Commercialization of Greywater Recycling

Environmental Management Division

Consultant
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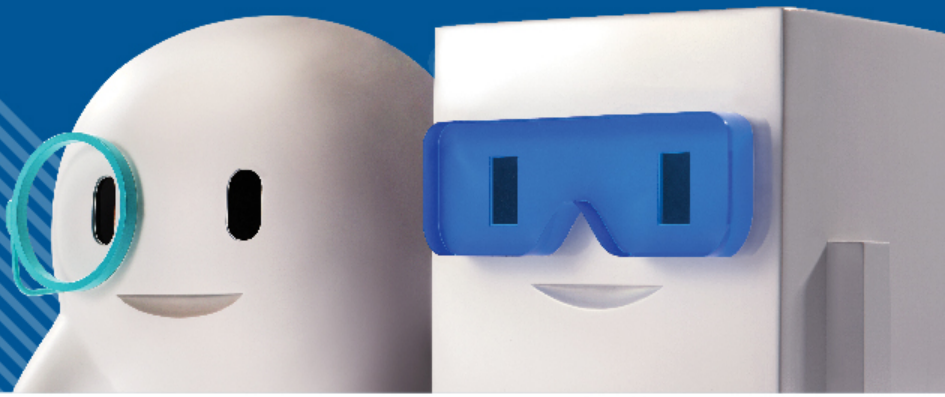
18th March 2019



All-round Productivity Partner
全方位企業伙伴

Introduction

June 1963 - May 1964

Severe Water Rationing - 4 hours of supply every 4 days

Introduction

- To prepare for the declining rainfall due to climate change and the rapidly increasing water demand in the Pearl River Delta region, the Government has formulated a Total Water Management (TWM) strategy.

降雨減6成 料明春續大旱

粵又鬧水荒 港商急應變

油荒之後，廣東省可能又要面對另一場荒——「水荒」。廣東省水文局指出，廣東省10月份平均雨量，僅是近年同期平均總量的4成，省內4大江河流域的水流量也明顯減少，直到明年春天，省內的水資源供應將呈緊張。 ■本報記者 陳子凌

有珠三角港商表示，今年的供水情況比上年更差，無論是生活用水還是工業用水，都要另想辦法解決。

廣東省水文局表示，省內本年10月的降雨量僅得31毫米，比多年來同期的平均量減少了6成，當中，主要供應珠三角及香港用水的東江流域，10月份降雨量只有16.1毫米，比去年同期的57.8毫米驟減7成多，當局預計，今年冬季至明年春季的水資源形勢，不容樂觀。

東江水庫存量 減三分一

事實上，廣東雨量明顯減少，區內江河水流量也相應明顯降低。據了解，目前全省32座大型水庫的蓄水量為127億立方米，而東江水庫只有40億立方米，比去年同期減少逾20億立方米。水利專家預計，由於11月全省降雨量仍會偏少，水資源供應將持續吃緊。

於東莞設廠的香港中小型企業聯合會會長余繼標表示，雖然目前珠三角地區仍未向工廠實施制水，但供水情況已經比去年較差，而且水質亦惡劣，「聽說隨知會停水，但近期供水經常斷斷續續，水力亦很弱，而且流出來的水都是黃泥色，明顯是未有足夠過濾。」余繼標道。

余繼標又指出，為預防供水緊張，部分珠三角港商只有從開源及節流兩方面去應對，開源方面，如果工廠靠近山區，便派人到山上取山水使用，又或者掘井取地下水，「不過政府規定不能私自掘井，所以工廠只會偷偷摸摸進行。」余繼標續。

港商外市買水 廢水循環

另外，亦有港商選擇在工廠天台加建水缸，趁仍有水供應時先行儲存更多用水，亦有港商索性直接從屈臣或河源買水，據余繼標指，建一車水的費用要幾千元人民幣。

節流方面，一些港商則採取「廢水循環再用」的辦法來節約用水，雖然要為此興建百多萬元人民幣一個的環保過濾水池，用來過濾污水，但能夠節省用水之餘，亦會應政府要求來環保，不失是個辦法。

HKPC

Total Water Management

- Water Demand Management
  - To enhance public education on water conservation
  - To promote use of water saving devices
  - To enhance water leak control
  - To extend use of seawater for toilet flushing

- Water Supply Management
  - To strengthen protection of water resources
  - To actively consider water reclamation (including reuse of greywater and rainwater harvesting)
  - To develop the option of seawater desalination

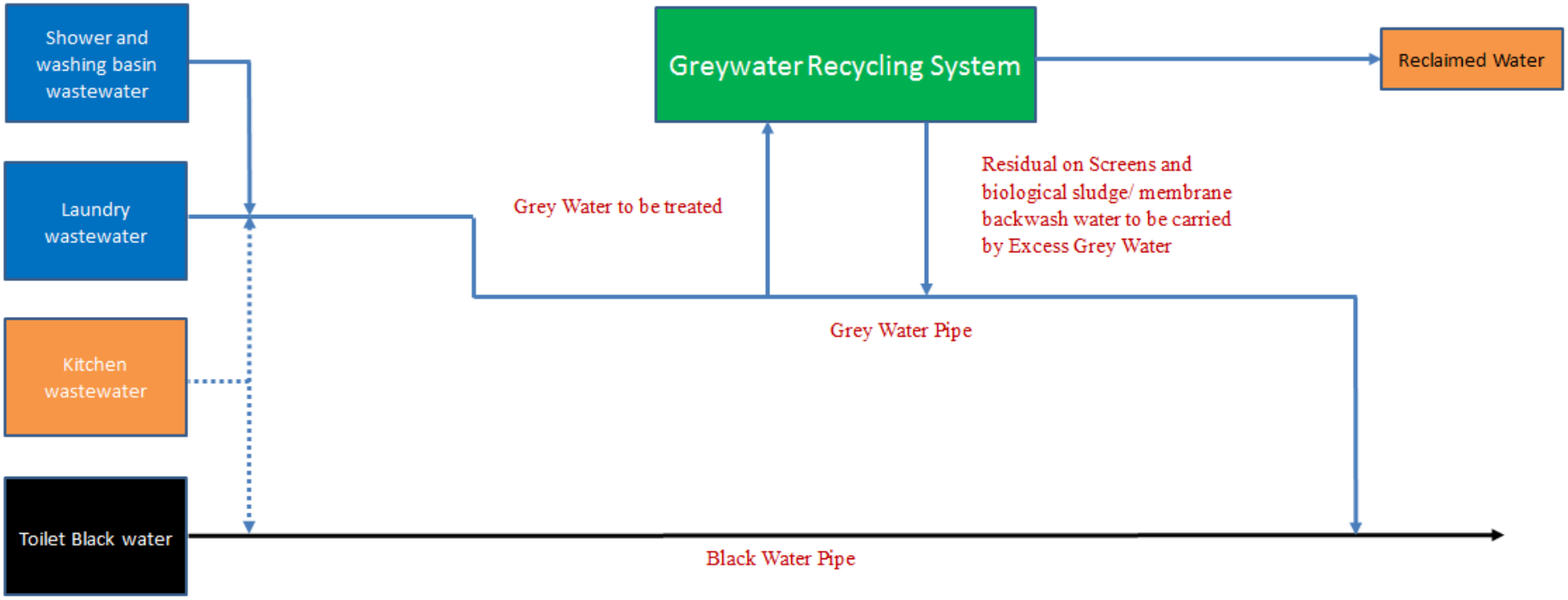

Greywater provides a
constant source of water for reuse

Greywater

- Domestic wastewater excluding wastewater from toilet or urinal (blackwater - feces, urine and flushing water)

- Wastewater from
  - Showers, baths, washing basins
  - Clothes washing/laundry
  - Kitchens

Greywater Mining



Potential Applications – Unrestricted Non-potable Reuse

Toilet Flushing (for the remaining 20% areas without seawater flushing)

