North Runcton & West Winch Surface Water Management Strategy

Prepared by the Middle Level Commissioners for the East of Ouse, Polver and Nar Internal Drainage Board

April 2014

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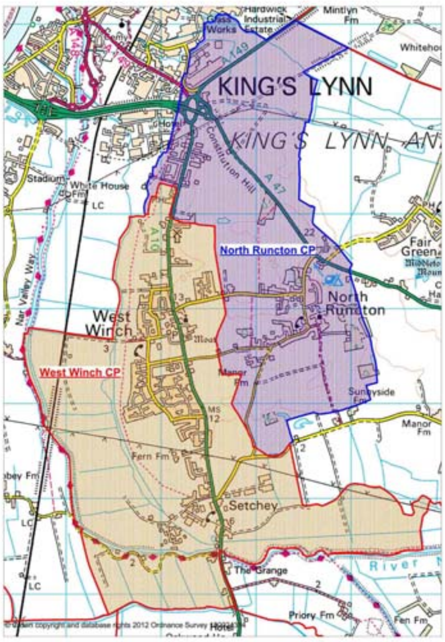
<u>Introduction</u>

The Borough Council of King's Lynn and West Norfolk (BCKLWN) have proposed significant urban growth within the parishes of West Winch and North Runcton, south east of King's Lynn. The Core Strategy (adopted 2011) proposes 1600 new dwellings by 2026, and promotes the potential for several thousand more dwellings in subsequent decades.

The two parish councils have subsequently undertaken to work together to produce a Neighbourhood Plan with a view to representing the views of local residents in the development process. Due to the 'fen edge' setting of the parishes, underlying clay soils, and poor drainage provision in some previous development, residents have highlighted the critical nature of surface water management planning for the area. There has been a history of minor flooding and poor drainage within both parishes. Residents have raised concern about the potential drainage impacts of proposed development on higher ground for existing development on lower ground.

Using a grant from *Locality*, and with funding assistance from BCKLWN and the East of Ouse Polver and Nar Internal Drainage Board (IDB), the parishes appointed the IDB to prepare a strategic surface water management plan for the Neighbourhood Plan area – which represents the full extent of both parishes (see Figure 1 below). However, it has been necessary to consider the likely form of future development – which in early 2014 is not fixed. For the purposes of this study we have therefore referred to a plan produced by developers in 2013 for an ES scoping exercise (refer page 10, Map 2: Developer Concept Master Plan). This plan may or may not reflect the eventual development pattern but provides a good basis for surface water management analysis. The whole neighbourhood plan area has been considered when assessing drainage mitigation opportunities.

This strategy is therefore intended to be used as a technical addendum to the Neighbourhood Plan and as a guide for drainage planning in future sustainable development within the study area. It identifies a practicable and robust approach to achieving an appropriate drainage system for the area within presently identified constraints.



Map 1:
The North Runcton and West Winch Neighbourhood Plan area.

Objectives

The primary purpose of the strategy is to identify and develop in outline a planned sustainable strategic surface water management plan for the two parishes, taking into account proposed development, potential future climate change and likely management and maintenance constraints.

Investigations undertaken in the preparation of this report have also sought to identify weaknesses in the current arrangements for surface water management and to define opportunities for drainage improvement.

The strategy identifies a framework which could be implemented in phases and has some intrinsic flexibility should development goals alter from the indicative designs available for review in early 2014.

It is recognised that drainage corridors could have multifunctional benefits for landscape amenity, biodiversity, local non-vehicular access, recreation and other purposes.

Aims

- To gain an understanding of the current drainage arrangement serving the area by way of a desk study and site visits, this involved gathering information from parties involved with the project, local & county councils, local residents, the IDB and internet sources such as DIGDAT for Anglian Water sewer information.
- To identify any current and potential constraints effecting the development and the surface water infrastructure within the parishes. This was achieved by using information gathered from the desk study and on-site research. The parish districts were then split into drainage areas based on contour data and potential development zones assessed for surface water run-off and its associated management.
- To outline general advice for the areas. This information provides details on the major constraints which should be placed on the final designs and any information that may be critical to that design.
- To outline the preferred layouts of each of the areas. Whilst not aiming to dictate a rigid plan, the suggested design options provide examples of the form solutions could take and what would be preferred by the Borough Council of King's Lynn and West Norfolk, East of Ouse, Polver and Nar IDB and the two parish councils.
- To list conclusions from the investigation and report.

Assumptions

For the purposes of preparing the strategy there were a number of assumptions that had to be made, many of which take their lead from those within the developing Neighbourhood Plan document, namely;

- It is assumed that a masterplan will evolve and be adopted by BCKLWN in coming months and that this master plan will identify all major development areas envisaged for the parishes on North Runcton and West Winch for at least 50 years (i.e. two planning cycles).
- That master plan is likely to allow for between 3000 and 3500 new homes and associated local employment land, transport infrastructure, community facilities and green infrastructure.
- That the anticipated 'urban structure' will constitute four residential centres – approximately located at Constitution Hill in the north, West Winch old village centrally and towards the Gravelhill Lane estate to the south. North Runcton village will remain a separate 'satellite' village.
- That the four residential 'villages' will be separated by protected farmland and green space. These corridors would also aim to serve multifunctional purposes including buffers for the gas mains, surface water management areas, farmland, wildlife corridors and recreational and amenity public open space.
- That there will be a substantial new north-south road corridor (the 'parallel route') constructed between West Winch and North Runcton with the object of easing future traffic on the A10 and A47 and within the adjacent settlement.

- That the councils will support a strategic approach to surface water management and that they will adopt the neighbourhood plan and this report as material planning considerations to ensure that surface water management serving development is not progressed in a piecemeal manner.

Report Structure and Limitations

This report incorporates tables, maps and appendices which have been developed to assist in formation of the strategic overview and proposals. The report includes where possible observational records of localised flooding which have been obtained and collated from parishioners, the IDB and council officers. Anglian Water and the Highway Authority have also been approached for information they hold on flooding and for their adopted sewer records. LIDAR information has been supplied by the BCKLWN which has been imported into ARCGIS software to produce the contour plan (see Appendix 2 – Map 5: LIDAR contour map (1:10000)). It is however important to note that the accuracy of LIDAR information varies and therefore should never be used for final design purposes. It does however provide a good guide to natural falls and has been of great assistance with identifying sub-catchments and hence has informed the outline drainage system design.

Research found that there is a significant lack of data on the existing drainage infrastructure in the area and in particular the storm water sewer network.

The report is intended to provide guidance at the sub-catchment level and not to provide detailed design proposals for surface water management on a site by site basis.

The report assumes that strategic drainage provision will in future be implemented in the most part by developers. Where infrastructure will be required beyond development sites it is anticipated that planning related agreements (section 106) will be required. The report does not attempt to provide cost estimates for the suggested infrastructure or propose a methodology for the delivery process.

The report assumes that key drainage corridors will be safeguarded from development that would undermine their proposed drainage function and that this can be a requirement of planning consent. Other proposed protected green spaces will also have a function in a sustainable drainage plan for the area and will also need to be safeguarded.

Strategic Context

The landscape of the study area east of the A10 corridor is described as 'farmland with woodland and wetland' and has a variable topography with a highpoint of 22m AOD near the A47 at North Runcton. However the landscape to the west and south of the study area is low lying, flat, 'fenland' generally lying below the 5m aOD contour line. West Winch is therefore a 'Fen edge' village which has grown along the slightly higher and better drained land (and possibly as a result of early drainage and flood protection schemes). North Runcton, set on higher ground to the east (18-20m aOD), is thought to have been the original settlement. Much of the proposed future development is proposed on the land in between today's villages (and therefore on land typically lying between 10 and 20m aOD).

The low lying fens are a unique drained landscape, where runoff to ditches is typically pumped into higher main drains and rivers which then discharge to the sea. This is the case at West Winch and North Runcton, where surface water from the parishes drains mainly to the Puny Drain but also to the Pierpoint Drain, both of which are then pumped to the River Ouse and its Relief Channel. The fens are characterised by clay overlain by peat, silts, sands or gravels. Higher ground is often associated with underlying clay – as is the case at North Runcton. Clay is characteristically not 'free draining' and is therefore one of the poorest materials for supporting drainage design based on infiltration (i.e. soakaways).

A sustainable approach to drainage design in the area must therefore consider:

- The potential impact of run-off from higher areas to lower areas – especially where development in lower areas may already have inadequate surface water drainage provision.
- The capacity of the existing drainage system to cope with additional runoff especially at key 'pinch points' such as the Puny and Pierpoint drains.
- The natural constraints on drainage design options defined by the clay soils.

Sustainable Drainage System (SuDS)

It has now become widely accepted that new development should seek to incorporate *sustainable drainage systems* (SuDS) that seek to mimic natural systems and control the run-off of surface water as close to source as is practical.

The change in approach followed a recognition that numerous pollutants (such as oil, sediments, fertilizers, pesticides, animal waste and litter) entering drainage systems can have adverse economic, environmental and social impacts. Often, this is not adequately managed by traditional piped drainage. Pollutants or contaminants can be washed into sewers and eventually watercourses in surface water runoff, making it difficult to comply with water quality legislation. Some SuDS components provide water quality improvements by reducing sediment and contaminants from runoff either through settlement or biological breakdown of pollutants.

Drainage systems also need to adapt to and manage extreme events including flooding and periods of drought, while helping to reduce our carbon emissions. SuDS schemes can be designed to slow water down (attenuate) before it enters a watercourse, provide areas for water storage in natural contours, and can be used to allow water to soak (infiltrate) into the ground, be evaporated from open surface water and/or transpire from vegetation (known as evapotranspiration).

The benefits of providing 'green infrastructure' with development are now more widely accepted and can include SuDS provision. SuDS components (like ponds and wetlands) provide an array of amenity, recreational and biodiversity benefits. However, they will only fulfil their ecological potential if their design criteria consider ecology, flood risk and water quality management together. SuDS provide opportunities to create visually attractive green (vegetated and landscaped) and blue (water) corridors in developments connecting people to water.

As stated above, the SuDS design philosophy generally seeks to control water as close to the source as possible and to convey water 'naturally'. However, in this study area the low lying landscape, high water table and underlying clay will limit natural infiltration. There are also established constraints for conveying water in ditches and channels in some locations. It is therefore envisaged that balancing ponds and other water storage capacity must be provided in order to facilitate sustainable surface water management in periods of high rainfall, and that water may need to be piped in some situations.

Surface water infrastructure and land ownership

Much of the land to the immediate east of the Puny Drain is grazing common. Other common lands with similar grazing rights exist in North Runcton and Setchey. These are private land holdings with long established grazing rights held by various parties. Although these areas are in the main, low lying permanent pasture that would be ideal for temporary storm water drainage, it is anticipated that there would be legal issues and a need for extensive negotiation if such plans were made for these areas. It is a drainage management option that might be considered, but alternative attenuation areas may be easier to implement.

Managing private ditches

A concern of local residents is that in the past drainage ditches have been filled in and others poorly maintained leading to drainage problems in periods following prolonged rainfall. The importance of a fully integrated and well maintained network of ditches cannot be overestimated. It is therefore suggested that further study is required to identify all important ditches in the area and, in future, when planning consent is granted it is given subject to protection (via conditions) of any open watercourses. This may best be achieved through the passing of watercourse corridor land to the borough or parish council, with a commuted sum passed to them to cover the cost for maintenance.

Adopted surface water infrastructure

At the time of writing this report the Flood and Water Management Act 2010 has been passed but the section relating to the setting up of Sustainable Drainage Approval Bodies (SABs) has not yet been implemented – although it is still understood that they will be introduced. The SABs main duty will be to approve sustainable drainage systems, as long as they meet the requirements set out in the Flood and Water Management Act 2010, and then the system could be suitable for adoption by the County Council. At the moment any system which is implemented cannot rely on using SABs as a maintenance solution for the proposed development and hence alternative arrangements must be considered.

It is important that a statutory body adopts the key principle elements of the scheme proposed by this report. Suitable bodies would be Norfolk County Council, BCKLWN or the Parish Councils. It would be helpful if discussions between these bodies take place and agreement reached on which would be the most appropriate organisation to adopt and manage the new infrastructure. It would also be prudent to ensure that the long term maintenance is funded by the developers through the payment of commuted sums. It is suggested that these sums should be sufficient to cover the entire predicted cost of initial maintenance over a period of not less than 30 years.

Current situation

Puny Drain

The Puny Drain is the principal receiving watercourse for the study area and until 2008 it drained to the Great Ouse at South Lynn. Further to engineering works in 2008, a new 4 cumec pumping station was located adjacent to Clarks Chase, where water is now pumped from the Puny to the Great Ouse Relief Channel. The northern section of the Puny Drain is now oversize in terms of capacity but does provide on-line storage within it. As part of the diversion design the post implementation flood plain was modelled (see Appendix 4 – Map 9: Map of 100 year flood outlines). This flood plain depicts the situation in a 1 in 100 year event with an allowance made for climate change. Whilst flooding is expected, it is important to note that this is restricted to farm land and not the urban areas. There is a history of discrete flooding within the parishes of West Winch and North Runcton but this is due to poorly maintained and inadequate local drainage and not the functioning of the Puny Drain.

Adopted Sewers

Both Anglian Water (urban adopted sewers) and Norfolk County Council (A10 carriageway drainage) were approached and asked to supply records in the area. Anglian Water's plans show that the only adopted surface water sewers within the area of interest appear to be situated within one isolated housing estate.

Whilst the A10 was originally classified as trunk road and maintained by the Highways Agency, in recent years it has undergone a change in classification and the responsibility for maintenance has been passed to Norfolk County Council. Norfolk County Council was unable to provide records of any storm water sewers which might exist. Indeed the only records available appear to be those linked with local estate road drain clearance, where contractors carrying out the clearance have investigated the local system and passed what they had found on to the Council. The Highway Authority was also approached but they advised that any records they had would have been passed on to Norfolk County Council.

Existing Flooding

Some information gathered from locals on local flooding problems is shown on Maps 10, 11 and 12 in the appendices. The majority of the flooding appears to be localised. It is, however, indicative of the issues the Parishes have with the abundance of non-adopted sewers and the fact that the catchment is clay based.

Due to the poor drainage in the area and the apparent lack of clarity in terms of maintenance responsibility there are a significant number of areas of localised flooding that the residents have experienced in recent years. It is believed that many houses rely on soakaway drainage, which for reasons outlined earlier in the report is less than ideal. Poor sewer maintenance of piped and open channel drainage coupled with a lack of fall and in some instances no doubt inadequate design, may have all contributed towards these problems.

Analysis and Calculations

Analysis has drawn on all the available information and uses it to inform our suggested surface water drainage management proposals. The first step taken was to divide the study area into smaller 'sub-catchments', where development will be naturally divided by constraints such as topography, the existing drainage pattern and existing urban development. These smaller areas have been named Zones 1 to 7 and can be seen on Map 3 (refer below). The Zones have then been assessed to identify indicative drainage paths and the most suitable areas for potential surface water attenuation areas (refer Map 4). These attenuation areas (1 to 11) where potential temporary surface water storage facilities can be sited are shown on Map 5.

The area of each Zone has been calculated and then using information from the *MicroDrainage* specialist software program the approximate volumes required for surface water storage have been calculated. All the calculations are for guidance only and should not be used for the final design stage.

The current accepted standard for flood protection for new property in inland areas is to plan for a 1 in 100 year return period rainfall event with the allowance of 30% for climate change given. This figure is quoted in various British Standards, Eurocodes and in the Planning Policy Statement 25 (PPS25) Technical Guidance. (Although the main PPS25 document is superseded by the NPPF the technical guidance is still current as of the publish date of this document). The 1:100 year figure reflects the probability of an area flooding once in a century based on previous weather records. One alternative way of viewing this is that there is a 1% chance of a flood event in any given year. The design life of most urban development is estimated at between 60 and 100 years before an expected need for redevelopment. This effectively means, statistically, that we are designing to parameters where one flood event might be expected within the lifetime of a development. It does not of course mean that it won't be possible to have more than one 1 in 100 year flood event in a century, or, none at all.

General

Most of the water falling within the two Parishes discharges into the Puny Drain and this will remain the case as the proposed development areas are built out. However the proposed development can be expected to greatly increase the impermeable land cover and this is likely to lead to a large increase in the speed and rate of runoff, potentially exacerbating the existing problem of flooding and potential flood risk within the existing village settlements and surrounding farm land. The *MicroDrainage* calculations take account of the increase in impermeable surfaces. The development zones have been assumed to have impervious areas amounting to 55%

of the total development land for lower density residential areas (plus an additional 10% allowance for urban creep) and 85% for the higher denser village centres. This is considered to be a slightly conservative approach, but generally appropriate. An allowance has also been made for expected climate change impacts over the period.

