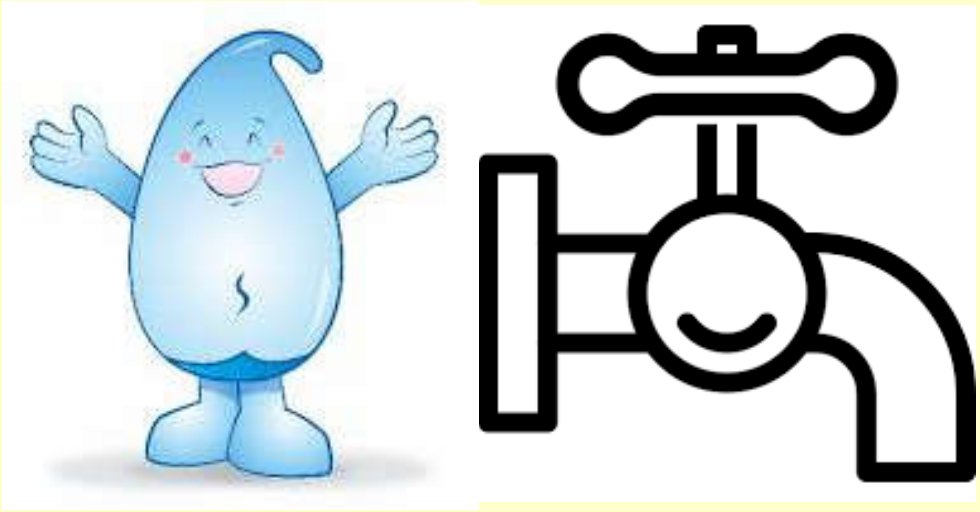

3. Plumbing and Drainage Part 1

3.1 Cold and hot water systems

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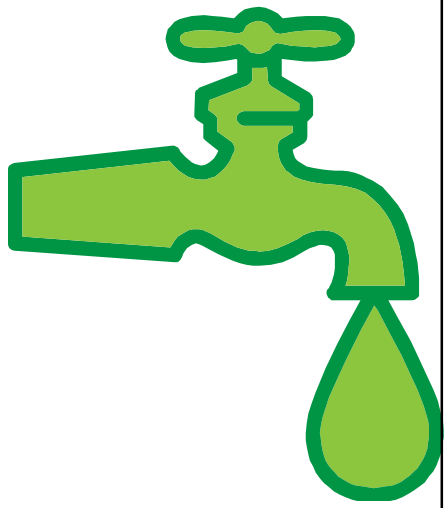
Mar 2021

Contents

- Water supply in Hong Kong
- Cold water systems
- Hot water systems
- Water heaters

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://youtu.be/yQVyRG6P09s

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 (Dongjang)
  - 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)

1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974

1957
Use of seawater for toilet flushing in Shek Kip Mei and Lei Cheng Uk Estate

1960
Water Supply Agreement with Guangdong Supply from Shenzhen Reservoir

1963
Completion of Shek Pik Reservoir
24.5 mcm capacity

1968
Completion of Plover Cove Scheme and Extension in 1973
230 mcm capacity

1959
Completion of Tai Lam Chung Reservoir
20.5 mcm capacity

June 1963 - May 1964
Severe Water Rationing
4 hours of supply every 4 days

1965
Completion of Lower Shing Mun Reservoir
4.3 mcm capacity

1965
Water Supply Agreement with Guangdong
68.2 mcm/year of Dongjiang water supply

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

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

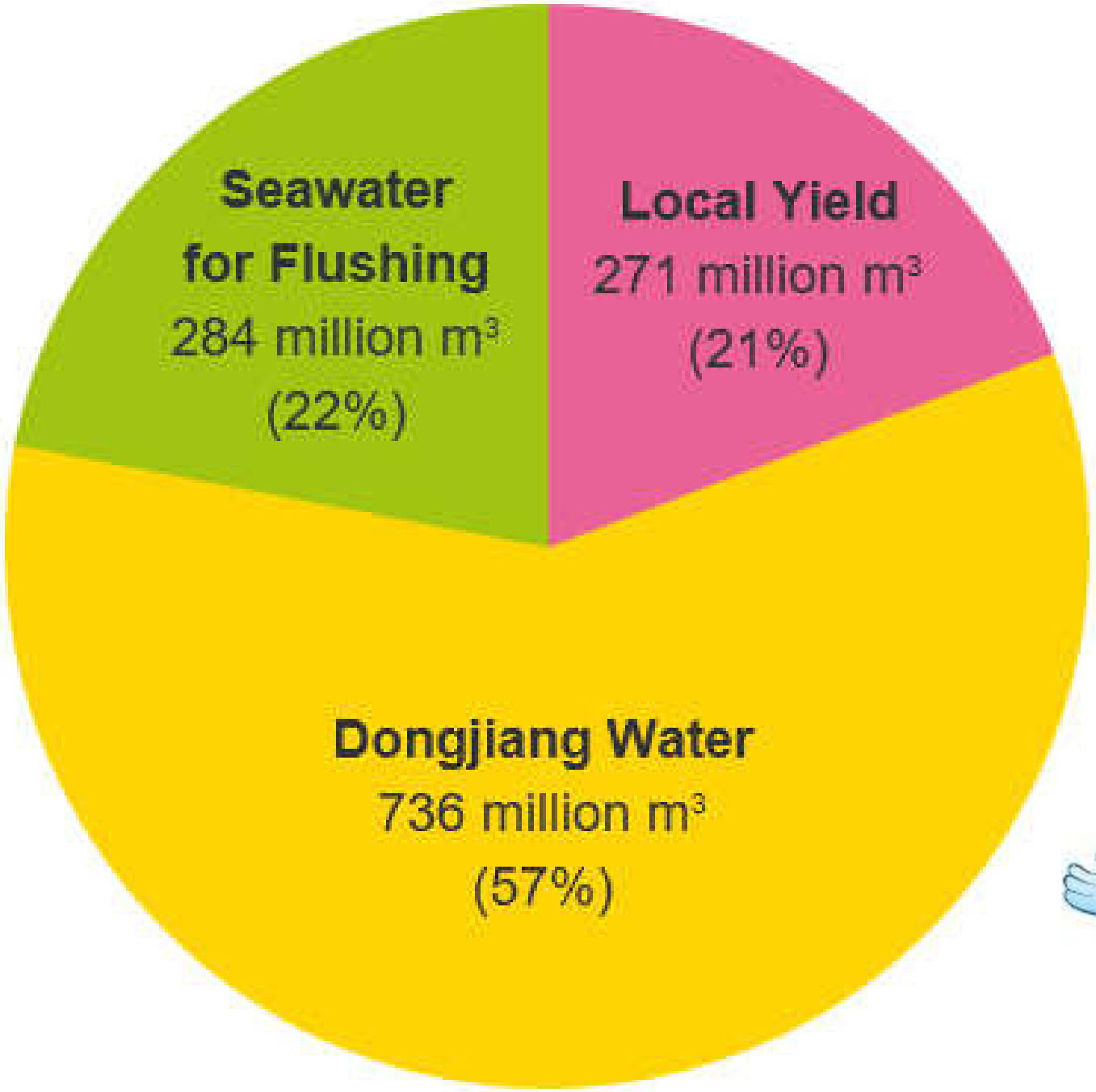
1981-1982
Last water rationing
in Hong Kong

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

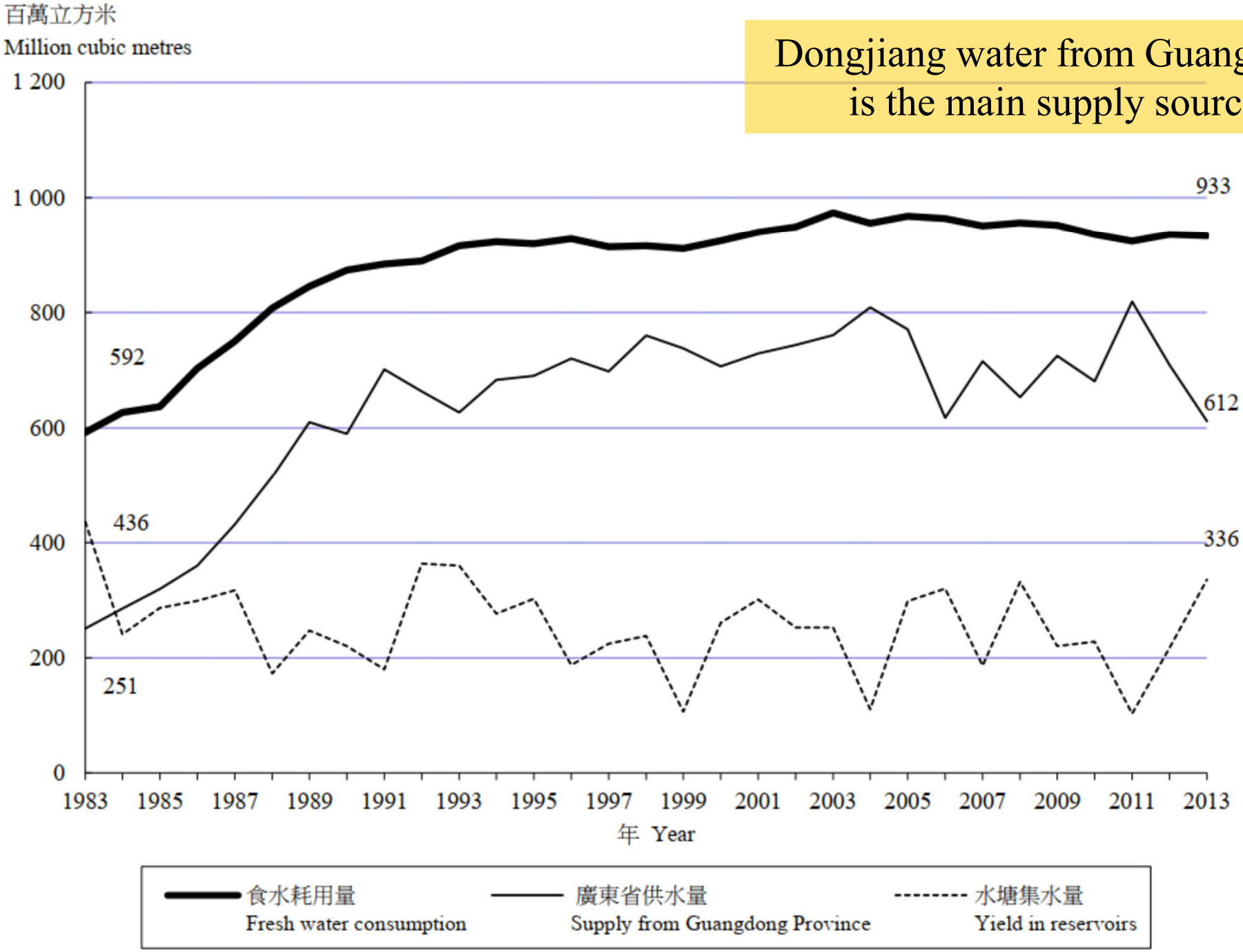
(Source: Water Supplies Department www.wsd.gov.hk)

Water consumption in Hong Kong in 2018 (1.292 billion m^3)



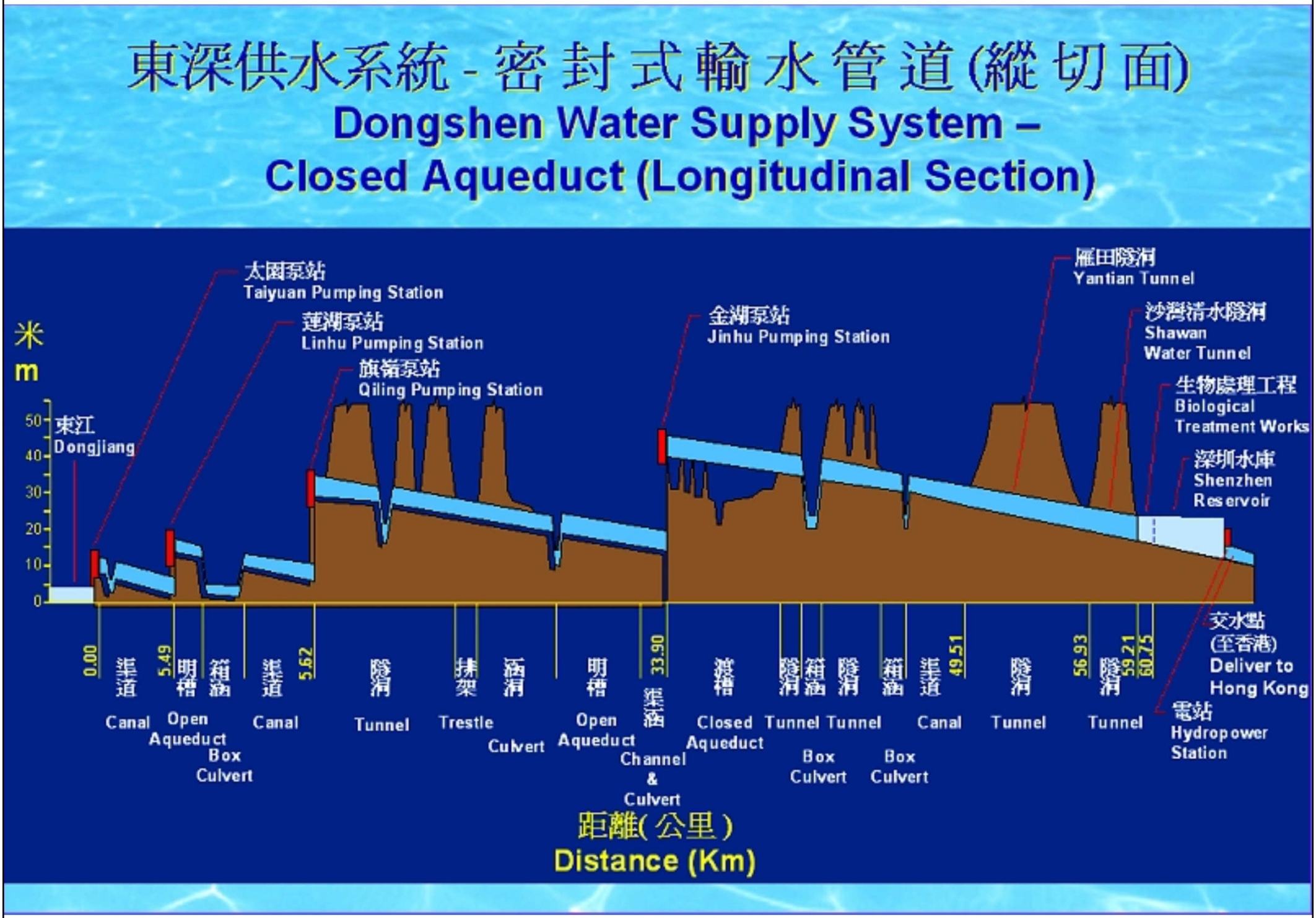
(Source: Water Supplies Department www.wsd.gov.hk)