Irrigation for Plants & Green Roof

Makeup Water for Cooling Tower

General Cleaning (Car Washing & Street Cleaning)

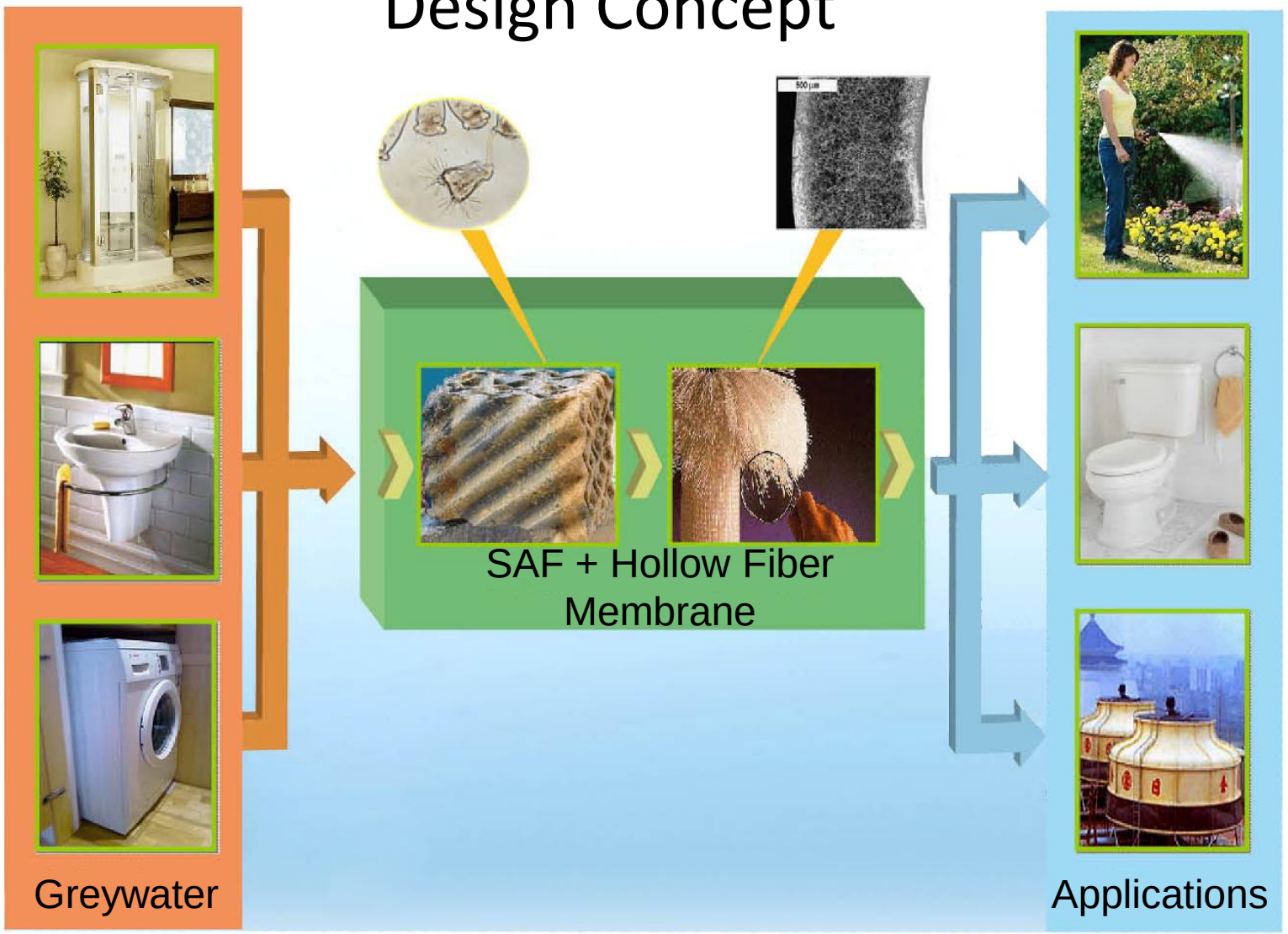
Water Features

Fire Fighting

HKPC

HKPC's patented greywater recycling system

Design Concept



Treatment Process

Submerged Aerated Filter (SAF)

- Media are installed for the attached growth of micro-organisms
- Can hold a large amount of biomass and have a much higher treatment efficiency

Micro-filtration (MF)

- Hollow fibre membranes of pore size 0.1-0.4 μm to separate clean water from the SAF effluent
- No sedimentation tank, so reducing the space required
- The treated water is crystal-clear, free of germs and odour
- Membrane can be automatically backwashed

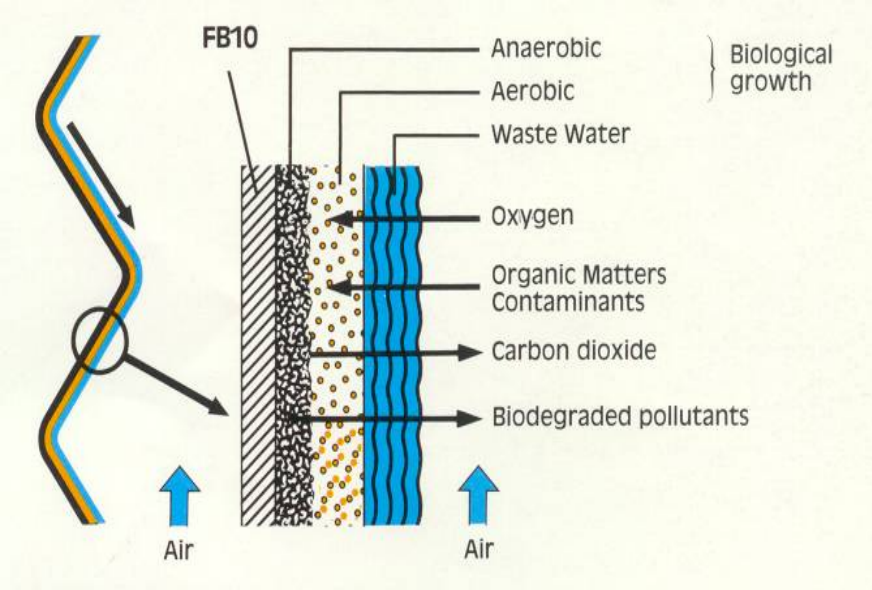
Submerged Aerated Filter (SAF)

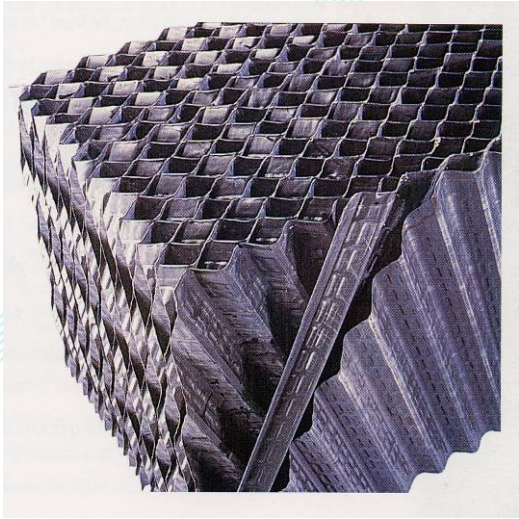
Packing Media

- PVC 60^{o} cross-fluted media with large specific surface area up to 240 m^2/m^3
- Large voidage of >97%

