



ATKINS

Stevenston Development
Options Review

October 2005

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Document History

JOB NUMBER: 5010600			DOCUMENT REF: 5010600/63/DG/85			
Revision	Purpose and Description	Originated	Checked	Reviewed	Authorised	Date
1	First Draft	JAM	JM	WB	DW	12/10/05

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1. Introduction

The purpose of this study was to undertake a development strategy review for the Stevenston catchment, to permit Scottish Water (SW) to present an overview report on strategic drainage requirements for identified developments. It is anticipated that SW's report will be presented to the Ayrshire Joint Structure Plan & Transportation Committee.

The Stevenston catchment is approximately 37km south west of Glasgow and comprises the larger towns of West Kilbride, Ardrossan, Saltcoats, Kilwinnig, Stevenston, Dalry, Kilbirnie and Beith.

Developments considered as part of this study are limited to the provision of new housing in the Ayrshire region up to 2011. Some non-effective housing developments were defined as those that could possibly take place beyond 2011. The use of this development data permits the analysis of changes in the Stevenston catchment following the hydraulic model's completion in 2003 and the effects of future developments on the performance of the sewerage system.

This study identifies a preferred option to manage the developments' effects on the sewerage system. The strategic options proposed in this report address the impact of future developments only and do not address other sewerage deficiencies or other regulatory drivers.

It is also highlighted that a more up to date model of the Stevenston catchment has recently been produced following audit to address a number of limitations. It is not known if this model has been issued to SW, and this updated model has not been used for this study.

The optioneering undertaken within this report, and the parallel Meadowhead Development Options Review, is based on the data and analysis presented in the earlier Meadowhead and Stevenston Development Impact Assessment Report.

2. Design Methodologies

2.1 Data Sources

Hydraulic modelling of the Stevenston sewerage systems was undertaken using InfoWorks software. The model which was used as the basis of this study originated from a number of DAP models, combined to form the Stevenston Macro Model, used as part of SW's Ayrshire Coast Bathing Beach Study. The model has been updated to include developments up to the year 2004 and the population inputs are considered representative of those currently connected to sewerage system. This model has been used in accordance with the Meadowhead and Stevenston Macro Model User Manual.

New development data has been added to the model in accordance with Section 3.3 of the Meadowhead and Stevenston Development Impact Assessment Report. In summary, development data sources were Housing Land Supply 2004-2011, NAC Urban Capacity Studies and Greenfield Development. Future developments account for a population increase of 20,007, resulting in an additional average population flow of 38.2l/s and an additional infiltration flow of 15.2/s.

The model was simulated with a year of stochastically generated synthetic rainfall data, calibrated against historical data for Prestwick, which is referred to as time series rainfall (TSR). Simulation results, using TSR, permitted the quantification of CSO annual spill frequencies, total annual spill volumes and individual spill volumes for each TSR event and at each of the individual CSOs.

2.2 Limitations

In addition to the limitations stated in the Meadowhead and Stevenston Macro Model User Manual, it should be noted that the whole macro model, made up of individual sewer models, has not been verified against observed flow survey data as a single entity. This results in a lower level of confidence in model predictions in areas where there are interactions between the various individual models.

Planned developments located further than 2km from the modelled sewer network have been considered unlikely to be connected to the sewer network due to their geographical remoteness or too small a scale to be economically connected to the network. Reasonable assumptions have been made with respect to the point of connection of planned developments to the sewerage system. Larger developments are assumed to connect further down the sewer system or at multiple locations in order to limit the likelihood of flooding from local, small diameter sewers.

The diurnal profile for the Stevenston catchment was applied by assigning the diurnal profile from the local catchment. As the modelling of the Stevenston models was more simplistic in nature in comparison with the Meadowhead model, i.e. single unique diurnal profile applied to each of the eight township catchments, it was deemed more representative to apply known local diurnal profiles in preference to applying an averaged diurnal profile for the proposed future areas across the entire Stevenston catchment. An infiltration flow was applied to all future development areas, equivalent to 40% of the population-generated flows.

The sewer models were originally produced to investigate CSO performance and are unlikely to accurately reflect flooding, for higher return period design storm events. The models have been verified against low return period storm events.

This study focuses on developing strategic solutions to address the impact of planned developments on the sewerage system. Issues surrounding on-site storage of flows within planned developments and localised sewerage improvements immediately downstream of the points of connection have not been considered in detail as part of this study.