Fresh water consumption and supply in Hong Kong

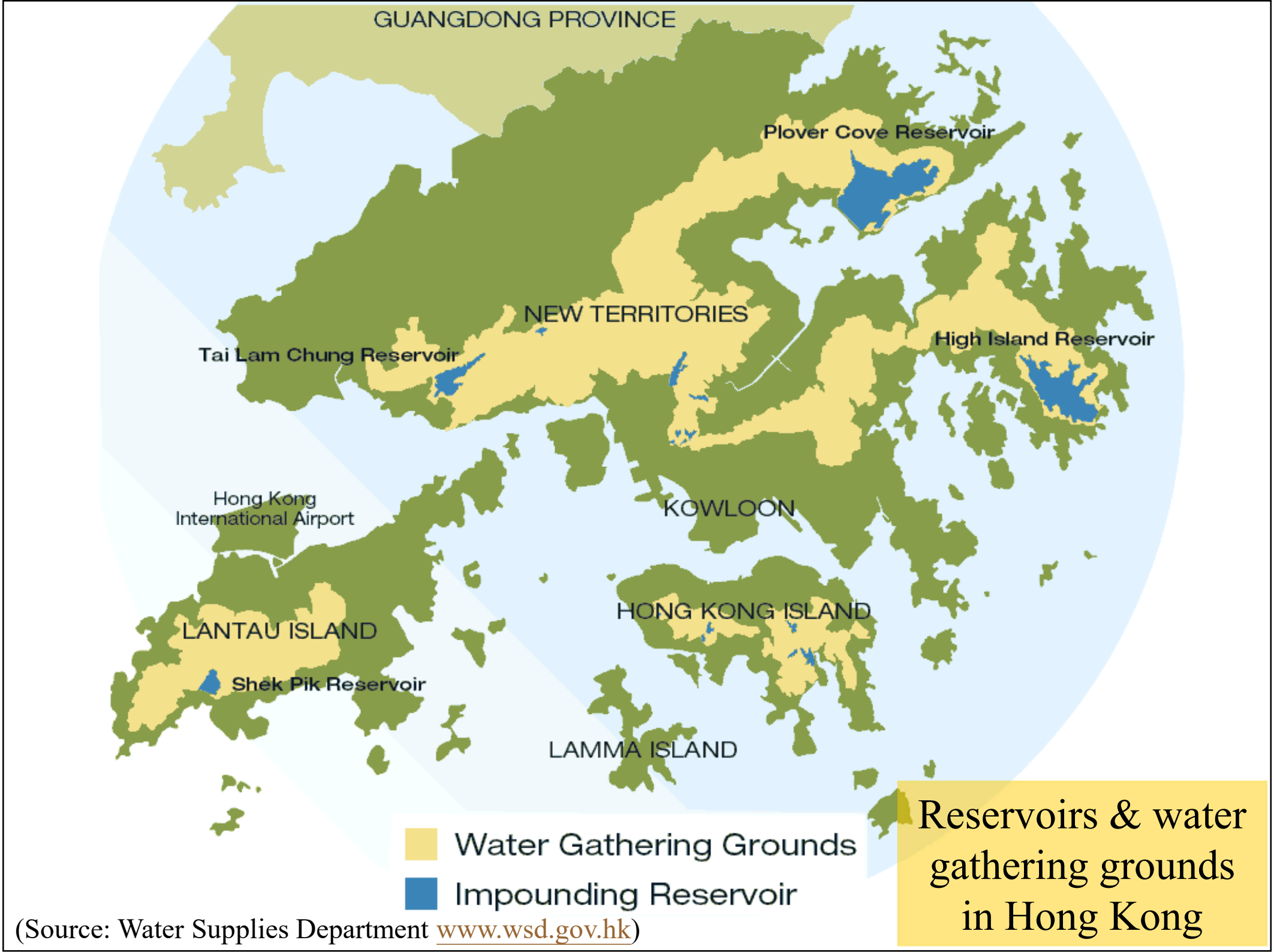


Dongjiang water from Guangdong is the main supply source

(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)

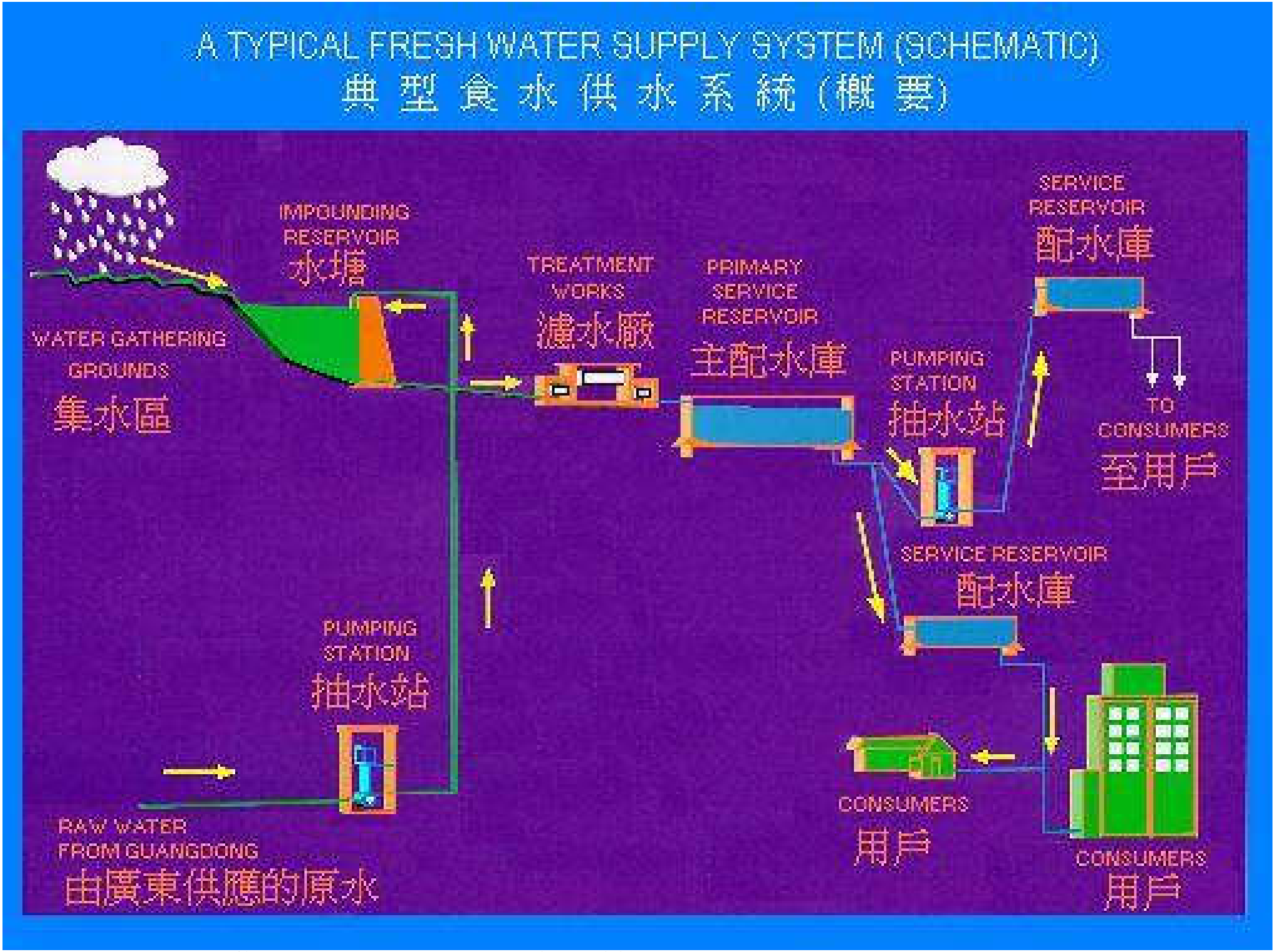


(Source: Water Supplies Department www.wsd.gov.hk)