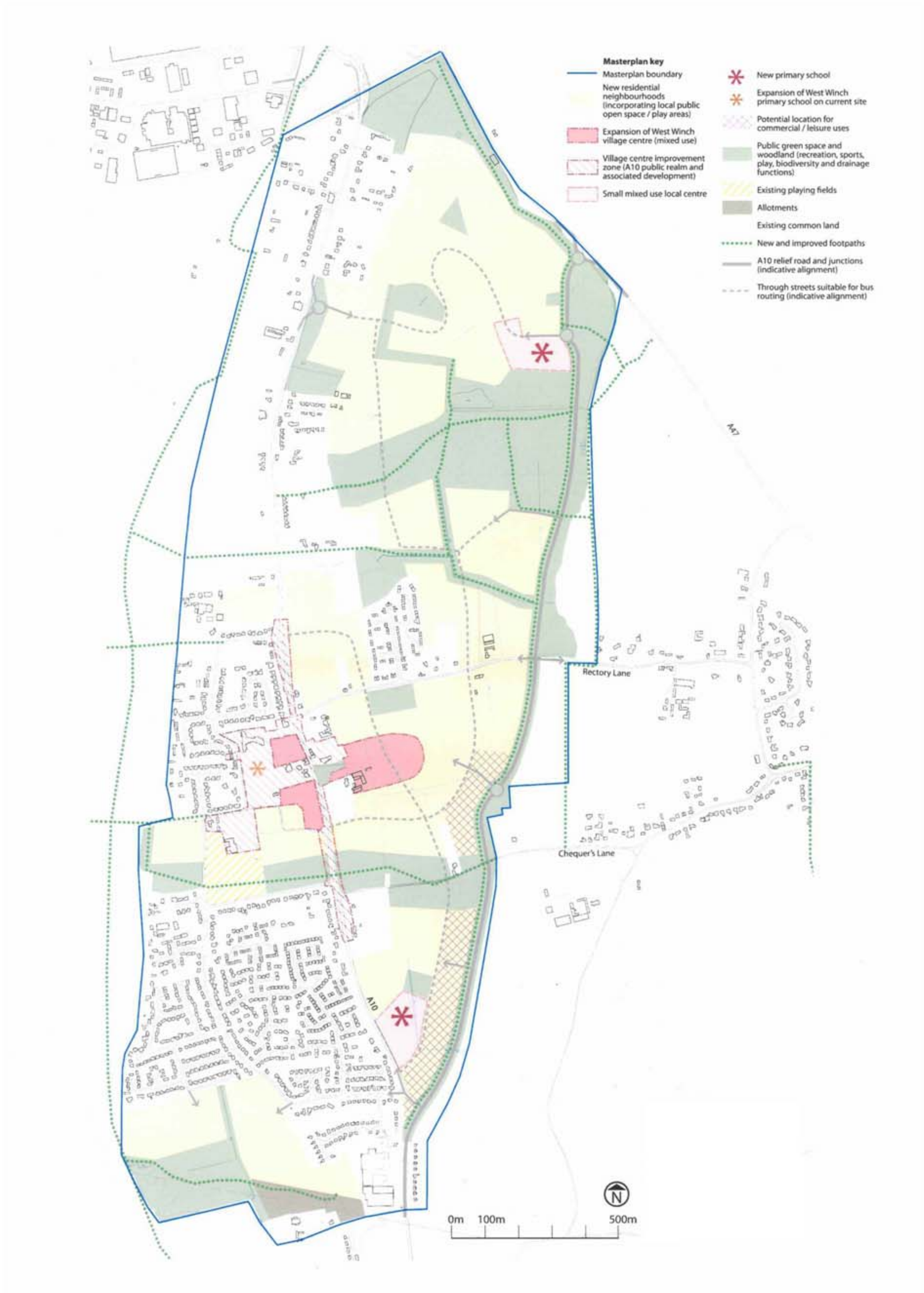
Zone by Zone

The following proposed strategic approach to storm water management is based on the premise that the existing pumping stations do not have the capacity to deal with additional peak inflow. Therefore the new development areas will need to incorporate within them sufficient surface water attenuation capacity to balance storm water discharge to pre-development green field run-off rates. Methods such as tanks and storage ponds (on and off-line) have been considered. Use of flow control devices such as hydro-brakes, or similar, have also been utilized in the schematic designs to ensure maximum efficiency of storage. As with any current system, design exceedance flows and the effects of blockage must be considered together with overland flow routes to ensure that property and life would not be at risk should a greater than 1 in 100 year event be encountered.

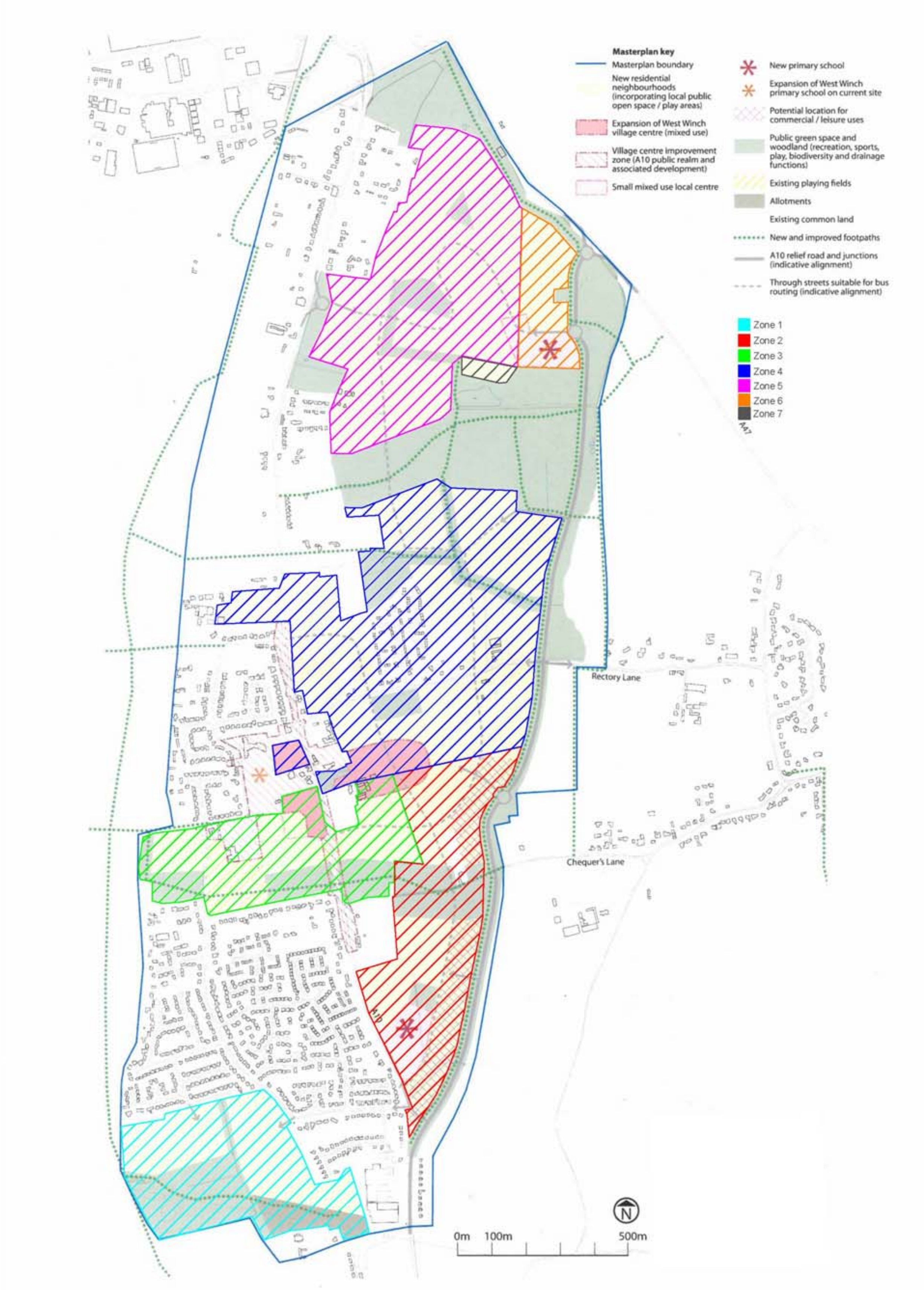
Puny Drain

As previously noted, towards the western side of the study area it may be complicated to negotiate provision of attenuation basins on common land. Another approach may be to increase the storage capacity of the Puny Drain channel by expanding the width of the drain to create a 'two-stage' channel, where re-profiled banks provide a wider cross section. A problem with this approach is that calculations necessary to assess the capacity of 'within-channel' systems tend to be less precise due to the complexities of allowing for storage take up. It will therefore be necessary to allow for an additional 30% uplift in storage provision for this option.

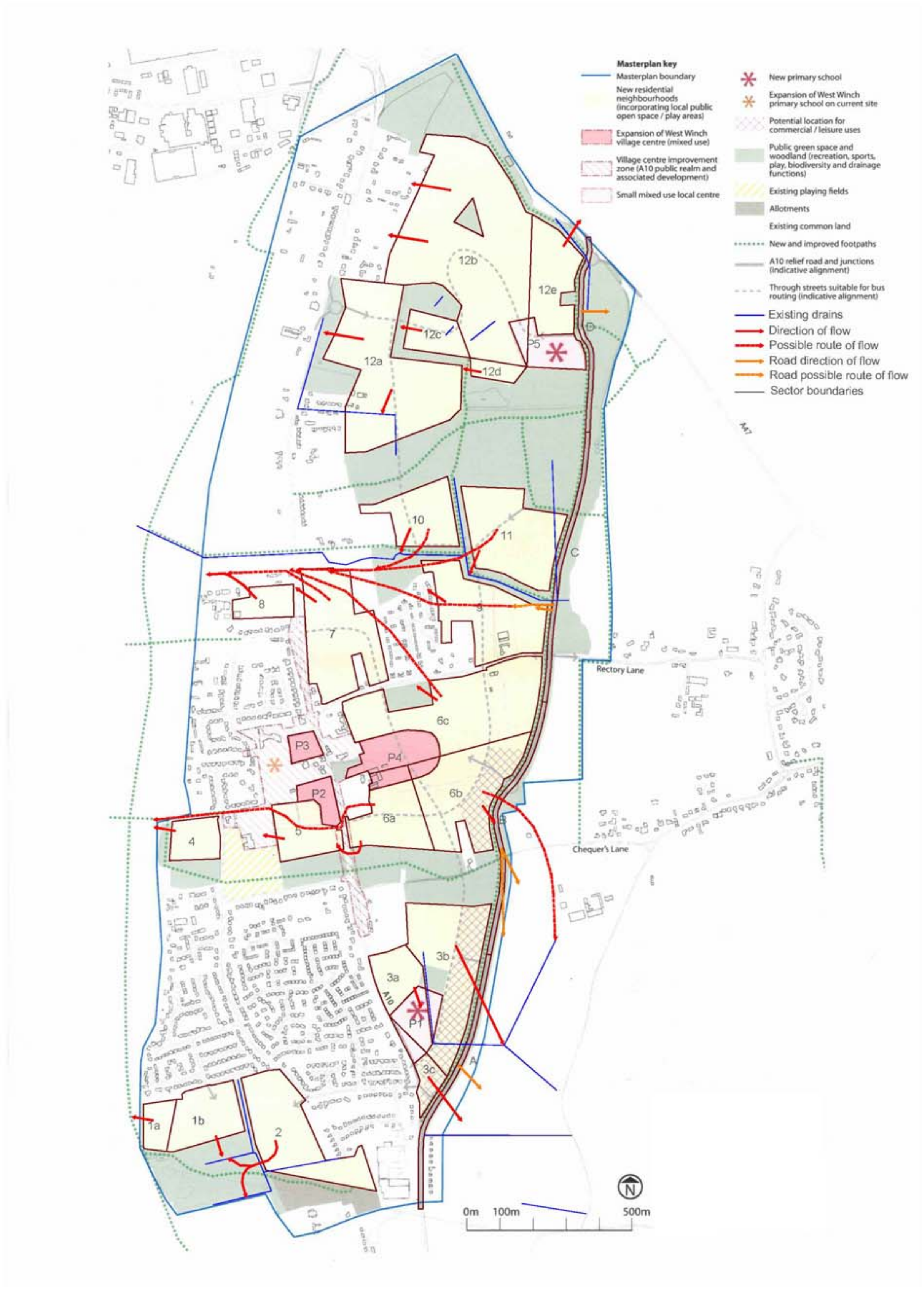
This would be our preferred approach – but it will still require land ownership negotiation and detailed planning and funding. Our view is that costs should be covered by a commuted sum from developers and then it would be probable that the IDB would be able to adopt and manage the expanded drain in future.



Map 2: Developer Concept Master Plan



Map 3: Zone Boundary map



Map 4: Drainage direction and possible paths map, including the zones split into sub-zones

Map 5: Possible storage areas map

Zone One

Description of Zone One

Zone 1 is an area of approximately 11.35 hectares and is located south-west of the existing Gravelhill Lane residential area. It has been put forward for development in the site allocation process and ZAL are believed to own the land. The zone drains to the southwest towards Puny Drain, south of the pumping station. At the moment there are a few drainage ditches which could be utilized to convey water to storage. The drains are not well cared for however and will need maintenance to operate at their design standard.

Zone One Analysis

The LIDAR data shows there is a fall across the area from the north to the south and then in the eastern part a fall from the east to the west (see Appendix 2 – Map 5: LIDAR contour map (1:10000) and Map 4). The principle of the design is to work with existing falls and utilize existing or newly formed drainage ditches. At the moment there are some ditches that run towards the Puny Drain, but these ditches seem to have had a lack of maintenance over the years so will need to be improved or replaced. At the time of writing it is not yet clear whether this area, which has been put forward for development, will be supported by the neighbourhood plan – as many residents have objected. However we believe that in terms of drainage constraints this area is developable, as long as appropriate drainage infrastructure is implemented. It is understood that there have been previous minor flooding and drainage issues in the existing neighbouring estate, and there may be some potential to relieve these problems with appropriate design in the new development area.

- Maximum design head for storage area – 0.65m
- Worst storm event – 8640 min winter storm event
- Amount of water needed to be stored from storm event – 11022.0 m^3
- Most efficient type of Hydro-brake – Md4
- Maximum storage area – 495652.39 m^2
- Storage used – at 0m depth 18000m^2, at 1m depth 20000m^2

Possible storage Area 1 on Map 5

The favoured solution for this area is to have a pond in the area identified; MicroDrainage calculated that during a 1 in 100 year plus climate change (+30%) event there will need to be 11,022 m^3 worth of storage to accommodate the influx of water. The usable area is 495,652 m^2 which could easily accommodate a 1m deep drainage pond or tank while retaining green space within the area for the amenity of the residents.

The drains may have to be improved to take the heavier load from the surface run off from the new impermeable areas.

Zone Two

Description of Zone Two

Zone 2 lies east of the A10 and straddles Chequers Lane and is predominantly arable land. The proposed ‘relief road’ as well as residential areas are proposed here. It drains towards the south and south-east (towards a lane in North Runcton parish known as the ‘Twistey Twiney’). The existing field ditches flow into the Puny Drain before it passes through Setchey. A high pressure gas main crosses the area east/west towards the northern edge of the Zone and due to associated land use constraints, this will be proposed as a ‘green corridor’ in future development.

Zone Two Analysis

The area consists of mostly farm land which is drained by a series of ditches. It is worth noting that several fields have recently been under drained, and previous field ditches filled in, and that residents had noted subsequent standing water on the land. Based on the present development masterplan for the area it is anticipated that surface water storage areas are likely to need to be accommodated beyond the presently defined development boundary.

- Maximum design head for storage area – 0.65m
- Worst storm event – 4320 min winter storm event
- Amount of water needed to be stored from storm event – 17083.6 m^3
- Most efficient type of Hydro-brake – Md4
- Maximum storage – 118679.77 m^2
- Storage used – at 0m depth 48000m^2, at 1m depth 50000m^2

Possible storage Area 2 on Map 5

It is proposed that a facility could be provided outside the master plan boundary to accommodate a storage solution. The area identified has 118,680 m^2 worth of surface area which will have to accommodate 17,083.6 m^3 of water in the design storm event. The area indicated on the map is only a representation of the area in which the storage could be placed.

Considering Area 2 is outside the master plan area, negotiations would need to be held with land owners to secure this area for storage or drainage systems. The area actually required will be much smaller than the area identified which is solely for the purpose of suggesting roughly where a facility could be sited. Most of the land in this area is high grade agricultural land (Grade 2) and it will be a goal of the Neighbourhood Plan to minimise the loss of arable land. Hence any infrastructure within this area of land will need to be designed to have a minimum footprint.

Zone Three

Description of Zone Three

Zone 3 includes land north of Chequers Lane to the east of the A10 and land west of the A10 including agricultural land and the sports fields north of Long Lane in West Winch. This area drains to the west towards Puny Drain, just south of Clarks Chase. Future development is likely to include residential and mixed use types and towards the northern edge this may be reasonably intensive development as it is intended to become an important local centre. Some areas of existing residential development and agricultural land have historic minor flooding problems in this area.

Zone Three Analysis

Towards the southern edge of the area there is constraint in the form of a high pressure gas main, hence there can be no deep ditches or storage facilities here that may potentially disturb the gas main. However as building will also be restricted near the gas main this does provide the opportunity to create a 'green corridor' with some infiltration benefits.

Another constraint is the existing West Winch playing field. Existing arable land between this and the A10 may be the best opportunity for surface water storage, along with another arable field to the far west of the area (north of Birch Grove and west of Hall Lane), although it is noted that there is already some Anglian Water sub-surface storage infrastructure in this area.

- Maximum design head for storage area – 0.65m
- Worst storm event –120 min winter storm event
- Amount of water needed to be stored from storm event – 3427.7 m^3
- Most efficient type of Hydro-brake – Md4
- Maximum storage – 3146.28 m^2
- Storage used – at 0m depth 2800m^2, at 1m depth 3100m^2

The current area identified as available for installing a balancing pond is not large enough to serve the whole of Zone 3 (see Map 5). Some development space will therefore need to be sacrificed to accommodate the facilities or, alternatively, underground storage provided under roads or public parking.

- Maximum design head for storage area – 0.65m
- Worst storm event –2880 min winter storm event
- Amount of water needed to be stored from storm event – 8190.3 m^3
- Most efficient type of Hydro-brake – Md4
- Maximum storage – 13000 m^2
- Storage used – at 0m depth 13000m^2, at 1m depth 15000m^2

Possible storage Area 3 on Map 5

Whilst the thinner northern part of this area can be used for storage it is unfortunately not large enough to store the amount of water needed. The options here would be to investigate creation of a deeper pond or to extend the storage area into the development land.

