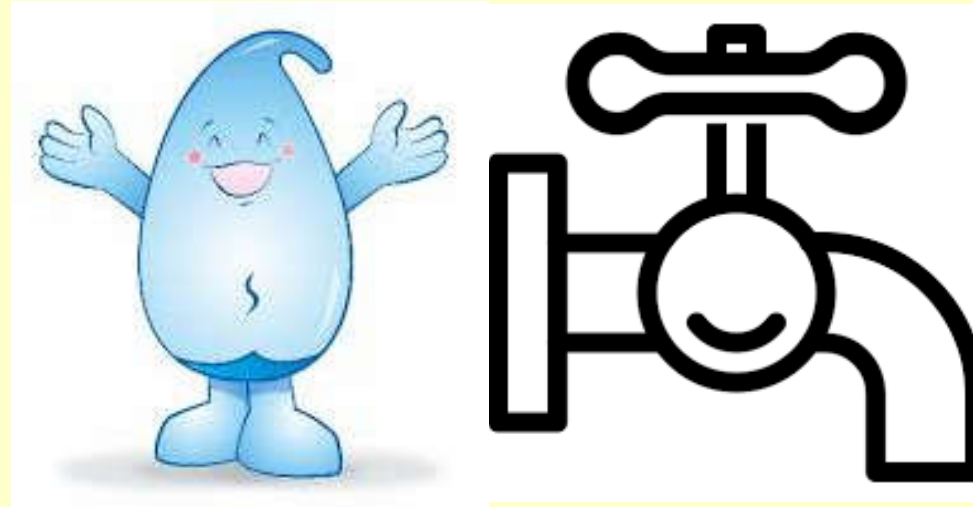


IBTM6010H Utility Services

<http://ibse.hk/IBTM6010H/>



Cold Water Supply

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<http://ibse.hk/cmhui/>

Feb 2022

Contents



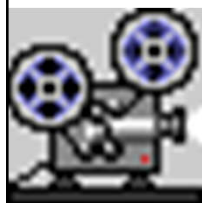
- Water supply in Hong Kong
- Water sources & treatment
- Water supply distribution
- Water tanks & pumps
- Water quality & management



Water supply in Hong Kong



- Early history of water supply in Hong Kong
 - 1851: sinking of 5 wells in the “City of Victoria”
 - 1860: tanks constructed at Bonham Road
 - 1863: Pok Fu Lam Reservoir (first one)
 - 1889: Tai Tam Reservoir
 - 1910: Kowloon Reservoir
 - 1917: Tai Tam Tuk Reservoir
 - 1937: Shing Mun Reservoir



- Video: TVB HK Historical Site’s feature story on water supplies history (7 June 2020) 無綫電視《探古尋源》供水歷史專題故事（2020年6月7日）
(3:30) <https://www.bilibili.com/video/BV1nh411o71g>

Water supply in Hong Kong



- Milestones of Hong Kong Water Supply

- <https://www.wsd.gov.hk/en/about-us/our-milestone/>

- Water wells & water streams

- Building of reservoirs (for storing rainwater)

- Droughts & hygiene conditions

- Water rationing

- Import water from Mainland China (Dongjiang)

- Desalination technology

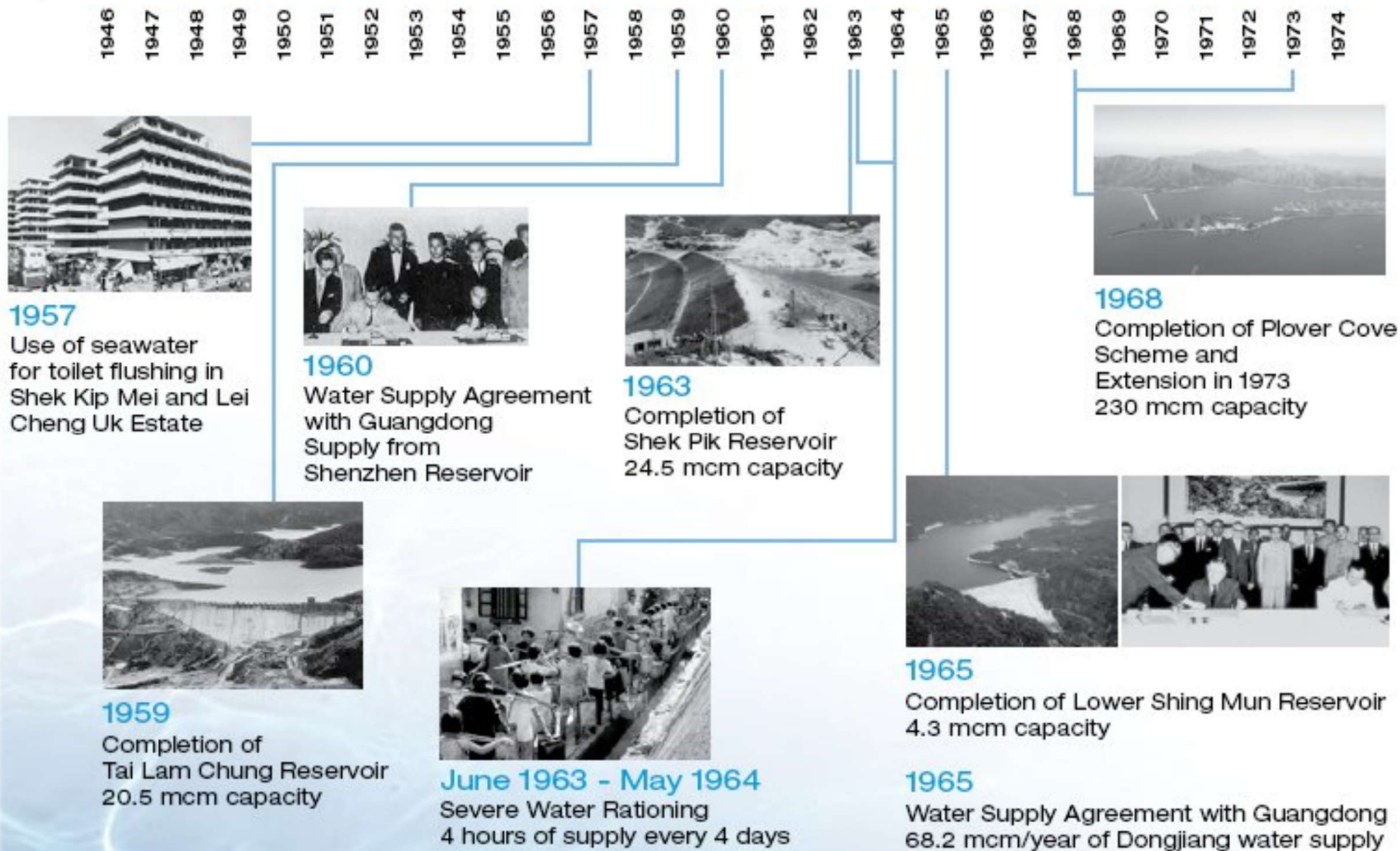
- Reclaimed water & seawater for flushing



(See also: 150 Years of Water Supply in Hong Kong 香港供水一百五十年

<https://web.archive.org/web/20060516074137/http://www.info.gov.hk/water150/index.htm>)

History of water supply in Hong Kong (1946-2007)



History of water supply in Hong Kong (1946-2007) (cont'd)



1978

Completion of High Island Scheme
281 mcm capacity



1989

Water Supply Agreement
with Guangdong
Maximum 1,100 mcm/year
of Dongjiang water supply



2006

Water Supply Agreement
with Guangdong
Flexible supply of Dongjiang water



1981-1982

Last water rationing
in Hong Kong



2003

Commissioning of 83km dedicated
aqueduct for delivery of Dongjiang water

1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007

Water supply in Hong Kong



- Water Supplies Department (WSD)

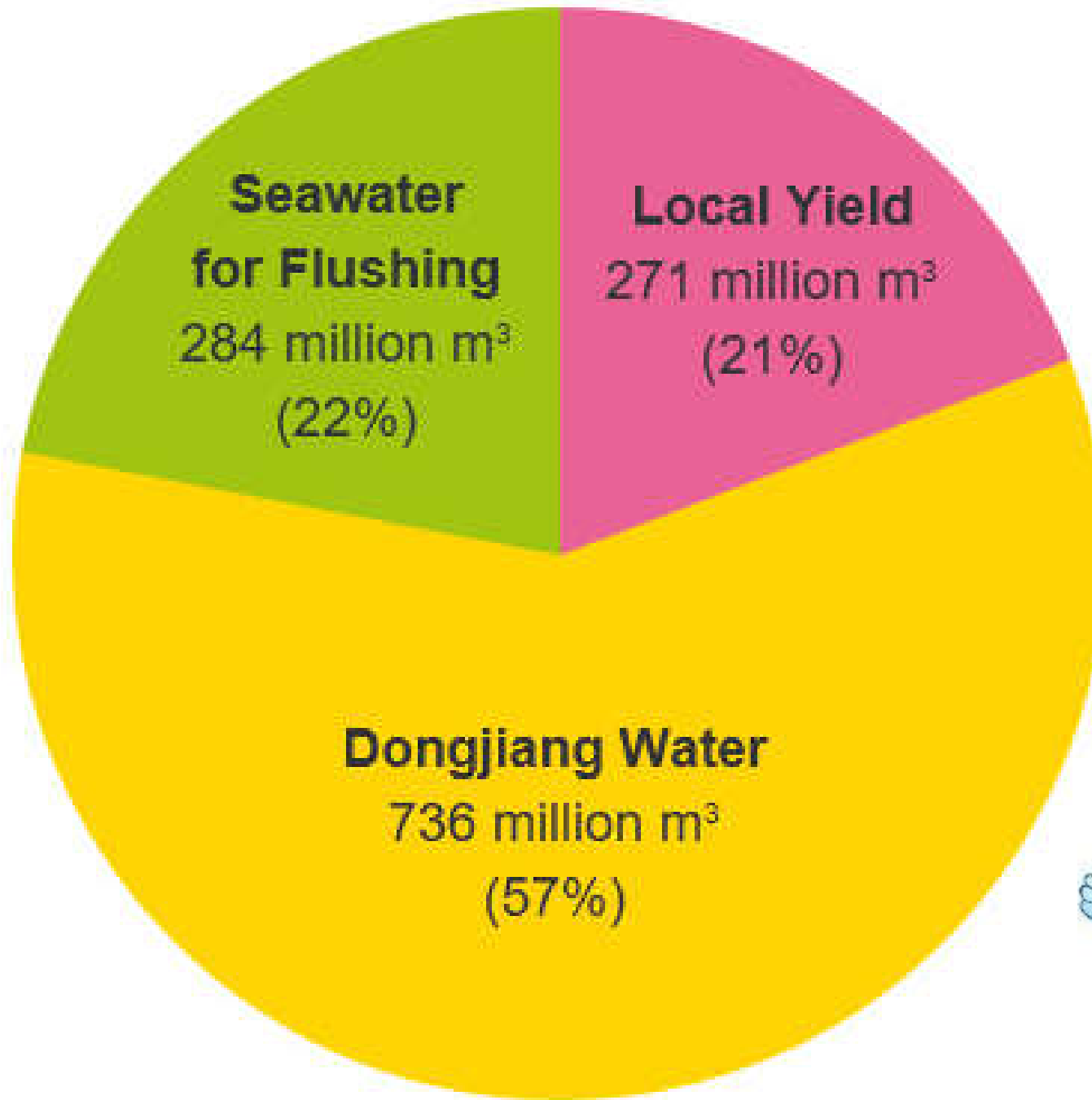


- To plan & manage water resources & water supply systems
- To design & construct waterworks projects
- To operate & maintain water supply & distribution systems
- To control the quality of water supply to customers
- To enforce the Waterworks Ordinance & Regulations
 - Include vetting plumbing proposals for buildings (from 'Licensed Plumbers')

- Water resources in HK

- Rainfall from natural catchment + supply from Guangdong
 - 70% of water demand is now met by water from Dongjiang River
- Sea water for flushing toilets (for over 80% population)

Water consumption in Hong Kong in 2018 (1.292 billion m³)

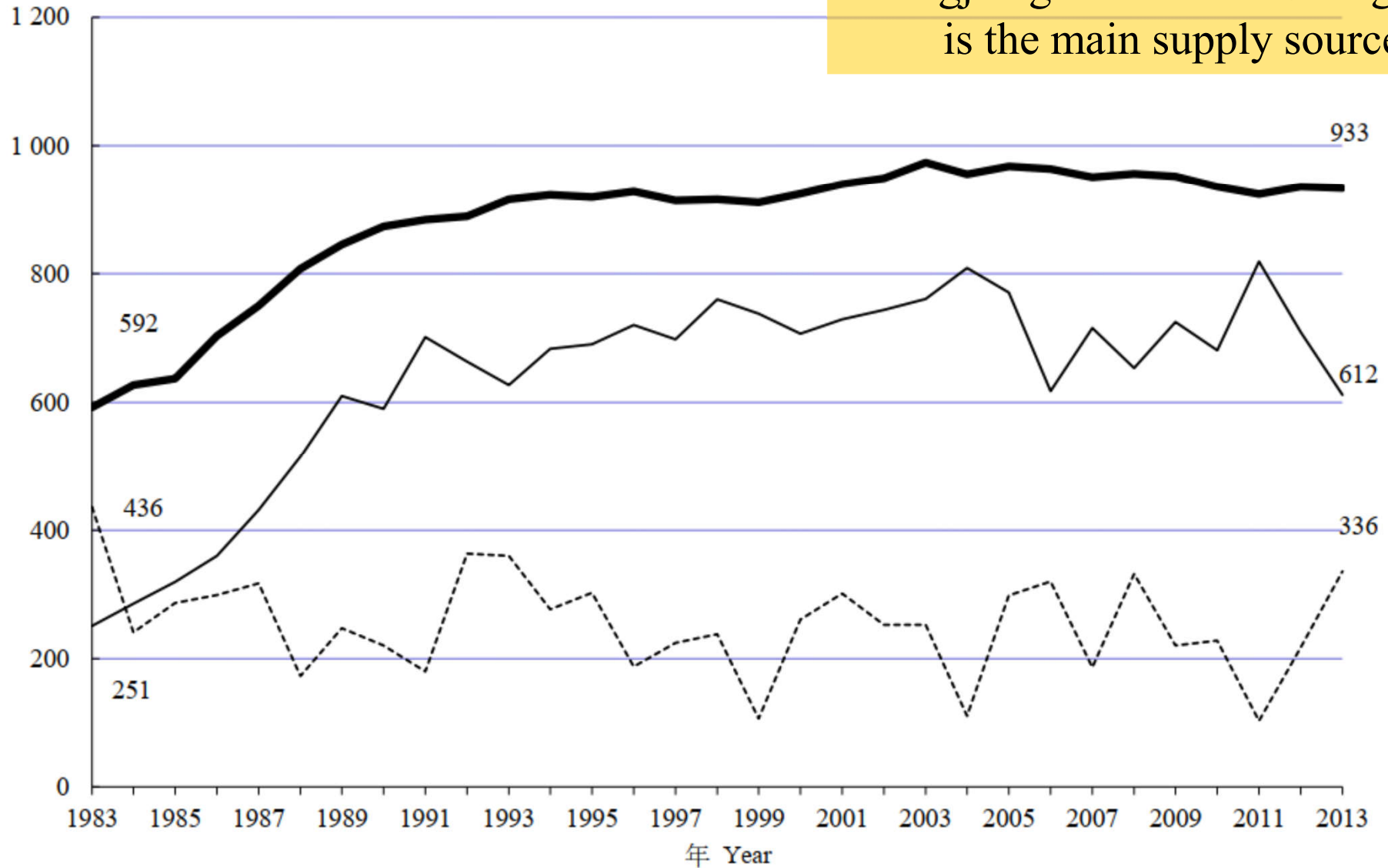


Fresh water consumption and supply in Hong Kong

百萬立方米

Million cubic metres

Dongjiang water from Guangdong is the main supply source



(Source: Hong Kong Monthly Digest of Statistics, Feature Article: An Overview of Water Supplies in Hong Kong, April 2015. <https://www.statistics.gov.hk/pub/B71504FB2015XXXXB0100.pdf>)



- Water Gathering Grounds
- Impounding Reservoir

Reservoirs & water gathering grounds in Hong Kong

(Source: Water Supplies Department www.wsd.gov.hk)



Xinfengjiang Reservoir
新豐江水庫

Dongjiang 東江

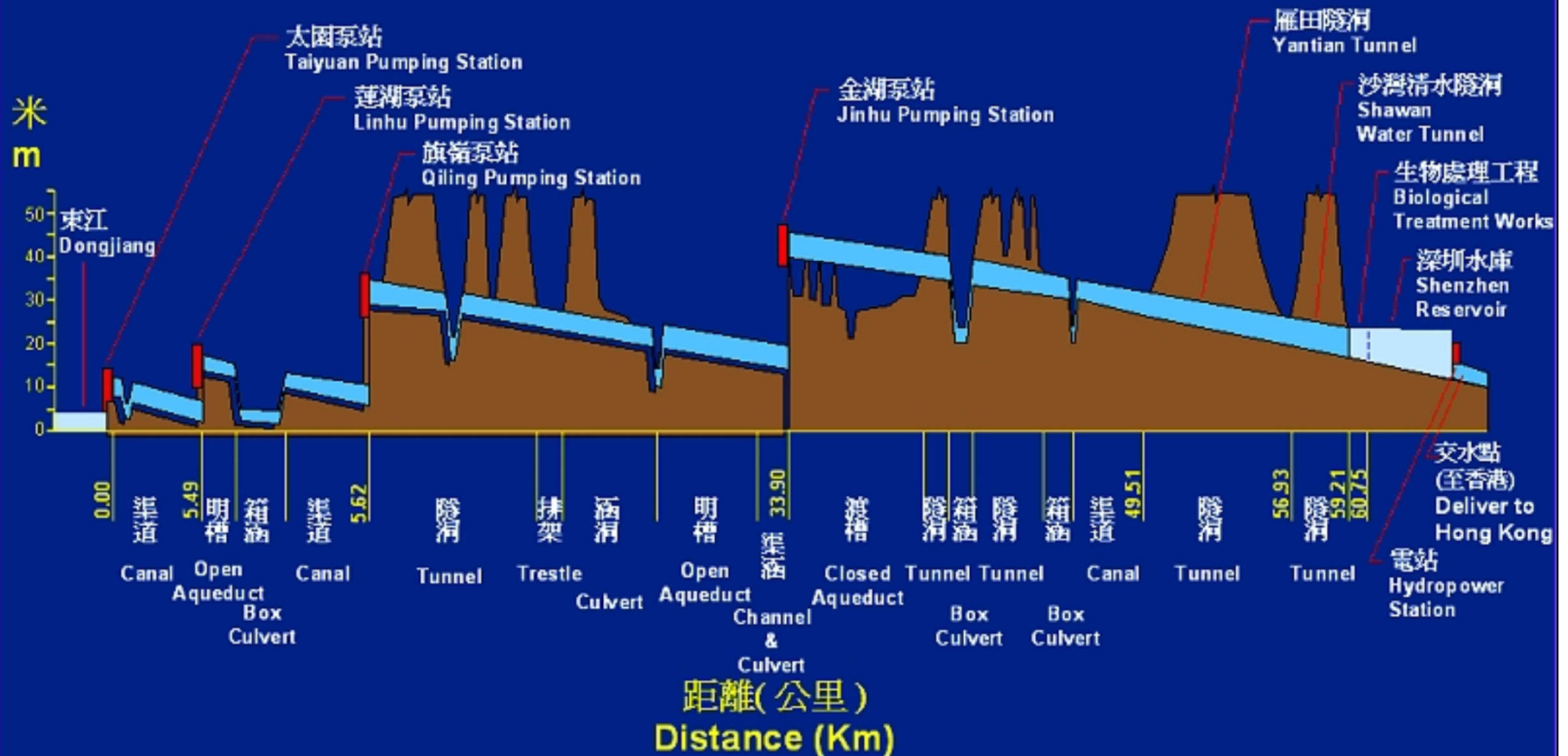
Shenzhen Reservoir
深圳水庫

Muk Wu Pump Station (HK)
木湖泵站(香港)