Process Microbiology

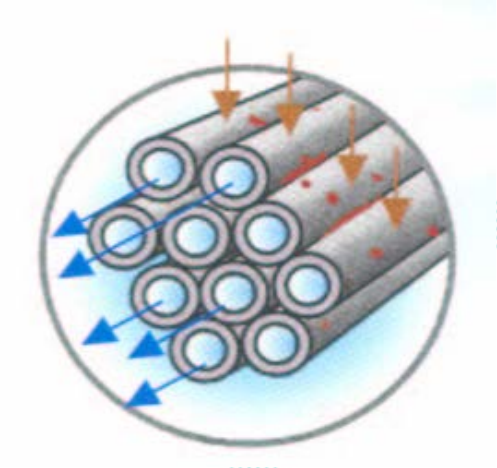
- Micro-organisms grow and develop on the surface of media (biofilm)
- Decomposition of organic takes place in biofilm
- As the biofilm grows thicker, it will slough off from the media
- MLSS is much lower than that of activated sludge (~100 mg/L)

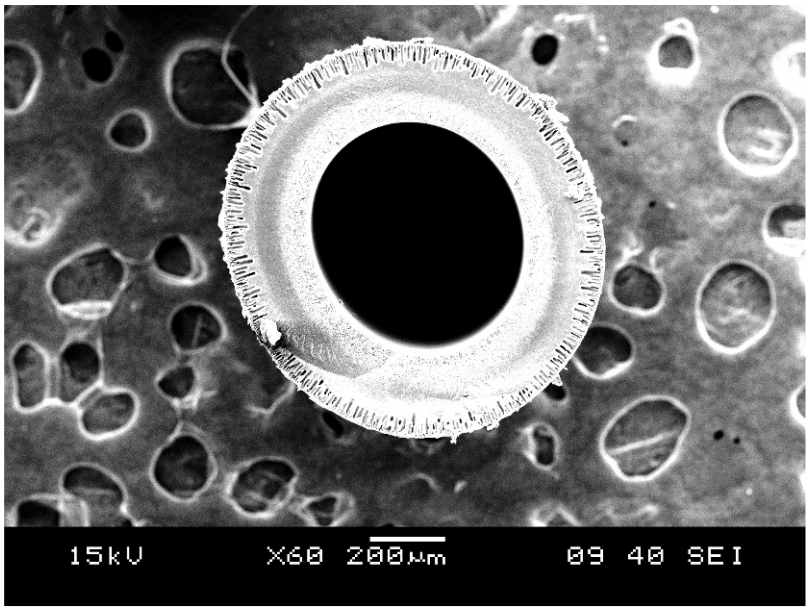


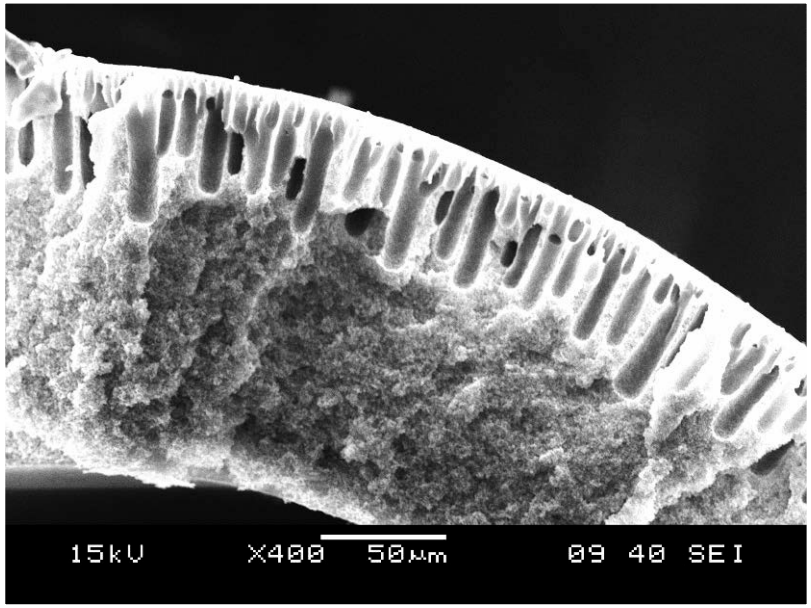


Microfiltration (MF)

- Typical fibre diameter ~1.0 mm
- Pore size 0.1–0.4 μm (smaller than bacteria)
- Water flow is outside-in
- Cross-flow filtration to suppress membrane fouling
- Auto-backwash and air scouring for membrane cleaning







Treatment Process

Disinfection

- To maintain a residual chlorine level to prevent re-growth of bacteria in pipes, a certain amount of chlorine disinfectant is dosed

The whole treatment process has been patented

- HK Short Term Patent No.: HK1095980

Case references in Hong Kong and Mainland

70 m^3/day
City University of Hong Kong
(First installation in HK, 2009)

12 m^3/day
URA Redevelopment

1 m^3/day
Office building in HK

1 m^3/day
Office building in HK

30 m^3/day
Collaborated with
深圳建築科學研究院
To build a demo plant in Shanghai

50 m^3/day
Public Estate in Tuen Mun
(First installation for housing estate in HK)

HKPC

Greywater Recycling System in CityU

Start Operation: September 2009

Designed Treatment Capacity: 7 m^3/hr

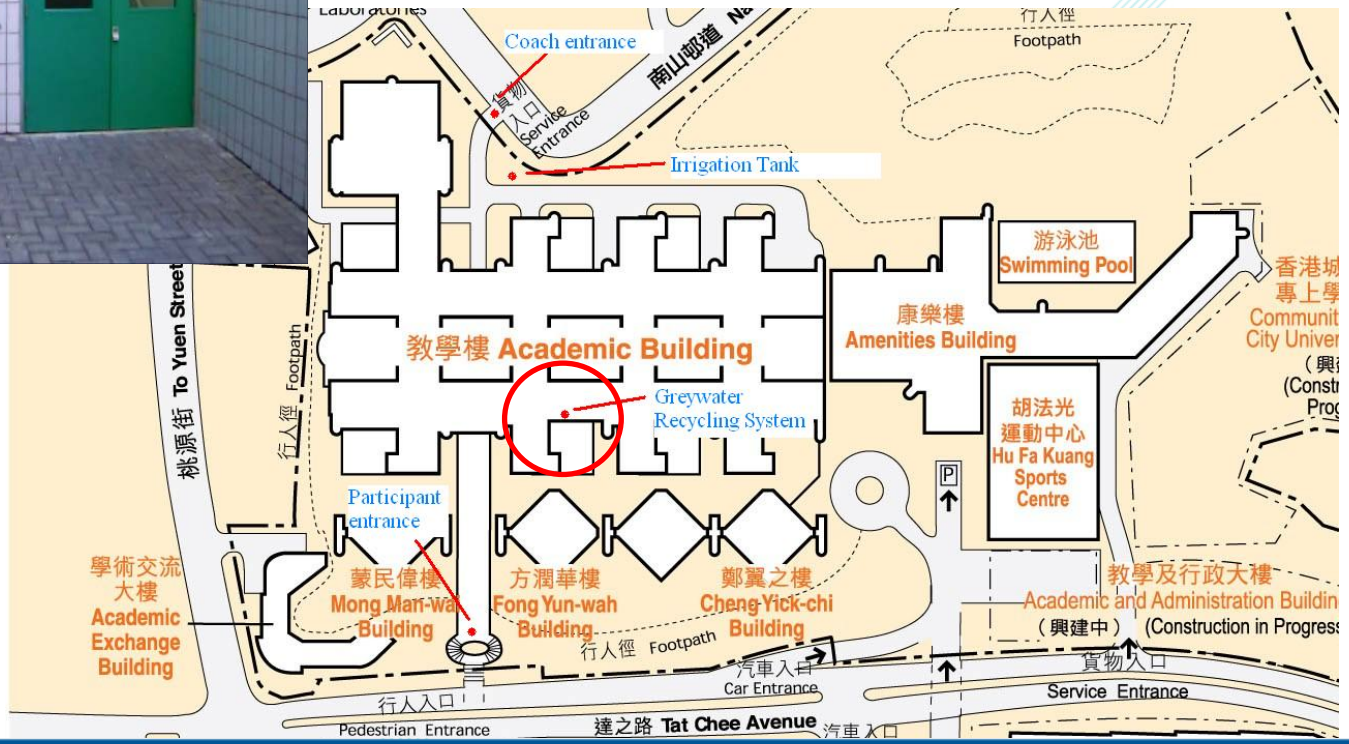
Aim: Reduction of the use of city water for irrigation so as to achieve water conservation