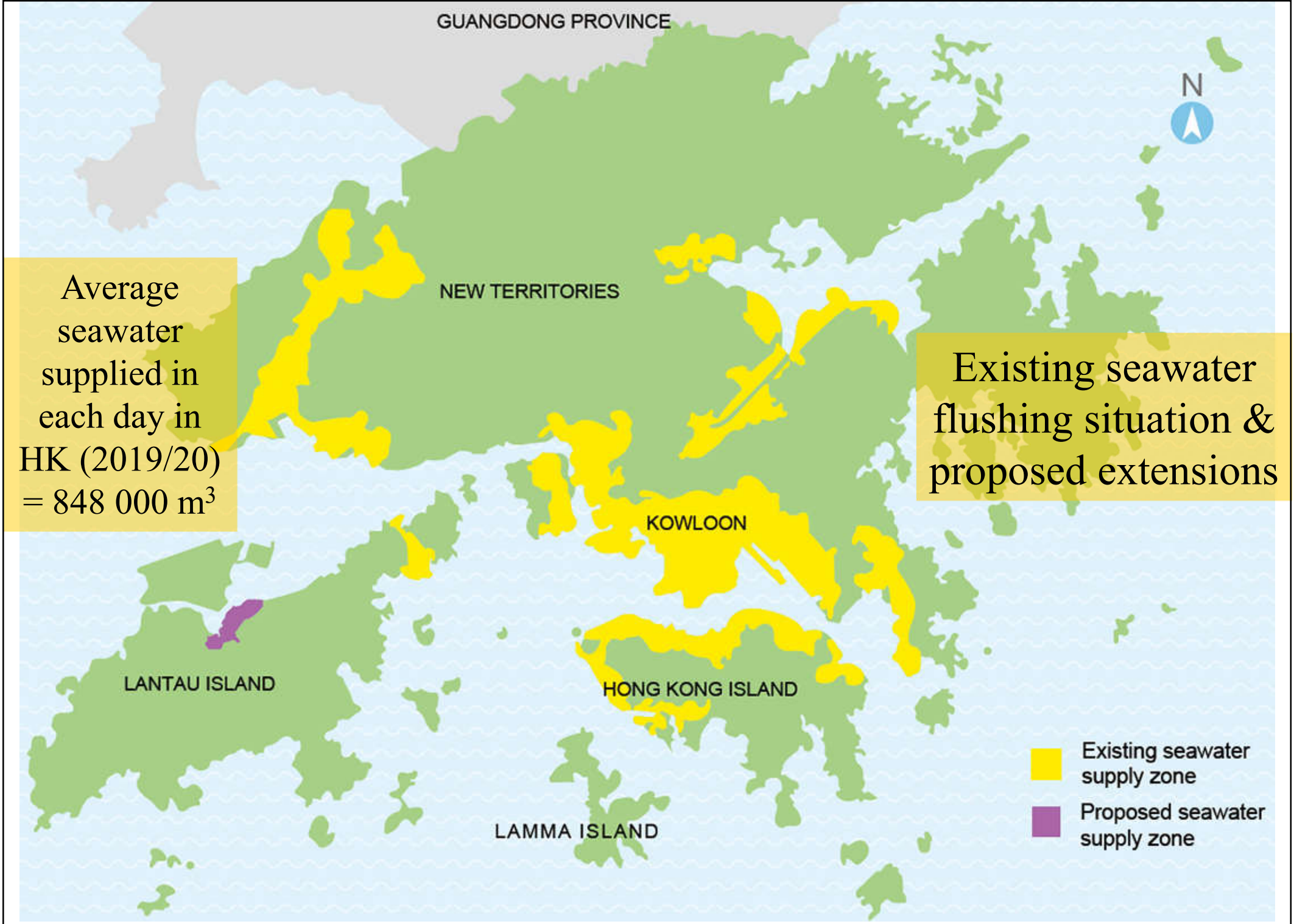


Reservoirs & water gathering grounds in Hong Kong

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

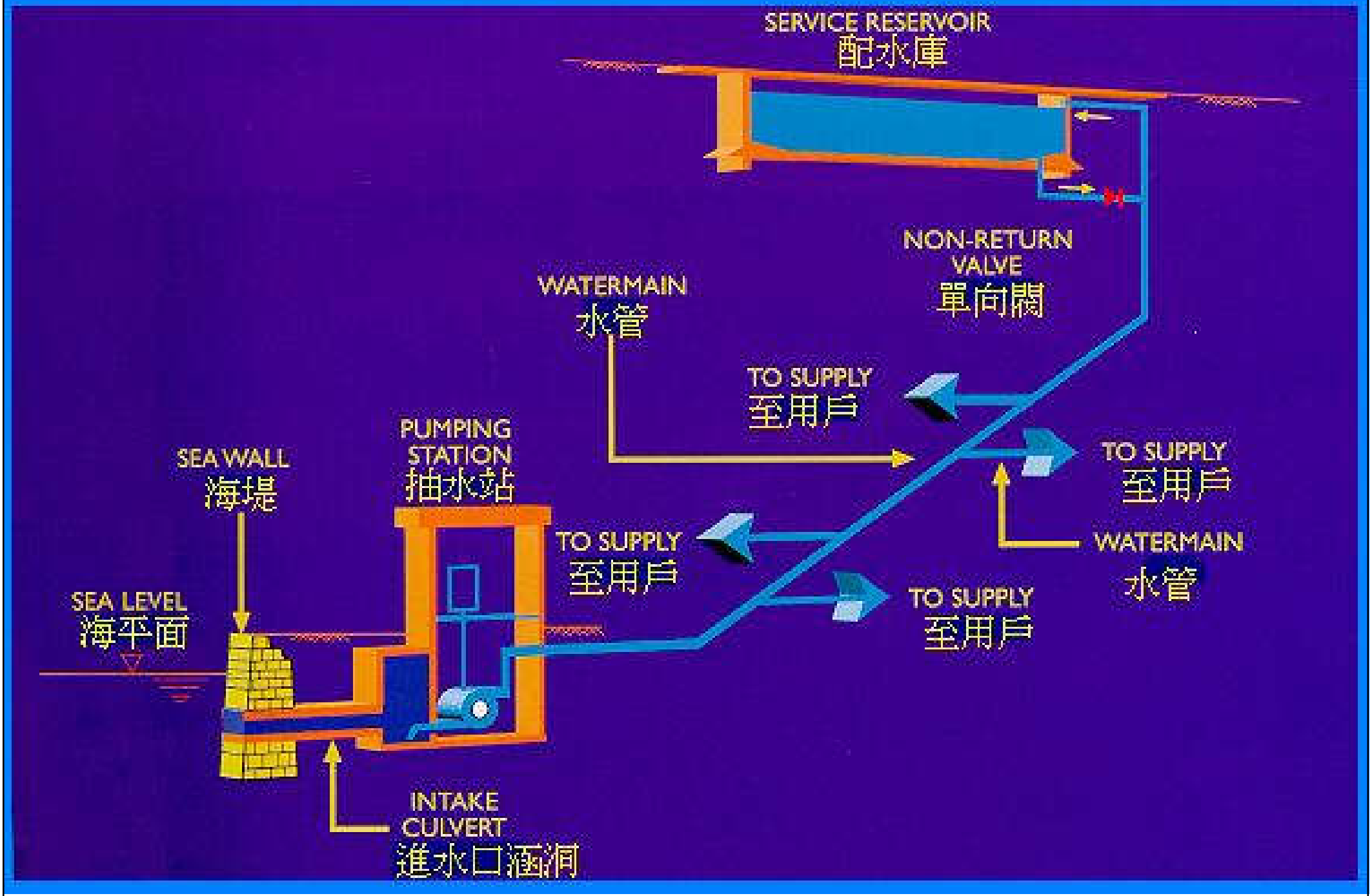


(Source: Water Supplies Department www.wsd.gov.hk)



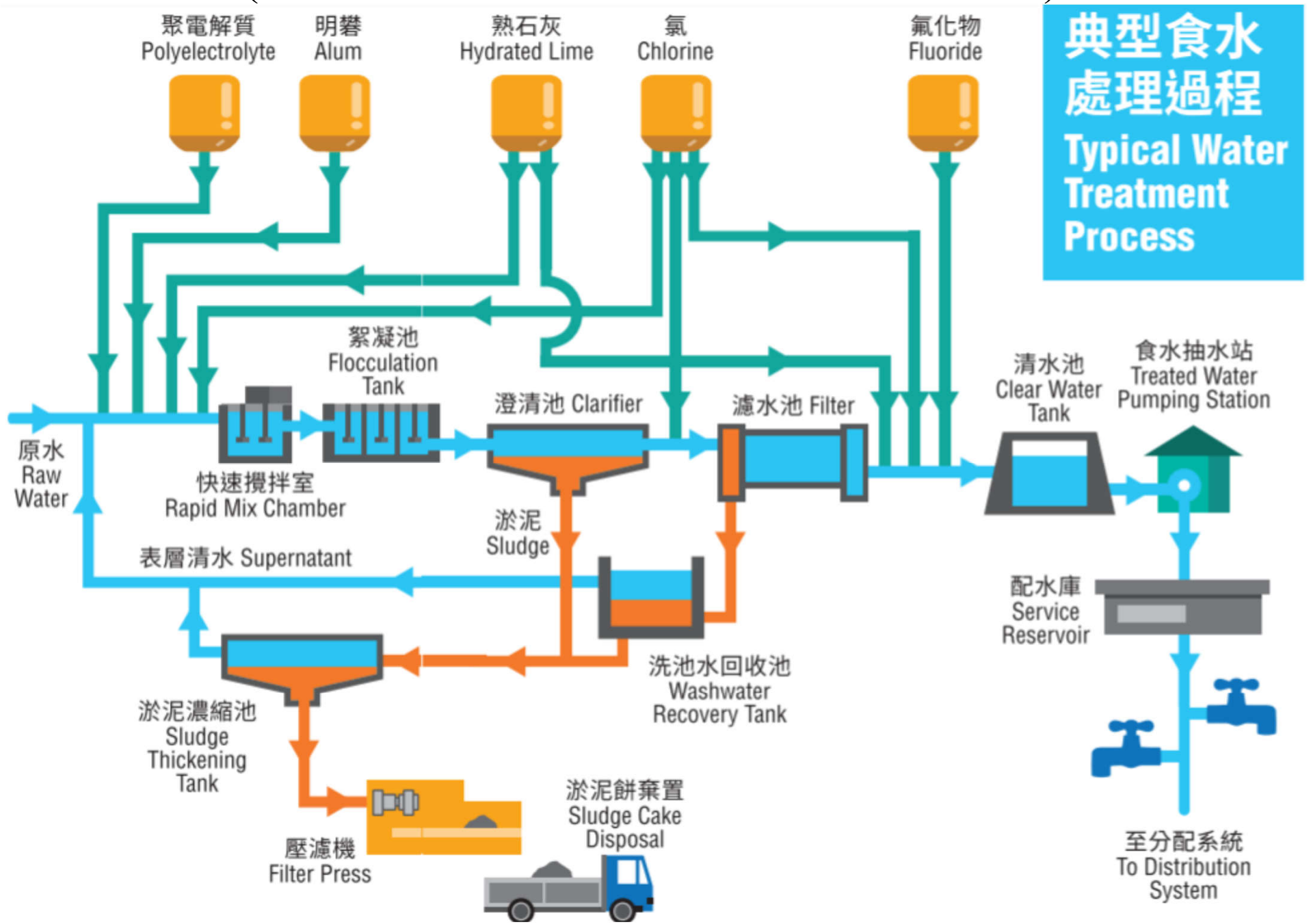
(Source: Water Supplies Department www.wsd.gov.hk)

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



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

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

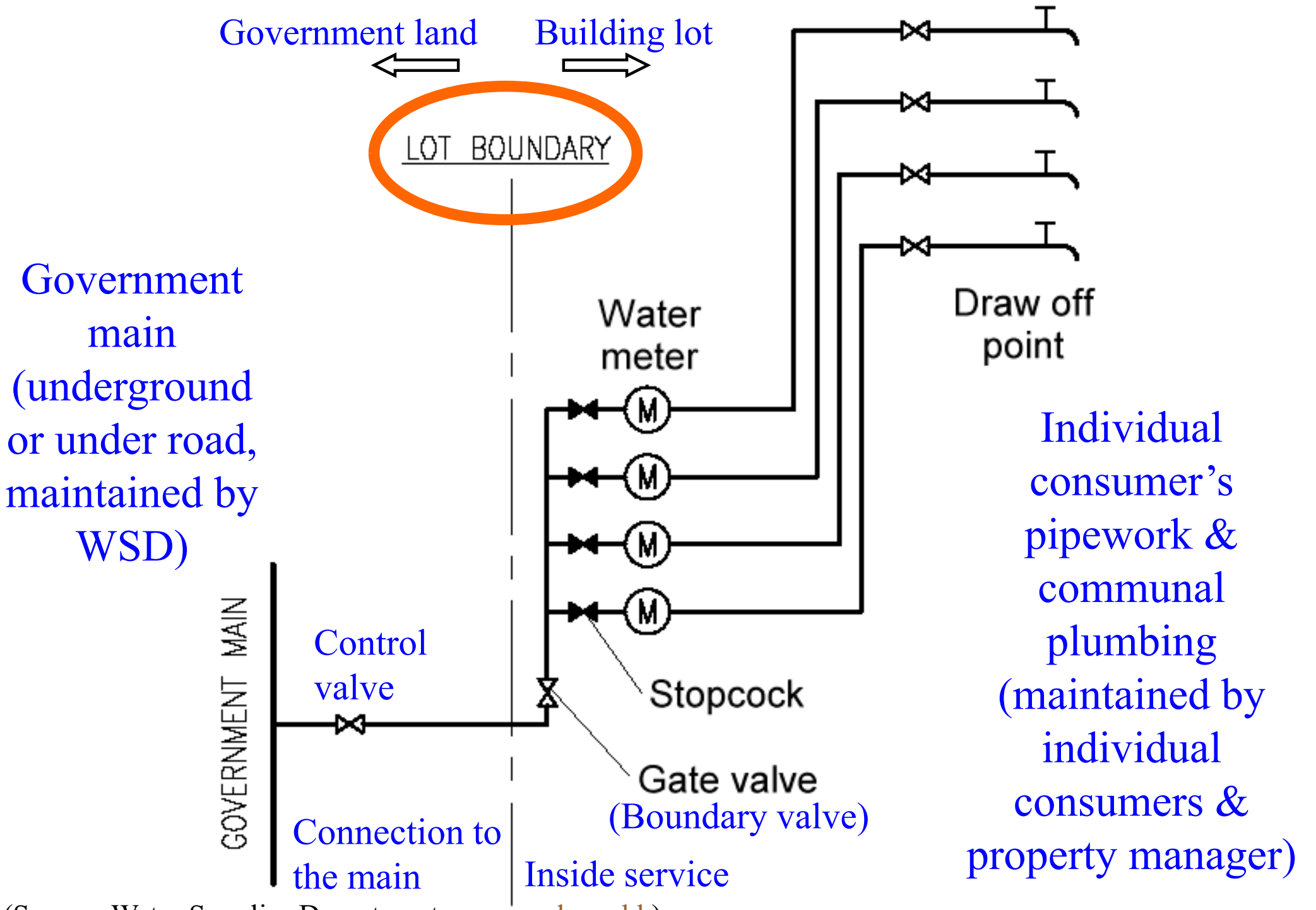


(Source: https://www.wsd.gov.hk/filemanager/en/share/pdf/water_treat.pdf)

