



**718 – North Mymms
North Mymms Metaldehyde Removal**

Mass Balance

28/08/2018

P018849-CA-520-0001

Rev. C

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Document control

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A	18/04/2018	For Comment	M Royle	B Hazard	R Hill
B	17/05/2018	For information	M Royle	B Hazard	R Hill
C	28/08/2018	For information	M Royle	B Hazard	N Marshall

When updating from a previous issue:

Changes from last issue are shown in **bold italics** with the Revision number of the change in the left hand column. At the next issue sections in bold italics will revert to normal text.

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Amendments

Rev.	Date	Description of Changes
B	11/05/2018	Lamella Thickener supernatant returns to match Veolia mass balance
B	11/05/2018	ActiSand Consumption to match Veolia mass balance
B	11/05/2018	PAC Min & Ave dose to match Veolia mass balance
B	11/05/2018	Actiflo recycle rate
B	11/05/2018	Actiflo sludge flow
B	11/05/2018	Lamella Thickener PACI dose
B	11/05/2018	Lamella Thickener Polyelectrolyte dose
B	11/05/2018	Polymer Carrier Water added to match Veolia mass balance
C	31/05/2018	Desludging time
C	31/05/2018	Sludge storage tank Size
C	10/07/2018	Centrifuge feed flow and run time
C	15/08/2018	PACL Storage


List of Holds

Rev.	Section	Description / Status

Refer to Master Holds list, document no: P018849-RG-120-0004 for status of Hold.

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Project Title:	North Mymms Metaldehyde Removal
Subject:	Process Calculation Sheet

Key: Input data	
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Output Summary: 1 Introduction 2 Raw water data 3 Actiflo Carb Chemical Dosing Calculations 4 Actiflo Carb Mass Balance 5 Lamella Thickener Chemical Dosing Calculations 6 Lamella Thickener Mass Balance 7 Centrifuge Chemical Dosing Calculations 8 Centrifuge Mass Balance 9 Whole Works Polyelectrolyte use 10 Whole Works Service Water use

Notes: This document is to be read in conjunction with P018849-DR-521-0001 - Process Flow Diagram
The minimum flow has not been confirmed, it is assumed that it will not be below 20% of the design flow

1 Introduction

The design is based around a single AS5 Actiflo Carb stream operating at 33.2m/h mirror velocity to treat the Tyttenhanger source flow only. The Roestock, Essendon, and North Mymms raw water flows will continue to be treated using the existing process streams already in place and are outside of the Trant scope of responsibility.

We have included within our design a single 100% duty lamella thickener to treat the sludge produced by the Actiflo AS5 Carb stream with the supernatant from the Lamella Thickener to be recycled to the Actiflo Carb inlet.

We have included within our design a single 100% duty centrifuge to treat the thickened sludge produced by the lamella thickener stream. It is proposed to discharge centrate to foul water sewer and collect the sludge cake in a skip for disposal.

2 Raw water data

Tyttenhanger Raw Water Data

	Ft	Minimum	Average	95%ile	Maximum
Flow (Ml/d)		9.09			
Metaldehyde (µg/l)	-	0.018	0.187	0.221	0.241
Total Pesticide (µg/l)		0.032	0.208	0.269	0.292
Turbidity (FTU)	1.5	0	0.40	1.06	11.30
Colour (mg/l Pt/Co)	0.08	1.00	1.15	1.92	2.90
Aluminium (total) (mg/l)	2.9	0.005	0.009	0.028	0.054
Iron (total) (mg/l)	1.9	0.015	0.018	0.031	0.048
Manganese (total) (mg/l)	1.62	0.003	0.005	0.007	0.009
Bromate as BrO3 (ug/l)		0.5	0.5	0.5	2.1
Nitrate as NO3 (mg/l)		16.8	20.5	22.6	24.3
Temperature (deg C)		8.1	11.71	14.02	15.3
pH Value	-	6.7	7.0	7.1	7.4
Alkalinity (mg/l as HCO3)		343	359	376	383
Hardness (mg/l as Ca)		146	160	173	185