Based on a storage depth of 0.65m, the thin northern area identified only has 3146 m^2 of storage, whereas roughly 9000 m^2 worth of storage is required for a 1 in 100 year (+ climate change) event to accommodate the influx of water.

Possible storage Area 4 on Map 5

Area 4 is located east of Area 3 and north of Long Lane and falls from the east to the west. Like the southern part of Area 3 this whole area has a high pressure gas main running through it. The gas main and its exclusion zone are anticipated to be a considerable constraint to providing surface water attenuation in this area, pending further review.

Zone Four

Description of Zone Four

Zone 4, straddles Rectory Lane and is the biggest zone (38.56 Ha). It is notable for the presence of a shallow valley with central ditch/stream course that drains west and eventually into the Puny Drain, north of Clarks Chase. At the moment the land is predominantly arable with small areas of housing – most notably Coronation Avenue. Development proposals include a section of the relief road and substantial new residential areas.

Zone Four Analysis

In the base of the valley there is a drainage ditch that takes all the water from the area. This drain is not maintained by the East of Ouse, Polver & Nar IDB and would benefit greatly from better and more regular maintenance. There is also a culvert under the A10 serving development east of the road. The natural catchment of the 'valley' is approximately 800m wide (stretching from Mill Lane Farm in the north to south of Rectory Lane). The undeveloped land is generally arable in the east and pasture towards the west. Behind Coronation Avenue there is grassland (including a paddock owned by West Winch Parish Council and another paddock which is a County Wildlife Site) which could be used to install a storage facility but this would not be able to serve a large area due to the natural water shed resulting in limited land draining to this point. Potential ecological impacts would also have to be addressed.

It is most likely that there would be capacity for surface water attenuation on an area of paddock and arable land west of the A10 (see attenuation Area 5). This area is presently outside of the land earmarked for development.

Towards the northern edge of Zone 4 there is another high pressure gas main that will restrict options for surface water attenuation but could be used as a green infrastructure corridor with benefits for surface water infiltration.

- Maximum design head for storage area – 0.65m
- Worst storm event – 4320 min winter storm event
- Amount of water needed to be stored from storm event – 31852.5 m^3
- Most efficient type of Hydro-brake – Md4
- Maximum storage – 53635.79 m^2
- Storage used – at 0m depth 48000m^2, at 1m depth 50000m^2

Possible storage Area 5 on Map 5

Both the northern and the southern parts of Area 5 could cater for storage (as can be seen on the map, marked in red), and there is sufficient capacity in either to cater for the whole of Zone 4 without affecting the development area.

The drainage ditch from the identified valley will have to be retained because of its importance within the system. It will however need to be improved to cope with the overall increase in peak discharge generated by development proposed to the east. The drain will also need to be accessible to allow the maintenance required to ensure it runs at the required design efficiency.

For the area there will need to be 31852.5 m^3 of storage which can be easily achieved as analysis shows the area covers 53636 m^2 of surface area split between the two defined land parcels. These can easily be linked with a simple pipe system or one could overflow into the other.

Zone Five

Description of Zone Five

Zone 5 drains west towards Puny Drain, north of the pumping station. The land at the moment is partly semi-natural grassland which is understood to have established in a former borrow pit and appears to have very impeded drainage. Other parts of the zone are agricultural land and existing settlement. The area is included in land proposed for a residential development with primary school and an outline planning application has already been made.

Zone Five Analysis

There have been historic flooding issues in this area due to water draining off the borrow pit to lower lying properties to the west and a 'dam' was formally constructed to address this problem. Two areas are now indicated as potentially suitable for surface water attenuation to cater for the new development proposals - Area 6 is on the outer west edge of Zone 4, adjacent to the A10, whereas Area 7 is within the current semi-natural grassland and proposed residential area.

Both of these areas could be linked to provide a larger connected system. Area 6 needs to take account of existing drainage issues along the A10, whilst Area 7 may need to connect to corridors with ditches or swales within the proposed housing area. Both attenuation areas eventually need to drain into the Puny Drain to the north of Clarks Chase.

- Maximum design head for storage area – 0.65m
- Worst storm event – 2880 min winter storm event
- Amount of water needed to be stored from storm event – 3011.5 m^3
- Most efficient type of Hydro-brake – Md4
- Maximum storage – 22554.19 m^2
- Storage used – at 0m depth 18000m^2, at 1m depth 20000m^2

These numbers are based on using only Area 6 for attenuation but Area 7 could be linked in to allow for more storage.

Possible storage Area 6 & 7 on Map 5

Area 6 provides a maximum of 22554 m^2. 3011.5 m^3 will need to be stored during a storm event. Area 6 would not therefore be able to accommodate sufficient stored water, but the capacity could be provided by linking to Area 7.

It may be a challenge routing storm water from the storage facilities to the Puny Drain due to the lack of an effective drainage path past the existing properties here. Therefore the final drainage solution will need to incorporate an improved system of pipes or open channels to the Puny Drain.

Zone Six

Description of Zone Six

Zone 6 forms part of the land at Constitution Hill that is presently the subject of an outline planning application. It is unusual in the study area in that it doesn't drain west to the Puny Drain, but north-east in to the Pierpoint catchment within the King's Lynn IDB area. More land north of the A47 and within North Runcton and the Neighbourhood Plan area also drains to the Pierpoint Pumping station, but is not earmarked for development.

The land presently consists mainly of derelict land relating to the former borrow pit and includes self-naturalised oak woodland. Residential development, the proposed Primary School and a section of the 'relief road' are proposed in this area.

Zone Six Analysis

Three attenuation areas are proposed in this Zone, but all could potentially clash with existing mature vegetation and other landscape and ecological assets in the study area. It is also understood that parts of the A47 road boundary may be registered common land.

- Maximum design head for storage area – 0.65m
- Worst storm event – 5760 min winter storm event
- Amount of water needed to be stored from storm event – 5564.4 m^3
- Most efficient type of Hydro-brake – Md4
- Maximum storage – 25392.06 m^2

Possible storage Area 9 - Map 5

This area has been identified to help with the storage of water discharging from Zone 6. This area is situated between the A47 and proposed relief road. Access from the road to the pond for maintenance would be a possible benefit. However it would not be favoured within the Neighbourhood Plan as it is established woodland and largely registered common land.

Possible storage Area 10 - Map 5

Area 10 is a thin strip of land north of Zone 5 and alongside the A47. It is envisaged that a landscape corridor will be required between the road and the residential development and that there may therefore be opportunities for SuDS components. However there is little fall over much of this area, existing mature vegetation would ideally be retained and some of the area appears to be registered common land.

There is a maximum area identified for a storage facility of 25392.06 m^2 but only 5564.4 m^3 of water needs to be stored hence a 1m metre deep pond will be able to comfortably accommodate all of the storm water run-off and the pond could either be oversized for environmental purposes or kept small to allow the retention of green space.

Possible storage Area 11 - Map 5

This area has the largest surface area to serve Zone six, and is an existing low lying area with some existing wetland habitat. The major problem with this area is that it does not lie directly adjacent the Zone and drainage ditches/pipes will have to be designed to direct the water to the area. The water also discharges into the King's Lynn IDB's Pierpoint system so any design will have to be approved by them. However with appropriate ditches or pipes this area could also serve part of Zone 5.

Zone Seven

Description of Zone Seven

Zone seven is a very small area of land lying immediately adjacent an existing pond in the former borrow pit and stands within the current outline planning application site. This area drains south and west towards the pond. It is considered there may be some benefits to utilising the pond within the surface water management plan.

Zone Seven Analysis

It is anticipated that the land in the vicinity of the pond, presently proposed for residential, primary school and school playing field, will have poor natural drainage as it has been disturbed by the previous borrow pit activities and is presently supporting seasonally wet grassland. By enlarging the pond it may be possible to attenuate surface water runoff in wet weather events and enhance the pond as a landscape asset. It will have to link to the wider drainage system.

- Maximum design head for storage area – 0.65m
- Worst storm event – 5760 min winter storm event
- Amount of water needed to be stored from storm event – 783.4 m^3
- Most efficient type of Hydro-brake – Md4
- Maximum storage – 20538.37 m^2
- Storage used – at 0m depth 10000m^2, at 1m depth 12000m^2

Possible storage Area 8 - Map 5

Area 8 has a surface area of 20538.37 m² whereas only 783.4 m³ of water needs to be stored. There would seem to be potential landscape and educational benefits next to the school, but public safety will also be an issue.

At present the system will not naturally drain to this area but it remains under consideration as there is an existing pond there which could have the potential to reduce infrastructure investment if it can be utilized. Checks would need to be done to prove that a hydraulic connection can be made which would function effectively before this option is considered further.

Proposed Strategy

Based on the analysis and calculations set out above, a strategic approach has been developed and will be promoted to BCKLWN and future developers considering design in the study area.

As previously stated West Winch and North Runcton are clay based catchments which in effect will mean that the most desirable at-source SuDS based systems may not always function effectively. SuDS is a step based approach to drainage which is underlined by a philosophy that water should be controlled as close to source as possible. It is also imperative that the design solution proposed is effective, economical to manage and enhances the environment by way of visual amenity and wildlife value. Opportunities to incorporate pervious pavements, green drainage corridors, swales and the like should be included within development phases but due to the impervious nature of the sub-soils these elements should be seen as enhancements to the main system rather than the whole system. In this way flood risk can be managed at an acceptable level.

The proposed system relies on a series of large balancing ponds. These would be designed to be either normally grassland based amenity areas (normally dry) or over-dug to create ponds which would create wetland habitat with a range of amenity and biodiversity benefits. However care is required where there is to be standing water, as whilst it can be desirable there may be other management issues including public safety, undesirable wildlife such as rats and the seasonal effects (midges, rotting vegetation smells and algal growth). It is therefore considered most appropriate to provide a buffer of 30 to 50m between residential housing and open water. This will help to develop an attractive setting for new development – which is a principal goal for the Neighbourhood Plan. The setbacks could also assist with maintenance access – which should be a key design requirement. The maintenance costs associated with permanently wet features is also higher and a fully costed schedule of maintenance will need to be initially drawn up, defining who will be responsible for the maintenance of these key features.

Due to the poor drainage in the area and the apparent lack of clarity in terms of current maintenance responsibility, there are a significant number of areas of localised flooding that the residents have experienced in recent years. This is believed to be mostly due to the inadequacy of the current drainage system serving the housing. It is believed that many houses rely on soakaways drainage which for reasons outlined earlier in the report is less than ideal. Poor sewer maintenance of piped and open channel drainage coupled with a lack of fall and in some instances no doubt, inadequate design, are all likely to have contributed towards these problems. It is therefore desirable that where new development takes place improvements to the existing system are incorporated and whilst it is unlikely that all the parishes' problems can be addressed in this way, there should be scope for measurable improvement.

To achieve the maximum from a strategic drainage approach it is recommended that a further full survey of the drainage network be carried out. With the marked lack of information currently available it is difficult to accurately pinpoint where the weaknesses in present system might lie.

Main recommendations for a strategic approach to surface water management:

- Plan and provide sufficient areas for surface water attenuation areas: Due to identified site constraints in this initial study it is likely that some indicative development areas will need to be reduced or altered to make space for attenuation basins and that some attenuation basins will need to be provided outside of the presently envisaged 'West Winch 1' masterplan area. Further research and planning will be required to confirm that these areas can be connected to the Puny or Pierpoint Drains to create an integrated system.
- Increase the storage capacity of the Puny Drain with a two-stage bank design: There would be a number of benefits for this type of storage: storage is built into the drain meaning that the facility can be maintained easily and at the same time as the drain; the local IDB are receptive to taking on the responsibility of maintaining the facility for this type of storage; being part of the drain means that it will be an 'on-line' storage so it will minimise the disadvantages relating to standing water; it is some distance from existing and proposed development so any seasonal odours will not be an issue; with the storage being part of the existing drain it means that none of the potential development space will be affected.
- Safeguard the important existing drainage corridors from development: The current green drainage corridors within West Winch and North Runcton will have even more importance when development commences: most of the green corridors have drainage ditches that are already established and need to be protected and improved so they are able to work to their optimum design capacity. With the possible limitations relating to common land, the current drainage ditches on the commons need to be fully recognised and protected, because it may require complex negotiation to build new surface water management components in these areas.
- Further survey required: The lack of information found during this study means there could be undiscovered pipework or drainage provision, or conversely, a lack of it, within the area. For a comprehensive surface water management design for the whole area it will be essential that this information is gathered before the preferred design is confirmed.
- SuDS is still desirable at detailed design: Even though the clay soils may not be ideal for infiltration, there will still be great advantages from embracing SuDS design. This needs to be considered from the earliest stages of development design, through construction and especially in consideration of long term management of settlement areas.
- Wider catchment analysis: Because the Puny Drain flows to the Puny Pumping station and is then pumped into the River Ouse Relief Channel – a much wider drainage system will be affected by development at West Winch and North Runcton. A survey of the downstream areas and the impact on them will need to be completed.

Proposed layouts

(Refer also to Appendix 'A' Drawings)

This section provides preliminary design examples for our preferred approach to surface water management in different areas of the 'West Winch 1' master plan area. We have not provided designs for all of the suggested possible attenuation areas. However, we recommend the same approach to design is applied in the different areas and in new locations if the masterplan alters. The designs are based on retaining and improving the existing drainage ditches.

It is important to note that maintainability of the facilities will be critical to their long term effectiveness. With this in mind it is recommended that allowance is made for a 10m wide grass maintenance easement (and an absolute minimum width at pinch points of 6m) to allow access to all principal basins and channels. This will allow for access for vehicles to perform maintenance such as bank mowing and sloughing out.

Zone 1, Area 1 - Option A (310/PL/11/Sketch1)

The drawing 310/PL/11/Sketch1 shows an off-line pond which incorporates an area which will be permanently wet. With this option a new channel would be cut which outfalls to the Puny Drain after passing through a chamber incorporating a vortex flow control device. The principle of this design is that when a storm event occurs the water level in the new drainage channel will start to rise and at a set point start to spill into the off-line pond taking up available storage within it. After the storm abates the water will drain away returning the water level within the pond to its pre-storm level. Ponds of this type offer higher levels of environmental value and can be aesthetically pleasing. This could be especially advantageous in this location as residents are unhappy about the proposed loss of existing paddock, and well-designed multi-functional green infrastructure could go some way to compensate for the loss. However disadvantages could include an increased maintenance requirement covering reed and silt management and they will of course have the health and safety implications as is the case for any situations where open water exists. An adequate buffer between facilities such as this and residential areas is essential.

Zone 1, Area 1 - Option B (310/PL/11/Sketch2)

The drawing (310/PL/11/Sketch2) shows Area One with an alternative possible storage solution. This is an on-line storage facility which straddles a newly formed drainage channel. The principle of this design is to limit the amount of discharge to mimic pre-development run-off rates; this will be achieved (as in option A) through the incorporation of a vortex flow control device in the final discharge chamber, controlling the flow at the point of outfall into the Puny Drain. The storage facility will be in the form of a normally dry pond which incorporates a shallow channel passing through it to convey low flows. In higher flow situations water will back up causing the pond to flood temporarily. The facility will be designed to take a 1 in 100 year plus 30% climate change storm event. The example on drawing 310/PL/11/Sketch1 shows infrastructure that does not integrate with the existing drainage system, i.e. it is standalone serving new development only. The existing surface water infrastructure serves a much larger area than the proposed development and another option could be to re-design the drainage facility to include for the existing system within it. However, if the existing system were to be included then the surface water storage structure would have to be significantly larger to accommodate the increase in calculated discharge from the larger sub-catchment.

As we have highlighted, a third option for this area could include widening of the Puny Drain (to incorporate a two stage channel) to allow for on-line storage within the drain itself, but negotiation would be needed to secure the permission of the East of Ouse, Polver and Nar Internal Drainage Board and the appropriate land owners. The two stage channel storage is not appropriate for all of the areas but if this option was to be considered further then it is recommended that further analysis be carried out to define exactly what areas could benefit and by how much.

Zone 2, Area 2 – Option A (310/PL/11/Sketch5)

The outline design for this is similar to that for option A, Zone 1. This consists of lagoon which is connected to the drain ditches by a shallow channel to allow shallow flows to pass during storm events. Most of the area identified is high grade agricultural land at the moment and is located outside of the masterplan boundary. An advantage to the location, east of the proposed relief road, is the distance from proposed development – which would avoid the potential adverse impacts (midges, odours) and perhaps create a better environment for wildlife. This outline design relies on the current drainage ditches being improved and properly maintained so they are in a good working condition at all times to take any flows.

The drainage ditches in the area all drain to the Puny Drain to the south of Setchey, at this point the Puny Drain is in poor condition and improvement works should be carried out to ensure that the system can operate at maximum efficiency.

Zone 2, Area 2 – Option B (310/PL/11/Sketch6)

This option is similar to option B for Zone 1. The outline is simply an on-line storage pond built within a current drainage ditch. As before there would be a control chamber with a vortex flow control device incorporated so as to limit the outflow to pre-development levels.

Note for the purposes of the plan we have shown the attenuation basin in both options in a considerable area of 'green space'. However this area could remain as farmland.

Zone 3, Area 3 - Option A (310/PL/11/Sketch3)

Is similar in design philosophy to Area 1 – option B, it is a lagoon design, as seen on 310/PL/11/Sketch3. However, unlike the Area 1 design, there is not enough space for the required storage within the green area due to the presence of a high pressure gas main that runs through the site at this point. It is important to note that not only will prior consent be required for work over the main itself, but there is also a wider easement area where any works will need to have prior approval from the National Grid. It is considered unlikely that such consent would be given to a storage facility. Hence, the storage area will have to take up some of the presently proposed development area.