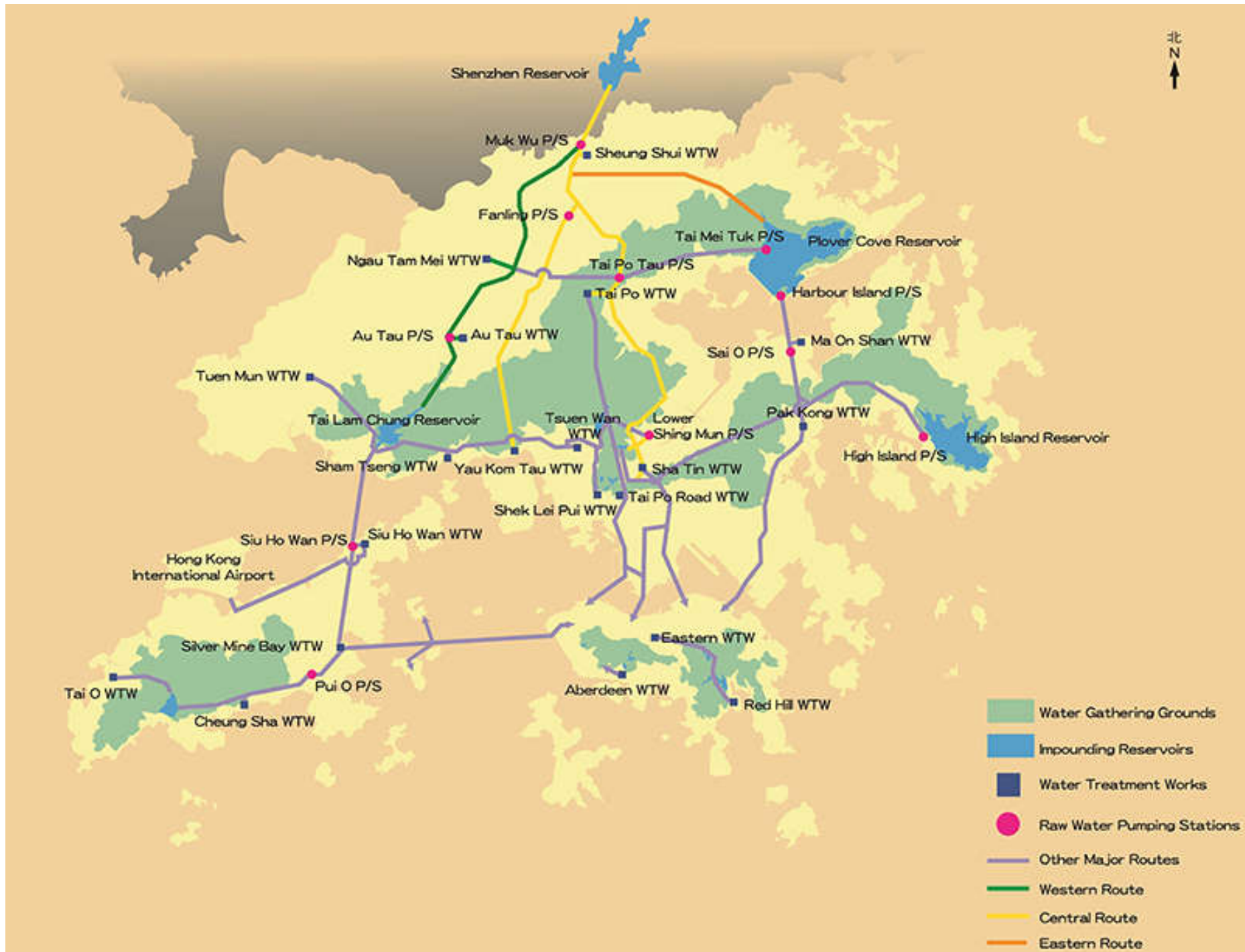
Water pipes along the
railway line

東深供水系統 - 密封式輸水管道(縱切面)

Dongshen Water Supply System – Closed Aqueduct (Longitudinal Section)



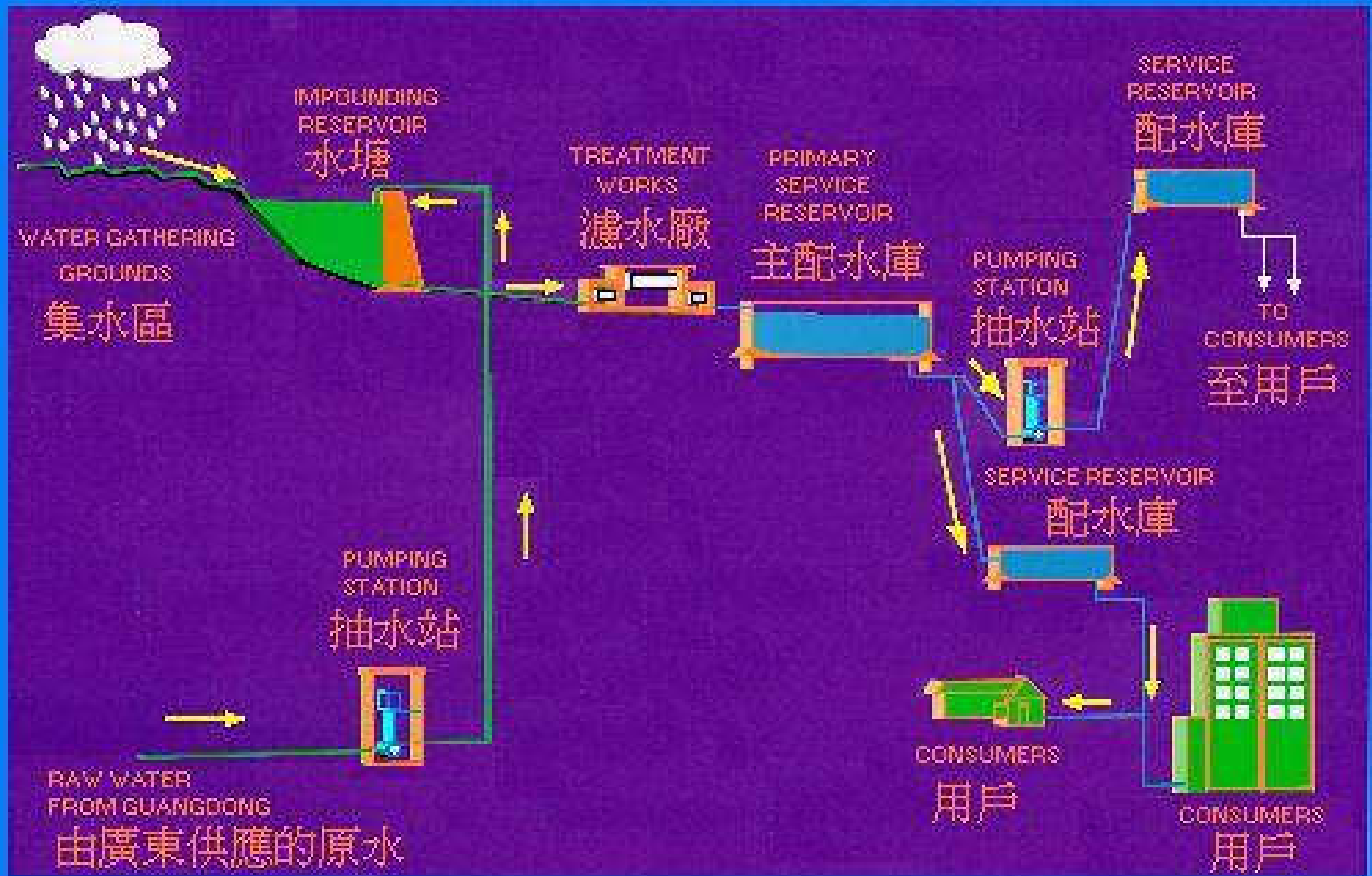
Principal water supply system in Hong Kong



(Source: Water Supplies Department www.wsd.gov.hk)

A TYPICAL FRESH WATER SUPPLY SYSTEM (SCHEMATIC)

典型食水供水系統 (概要)



GUANGDONG PROVINCE



Average
seawater
supplied in
each day in
HK (2019/20)
= 848 000 m³

Existing seawater
flushing situation &
proposed extensions



NEW TERRITORIES

KOWLOON

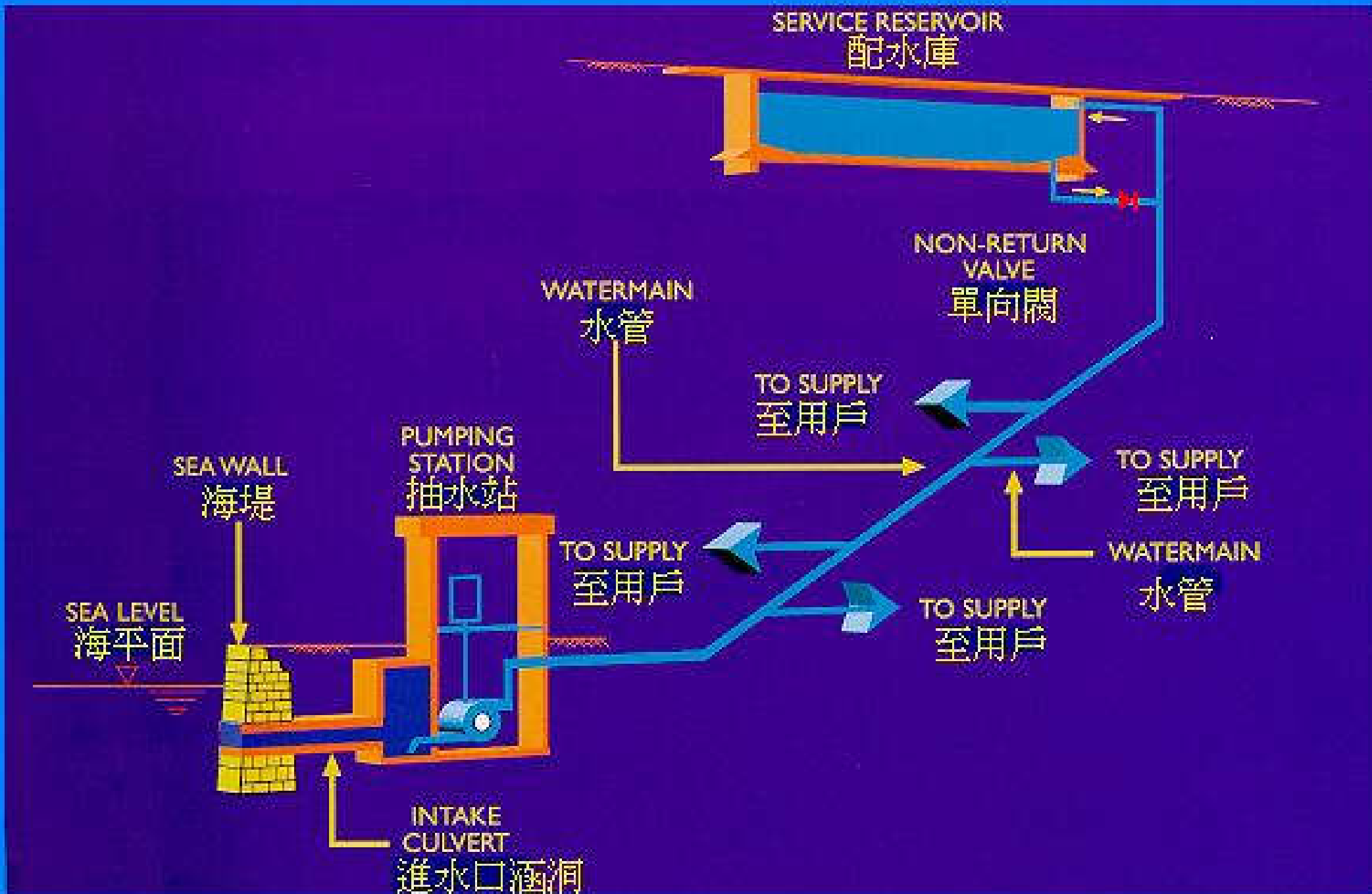
LANTAU ISLAND

HONG KONG ISLAND

LAMMA ISLAND

-  Existing seawater supply zone
-  Proposed seawater supply zone

A TYPICAL SEA WATER SUPPLY SYSTEM (SCHEMATIC) 典型海水供水系統 (概要)



Waterworks installations in Hong Kong

WATERWORKS INSTALLATIONS:

(as at 31 March 2020)

Impounding Reservoirs	17 nos.
<i>Total storage capacity</i>	586.05 Mm ³
Water Treatment Works	20 nos.
<i>Total capacity</i>	4.68 Mm ³ /d
Pumping Stations / Houses	
Fresh Water	151 nos.
<i>Total installed capacity</i>	32.14 Mm ³ /d
Salt Water	35 nos.
<i>Total installed capacity</i>	2.09 Mm ³ /d
Fresh Water and Salt Water (Combined)	7 nos.
<i>Total installed capacity</i>	0.30 Mm ³ /d
Service Reservoirs	
Fresh Water	178 nos.
<i>Total storage capacity</i>	4.35 Mm ³
Salt Water	54 nos.
<i>Total storage capacity</i>	0.26 Mm ³
Water Mains	
Fresh Water (20mm - 2,400mm diameter)	7,016 km
Salt Water (20mm - 1,200mm diameter)	1,800 km
Catchwater	120 km
Water Tunnel	199 km

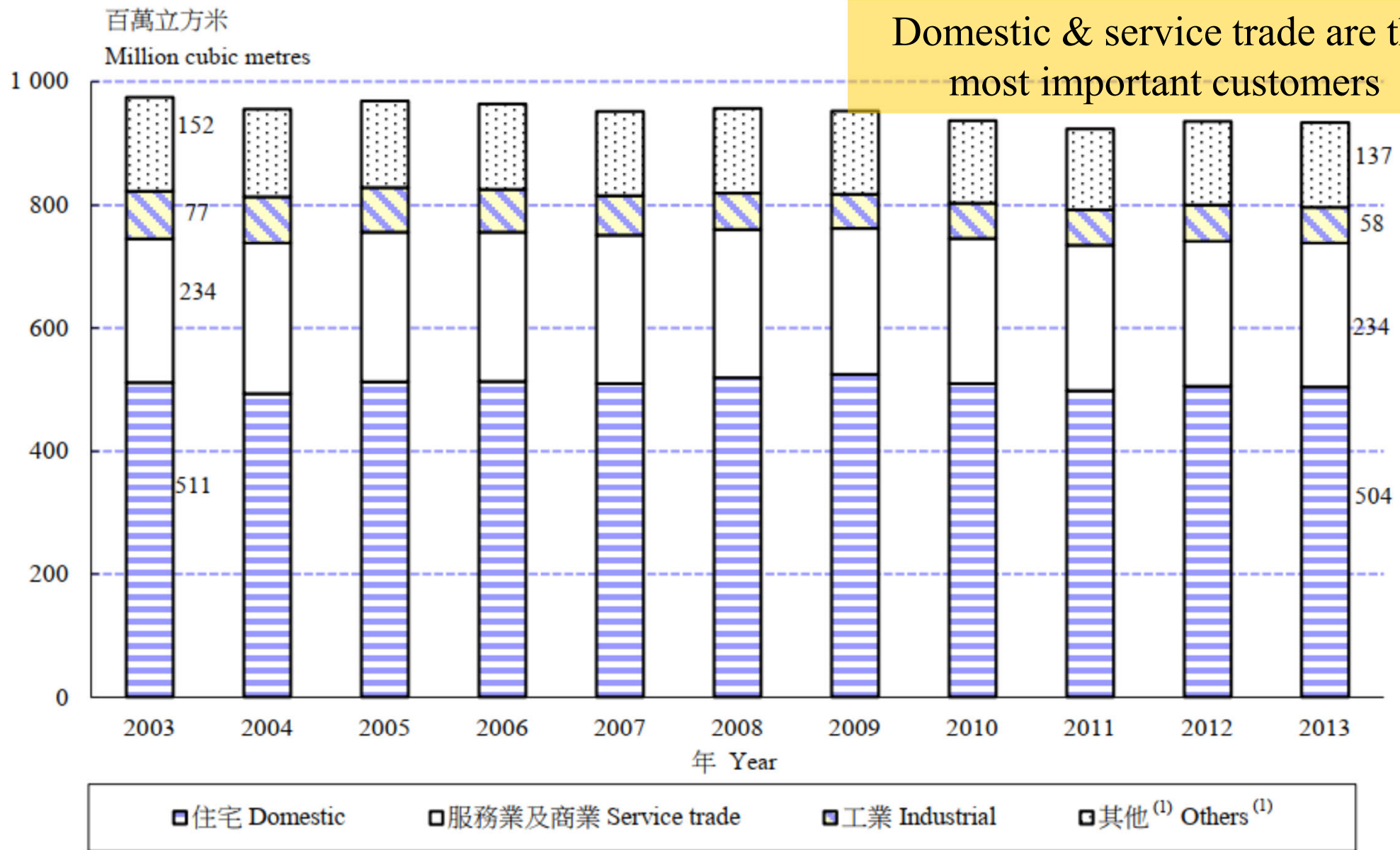
(Mm³ - million cubic metre)

水務設施：

(截至2020年3月31日止)

水塘	17個
總容量	586.05百萬立方米
濾水廠	20座
日產量	4.68百萬立方米
抽水站/泵房	
食水	151座
日產量(裝機容量計)	32.14百萬立方米
海水	35座
日產量(裝機容量計)	2.09百萬立方米
食水及海水(合併)	7座
日產量(裝機容量計)	0.30百萬立方米
配水庫	
食水	178座
總容量	4.35百萬立方米
海水	54座
總容量	0.26百萬立方米
水管	
食水(直徑20毫米 - 2,400毫米)	7,016公里
海水(直徑20毫米 - 1,200毫米)	1,800公里
引水道	120公里
輸水隧道	199公里

Fresh water consumption by major customer sector, 2003 to 2013



註釋： (1) 包括政府單位、建築地盤及船舶用水，以及淡水沖廁用水。

Note: (1) Including fresh water consumption of government units, construction sites and ships, and for flushing.