Model instabilities have limited the ability of the model to accurately reflect flooding within the catchment. These instabilities are considered to be as a result of the complexity of the model and limitations of the modelling software. Likewise, but not to the same extent, model instabilities were also apparent within the TSR simulations. During the analysis there was a requirement to decipher where increases in spill volumes were caused due to model instability, and as a consequence filtered out from the results. Any spill volumes found to be caused by model instability have been omitted from the analysis.

2.3 Assessment of Development Impact

Model limitations concerning instabilities and the lack of confidence in the model's flooding predictions highlight the need to treat flood analysis results with a high degree of caution.

Options to assess the impact of developments on the sewerage network have been developed based upon their impact on CSOs within the catchment.

TSR events have been used to identify the predicted existing and future performance of CSOs.

Improvement options do not take account of the cost of treating foul flows from the 20,007 additional people planned to inhabit future planned developments. These costs are considered to exist irrespective of which strategic improvement option is judged more appropriate. It is expected that such costs form part of developers' standard contributions to SW.

3. Predicted Sewer Flooding

Instabilities in the Stevenston Macro Model limit the accuracy of flooding predictions and prevent a precise analysis of differing flooding volumes for existing and future scenarios.

The macro model was constructed to investigate CSO performance, rather than flooding. Similarly, the performance of individual DAP models was generally verified against low return period storm events, many of which were similar to TSR events. As a result, the model performance and reliability is better for TSR, low return period storm events compared to generated 1, 2, 5 and 10 year design rainfall events.

Due to the presence of instabilities and the reduced confidence in the model's flooding predictions, the strategic sewerage options considered for this study do not use the assessment of flooding volumes as a criterion for performance improvement. This approach was agreed with SW following the initial system performance appraisal. If storage improvements to CSOs are developed as online solutions, they will generally reduce predicted flooding volumes near to the improved CSOs. Under this investigation all upgrades to CSO storage have been developed as offline, and thus the impact of any CSO improvement scheme on flooding is likely to be small.

4. Predicted CSO Performance

4.1 Current CSO Performance

The TSR analysis carried out on the overflows within the Stevenston catchment predicted that the annual spill frequency of the overflows would increase from 1,139 times to 1,150 times, an increase of 1%. As a consequence the total spill volume for the annual period would increase from 711,230m³ to 751,932m³, an increase of 6%. The analysis carried out showed that 22 CSOs exceeded the 10 spills per year threshold. The total number of CSOs failing the 10 spills per year criteria was not predicted to increase for the future conditions system.

21 CSOs have been identified as failing to pass forward Formula A flows. When future planned developments are added to the model, the number of failing CSOs increases to 22, and therefore it was considered that future development has a minor impact on the Formula A performance.

4.2 Development Impact Upon CSOs

The Stevenston Macro Model has been constructed from individual DAP models, each used specifically to investigate the performance of CSOs within the catchment. Generally, models have been locally verified against actual flow survey data, for rainfall events comparable to TSR events used for this study.

Comparisons between existing CSO performance and the predicted performance of CSOs following future developments showed a 6% increase in annual spill volumes. Results also showed that, on occasions, individual TSR events caused increases in CSO spills in excess of 6%. The CSOs most affected by the future development were identified to be Saltcoats TPS and Holmes Road CSO. Further detail is given within the Meadowhead and Stevenston Development Impact Assessment.

The objective of this study was to develop strategic options to address the predicted increase in CSO spills for individual TSR, annual rainfall series events.

Strategic options considered in this report address the impact of future developments only and do not address other sewerage deficiencies or other regulatory drivers.

5. Options

5.1 Option 1: Localised CSO Storage Option

5.1.1 Proposed Option

Analysis of individual TSR series events has shown that the introduction of planned developments into the hydraulic model causes 33 CSOs within the catchment to spill more than they do currently. From a more detailed analysis of individual spills it has been determined that spills from 14 of these CSOs are increased by more than 25m³. This number is a reduction on the earlier reported figure of 17 (reported within the Meadowhead and Stevenston Development Impact Assessment), as total TSR difference in spill was determined for the earlier report.

This option involves the construction of storage at each CSO where individual spill volumes increase by more than 25m³. It is considered that the most economical way to provide this storage is in shaft tanks, generally constructed of segmental precast concrete rings. These shaft tanks are sized to hold the additional spill volume from the worst case CSOs. This worst case spill volume is generated from the TSR event, which demonstrates the largest increase in spill volume between present and future conditions at each of the individual CSOs. Notably a worst case difference in spill does not occur during the same TSR event for all of the individual CSOs. Flows are returned to the sewer system, following the rainfall event, by pumped controls.