Cold water systems

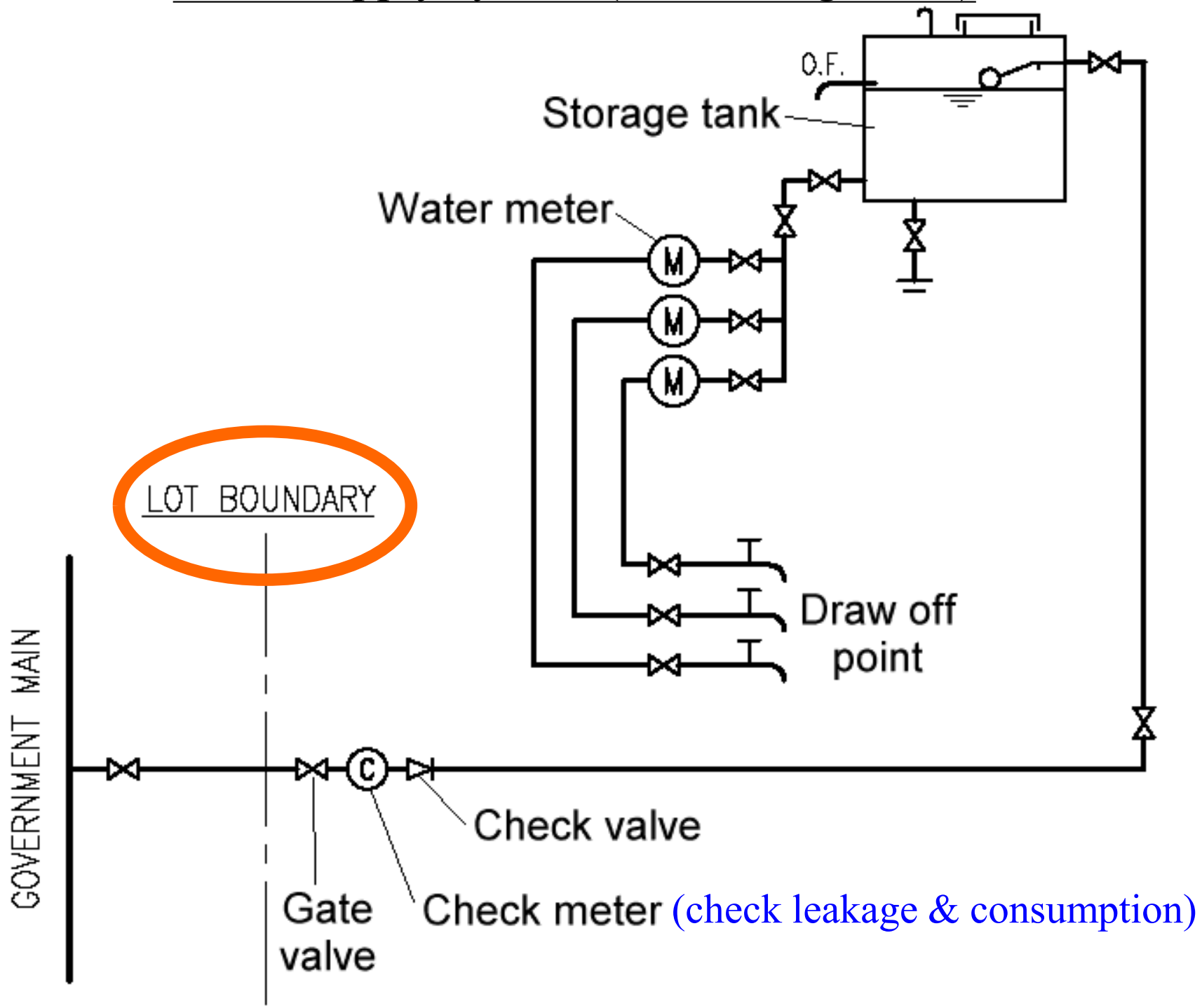
- Water supply systems in buildings
  - *Direct supply system*: conveys water directly from water mains to the point of usage without any transit water storage tanks
  - *Indirect supply system*: conveys water from water mains to the point of usage through a transit water storage tank (usually a sump 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)



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

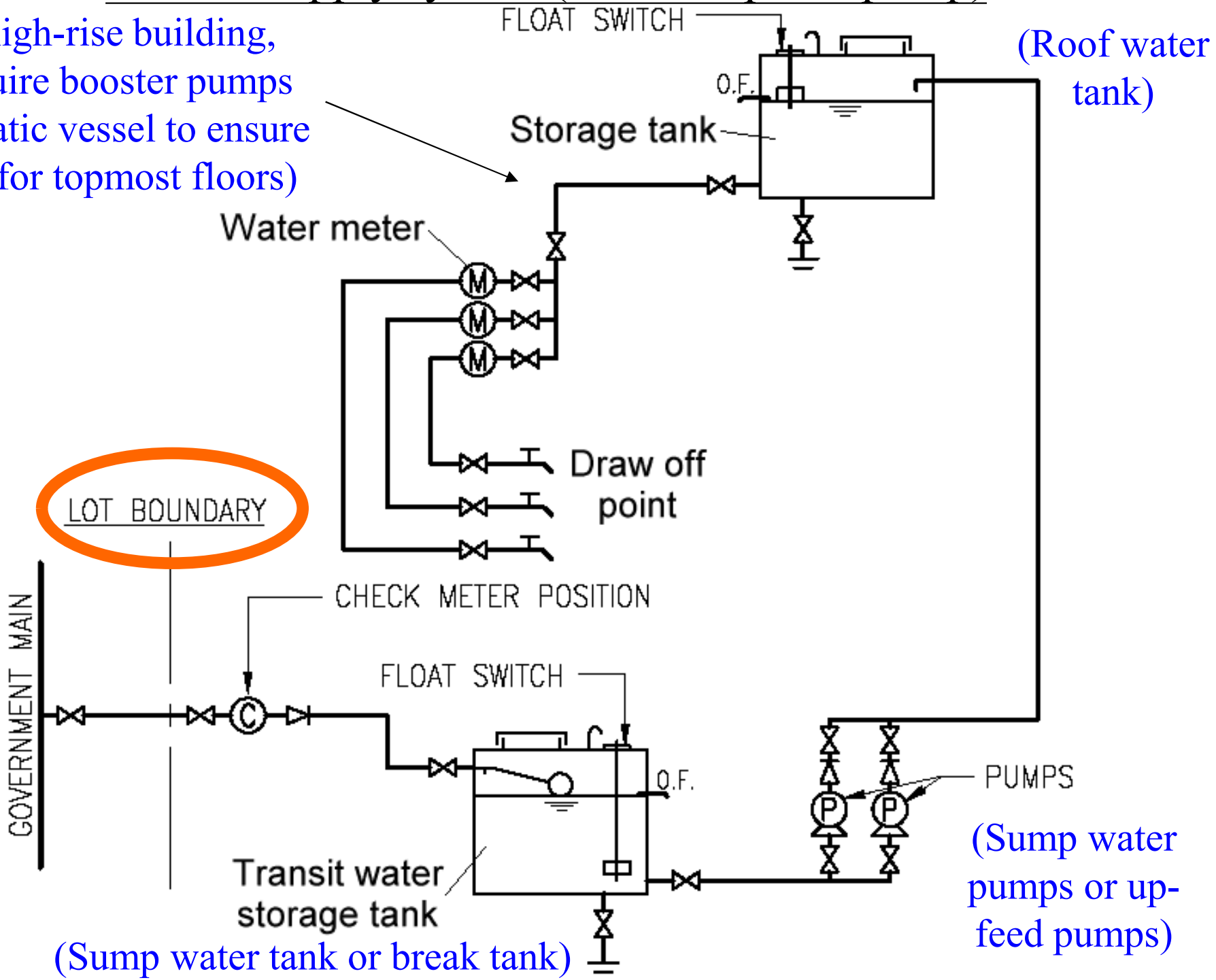
Direct supply system (with storage tank)



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

Indirect supply system (with sump and pump)

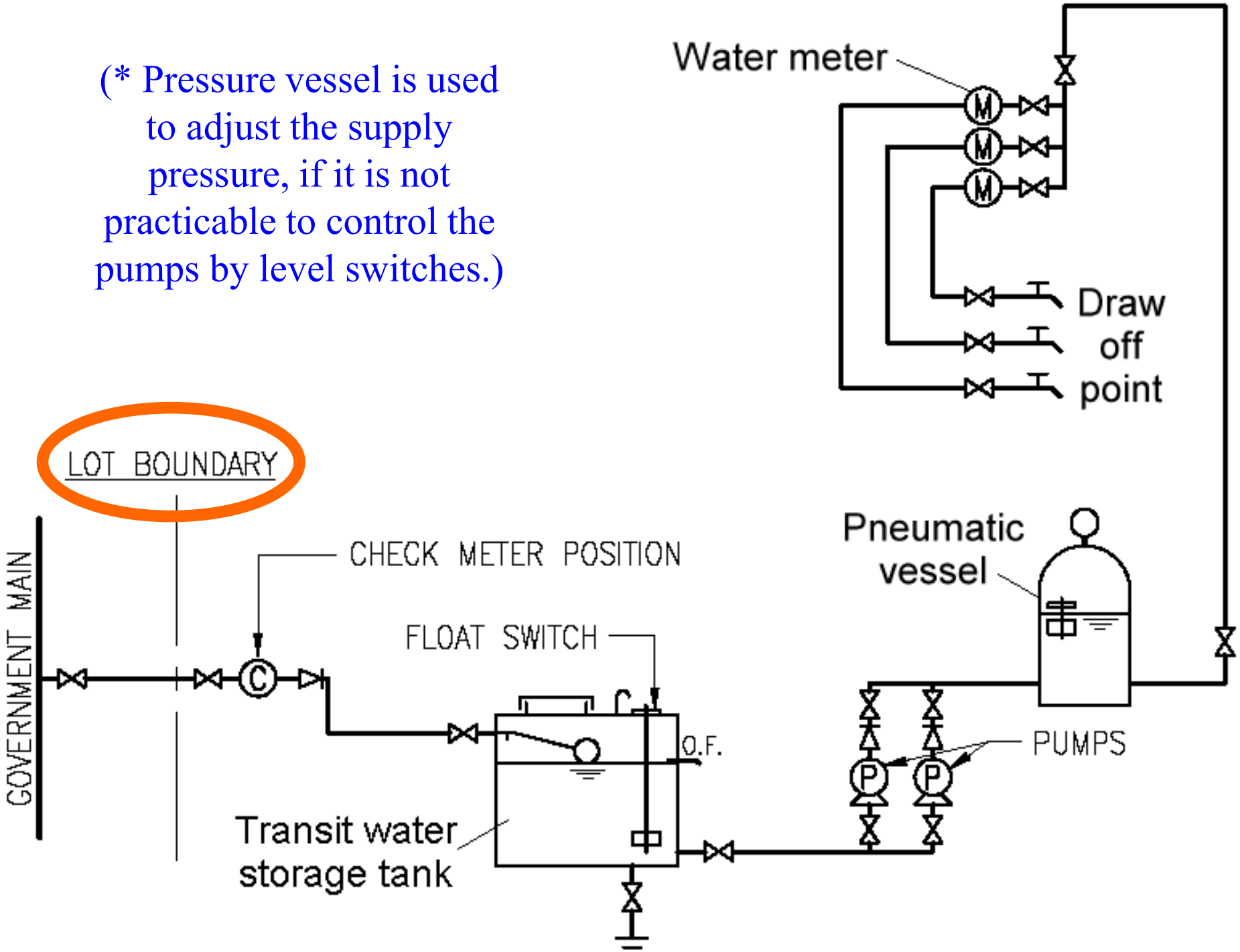
(For a high-rise building, may require booster pumps & pneumatic vessel to ensure pressure for topmost floors)



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

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.)



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

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

Cold water systems

- 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

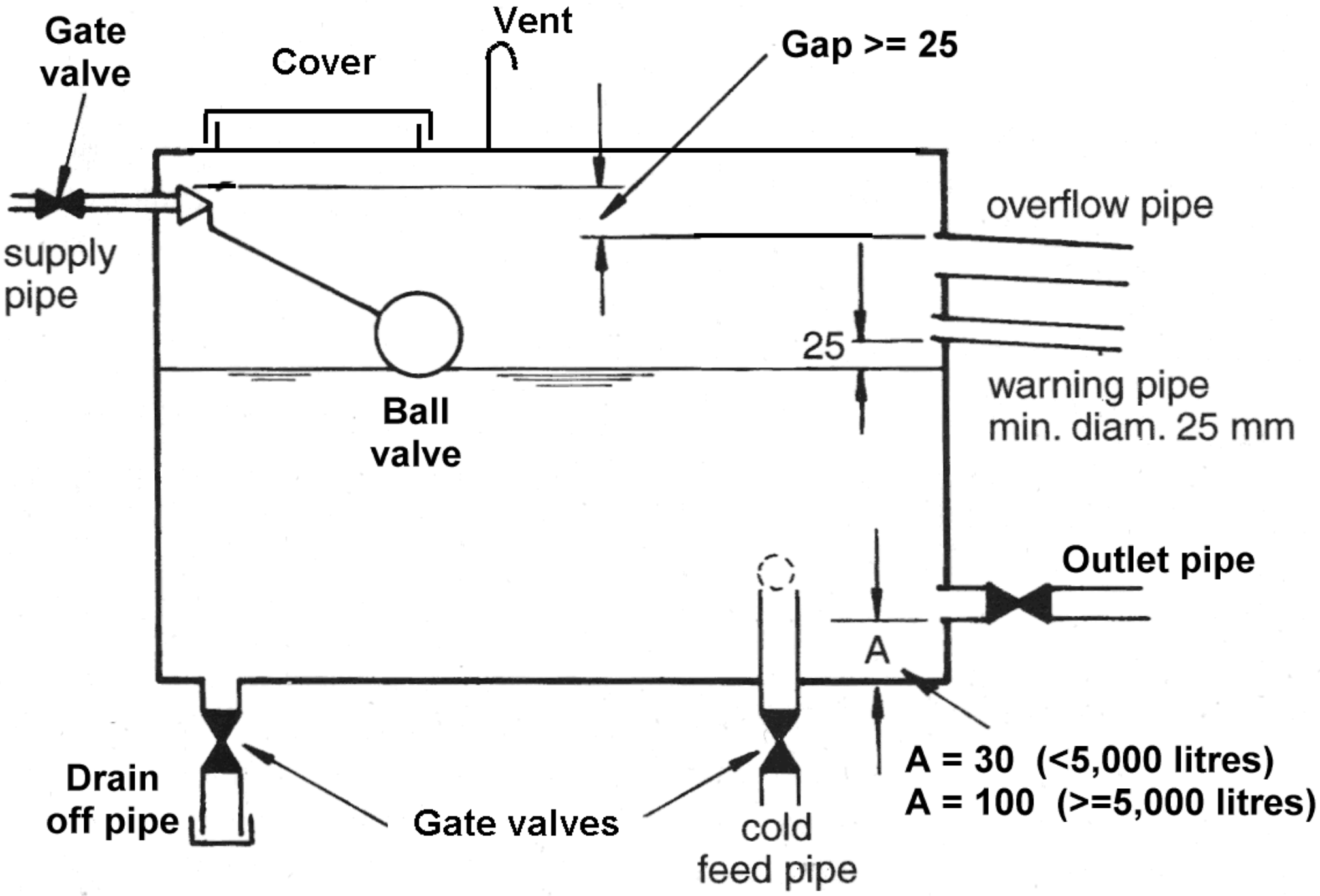
* For industrial use, recommended storage capacity is one-day demand.