Sources:

i) Washing basins in about 60 toilets

ii) Condensate from central air handling unit (AHU)

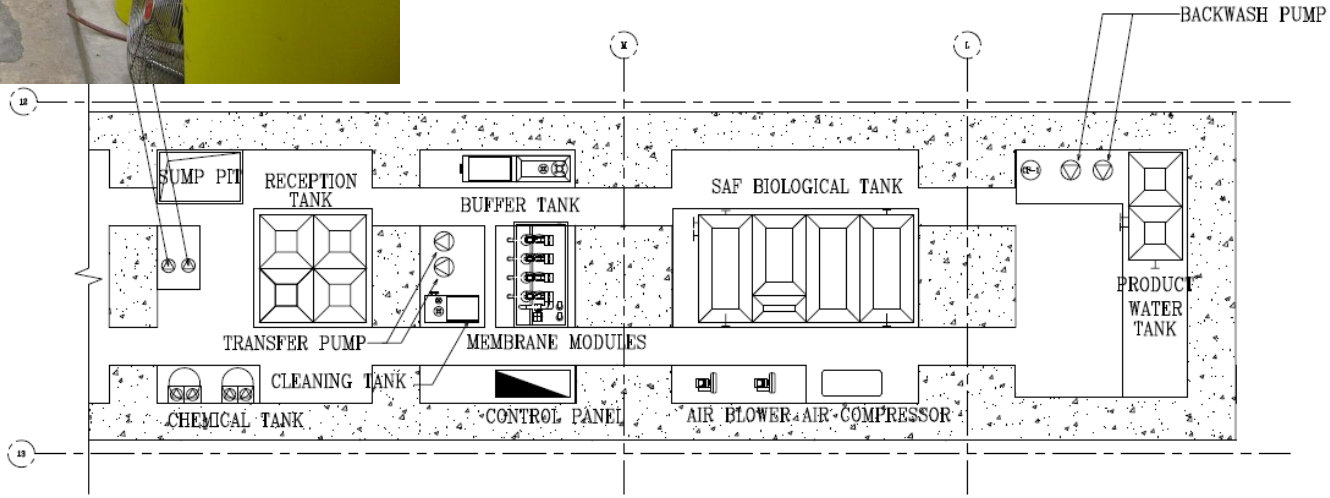
Location of the Plant



Plant Layout

Plant room:

- 15 m x 4.7 m
  (58 m^2 effective floor area)
  separated into 4 compartments
- 2.3 m headroom



System Outlook

Reception/Biological Tanks

Membrane Filtration Unit

Reclaimed Water Quality

Parameter	Water Quality	HK Technical Specifications
pH	6.4–8.2	6 ~9
Colour (Hazen unit)	<5	≤20
Odour (Odour unit)	--	≤100
Turbidity (NTU)	<0.1–0.3	≤5
Conductivity (μS/cm)	67–410	--
Biochemical oxygen demand (BOD_5)/(mg/L)	<3–8	≤10
Chemical oxygen demand (mg/L）	<5–29	--
Ammonia nitrogen (mg/L)	<0.05–0.2	≤1
Anionic Surfactant (mg/L)	0.1–0.3	--
Suspended solids（mg/L)	<5	≤5
E. Coli (cfu/100 mL)	<1	<1
Total residual chlorine (mg/L)	System outlet 1.0–1.8	System outlet≥1.0，End of pipe≥0.2