(Source: Hong Kong Monthly Digest of Statistics, Feature Article: An Overview of Water Supplies in Hong Kong, April 2015. <https://www.statistics.gov.hk/pub/B71504FB2015XXXXB0100.pdf>)

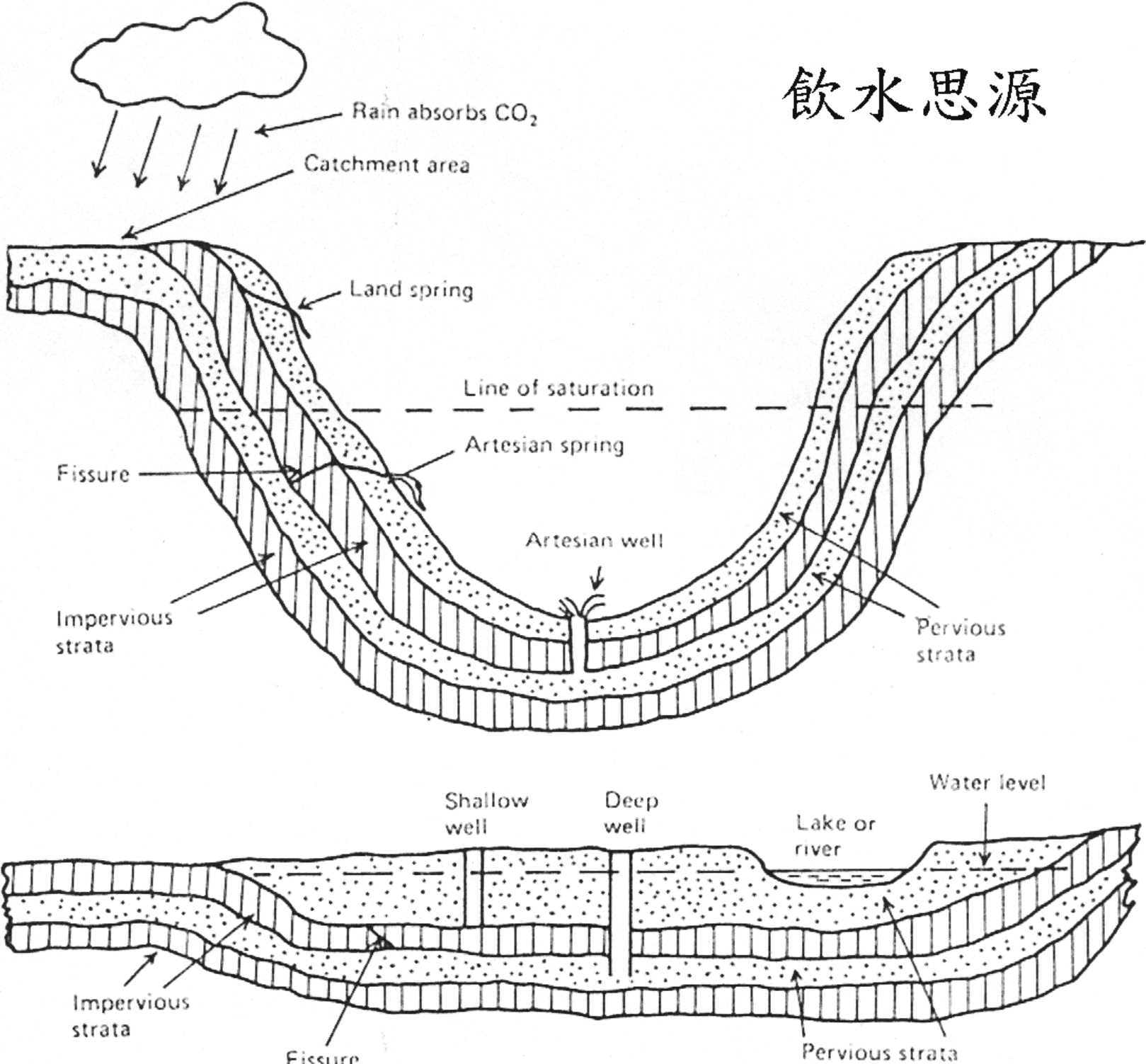


Water sources & treatment

- Surface & underground water sources:
 - Shallow wells
 - Sinkings in top water-bearing strata
 - Intermittent or land springs
 - From top water-bearing strata
 - Deep wells
 - Sinkings below the first impervious strata
 - Artesian wells and springs
 - The same source as deep wells
 - Lakes & rivers
 - Catchment of surface and subsoil water

飲
水
思
源

飲水思源



(Source: Hall, F. and Greeno, R., 2007. *Building Services Handbook*)

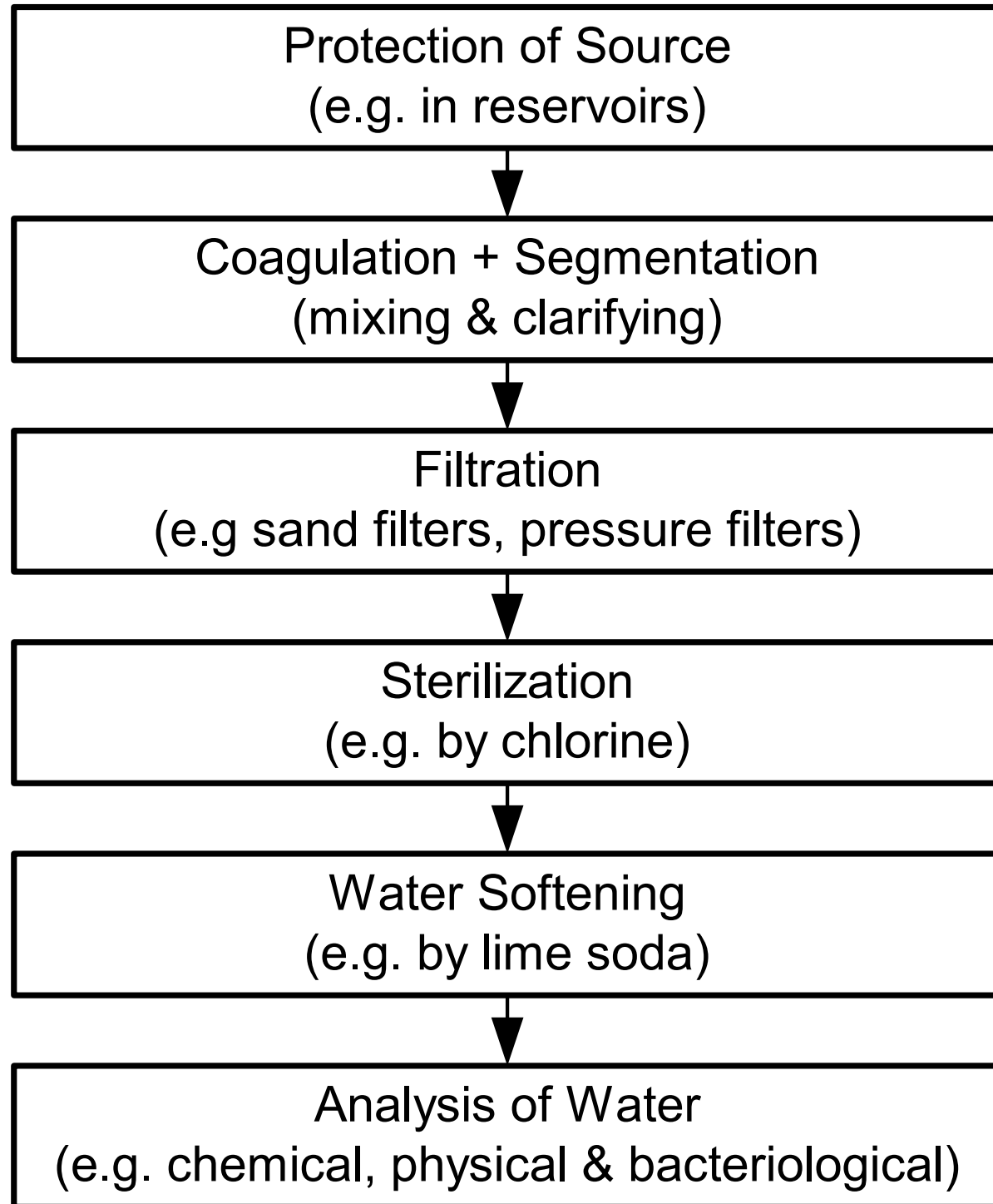


Water sources & treatment

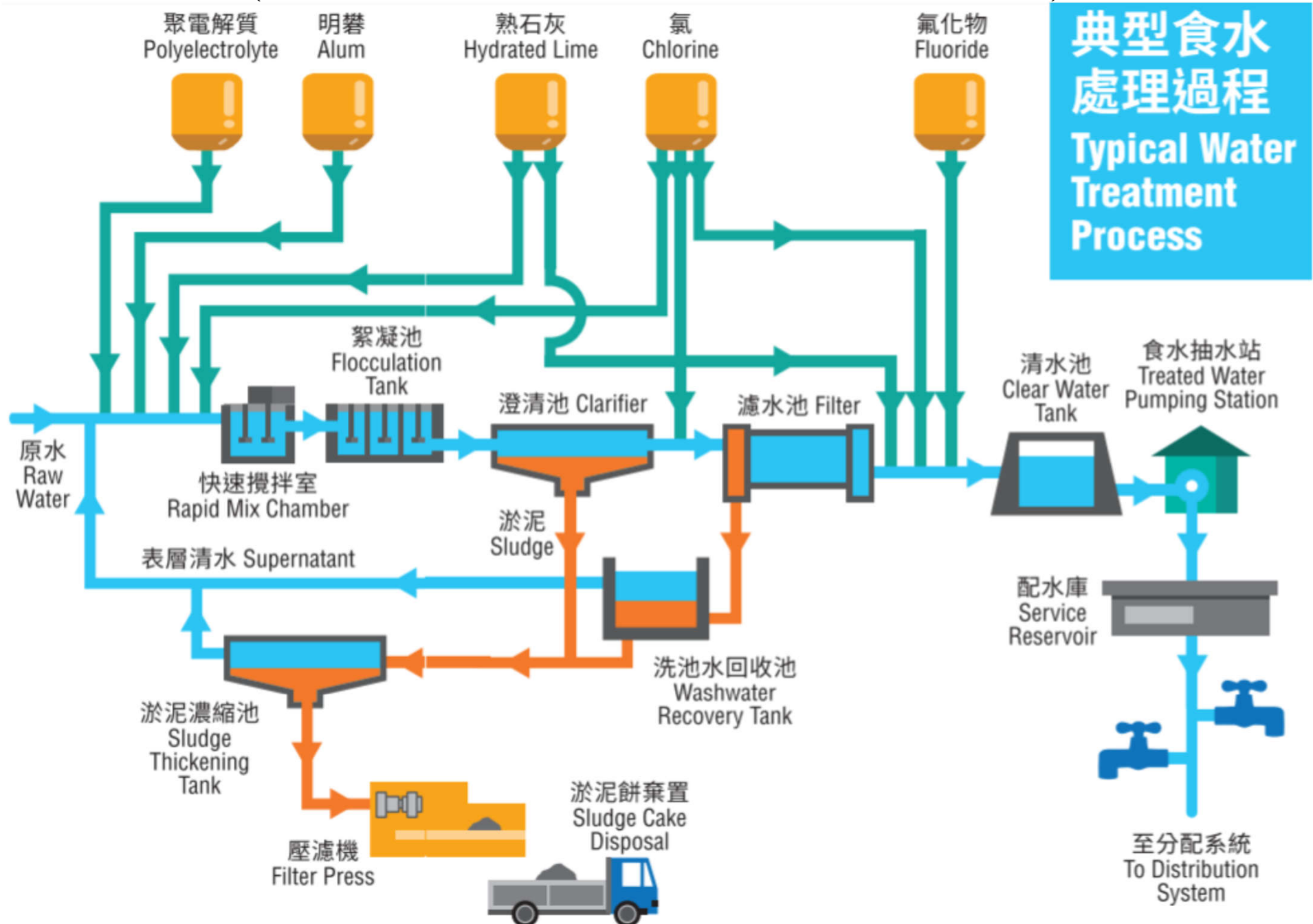
- Water for human consumption must be:
 - Free from harmful bacteria & suspended matter
 - Colourless
 - Pleasant to taste
 - For health reasons, moderately 'hard' (CaCO_3)
- Water storage & treatment process to ensure good water quality
 - Complies with World Health Organization (WHO) guidelines for drinking water*



Typical water treatment process



Typical water treatment process in Hong Kong (clarification >> filtration >> disinfection)





Water sources & treatment

- Water treatment process in HK
 - 1. Raw water
 - Comes from different sources, including reservoir(s) and Dongjiang water of Guangdong
 - 2. Mixing
 - Raw water is dosed at the mixing chamber with
 - Hydrated lime to precondition the raw water
 - Chlorine to control algae
 - Alum to coagulate impurities
 - Polyelectrolyte to improve the coagulation and flocculation of impurities

Water sources & treatment



- Water treatment process in HK (cont'd)

- 3. Flocculation and Sedimentation

- After mixing, water is passed to the clarifiers where coagulation and flocculation of the impurities in the water will occur
 - The dissolved alum coagulate impurities in the water into large particles where settle as sludge
 - The sludge is collected and conveyed to sludge thickening tanks for further treatment before disposal



Water sources & treatment



- Water treatment process in HK (cont'd)

- 4. Rapid Gravity Filtration



- Settled water from the clarifiers flows to the constant rate sand filters for removal of more finely divided suspensions
 - Periodically the filter beds are cleaned by backwashing with air and then water

- 5. Clear Water Tanks

- Chlorine, fluoride and lime are dosed into the filtered water in the contact tanks and disinfect, fluoridate and control the alkalinity of the final treated water
 - The treated water is stored in the clear water tank before conveying to service reservoirs for distribution to people

Water sources & treatment



- Water treatment process in HK (cont'd)

- 6. Pumping Facilities



- Pumping station in the treatment to pump the water to the distribution

- 7. Environmental Friendly Facilities



- The washwater is collected in the recovery tanks for repumping to the inlet for recycling
- Sludge produced is thickened by three circular sludge thickening tank using electrolyte as coagulant
- Thickened sludge is compressed by membrane type filter presses into cakes for disposal at landfill sites

Water sources & treatment



- Water treatment process in HK (cont'd)
 - 8. Water Quality Control
 - The quality of water is closely monitored by means of chemical, bacteriological and biological examinations of water samples taken
 - To comply with the Guidelines for Drinking Water Quality recommended by WHO, to ensure a safe and wholesome potable supply



Water sources & treatment



- Water charges in Hong Kong

- Domestic supplies

- Billed at 4-monthly intervals (121.64 days)
 - 4 tiers with progressively increasing prices
 - To discourage excessive and unnecessary use of water
 - First tier: 12 cubic metres: free of charge
 - Second tier: 31 cubic metres: \$4.16 per cubic metre
 - Third tier: 19 cubic metres: \$6.45 per cubic metre
 - Fourth tier: > 62 cubic metres: \$9.05 per cubic metre



Water sources & treatment



- Water charges in Hong Kong (cont'd)



- Non-domestic supplies

- Billed at 4-monthly intervals (for large consumption consumers, billed at monthly intervals)
 - At a flat rate dependent on the purpose of the supply
 - For trade: \$4.58 per cubic metre
 - For construction: \$7.11 per cubic metre
 - For non ocean-going shipping: \$4.58 per cubic metre
 - For ocean-going shipping: \$10.93 per cubic metre

Water sources & treatment



- Water charges in Hong Kong (cont'd)

- Flushing supplies



- Sea water supply for flushing is free of charge
 - Fresh water supply for flushing is usually billed at 4-monthly intervals
 - First tier: 30 cubic metres per flat: free of charge
 - Second tier: > 30 cubic metres per flat: \$4.58 per cubic metre
 - Only one meter installed in each building to record the total consumption of all flats in the same building
 - Billed separately to the management office, agent, incorporated owner or development company

Water sources & treatment



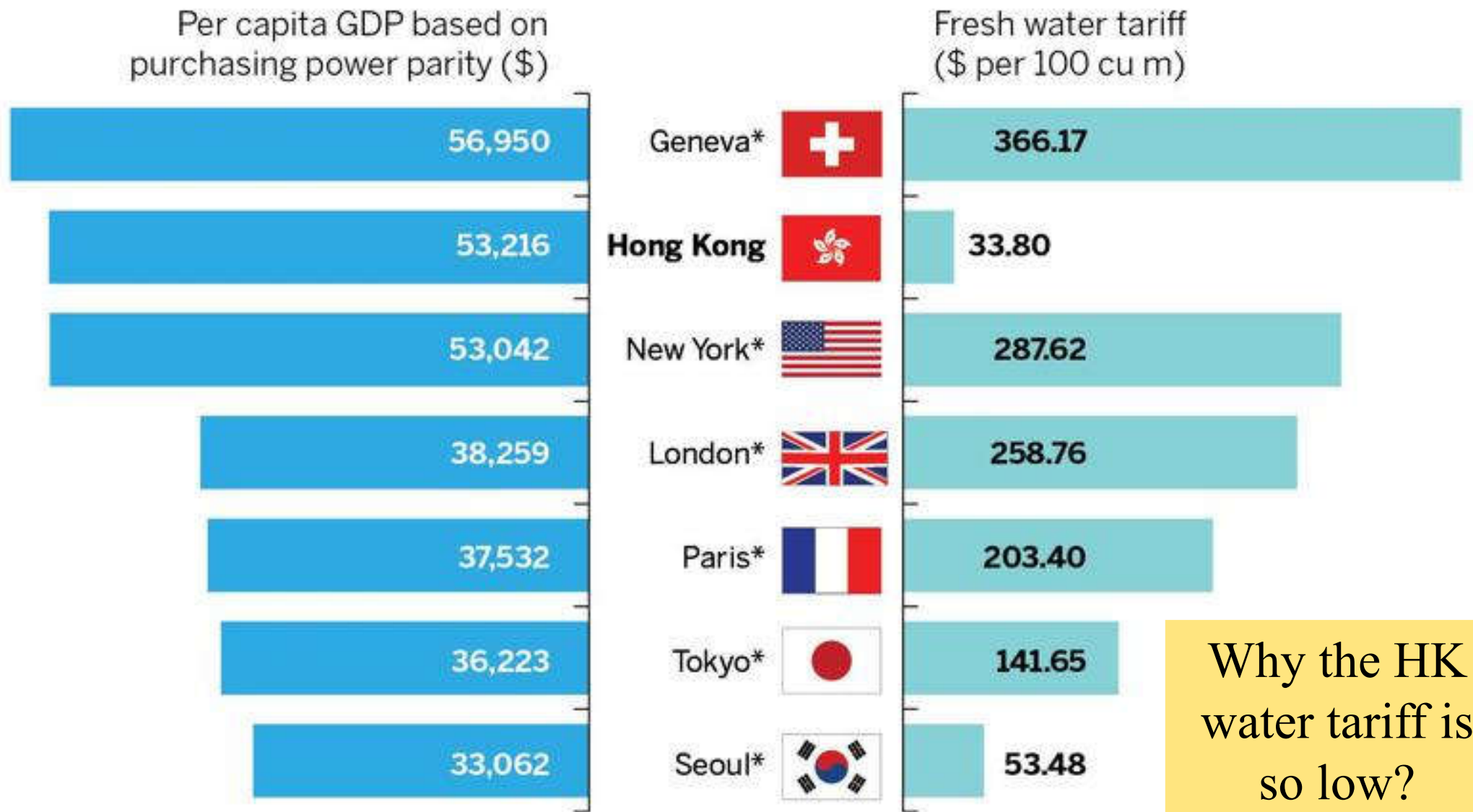
- Water charges in Hong Kong (cont'd)



- Sewage charges

- For domestic consumers: at a 4-month interval: \$2.92 per cubic metre, with an exemption for the first 12 cubic metres
- For trade, business and manufacture consumers: \$2.92 per cubic metre. Some trades are eligible for 30% discount (e.g. bleaching & dyeing, restaurants, softdrinks & ice-making industries)
- For 27 types of trade/business/manufacture which discharge trade effluent, the consumer shall also pay a Trade Effluent Surcharge

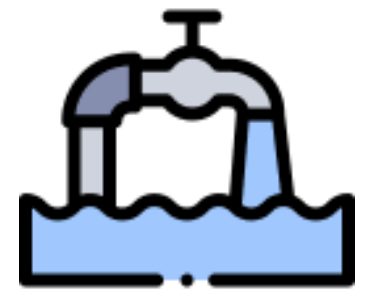
HK water tariff is much less than that in cities of comparable or lower per capita GDP



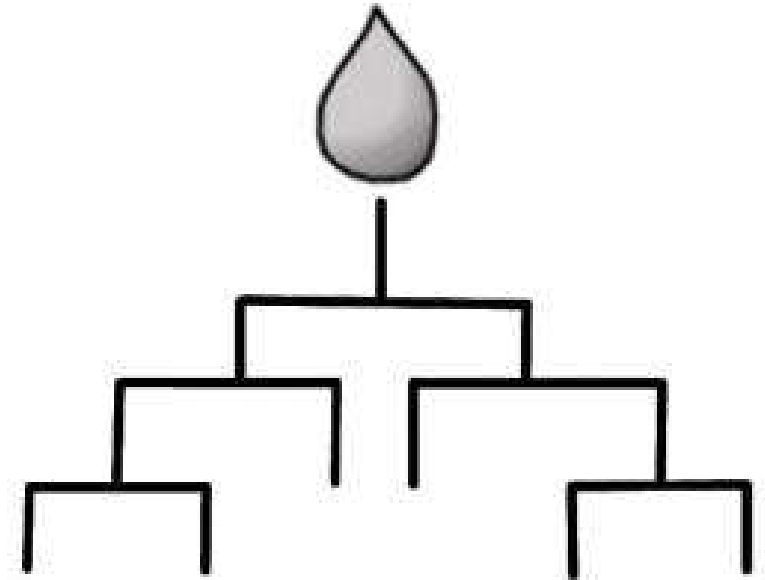
Why the HK water tariff is so low?

* Per capita GDP is country/region-wide figure whereas fresh water tariff is city-specific figure.