Zone 3, Area 3 - Option B (310/PL/11/Sketch4)

This option is similar to Area 1, option A, but would be located on part of West Winch common. Whilst the advantage of this option is that it would not restrict the full development of area three, there may be issues in gaining agreement from the land owner (understood to be the Cholmondeley family) and the common rights holders. It is recommended that the associated legal issues be explored further before this option is seriously considered.

Zone 4, Area 5 – Option A (310/PL/11/Sketch7)

As in Zone 3 there is a high pressure gas main that runs through the area. What drainage infrastructure can be located over the gas main is likely to be limited, and maintaining access to the ground above the gas main will be key to any layout design. Due to the large area of development this facility will be serving, there will have to be a sizable provision for storage, and this is likely to require two linked lagoons either side of the gas main. The secondary pond will only be used when storm event generating flows that cannot be catered for in the primary pond. The design in sketch 7 shows a shallow channel or pipe that passes over the top of the gas main (hopefully acceptable – but needs to be confirmed) which will only flow when there is a storm event triggering the need to store water.

This outline layout relies on the existing drain that runs through the proposal area. In its current state it will not be able to convey the anticipated flows because it is over grown and requires maintenance and improvement. Such improvement work will be required along the length of the drain and also at the culvert under the A10 – which is almost certainly inadequate and should be enlarged and replaced.

Zone 4, Area 5 – Option B (310/PL/11/Sketch8)

As mentioned before as the third option for Zone 1, a 'two-stage' bank could be added to the Puny Drain to serve Zone 4 as well. This involves digging a step into the west bank of the drain to add on-line storage, as can be seen in the cross section A-A on 310/PL/11/sketch8. The extra storage is only utilized when water levels within the Puny Drain rise above a threshold. There are many advantages, as noted on the recommendations on page 21 of this report. The IDBs approval and consent would be required for such a scheme and agreements with adjacent landowners.

Zone 5, Areas 6 and 7 – Option A (310/PL/11/Sketch15)

This design is very similar to the one put forward by Hopkins Homes in their current outline planning application, but utilizes a single pond next to the proposed roundabout on the A10, rather than the two ponds identified within the Hopkins submission. We feel this is preferable as the infrastructure costs will be less and the pond larger, allowing easier maintenance and a larger flow 'throttle' (reducing the risk of blockage). There would still need to be two ponds serving the area though (on 310/PL/11/Sketch9) which are connected by a drain. This means the ponds could act in a cascading arrangement, and higher pond storing the first with a vortex device limiting flow. Once this pond is full, water could spill over a weir into the drainage ditch and then into the second pond where the final exit flows can again be controlled. There is however an issue with drainage beyond the new development envelope, flowing west towards the Hardwick Narrows Common and the Puny Drain, where the local drains will need to be improved or replaced.

There is also the opportunity to provide a storage facility as an extension to the existing pond within the Hopkins site (former borrow pit). This could be a beneficial landscape feature and incorporate features for educational purposes (linked with the proposed new school), perhaps to showcase ecology and wildlife.

Zone 5 – Option B (310/PL/11/Sketch15)

This outline design is similar to Zone 4, option B, in that it is a two stage channel design where extra capacity is added to the Puny Drain, by adding extra space for on-line storage. The caveats which are described previously would apply.

Zone 6, Area 9 – Option A (310/PL/11/Sketch16)

This option comprises of a storage pond to supplement the existing drainage ditches. Like previous design proposals it would incorporate a control chamber at the point of outfall from the pond, with a vortex flow control device within it. The pond would be placed between the new 'relief road' and the A47, so there will be screening from the public. There would also be opportunity to incorporate easy, safe access onto the site due to the close proximity of roads.

Drainage ditches will have to be formed to link the development area with the storage facility. Culverts under the two roads would also need to be installed. The final discharge would connect this system to King's Lynn IDB system, which eventually ends at Pierpoint Pumping Station. However, this option is unlikely to be acceptable within the Neighbourhood Plan as it lies within established woodland (Sheep's Course Wood and adjacent self-naturalised oak woodland), part of which is also registered common land.

Zone 6, Area 10 – Option B (310/PL/11/Sketch16)

This option is based on an attenuation basin that would be situated to the north of the A47 on land currently outside of the master plan area. The outline design incorporates the existing drainage system that flows towards Pierpoint Pumping Station. This would be achieved by forming a network of drainage ditches that would discharge to culverts under the road and hence into a drain the discharging to a newly formed lagoon. Land owner agreement would be required as would the consent of the King's Lynn IDB.

The drainage system on the map is indicative only as it is anticipated that the finalised development layout would influence the design. However, one option would be to have a drain running parallel with the A47 which would run along the contour line and collect all surface water run-off from the development before feeding under the road and into the storage facility.

Another alternative would be to enter into discussions with the Kings Lynn Internal Drainage Board who may be willing to take direct and unbalanced flows into attenuation ponds they have proposed near the A149 – all subject to agreement and payment of a commuted sum.

Zones 5 & 6, Area 11 – Option A (310/PL/11/Sketch17)

The two designs have been put forward making reference to the Hopkins Homes surface water management plan, which identified the most northerly corner of their development site as a prime location for a storage facility.

The first option is a basic pond design with the facility straddling the drainage ditch; this means the design would provide on-line storage.

However, not much of the proposed development land falls towards the proposed pond, so it is suggested a drainage ditch system will have to designed to direct surface water to the north. This could be achieved by running a ditch along the western side of the development area (at the rear of existing development). This may also have drainage benefits for the existing dwellings.

Zones 5 & 6, Area 11 – Option B (310/PL/11/Sketch17)

The second of the two options in this area would be in the form of an 'off-line' lagoon design, connected to the drain system by a shallow channel. Detailed survey of existing levels would determine the best position for such a facility.

The drain system would be largely as option A.

Conclusions

- It is clear from our investigations that there is a significant lack of information available relating to the existing buried surface water infrastructure. It is also known that there have been historical reports of localised flooding due to inadequacies within this system and perhaps relating to its maintenance. It is therefore recommended that further comprehensive survey of the current drainage system be commissioned to allow a full analysis of the system and for recommendations to be made on where modification and improvements are required. An ongoing management and maintenance plan for all surface water drainage infrastructure should also be drawn up and agreed with the relevant authorities and land owners.
- As stated above there needs to be full survey of the drainage ditch network with cross sections and asset condition information. This information will be vital to plan the works that need to be carried out on the drainage ditches to bring them back up to their full carrying and storage potential. We suggest that developers are required to undertake this survey and identify what on-site and off-site surface drainage improvements are required in order to integrate proposed development into the overall drainage strategy outlined in this report. Such planning should be carried out in liaison with Anglian Water and the County Council in their capacities as Lead Local Flood Authority and managers of the A10, and the local IDB bodies.
- The solutions outlined in this report are the preferred options based on our initial analysis. It is, however, recognised that this strategic overview will not have identified all the constraints or the opportunities that future development might be able to deliver, and that development plans are not yet fixed. It is therefore expected that where proposals move away from those identified within this strategy the fundamental principles are retained.
- Whilst infiltration drainage is not considered to be appropriate for the primary drainage design within the two parishes it is believed that site level SuDS techniques can and should be incorporated into the development designs. Whilst unlikely to be meaningfully utilized when the ground is saturated in the wettest winter months, they will have real value in taking up water in high intensity summer storms and can increase the diversity of soft landscaping features within the development zones.
- The key to the long term success of surface water run-off management will be in the achievement of securing a long term maintenance strategy for the entire surface water infrastructure serving the developments. This would best be achieved through adoption of primary infrastructure by a statutory authority, with the appropriate payment of commuted sums to ensure that sufficient funds are available for this purpose.
- Negotiations with land owners beyond the development areas identified in the master plan will be necessary to achieve the best outcome. This should include opening discussions with the East of Ouse Polver and Nar IDB to explore how the Puny Drain could be modified to accommodate un-attenuated discharges. This could be of particular value in providing alternatives where a 'ransom' situation might otherwise arise.
- It is understood that the North Runcton and West Winch Neighbourhood Plan will refer to this strategy in policy relating to drainage and surface water management. The strategy will also ideally be adopted by BCKLWN as a preferred approach for addressing surface water management in the area and should be used to inform the planning process when considering all new development proposals in the North Runcton and West Winch Neighbourhood Plan area.
- The section of the Puny Drain that runs east-to-west south of Setchey and at the rear of the Garage Lane business area, is in poor condition and would ideally be improved with the assistance of funding generated from wider development. The optimum functioning of the Puny Drain will be essential for sustainable surface water management in the Neighbourhood Plan area and will also benefit the wider catchment. The East of Ouse, Polver and Nar IDB can advise further on this matter.

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Glossary of terms

Surface Water Management Strategy. A Surface Water Management Plan (SWMS) is a strategy which outlines the preferred surface water management arrangements for a given location/sub-catchment

Surface Water Flooding. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small water courses and ditches that occurs as a result of heavy rainfall.

Internal Drainage Board (IDB). An internal drainage board (IDB) is a type of operating authority which is established in areas of special drainage need in England and Wales with permissive powers to undertake work to secure clean water drainage and water level management within drainage districts. For West Winch & North Runcton there are two IDBs present, these are East of Ouse, Polver & Nar IDB and King's Lynn IDB.

Flood risk. An assessment of the likelihood of flooding in a particular area so that development needs and mitigation measures can be carefully considered. Flood events are usually measured in 1 in X amount of years i.e. 1 in 10 year event which has a 10% chance of happening in any given year. The higher the 1 in X amount of year event the smaller chance of it happening.

Sustainable Drainage System (SuDS). A sequence of management practices and control structures designed to drain systems (SuDS) surface water in a more sustainable fashion than what is considered to be the more conventional techniques.

Phased implementation. This approach means that a number of project phases are defined, and the functionality of each phase is carefully planned in order to avoid solutions that make no allowance for future development. Each new phase is a discreet project carried out when the work with the preceding phase draws to an end, and each phase can, consequently, profit by an understanding of the final aims and a holistic approach to shared benefits from infrastructure.

LIDAR information. LIDAR, which stands for *Light Detection and Ranging,* is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses—combined with other data recorded by the airborne system— generate three-dimensional information about the shape of the Earth and its surface characteristics.

ArcGIS software. Esri's ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used for: creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database.

Contour plan. A topographic map upon which the shape of the land surface is shown by contour lines, the relative spacing of the lines indicating the relative slope of the surface.

Infiltration drainage. This is a type of drainage which allows the water to filter into the ground and be transported away via the groundwater flows.

Saturated. When the ground water table reaches the surface the ground is said to be saturated. It therefore is unable to accommodate any rainfall and instantaneous run-off will follow.

Direct discharge. Discharge of water which is allowed to pass through surface water infrastructure in an unimpeded manor. For development this usually means that rainfall enters the main arterial watercourse system much more quickly than it would have prior to development taking place.

Return period rainfall event. Refers to how often on average an event is expected to occur based upon a statistical analysis.

Surface Run-off. Water flow over the ground or developed area surface which has not yet entered a drainage system. This can occur if the ground is impermeable, is saturated or rainfall is particularly intense (Sometimes referred to as, surface runoff).

Re-graded. All drains have a bed level that has a certain height. When a drain is re-graded the bed slope is changed to be steeper or shallower, it can even be re-graded to point where the drain's flow direction can be changed as was the case in the northern section of the Puny Drain.

On-line storage. A conveyance or storage component which forms part of the main conveyance route for the drainage system. This can be seen in the two stage channel outlined earlier in this report and in some of the storage pond options.

Off-line storage. A conveyance or storage component which where the main conveyance route is separated from the storage element. This can be seen in some of the lagoon designs within this report.

Post implementation flood plain. Land adjacent to a watercourse that would be subject to repeated flooding under natural conditions (see Environment Agency's Policy and practice for the protection of flood plains for a fuller definition of floodplain).

Trunk road. A trunk road, trunk highway, or strategic road is a major road, usually connecting two or more cities, ports, airports and other places, which is the recommended route for long-distance and freight traffic. The A10 was previously trunk road but was de-trunked 8 years ago and now the reasonability for road maintenance has fallen to the Norfolk County Council.

Adopted sewers. A pipe or channel taking domestic foul and/or surface water from buildings and associated paths and hard-standings from two or more curtilages for which the local water authority is obligated to maintain.

Non-Adopted sewers. A pipe or channel taking domestic foul and/or surface water from buildings and associated paths and hard-standings from two or more curtilages and having a proper outfall for which no statutory body has an obligation to maintain.

Catchment. The area contributing surface water flow to a point on a drainage or river system. This can be divided into sub-catchments, which are elements of a catchment.

Balancing ponds. A pond designed to attenuate flows by storing surface water runoff during the storm and releasing it at a controlled rate during and after the storm.

Standing water. Standing water occurs when water stops flowing. This can lead to water stagnation which can be an environmental hazard.

Soakaway drainage. See infiltration drainage.

Open channel. An uncovered conduit in which liquid (usually water) flows with its top surface bounded by the atmosphere. Typical open channels are rivers, streams, ditches or canals.

Impermeable/impervious areas. Impermeable/Impervious areas are mainly artificial structures—such as pavements (roads, driveways and car parks) that are covered by impenetrable materials such as asphalt, concrete, brick, and stone--and roof tiles. Heavily compacted soils or clay based areas are often also highly impervious.

River Great Ouse Relief Channel. This channel was dug in the 1960s to relieve the pressure on the River Great Ouse. It effectively provides an alternative flow path for river flows in major events when the Ouse is tide locked and a secondary flow path when not.

Peak flows. The maximum expected flow discharging from the developed area. This differs from balanced flow in that it occurs pre-control.

Two stage channel. A two stage channel is a method of providing storage within an existing watercourse where a shelf is effectively cut into the channel so that as water levels within the channel rise there is additional storage available within the upper section of the channel. The benefit of such an arrangement is that in normal flow conditions the lower channel is not overly wide and will therefore not be susceptible to siltation through sediment dropping out as a result of lower flow velocity.

High pressure gas main. A high pressure gas main is a pipe can contains gas at a high pressure. In this report it presents a limitation on the structures that can be place above or even near to the main. Any work carried out above or near to it will have to have permission from Transco.

Pumping station. Pumping stations are facilities for pumping fluids from one place to another. They are used for a variety of infrastructure systems, such as the supply of water and the drainage of low-lying land.

Green field run-off rates. The runoff that would occur from the site it its undeveloped and undisturbed state. Greenfield runoff characteristics are described by peak flow and volumes of runoff for rainfall events of specified duration and return period (frequency of occurrence).

MicroDrainage. MicroDrainage is a widely used computer program to aid in the design of surface water management systems.

Storage facility. A storage facility a piece of infrastructure whose purpose is for the temporarily storage the surface run-off, this could be a pond, underground tank, lagoon or two stage channel.

Infrastructure. The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communications systems, water and power lines, and public institutions including schools, post offices, and shops.

Hard landscaping. Hard landscaping is usually features within the landscape which are made from inert materials. Examples are street lighting, pavements, park benches.

Soft landscaping. Soft landscaping is landscaping which is formed using living materials such as grass, trees and shrubs.

Vortex flow control device. A vortex flow control device uses the natural process of creating an air pocket when flow is forced to swirl which provides a throttle on discharge. This will often provide the most efficient means of balancing the need to control discharge rates with keeping the amount of upstream storage that is required to a minimum.

Final discharge chamber. This is a camber that may contain a vortex flow control device and is the final chamber before the water is discharged into the drainage network outside of the developed area boundary.

Sustainable Drainage Approval Body's (SAB's). These are planned to be organizations formed by an upper tier or unitary authority and are expected to be responsible for the approval and adoption of drainage schemes in accordance with the National Standards for Sustainable Drainage.

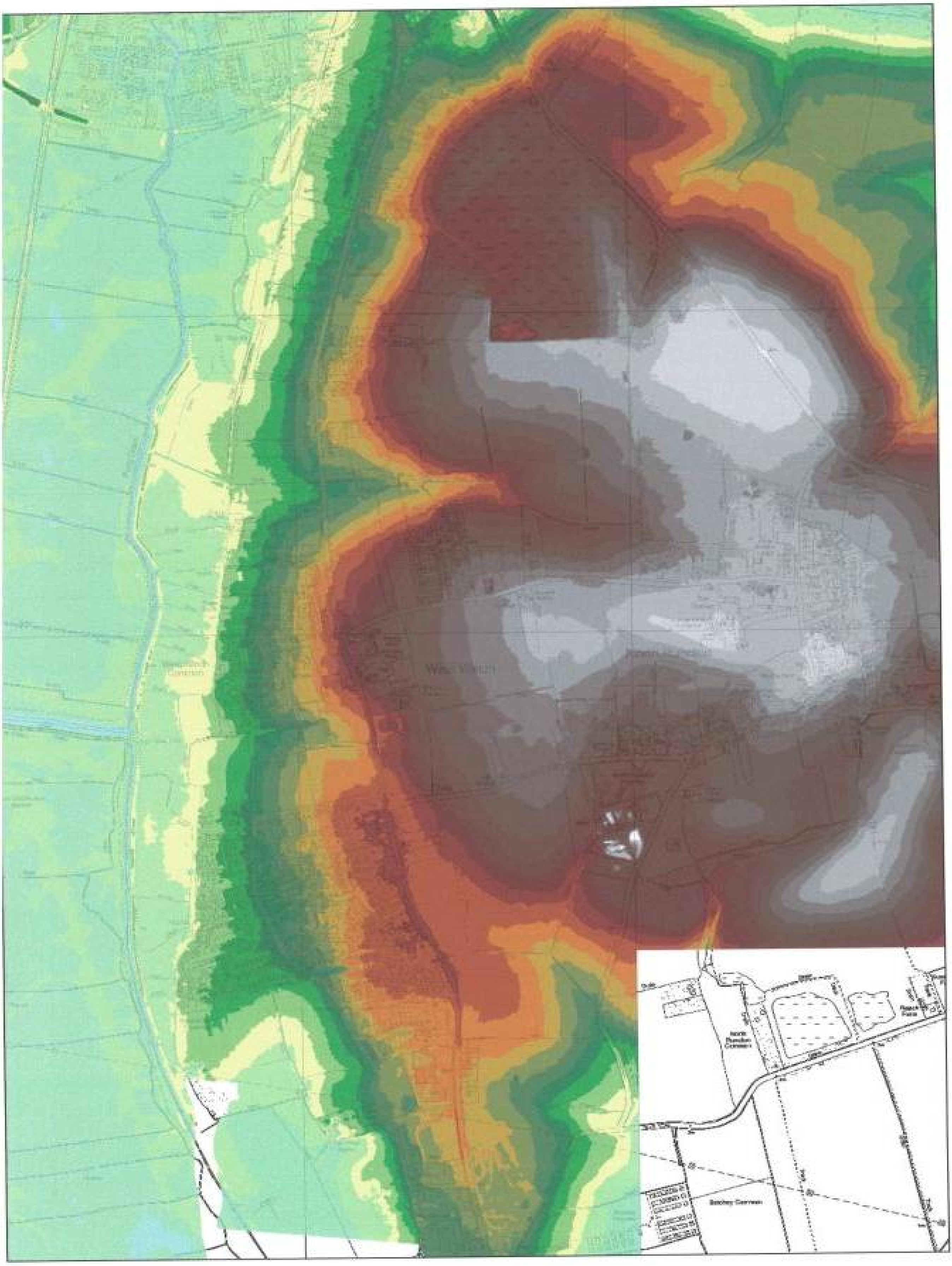
Lead Local Flood Authority (LLFA). The Lead Local Flood Authority (LLFA), are either the county councils or unitary authorities. They are required to develop a strategy to tackle local flood risks, involving flooding from surface water, ordinary watercourses, groundwater and small reservoirs. They are also required to investigate the causes of local flooding and to manage the consenting process for culverting of watercourses not inside an IDB district.