Performance

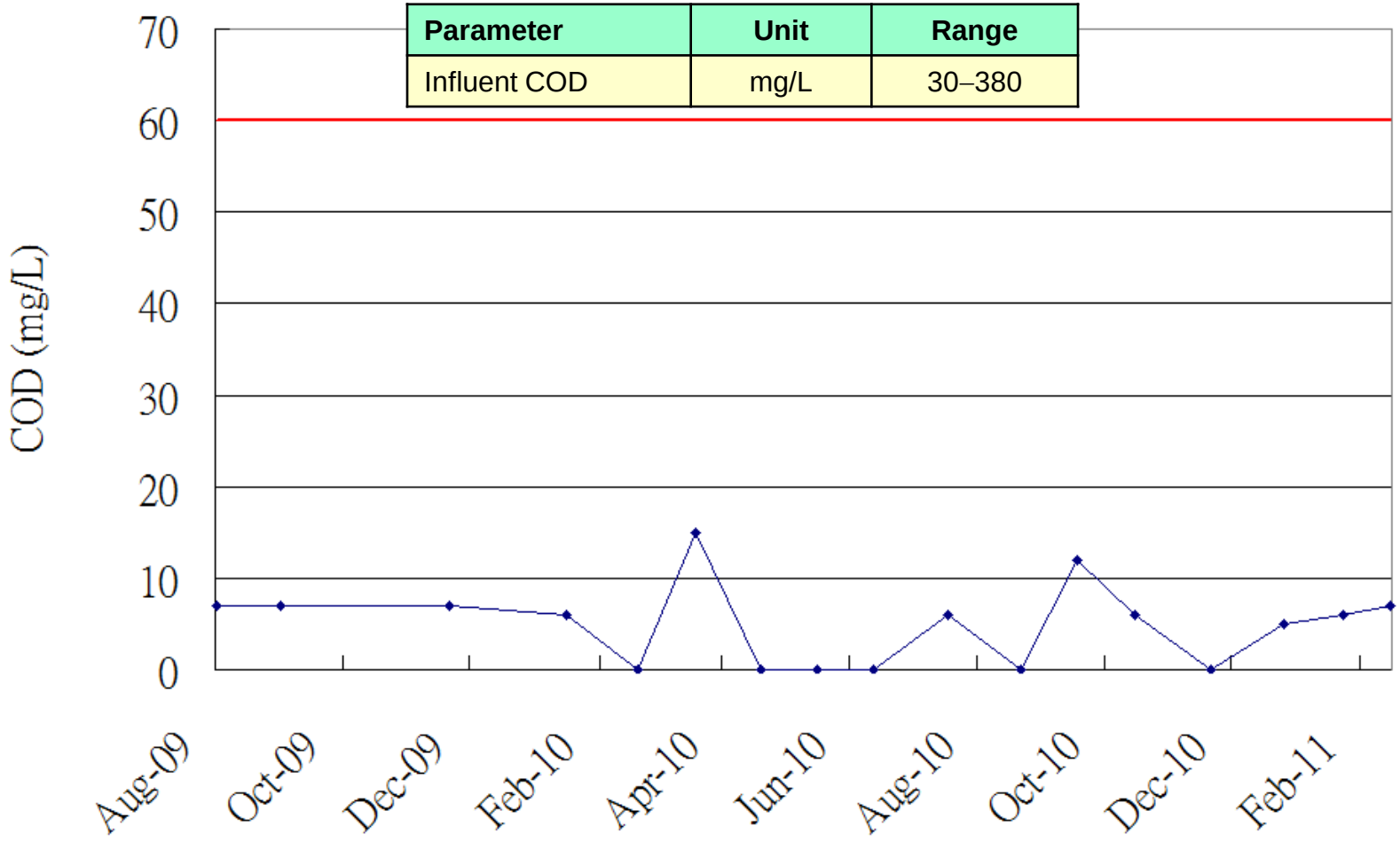
Membrane Product Water

Membrane Feed Water

Reclaimed Water Quality

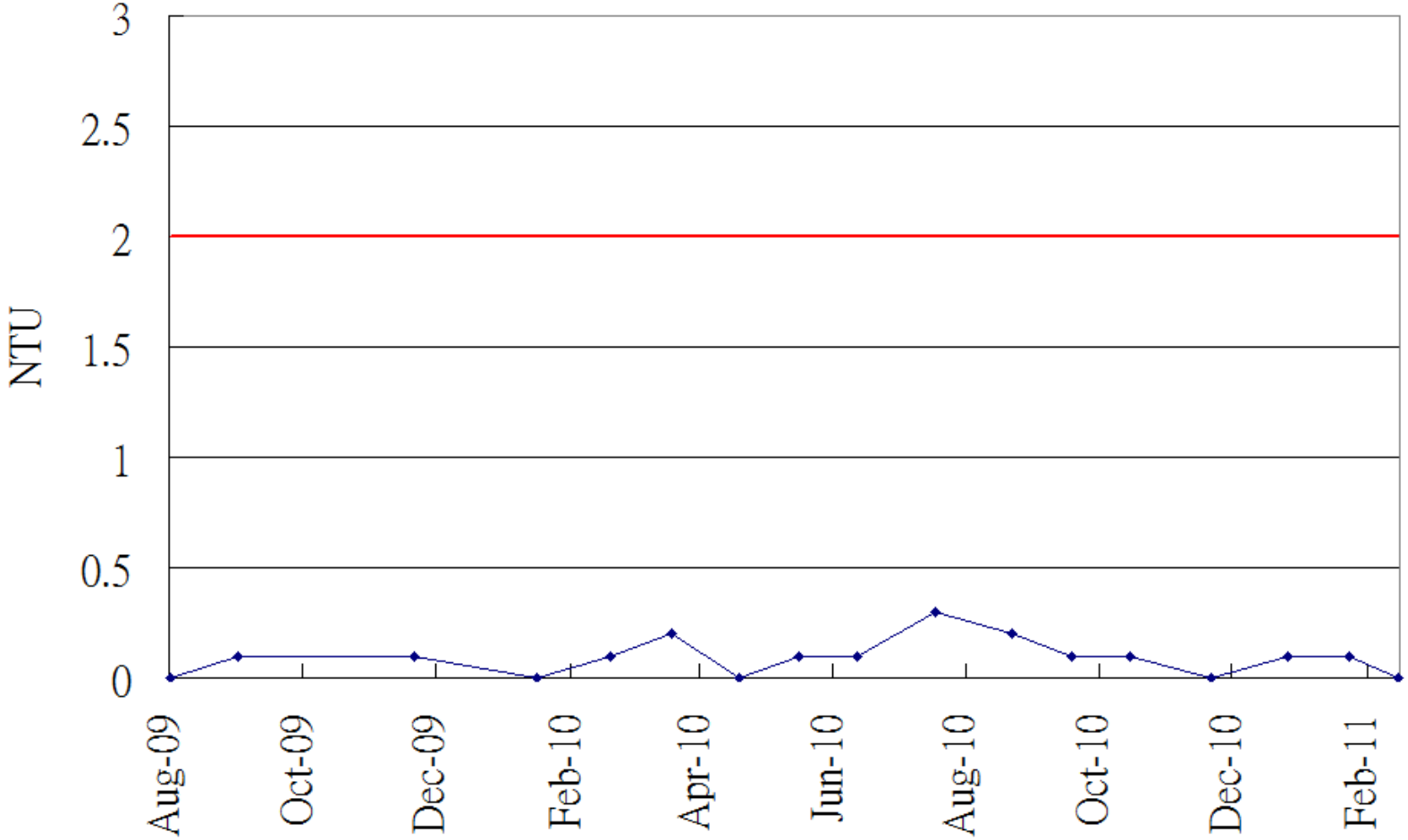
COD of Reclaimed Water

Parameter	Unit	Range
Influent COD	mg/L	30–380



Reclaimed Water Quality

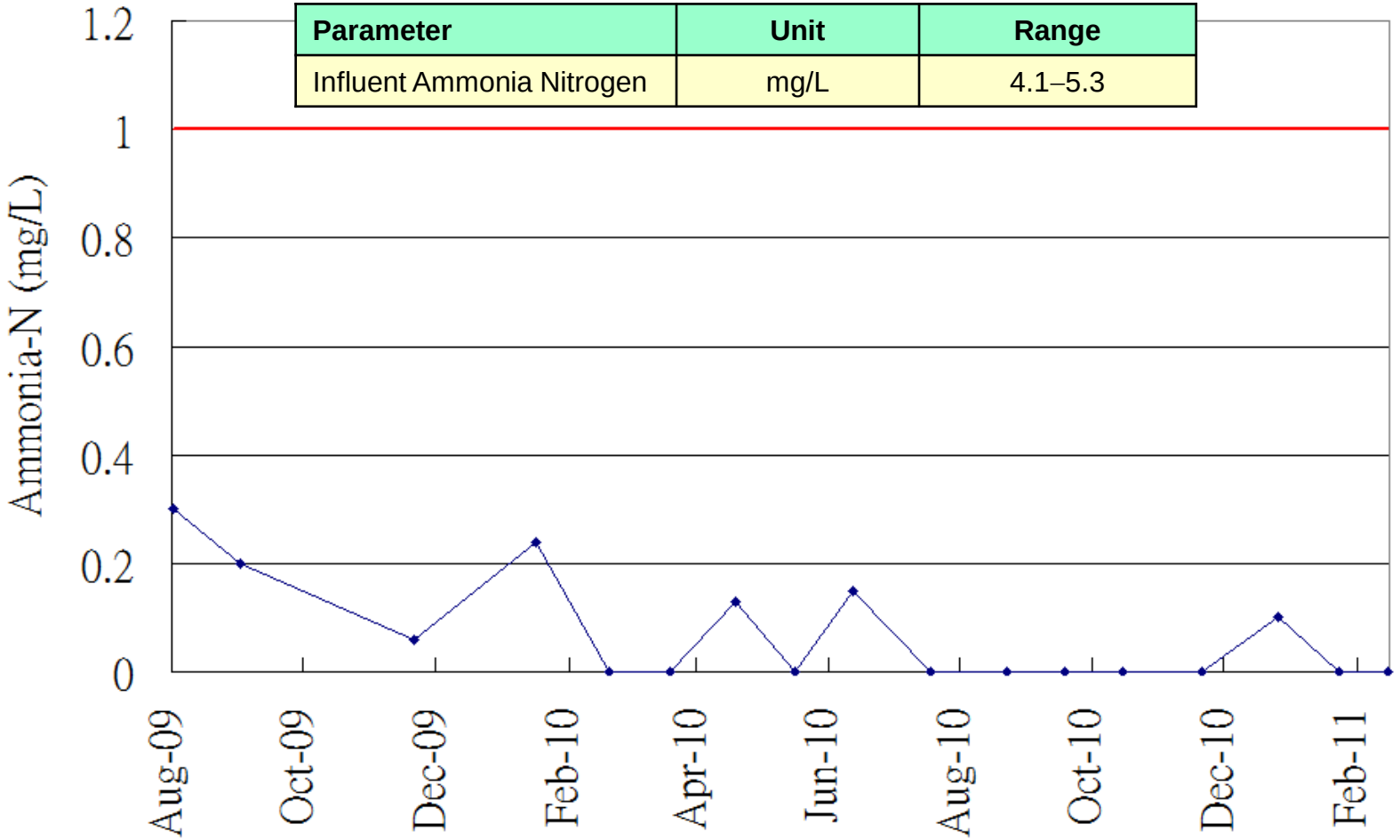
Turbidity of Reclaimed Water



Reclaimed Water Quality

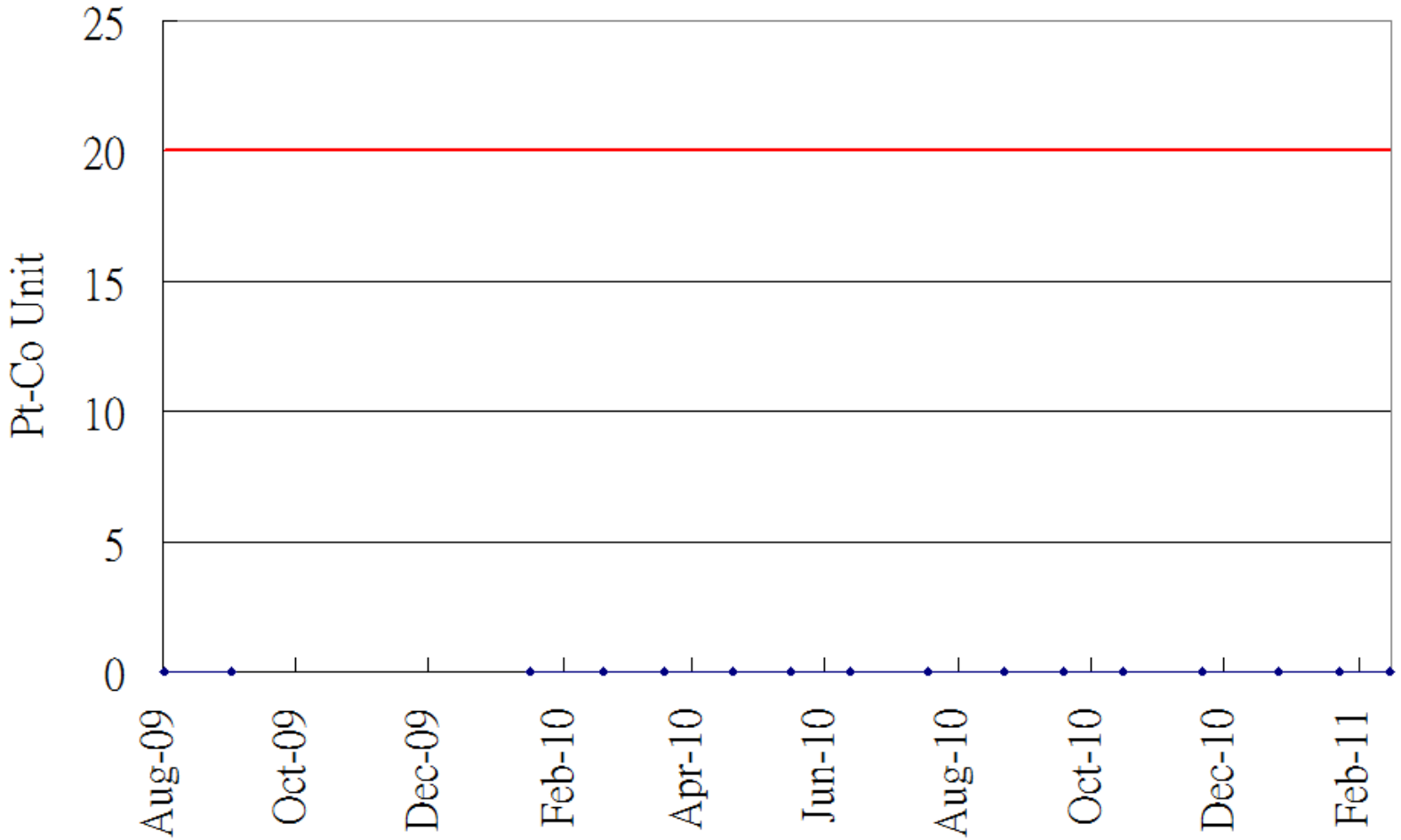
Ammonia Nitrogen of Reclaimed Water