Water supply distribution

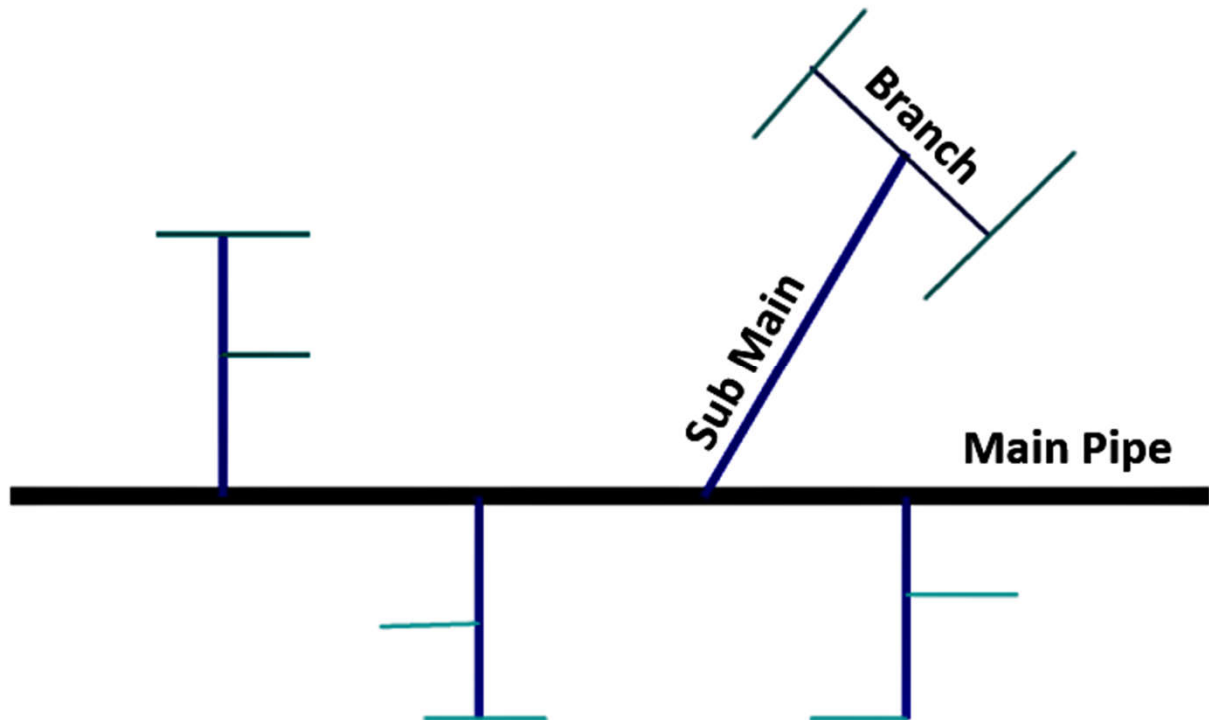
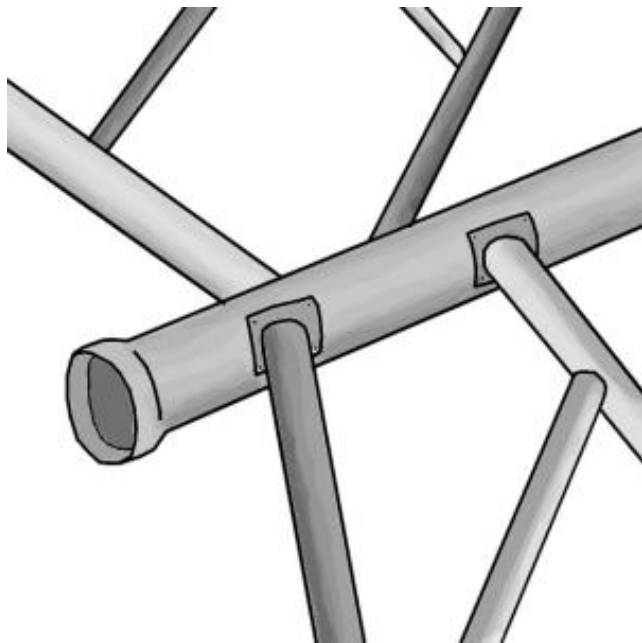


- Distribution network of water supply
 - Main reservoir
 - Pumping stations
 - Water treatment plants
 - Pumping substations
 - Service reservoirs
 - Trunk mains or service trunks
 - Street mains or water mains (into buildings)
- For fresh/flushing water supply & fire services

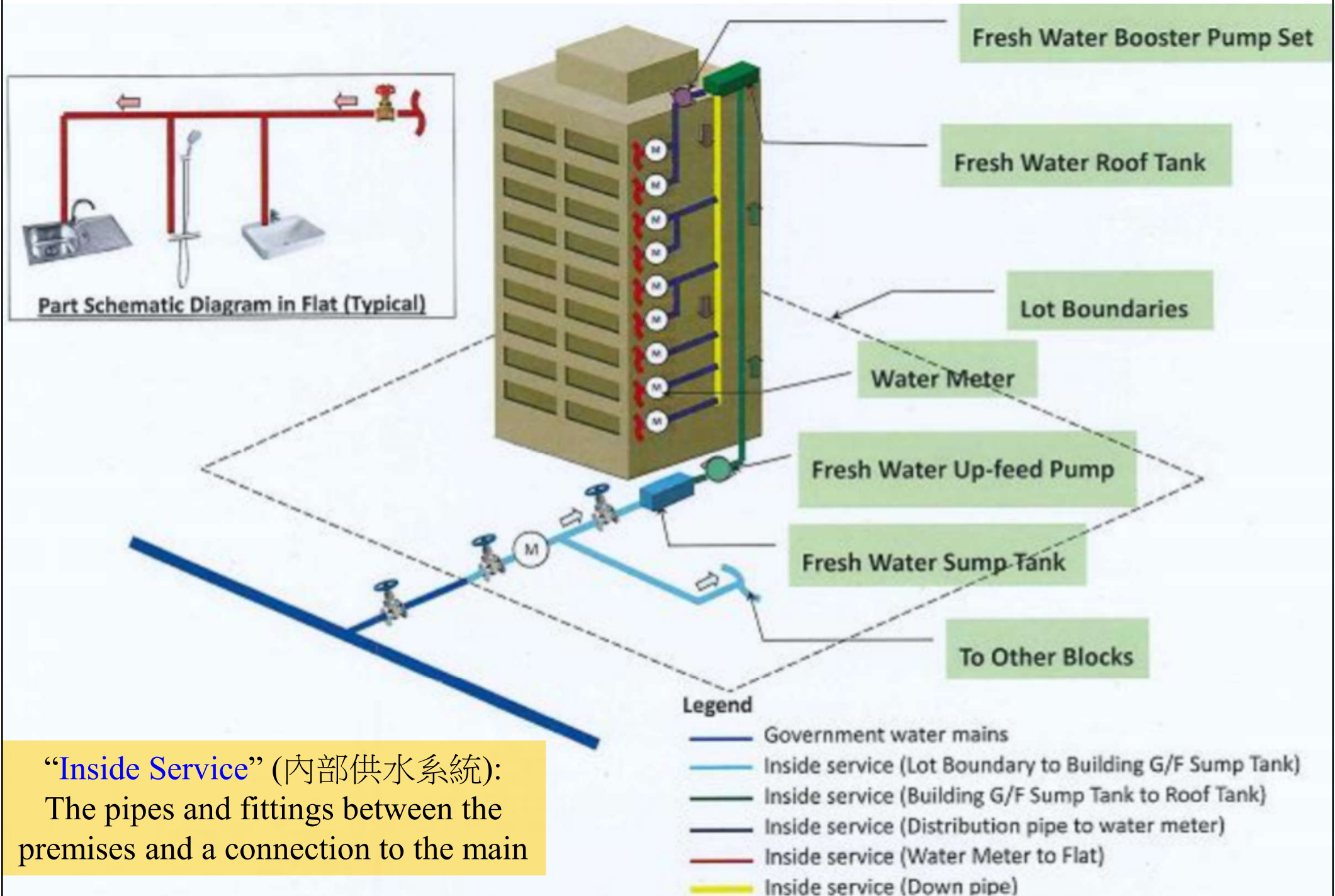


Three categories of water supply mains

(a) Trunk mains	Generally described as those which convey water from a source of supply (reservoir, pumping station etc.) to a district without supplying consumers en route
(b) Secondary mains	The distribution mains in any district, usually fed from a trunk main and supplying the consumers' connections in the district
(c) Service pipes	The branch supplies from the secondary mains which serve individual consumers or premises

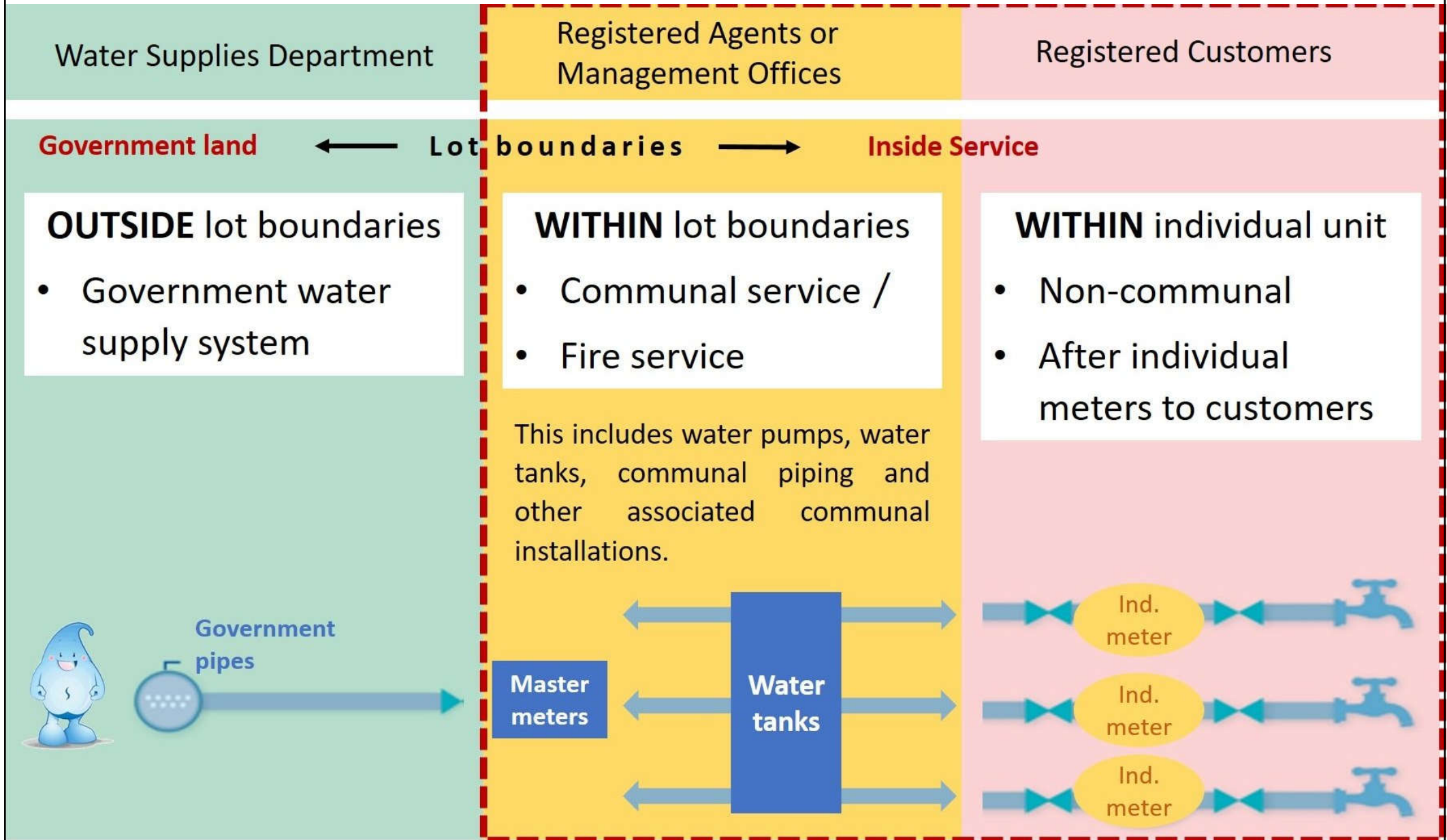


Schematic diagram of a typical inside service

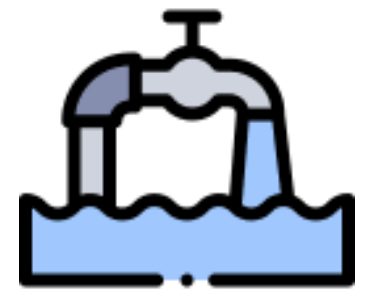


“**Inside Service**” (内部供水系統):
The pipes and fittings between the premises and a connection to the main

Maintenance responsibility of government waterworks and inside service

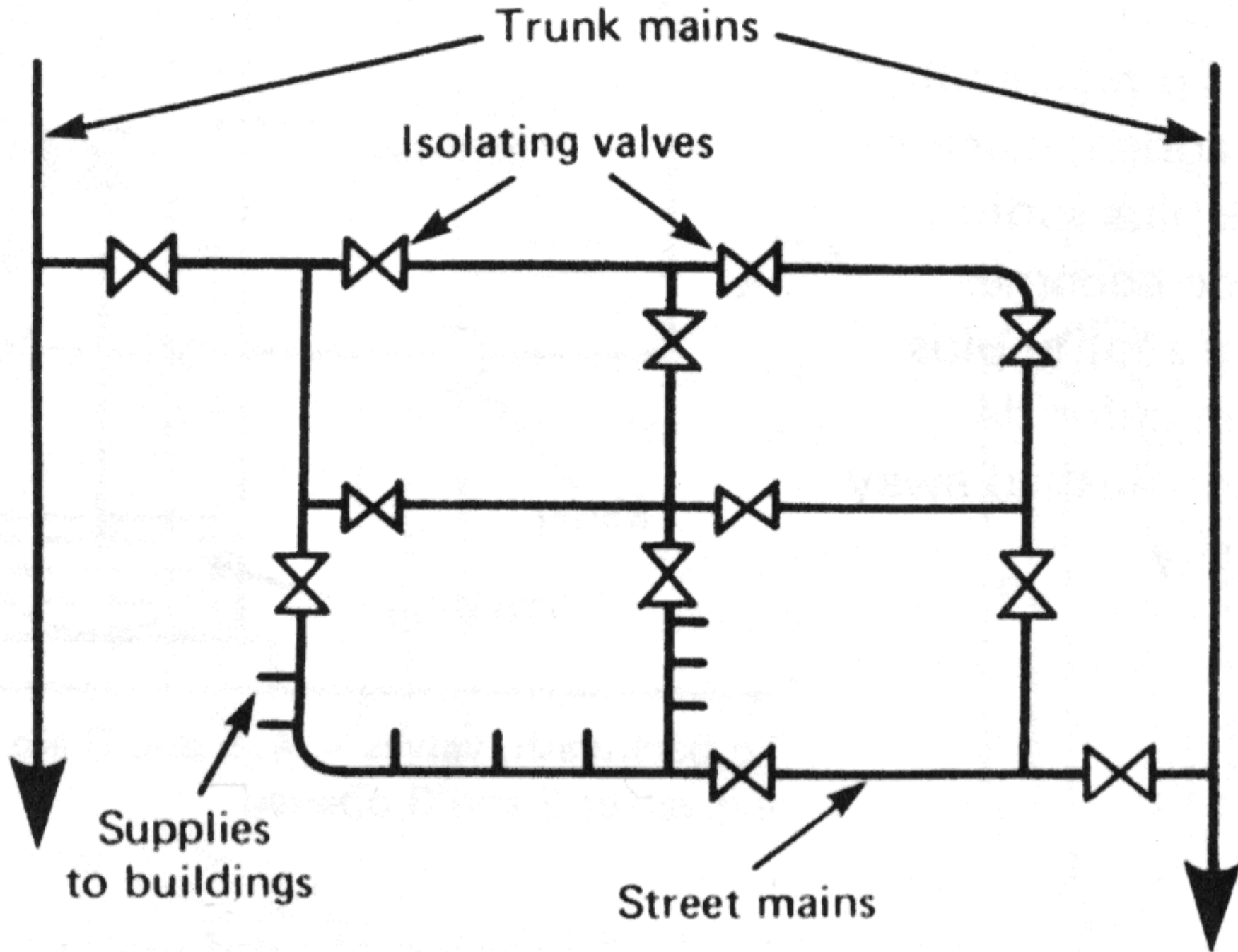


Water supply distribution

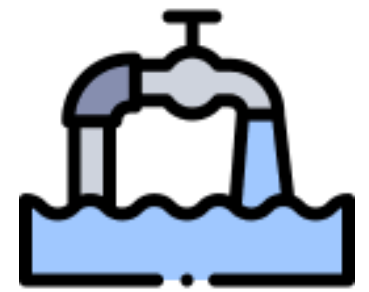


- Mains water supply
 - Size of the water mains
 - Such as a 75 mm diameter pipe fed from both ends or a 100 mm diameter pipe fed from one end
 - Pressure (or head) of water (20 or 30m head) & pressure fluctuations
 - Min. head of 30 m head for firefighting purposes
 - Max. head of 70 m head to limit wastage and pipe noise
- A ring circuit & a grid of pipes
 - To increase reliability & facilitate maintenance

Ring main distribution (with water fed from both ends)

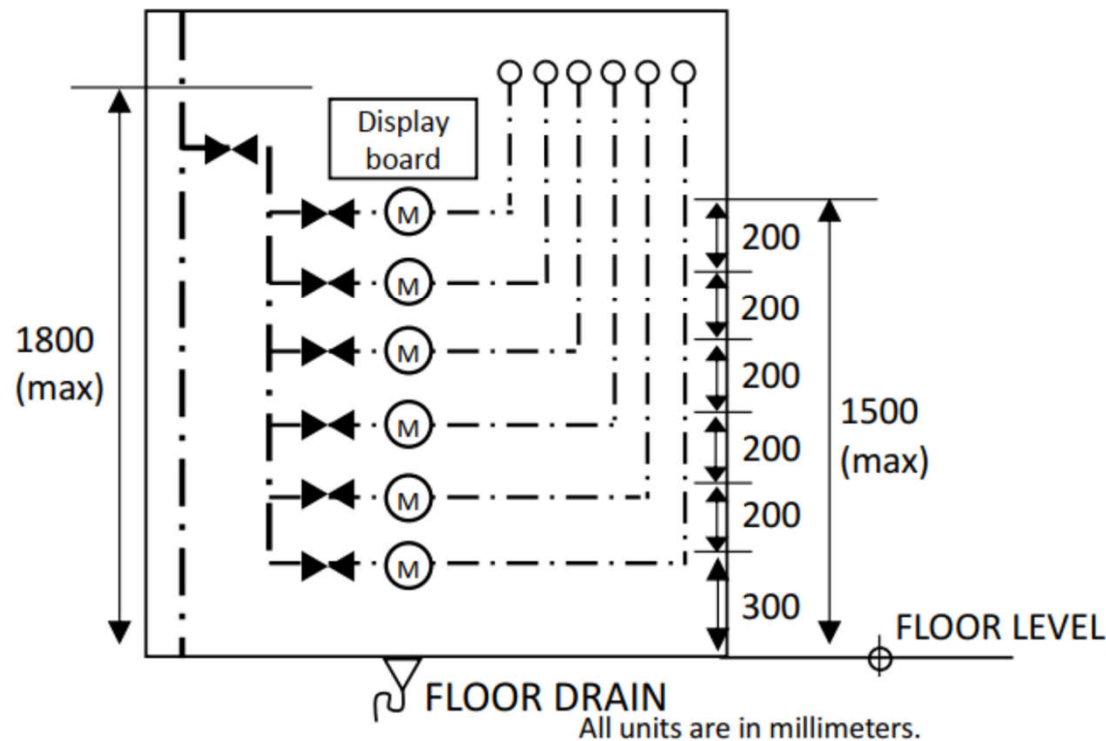
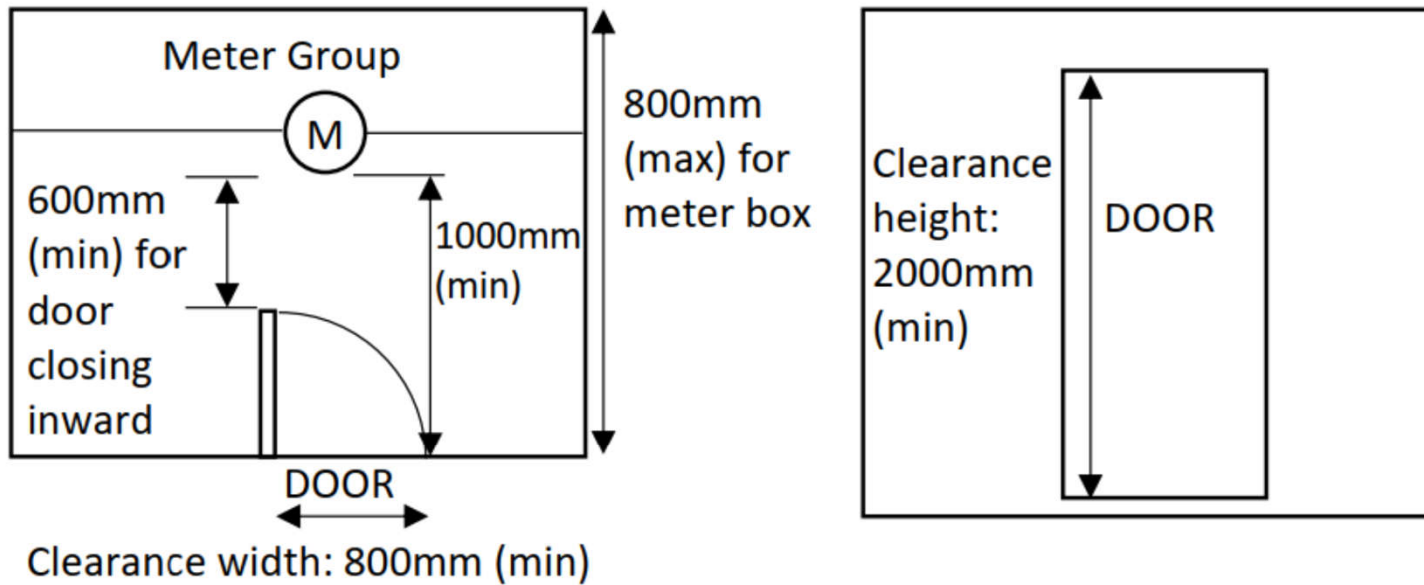