Ft = Solids converter factor

Estimated Tyttenhanger Raw Water Solids

		Minimum	Average	95%ile	Maximum
Solids concentration (mg/l)	-	0.13	0.76	1.90	17.44
Load (kg/d)		1.16	6.92	17.26	158.57

Solids concentration (mg/l) =

$$\text{Turbidity} \times 1.5 + \text{Colour} \times 0.08 + \text{Aluminium} \times 2.9 + \text{Iron} \times 1.9 + \text{Manganese} \times 1.62$$

The raw water flow is as per invitation to tender document from Affinity Water, Schedule 1 - Description of the Works.

The raw water quality data has been evaluated from the North Mymms Sources WQ Data 2007 - 2016 spreadsheet provided by Affinity Water.

Lamella Thickener supernatant returns

	Minimum Case	Average Case	95%ile Case	Maximum Case
Supernatant flow (Ml/d)	0.09	0.09	0.08	0.07
Supernatant solids (mg/l)	15			
Supernatant load (kg/d)	1.372	1.333	1.211	1.105

Based on an expected lamella supernatant turbidity of ≤ 10NTU and assumed ratio TSS/NTU=1.5

Combined raw water and returns

	Minimum Case	Average Case	95%ile Case	Maximum Case
Flow (Ml/d)	9.18	9.18	9.17	9.16
Solids (mg/l)	0.28	0.90	2.01	17.42
Load (kg/d)	2.53	8.26	18.47	159.67

3 Actiflo Carb Chemical Dosing Calculations

	Minimum	Average	95%ile	Maximum
Actiflo Carb inflow (Ml/d)	9.18	9.18	9.17	9.16

Powdered Activated Carbon (PAC)		Minimum	Average	95%ile	Maximum
Dose (mg/l)		8	13	35	35
Dose (kg/d)		73	118	318	318
Service water (m3/h)	3 barg	2.55			
Silo storage (days)	31				
Bulk density (kg/m3)	250				
Silo capacity required (kg)	110%		4030		
Silo Volume required (m3)	110%		16.1		

PAC dose rate based on pilot trial results April to May 2015 under all tested conditions

Service water as per Veolia email 12/04/2018

Silo storage sized for 31 day capacity at average consumption plus 10%

Actisand		Minimum	Average	95%ile	Maximum
Consumption (g/m3 treated)		1	1.1	3	3
Maximum sand loss (kg/d)		9.09	10	27	27
Service water (m3/h)	3 barg	2.5			
Dosing time (min/d)		5	10	10	15
Daily Volume (m3/d)		0.21	0.42	0.42	0.63
Apparent density (kg/m3)	1300				
Daily sand volume (m3/d)		0.007	0.008	0.021	0.021
Assuming bag volume of (m3)	1				
Days per bag			130		

Actisand consumption as per PCA202 ACTIFLO CARB KEY DESIGN DATA from Veolia 20/04/17

Service water as per Veolia email 12/04/2018

Polyelectrolyte		Minimum	Average	95%ile	Maximum
Dose (mg/l)		0.16	0.25	0.5	0.5
Dose (kg/d)		1.45	2.27	4.55	4.55
Batch solution concentration	0.20%	Assuming specific gravity of the solution of 1			
Dosing capacity required (m3/d)		0.73	1.14	2.27	2.27
Dosing capacity required (l/h)		30	47	95	95
Polyacrylamide contains	0.02%	Acrylamide Monomer			
Acrylamide Monomer content (µg/l)		0.03	0.05	0.10	0.10

Polyelectrolyte Makeup

Preparation time required (hrs)	1
Preparation capacity required (m3)	0.09
Working volume required (hrs)	3
Storage tank capacity required (m3)	0.28

Poly dose rate based on pilot trial results April to May 2015 under all tested conditions

Polymer batch solution concentration recommended by Veolia 12/04/2018

Assuming the minimum retention time in the preparation tank shall be 60 minutes.