Parameter	Unit	Range
Influent Ammonia Nitrogen	mg/L	4.1–5.3



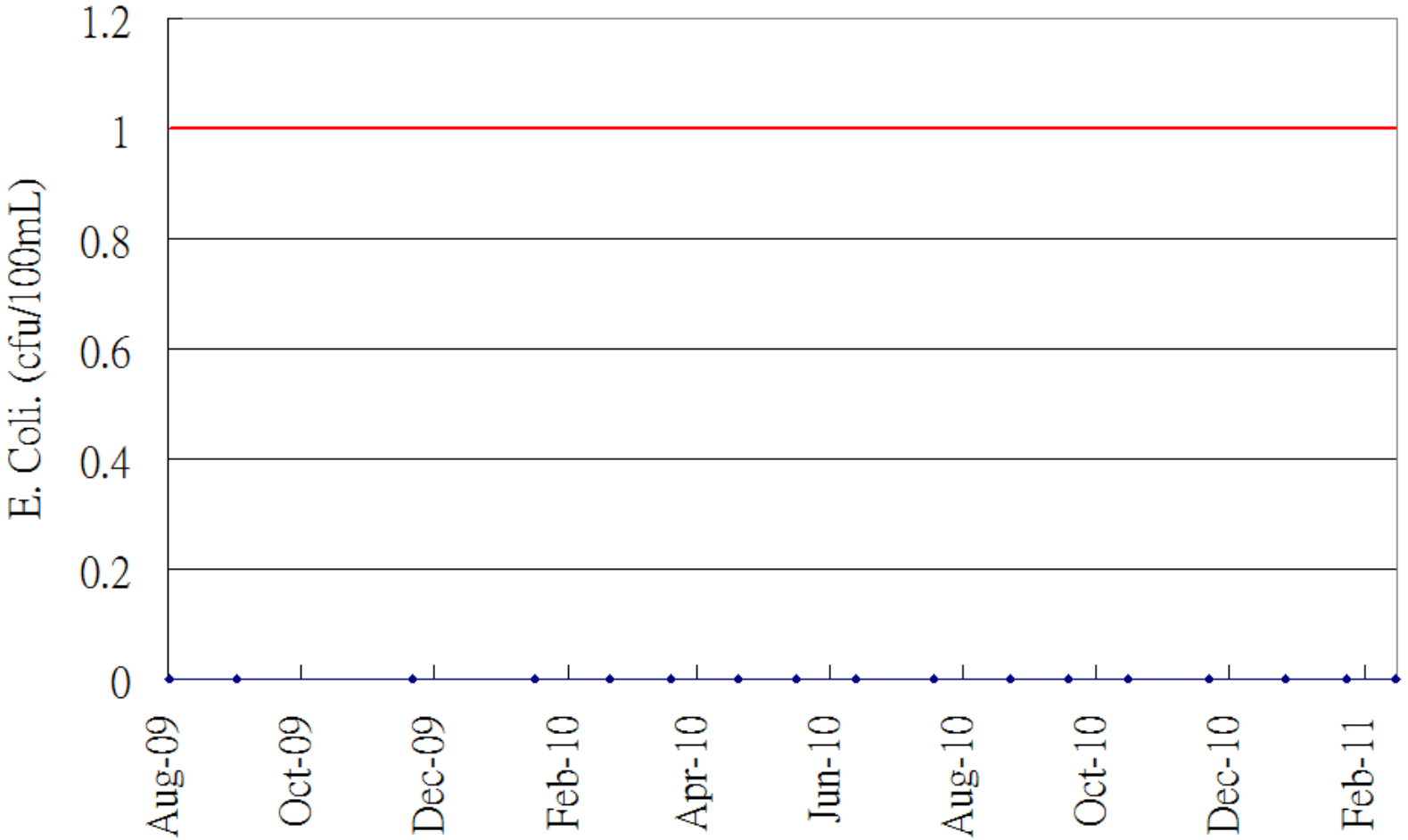
Reclaimed Water Quality

Colour of Reclaimed Water



Reclaimed Water Quality

***E.Coli* of Reclaimed Water**



Running Cost

Source	Cost (HK$ per m^3)
Electricity cost	~1.2
Chemical cost	~0.2
Consumables and membrane replacement	~0.45
Reclaimed water from greywater recycling (Tuen Mun Project)	~ HK$ 1.85