Water supply distribution



- Pressure of water supplies in HK
 - Fresh water supply: 15-30 metres head
 - Salt water supply: 15 metres head
 - They are maintained in the distribution systems except at their extremities
 - Reduction of the minimum residual pressure (since 2007): lower from 30- to 20-metre head
- Master meter, sub-meters & check meters

Typical arrangement of water meters in a meter box/chamber/room



(Source: WSD, 2020. *Technical Requirements for Plumbing Works in Buildings (November 2020 version)*, Water Supplies Department (WSD), Hong Kong. <https://www.wsd.gov.hk/en/plumbing-engineering/requirements-for-plumbing-installation/technical-requirements-for-plumbing-works-in-bldgs/>)

Communal plumbing (maintained by property manager or agent)

Individual consumer's water main (maintained by consumer)

valve

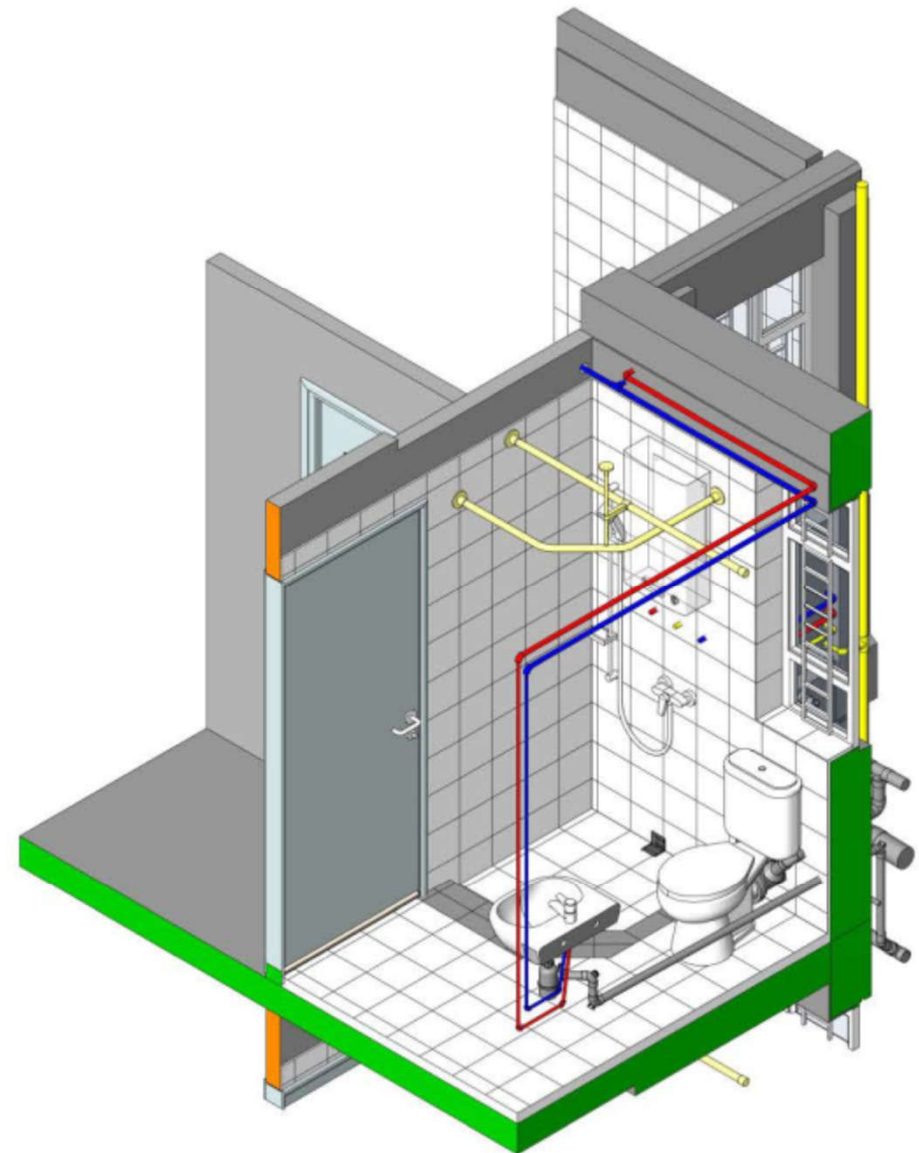
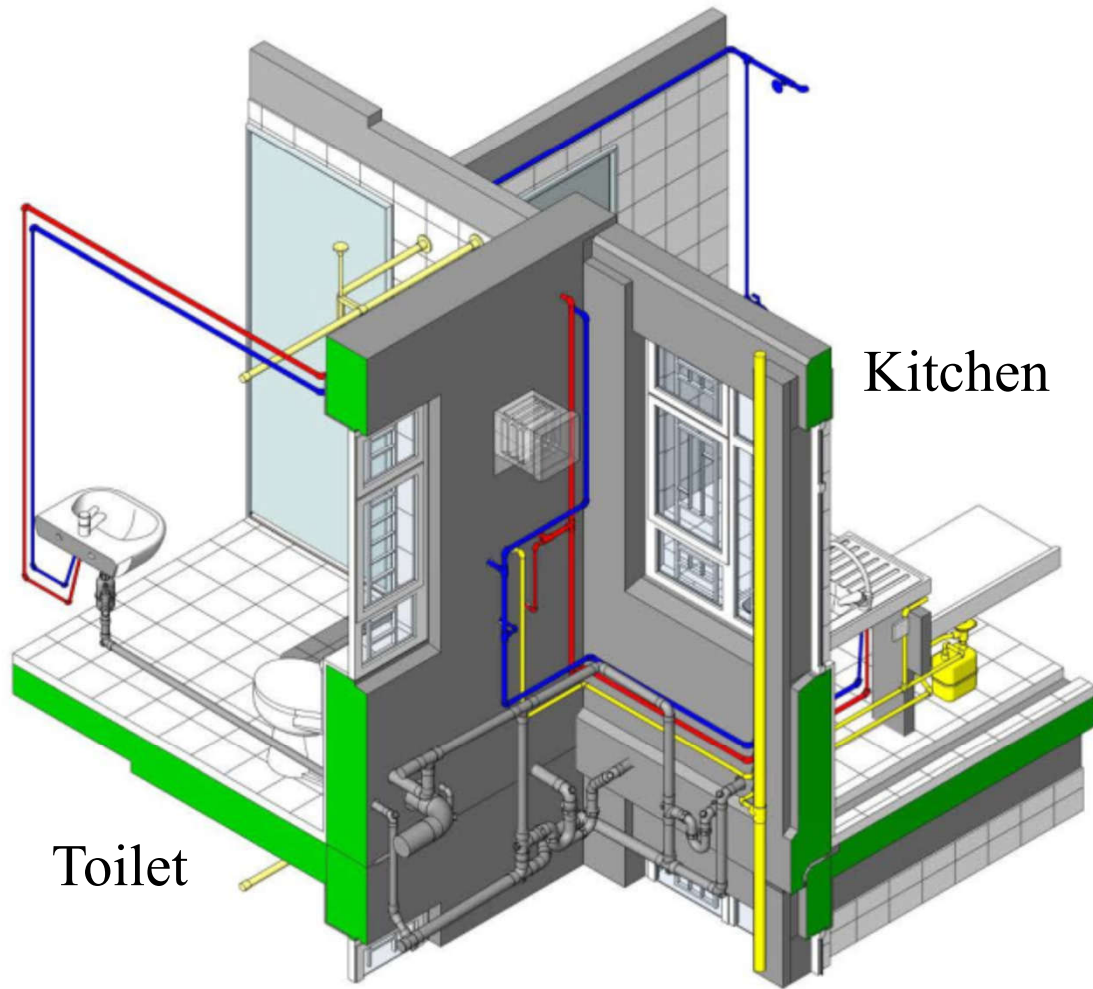
Meter (consumer is responsible for its custody & WSD its maintenance)

Sketch No.4

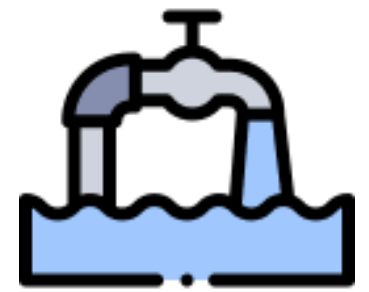
Communal plumbing system (maintained by property management office or agent)

Government main (maintained by WSD)

Typical plumbing layout inside a residential flat

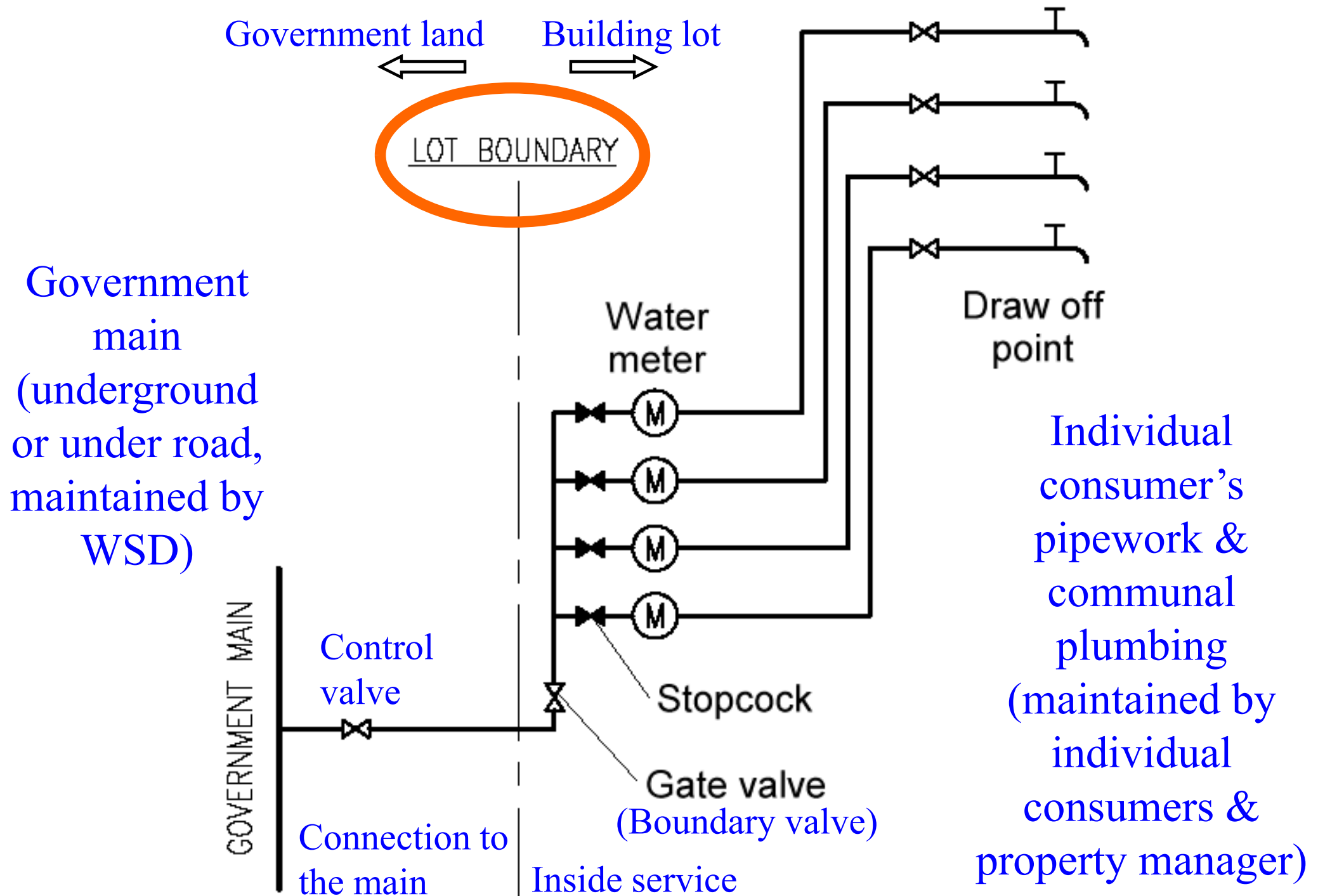


Water supply distribution

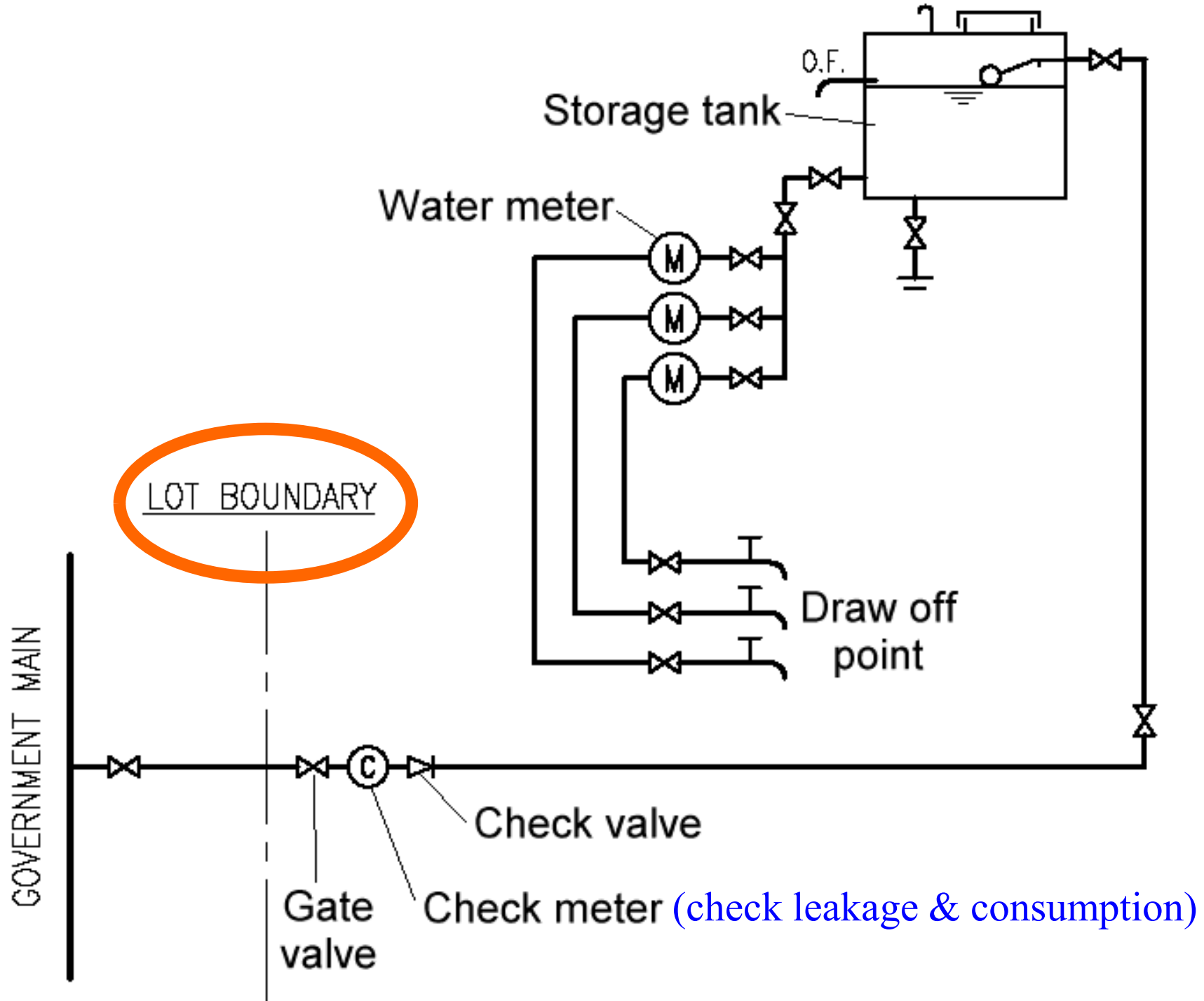


- Water supply systems in buildings
 - *Direct supply system*: conveys water directly from water mains to the point of usage without any transit water storage tanks
 - *Indirect supply system*: conveys water from water mains to the point of usage through a transit water storage tank (usually a sump water tank and a roof water tank)
- Potable/fresh water, flushing/salt water and water for fire services (e.g. FH/HR, sprinkler)

Direct supply system (without storage tank)

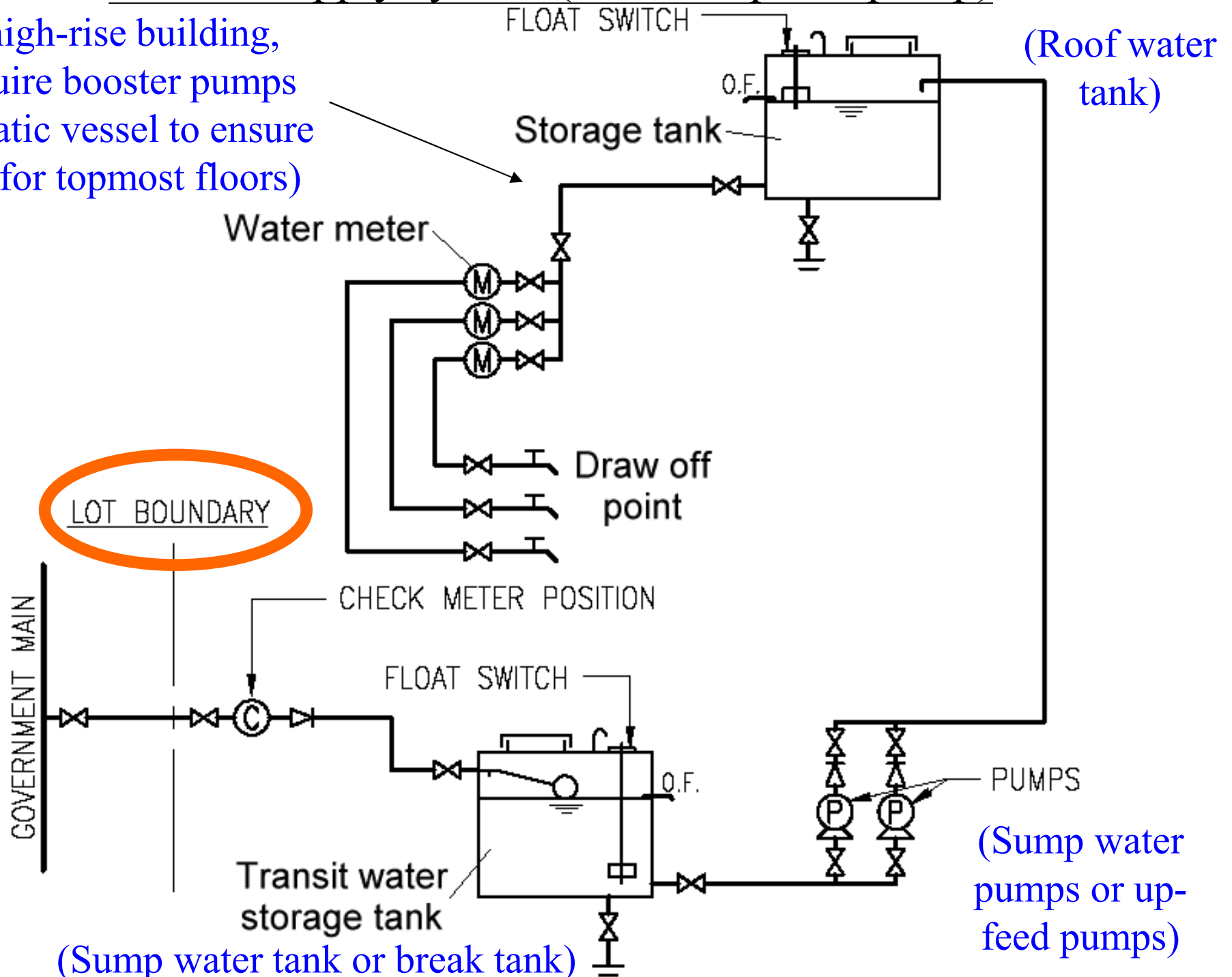


Direct supply system (with storage tank)