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

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

(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-plumging-works-in-bldgs/)

Water tank basic requirements (for a gravity supply)

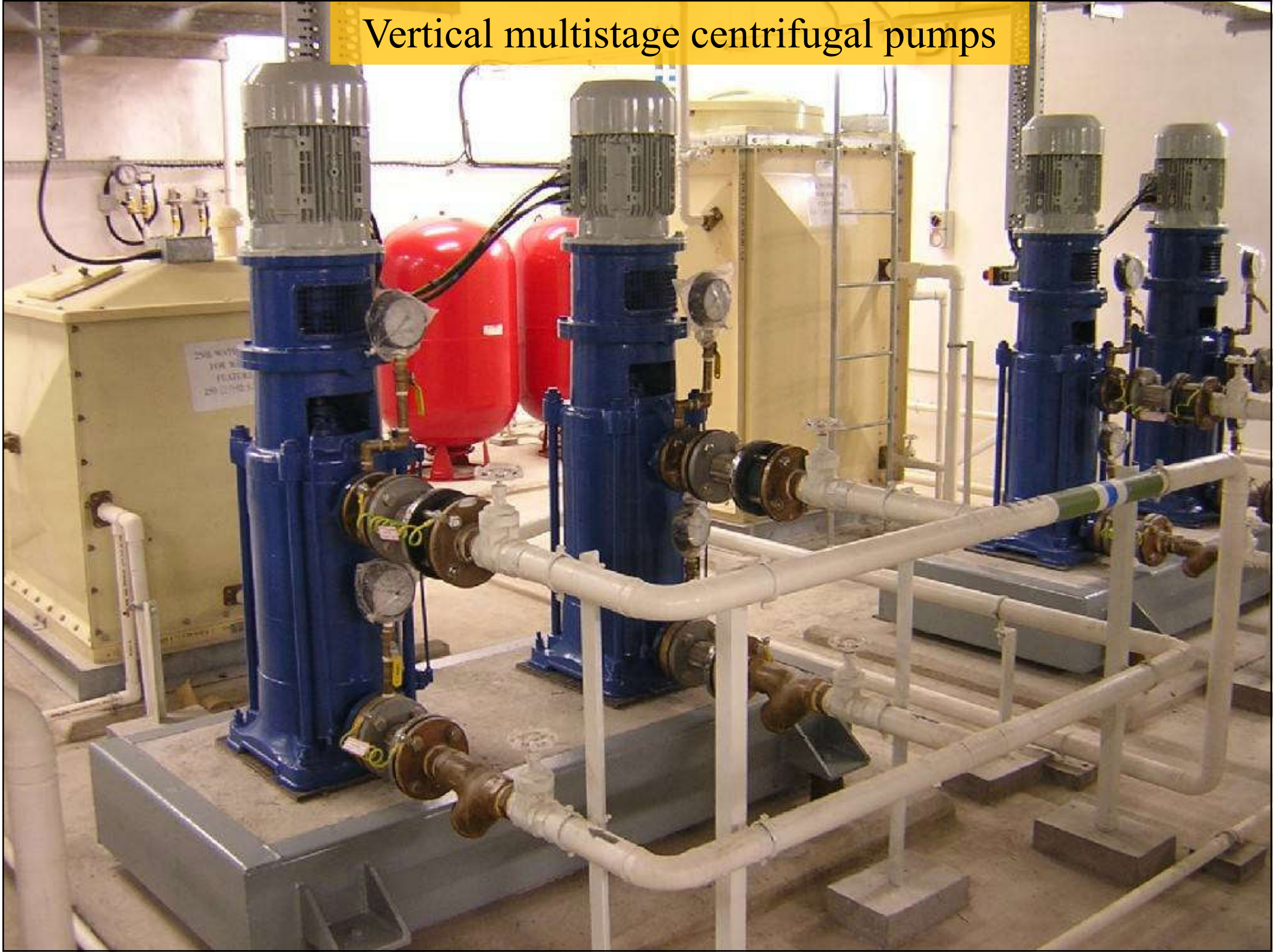


(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)

Cold water systems

- Water pumps
  - Provide a duplicate set (duty + standby)
  - Pumping capacity >= 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

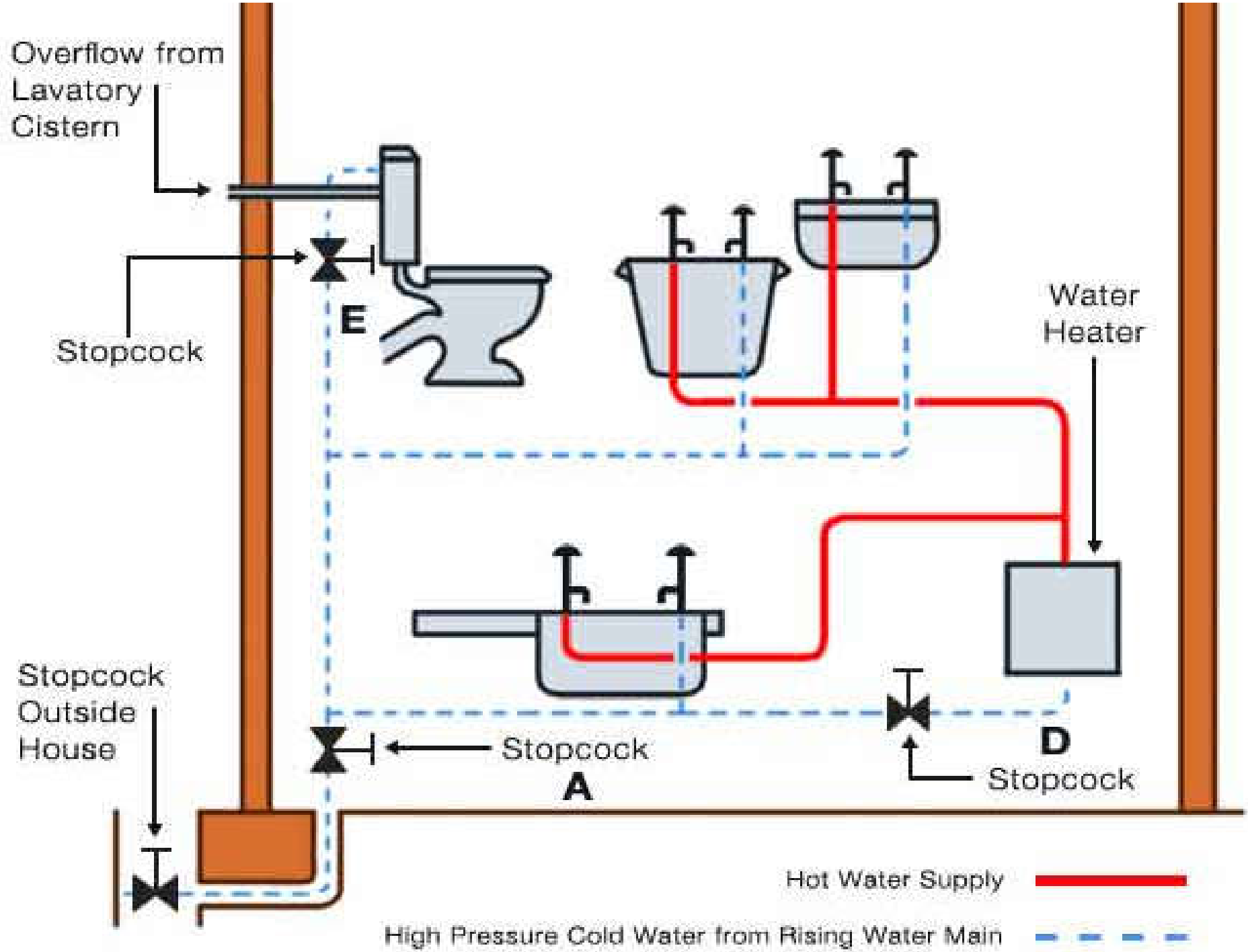
Vertical multistage centrifugal pumps



Hot water systems

- Design of a hot water system:
  - Determine the demand of hot water - quantity and temperature
  - Selecting the type, capacity and heating surface of the calorifier - or heat exchanger
  - Selecting the water heater or boiler
  - Design pipe scheme and size pipes
- Domestic hot water (DHW)
  - Supply to taps & appliances

An example of cold and hot water supply system

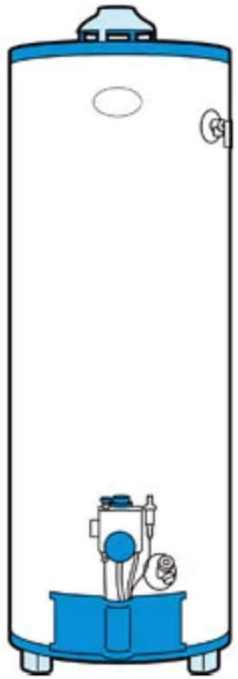


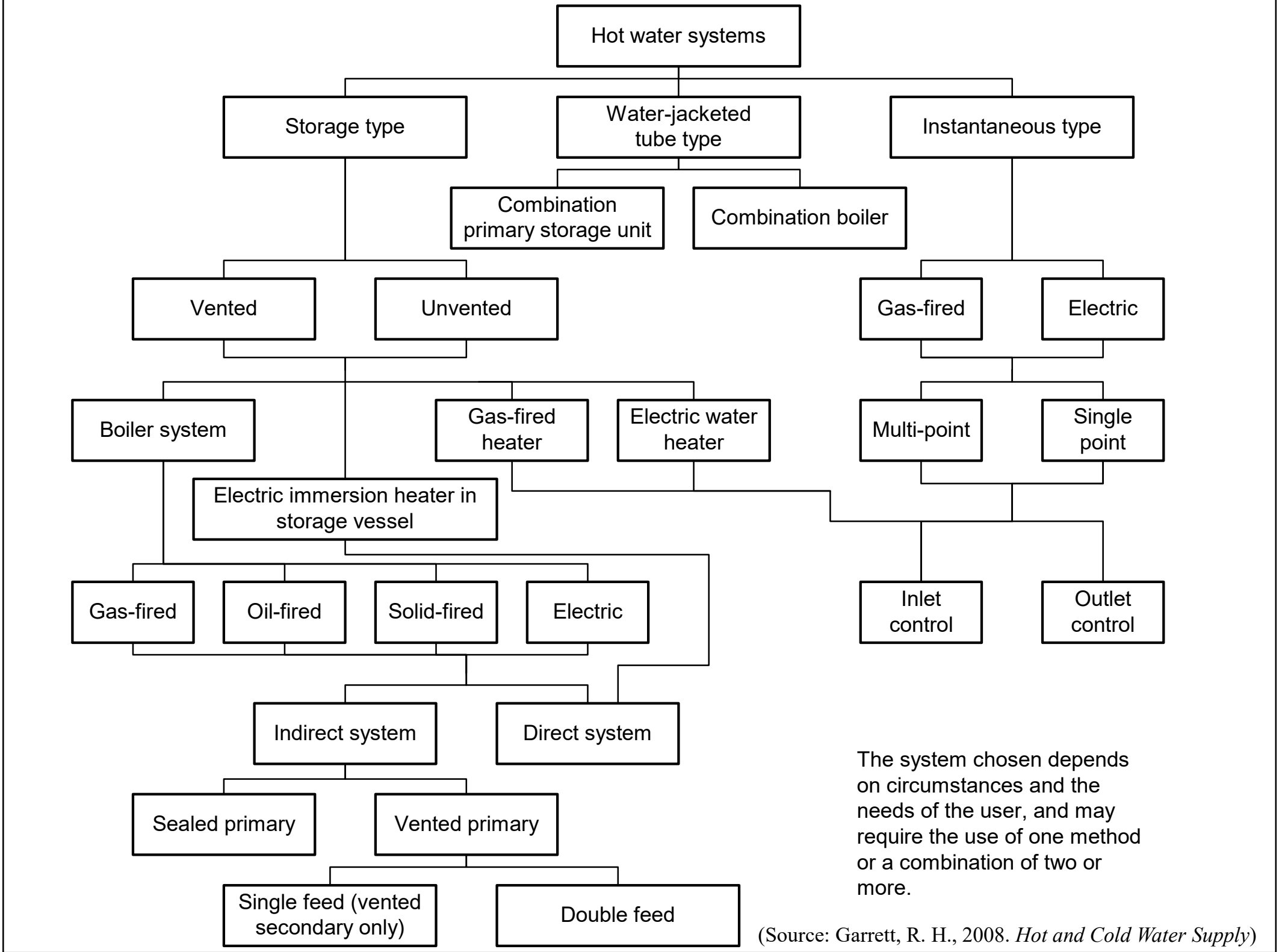
Hot water systems

- Key factors to consider:
  - Quantity of hot water required
  - Temperature in storage & at outlets (55-65 ºC)
  - Cost of installation & maintenance
  - Fuel energy requirements & running costs
  - Conservation of water & energy
  - Safety (explosion hazard, thermal burns, bacteria)
- Hot water supply may be combined with central heating systems (to radiators)

Hot water systems

- System types:
  - Central & local
  - Gas-fired & electric
  - Single point & multi-point
  - Vented & unvented
  - Direct & indirect
- Types of water heaters:
  - Instantaneous type (tankless)
  - Storage type
  - High pressure (larger storage)



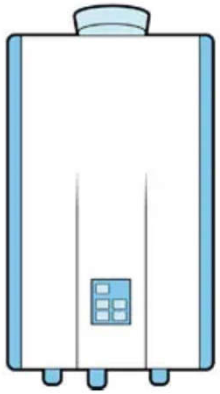


The system chosen depends on circumstances and the needs of the user, and may require the use of one method or a combination of two or more.