Money saving from greywater recycling = HK$ (4.58+2.92–1.85)

(with effect from 1st April 2017) = HK$ 5.65 /m^3 reclaimed water

Reference costs from local installations

Project	Capacity (m^3/day)	Capital Cost (HK$)	Recurrent Cost (HK$/month)
City University of Hong Kong	70	$0.9 Million	$3 k
EMSD Headquarters	30	$1 Million	-
TKO Area 86	440	$6.7 Million	$20 k

Major Constraints of Greywater Recycling in HK

- Space constraint
  - Conventional/off-the-self systems would not be compact and flexible enough to fit into the congested space
- Operation requirement
  - Need simple and forgiving operation to minimize operator attendance
- Reclaimed water quality for hygiene concerns
  - Need sophisticated treatment processes to provide safe reclaimed water complying to Technical Specifications
- Economic viability
  - Need reduced capital investment to encourage greywater recycling
  - Need to minimize operating cost to achieve net money saving

Greywater Recycling System in CityU

CityU system has demonstrated that:

- Very little space required
  - System is very compact and flexible, and can be fit into a 58 m^2 basement plant room
- Minimal operation & maintenance
  - Consistently superior reclaimed water quality with little operator attendance for over 5 years
- Relatively low capital investment
  - System cost : less than HK$1 million
- Operation cost
  - ~HK$1.5/$m^3$ resulting in a net money saving of HK$6/$m^3$

Greywater Recycling System in Tuen Mun

Start Operation: November 2018

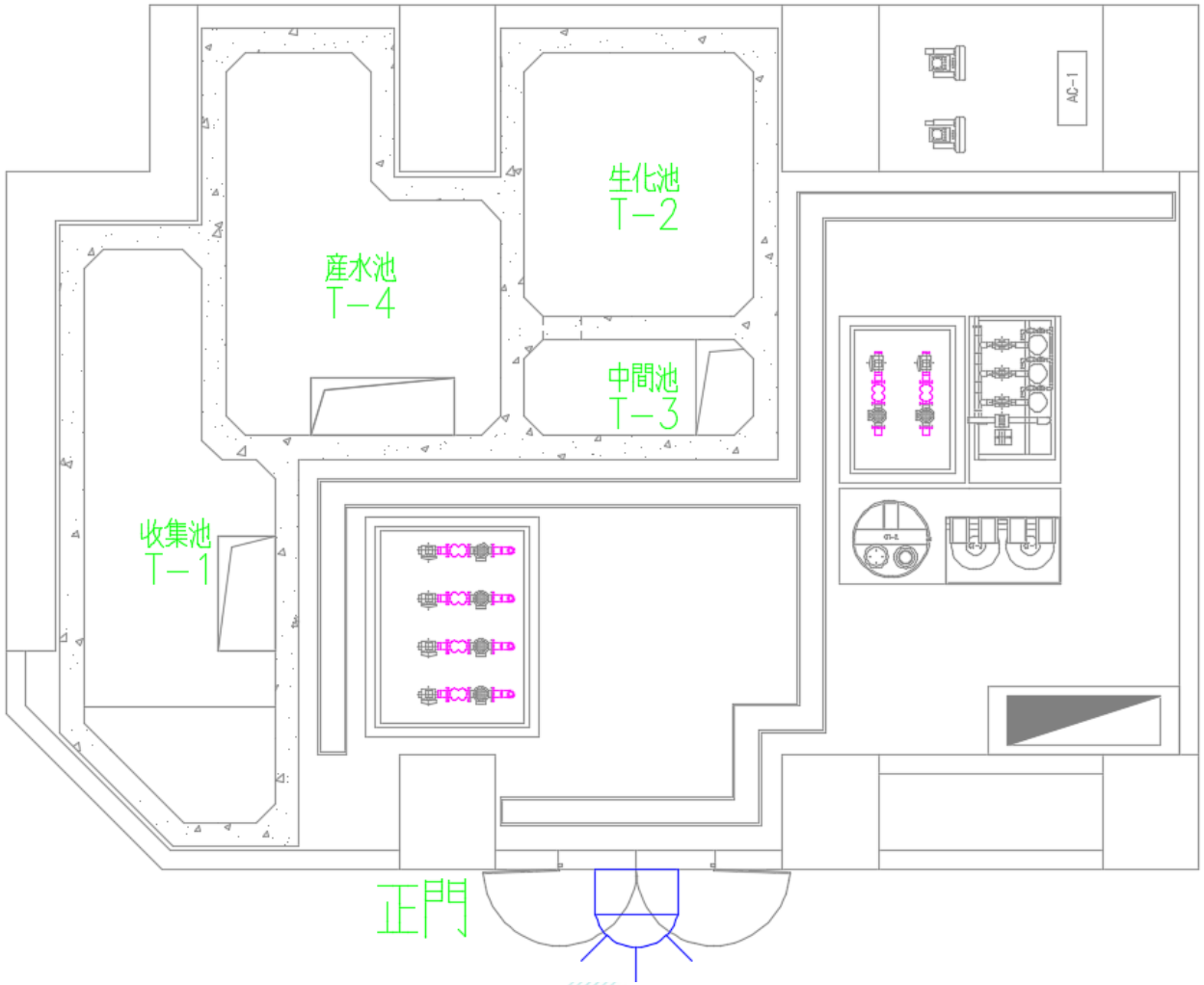
Designed Treatment Capacity: 5 m3/hr

Aim: Reduction of the use of city water for irrigation so as to achieve water conservation

Sources:

Shower trays, water basins of tenants' toilets, floor drain of tenants and washing machine

Greywater Recycling System in Tuen Mun



Reclaimed Water Quality

Parameter	Water Quality	HK Technical Specifications
pH	6.9–7.1	6 ~9
Colour (Hazen unit)	<5	≤20
Odour (Odour unit)	--	≤100
Turbidity (NTU)	<0.4–0.5	≤5
Biochemical oxygen demand (BOD5)/(mg/L)	<5	≤10
Ammonia nitrogen (mg/L)	<0.05-0.2	≤1
Suspended solids（mg/L)	<5	≤5
E. Coli (cfu/100 mL)	<1	≤1
Total residual chlorine (mg/L)	System outlet 1.0~1.8	System outlet≥1.0，End of pipe≥0.2
Threshold Odour Number	<1	≤ 100
Legionella Bacteria Count	<10	≤ 10 (cfu/ml)
Heterotrophic Colony Count	<1	≤ 100,000 (cfu/ml)

