year development life, the impact of the rise in sea levels on flood depths in this area is not significant. Flow velocities during a 0.1% chance event would increase, although largely below 0.3m/s over the area.

Over a 100 year development life, the increased flooding via the Cartlett Brook results in flow velocities increasing. In the overland flow path through this area, velocities are in the range 0.3 to 0.45m/s.

This area unsuitable for any type of development, without some form of mitigation of the flood risk.

Under the blockage scenario tested, flood depths will exceed 1.0m over this entire area in the base year, 2007.

Area B Riverside Quay Development & A40 Road

Under the existing situation, flood depths during a 0.1% flood event exceed 1.0m over most of the area, although maximum velocities will be below 0.15 m/s.

The flow path along the A40 will pose a particular risk with respect to access to this area during a 0.1% chance event. Under existing conditions, depths will exceed 1.0m.

Under the blockage scenario tested, flood depths will exceed 1.0m over this entire area in the base year, 2007.

Development in this area will need mitigation of existing flood risk for all types of development.

Area C - County Hall and A40 Cartlett Brook area

Under existing conditions in the base year, a 0.1% flood event from the Cartlett Brook would result in the development of overland flow paths along the A40 west to the County Hall car park and north along the A40, to areas A & B.

Flood depths along the A40 west from the culvert inlet to the roundabout are above 0.6m and fail TAN15 indicative criteria for residential development. North of the A40, depths exceed 1.0m, including the Jaguar car dealership, Aldis supermarket and an electricity sub station.

Flow velocities are within acceptable limits in this area in the base year, but by the end of a 50 year lifetime, exceed the indicative guidance along the A40 and through the County Hall Car Park.

Over a 50 year lifetime, the majority of the area fails TAN15 criteria for either depth or velocity for all types of development. Development of individual sites within this area may comply, but care will be needed to ensure safe access and egress.

Any development with a greater than 50 year lifetime in this area will require mitigation of flood risk.

Area D – Priory and bottom of Union Hill

The Priory grounds will be flooded to depths in excess of 1.0m during 0.1% chance tidal event under existing conditions. For events of this probability, over a 50 year period, flooding will also occur at the bottom of Union Hill, with depths less than 0.6m. Velocity may peak above 0.45m/s in locally.

Due to the resolution of the flood depth and velocity contours output from the modelling care will need to exercised for any development on the riverside of Union Hill Road.

Area E – Western Cleddau right bank Old & New Quay Areas

This area is affected by the 0.5% tidal event under existing conditions, failing TAN15 over much of the area.

Over a 50 year development life much of this area will be affected by depths of flooding during a 0.1% chance event in excess of the indicative guidance in TAN15. This would makes much of the area unsuitable for both residential and other types of development.

Site specific FCAs will need to clarify mitigation of risk, possibly by means of high level access to areas flood free in 0.1% events.

Area F – Right bank of Western Cleddau between A487 bridge and New Bridge

This area remains flood free over a 50 year development lifetime for the 0.5% tidal and 1% fluvial events, assuming all bridges remain unblocked and flood defence walls are maintained. The 0.1% chance events result in two small localised areas of flooding over a 50 year development lifetime, both are within the TAN15 criteria limits for maximum velocity and maximum depth. At the end of a 100 year development life, flooding increases such that most of the area is inundated by 0.5% tidal or 1% fluvial events.

Under the blockage scenario considered, the northern part of the area is flooded to depths in excess of 1.0m, although the southern end remains flood free, during 0.1% event on Western Cleddau.

Mitigation of the risk of blockage and the integrity of the flood defence walls will be key to future development in this area.

Area G – Morrison's supermarket and associate retail units

This site remains flood free under free flow conditions for the 0.1% chance event over a 100 year development lifetime. However, if 50% blockage of the Wilkinson's access bridge were to occur, flood depths would exceed TAN15 criteria for a 0.1% chance event under existing conditions in the base year.

Development of this area would comply with TAN15 for all types of development, assuming mitigation of the risk of blockage of the bridges can be achieved.