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

Hot water systems

- Consider instantaneous water heaters

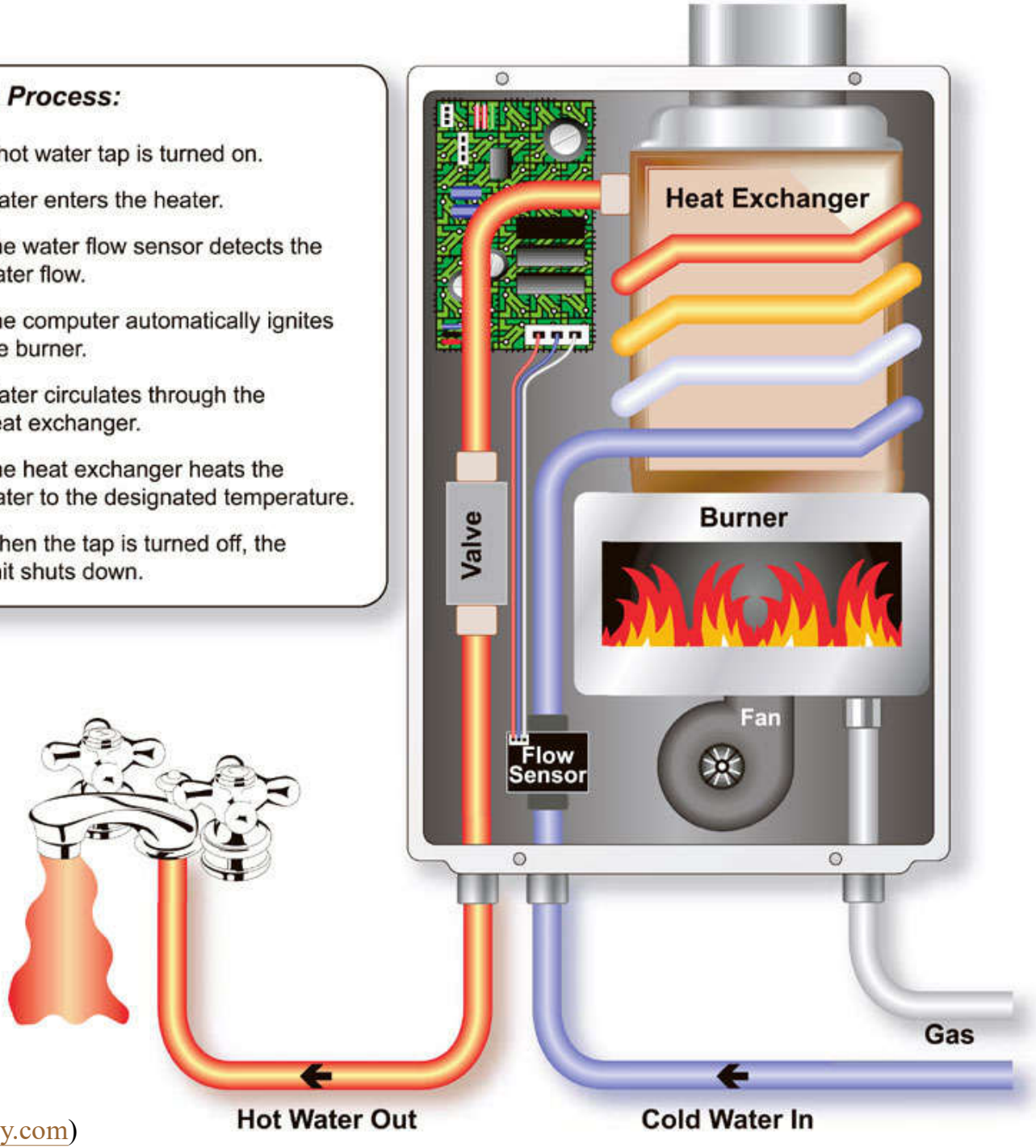


  - Adequate gas or electricity supplies
  - Where constant flow temp. is important, the heater should be fitted with a water governor at its inflow
    - Close control of temperature for showers
  - Variations in pressure can cause flow and temperature problems
  - Multi-point heaters for showers should be avoided
  - Room-sealed types are preferred for gas-fired
  - Electric heaters must comply safety regulations

How Does a Tankless Water Heater Work?

The Process:

1. A hot water tap is turned on.
2. Water enters the heater.
3. The water flow sensor detects the water flow.
4. The computer automatically ignites the burner.
5. Water circulates through the heat exchanger.
6. The heat exchanger heats the water to the designated temperature.
7. When the tap is turned off, the unit shuts down.



(Source: www.affinityenergy.com)

Sizing hot water systems for households

Electric storage hot water services

Off-peak electricity rate (storage type heater)*		Peak electricity rate (continuous type heater)**	
Max. no. of persons served	Capacity (litres)	Max. no. of persons served	Capacity (litres)
1 – 3	160	2	40
2 – 4	250	3	63
3 – 6	315	4	80
5 – 8	400	5	125

* Water is heated overnight to provide adequate hot water for daily usage.

** Can be very expensive to run so should only be used when other options are not possible. For example, where space is limited.

(Source: www.energysmart.com.au)

Sizing hot water systems for households (cont'd)

Gas water heaters

Storage		Instantaneous (continuous flow)	
Max. no. of persons served	Capacity (litres)	Max. no. of outlets served at one time	Flow rate (litres per minute)
1 – 3	90	1	16
2 – 4	130	2	20
3 – 5	170	3+	24
4 – 6	200		
5 – 9	260		

(Source: www.energysmart.com.au)

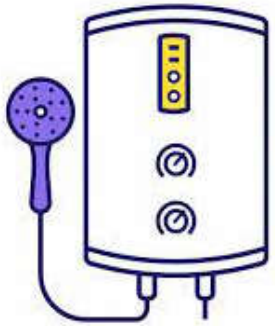
Sizing hot water systems for households (cont'd)

Solar hot water

No. of persons served	Capacity (litres)	Collector (m^2)
1 – 2	160 – 200	2
3 – 4	300 – 370	4
5 – 6	440	6

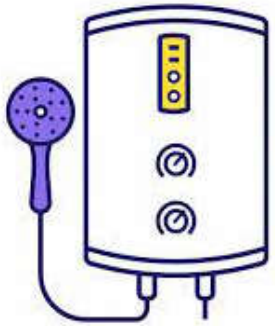
(Source: www.energysmart.com.au)

Water heaters



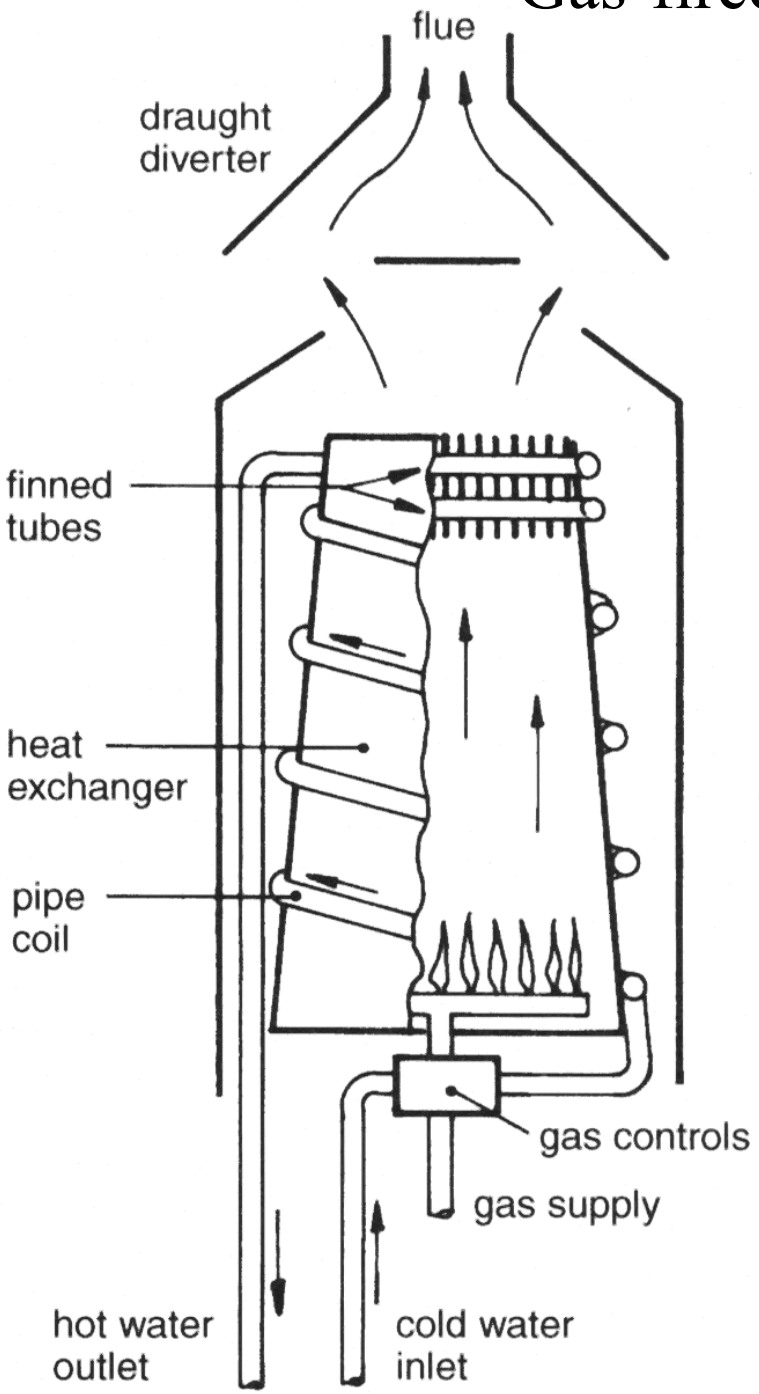
- Common types of water heaters
  - Gas-fired water heaters
  - Electric water heaters
  - Water-jacketed tube heaters
  - Solar water heating
  - Heat pump water heaters