Assuming the storage tank is sized to store 3 hours working volume of polymer solution

Polymer motive water	Minimum	Average	95%ile	Maximum
Carrier water (l/h)	473			
Total polymer flow (l/h)	504	521	568	568
Total polymer flow (m3/d)	12.1	12.5	13.6	13.6

Carrier water to be > = 5 times the polymer flow

Total polymer flow based on Max. dosing capacity required

Polyaluminum Chloride (PACl)		Minimum	Average	95%ile	Maximum
Estimated dose (mg/l as Al)		0.04	0.08	0.16	1.0
Pilot plant dose (mg/l as Al)		1	1.5	3	4.2
Selected dose (mg/l as Al)		1	2	3	6
Precipitate (kg/d) as Al(OH)₃		26	53	79	158
PAX10 Al content	5%				
Density (at 20Deg C) g/cm3	1.21				
Dose as Commercial product (mg/l)		20.0	40.0	60.0	120.0
Dosing capacity required (kg/h)		7.58	15.15	22.73	45.45
Dosing capacity required (l/h)		6.26	12.52	18.78	37.56

Al dose estimated as follow: Al dose = (0.04*Colour + 0.08*Turbidity), Typical Al dose range for Actiflo Carb 1 to 3 mg/l as pure Al. Selected Al dose based on maximum between pilot plant results and estimated.

Kemira PAX10 selected coagulant as currently dosed on site.

Clarified water PACl		Minimum	Average	95%ile	Maximum
Dose (mg/l as Al)		0.02	0.08	0.2	0.2
Precipitate (kg/d) as Al(OH)₃		0.54	2.15	5.36	5.36
Dose as Commercial product (mg/l)		0.40	1.60	4.00	4.00
Dosing capacity required (l/h)		0.127	0.509	1.273	1.272

Downstream of the Actiflo Carb the clarified water will be dosed with PACl for improved filterability

PACl Storage

Bulk storage (days)	31
Storage Volume required (m3)	9.789

Based on 31 days storage at average consumption

Break tank working volume (l)	600	Minimum	Average	95%ile	Maximum
Coagulant storage time (hours)		93.0	45.6	29.5	15.3

4 Actiflo Carb Mass Balance

Actiflo Carb Feed	Minimum Case	Average Case	95%ile Case	Maximum Case
Total inlet flow to Actiflo Carb (MI/d)	9.255	9.253	9.246	9.240
Dosed water solids concentration (mg/l)	12	21	48	72
Load (kg/d)	112	191	448	668

Flow production for the Actiflo Carb		Expected
calculated recycle rate	(MI/d)	0.833
	(m3/h)	34.7
Selected recycle rate	(m3/h)	36.0
Service water to Hydrocyclone	(MI/d)	0.086
	(m3/h)	3.60
Total flow to Hydrocyclone	(MI/d)	0.950
	(m3/h)	39.6
Sand returns	(MI/d)	0.173
	(m3/h)	7.2
Flow to PAC extraction	(MI/d)	0.778
	(m3/h)	32.4
PAC returns	(MI/d)	0.685
	(m3/h)	28.5
Sludge wasted	(MI/d)	0.093
	(m3/h)	3.9

Recycle rate is 9% of total inlet flow

Service water feeding the hydrocyclone is 10% of selected recycle rate.

