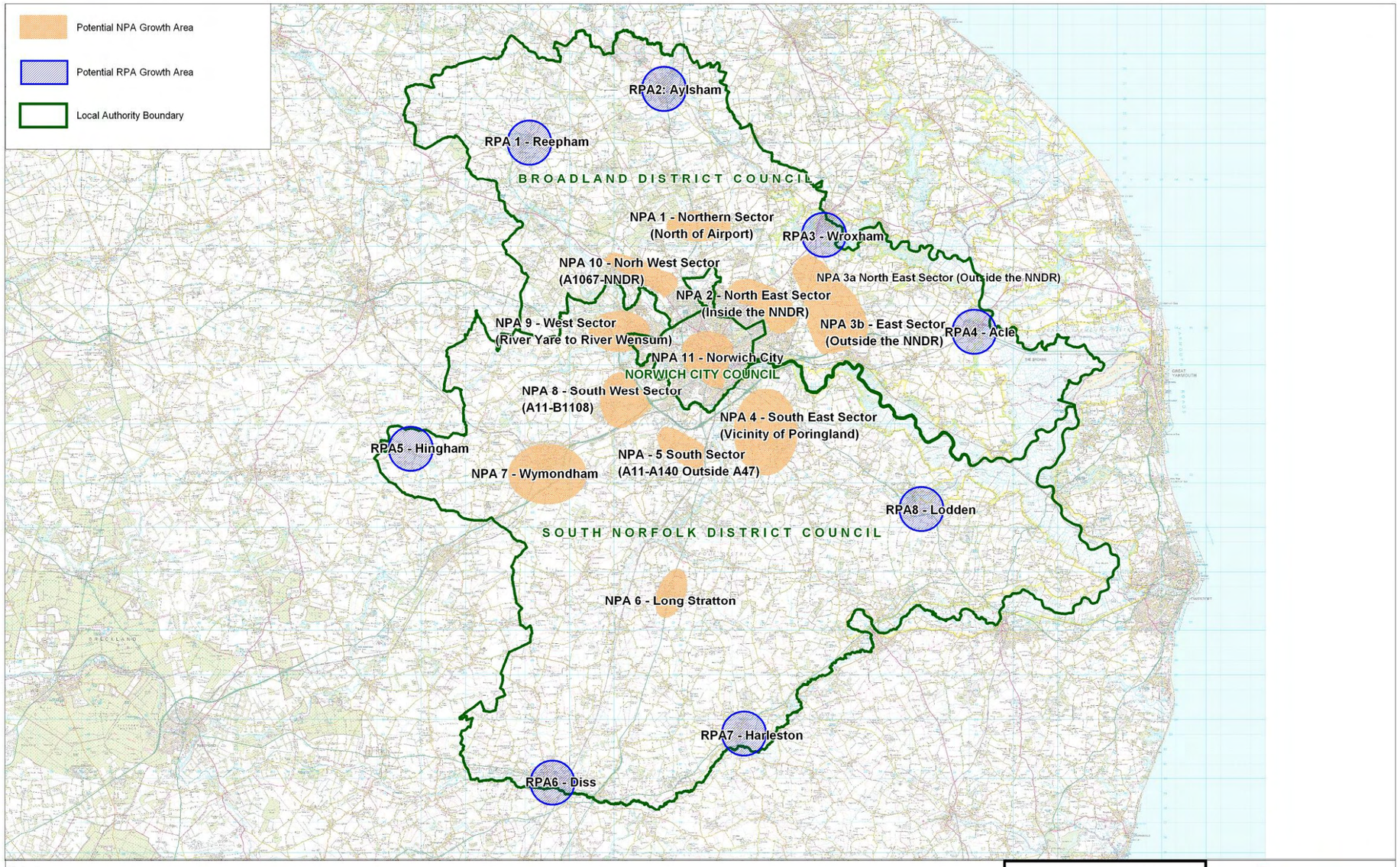
9 Appendices

Appendix A: Reference changes from Water Cycle Study Stage 1 and Stage 2

Stage 2 Reference	Stage 1 Reference	Description
-	NPA4	North East and East Combination
NPA1	NPA10	North Sector (North of Airport)
NPA2	NPA1	North East Sector (inside the NNDR)
NPA3a	NPA2	North East Sector (outside the NNDR)
NPA3b	NPA3	East Sector (outside the NNDR)
NPA4	NPA5	South East Sector (Vicinity of Poringland)
NPA5	NPA6	South Sector (A11-A140 outside A47)
NPA6	-	Long Stratton
NPA7	NPA11	Wymondham
NPA8	NPA7	South West Sector (A11-B1108)
NPA9	NPA8	West Sector (River Yare to River Wensum)
NPA10	NPA9	North West Sector (A1067 - NNDR)
NPA11	CITY	Norwich
RPA1	RPA1	Reepham
RPA2	RPA2	Aylsham
RPA3	RPA3	Wroxham
RPA4	RPA4	Acle
RPA5	RPA5	Hingham
RPA6	RPA6	Diss
RPA7	RPA7	Harleston
RPA8	RPA8	Loddon