Area H – includes Cattle Mart and football ground

Under unblocked scenario, existing sites, such as the cattle Mart and football ground, are compliant with TAN15 criteria over a 50 year development lifetime. However, a large portion of this area north of the cattle Mart site and west of the football ground is active flood plain. Development in this part of Area H would not be compliant with the indicative guidance in TAN15 and would be anticipated to have an adverse impact on flood levels in other areas, although this impact has not been quantified in this study.

If a 100year development life is considered the football ground site is inundated by the 1% fluvial event and so would not comply with Appendix 1.15 of TAN15.

In the bridge blockage scenario in the base year (2007) flood levels during a 0.1% chance flood event in the Western Cleddau would increase sufficiently to increase flood depths on the Cattle Mart site to exceed TAN 15 criteria.

We consider that it is questionable whether further development in this area would pass the Tan15 justification test.

8.5 Other Sources of flooding

8.5.1 Surface water flooding

Very little information exists on the incidence of flooding arising from direct runoff or from under capacity of surface water and highway drainage systems.

It can be can be expected that low lying areas of the town will be prone to surface water flooding at times of elevated levels in the Western Cleddau, whether due to tidal or fluvial events. Site specific studies will need to be undertaken, particularly, but not exclusively in areas behind riverside walls, of the provision for the discharge of the surface water and highway drainage systems.

8.5.2 Sewer flooding

Reported incidents of sewer flooding show no clustering and are largely away from areas at risk from fluvial or tidal flooding. This source is not considered a significant risk on an area basis. It is anticipated that provisions for the disposal of foul water will need to be satisfied as part of specific development proposals.

8.6 Site Specific FCA recommendations

The current study is a strategic level assessment of flood risk in Haverfordwest town centre. For site specific proposals, assuming Environment Agency acceptance of the findings of this report, the location should be assessed in relation to the flood boundaries and acceptability criteria for that site.

It is likely that for most sites, in the areas considered, additional topographic survey will be required to confirm the level data derived in the current study from LiDAR.

Specific assessment of the consequences of any given development will need to be undertaken when proposed site layout and any proposed site specific mitigation of flood risk are known.

9 Mitigation of Flood Risk

The most significant sources of flooding in Haverfordwest are fluvial and tidal, with a range of mechanisms and interacting overland flow paths. The causative mechanisms are combinations of fluvial and tidal as described in Section 7.2 and Section 8.3.2.

The solutions to mitigate flood risk will include combinations of options. No one option alone will provide necessary alleviation. It must be remembered that reduction in risk to any area or site must not adversely affect flood risk elsewhere. Each potential option will need to be assessed in detail in order to determine the most effective combination.

- Raise/replace the flood defence on left bank downstream of A487 bridge to Old Bridge to reduce overtopping into Area A during 0.1% annual chance event.
- Re-engineering of road levels and landscape levels to contain and better direct overland flow of Cartlett Brook south away from Area B during overtopping events.
- Engineer greater flood storage on the Western Cleddau upstream of town centre.
- Additional flood storage on Cartlett Brook.
- Measures to prevent trash from upstream entering the town centre area and blocking the bridges on the Western Cleddau or culvert inlets on the Cartlett Brook.
- Remove/replace Wilkinsons' access bridge.
- Town Weir – replace with moveable gate.
- Flood gate to prevent backflow up the Cartlett Brook during tidal flood events in the Western Cleddau channel.
- Tidal Barrage downstream of Haverfordwest to reduce tidal impact
- Managed retreat from the left bank of the Western Cleddau (Areas A & B)

These options have not been discussed with the Environment Agency, who will need to be consulted on any works affecting land drainage or flood risk management on main rivers.

Currently, the responsibility for the maintenance of walls functioning as flood defences, informal or otherwise, along the Western Cleddau is far from clear. The walls are for the most part likely to be privately owned, and are certainly not Environment Agency assets. It is recommended that the responsibilities should be more clearly defined to ensure future integrity of walls serving flood defences function; certainly before allocating parcels of land for future development.