The resultant effect of providing storage to contain the increased spill volume for the worst-case TSR event is that the future total annual spill volume and annual total spill frequencies will be reduced from that predicted for the existing situation. This provides an environmental benefit, but increases the volume of sewage flows requiring treatment at Stevenston WwTW. There is no simple way to resolve this conflicting situation, without the introduction of complex real time control devices and telemetry. These have not been considered in detail during this study.

Where the required storage is below 25m³, it is considered that this could be achieved by providing attenuation and increased localised storage at the planned development. This would be a more economical solution than upsizing existing sewers or providing small volumes of storage at many CSO locations within the catchment. The development of CSO storage options has been undertaken as a desktop exercise, based on analysis of predicted flows in existing and future sewerage networks, with storage volumes validated by rerunning the future system model with the increased storage volumes.

Table 1 shows the storage required at each CSO in order to ensure that spill volumes are not increased, during individual TSR events when future planned developments are considered.

CSO Ref	CSO Name / Location	Storage requirement (m³)
1	West Kilbride TPS	1,949
2	Off Chapelton Road (Manhole Reference NS20476603)	1,763
3	27 Glenside Overflow (No1)	95
4	Summerlea Road	-
5	Seamill (New Mill Overflow)	-
6	Kilbride Bridge Overflow	-
7	Canal Place EO	19
8	Harbour Road No1 Pumping Station	181
9	The Pavilion Emergency Outfall	60
10	27 North Crescent Road	90
11	The Pavilion Emergency Outfall	2
12	Holm Plantation / Bute Terrace Overflow	2
13	Parkhouse Road	0
14	Saltcoats PS EO	811
15	West Area Moor Park Road East	183
16	55 Shore Road	2
17	Stevenston WwTW Overflow	-
18	7 Hayocks Road	0
19	Pumping Station EO (no longer modelled)	-
20	Braidwood Road No.1	68
21	Nethermains Road	35
22	Woodwynd	35
23	Bridge End Bannoch Burn Overflow	15
24	David Gage Street CSO	2
25	Waterside Overflow, 23 Waterside Road (Braidwood Road No. 2)	1
26	Dirrans PS	0
27	Longford Bridge CSO	-
28	Almswall Road PS EO	-
29	Nethermains Road N.2	0
30	West Area Putyan Overflow	23
31	7 Bridgend Overflow Chamber	1
32	2 Blair Road Overflow	0
33	21 Braehead Overflow	0
34	Holmes Road CSO*	-
35	Mains Road CSO	80
36	Westfield Sewer River Crossing	42
37	Hawthorn Crescent	19
38	Garnock Street (Townhead)	8
39	Down stream of Holmes Road CSO	-
40	Fudstone Pumping Station	-
41	11 Townhead Overflow	6
42	Main Road	15

Table 1: Storage Requirements To Maintain Performance of CSO Following Planned Developments.

The total storage volume required is 5,818m³. 14 CSOs require more than 25 m³ of storage ,12 CSOs require less than 25 m³ of storage and 15 of which require no storage at all. Of the 15 CSOs which do not require storage, 7 CSOs have been reported as requiring between 0 and 1 m³ of storage which would be considered to be outside the accuracy tolerances of the model.

CSOs requiring large (greater or equal to 500 m³) volumes of storage are:

West Kilbride TPS
Off Chapelton Road, West Kilbride (Manhole Reference NS20476603)
Saltcoats PS EO

**Careful consideration should be given to the solution developed at Holmes Road CSO. The current modelling representation shows this CSO to spill during dry weather flow. Therefore the allocation of off line storage will not work in modelling or practical terms as the off line storage tank will fill during DWF. The storage volume suggested is purely to maintain the existing situation irrelevant of DWF operation. Addressing CSOs that spill in DWF should be high priority SW regulatory drivers and it is presumed that this issue will be reviewed separately by SW. A more suitable solution would be to increase pass forward flows from the CSO so that it meets Formula A flows. The modelling of increased pass forward flows is considered in more detail in Section 5.2 of this report.*

5.1.2 Risk & Value Considerations

Opportunities may exist to increase pumping rates at West Kilbride, Ardrossan and Saltcoats Terminal Pumping Stations. This would reduce the volume of storage required at each location but would require modifications to pumping stations and rising mains, the extent of which is unknown and falls outside of the scope of this study. Increasing pumping rates in this way would also be likely to increase the peak load on Stevenston TPS / WwTW, the associated costs of which cannot be quantified with the information available.