Appendix B: NPA and RPA Policy Areas



Appendix C: Development Results and Summary from Stage 1

Table 9-1: Development Numbers (in thousands) per PGA (from Stage 1)

				Number (000's)				
	Stage 1 Ref	Stage 2 Ref	Description	Flood Risk	Water Resources	Wastewater	Environment	Limiting No.
NPA	NPA1	NPA2	North East Sector (inside the NNDR)	20	10	5	5	5
	NPA2	NPA3a	North East Sector (outside the NNDR)	20	20	1	20	1
	NPA3	NPA3b	East Sector (outside the NNDR)	20	15	5	5	5
	NPA4	-	North East and East Combination	20	15	5	5	5
	NPA5	NPA4	South East Sector (Vicinity of Poringland)	20	5	5	10	5
	NPA6	NPA5	South Sector (A11-A140 outside A47)	20	5	0	20	0
	NPA7	NPA8	South West Sector (A11-B1108)	20	5	5	5	5
	NPA8	NPA9	West Sector (River Yare to River Wensum)	0	1	1	1	0
	NPA9	NPA10	North West Sector (A1067 - NNDR)	20	5	1	1	1
	NPA10	NPA1	North Sector (North of Airport)	20	5	1	20	1
	NPA11	NPA7	Wymondham	20	4	4	20	4[11]
	CITY	NPA11	Norwich	1	1	10	1	1
	Total							**33**
RPA	RPA1	RPA1	Reepham	1	1	0.1	0.1	0.1
	RPA2	RPA2	Aylsham	2	2	0	2	0
	RPA3	RPA3	Wroxham	0.5	0.5	2	0.5	0.5
	RPA4	RPA4	Acle	0.1	2	0.1	0.1	0.1
	RPA5	RPA5	Hingham	2	2	2	0.1	0.1
	RPA6	RPA6	Diss	2	1	2[12]	2	1[13]
	RPA7	RPA7	Harleston	2	0	1	2	0
	RPA8	RPA8	Loddon	2	2	2	0.5	0.5
	Total							**2.3**

[11] Subject to further investigation of drainage related flooding
[12] Indicates no information
[13] Subject to wastewater information

Table 9-2: GNDP Summary of Stage 1 Findings (NPA)[14]

NPA *Degree of constraint*	*JCS PGA*	*Existing Constraints*
Least constrained locations	NPA1 *(now NPA2)* North east sector (inside NNDR)	
	NPA3 *(now NPA3b)* East sector (outside the NNDR)	
	NPA4 *(now defunct)* North east and East Combination	
	NPA5 *(now NPA4)* South east sector (vicinity of Poringland)	
	NPA7 *(now NPA8)* South west sector (A11-B1108)	
	NPA11 *(now NPA7)* Wymondham	
Locations with some constraints	NPA2 *(now NPA3a)* North east sector (outside NNDR)	wastewater (need to upgrade Rackheath WWTW)
	NPA9 *(now NPA10)* North west (A1067-NNDR)	water supply, wastewater and environmental issues
	NPA10 *(now NPA1)* North sector (north of airport)	wastewater and water supply
	CITY *(now NPA11)* Norwich	flood risk, water resources and environment
Most constrained locations	NPA 6 *(now NPA5)* South Sector (A11-A140, outside A47)	wastewater (no capacity at existing Stoke Holy Cross SWT)
	NPA8 *(now NPA9)* West sector (River Yare to River Wensum)	flood, water supply , wastewater (route through city centre) and environmental issues

[14] NB the NPA references reflect the Stage 1 findings.