10 Conclusions

10.1 Conclusions

1. The areas of Haverfordwest town centre have been assessed for compliance with indicative guidance in TAN15.

2. Each of the areas has been assessed for the type of development that may be appropriate for each of the areas.

3. This study does not replace the need to carry out site specific FCAs for developments proposed in each of the areas of the town. Rather, the findings of this study will direct the type of development which may be appropriate and inform future decisions on the extent of site specific FCAs that will be required.

4. A table and accompanying figures showing maximum depth and maximum flow velocity have been produced which provide quick reference as to which areas are compliant or otherwise with TAN15 indicative guidance.

Area specific Comments

5. Over a 50 year development lifetime, the area on the right bank of Haverfordwest Town Centre, Area F, satisfies the acceptability criteria for TAN15 - assuming that the defences are maintained at least their current height and that bridges on the Western Cleddau remain unblocked.

6. Over a 100 year lifetime, flood depths in Area F would be expected to exceed TAN15 indicative levels during a 0.1% flood event.

7. Area G will remain flood free assuming blockage of the bridge structures are prevent during a 0.1% flood event over a 100 year development lifetime.

8. All other areas assessed fail the indicative guidance in TAN15 either currently or over development lifetime.

9. Large areas of the left bank of the town centre, south of the A487 bridge are currently subject to flooding during a 1% fluvial flood event on the Cartlett Brook and on the Western Cleddau.

10. The blockage of bridges on the Western Cleddau and the culvert inlets on the Cartlett Brook is a significant risk.

11. Some degree of mitigation of flood risk will be required in all areas considered. A range of options are available. Detailed study of the impact of these mitigation measures has not been assessed as part of this study.

12. The range of mitigation options listed in the report is intended to inform planners in consideration of the development potential for any given site within the areas assessed.

13. There is no clear maintenance regime in place to ensure the integrity of flood defence in Haverfordwest. This position should be clarified and formalised as part of any proposed development in the flood plain.

11 Appendices

Appendix A: **Survey Drawings**
Appendix B: **Tables of Assumptions used in model**

Appendix A: SURVEY DRAWINGS

CONTRACT SURVEYS

LAND AND ENGINEERING SURVEYORS
SETTING OUT ENGINEERS
A QUALITY ASSURED ORGANIZATION

CONTRACT SURVEYS (WALES) LIMITED
12 London Road
Neath
SA11 1HB
Tel:(01639)637801
Fax:(01639)637844
E-Mail:Surveys@contractsurveys.co.uk
Company No. 3094598

LINE TYPES

Buildings
Kerbs, Walls
Fences
Top of banks
Bottom of banks
Hedges
Overhead Wires
Surface Change

ABBREVIATIONS

AV – Air Valve
B – Bollard
BB – Bellsha Beacon
BH – Bore Hole
BL – Basement Level
BM – Site Bench Mark
BT – British Telecom
B/W – Barbed Wire Fence
CAM – Camera
CB – Tel. Call Box
CL – Cover Level
C/B – Closed Board Fence
C/I – Corrugated Fence
DP – Down Pipe
DK – Drop Kerb
EL – Eaves Level
EP – Electricity Pole
ER – Earthing Rod
FFL – Floor Level
FH – Fire Hydrant
FL – Flood Light
FP – Flag Pole
G – Gulley
G 1.2 – Tree Girth (m)
GV – Gas Valve
IC – Inspection Cover
IL – Invert Level
I/R – Iron Railings
JB – Junction Box
KO – Kerb Outlet
LB – Letter Box
LP – Lamp Post
Mkr – Utility Marker
MP – Mile Post
OSBM – Ordnance Survey Bench Mark
P – Post
PS – Paving
P/R – Post/Rail Fence
P/W – Post/Wire Fence
RE – Rodding Eye
RL – Ridge Level
RS – Road Sign
SAP – Sapling
SC – Stop Cock
SL – Step Level
SP – Sign Post
SV – Stop Valve
TAC – Tactile Paving
TH – Trial Hole
T.O.W – Top of Wall
TP – Telegraph Pole
TS – Traffic Signal
TV – Cable Television
UTL – Unable To Lift
VP – Vent Pipe
WL – Water Level
WM – Water Meter
△ – Survey Station
ø – Pipe Diameter(m)