Water heaters

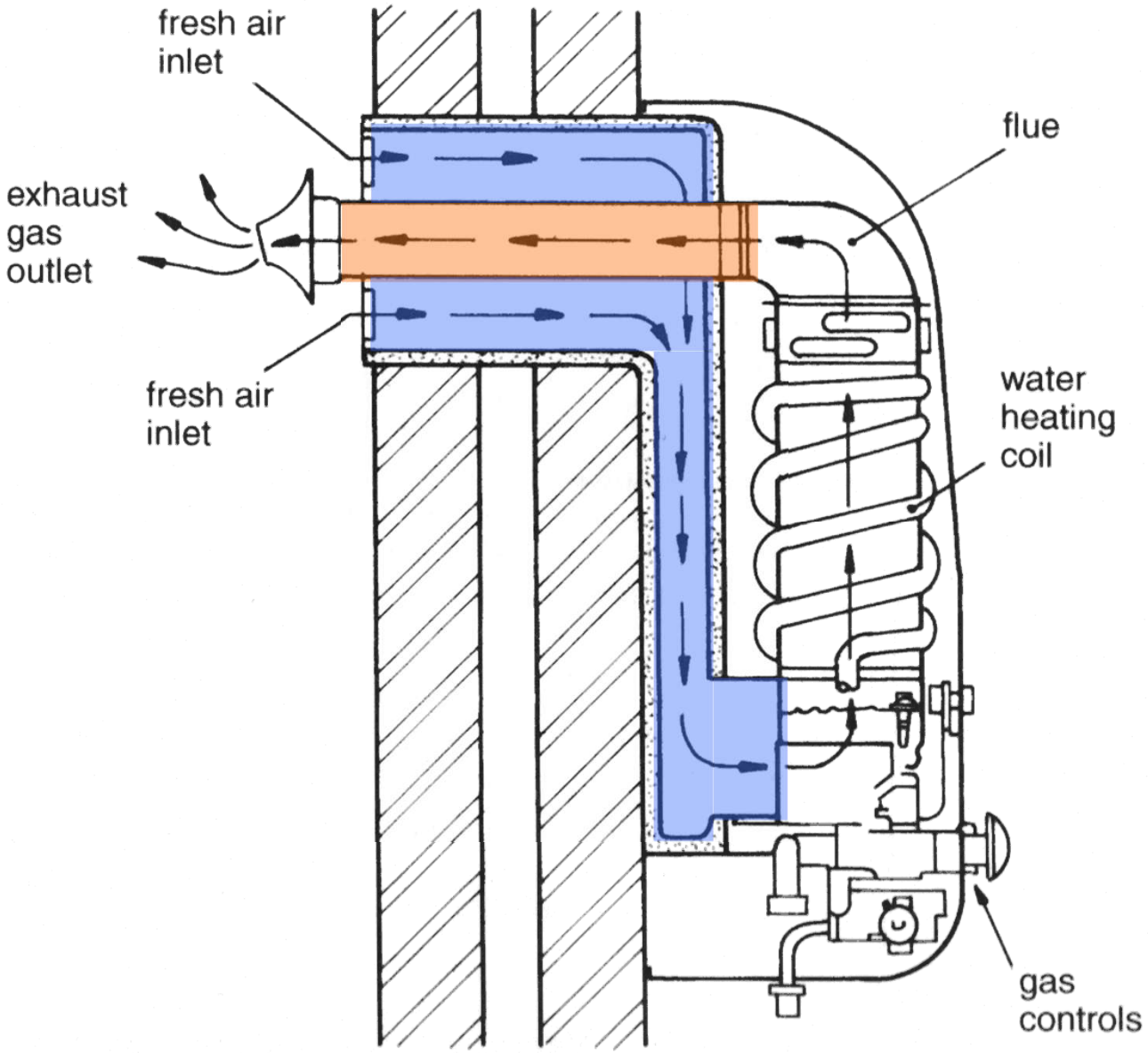


- Gas-fired water heaters
  - Three types:
    - Instantaneous
    - Storage
    - Circulatory
  - With conventional or balanced flue
  - Pilot flame lights the burner
  - The heater may be supplied direct from the main or a cold water storage tank

Gas-fired instantaneous water heater



With conventional flue



With balanced flue

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

禁止使用無煙道式氣體熱水爐以供浴室或淋浴使用

Prohibition of Flueless Gas Water Heaters Used to Serve a Bathroom or Shower

機電工程署
Electrical & Mechanical Services Department

1. 不合規格的無煙道式氣體熱水爐裝置
Substandard Flueless Gas Water Heater Installations

無煙道式氣體熱水爐供浴室或淋浴用途屬於危險的裝置，因為該熱水爐會從室內抽取供燃燒用之空氣，而燃燒後之廢氣(包括有毒的一氧化碳)會直接帶進裝有這類熱水爐的房間內，如在通風不足下可能積聚至危險水平。

Flueless gas water heaters serving bathrooms or showers are considered dangerous because they consume the air inside the room and the products of combustion containing toxic carbon monoxide discharge directly into the room where the heater is situated, and may build up to dangerous levels if ventilation is inadequate.

2. 禁止使用無煙道式氣體熱水爐以供浴室或淋浴用途
Prohibit Use of Flueless Gas Water Heaters Supplying Bathroom or Shower

為防止不適當使用無煙道式氣體熱水爐而引致危險，立法局於1999年11月通過氣體安全規例修訂，禁止使用無煙道式氣體熱水爐以供浴室或淋浴用途。該項修訂將於**2000年4月1日**正式實施。此外，新規例亦禁止任何人供應或安裝新的無煙道式熱水爐，或以其他無煙道式型號替換現時無煙道式氣體熱水爐。

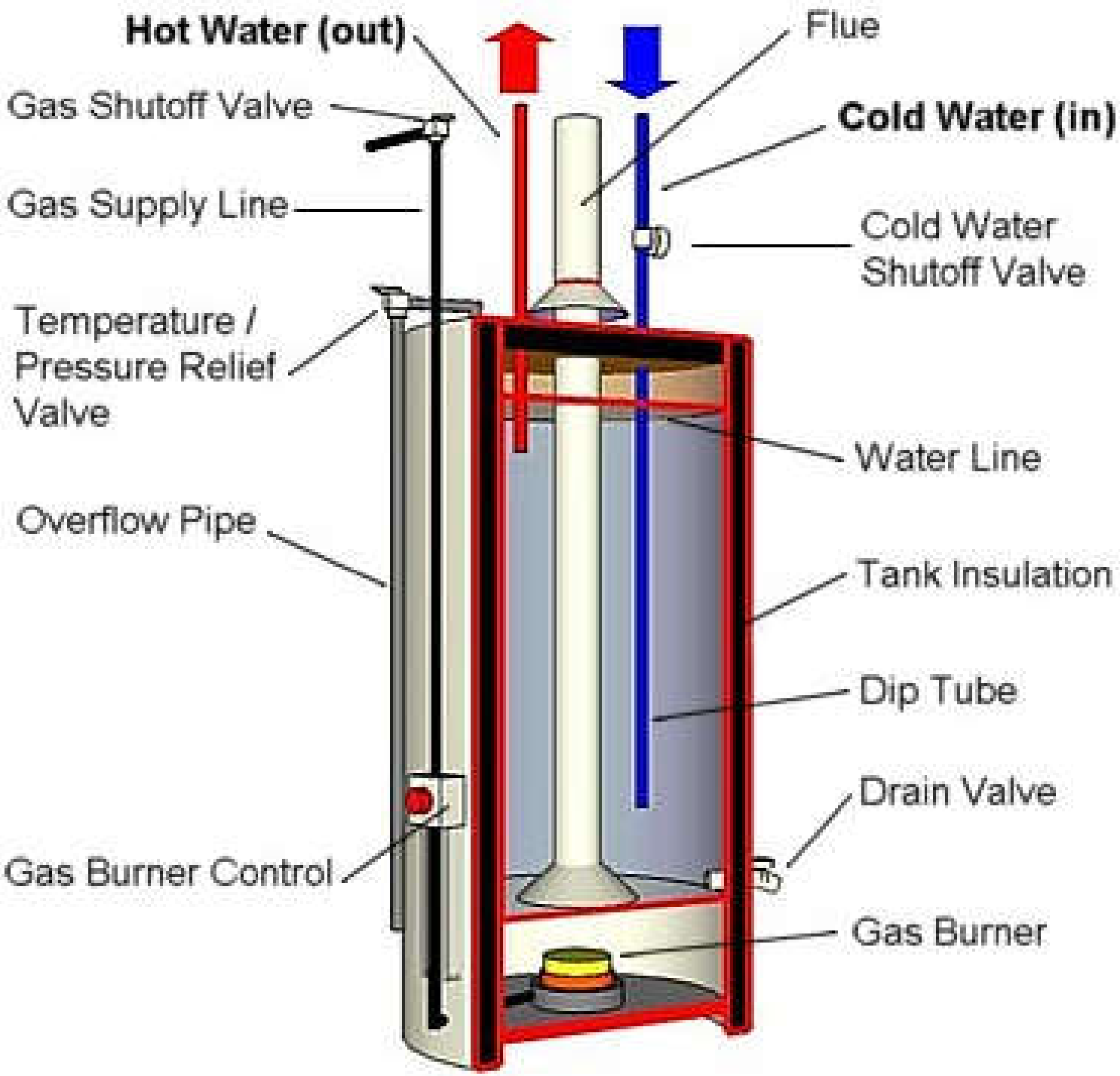
In order to eliminate dangers from improper use of flueless gas water heaters, LEGCO passed an Amendment of the Gas Safety Regulations in November 1999, which prohibits the use of a flueless gas water heater to serve a bathroom or shower. The Amendment will come into effect on **1 April 2000**. In addition, the new law also prohibits anyone from supplying or installing a new flueless gas water heater or replacing an existing flueless gas water heater by another flueless model.

3. 氣體安全規例修訂內容
Details of Amendment to Gas Safety Regulations

修訂主要分為二部份，第一，<氣體安全(裝置及使用)規例>修訂確立自**2000年7月1日**開始任何人不得將無煙道式氣體熱水爐供浴室或淋浴間使用。

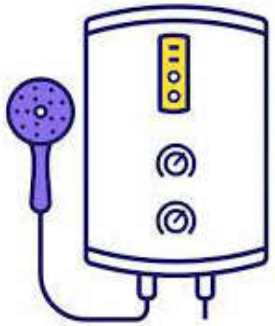
(See also: https://www.emsd.gov.hk/gsp/en/a04.html)

Gas hot water heaters components



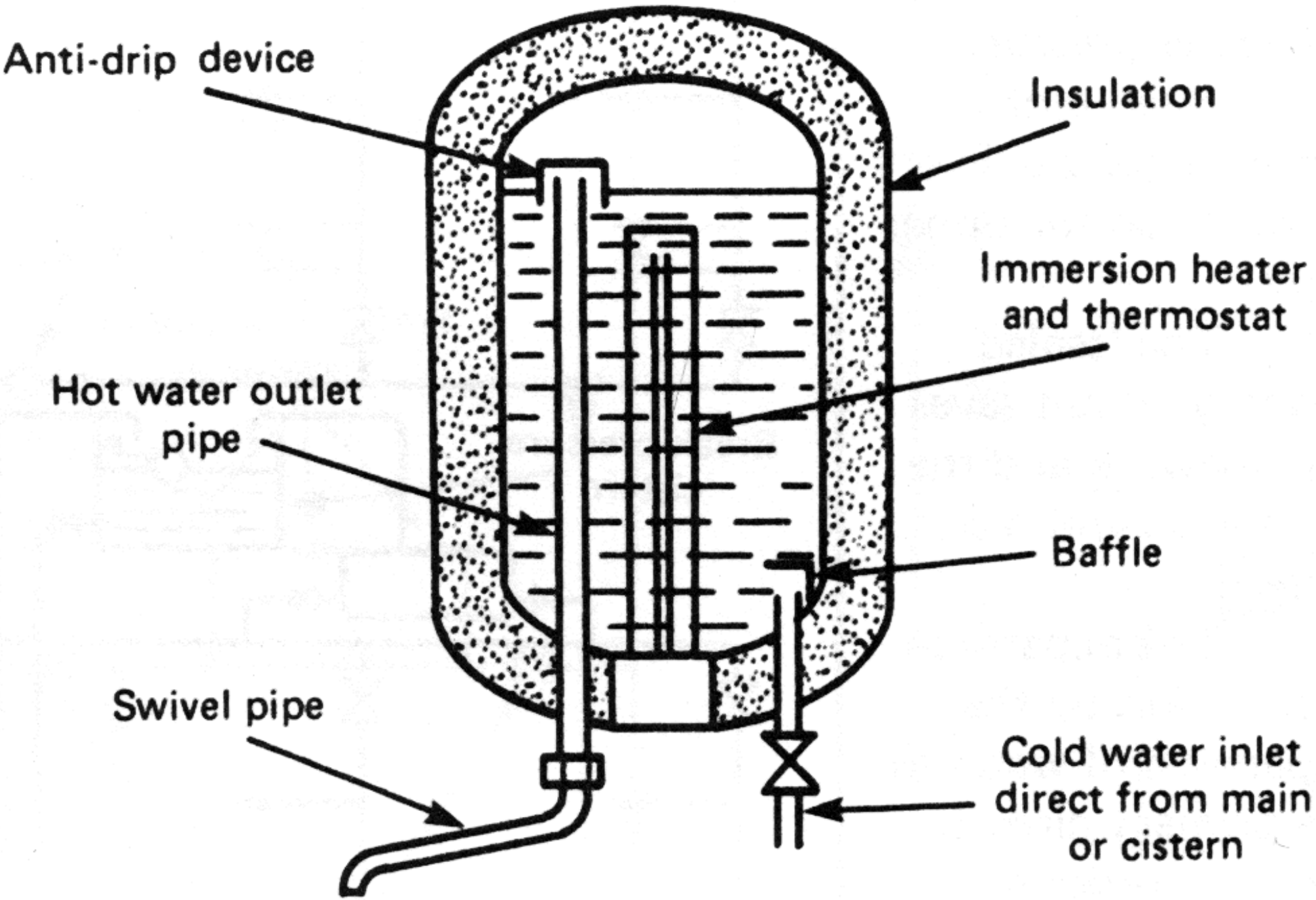
(Source: http://homerepair.about.com)

Water heaters



- Electric water heaters
  - Common types:
    - Instantaneous
    - Cistern type (with storage)
  - Usually power consumptions of up to 6 kW
  - May be fitted above basins, baths or sinks
  - Hot water pipes must be as short as possible
  - Immersion heater must be electrically earthed
  - Cable of appropriate size (may need 3 phase supply)