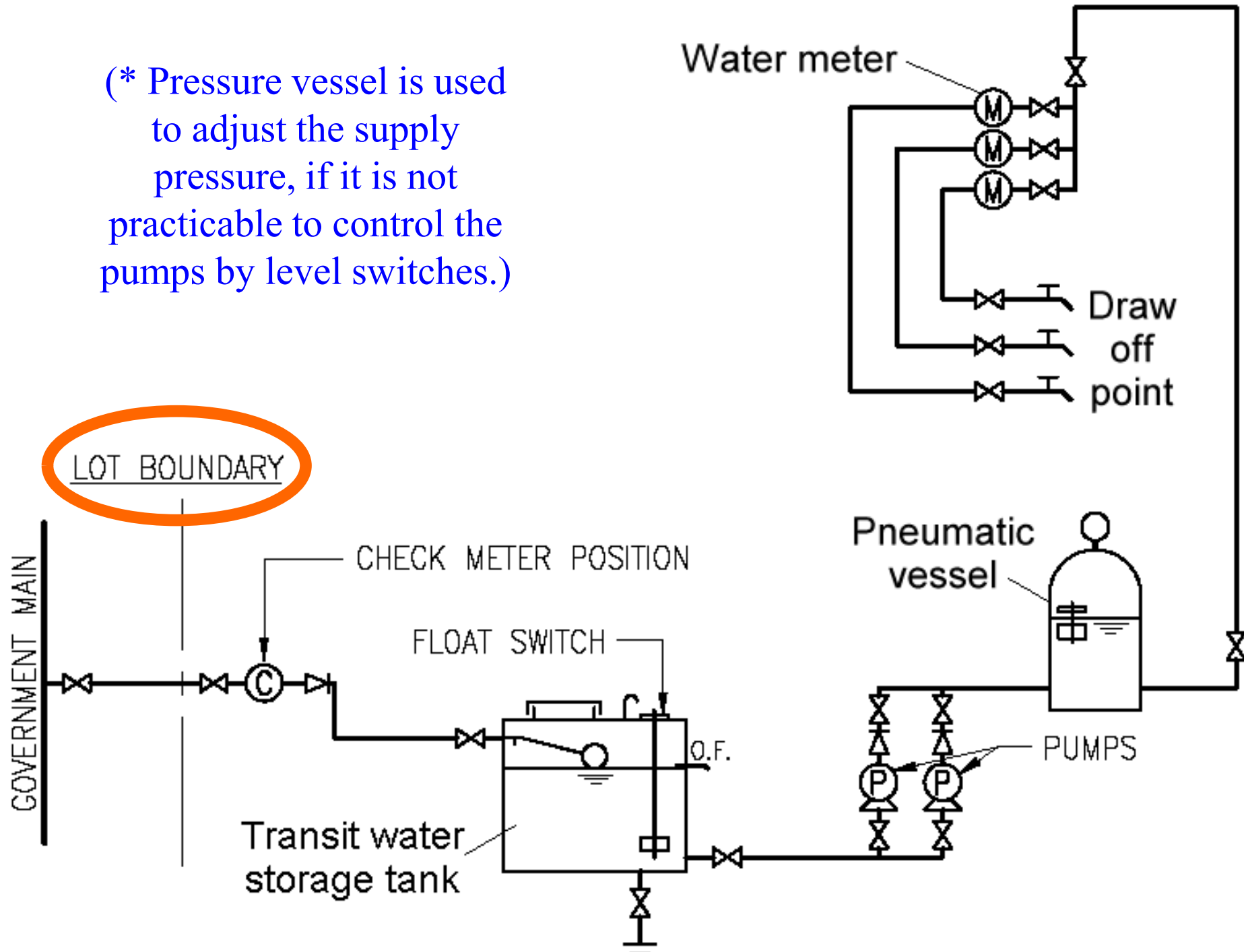
Indirect supply system (with sump and pump)

(For a high-rise building, may require booster pumps & pneumatic vessel to ensure pressure for topmost floors)



Indirect supply system (with pneumatic vessel)

(* Pressure vessel is used to adjust the supply pressure, if it is not practicable to control the pumps by level switches.)



Comparison of direct and indirect water supply systems

Direct supply	Indirect supply
- Less pipework, smaller or no water tank	- More pipework, large water storage tank
- No storage to satisfy peak demand period	- Water storage to meet peak demand
- Risk of contamination and pressure fluctuation of mains	- Less risk of adverse effects by water mains
- Not feasible for high-rise buildings due to main pressure	- Can be used in high-rise buildings



Water tanks & pumps

- Water tanks
 - Materials: reinforced concrete, fibre glass, etc.
 - Reinforced concrete is the most common material used
 - Fibreglass storage cistern for potable water shall be of an approved type or certified, with no toxic materials and suitable for storage of potable water
 - Storage capacities:
 - Assessment of water consumption & demand
 - Proportion:- Sump tank : Roof tank = 1 : 3
 - Recommend to meet one-day (24 hours) demand
 - Domestic supply – follows WSD recommendations

Recommended storage capacities in water supply systems

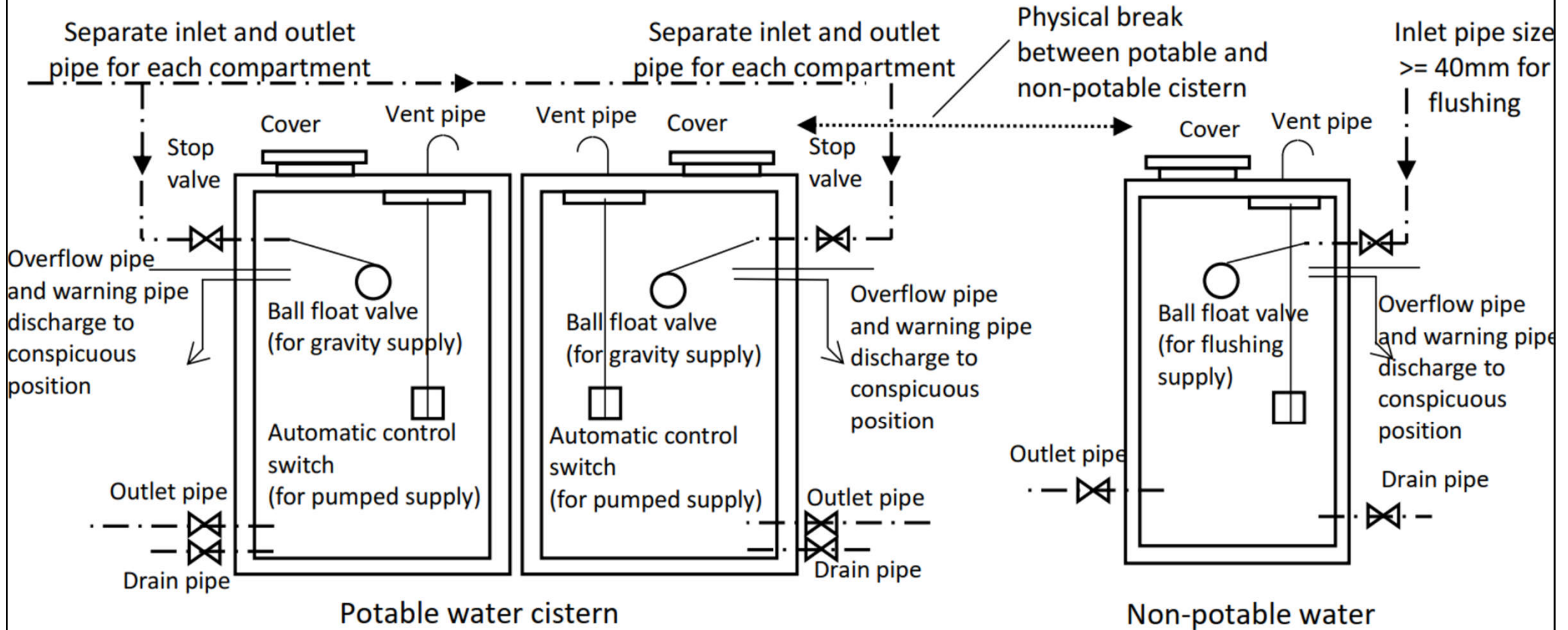
Domestic water supply with sump and pump		Flushing supply using salt water*	Temporary mains fresh water for flushing (TMF)
Up to 10 flats	> 10 flats		
135 litres/flat (total storage including sump tank)	90 litres for each additional flat	Minimum 1/2 day consumption	45 litres per flushing apparatus, minimum 250 litres

* For industrial use, recommended storage capacity is one-day demand.

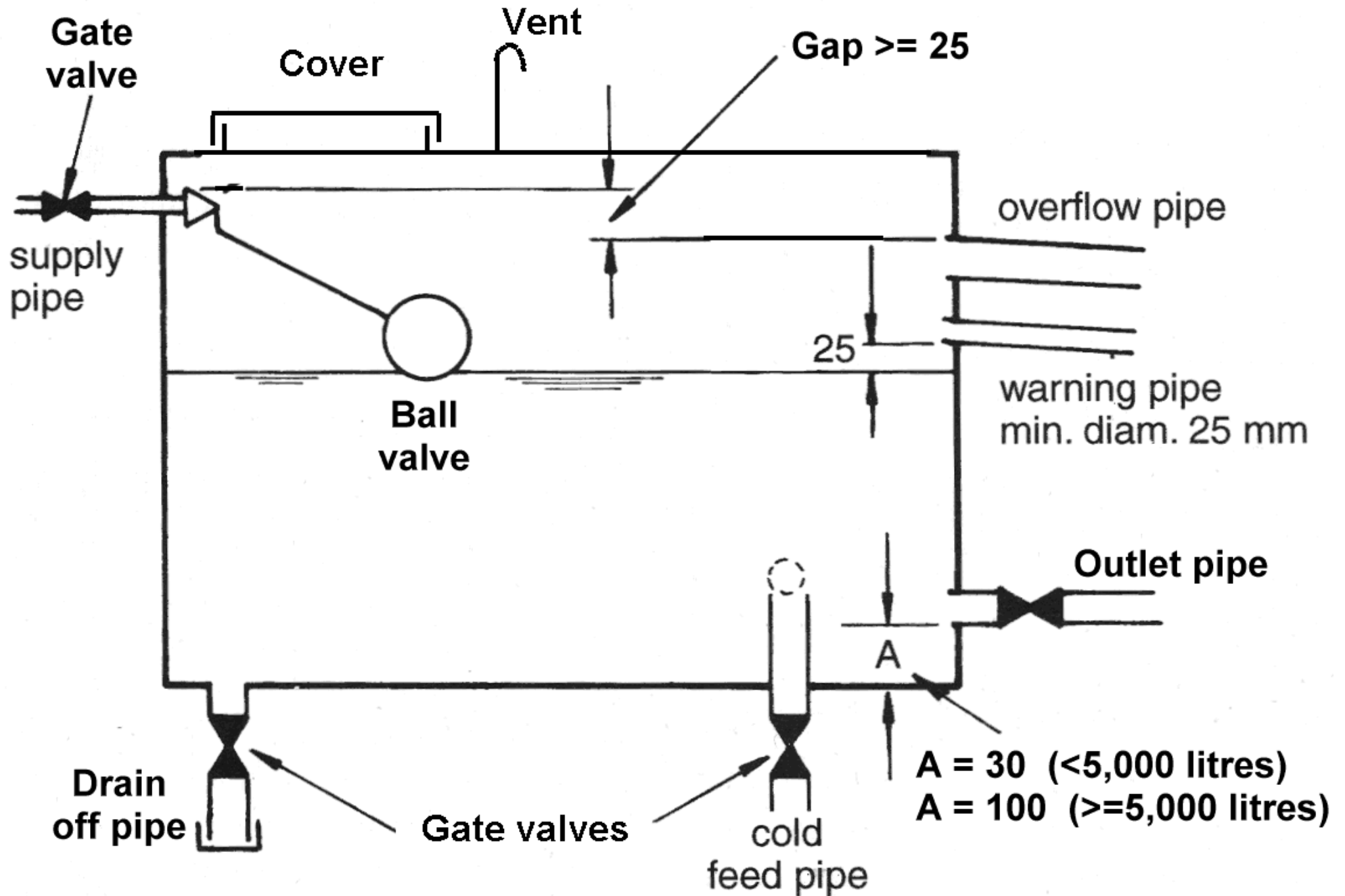
Design criteria for flushing water storage: (Litres per flushing apparatus)
[minimum capacity = 250 litres]

1. Residential: - Water closet	30
2. Commercial - Urinal	30
- Water closet	40

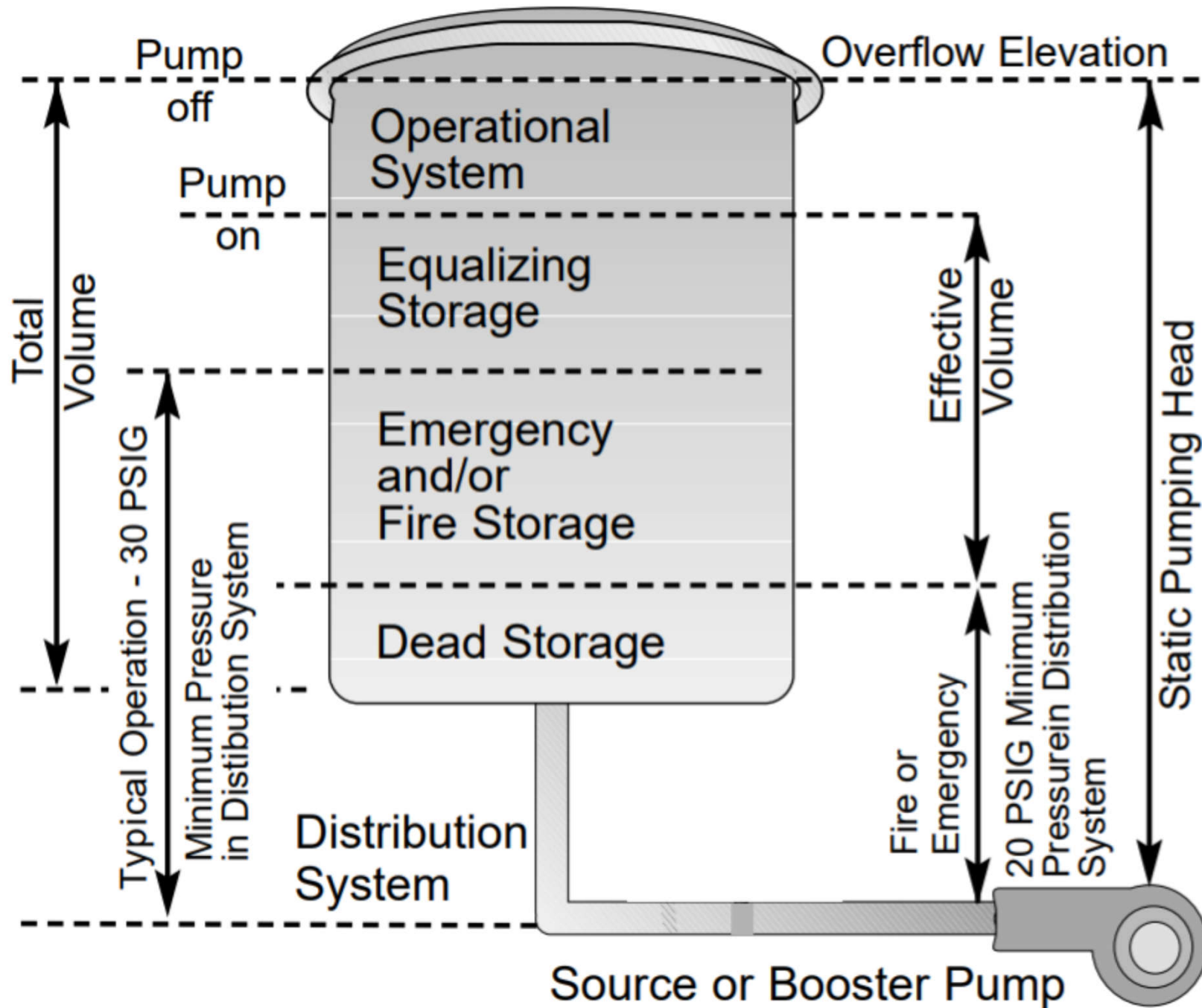
Typical components of water cisterns (storage tanks)

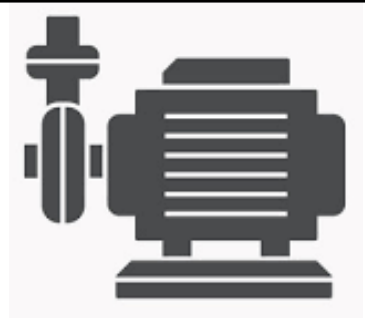


Water tank basic requirements (for a gravity supply)



Storage volume classification





Water tanks & pumps

- Cleansing of water storage tanks
 - Such as sump tank & roof tank
 - They should be cleansed once every three months
- Maintenance of internal plumbing
 - WSD maintains the water supply distribution system up to the building lot boundaries
 - Internal & communal plumbing are maintained by the consumers