NOTES

1. OS grid used.
2. North arrow indicates approximate North.
3. All levels relate to Ordance Datum.

CLIENT

ATKINS

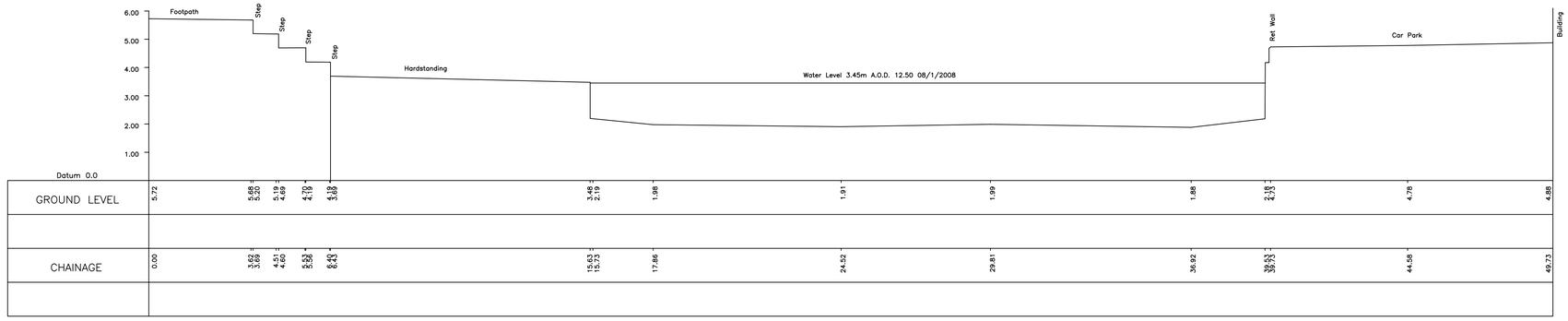
SHEET DIAGRAM

One Sheet Only

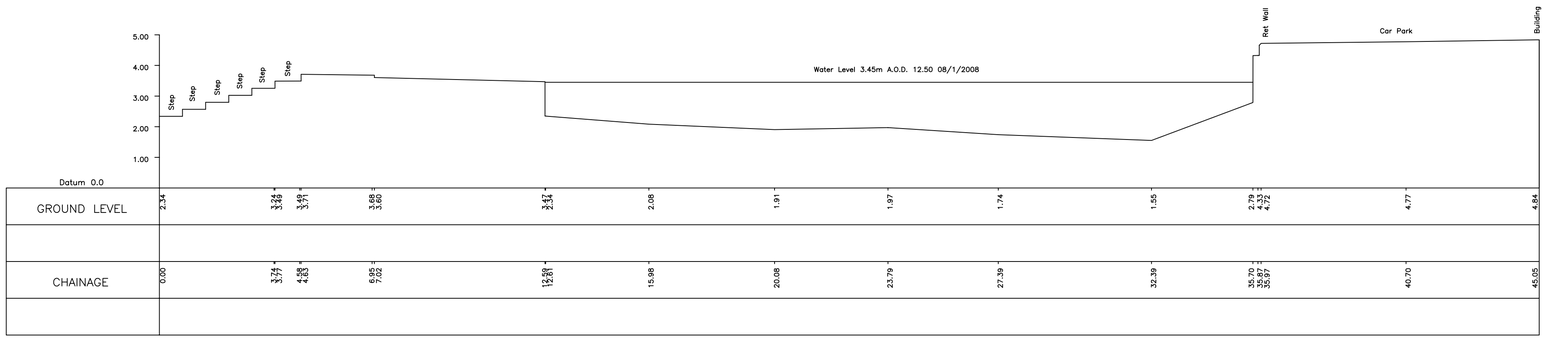
SCALE:	1:500 at A0
JOB No.	5656
DRAWING No.	5656/500A0/1.1
DRAWN:	RSL
CHECKED:	AC
APPROVED:	MJH
DATE	DEC 2007

