

## Cost functions for water treatment

Units

based on an average daily flow  $0.24 \cdot 10^6$  m<sup>3</sup>

### Polymer feeding [DADMAC]

ACC	2,759.61	\$/yr
USRT	140.00	kg/d
CCI	3.25	
UN	1.00	
G	1.00	s <sup>-1</sup>
a f	0.05	

### Polymer feeding

ACC	1,949.29	\$/yr
USRT	10.56	kg/d
CCI	3.25	
UN	1.00	
OM	4,065.06	\$/yr
PR	0.10	
PPI	1.45	
DHR	8.87	\$/hr
G	1.00	s <sup>-1</sup>
a f	0.05	

### Filtration super structure

ACC	243,849.54	\$/yr
Vf	28,224.00	m <sup>3</sup>
CCI	3.25	
a f	0.05	

### Filtration other structures

ACC	261,483.88	\$/yr
A	2,352.00	m <sup>2</sup>
CCI	3.25	
a f	0.05	

### Filtration gravel bed

ACC	2,456.91	\$/yr
A	2,352.00	m <sup>2</sup>
CCI	3.25	
a f	0.05	

### Filtration silica sand

ACC	11,134.39	\$/yr
Vm	1,411.20	m <sup>3</sup>
CCI	3.25	
a f	0.05	

### Filter structure

OM	184,177.76	\$/yr
A	2,352.00	m <sup>2</sup>
PR	0.10	
PPI	1.45	
DHR	8.87	\$/hr
720/tr	1.6	

**Backwash facility**

OM	77,876.01	\$/yr
A	2,352.00	m2
PR	0.10	
PPI	1.45	
DHR	8.87	\$/hr
720/tr	1.6	

**Surface wash facility**

OM	49,795.77	\$/yr
A	2,352.00	m2
PR	0.10	
DHR	8.87	\$/hr
720/tr	1.6	

**Costs of Chemicals**

OM	832,437	\$/yr
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**Clear water tank**

ACC	1,434,655.11	\$/yr
USRT	21,108,179.42	gallons
CCI	3.25	
UNTS	2.00	

**Lime feed-no recalcination**

ACC	14,255.87	\$/yr
USRT	277.04	lb/hr
CCI	3.25	
OM	15,529.42	\$/yr
PR	0.10	
PPI	1.45	
DHR	8.87	\$/hr

**Lime stock-powder**

ACC	9,112.11	\$/yr
USRT	277.04	lb/hr
CCI	3.25	
OM	5,191.15	\$/yr
PR	0.10	
PPI	1.45	
DHR	8.87	\$/hr

**Lime stock-slurry**

ACC	23,730.55	\$/yr
USRT	277.04	lb/hr
CCI	3.25	
UN	3.00	
OM	4,325.76	\$/yr
PR	0.10	
DHR	8.87	\$/hr

**Sodium hypochloride feed onsite storage**

ACC	33,110.75	\$/yr
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USRT	450.33 lb/day
CCI	3.25
UN	3.00
<b>OM</b>	<b>8,114.63</b> \$/yr
PPI	1.45
DHR	8.87 \$/hr

#### Alum feed liquid stock

<b>ACC</b>	<b>12,360.98</b> \$/yr
USRT	176.60 lb/hr
CCI	3.25
UN	2.00
<b>OM</b>	<b>3,676.78</b> \$/yr
PR	0.10
DHR	8.87 \$/hr

#### Ortho Phosporic Acid storage

<b>ACC</b>	<b>3,070.42</b> \$/yr
USRT	13.91 lb/hr
CCI	3.25
UN	2.00
<b>OM</b>	<b>1,468.97</b> \$/yr
PR	0.10
DHR	8.87 \$/hr

#### Sub totals

ACC	2,053,929.42 \$/yr
OM	1,186,658.56 \$/yr

<b>Total annual costs WaterTreatment</b>	<b>3,240,587.97</b> \$
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### Costs for sludge treatment