The rate that sand is returned to the Actiflo Carb is 20% of the selected recycle rate

The rate that sludge is removed from the system is 1% of the incoming flow

The remaining sludge and PAC is returned to the contact tank

Actiflo Waste Sludge	Minimum	Average	95%ile	Maximum
Sludge flow (MI/d)	0.09			
Sludge solids (mg/l)	1137	1994	4612	6918
Load (kg/d)	105	184	427	640

Actiflo Clarified water	Minimum Case	Average Case	95%ile Case	Maximum Case
Clarified water flow (MI/d)	9.25	9.25	9.24	9.23
Clarified water turbidity (NTU)	0.5	0.5	1.5	2
Clarified water solids (mg/l)	0.75	0.75	2.25	3
Load (kg/d)	6.9	6.9	20.8	27.7
Dosed clarified water flow (MI/d)	9.25	9.25	9.24	9.23
Load with Post Coagulation (kg/d)	7.5	9.1	26.2	33.1

Assumed Clarified water solids concentration considering a ratio TSS/NTU=1.5

5 Lamella Thickener Chemical Dosing Calculations

Coagulant is to be dosed immediately after the Actiflo Carb hydrocyclone discharge into the Lamella Thickener feed line. The blended Actiflo Carb sludge continues to the flocculation tank, where it is mixed with dosed polymer.

Lamella Thickener Feed	Minimum	Average	95%ile	Maximum
Sludge flow (Ml/d)	0.09			
Sludge flow (m3/h)	3.86			

PACI	Minimum	Average	95%ile	Maximum
Dose (mg/l as Al)	1	2	5	5
Precipitate (kg/d) as Al(OH)₃	0.27	0.54	1.34	1.34
Dose as Commercial product (mg/l)	20.00	40.00	100.00	100.00
Dosing capacity required (l/h)	0.06	0.13	0.32	0.32

The provision for coagulant dosing to the lamella thickener has been made as advised by Veolia. North Mymms WTW Proposal 26/01/18

Polyelectrolyte	Minimum	Average	95%ile	Maximum
Dose (mg/l)	0.5	0.8	1.0	1.0
Dose (kg/d)	0.05	0.07	0.09	0.09
Batch solution concentration	0.20%			
Dosing capacity required (m3/d)	0.02	0.04	0.05	0.05
Dosing capacity required (l/h)	1.0	1.5	1.9	1.9
Polyacrylamide contains	0.02% Acrylamide Monomer			
Acrylamide content (µg/l)	0.10	0.16	0.20	0.20

Multiflo polymer dose is based on Veolia experience in thickening similar sludges.

Selection of the polymer to be confirmed at commissioning, expected to be the same polymer as dosed into the Actiflo Carb flocculation tank.

Polymer batch solution concentration expected to be the same as the Actiflo Carb

Polyelectrolyte Makeup

Polymer preparation time required (hrs)	1
Polymer preparation capacity required (m3)	0.002
Working volume required (hrs)	3
Storage tank capacity required (m3)	0.01

Assuming the minimum retention time in the preparation tank shall be 60 minutes.

Assuming the storage tank is sized to store 3 hours working volume of polymer solution

Polymer motive water	Minimum	Average	95%ile	Maximum
Carrier water (l/h)	100			
Total polymer flow (l/h)	101	102	102	102
Total polymer flow (m3/d)	2.42	2.44	2.45	2.45

Carrier water to be > = 5 times the polymer flow

Total polymer flow based on Max. dosing capacity required

100 l/h assumed to be acceptable dilution

6 Lamella Thickener Mass Balance

Operational Days (d/week)	7
Operational Hours (h/d)	24

Lamella Feed	Minimum	Average	95%ile	Maximum
Lamella feed flow (m ³ /d)	95.0	95.0	95.0	95.0
Solids (mg/l)	1111	1949	4508	6754
Load (kg/d)	106	185	428	642

Lamella Supernatant	Minimum Case	Average Case	95%ile Case	Maximum Case
Supernatant flow (m ³ /d)	91.5	88.8	80.8	73.6
Supernatant turbidity (NTU)	10			
Supernatant solids (mg/l)	15			
Supernatant load (kg/d)	1.4	1.3	1.2	1.1

At times of high raw water solids, the supernatant return flow decreases due to greater volumes of water being lost with the dewatering process

Based on an expected lamella supernatant turbidity of ≤ 10 NTU

Expected performances on daily average composite samples met providing chemical conditioning is satisfactory.