Common land. In general terms, common land is land owned by one person over which another person is entitled to exercise rights of common (such as grazing animals or cutting bracken for livestock bedding), and these rights are generally exercisable in common with others. The land needs to be registered with county council to be protected, and this protects the land to point where access to or over the land can't be impeded.

North Runcton & West Winch Surface Water Management Strategy

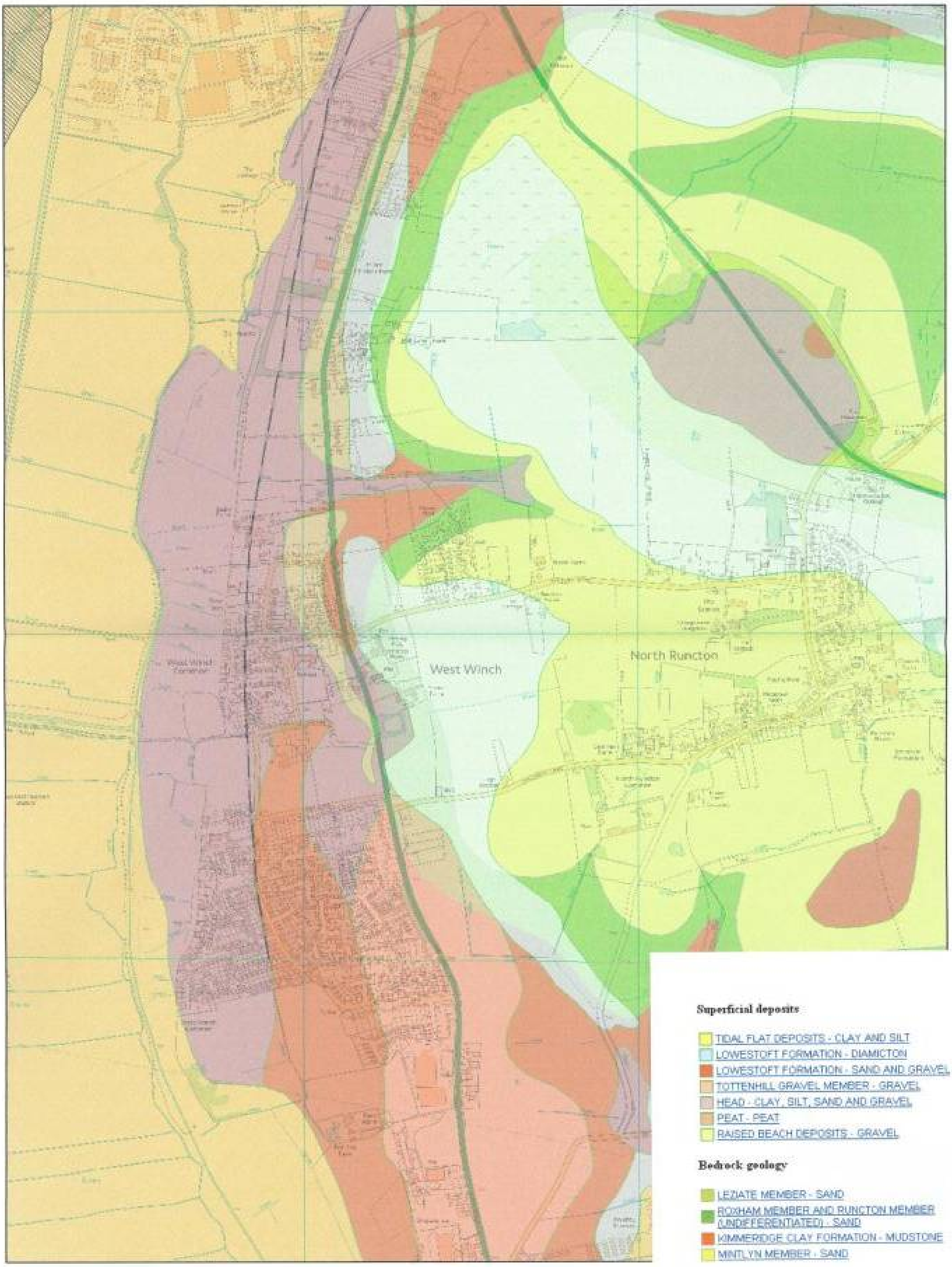
Appendices

Appendix 1 – Map 6: LIDAR contour map (1:10000)

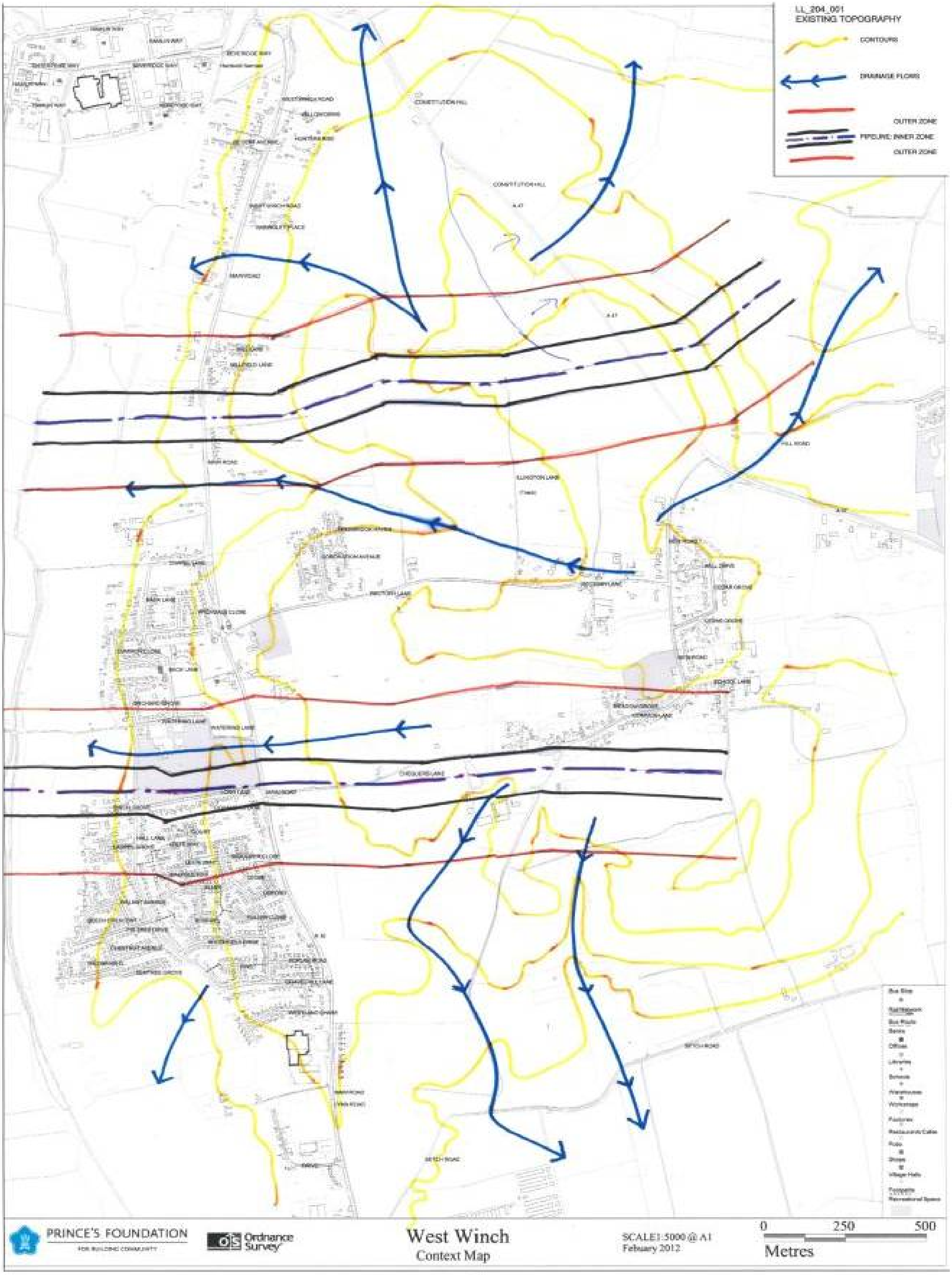


Blue/green is low ground; grey/white is high ground.

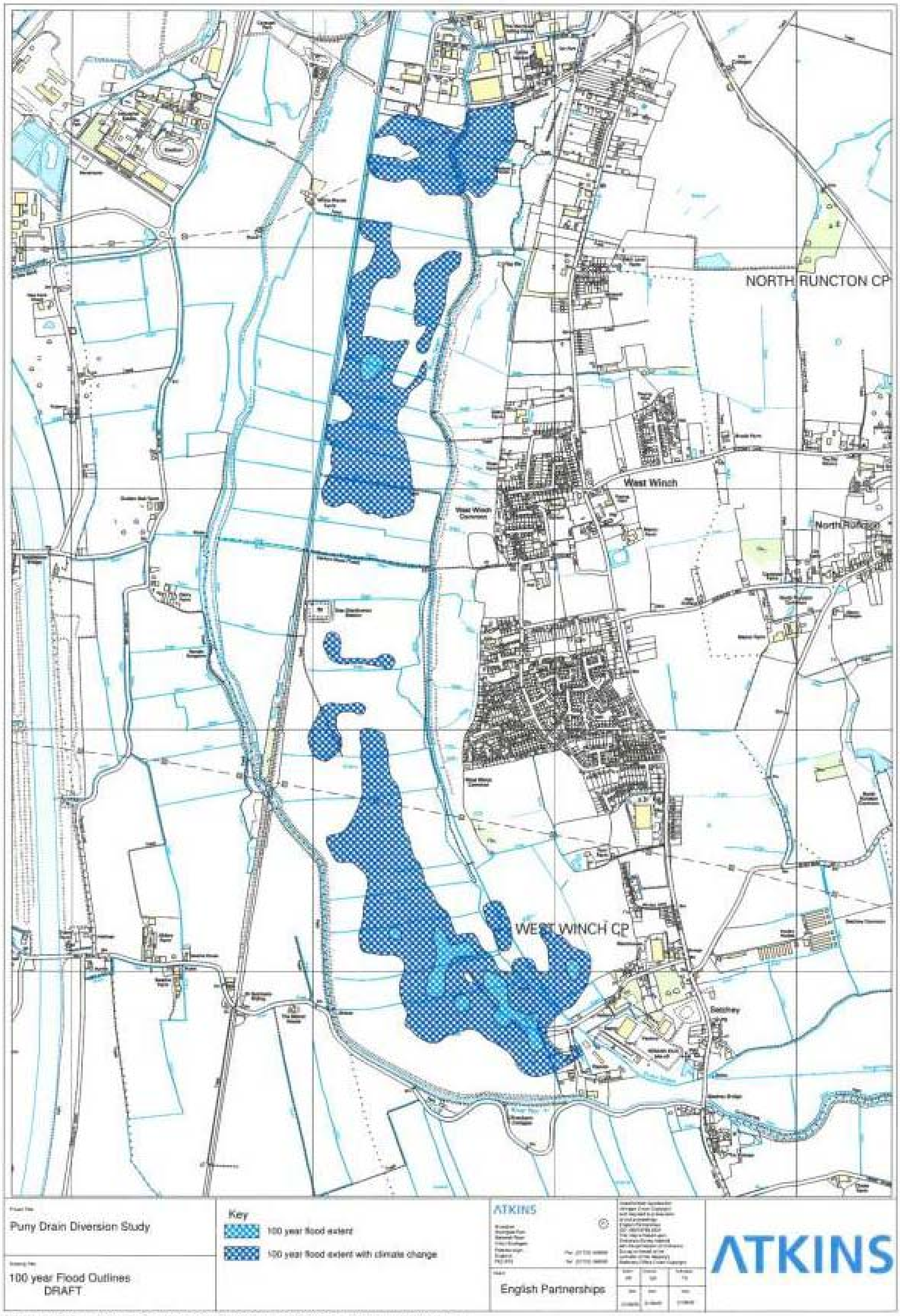
Appendix 2 – Map 7: West Winch & North Runcton geological map



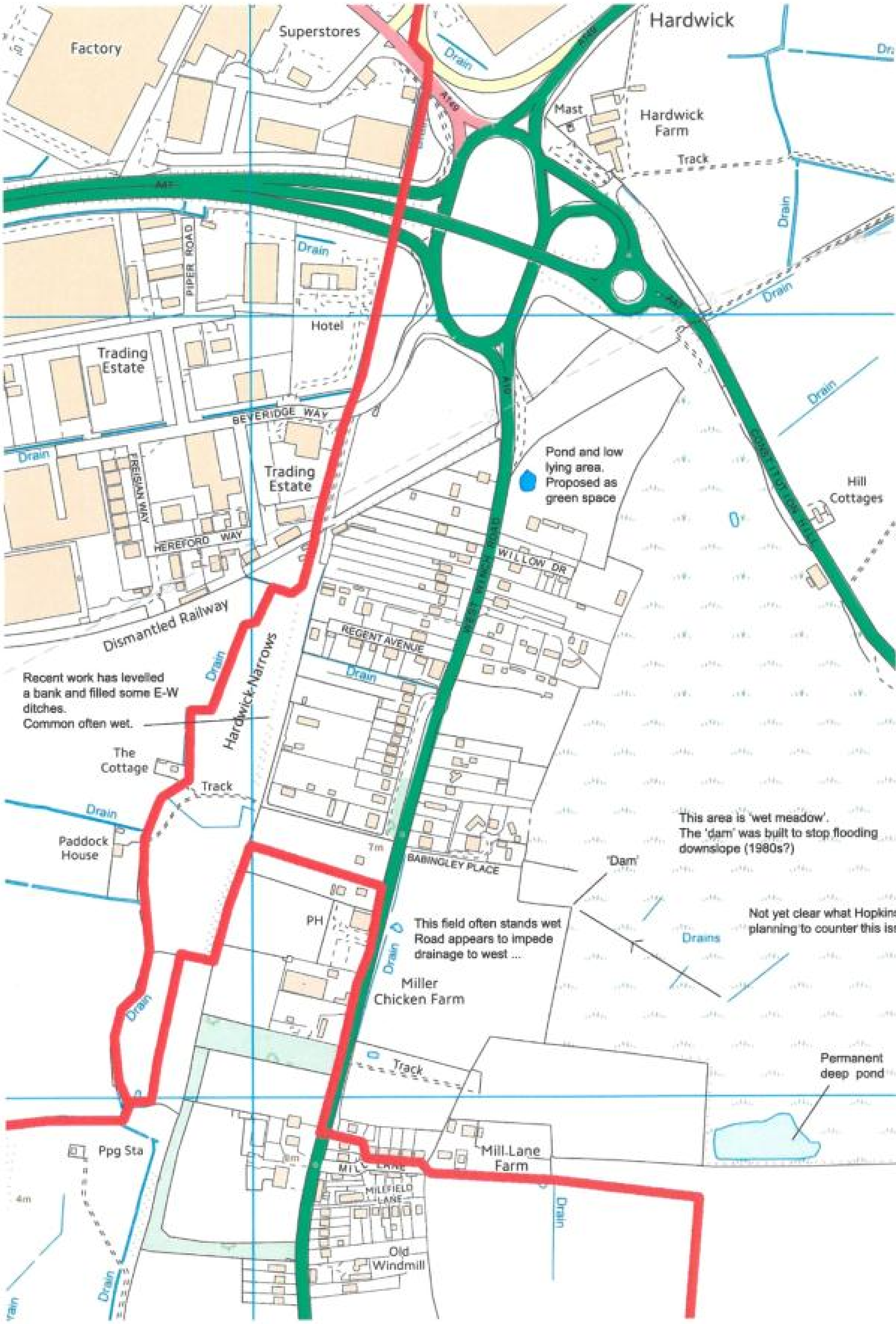
Appendix 3 – Map 8: Indicative location of high pressure gas main corridors