HAVERFORDWEST FLOOD CONSEQUENCES ASSESSMENT

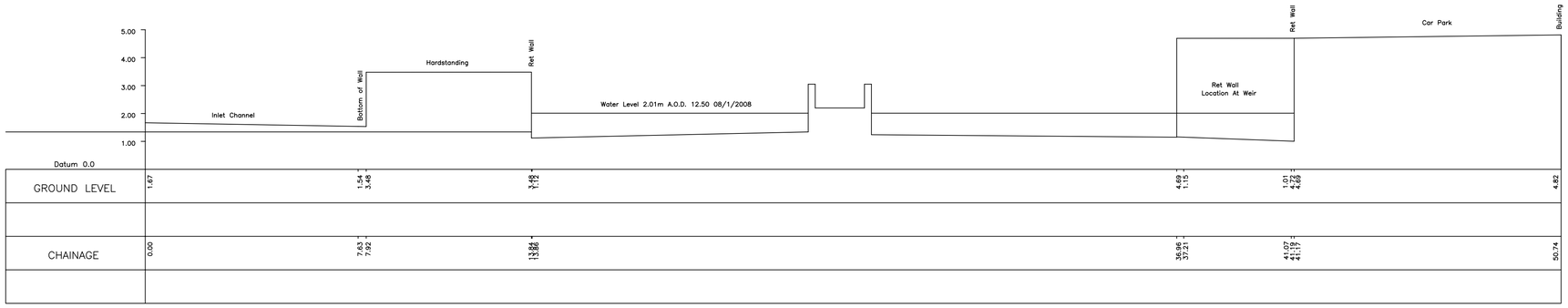
Level Survey



Section 4 – 10m upstream of weir



Section 5 – upstream of weir.



Section 6 – downstream of weir

CONTRACT SURVEYS

LAND AND ENGINEERING SURVEYORS
SETTING OUT ENGINEERS
A QUALITY ASSURED ORGANIZATION

CONTRACT SURVEYS (WALES) LIMITED
12 London Road
Neath
SA11 1HB
Tel:(01639)637801
Fax:(01639)637844
E-Mail:Surveys@contractsurveys.co.uk
Company No. 3094598

LINE TYPES

Buildings
Kerbs, Walls
Fences
Top of banks
Bottom of banks
Hedges
Overhead Wires
Surface Change

ABBREVIATIONS

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B/W – Barbed Wire Fence
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CB – Tel. Call Box
CL – Cover Level
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C/I – Corrugated Fence
DP – Down Pipe
DK – Drop Kerb
EL – Eaves Level
EP – Electricity Pole
ER – Earthing Rod
FFL – Floor Level
FH – Fire Hydrant
FL – Flood Light
FP – Flag Pole
G – Gulley
G 1.2 – Tree Girth (m)
GV – Gas Valve
IC – Inspection Cover
IL – Invert Level
I/R – Iron Railings
JB – Junction Box
KO – Kerb Outlet
LB – Letter Box
LP – Lamp Post
Mkr – Utility Marker
MP – Mile Post
OSBM – Ordnance Survey Bench Mark
P – Post
PS – Paving
P/R – Post/Rail Fence
P/W – Post/Wire Fence
RE – Rodding Eye
RL – Ridge Level
RS – Road Sign
SAP – Sapling
SC – Stop Cock
SL – Step Level
SP – Sign Post
SV – Stop Valve
TAC – Tactile Paving
TH – Trial Hole
T.O.W – Top of Wall
TP – Telegraph Pole
TS – Traffic Signal
TV – Cable Television
UTL – Unable To Lift
VP – Vent Pipe
WL – Water Level
WM – Water Meter
△ – Survey Station
φ – Pipe Diameter(m)

NOTES

All levels relate to Ordnance datum.