Table 9-3: GNDP Summary of Stage 1 Findings (RPA)

RPA *Degree of constraint*	*JCS PGA*	*Existing Constraints*
Least constrained locations	Diss	(subject to wastewater information)
Locations with some constraints	Reepham	wastewater, environment
	Loddon	environment
	Wroxham	flood risk, water resources, environment
	Loddon	environment
	Hingham	environment
	Acle	flood, wastewater, environment
Most constrained locations	Aylsham	wastewater
	Harleston	water resources

Appendix D: Stage 1 Identified Data Gaps

Flood Risk and Hydrology

A key missing data source for Stage 1 of the Water Cycle Study was the Strategic Flood Risk Assessment (SFRA). Completion of this should be progressed as a priority to enable it to be incorporated into Stage 2. Key elements that are required from this include:

- Updated flood zone maps for the 1 in 100 year and 1 in 20 year (functional floodplain) return period for fluvial systems and the 1 in 200 year floodplain return period for tidal systems;
- The impacts of the predicted climate change onto these floodplains;
- The assessed flood risk from surface water runoff within each of the PGAs, especially within Wymondham which has been identified as having related drainage problems;
- Identification of the required infrastructure to improve, where necessary, the flood defences in order to facilitate the required growth in each of the PGAs. This should again be informed by the SFRA which should provide an assessment of the condition of the defences;
- Undertake a study to ascertain the capacity of the receiving watercourses within the Study Area;
- The assessment of the potential SUDS schemes identified in the SFRA which can be implemented in the Study Area should be considered in light of incorporating this into an overall water strategy to:
- Address any flood risk issues;
- Provide additional storage capacity for water resources;
- Provide a means for increasing groundwater recharge.

Water Resources and Supply

Stage 2 of the Water Cycle Study needs to address the following in terms of water resources:

- Provide greater clarity on the effects on groundwater of development, particularly in Norwich, where this has been identified as a major issue.
- Considerable liaison with Anglian Water Services is required to:
- Review the water resource plans for the area (to be published in early 2008);
- Review the demand forecasts to see what growth has been included. This review should be carried out at Water Resource Zone level (of which there is likely to be three covering the Greater Norwich area).
- Identify any potential local water infrastructure constraints to the development of specific areas and the infrastructure required, if possible, to overcome these;
- Use the SFRA to review of the local geology in terms of the options for groundwater recharge and water supply in conjunction with the widespread use of SUDS;
- A review the raw water quality, mainly of the groundwater sources and to identify any problems. Deteriorating water quality (mainly by nitrates) is likely to be the major problem that AWS will face with many of its isolated groundwater sources and where the options for blending are limited.
- Undertake a review of the phosphate levels in the watercourse and ascertain the impact of development on these;
- Assess any potential constraints on future water resources by climate change;
- The Review of Consents process should be fully incorporated into Stage 2 once the results have been are determined. Although the discharge and abstraction issues are considered in isolation in relation to each of the PGAs, the combined effect of this should be assessed throughout the Study Area. It should identify through Environment Agency Review of Consents methodologies, the overall ceiling for development within the Study Area for each combination of developments. This would give context as to which combinations of development might be viable and sustainable.

Wastewater Drainage and Treatment

The scope of Stage 2 in terms of the wastewater drainage and treatment should include the following:

- The development of (if necessary) or the upgrade of, an appropriate hydraulic model of the existing sewer network. This will enable the assessment of the capacity of the existing sewers within the PGAs, and will inform the PDSs in terms of the availability to develop within the existing infrastructure. This will need to be undertaken in conjunction with Anglian Water Services;
- Once the appropriate PDSs have been identified and agreed with the stakeholders15, then further hydraulic modelling will be necessary to inform the design of any proposed infrastructure required. The model should be developed so that it can inform the distribution of proposed developments;
- Further clarification of the existing capacities of the WWTWs, potential process “bottle necks” within them and options for upgrading or improving WWTWs should be undertaken;
- Once the options for potential growth in each of the PGAs have been identified, then the required infrastructure for providing the necessary service to these will need to be identified. It is advised that the option numbers are limited for each PGAs to minimise the permutation that can be undertaken and avoid abortive work;

Environment

The scope of Stage 2 should address the following points:

- Undertake further study on the existing and potential phosphate discharges into the receiving watercourse (particularly the Rivers Yare and Wensum). The impacts on the downstream areas such as The Broads should be assessed in conjunction with Natural England and the Broads Authorities;
- Stage 2 will aim to quantify the likely increase of phosphates into the receiving watercourse in light of the Review of Consents, and where possible, provide costing on the required improvements to the WWTW process to mitigate against this;
- Further investigate the sensitivity of those SSSIs that have been identified as potential constraint on development areas;
- The Review of Consents results should be wholly incorporated into Stage 2, to include not only the Study Area, but the Redgrave and Lopham Fens SSSI and Blo’ Norton & Thelnetham Fens SSSI, where water resources issues have been identified.