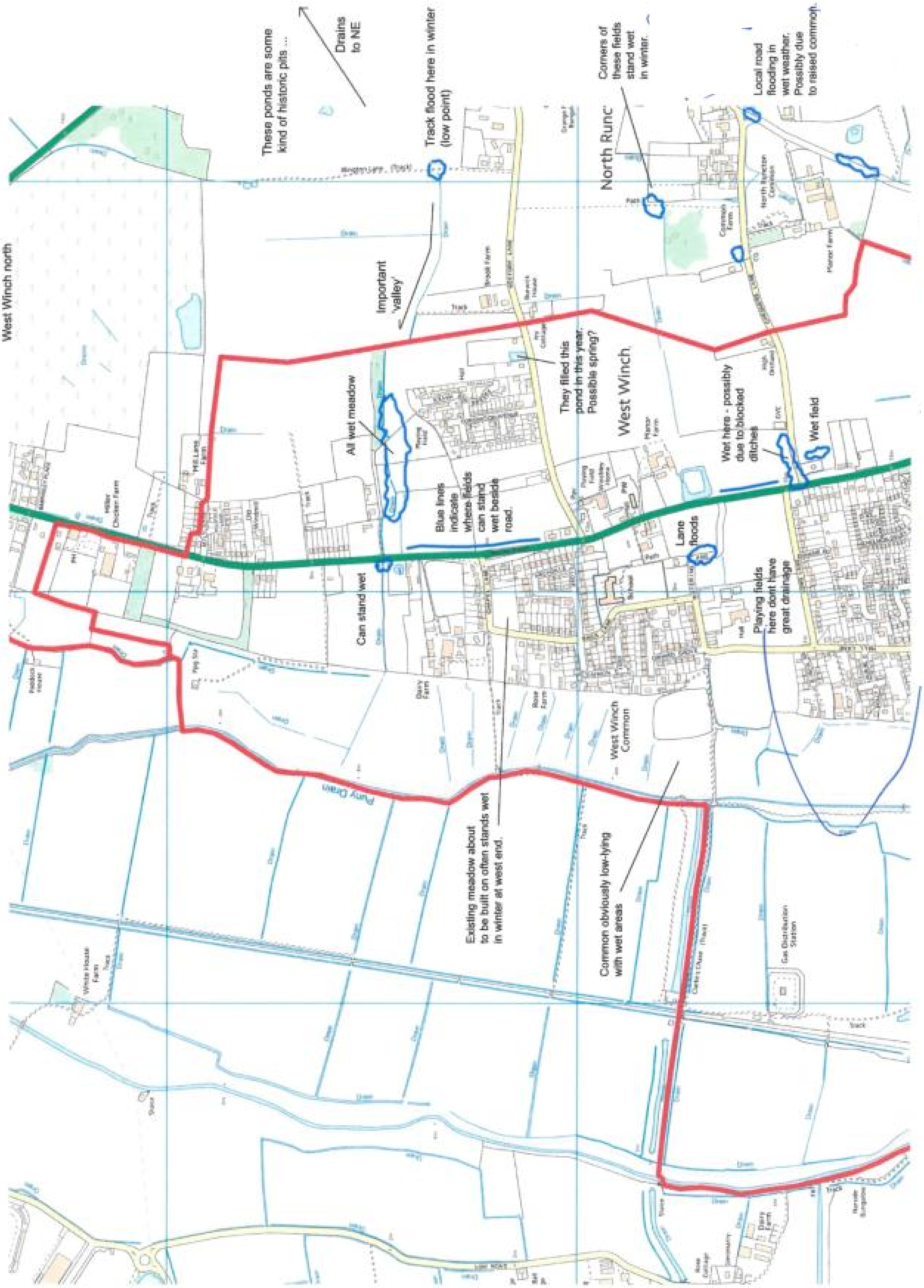
Appendix 4 – Map 9: map of 100 year flood outlines



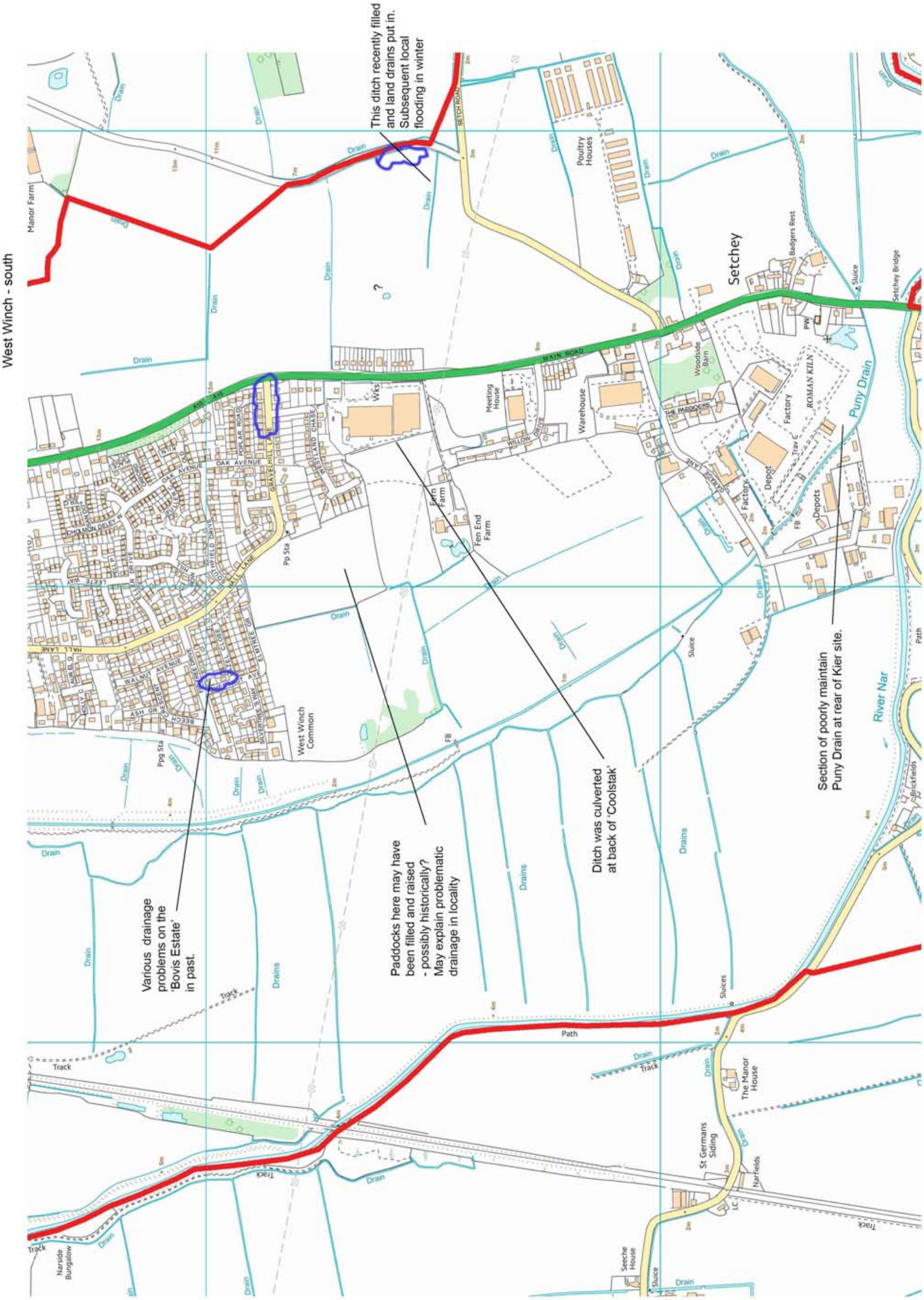
Appendix 5 – Map 10: Residents perceived flooding problems map (north)



Appendix 5 – Map 11: Residents perceived flooding problems map (central)



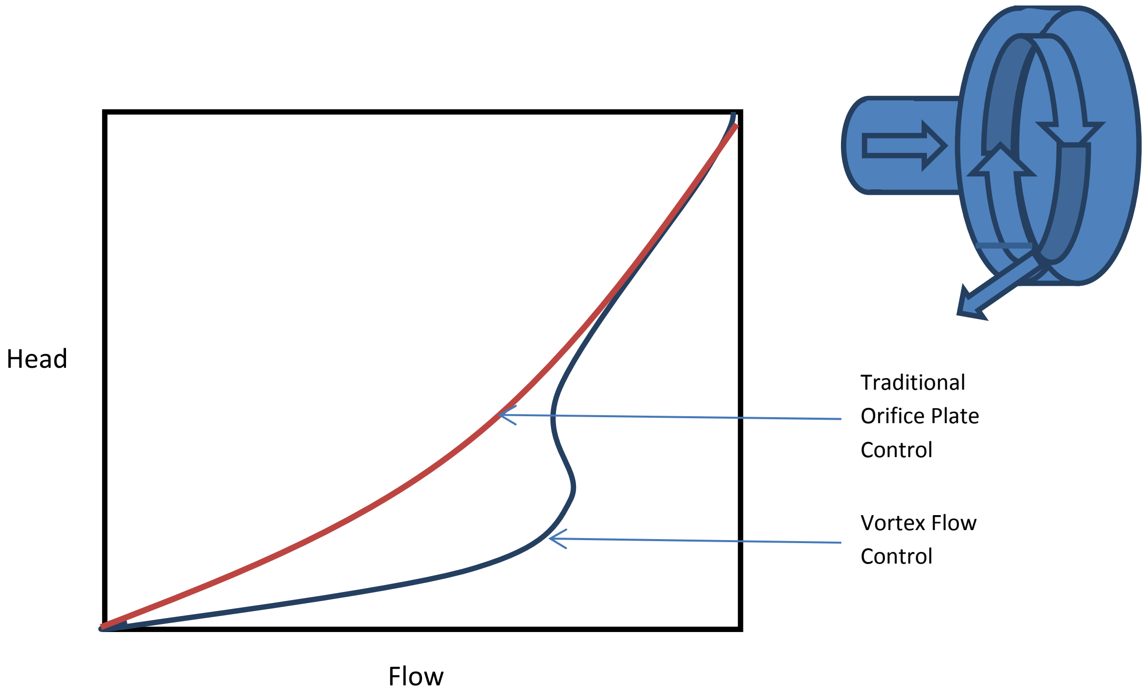
Appendix 5 – Map 12: Residents perceived flooding problems map (south)



Appendix 6 - Technical note for vortex flow control device

Technical note for vortex flow control device

A vortex flow control device will often provide the most efficient means of balancing the need to control discharge rates with keeping the amount of upstream storage that is required to a minimum. It controls flow by generating a vortex within the flow path as water passes through the device, this then acts as an additional throttle on flow at a critical point within the depth/flow relationship. It also allows the outlet to be larger than a simple orifice plate thus reducing the risk of blockage caused by debris passing through the flow path.



Appendix 7 - MicroDrainage Outputs

Area 1

Storm Event	Rain (mm/hr)	Time to Vol Peak (mins)	Max Water Level (m)	Max Depth (m)	Flooded Volume (m³)	Max Control (l/s)	Discharge Volume (m³)	Max Overflow (l/s)	Σ Max Outflow (l/s)	Overflow Volume (m³)	Maximum Volume (m³)	Status
30 min Summer	80.084	50	0.187	0.187	0.0	7.2	572.5	0.0	7.2	0.0	3398.1	O K
60 min Summer	49.937	80	0.232	0.232	0.0	7.6	1248.1	0.0	7.6	0.0	4231.8	O K
120 min Summer	30.128	138	0.279	0.279	0.0	7.6	1271.1	0.0	7.6	0.0	5094.9	O K
180 min Summer	22.143	198	0.306	0.306	0.0	7.6	1215.7	0.0	7.6	0.0	5606.0	O K
240 min Summer	17.703	258	0.326	0.326	0.0	7.6	1164.6	0.0	7.6	0.0	5964.9	O K
360 min Summer	12.819	378	0.352	0.352	0.0	7.6	1095.2	0.0	7.6	0.0	6455.7	O K
480 min Summer	10.203	498	0.372	0.372	0.0	7.6	1050.1	0.0	7.6	0.0	6827.8	O K
600 min Summer	8.542	616	0.387	0.387	0.0	7.6	1019.1	0.0	7.6	0.0	7121.4	O K
720 min Summer	7.384	736	0.400	0.400	0.0	7.6	995.5	0.0	7.6	0.0	7363.6	O K
960 min Summer	5.863	976	0.421	0.421	0.0	7.6	959.4	0.0	7.6	0.0	7747.4	O K
1440 min Summer	4.231	1454	0.449	0.449	0.0	7.6	902.4	0.0	7.6	0.0	8282.5	O K
2160 min Summer	3.048	2172	0.476	0.476	0.0	7.6	1917.4	0.0	7.6	0.0	8790.6	O K
2880 min Summer	2.413	2892	0.493	0.493	0.0	7.6	1846.9	0.0	7.6	0.0	9116.8	O K
4320 min Summer	1.734	4328	0.513	0.513	0.0	7.6	1697.3	0.0	7.6	0.0	9490.9	O K
5760 min Summer	1.370	5768	0.522	0.522	0.0	7.6	3754.3	0.0	7.6	0.0	9662.9	O K
7200 min Summer	1.141	7208	0.525	0.525	0.0	7.6	3612.3	0.0	7.6	0.0	9719.8	O K
8640 min Summer	0.982	8640	0.524	0.524	0.0	7.6	3461.3	0.0	7.6	0.0	9703.4	O K
10080 min Summer	0.865	9984	0.521	0.521	0.0	7.6	3300.0	0.0	7.6	0.0	9636.3	O K
15 min Winter	122.425	35	0.160	0.160	0.0	6.3	488.5	0.0	6.3	0.0	2911.9	O K
30 min Winter	80.084	49	0.209	0.209	0.0	7.6	620.5	0.0	7.6	0.0	3806.4	O K
60 min Winter	49.937	78	0.260	0.260	0.0	7.6	1289.5	0.0	7.6	0.0	4741.5	O K
120 min Winter	30.128	138	0.312	0.312	0.0	7.6	1217.7	0.0	7.6	0.0	5710.6	O K
180 min Winter	22.143	196	0.343	0.343	0.0	7.6	1144.3	0.0	7.6	0.0	6284.6	O K
240 min Winter	17.703	256	0.364	0.364	0.0	7.6	1100.1	0.0	7.6	0.0	6687.7	O K
360 min Winter	12.819	374	0.394	0.394	0.0	7.6	1054.1	0.0	7.6	0.0	7239.6	O K
480 min Winter	10.203	492	0.416	0.416	0.0	7.6	1029.6	0.0	7.6	0.0	7658.1	O K
600 min Winter	8.542	610	0.434	0.434	0.0	7.6	1013.9	0.0	7.6	0.0	7988.5	O K
720 min Winter	7.384	728	0.448	0.448	0.0	7.6	1002.1	0.0	7.6	0.0	8261.1	O K
960 min Winter	5.863	966	0.471	0.471	0.0	7.6	982.1	0.0	7.6	0.0	8693.6	O K
1440 min Winter	4.231	1438	0.503	0.503	0.0	7.6	942.6	0.0	7.6	0.0	9298.4	O K
2160 min Winter	3.048	2148	0.533	0.533	0.0	7.6	1999.5	0.0	7.6	0.0	9876.6	O K
2880 min Winter	2.413	2856	0.553	0.553	0.0	7.6	1946.9	0.0	7.6	0.0	10252.1	O K
4320 min Winter	1.734	4248	0.576	0.576	0.0	7.6	1813.3	0.0	7.6	0.0	10694.4	O K
5760 min Winter	1.370	5648	0.587	0.587	0.0	7.6	3962.5	0.0	7.6	0.0	10913.8	O K
7200 min Winter	1.141	6992	0.592	0.592	0.0	7.6	3841.1	0.0	7.6	0.0	11008.1	O K
8640 min Winter	0.982	8376	0.593	0.593	0.0	7.6	3701.4	0.0	7.6	0.0	11022.0	O K
10080 min Winter	0.865	9680	0.591	0.591	0.0	7.6	3546.1	0.0	7.6	0.0	10983.1	O K