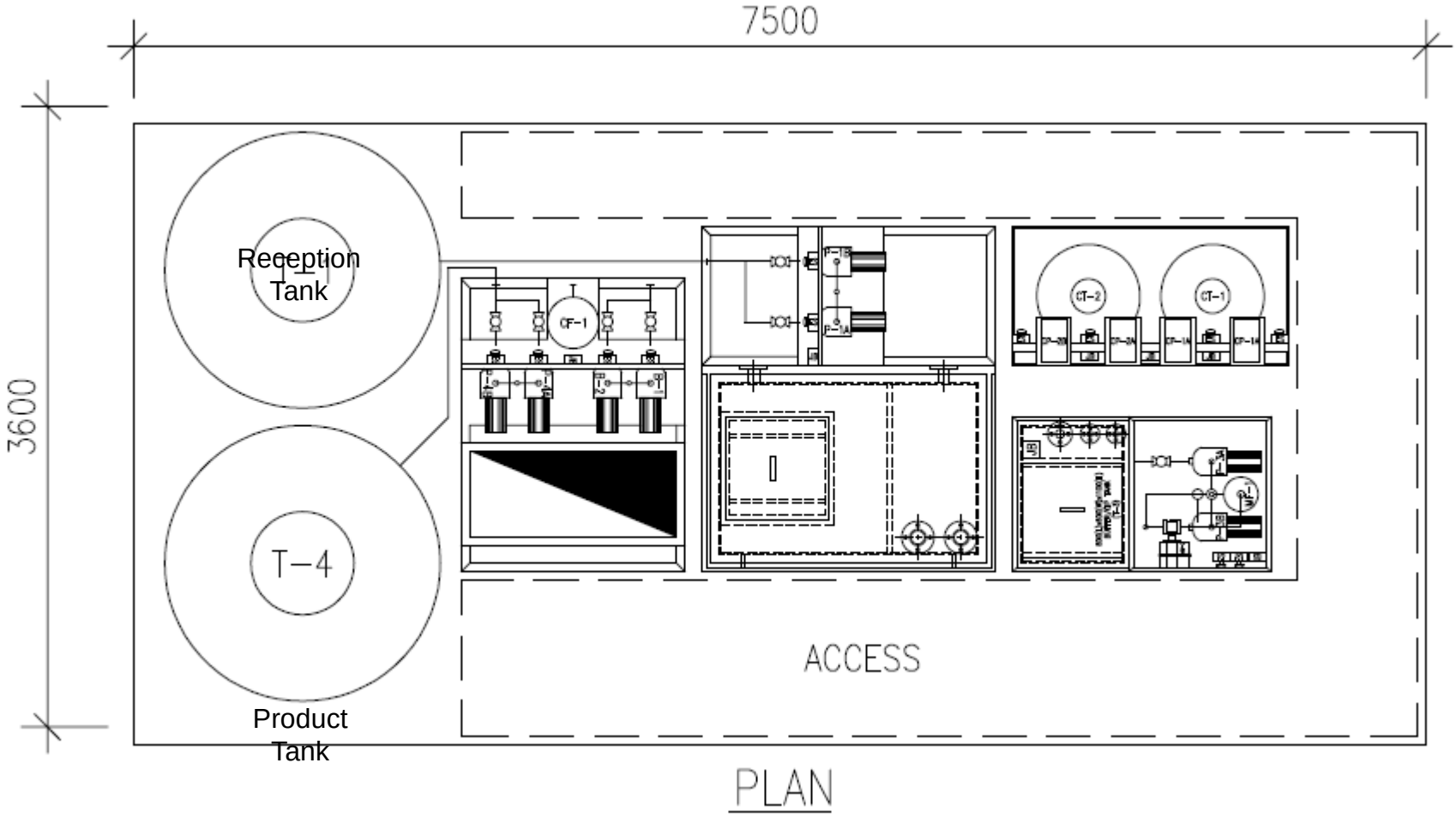
Standard Packaged Systems

System Model	Operating Hours	Reclaimed Water		Reclaimed Water for		No. of User	Reception Tank Required	Product Tank Required	Space Required
		Hourly Flow Rate	Daily Flow Rate	Irrigation[1]	Toilet Flushing[2]				
	hr/day	m^3/hr	m^3/day	m^2	No. of users		m^3	m^3	m^2
GW-01	5~10	0.1	1	200	27	Up to 27	0.2	0.2	~1.2
GW-05		0.5	5	1,000	130	Up to 130	2	2	~25
GW-10		1	10	2,000	130~260	130~260	3	3	~28
GW-20		2	20	4,000	260~530	260~530	5	5	~38
GW-50		5	50	10,000	530~1,330	530~1,330	5	5	~50
GW-100		10	100	20,000	1,330-2,660	1,330-2,660	5	5	~75

1 *5L/m^2/d*
Reference: Project Profile of "Rainwater and Greywater Recycling in Tseung Kwan O (TKO) Area 86 Property Development"

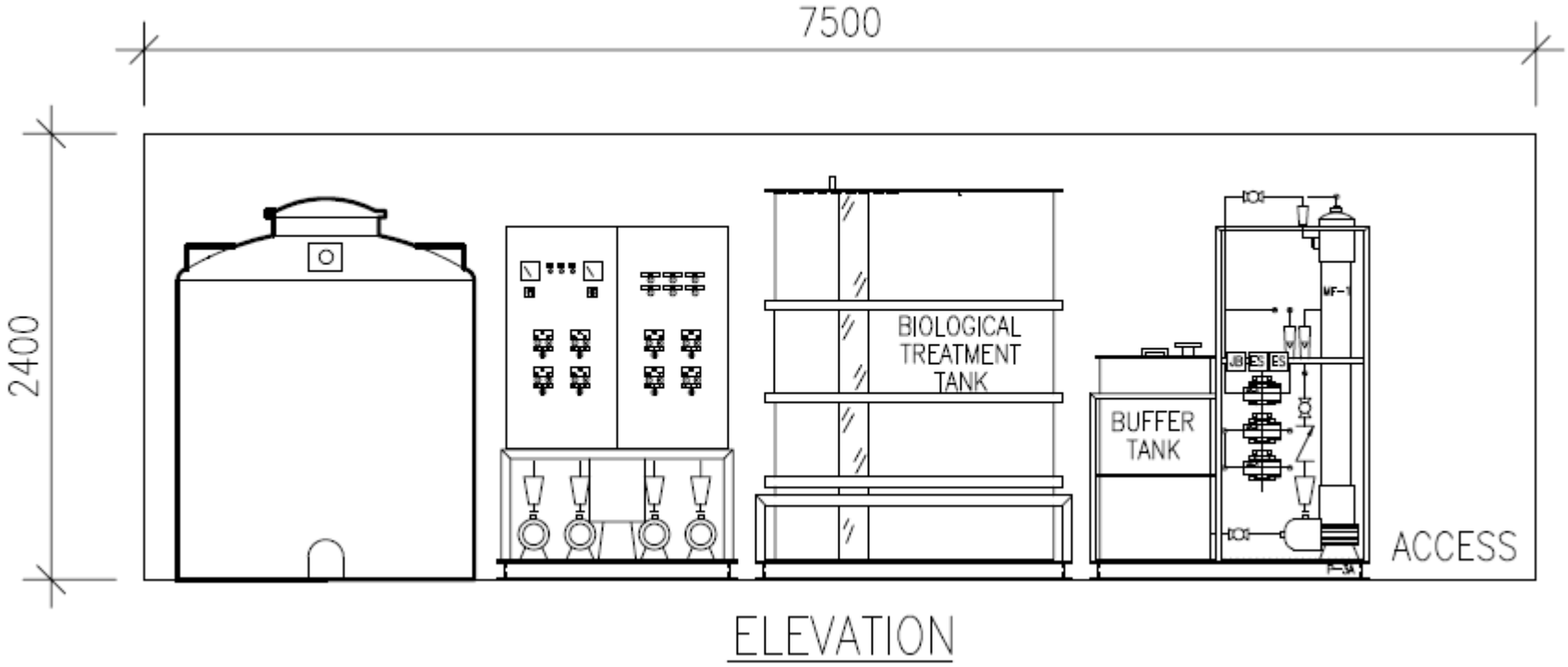
2 *37.5 L/head/day*
Reference: Baseline WC Water Use in BEAM Plus for Existing/New Buildings Version 1.2

Layout Sample



Capacity: 1 m³ /hr

Layout Sample



Capacity: 1 m³ /hr

Major Potential Users in Hong Kong

- School and university campuses
- Youth campsites and sports centres
- Residential and commercial buildings (esp. green buildings)
- Hotels
- Shopping centres

Potential Market in Mainland China

- Starred hotels and resorts
- Large shopping centres (including hypermarkets and department stores)
- Factories and worker dormitories
- Small residential communities
- Commercial buildings in urban areas

Q & A