In some instances the provision of storage at a CSO will reduce the frequency of spills at downstream CSOs. This could, in turn, reduce the amount of storage required to be provided in order to accommodate planned future development flows. Such detailed analysis has not been undertaken as part of this study as the resultant reduction in storage volumes is likely to be small and will have a negligible effect on the construction estimate. It is noted that all storage modelled as part of this optioneering process has been represented as off line.

5.1.3 Construction Estimate

The estimated cost of constructing storage tanks, of varying volumes as shown in Table 1 and on Plans 1 to 6 is £3.7m.

This estimate is based upon SW's Cost Schedule. Unit costs have been interpolated where information is not available. The estimate includes proposed shaft tank storage, associated pumping stations and limited, localised sewer improvements in order to accommodate the proposed improvements.

The estimate includes an allowance of 12% for utility apparatus diversions, due to the location of the proposed sewers within highways and for traffic management during the works.

The estimate does not include for costs associated with detailed feasibility studies, detailed design, contract administration or site supervision, SW operational support

costs, SW overheads or costs associated with any other investigative or exploratory work.

5.2 Option 2: Strategic Interceptor Sewer Option, Combined with Localised Storage & Wastewater Treatment

5.2.1 Option Consideration

The option of implementing large interceptor sewers to intercept the CSO spills has been considered. However, due to the spread in geographic locations of the affected CSOs which require additional storage, the large distance between catchments and the hydraulically independent nature of the system (due to the TPS's in parts of the catchment), no cost effective strategic solution could be determined along the lines of implementing a strategic interceptor sewer.

From the inspection of the major spill locations it is concluded that the only feasible solution would be to increase pass forward pump rates at the terminal pump stations. This would reduce the volume of storage required at each location but would require modifications to pumping stations and rising mains, the extent of which is unknown. Increasing pumping rates in this way would also be likely to increase the peak load on Stevenston TPS / WwTW. It is likely that the same amounts of total storage would be required at the downstream locations, though additional costs would be incurred transferring the flow downstream through PS and sewer upgrades.

5.2.2 Localised Option Proposal

As discussed within Section 5.1.1, Holmes Road CSO is modelled as spilling during dry weather flow and therefore is not suitable for the allocation of off line storage.

It is therefore proposed that the pass forward flow at Holmes Road CSO be increased to meet Formula A.

5.2.3 Construction Estimate

The estimated cost of constructing the sewer upgrade to the continuation pipe from Holmes Road CSO as shown on Plan 6 is £45k.

This estimate is based upon SW's Cost Schedule. Unit costs have been interpolated where information is not available. The estimate includes proposed localised sewer upsize and improvements.

The estimate includes an allowance of 12% for utility apparatus diversions, due to the location of the proposed sewers within highways and for traffic management during the works.

The estimate does not include for costs associated with detailed feasibility studies, detailed design, contract administration or site supervision, SW operational support costs, SW overheads or costs associated with any other investigative or exploratory work.

6. Conclusions & Recommendation

Future developments planned by 2011 would cause annual spill volumes at CSOs within the Stevenston catchment to increase by 6%. This report details the strategic storage option to limit the impact of planned developments on the performance of CSOs, based on Time Series Rainfall (TSR) events. The strategic option considered in this report addresses the impact of future developments only and does not address other sewerage deficiencies or other regulatory drivers.

Construction of storage tanks at individual CSOs limits the maximum spill volume at each CSO, during each TSR event to those volumes currently predicted for the existing system. Storage tanks are generally pumped back into the sewer system after storm flows have subsided; contributing additional flows to Stevenston WwTW. This option is robust, satisfies this study's objective to maintain current CSO performances, but causes the prolonging of treatment processes Stevenston WwTW. The high cost of the option could potentially be reduced by considering whether CSOs may be permitted to spill more, within their current consents.

The option of implementing large interceptor sewers to intercept the CSO spills has been considered. However, due to the spread in geographic locations of the affected CSOs which require additional storage, the large distance between catchments and the hydraulically independent nature of the system (due to the TPS's in parts of the catchment), no cost effective strategic solution could be determined along the lines of implementing a strategic interceptor sewer.

It is recommended that the individual CSO storage option cost of £3.7M be considered as the outline construction cost associated with accommodating planned future developments, to 2011, in the modelled sewerage network; to permit no deterioration in the performance of CSOs within the Stevenston catchment.

It should be recognised that it would be more cost-effective to consider planned developments alongside solutions to address other sewerage deficiencies within the Stevenston catchment, rather than in isolation. The cost of the strategic option presented in this report will reduce if the option is progressed in conjunction with other CSO improvement projects necessary to meet SW's regulatory requirements.