Area 2

Storm Event	Rain (mm/hr)	Time to Vol Peak (mins)	Max Water Level (m)	Max Depth (m)	Flooded Volume (m³)	Max Control (l/s)	Discharge Volume (m³)	Max Overflow (l/s)	Σ Max Outflow (l/s)	Overflow Volume (m³)	Maximum Volume (m³)	Status
30 min Summer	80.119	64	0.126	0.126	0.0	7.0	542.1	0.0	7.0	0.0	6084.6	O K
60 min Summer	49.937	92	0.157	0.157	0.0	10.8	1496.3	0.0	10.8	0.0	7573.7	O K
120 min Summer	30.115	152	0.189	0.189	0.0	15.2	2044.2	0.0	15.2	0.0	9107.6	O K
180 min Summer	22.129	210	0.208	0.208	0.0	17.7	2371.5	0.0	17.7	0.0	10008.0	O K
240 min Summer	17.690	270	0.221	0.221	0.0	19.5	2595.3	0.0	19.5	0.0	10634.0	O K
360 min Summer	12.802	388	0.238	0.238	0.0	21.8	2879.7	0.0	21.8	0.0	11470.9	O K
480 min Summer	10.192	506	0.251	0.251	0.0	23.5	3076.1	0.0	23.5	0.0	12098.0	O K
600 min Summer	8.531	626	0.261	0.261	0.0	24.8	3208.4	0.0	24.8	0.0	12576.6	O K
720 min Summer	7.374	744	0.269	0.269	0.0	25.7	3298.5	0.0	25.7	0.0	12960.2	O K
960 min Summer	5.855	982	0.280	0.280	0.0	27.0	3392.2	0.0	27.0	0.0	13541.4	O K
1440 min Summer	4.224	1456	0.296	0.296	0.0	28.7	3367.4	0.0	28.7	0.0	14273.5	O K
2160 min Summer	3.042	2168	0.307	0.307	0.0	29.7	6846.1	0.0	29.7	0.0	14827.8	O K
2880 min Summer	2.408	2884	0.312	0.312	0.0	30.1	6837.6	0.0	30.1	0.0	15050.5	O K
4320 min Summer	1.730	3648	0.314	0.314	0.0	30.3	6315.9	0.0	30.3	0.0	15151.3	O K
5760 min Summer	1.367	4344	0.315	0.315	0.0	30.4	12103.4	0.0	30.4	0.0	15204.9	O K
7200 min Summer	1.138	5120	0.315	0.315	0.0	30.4	12053.5	0.0	30.4	0.0	15214.4	O K
8640 min Summer	0.980	5904	0.314	0.314	0.0	30.3	11748.2	0.0	30.3	0.0	15180.8	O K
10080 min Summer	0.863	6760	0.313	0.313	0.0	30.2	11194.3	0.0	30.2	0.0	15111.2	O K
15 min Winter	122.529	50	0.108	0.108	0.0	5.1	400.3	0.0	5.1	0.0	5214.6	O K
30 min Winter	80.119	64	0.142	0.142	0.0	8.9	674.1	0.0	8.9	0.0	6813.4	O K
60 min Winter	49.937	92	0.176	0.176	0.0	13.4	1822.3	0.0	13.4	0.0	8480.3	O K
120 min Winter	30.115	150	0.212	0.212	0.0	18.3	2456.6	0.0	18.3	0.0	10197.1	O K
180 min Winter	22.129	208	0.232	0.232	0.0	21.1	2827.3	0.0	21.1	0.0	11204.7	O K
240 min Winter	17.690	266	0.247	0.247	0.0	23.0	3076.5	0.0	23.0	0.0	11905.3	O K
360 min Winter	12.802	382	0.266	0.266	0.0	25.4	3385.3	0.0	25.4	0.0	12842.7	O K
480 min Winter	10.192	498	0.281	0.281	0.0	27.1	3591.4	0.0	27.1	0.0	13546.3	O K
600 min Winter	8.531	614	0.292	0.292	0.0	28.3	3724.3	0.0	28.3	0.0	14084.0	O K
720 min Winter	7.374	730	0.301	0.301	0.0	29.1	3808.9	0.0	29.1	0.0	14516.0	O K
960 min Winter	5.855	964	0.314	0.314	0.0	30.3	3881.9	0.0	30.3	0.0	15173.8	O K
1440 min Winter	4.224	1428	0.331	0.331	0.0	31.6	3797.7	0.0	31.6	0.0	16012.9	O K
2160 min Winter	3.042	2116	0.345	0.345	0.0	32.3	7774.2	0.0	32.3	0.0	16675.6	O K
2880 min Winter	2.408	2788	0.351	0.351	0.0	32.6	7693.8	0.0	32.6	0.0	16981.4	O K
4320 min Winter	1.730	4040	0.353	0.353	0.0	32.7	7004.3	0.0	32.7	0.0	17083.6	O K
5760 min Winter	1.367	4560	0.352	0.352	0.0	32.7	13746.4	0.0	32.7	0.0	17014.5	O K
7200 min Winter	1.138	5472	0.350	0.350	0.0	32.6	13641.7	0.0	32.6	0.0	16930.1	O K
8640 min Winter	0.980	6344	0.347	0.347	0.0	32.4	13252.0	0.0	32.4	0.0	16774.3	O K
10080 min Winter	0.863	7272	0.343	0.343	0.0	32.2	12590.7	0.0	32.2	0.0	16573.8	O K

Area 3 – Insufficient area

Storm Event	Rain (mm/hr)	Time to Vol Peak (mins)	Max Water Level (m)	Max Depth (m)	Flooded Volume (m^3)	Max Control (l/s)	Discharge Volume (m^3)	Max Overflow (l/s)	Σ Max Outflow (l/s)	Overflow Volume (m^3)	Maximum Volume (m^3)	Status
30 min Summer	80.119	45	1.011	1.011	34.7	16.5	1276.7	20.3	36.8	14.5	2983.4	FLOOD
60 min Summer	49.937	56	1.095	1.095	292.9	17.1	3202.9	496.9	514.1	714.3	3241.6	FLOOD
120 min Summer	30.115	84	1.125	1.125	386.9	17.4	3936.4	750.7	768.1	1447.1	3335.7	FLOOD
180 min Summer	22.129	116	1.130	1.130	401.6	17.4	4354.1	796.3	813.7	1866.7	3350.4	FLOOD
240 min Summer	17.690	146	1.127	1.127	393.8	17.4	4633.4	773.4	790.8	2150.5	3342.5	FLOOD
360 min Summer	12.802	206	1.117	1.117	362.1	17.3	4981.7	679.7	697.0	2514.1	3310.9	FLOOD
480 min Summer	10.192	266	1.108	1.108	335.9	17.3	5225.7	606.8	624.1	2776.3	3284.6	FLOOD
600 min Summer	8.531	326	1.101	1.101	313.2	17.2	5399.8	544.9	562.1	2966.4	3261.9	FLOOD
720 min Summer	7.374	384	1.095	1.095	293.3	17.1	5533.2	496.9	514.1	3111.0	3242.0	FLOOD
960 min Summer	5.855	502	1.085	1.085	262.1	17.1	5724.8	420.4	437.4	3310.9	3210.8	FLOOD
1440 min Summer	4.224	740	1.070	1.070	218.2	17.0	5927.5	317.3	334.2	3506.7	3166.9	FLOOD
2160 min Summer	3.042	1100	1.057	1.057	176.7	16.9	8000.9	233.4	250.2	3546.2	3125.5	FLOOD
2880 min Summer	2.408	1468	1.048	1.048	149.3	16.8	8221.3	180.6	197.4	3436.1	3098.1	FLOOD
4320 min Summer	1.730	2200	1.038	1.038	117.1	16.7	7802.2	125.0	141.7	3128.6	3065.8	FLOOD
5760 min Summer	1.367	2928	1.032	1.032	97.9	16.6	9789.8	96.4	113.0	2837.8	3046.6	FLOOD
7200 min Summer	1.138	3672	1.027	1.027	83.8	16.6	10161.6	76.6	93.3	2564.4	3032.5	FLOOD
8640 min Summer	0.980	4408	1.024	1.024	74.6	16.6	10431.2	64.3	80.9	2304.1	3023.3	FLOOD
10080 min Summer	0.863	5144	1.021	1.021	66.7	16.6	10466.5	52.8	69.3	2054.9	3015.5	FLOOD
15 min Winter	122.529	31	0.875	0.875	0.0	16.0	1195.4	0.0	16.0	0.0	2563.9	Flood Risk
30 min Winter	80.119	38	1.077	1.077	238.4	17.0	1619.7	362.3	379.3	351.4	3187.1	FLOOD
60 min Winter	49.937	54	1.141	1.141	437.8	17.5	3653.3	904.5	922.0	1162.5	3386.5	FLOOD
120 min Winter	30.115	84	1.154	1.154	478.9	17.6	4480.9	1032.2	1049.8	1989.1	3427.7	FLOOD
180 min Winter	22.129	116	1.145	1.145	449.4	17.5	4955.1	943.2	960.7	2464.4	3398.1	FLOOD
240 min Winter	17.690	146	1.134	1.134	414.6	17.4	5275.0	833.4	850.9	2788.2	3363.4	FLOOD
360 min Winter	12.802	206	1.115	1.115	355.5	17.3	5680.3	662.3	679.6	3207.3	3304.2	FLOOD
480 min Winter	10.192	266	1.101	1.101	314.5	17.2	5968.7	548.9	566.1	3512.6	3263.2	FLOOD
600 min Winter	8.531	324	1.091	1.091	282.8	17.1	6178.5	469.7	486.8	3737.3	3231.6	FLOOD
720 min Winter	7.374	382	1.083	1.083	258.7	17.1	6341.8	409.3	426.3	3910.9	3207.4	FLOOD
960 min Winter	5.855	498	1.072	1.072	221.8	17.0	6582.5	327.5	344.4	4158.3	3170.5	FLOOD
1440 min Winter	4.224	746	1.057	1.057	176.8	16.9	6860.1	233.4	250.2	4425.0	3125.5	FLOOD
2160 min Winter	3.042	1096	1.045	1.045	139.9	16.8	8996.1	164.0	180.8	4540.1	3088.6	FLOOD
2880 min Winter	2.408	1448	1.038	1.038	117.9	16.7	9292.7	127.5	144.2	4486.7	3066.7	FLOOD
4320 min Winter	1.730	2164	1.030	1.030	91.6	16.6	8909.1	87.4	104.1	4151.0	3040.3	FLOOD
5760 min Winter	1.367	2800	1.024	1.024	74.6	16.6	10973.3	64.3	80.9	3770.2	3023.3	FLOOD
7200 min Winter	1.138	3544	1.021	1.021	64.0	16.6	11388.6	50.9	67.5	3410.5	3012.7	FLOOD
8640 min Winter	0.980	4408	1.018	1.018	56.1	16.5	11677.4	42.0	58.5	3046.5	3004.9	FLOOD
10080 min Winter	0.863	5040	1.016	1.016	49.8	16.5	11566.3	35.3	51.8	2686.2	2998.5	FLOOD

Area 3 – Predicted area needed

Storm Event	Rain (mm/hr)	Time to Vol Peak (mins)	Max Water Level (m)	Max Depth (m)	Flooded Volume (m^3)	Max Control (l/s)	Discharge Volume (m^3)	Max Overflow (l/s)	Σ Max Outflow (l/s)	Overflow Volume (m^3)	Maximum Volume (m^3)	Status
30 min Summer	80.119	46	0.227	0.227	0.0	14.0	958.8	0.0	14.0	0.0	2998.8	O K
60 min Summer	49.937	76	0.281	0.281	0.0	15.8	1980.5	0.0	15.8	0.0	3724.9	O K
120 min Summer	30.115	134	0.335	0.335	0.0	16.0	2353.4	0.0	16.0	0.0	4467.2	O K
180 min Summer	22.129	194	0.367	0.367	0.0	16.0	2489.4	0.0	16.0	0.0	4899.4	O K
240 min Summer	17.690	254	0.389	0.389	0.0	16.0	2531.3	0.0	16.0	0.0	5197.6	O K
360 min Summer	12.802	374	0.417	0.417	0.0	16.0	2504.0	0.0	16.0	0.0	5592.1	O K
480 min Summer	10.192	492	0.438	0.438	0.0	16.0	2425.4	0.0	16.0	0.0	5887.0	O K
600 min Summer	8.531	612	0.455	0.455	0.0	16.0	2337.3	0.0	16.0	0.0	6110.8	O K
720 min Summer	7.374	732	0.467	0.467	0.0	16.0	2253.6	0.0	16.0	0.0	6289.3	O K
960 min Summer	5.855	970	0.487	0.487	0.0	16.0	2111.8	0.0	16.0	0.0	6557.8	O K
1440 min Summer	4.224	1448	0.510	0.510	0.0	16.0	1906.6	0.0	16.0	0.0	6889.9	O K
2160 min Summer	3.042	2164	0.527	0.527	0.0	16.0	4215.2	0.0	16.0	0.0	7127.5	O K
2880 min Summer	2.408	2884	0.533	0.533	0.0	16.0	3901.1	0.0	16.0	0.0	7204.4	O K
4320 min Summer	1.730	3940	0.528	0.528	0.0	16.0	3424.3	0.0	16.0	0.0	7129.9	O K
5760 min Summer	1.367	4568	0.519	0.519	0.0	16.0	7831.1	0.0	16.0	0.0	7007.8	O K
7200 min Summer	1.138	5328	0.509	0.509	0.0	16.0	7636.7	0.0	16.0	0.0	6866.6	O K
8640 min Summer	0.980	6064	0.498	0.498	0.0	16.0	7250.0	0.0	16.0	0.0	6711.6	O K
10080 min Summer	0.863	6864	0.486	0.486	0.0	16.0	6786.4	0.0	16.0	0.0	6542.4	O K
15 min Winter	122.529	31	0.195	0.195	0.0	11.8	785.8	0.0	11.8	0.0	2573.5	O K
30 min Winter	80.119	45	0.254	0.254	0.0	15.2	1091.1	0.0	15.2	0.0	3358.9	O K
60 min Winter	49.937	74	0.314	0.314	0.0	16.0	2222.7	0.0	16.0	0.0	4174.5	O K
120 min Winter	30.115	134	0.375	0.375	0.0	16.0	2527.2	0.0	16.0	0.0	5010.8	O K
180 min Winter	22.129	192	0.410	0.410	0.0	16.0	2571.7	0.0	16.0	0.0	5499.2	O K
240 min Winter	17.690	250	0.435	0.435	0.0	16.0	2535.8	0.0	16.0	0.0	5836.9	O K
360 min Winter	12.802	368	0.467	0.467	0.0	16.0	2419.6	0.0	16.0	0.0	6285.3	O K
480 min Winter	10.192	486	0.491	0.491	0.0	16.0	2308.6	0.0	16.0	0.0	6621.2	O K
600 min Winter	8.531	604	0.509	0.509	0.0	16.0	2221.4	0.0	16.0	0.0	6876.8	O K
720 min Winter	7.374	722	0.524	0.524	0.0	16.0	2153.3	0.0	16.0	0.0	7081.2	O K
960 min Winter	5.855	956	0.546	0.546	0.0	16.0	2052.6	0.0	16.0	0.0	7390.7	O K
1440 min Winter	4.224	1426	0.574	0.574	0.0	16.0	1914.1	0.0	16.0	0.0	7779.5	O K
2160 min Winter	3.042	2120	0.594	0.594	0.0	16.0	4113.9	0.0	16.0	0.0	8073.0	O K
2880 min Winter	2.408	2804	0.603	0.603	0.0	16.0	3891.7	0.0	16.0	0.0	8190.3	O K
4320 min Winter	1.730	4116	0.601	0.601	0.0	16.0	3547.7	0.0	16.0	0.0	8164.7	O K
5760 min Winter	1.367	5352	0.587	0.587	0.0	16.0	8188.3	0.0	16.0	0.0	7965.4	O K
7200 min Winter	1.138	5696	0.571	0.571	0.0	16.0	7769.0	0.0	16.0	0.0	7743.6	O K
8640 min Winter	0.980	6584	0.555	0.555	0.0	16.0	7308.5	0.0	16.0	0.0	7521.5	O K
10080 min Winter	0.863	7480	0.538	0.538	0.0	16.0	6901.6	0.0	16.0	0.0	7273.1	O K

Area 5

Storm Event	Rain (mm/hr)	Time to Vol Peak (mins)	Max Water Level (m)	Max Depth (m)	Flooded Volume (m^3)	Max Control (l/s)	Discharge Volume (m^3)	Max Overflow (l/s)	Σ Max Outflow (l/s)	Overflow Volume (m^3)	Maximum Volume (m^3)	Status
30 min Summer	80.049	92	0.239	0.239	0.0	27.2	1935.6	0.0	27.2	0.0	11514.8	O K
60 min Summer	49.937	120	0.297	0.297	0.0	38.5	4770.6	0.0	38.5	0.0	14323.3	O K
120 min Summer	30.140	178	0.356	0.356	0.0	48.9	6180.4	0.0	48.9	0.0	17200.7	O K
180 min Summer	22.157	236	0.390	0.390	0.0	53.7	6953.2	0.0	53.7	0.0	18876.3	O K
240 min Summer	17.716	294	0.414	0.414	0.0	56.3	7443.6	0.0	56.3	0.0	20032.5	O K
360 min Summer	12.831	410	0.445	0.445	0.0	58.8	8003.9	0.0	58.8	0.0	21572.5	O K
480 min Summer	10.214	528	0.468	0.468	0.0	60.0	8318.4	0.0	60.0	0.0	22703.9	O K
600 min Summer	8.552	646	0.486	0.486	0.0	60.6	8477.1	0.0	60.6	0.0	23565.9	O K
720 min Summer	7.394	762	0.500	0.500	0.0	60.9	8535.0	0.0	60.9	0.0	24252.3	O K
960 min Summer	5.872	998	0.521	0.521	0.0	61.1	8460.8	0.0	61.1	0.0	25282.5	O K
1440 min Summer	4.238	1468	0.547	0.547	0.0	61.1	7927.1	0.0	61.1	0.0	26554.6	O K
2160 min Summer	3.054	2176	0.566	0.566	0.0	61.1	16252.1	0.0	61.1	0.0	27468.1	O K
2880 min Summer	2.418	2884	0.572	0.572	0.0	61.1	15781.7	0.0	61.1	0.0	27766.0	O K
4320 min Summer	1.738	3588	0.572	0.572	0.0	61.1	13957.2	0.0	61.1	0.0	27784.8	O K
5760 min Summer	1.373	4304	0.570	0.570	0.0	61.1	27479.8	0.0	61.1	0.0	27679.4	O K
7200 min Summer	1.144	5072	0.566	0.566	0.0	61.1	27395.9	0.0	61.1	0.0	27468.0	O K
8640 min Summer	0.984	5888	0.559	0.559	0.0	61.1	26751.0	0.0	61.1	0.0	27162.9	O K
10080 min Summer	0.867	6688	0.552	0.552	0.0	61.1	25551.8	0.0	61.1	0.0	26789.4	O K
15 min Winter	122.321	78	0.205	0.205	0.0	20.6	1483.6	0.0	20.6	0.0	9868.6	O K
30 min Winter	80.049	92	0.267	0.267	0.0	32.8	2331.4	0.0	32.8	0.0	12891.1	O K
60 min Winter	49.937	120	0.332	0.332	0.0	44.9	5621.9	0.0	44.9	0.0	16036.2	O K
120 min Winter	30.140	176	0.398	0.398	0.0	54.7	7148.0	0.0	54.7	0.0	19265.0	O K
180 min Winter	22.157	232	0.437	0.437	0.0	58.3	7934.0	0.0	58.3	0.0	21151.5	O K
240 min Winter	17.716	290	0.463	0.463	0.0	59.8	8397.3	0.0	59.8	0.0	22458.1	O K
360 min Winter	12.831	404	0.499	0.499	0.0	60.9	8863.6	0.0	60.9	0.0	24207.8	O K
480 min Winter	10.214	520	0.526	0.526	0.0	61.1	9061.1	0.0	61.1	0.0	25501.7	O K
600 min Winter	8.552	634	0.546	0.546	0.0	61.1	9099.3	0.0	61.1	0.0	26495.8	O K
720 min Winter	7.394	750	0.562	0.562	0.0	61.1	9042.0	0.0	61.1	0.0	27293.8	O K
960 min Winter	5.872	980	0.587	0.587	0.0	61.1	8773.0	0.0	61.1	0.0	28508.0	O K
1440 min Winter	4.238	1444	0.618	0.618	0.0	61.1	8013.4	0.0	61.1	0.0	30057.0	O K
2160 min Winter	3.054	2136	0.643	0.643	0.0	61.1	17070.5	0.0	61.1	0.0	31269.5	O K
2880 min Winter	2.418	2812	0.654	0.654	0.0	61.1	16182.4	0.0	61.1	0.0	31803.0	O K
4320 min Winter	1.738	4108	0.655	0.655	0.0	61.1	14047.7	0.0	61.1	0.0	31852.5	O K
5760 min Winter	1.373	4696	0.644	0.644	0.0	61.1	30088.9	0.0	61.1	0.0	31314.6	O K
7200 min Winter	1.144	5552	0.634	0.634	0.0	61.1	29640.7	0.0	61.1	0.0	30839.2	O K
8640 min Winter	0.984	6440	0.622	0.622	0.0	61.1	28606.8	0.0	61.1	0.0	30221.5	O K
10080 min Winter	0.867	7312	0.607	0.607	0.0	61.1	27098.4	0.0	61.1	0.0	29506.5	O K