CLIENT

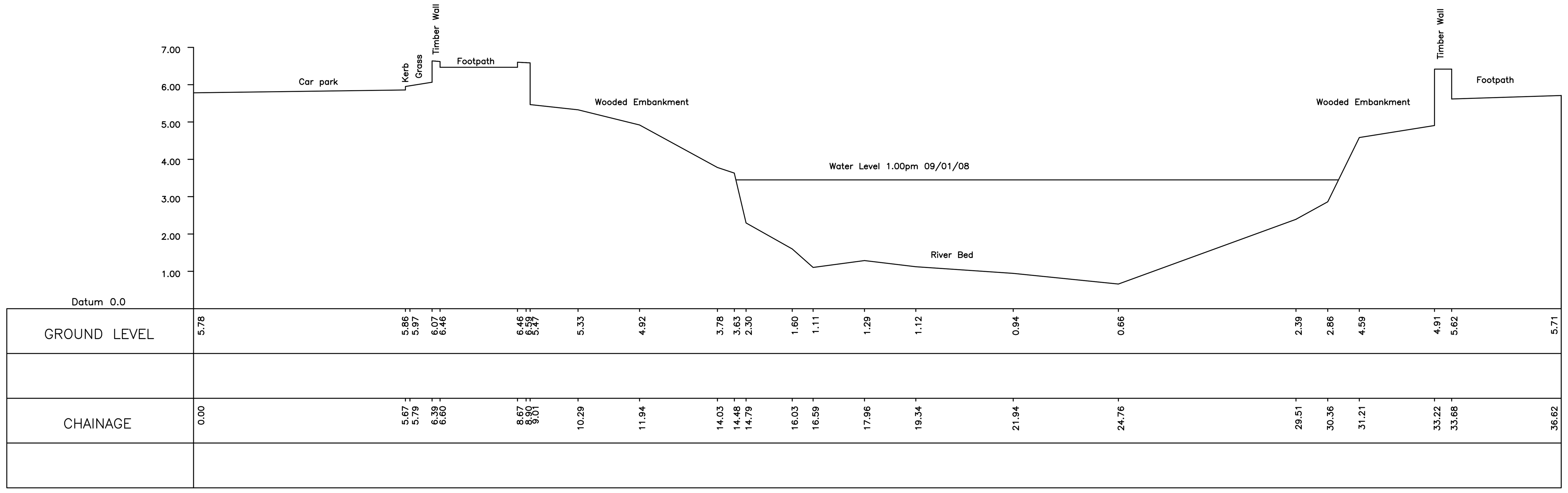
ATKINS WATER

SHEET DIAGRAM

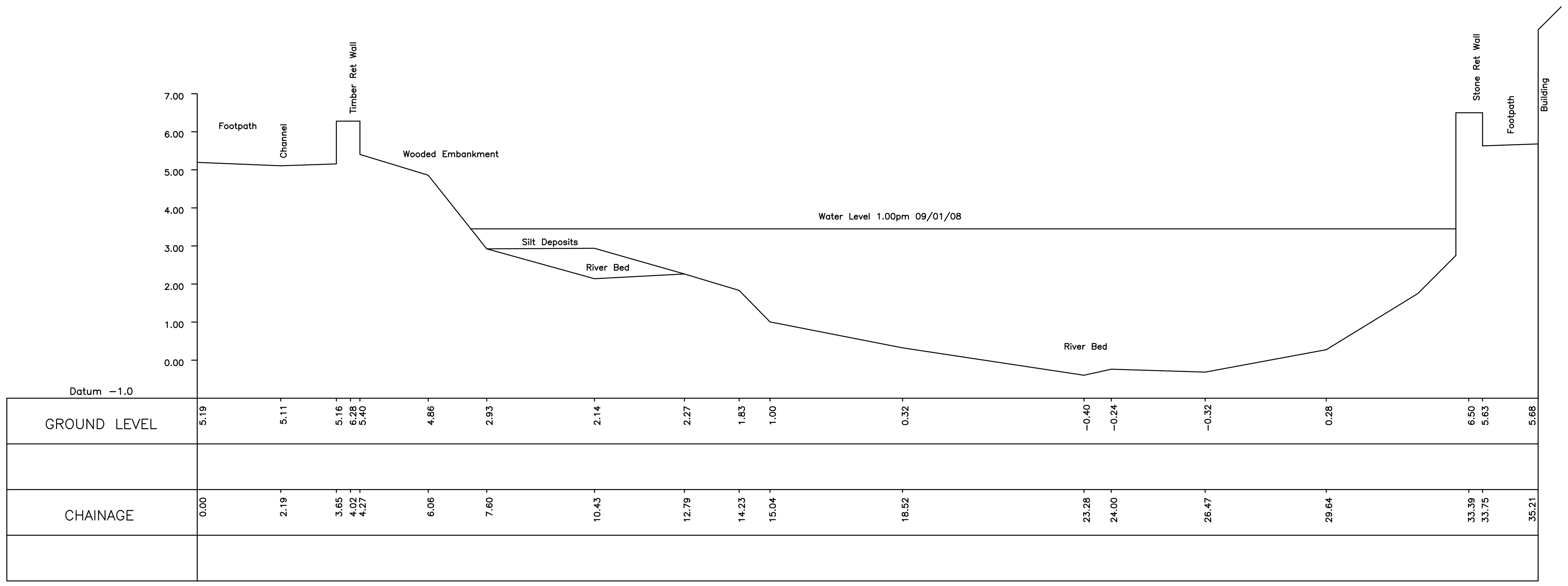
SCALE:	1:100 at A1
JOB No.	5656
DRAWING No.	5656/100A1/2.2
DRAWN:	RSL
CHECKED:	AC
APPROVED:	MJH
DATE	JAN 2008