Common problems for maintenance of water storage tanks



Double sealed tank cover with lock



Damaged water tank cover



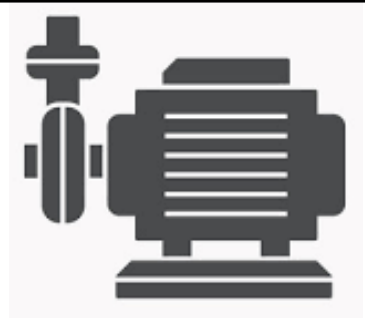
Water tank not cleaned



Rusty water tank cover



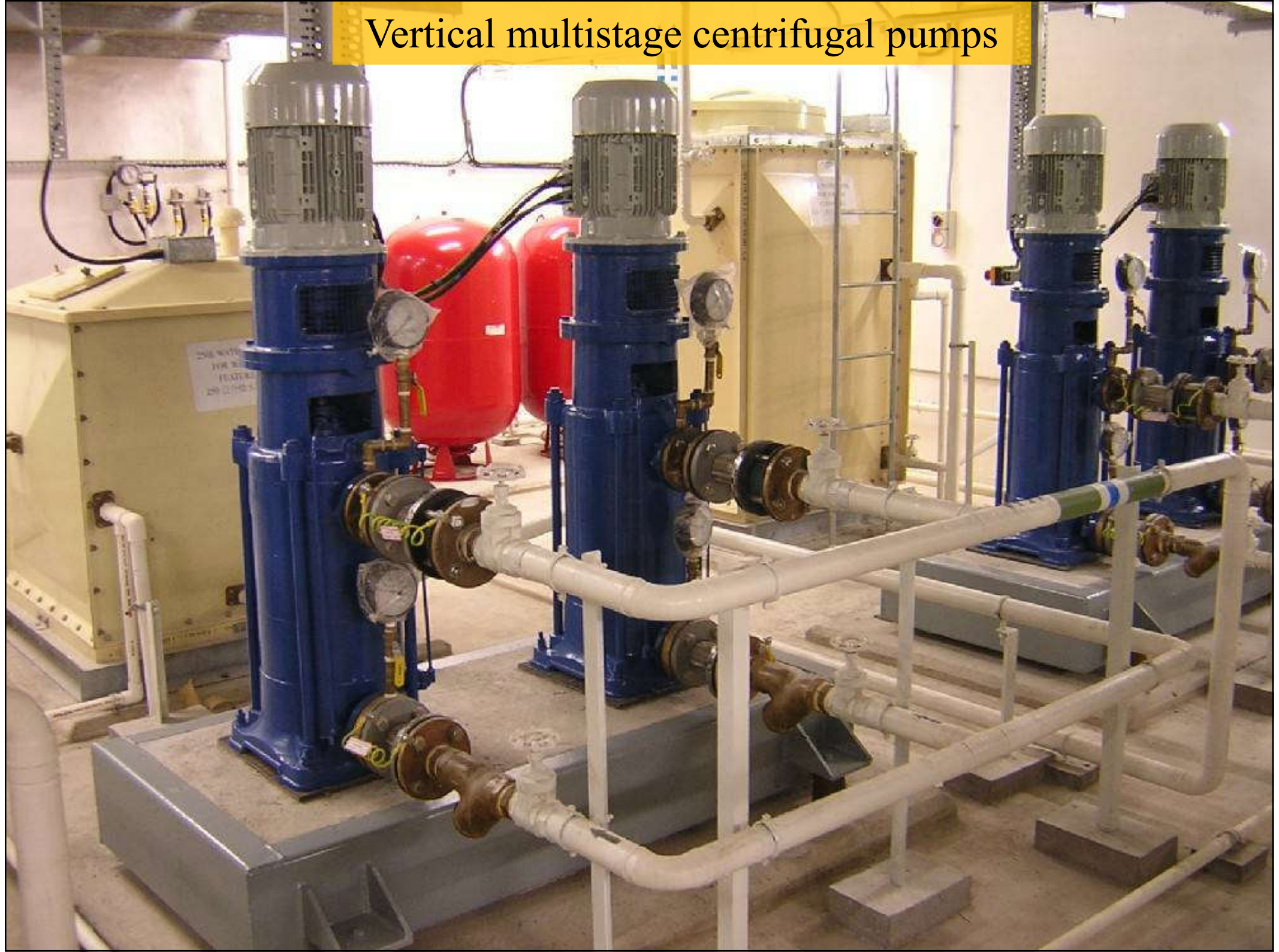
Storage tank without proper maintenance & management



Water tanks & pumps

- Water pumps
 - Provide a duplicate set (duty + standby)
 - Pumping capacity \geq designed out-flow of tank
 - Minimise vibration and noise problems
 - Adequate pipework support & anchor
 - Solid foundation
- Common pump types
 - Horizontal end suction centrifugal
 - Vertical multistage centrifugal

Vertical multistage centrifugal pumps

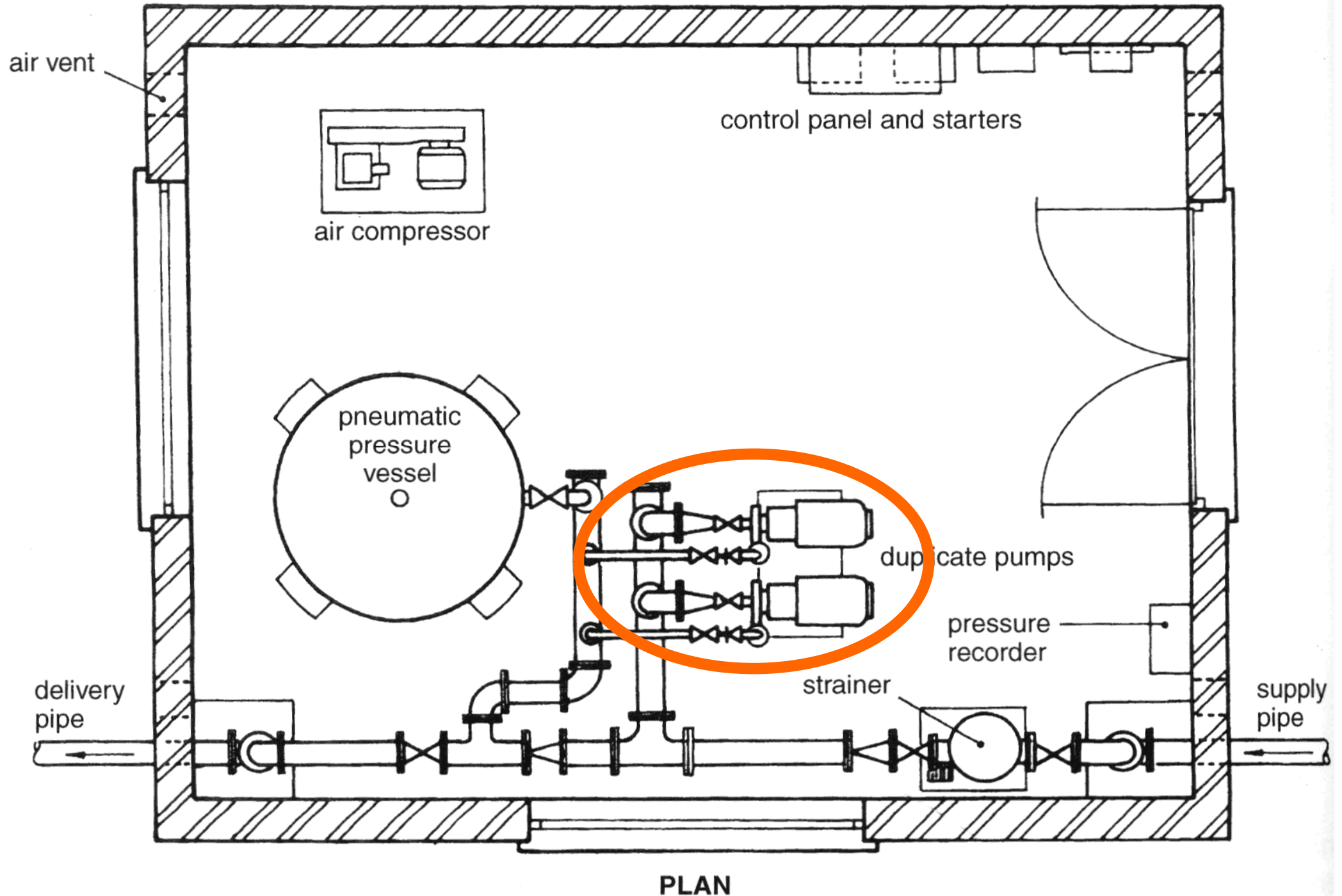




Water tanks & pumps

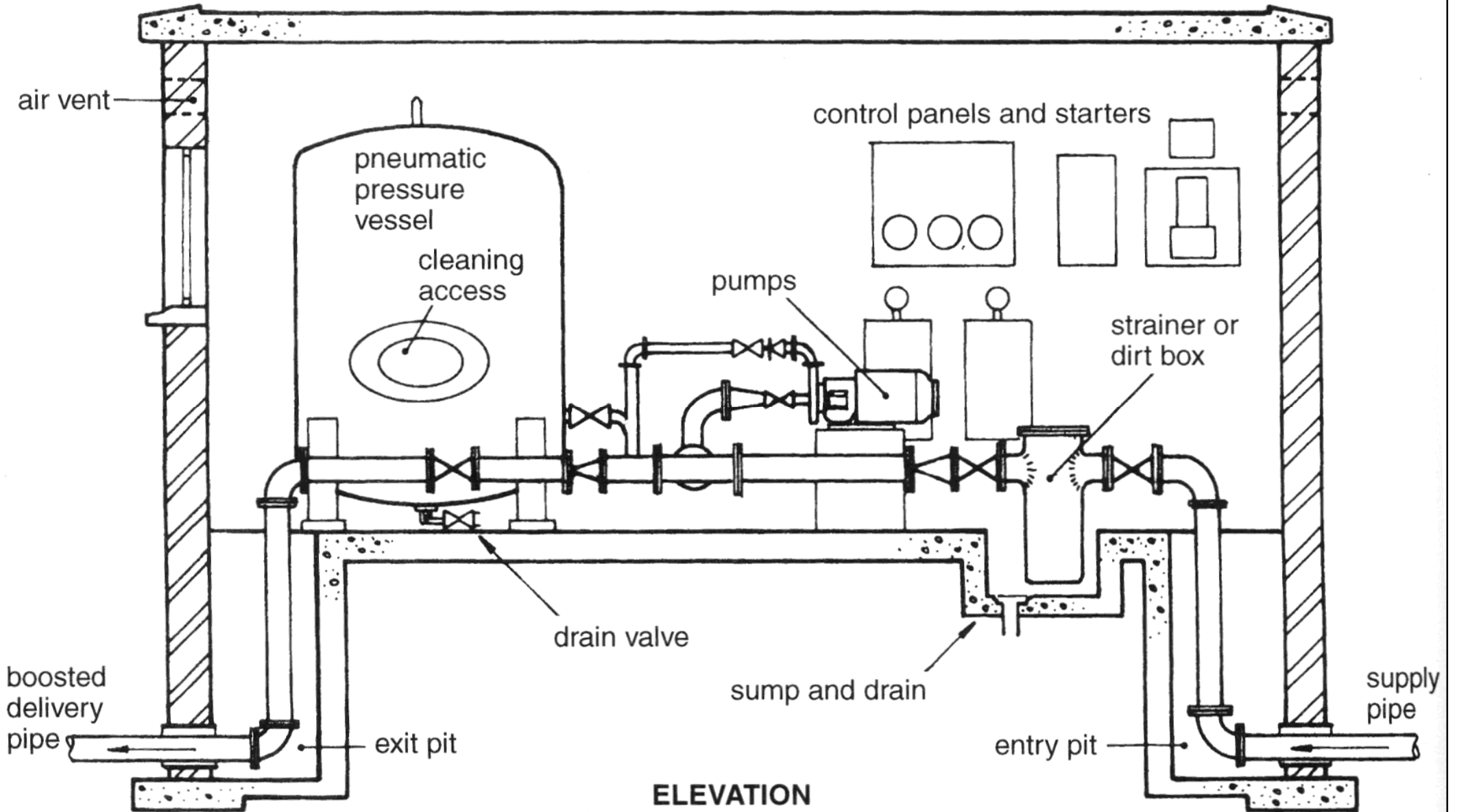
- Pump control
 - Automatic control using pressure switches, level switches, high-level & low-level electrodes
 - Pump selector switch & ON/OFF/AUTO
 - Low-speed preferred (longer life & quiet)
- Pump motor
 - Such as squirrel cage induction type
 - Overload protection (electrical)

Typical pump room (layout plan)



(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)

Typical pump room (elevation)





Water quality & management

- Water Safety Plan (WSP)
 - Developed by WSD in 2007 in accordance with WHO's recommendations
 - Launched an integrated Drinking Water Quality Management System (DWQMS) in 2017



- Water quality policy
- Principle of water quality management
- Health-based targets
- Water safety plans
- Surveillance



Drinking Water Quality Management System

Framework for Safe Drinking Water





Water quality & management

- Quality Water Supply Scheme for Buildings

- <https://www.wsd.gov.hk/en/core-businesses/water-quality/buildings/>

- To encourage building owners to maintain their plumbing systems properly

- Fresh Water (Management System)
 - Fresh Water (Plus)
 - Flushing Water

- There are 3 grades of certificates:

- Blue Certificates: New application or renewal with < 3 years
 - Silver Certificates: Continuous participation 4-6 years
 - Gold Certificates: Continuous participation \geq 6 years

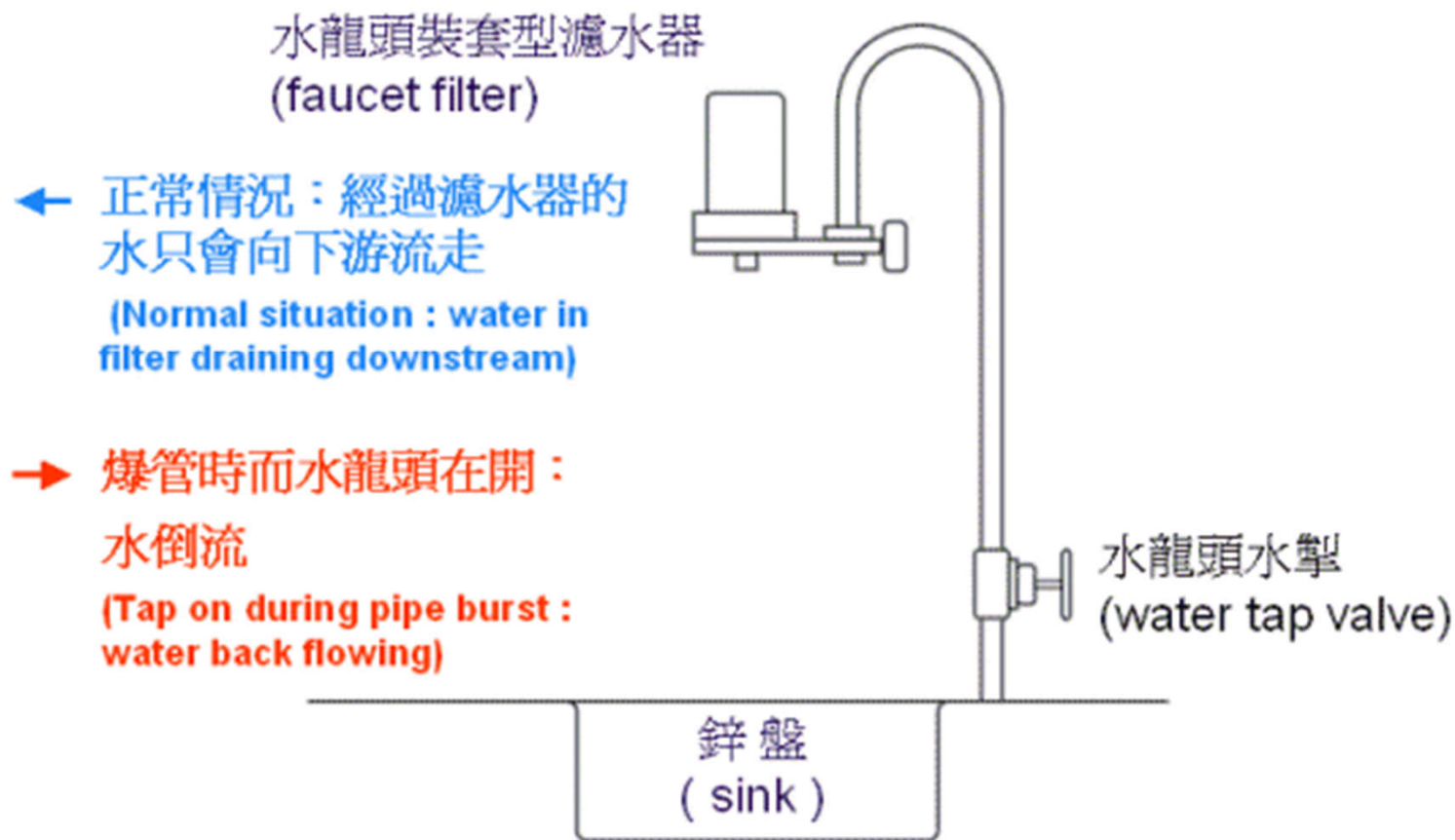




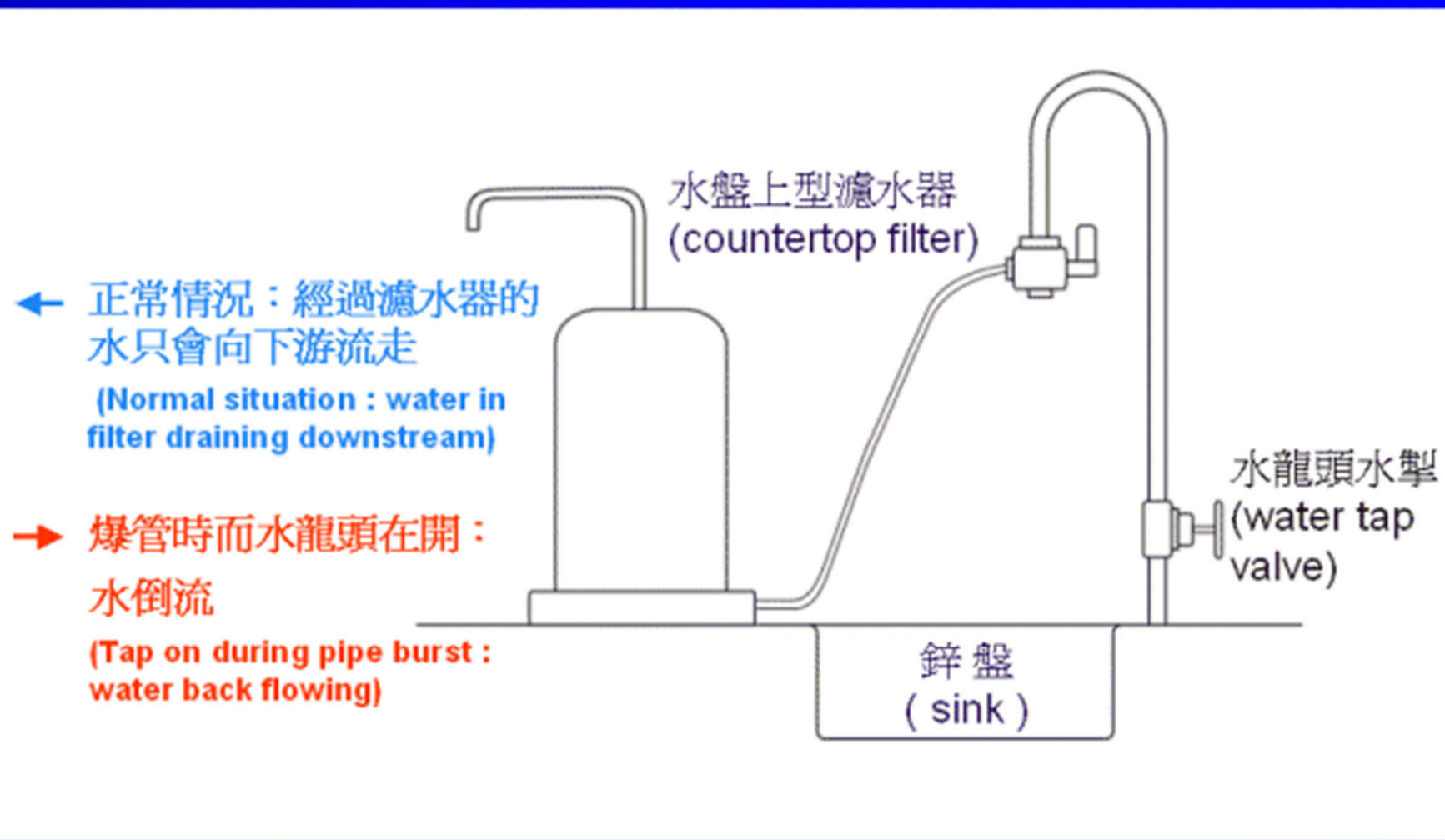
Water quality & management

- Treated water supplied by WSD at the connection points fully complies with the WHO guidelines for drinking water
- If the water is free from contamination within the plumbing system in a building, it is not necessary to use filter or purifier
- If a filter or purifier is used, it should be properly cleaned & maintained. Non-return valve may be needed to prevent back-flowing

圖二：水龍頭裝套型濾水器 (Fig 2 : Faucet filter)



圖三：水盤上型濾水器 (Fig 3 : Countertop filter)