Assumed supernatant solids concentration considering a ratio TSS/NTU=1.5

Thickened sludge	Minimum	Average	95%ile	Maximum
Thickened sludge flow (m ³ /d)	3.5	6.1	14.2	21.3
Thickened sludge solids (mg/l)	30000	30000	30000	30000
Thickened sludge load (kg/d)	104	184	427	640

Based on worse case sludge concentration of 3%DS. Range is between 3 and 4%

	Minimum	Average	95%ile	Maximum
Desludging time (min/hr)	2	5	10	10
Thickened sludge flow (m ³ /h)	4.34	3.06	3.56	5.34

Solids removal	Minimum	Average	95%ile	Maximum
Solids removal percentage	98.7%	99.3%	99.7%	99.8%

Sludge storage tank

Storage time (days)	4	
Tank volume (m ³)	110%	27.0

Sludge storage tank sized for 3 days storage at average conditions plus 10%

7 Centrifuge Chemical Dosing Calculations

Thickened sludge feed		Minimum	Average	95%ile	Maximum
Thickened sludge flow (m3/d)	7d/w	3.5	6.1	14.2	21.3
Thickened sludge flow (m3/wk)		24.3	42.9	99.6	149.4
Thickened sludge flow (m3/h)		4.0			
Centrifuge run time (h/d)		4.0	4.0	5.0	7.5
Centrifuge time in operation (d/wk)		1.5	2.7	5.0	5.0
Centrifuge feed flow (m3/d)		16.0	16.0	20.0	30.0

**Supplier advised a centrifuge feed flow range of 3.5 to 4.5m3/h. 4m3/h used as the basis
Assuming a minimum run time of 4 hours per day**

Polyelectrolyte		Minimum	Average	95%ile	Maximum
Dose (kg/TDS)		4	6	10	12
Dose (mg/l)		120.0	180.0	300.0	360.0
Dose (kg/d)	7d/w	0.4	1.1	4.3	7.7
Batch solution concentration		0.20%			
Dosing capacity required (m3/d)	7d/w	0.21	0.55	2.13	3.84
Actual daily dose required (m3/d)		0.96	1.44	3.00	5.40
Actual dose required (l/h)		240	360	600	720
Actual daily powder use (kg/d)		0.73	1.93	5.98	7.17

Polymer dose rate is to be confirmed. Supplier advised a dose between 4 and 12 kg per tonne of dry solids

Selection of the polymer to be confirmed at commissioning, expected to be the same polymer as dosed into the Actiflo Carb and lamella thickener.

Polymer batch solution concentration expected to be the same as the Actiflo Carb and lamella
Actual daily polymer dose based on 1.5 - 5 operational days per week

Polyelectrolyte Makeup

Preparation time required (hrs)	1
Preparation capacity required (m3)	0.72
Working volume required (hrs)	4
Storage tank capacity required (m3)	2.88

Assuming the minimum retention time in the preparation tank shall be 60 minutes.

Assuming the storage tank is sized to store 4 hours working volume of polymer solution

Polymer motive water	Minimum	Average	95%ile	Maximum
Carrier water (l/h)	0	0	0	0
Total polymer flow (l/h)	240	360	600	720
Total polymer flow (m3/d)	1.0	1.4	3.0	5.4

Carrier water to be confirmed (assumed no dilution required if made up at 0.2%)

8 Centrifuge Mass Balance

Dosed Thickened sludge

Dosed sludge flow (m3/d)	7d/w	3.68	6.68	16.37	25.19
Solids (mg/l)		28415	27688	26348	25729
Load (kg/d)	7d/w	105	185	431	648

		Centrifuge operating days per week			
		Minimum	Average	95%ile	Maximum
7	Days sludge dewatered in	1.5	2.7	5.0	5.0