WESTERN CLEDDAU, HAVERFORDWEST.

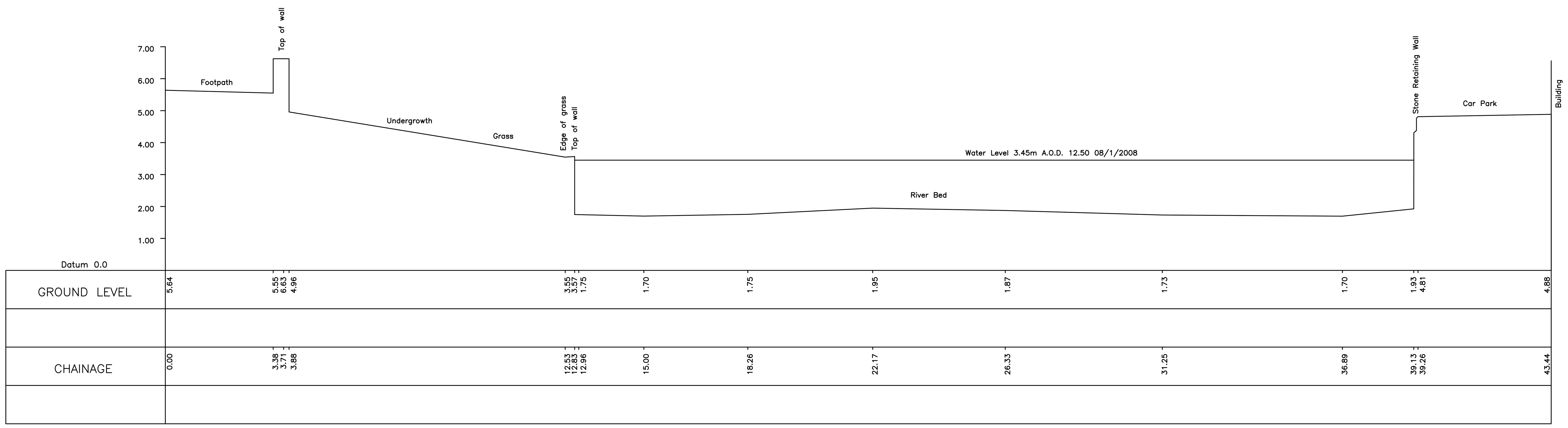
RIVER SECTIONS



Section 1 – 40m downstream of car park bridge.



Section 2 – 30m upstream of old bridge.