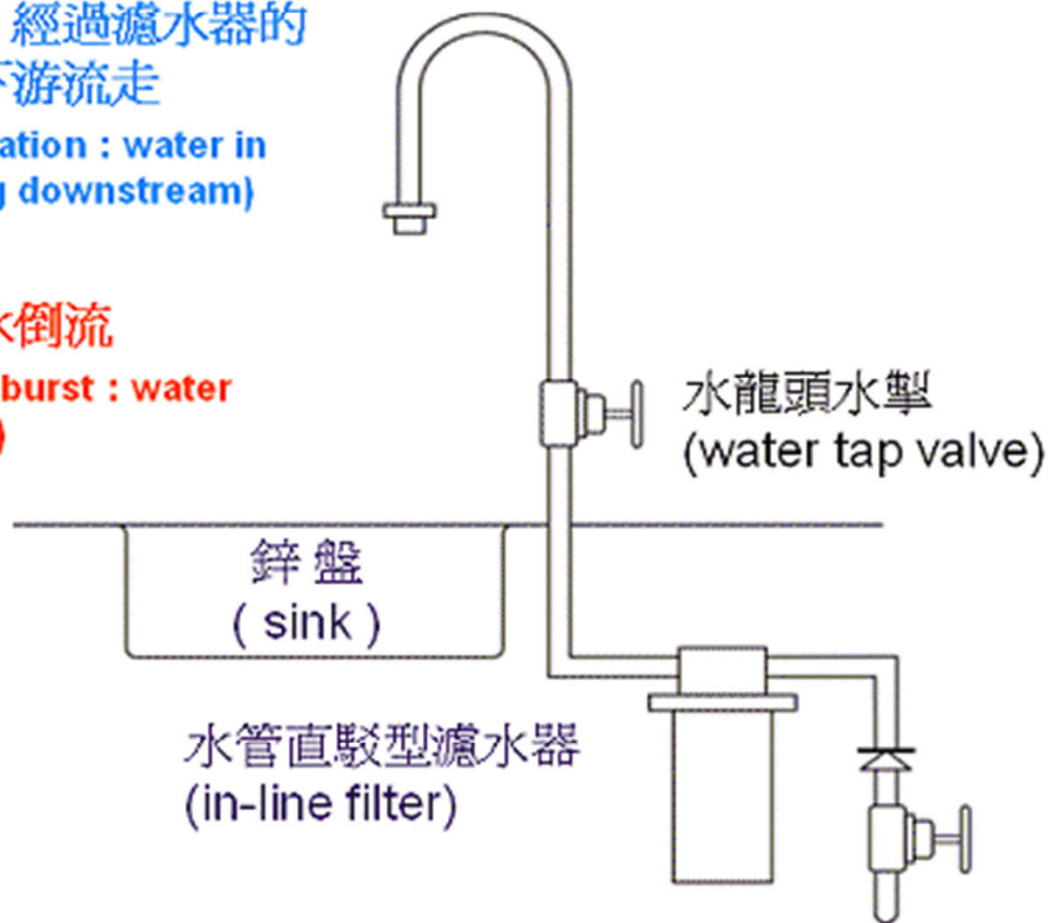




圖六：水管直駁型濾水器 (Fig 6 : In-line filter)

← 正常情況：經過濾水器的水只會向下游流走
(Normal situation : water in filter draining downstream)

→ 爆管時：水倒流
(During pipe burst : water back flowing)





Water quality & management

- In 2000-2015, WSD has launched a programme to replace or rehabilitate the aged water mains in stages
 - For both fresh water & salt water supplies
 - About 3,000 km of water mains (in a network of 7,600 km) were completed in 15 years





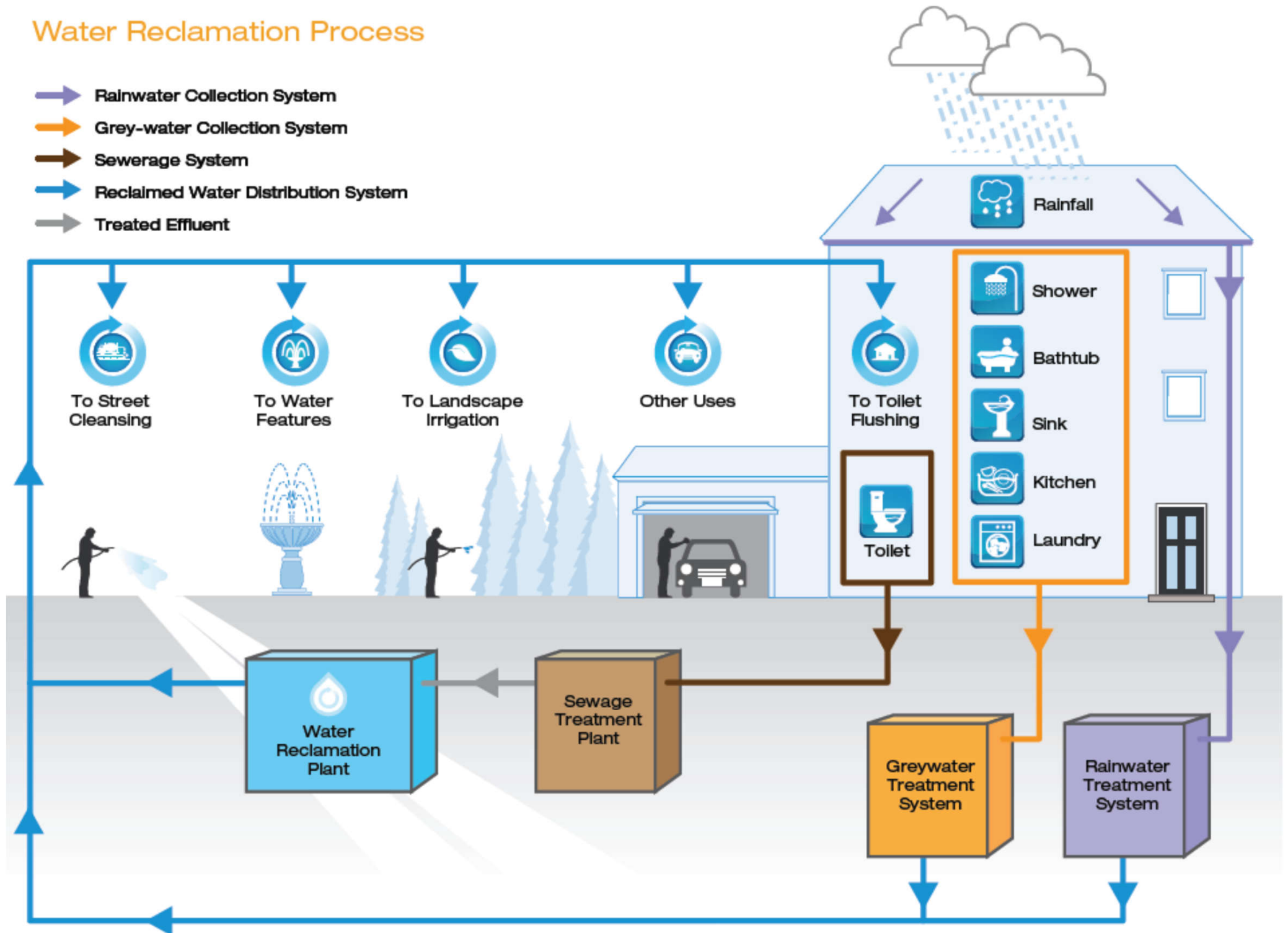
Water quality & management

- Total Water Management (TWM) strategy
 - Water demand management
 - To enhance public education on water conservation
 - To promote use of water saving devices
 - To enhance water leakage control
 - To extend use of seawater for toilet flushing
 - Water supply management
 - To strengthen protection of water resources
 - To actively consider water reclamation (reuse of greywater & rainwater harvesting)
 - To develop the option of seawater desalination



Water Reclamation Process

- ➔ Rainwater Collection System
- ➔ Grey-water Collection System
- ➔ Sewerage System
- ➔ Reclaimed Water Distribution System
- ➔ Treated Effluent



(Source: Water Supplies Department www.wsd.gov.hk)



Water quality & management

- Development of new water supply sources
 - Seawater desalination
 - Using reverse osmosis (RO) technology
 - Reclaimed water
 - Primarily for non-potable uses
 - Convert the tertiary treated sewage effluent into reclaimed water for toilet flushing
 - Grey water reuse and rainwater harvesting
 - Stormwater management and harvesting



Water quality & management

- Promoting water conservation
 - Water Efficiency Labelling Scheme (WELS)
 - Automatic meter reading
 - Public education
 - Water use efficiency guidelines
 - Water loss management (reduce leakages)
 - Water intelligent network (WIN) (monitor water loss)
 - Underground asset (water mains) management
 - Expand the use of low grade water (e.g. seawater flushing)

Voluntary Water Efficiency Labelling Scheme (WELS)



Showers for Bathing



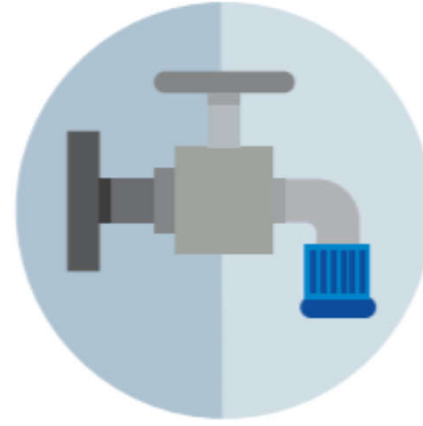
Water Taps



Urinal Equipment



Washing Machines



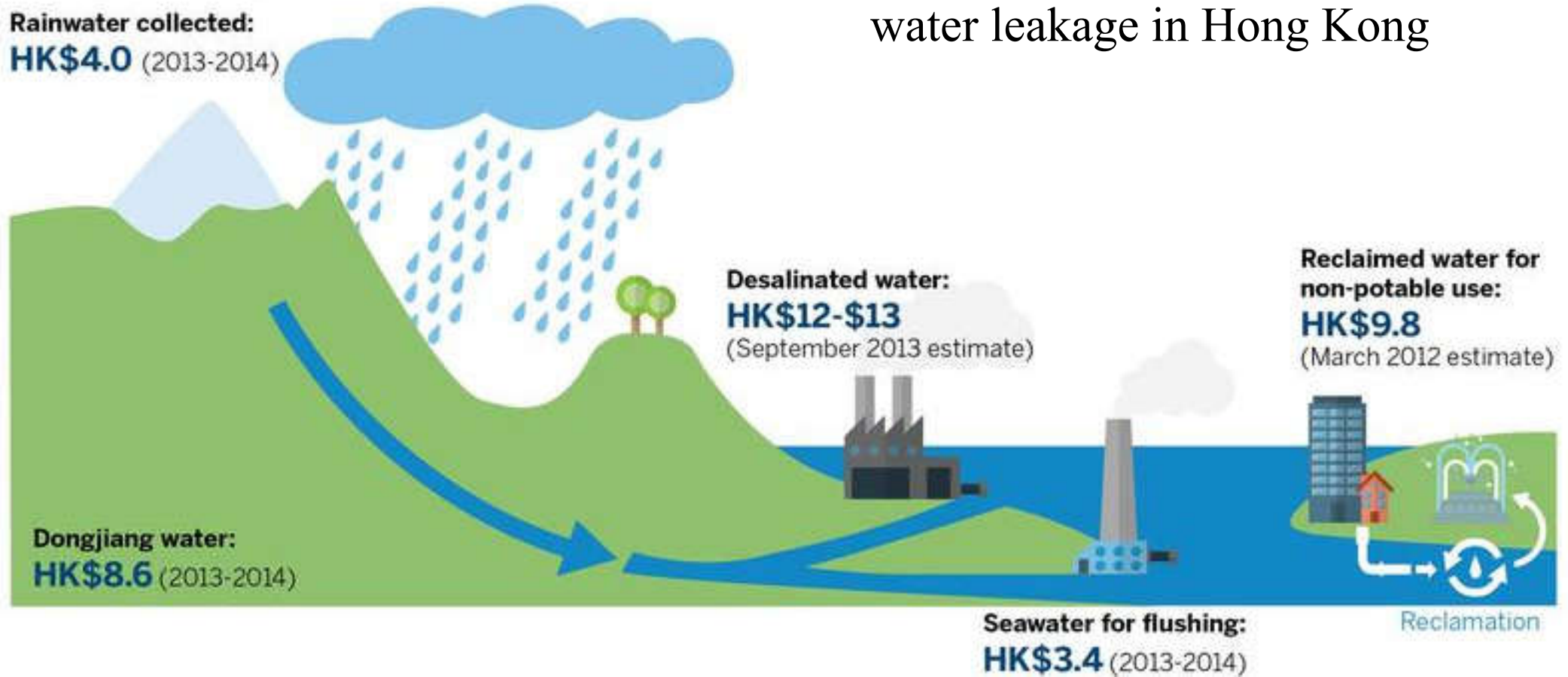
Flow Controllers



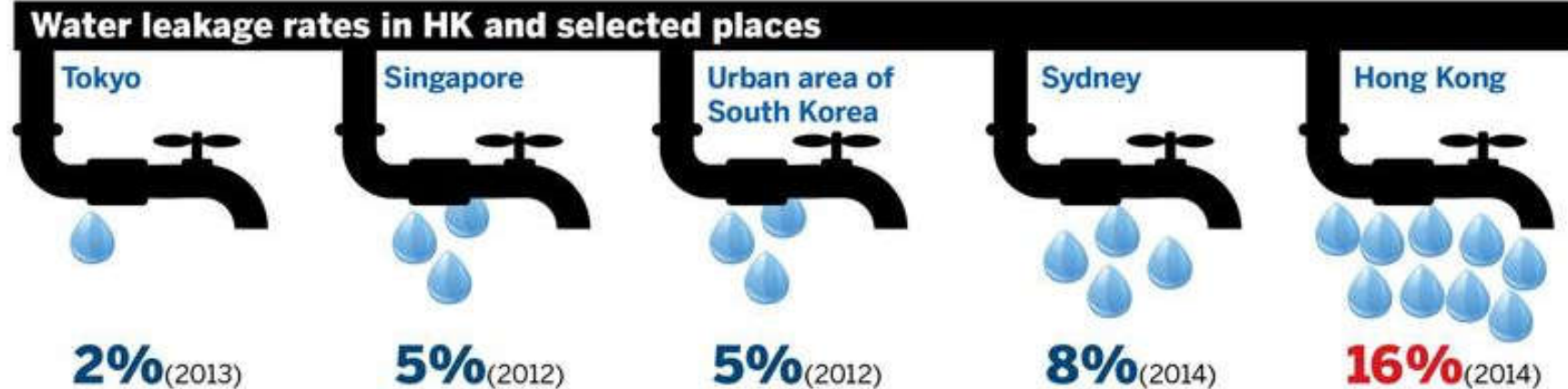
Water Closets

Production cost of water supply in HK (per cu m)

Rainwater collected:
HK\$4.0 (2013-2014)



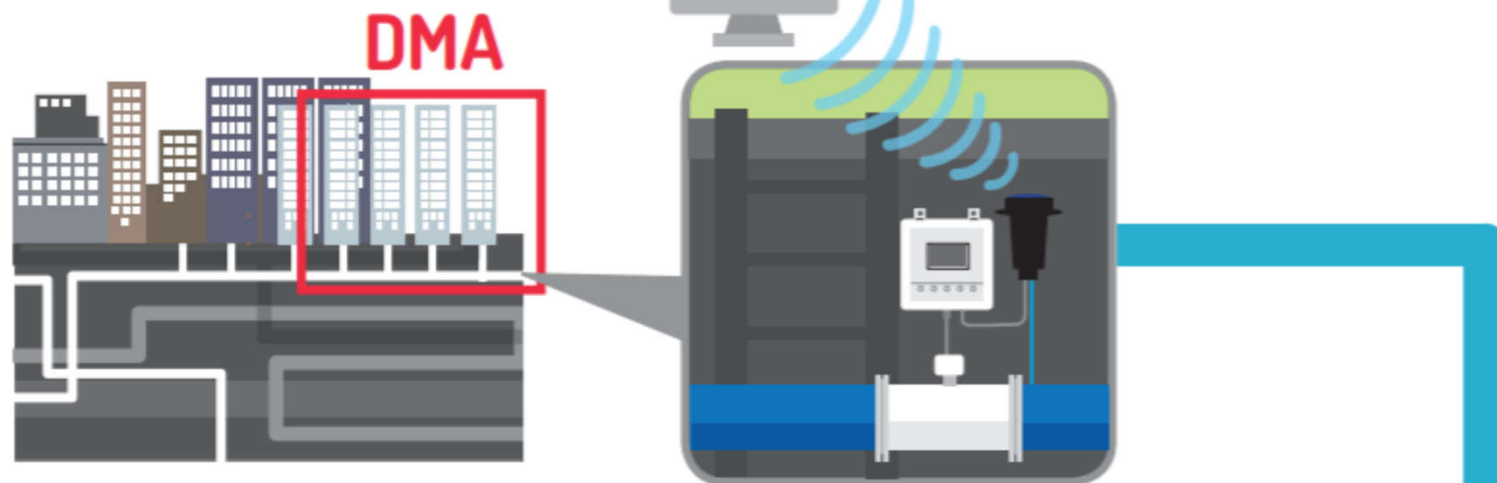
Production cost of water supply and water leakage in Hong Kong



Water intelligent network (WIN) (monitor water loss)

Fresh water distribution network divided in about 2,400 District Metering Areas (DMAs)

Monitoring and sensing equipment



Determination of the most effective network management measures

ACTIVE LEAKAGE DETECTION & CONTROL

PRESSURE MANAGEMENT

QUALITY & SPEEDY REPAIR

WATER MAINS REPROVISIONING

Intelligent Network Management System

INSIGHT

INFORMATION ANALYSIS

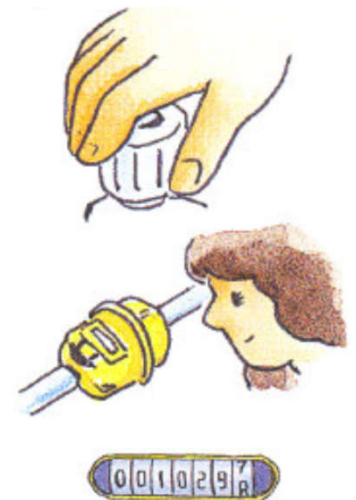
DATA COLLECTION





Water quality & management

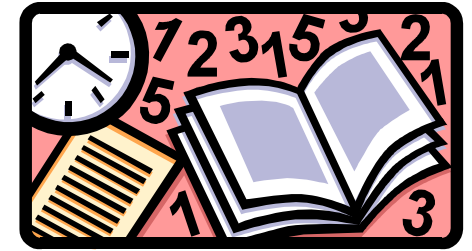
- Inspect & maintain plumbing to prevent water leaks
- Checking of water leakage: simple method
 - Turn off all water taps
 - Compare the water meter reading over a 30-minutes period
 - If the water meter registers flow when all water taps are turned off, it implies leaking
- However, this method cannot detect very small leakage (seepage)





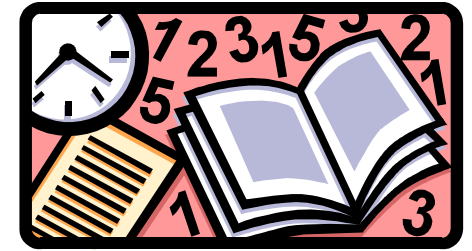
Further Reading

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 - https://en.wikipedia.org/wiki/Water_supply_and_sanitation_in_Hong_Kong
- Water Treatment in Hong Kong
 - https://www.wsd.gov.hk/filemanager/en/share/pdf/water_treat.pdf
- WSD & CIC, 2017. *Good Practice Guide on Plumbing Works*, Water Supplies Department (WSD) & Construction Industry Council (CIC), Hong Kong.
 - <https://www.wsd.gov.hk/en/plumbing-engineering/good-practice-guide-on-plumbing-works/>
- Total Water Management Strategy
 - <https://www.wsd.gov.hk/en/core-businesses/total-water-management-strategy/>



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- Garrett, R. H., 2008. *Hot and Cold Water Supply*, 3rd ed., Chichester, West Sussex, U.K.
- Hall F. & Greeno R., 2017. *Building Services Handbook*, 9th ed., Routledge, Oxon & New York.
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- WSD, 2018. *Handbook on Plumbing Installation for Buildings*, Water Supplies Department (WSD), Hong Kong.
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