Area 6 & 7

Storm Event	Rain (mm/hr)	Time to Vol Peak (mins)	Max Water Level (m)	Max Depth (m)	Flooded Volume (m^3)	Max Control (l/s)	Discharge Volume (m^3)	Max Overflow (l/s)	Σ Max Outflow (l/s)	Overflow Volume (m^3)	Maximum Volume (m^3)	Status
30 min Summer	80.119	38	0.067	0.067	0.0	1.9	141.0	0.0	1.9	0.0	1218.1	O K
60 min Summer	49.937	68	0.084	0.084	0.0	3.1	384.8	0.0	3.1	0.0	1515.5	O K
120 min Summer	30.115	128	0.101	0.101	0.0	4.7	542.2	0.0	4.7	0.0	1819.8	O K
180 min Summer	22.129	188	0.110	0.110	0.0	5.7	641.5	0.0	5.7	0.0	1996.0	O K
240 min Summer	17.690	246	0.117	0.117	0.0	6.5	712.7	0.0	6.5	0.0	2116.5	O K
360 min Summer	12.802	366	0.125	0.125	0.0	7.6	809.2	0.0	7.6	0.0	2272.6	O K
480 min Summer	10.192	484	0.132	0.132	0.0	8.4	881.9	0.0	8.4	0.0	2384.3	O K
600 min Summer	8.531	604	0.136	0.136	0.0	9.0	936.3	0.0	9.0	0.0	2464.8	O K
720 min Summer	7.374	724	0.139	0.139	0.0	9.4	978.6	0.0	9.4	0.0	2525.0	O K
960 min Summer	5.855	962	0.144	0.144	0.0	10.1	1037.3	0.0	10.1	0.0	2605.9	O K
1440 min Summer	4.224	1440	0.148	0.148	0.0	10.7	1087.1	0.0	10.7	0.0	2676.6	O K
2160 min Summer	3.042	1796	0.149	0.149	0.0	10.9	1867.5	0.0	10.9	0.0	2704.3	O K
2880 min Summer	2.408	2140	0.150	0.150	0.0	11.1	1933.4	0.0	11.1	0.0	2724.8	O K
4320 min Summer	1.730	2940	0.151	0.151	0.0	11.2	1922.3	0.0	11.2	0.0	2742.6	O K
5760 min Summer	1.367	3744	0.151	0.151	0.0	11.1	2895.2	0.0	11.1	0.0	2734.6	O K
7200 min Summer	1.138	4544	0.150	0.150	0.0	11.0	2951.6	0.0	11.0	0.0	2713.1	O K
8640 min Summer	0.980	5360	0.148	0.148	0.0	10.7	2955.7	0.0	10.7	0.0	2683.6	O K
10080 min Summer	0.863	6152	0.146	0.146	0.0	10.5	2902.8	0.0	10.5	0.0	2650.5	O K
15 min Winter	122.529	23	0.058	0.058	0.0	1.3	101.6	0.0	1.3	0.0	1043.9	O K
30 min Winter	80.119	38	0.075	0.075	0.0	2.4	179.2	0.0	2.4	0.0	1363.9	O K
60 min Winter	49.937	68	0.094	0.094	0.0	4.0	476.8	0.0	4.0	0.0	1696.6	O K
120 min Winter	30.115	126	0.112	0.112	0.0	6.0	665.8	0.0	6.0	0.0	2036.6	O K
180 min Winter	22.129	184	0.123	0.123	0.0	7.3	784.2	0.0	7.3	0.0	2233.0	O K
240 min Winter	17.690	242	0.131	0.131	0.0	8.3	868.7	0.0	8.3	0.0	2366.7	O K
360 min Winter	12.802	360	0.140	0.140	0.0	9.5	983.0	0.0	9.5	0.0	2539.0	O K
480 min Winter	10.192	478	0.147	0.147	0.0	10.5	1068.8	0.0	10.5	0.0	2661.5	O K
600 min Winter	8.531	594	0.151	0.151	0.0	11.2	1133.0	0.0	11.2	0.0	2749.2	O K
720 min Winter	7.374	708	0.155	0.155	0.0	11.8	1182.7	0.0	11.8	0.0	2814.3	O K
960 min Winter	5.855	936	0.160	0.160	0.0	12.5	1251.9	0.0	12.5	0.0	2901.2	O K
1440 min Winter	4.224	1374	0.164	0.164	0.0	13.2	1310.6	0.0	13.2	0.0	2978.4	O K
2160 min Winter	3.042	1756	0.165	0.165	0.0	13.3	2199.9	0.0	13.3	0.0	2995.9	O K
2880 min Winter	2.408	2192	0.166	0.166	0.0	13.5	2278.0	0.0	13.5	0.0	3011.5	O K
4320 min Winter	1.730	3108	0.165	0.165	0.0	13.3	2269.6	0.0	13.3	0.0	2991.4	O K
5760 min Winter	1.367	3976	0.162	0.162	0.0	12.8	3343.7	0.0	12.8	0.0	2941.0	O K
7200 min Winter	1.138	4832	0.159	0.159	0.0	12.4	3412.3	0.0	12.4	0.0	2880.1	O K
8640 min Winter	0.980	5704	0.155	0.155	0.0	11.8	3422.0	0.0	11.8	0.0	2816.5	O K
10080 min Winter	0.863	6552	0.152	0.152	0.0	11.3	3366.6	0.0	11.3	0.0	2754.0	O K

Area 8

Storm Event	Rain (mm/hr)	Time to Vol Peak (mins)	Max Water Level (m)	Max Depth (m)	Flooded Volume (m^3)	Max Control (l/s)	Discharge Volume (m^3)	Max Overflow (l/s)	Σ Max Outflow (l/s)	Overflow Volume (m^3)	Maximum Volume (m^3)	Status
30 min Summer	80.119	34	0.025	0.025	0.0	0.1	11.0	0.0	0.1	0.0	252.3	O K
60 min Summer	49.937	64	0.031	0.031	0.0	0.2	32.5	0.0	0.2	0.0	314.3	O K
120 min Summer	30.115	124	0.038	0.038	0.0	0.3	45.7	0.0	0.3	0.0	378.6	O K
180 min Summer	22.129	184	0.041	0.041	0.0	0.4	53.7	0.0	0.4	0.0	416.6	O K
240 min Summer	17.690	244	0.044	0.044	0.0	0.4	59.4	0.0	0.4	0.0	443.4	O K
360 min Summer	12.802	364	0.048	0.048	0.0	0.5	66.6	0.0	0.5	0.0	479.7	O K
480 min Summer	10.192	484	0.051	0.051	0.0	0.5	71.7	0.0	0.5	0.0	507.5	O K
600 min Summer	8.531	604	0.053	0.053	0.0	0.5	75.1	0.0	0.5	0.0	529.2	O K
720 min Summer	7.374	724	0.054	0.054	0.0	0.6	77.5	0.0	0.6	0.0	547.0	O K
960 min Summer	5.855	964	0.057	0.057	0.0	0.6	80.2	0.0	0.6	0.0	575.0	O K
1440 min Summer	4.224	1442	0.061	0.061	0.0	0.7	80.0	0.0	0.7	0.0	613.2	O K
2160 min Summer	3.042	2164	0.064	0.064	0.0	0.7	175.8	0.0	0.7	0.0	648.1	O K
2880 min Summer	2.408	2880	0.066	0.066	0.0	0.7	174.6	0.0	0.7	0.0	669.0	O K
4320 min Summer	1.730	4320	0.069	0.069	0.0	0.8	158.8	0.0	0.8	0.0	689.6	O K
5760 min Summer	1.367	5704	0.069	0.069	0.0	0.8	346.0	0.0	0.8	0.0	695.0	O K
7200 min Summer	1.138	6192	0.069	0.069	0.0	0.8	338.4	0.0	0.8	0.0	696.6	O K
8640 min Summer	0.980	6912	0.069	0.069	0.0	0.8	323.4	0.0	0.8	0.0	698.2	O K
10080 min Summer	0.863	7568	0.069	0.069	0.0	0.8	302.2	0.0	0.8	0.0	699.0	O K
15 min Winter	122.529	19	0.022	0.022	0.0	0.1	8.0	0.0	0.1	0.0	216.1	O K
30 min Winter	80.119	34	0.028	0.028	0.0	0.2	13.8	0.0	0.2	0.0	282.5	O K
60 min Winter	49.937	64	0.035	0.035	0.0	0.3	40.3	0.0	0.3	0.0	352.0	O K
120 min Winter	30.115	124	0.042	0.042	0.0	0.4	55.9	0.0	0.4	0.0	423.9	O K
180 min Winter	22.129	184	0.046	0.046	0.0	0.4	65.3	0.0	0.4	0.0	466.5	O K
240 min Winter	17.690	242	0.049	0.049	0.0	0.5	71.7	0.0	0.5	0.0	496.4	O K
360 min Winter	12.802	362	0.053	0.053	0.0	0.6	79.8	0.0	0.6	0.0	537.0	O K
480 min Winter	10.192	480	0.056	0.056	0.0	0.6	85.3	0.0	0.6	0.0	568.1	O K
600 min Winter	8.531	598	0.059	0.059	0.0	0.6	89.0	0.0	0.6	0.0	592.3	O K
720 min Winter	7.374	716	0.061	0.061	0.0	0.7	91.5	0.0	0.7	0.0	612.1	O K
960 min Winter	5.855	954	0.064	0.064	0.0	0.7	93.9	0.0	0.7	0.0	643.4	O K
1440 min Winter	4.224	1428	0.068	0.068	0.0	0.8	92.6	0.0	0.8	0.0	686.2	O K
2160 min Winter	3.042	2120	0.072	0.072	0.0	0.8	202.7	0.0	0.8	0.0	725.4	O K
2880 min Winter	2.408	2824	0.074	0.074	0.0	0.8	199.6	0.0	0.8	0.0	749.5	O K
4320 min Winter	1.730	4192	0.077	0.077	0.0	0.9	179.6	0.0	0.9	0.0	774.5	O K
5760 min Winter	1.367	5480	0.078	0.078	0.0	0.9	394.9	0.0	0.9	0.0	783.4	O K
7200 min Winter	1.138	6768	0.078	0.078	0.0	0.9	384.1	0.0	0.9	0.0	783.9	O K
8640 min Winter	0.980	7088	0.078	0.078	0.0	0.9	365.5	0.0	0.9	0.0	780.9	O K
10080 min Winter	0.863	7872	0.077	0.077	0.0	0.9	340.5	0.0	0.9	0.0	780.4	O K

Area 9

Storm Event	Rain (mm/hr)	Time to Vol Peak (mins)	Max Water Level (m)	Max Depth (m)	Flooded Volume (m^3)	Max Control (l/s)	Discharge Volume (m^3)	Max Overflow (l/s)	Σ Max Outflow (l/s)	Overflow Volume (m^3)	Maximum Volume (m^3)	Status
30 min Summer	80.049	42	0.100	0.100	0.0	3.0	225.1	0.0	3.0	0.0	1812.8	O K
60 min Summer	49.937	72	0.125	0.125	0.0	4.1	570.0	0.0	4.1	0.0	2258.0	O K
120 min Summer	30.140	132	0.150	0.150	0.0	5.1	727.3	0.0	5.1	0.0	2716.8	O K
180 min Summer	22.157	190	0.164	0.164	0.0	5.5	806.4	0.0	5.5	0.0	2986.6	O K
240 min Summer	17.716	250	0.175	0.175	0.0	5.8	851.6	0.0	5.8	0.0	3174.6	O K
360 min Summer	12.831	370	0.189	0.189	0.0	5.9	894.0	0.0	5.9	0.0	3429.1	O K
480 min Summer	10.214	488	0.199	0.199	0.0	6.0	909.2	0.0	6.0	0.0	3619.8	O K
600 min Summer	8.552	608	0.207	0.207	0.0	6.0	909.0	0.0	6.0	0.0	3768.4	O K
720 min Summer	7.394	728	0.214	0.214	0.0	6.0	900.2	0.0	6.0	0.0	3889.6	O K
960 min Summer	5.872	968	0.224	0.224	0.0	6.0	869.4	0.0	6.0	0.0	4078.8	O K
1440 min Summer	4.238	1446	0.238	0.238	0.0	6.0	789.7	0.0	6.0	0.0	4334.7	O K
2160 min Summer	3.054	2164	0.250	0.250	0.0	6.0	1697.4	0.0	6.0	0.0	4564.6	O K
2880 min Summer	2.418	2884	0.257	0.257	0.0	6.0	1576.9	0.0	6.0	0.0	4699.8	O K
4320 min Summer	1.738	4324	0.264	0.264	0.0	6.0	1341.8	0.0	6.0	0.0	4824.4	O K
5760 min Summer	1.373	5760	0.265	0.265	0.0	6.0	3144.7	0.0	6.0	0.0	4840.8	O K
7200 min Summer	1.144	6272	0.264	0.264	0.0	6.0	2953.4	0.0	6.0	0.0	4819.0	O K
8640 min Summer	0.984	7000	0.263	0.263	0.0	6.0	2743.9	0.0	6.0	0.0	4795.0	O K
10080 min Summer	0.867	7760	0.261	0.261	0.0	6.0	2537.0	0.0	6.0	0.0	4765.0	O K
15 min Winter	122.321	27	0.086	0.086	0.0	2.3	173.3	0.0	2.3	0.0	1552.5	O K
30 min Winter	80.049	41	0.112	0.112	0.0	3.5	269.8	0.0	3.5	0.0	2030.1	O K
60 min Winter	49.937	70	0.139	0.139	0.0	4.7	667.1	0.0	4.7	0.0	2528.6	O K
120 min Winter	30.140	130	0.168	0.168	0.0	5.6	827.7	0.0	5.6	0.0	3043.2	O K
180 min Winter	22.157	188	0.184	0.184	0.0	5.9	897.7	0.0	5.9	0.0	3346.2	O K
240 min Winter	17.716	246	0.196	0.196	0.0	6.0	931.1	0.0	6.0	0.0	3557.7	O K
360 min Winter	12.831	364	0.211	0.211	0.0	6.0	951.0	0.0	6.0	0.0	3845.0	O K
480 min Winter	10.214	484	0.223	0.223	0.0	6.0	946.1	0.0	6.0	0.0	4061.1	O K
600 min Winter	8.552	602	0.232	0.232	0.0	6.0	930.1	0.0	6.0	0.0	4230.4	O K
720 min Winter	7.394	720	0.240	0.240	0.0	6.0	909.0	0.0	6.0	0.0	4368.9	O K
960 min Winter	5.872	956	0.251	0.251	0.0	6.0	862.0	0.0	6.0	0.0	4586.7	O K
1440 min Winter	4.238	1430	0.268	0.268	0.0	6.0	772.7	0.0	6.0	0.0	4885.3	O K
2160 min Winter	3.054	2136	0.282	0.282	0.0	6.0	1658.7	0.0	6.0	0.0	5160.5	O K
2880 min Winter	2.418	2828	0.291	0.291	0.0	6.0	1530.2	0.0	6.0	0.0	5330.0	O K
4320 min Winter	1.738	4200	0.301	0.301	0.0	6.0	1325.5	0.0	6.0	0.0	5506.0	O K
5760 min Winter	1.373	5584	0.304	0.304	0.0	6.0	3115.9	0.0	6.0	0.0	5564.4	O K
7200 min Winter	1.144	6912	0.304	0.304	0.0	6.0	2901.6	0.0	6.0	0.0	5555.7	O K
8640 min Winter	0.984	8128	0.301	0.301	0.0	6.0	2708.2	0.0	6.0	0.0	5504.3	O K
10080 min Winter	0.867	9272	0.297	0.297	0.0	6.0	2536.6	0.0	6.0	0.0	5425.7	O K