Assuming a run time of 4 - 7.5 hours per day

Centrifuge Feed	Minimum	Average	95%ile	Maximum
Centrifuge feed flow (m3/d)	17.0	17.4	23.0	35.4
Centrifuge run time (h/d)	4.0	4.0	5.0	7.5
Centrifuge feed flow (m3/h)	4.2	4.4	4.6	4.7
Solids (mg/l)	28415	27688	26348	25729
Load (kg/d)	482	483	606	911

Centrate Waste	Minimum	Average	95%ile	Maximum
Centrate to sewer flow (m3/d)	14.8	15.3	20.3	31.4
Centrate to sewer flow (m3/h)	3.7	3.8	4.1	4.2
Centrate solids (mg/l)	975	946	894	871
Centrate load (kg/d)	14.46	14.49	18.18	27.32

Sludge Cake	Minimum	Average	95%ile	Maximum
Sludge cake flow (m3/d)	2.12	2.13	2.67	4.02
Sludge cake flow (m3/h)	0.5	0.5	0.5	0.5
Sludge cake solids (mg/l)	220000			
Sludge cake dry solids (%DS)	22			
Sludge cake load (kg/d)	467	468	588	883

Assuming 22%DS cake

Assuming solids removal of 97%

Skip Size	Minimum	Average	95%ile	Maximum
Skip volume (m3)	13.1			
Days Storage	6.2	6.2	4.9	3.3

17 yard Roll on roll off skip

Washwater Requirement

Washwater supply (m3/hr)	5
Shutdown wash duration (min)	15
Washwater volume (m3/d)	1.25

9 Whole Works Polyelectrolyte use

The whole works dose must average no more than 0.25 mg/l and never exceed 0.50 mg/l of the active polymer, including any polymer dosed as part of a proposed sludge treatment solution and recycled through the works in process returns. Polymer dosing to the centrifuge has been excluded from the whole works polymer dose calculation because no flow from the centrifuge returns to the works.

Actiflo Carb Feed	Minimum	Average	95%ile	Maximum
Flow (Ml/d)	9.2	9.2	9.2	9.2
Polymer dose rate (mg/l)	0.16	0.25	0.5	0.5
Polymer solids (kg/d)	1.45	2.27	4.55	4.55

North Mymms Clarifier (assumed values)	Minimum	Average	95%ile	Maximum
Flow (Ml/d)	9.09	9.09	9.09	9.09
Polymer dose rate (mg/l)	0.15	0.25	0.5	0.5
Polymer solids (kg/d)	1.36	2.27	4.55	4.55

Lamella Thickener	Minimum	Average	95%ile	Maximum
Flow (Ml/d)	0.09	0.09	0.09	0.09
Polymer dose rate (mg/l)	0.50	0.80	1.00	1.00
Polymer solids (kg/d)	0.05	0.07	0.09	0.09

Whole Works		Minimum	Average	95%ile	Maximum
Works Flow (Ml/d)		31.5	31.5	31.5	31.5
Polymer dose rate (mg/l)		0.09	0.15	0.29	0.29
Polymer solids (kg/d)		2.86	4.62	9.18	9.18
Acrylamide Monomer	0.02%	0.02	0.03	0.06	0.06

10 Whole Works Service Water use

	Minimum	Average	95%ile	Maximum
PAC Service water (m3/h)		2.55		
Actisand Service water (m3/h)		2.50		
Actiflo Polymer Service water (m3/h)	0.50	0.52	0.57	0.57
Hydrocyclone Service water (m3/h)		3.60		
Lamella Polymer Service water (m3/h)	0.10	0.10	0.10	0.10
Centrifuge polymer Service water (m3/h)	0.24	0.36	0.60	0.72
Centrifuge Service water (m3/h)		5		
Total (m3/h)	14.49	14.63	14.92	15.04