#### Polymer feeding

<b>ACC</b>	<b>2,230.91</b> \$/yr
USRT	28.80 kg/d
CCI	3.25
UN	1.00
<b>OM</b>	<b>4,288.36</b> \$/yr
PR	0.10
PPI	1.45
DHR	8.87 \$/hr
G	1.00 s <sup>-1</sup>
a f	0.05

#### Dewatered sludge hauling

<b>ACC</b>	<b>44,597.22</b> \$/yr
V	40,996.80 m <sup>3</sup> /yr
CCI	3.25
KM	100.00 km
a f	0.05
HPD	8.00 hr/day
<b>OM</b>	<b>588,654.47</b> \$/yr
PPI	1.45

DHR	8.87 \$/hr
DSL	1.28 \$/L

**Sub totals**

ACC	46,828.13 \$/yr
OM	592,942.83 \$/yr

<b>Total annual costs SludgeTreatment</b>	<b>639,770.96</b> \$
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**Other**

**Administration buildings and laboratory**

ACC	42,509.03 \$/yr
USRT	63.49 mgd
CCI	3.25
OM	134,438.44 \$/yr
PR	0.10
PPI	1.45
DHR	8.87 \$/hr

**Raw water pumping facility**

ACC	41,449.48 \$/yr
USRT	63.49 mgd
CCI	3.25
OM	378,600.15 \$/yr
PR	0.10
DHR	8.87 \$/hr
TDH	35.00 ft

**In plant pumping**

ACC	59,177.52 \$/yr
USRT	63.49 mgd
CCI	3.25
OM	222,772.40 \$/yr
PR	0.10
TDH	1.00 ft

**Finished water pumping facility**

ACC	41,243.58 \$/yr
USRT	63.49 mgd
CCI	3.25
OM	245,585.22 \$/yr
PR	0.10
DHR	8.87 \$/hr
TDH	0.00 ft

**Sub totals**

ACC	184,379.61 \$/yr
OM	981,396.22 \$/yr

<b>Total annual costs other</b>	<b>1,165,775.83</b> \$
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**TOTALS**

Total ACC	2,285,137.16 USD
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Total OM	2,760,997.60 USD
Total annual costs	<b>5,046,134.76</b> USD

**Reference**

Dharmappa *et al.* , 1994, p. 902

SW, 2009d

Dharmappa *et al.* , 1994, p. 907

Callaghan, 2010, interview

Vigneswaran, 2010, interview

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Dharmappa *et al.* , 1994, p. 907

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Vigneswaran, 2010, interview

Dharpamma *et al.* , 1992, p. 1309

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Dharpamma *et al.* , 1992, p. 1314

Vigneswaran, 2010, interview

Dharpamma *et al.* , 1992, p. 1309

Callaghan, 2010, interview

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Dharpamma *et al.* , 1992, p. 1310

Callaghan, 2010, interview

Vigneswaran, 2010, interview

ONS, 2010

HMRC, 2009

tr is assumed based on Dharmappa *et al.* , 1992, p. 1314

**1 Polymer feeding**

2 8758.868

3 0.1345

4 0.989

5 1

6 1

7 2101.845

8 0.0533

9 0.294

10 0.1037

11 0.537

12 1

13 1

14 25460

15 23.216

16 1

17 1

18 1

19 0.000001

20

A	Surface
a f	annualization factor
ACC	Annualized capital c
C f	fuel conversion effic
CCI	ENR construction c
DHR	hourly wage rate
DSL	cost of diesel fuel
ER	annual electrical en
G	velocity gradient
HPD	number of working t
KM	one-way hauling dis
LR	land requirement
OM	annual operating an
PPI	producer price inde
PR	cost of electricity
Q	feed flow rate
UN	number of units calc
UNTS	number of process t
USRT	volume of mixer/che
V	Volume of sludge
Vf	Volume of filter box
Vm	Volume of silica sa
tr	Filter run time in mir

Dharpamma *et al.*, 1992, p. 1310

Callaghan, 2010, interview

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tr is assumed based on Dharmappa *et al.*, 1992, p. 1314