Section 3 – 40m upsream of weir

CONTRACT SURVEYS
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A QUALITY ASSURED ORGANIZATION

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12 London Road
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Tel:(01639)637801
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E-Mail:Surveys@contractsurveys.co.uk
Company No. 3094598

LINE TYPES

Buildings
Kerbs, Walls
Fences
Top of banks
Bottom of banks
Hedges
Overhead Wires
Surface Change

ABBREVIATIONS

AV – Air Valve
B – Bollard
BB – Belisha Beacon
BH – Bore Hole
BL – Basement Level
BM – Site Bench Mark
BT – British Telecom
B/W – Barbed Wire Fence
CAM – Camera
CB – Tel. Call Box
CL – Cover Level
C/B – Closed Board Fence
C/I – Corrugated Fence
DP – Down Pipe
DK – Drop Kerb
EL – Eaves Level
EP – Electricity Pole
ER – Earthing Rod
FFL – Floor Level
FH – Fire Hydrant
FL – Flood Light
FP – Flag Pole
G – Gulley
G 1.2– Tree Girth (m)
GV – Gas Valve
IC – Inspection Cover
IL – Invert Level
I/R – Iron Railings
JB – Junction Box
KO – Kerb Outlet
LB – Letter Box
LP – Lamp Post
Mkr – Utility Marker
MP – Mile Post
OSBM– Ordnance Survey Bench Mark
P – Post
PS – Paving
P/R – Post/Rail Fence
P/W – Post/Wire Fence
RE – Rodding Eye
RL – Ridge Level
RS – Road Sign
SAP – Sapling
SC – Stop Cock
SL – Step Level
SP – Sign Post
SV – Stop Valve
TAC – Tactile Paving
TH – Trial Hole
T.O.W– Top of Wall
TP – Telegraph Pole
TS – Traffic Signal
TV – Cable Television
UTL – Unable To Lift
VP – Vent Pipe
WL – Water Level
WM – Water Meter
△ – Survey Station
ø – Pipe Diameter(m)

NOTES

All levels relate to Ordnance datum.

CLIENT

ATKINS WATER

SHEET DIAGRAM

SCALE:	1:100 at A1
JOB No.	5656
DRAWING No.	5656/100A1/1.2
DRAWN:	RSL
CHECKED:	AC
APPROVED:	MJH
DATE	JAN 2008

WESTERN CLEDDAU, HAVERFORDWEST.

RIVER SECTIONS

Appendix B: TABLES OF ASSUMPTIONS USED IN MODEL

B.1 Structures, Coefficients used & Manning's n

Table 11.1 Coefficients used to Model Culverts

Coefficient	Value
Height contraction coefficient	0.5
Width contraction coefficient	0.5
Entry loss coefficient	0.5
Exit loss coefficient	0.5

Table 11.2 Schedule of Hydraulic Structures along study reach of Western Cleddau and Cartlett Brook

Section Ref	Location	Structure Type	Comments
Western Cleddau (WC)			
WC1	A487	Bridge	Single span concrete bridge
WC2	Wilkinson car park	Bridge	Twin span concrete bridge
WC3	Old bridge	Bridge	Masonry arch bridge
WC4	Riverside shopping centre	Footbridge	Single span steel footbridge
WC5	New bridge (Victoria Place)	Bridge	Masonry arch bridge
WC6	County hall	Weir	Crest Level = 3.05m
WC7	County Hall	Footbridge	Single span steel footbridge
WC8	Freeman's Way	Bridge	Steel and concrete bridge with 2 concrete piers
WC9	Railway Bridge	Bridge	Steel and concrete bridge with 2 concrete piers
Cartlett Brook (CB)			
CB1	Scotchwell Caravan Park	Culvert	2.0 m diameter
CB2	A40 Culvert	Circular (C)	

Section Ref	Location	Structure Type	Comments
CB3	A40 Bridge	Bridge	Modelled as culvert
CB4	Cambrian Place	Culvert (R)	
CB5	Under the County Hall	Culvert (R)	

Table 11.3 Manning's Roughness Coefficient for different Land Use Patterns

Land Use Pattern	Manning's Roughness Coefficient
Open land including green fields	0.040
Water bodies	0.050
Roads, motorways, alleyways etc	0.025
Urban area including buildings	0.100

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