Other

Other aspects of the Water Cycle Study that will be required in Stage 2 include:

- In conjunction with Anglian Water, identifying the phasing of their works to align the potential development on this study;
- Once the estimated capital cost of the projects have been identified, it should be assessed where possible and to what extent, developers can contribute financially to the implementation of the

[15] The Government housing targets will need to be met

schemes. It is likely that a strategy will have to be formulated which will provide incentives for developers to invest into the project;

- If necessary, the provision of a developer checklist should be undertaken. This will provide guidance for developers in terms of a sustainable approach to development, and also act as a single development guide to avoid repetitive planning applications that will strain existing resources and finances.

Appendix E: Conclusions from Stage 3 RoC

River Wensum SAC

The River Wensum SAC is one of the best examples in the UK of a naturally enriched calcareous lowland river. The upper reaches of the river are fed by chalk springs and drainage from calcareous soils, and support chalk stream vegetation communities. These are identified in the text below.

In terms of discharge consents, the following conclusions can be drawn from the Environment Agency's assessment which is pertinent to the Greater Norwich WCS:

- At least 18 of the existing consented discharges could not be ruled out as having no adverse impact (either alone or in combination) on the SAC. All of these consents will be reviewed as part of Stage 4;
- The key impacts are in siltation, discharge of toxic substances and phosphorus (P)
- The Wensum is not reaching the required Water Framework Directive (WFD) P target as set out by the UK's Technical Advisory Group (UKTAG) for the WFD for SAC rivers and that this is the case upstream of the SSSI as well as through the SAC component; and
- Any proposed discharges to the Wensum, both upstream and within the SAC as a result of new development is likely to prove difficult to consent without very high levels of treatment, because measures are required to ensure that the existing condition is improved to further protect the SAC.

In terms of abstraction licences, the following conclusions can be drawn from the Environment Agency's assessment which is pertinent to the Greater Norwich WCS:

- It is considered that existing abstraction licences are adversely impacting on the integrity of the SAC by altering groundwater levels and hence river levels and flow (velocities); this in turn has the effect of reducing available habitat and reducing dilution capacity of in stream nutrients and pollution;
- 71 groundwater licences (including 1 mixed groundwater and surface water licence) could not be ruled out as not having an adverse impact (in combination) on the SAC. All of these licences (to be reviewed in Stage 4) are believed to result in a groundwater drawdown (level reduction) of 0.001m or more;
- Of these licences, one is considered to be impacting on the SAC on its own. Although it is not explicitly stated in the Stage 3 reports released, The Costessey AP licence (which is a mixed groundwater and surface water licence dependent on flow conditions in the Wensum) is the licence which is considered to be impacting on the SAC when considered on its own;
- Liaison with the Environment Agency and Natural England has confirmed that the AP licence is considered to be having an adverse impact in isolation from (as well as in combination with) other abstraction licences;
- 30 surface water abstractions can also not be shown to be having no adverse impact on the SAC.
- It can be concluded that further direct surface water abstraction from the Wensum is unlikely to be permitted until solutions have been put in place (Stage 4) to address the current abstraction impacts on the SAC and that this would extend to the development of groundwater sources which draw on aquifer water which is hydraulically connected to baseflow in the Wensum.

SAC Designated Species and Habitats

- Floating Vegetation of Ranunculus of plain and submontainous rivers;
- Bullhead;
- Brook lamprey;
- White-clawed crayfish; and
- Desmoulin's whorl Snail

Yare Broads and Marshes SAC/SPA

The Yare Broads and Marshes are a nationally important wetland site consisting of extensive areas of unreclaimed fen, carr woodland, open water and grazing marsh on shallow fen peats. The species-rich fens, dykes and unimproved meadows hold an outstanding assemblage of plants including many rare species. SAC/SPA designated features are outlined below. In terms of discharge consents, the following conclusions can be drawn which are pertinent to the GNWCS:

- Toxic substances, salinity, temperature and pH are not considered to be adversely impacting on the designated sites. P is considered to be the key issue with respect to nutrient enrichment in the River Yare and hence adverse impact on the downstream designated sites. Orthophosphate (or soluble reactive phosphorus) is considered to be a key concern;
- The discharge from Whitlingham WWTW (into the tidal Yare) cannot be ruled out as having an adverse impact on the designated European sites due to the substantial load contributed by this WWTW. All other water company WWTWs discharging to the tidal Yare have been ruled out as having an adverse impact (alone or in combination);
- Discharges from Wymondham and Long Stratton WWTWs (upstream of the tidal limit) cannot be ruled out as having an adverse impact on the downstream designated sites; however, P modelling has shown that even if these discharges (as well as 2 smaller water company discharges) were removed completely, the orthophosphate concentrations would still be greater than the current proposed WFD standards for SAC rivers;
- Reepham WWTW discharging into the Wensum cannot be ruled out as having no adverse impact on the downstream Yare Broads and Marshes site;
- Process discharge from Heigham WTW is not considered to be adversely impacting on the designated sites;
- In total, 12 discharges could not be ruled out as having no impact on the SAC/SPA and will be considered in Stage 4 of the RoC;
- Further discharges from those WWTWs whose consents have been highlighted as potentially impacting on the SAC will need to consider very high levels of treatment for P (and potentially other parameters) in order to prevent worsening of an already identified problem;
- Although the RoC has potentially highlighted some existing discharges as impacting on the SAC/SPA, increasing treated flow at other works which discharge upstream of the sites but eventually flow into the Yare Broads and Marshes, would also have to consider very high levels of treatment.
- Abstractions were not found to be impacted adversely on the SAC.

As the overall RoC process moves forward into Stage 4 (determination and production of management plans), more information should be made available on specific licences and consents which will need to be altered or have solutions implemented in order to address the impact of the consent/licence. It is recommended that this will be addressed in during **Stage 2b** of the GNWCS such that the impact of any existing consent or licence change is factored in the requirements of the future water environment baseline for detailed site selection and assessment.

SAC Designated Species and Habitats

- Transition mires and Quaking bogs
- Hard Oligo- mesotrophic waters
- Alluvial Forests
- Calcareous Fens
- Natural Eutrophic Waters
- Molinia Meadows
- Bittern
- Marsh Harrier
- Hen Harrier
- Gadwall
- Shoveler
- Ruff
- Assemblage
- Desmoulin's Whorl Snail
- Otter

Appendix F: Sewer/Water Supply Modelling

In undertaking the assessment of the capacity of critical sections of gravity sewers, the following parameters were used.

- The size of the sewer has been obtained from GIS sewer records provided by AWS;
- The gradient of the sewer has been obtained from GIS Sewer records. If not available from the records, it has been assumed that the sewer is at a gradient of 1 in 400;
- A pipe roughness (ks) value of 3mm has been used;
- Maximum allowable proportional depth of sewer has been taken as 0.75;
- Where the sewer drains a catchment that has existing industrial or commercial developments, a percentage of the sewer capacity has been set aside for trade effluent. This percentage has ranged from 15 to 30% of the sewers hydraulic capacity. 30% has been taken as the maximum allocation for trade effluent as this is commensurate with the percentage of trade effluent being treated at Whitlingham WWTW.

In undertaking the assessment of the capacity of the critical sections of sewer rising mains, the following parameters were used:

- The size of the sewer has been obtained from GIS sewer records provided by AWS;
- In line with recommendations of Sewers for Adoption a maximum flow velocity of 1.8m/s has been assumed;
- Where the sewer drains a catchment that has existing industrial or commercial developments, a percentage of the sewer capacity has been set aside for trade effluent. This percentage has ranged from 15 to 30% of the sewers hydraulic capacity. 30% has been taken as the maximum allocation for trade effluent as this is commensurate with the percentage of trade effluent being treated at Whitlingham WWTW.

Knowing the capacity of the sewer that is available to domestic flow, the theoretical maximum population that can drain to the sewer has been assessed using the formula

$$DWF_{peak} = P_f(PG) + I$$

where:

- Peak Factor (Pf) was taken as 6
- G was taken as 130l/c/d (i.e. 90% of a per capita water demand of 146litres being returned to sewer.)
- Infiltration (I) was taken as 25% of PG

The theoretical maximum population was converted to properties by assuming a property occupancy ratio of 2.1 people per property.

To obtain an indicative property headroom of the sewer, the number of existing properties that are already draining to that Section of sewer was deducted from the theoretical maximum no of properties that can be served by the sewer. The number of existing properties draining to a Section of sewer were estimated from GIS data obtained from the 2001 Census. Use of this data indicated that the number of properties draining to Whitlingham is approximately 105,000. Converting this to domestic PE by applying a property occupancy ratio of 2.1 yields a domestic PE of approximately 220,800. This compares well with a domestic PE of 234,900 that is quoted by AWS for the year 2006.

It should be noted that there are significant portions of the study area that have combined sewers. As a result of the complexity of the sewer network and the absence of a network model, the effect of surface water drainage has not been taken into account. This together with the inevitable gross uncertainty in the accuracy of the parameters listed above means that the results of this assessment are only indicative.