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Clark, 1982, p. 824-826

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Clark, 1982, p. 824-829

Report, table 27 and Clark, 1982, p. 824-826

Dharpamma *et al.*, 1994, p. 907

Vigneswaran, 2010, interview

ONS, 2010

HMRC, 2009

Based on Alum feed dry stock

Report, table 27 and Clark, 1982, p. 824-826

Dharmappa *et al.*, 1994, p. 907

Vigneswaran, 2010, interview

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Based on Alum feed liquid stock

Report, table 27 and Clark, 1982, p. 824-826

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Based on chlorine feed onsite storage

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Dharmappa *et al.*, 1994, p. 907  
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Clark, 1982, p. 824-829

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Dharmappa *et al.*, 1994, p. 905

SW, 2009d  
Dharmappa *et al.*, 1994, p. 907  
Assumption  
Vigneswaran, 2010, interview  
Assumption

ABS, 2009



ONS, 2010  
HMRC, 2009

Clark, 1982

Clark, 1082  
Clark, 1982, p. 829

Vigneswaran, 2010, interview  
ONS, 2010  
HMRC, 2009

Clark, 1982

Based on average daily flow  
Clark, 1982, p. 829

Vigneswarean, 2010, interview  
HMRC, 2009  
Observation

Clark, 1982

Based on average daily flow  
Clark, 1982, p. 829

Vigneswaran, 2010, interview  
Observation

Clark, 1982

Based on average daily flow  
Clark, 1982, p. 829

Vigneswarean, 2010, interview  
HMRC, 2009  
Observation

1,493,553.70 £

1,804,573.60 £

3,298,127.29 £

Clear water tank USRT	Sodium hypochloride feed onsite storage [ACC] USRT
0.916	125.78
0.7334	0.5398
1.0199	0.998
1	1

costs  
 efficiency  
 cost index [1967 basis] divided by 100

energy requirement

hours per day  
 distance

total maintenance cost  
 x

calculated  
 units  
 chemical feed rate

total medium  
 routes









**Sodium hypochloride feed onsite storage [OM]**

USRT

430.25  
0.272

-

0.37  
0.521











**Lime feed, no recalcination [ACC]**  
USRT

1532.75  
0.188  
0.995

**Lime feed, no recalcination [OM]**  
USRT

867.4  
0.2255  
0.087  
0.084  
0.818











Potassium Permanganate feed [ACC]	Potassium Permanganate feed [OM]
USRT	USRT
412.35	300.93
0.139	0.178
0.998	0.0789
	0.038
	0.883









Alum feed liquid stock [ACC]	Alum feed liquid stock [OM]	Filter structure	Backwash facility
USRT	USRT	913.377	747.398
114.16	1254.53	0.546	0.65
0.548	0.361	0.147	0.543
0.981	0.585	0.183	0.219
1		0.613	0.137
	0.254	0	1











<b>Surface wash facility</b>	<b>Administration building and Lab [ACC]</b>	
204.732	USRT	
0.7146		1674.24
0.526		0.4926
		1.0093
0.315		
1		











<b>Administration building and Lab [OM]</b>		<b>Alum feed dry stock [ACC]</b>
USRT		USRT
	9884.6	70.55
	0.367	0.656
	0.1836	0.994
	0.114	
	0.672	









Alum feed dry stock [OM] USRT	Raw water pumping facility [ACC] USRT	Raw water pumping facility [OM] USRT
13.11	305.36	27815.7
0.849	0.858	0.946
0.1847	0.999	0.868
0.0259		
0.743	1.00492	0.068
		1.015383











In plant pumping [ACC]	In plant pumping [OM]	Finished water pumping facility [ACC]
USRT	USRT	USRT
537.98	49857.7	300.73
0.851	0.812	0.903
0.991	0.821	0.995
		1.00263
	1.017	









**Finished water pumping facility [OM]**

USRT

31646.8

0.955

0.887

0.0583

1.004986