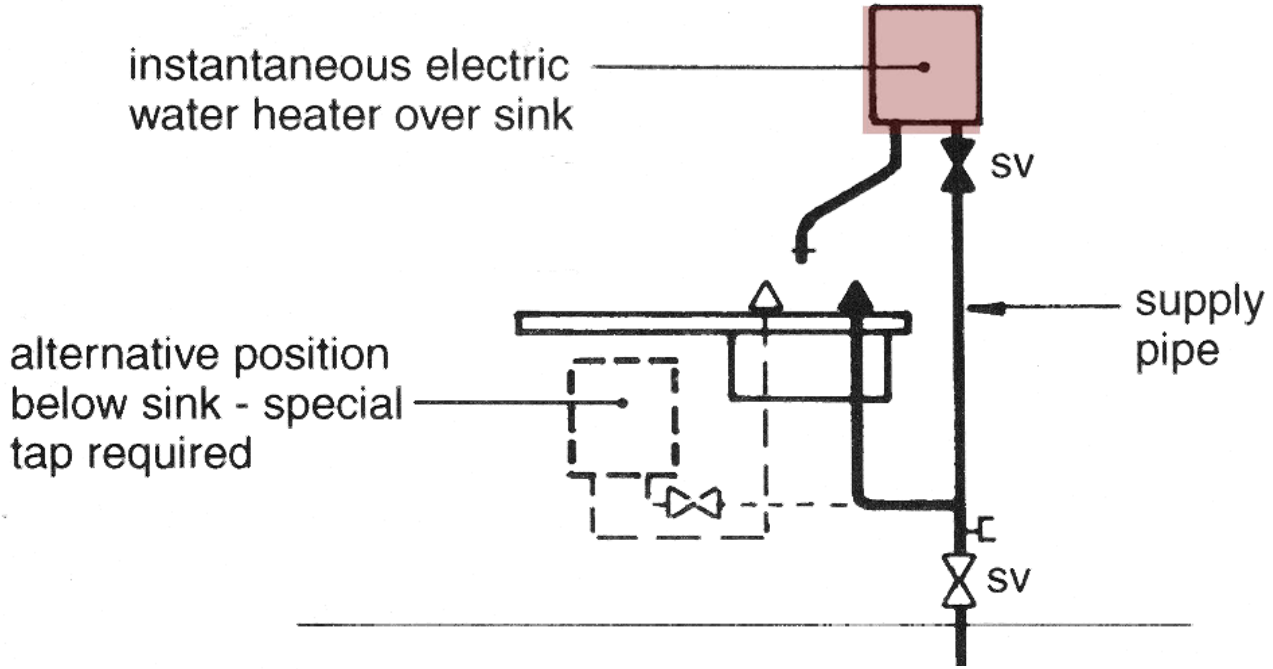
Instantaneous electric water heater (non-pressure type)



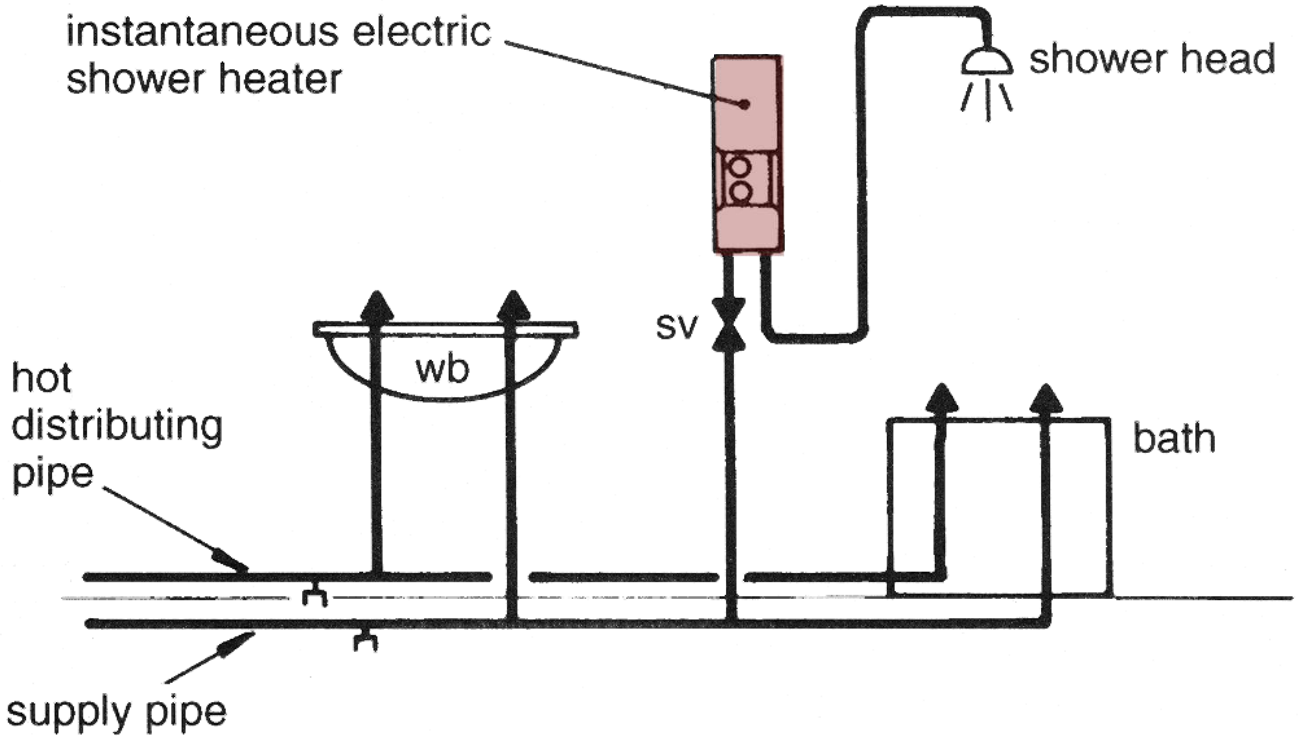
(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

Typical uses for instantaneous electric water heaters

Sink installation

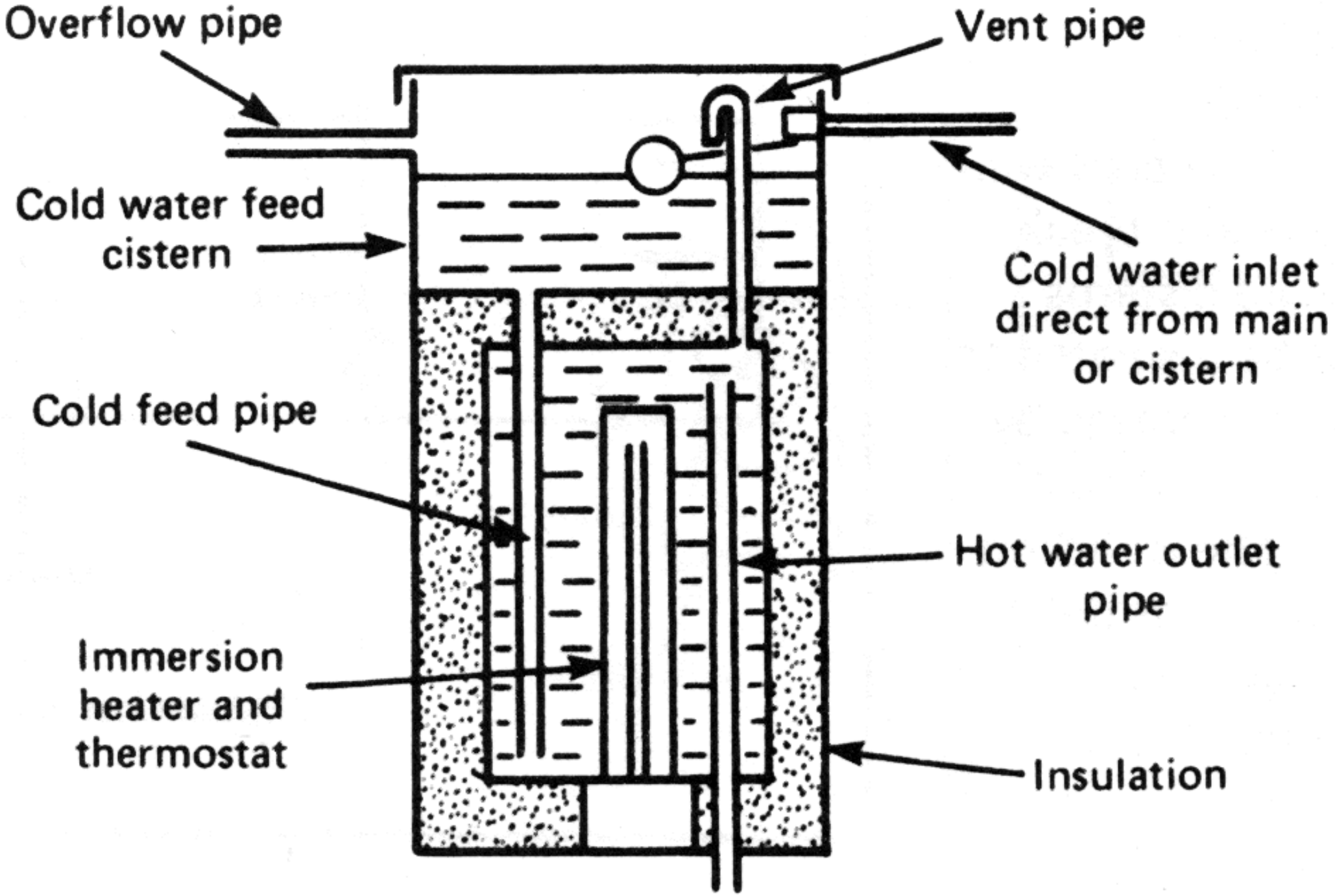


Shower installation

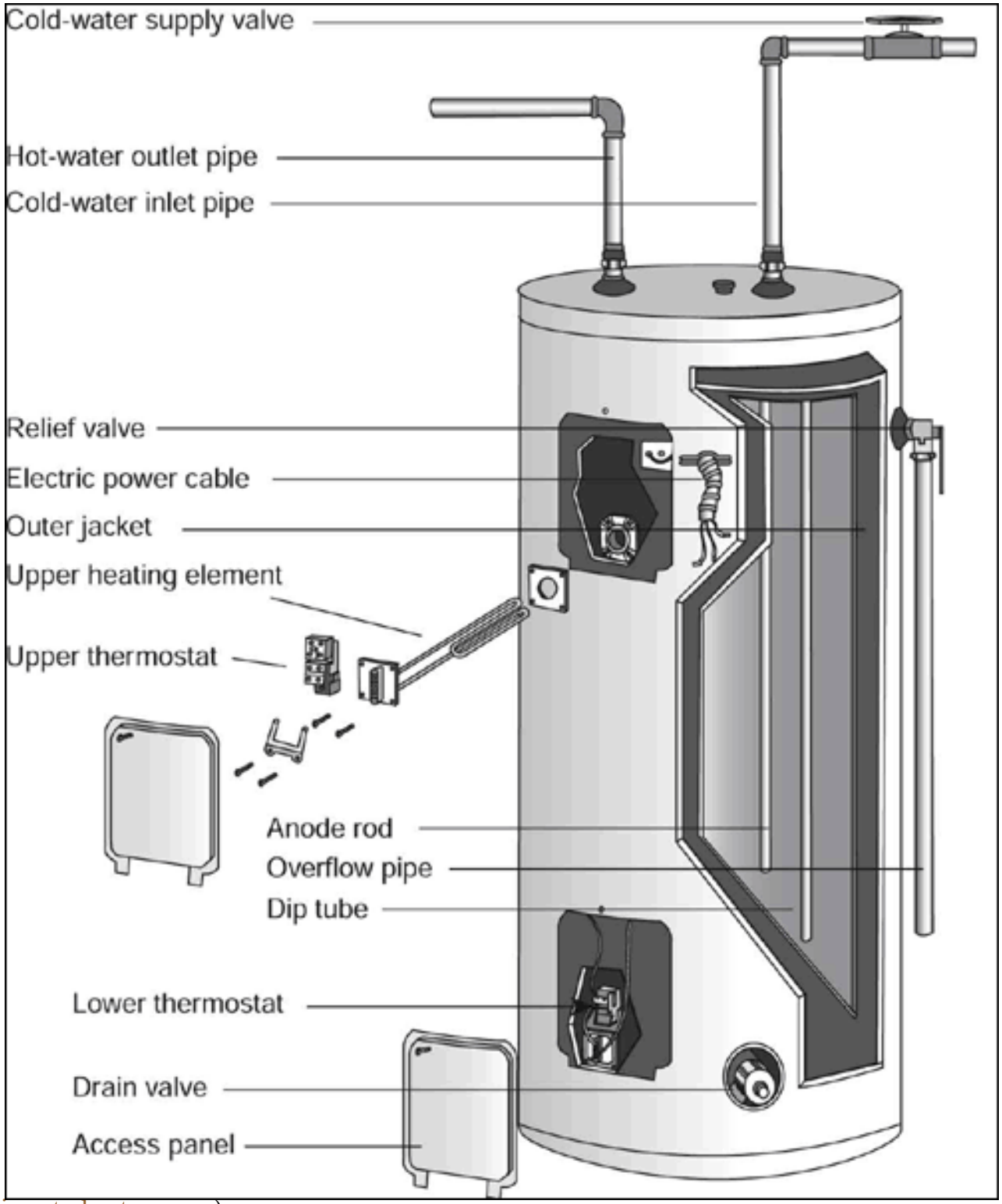


(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)

Cistern type water heater



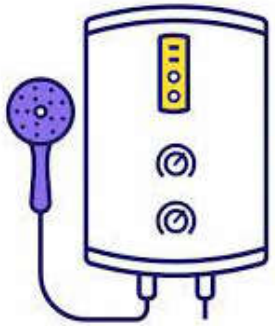
(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)



Components of a large electric water heater

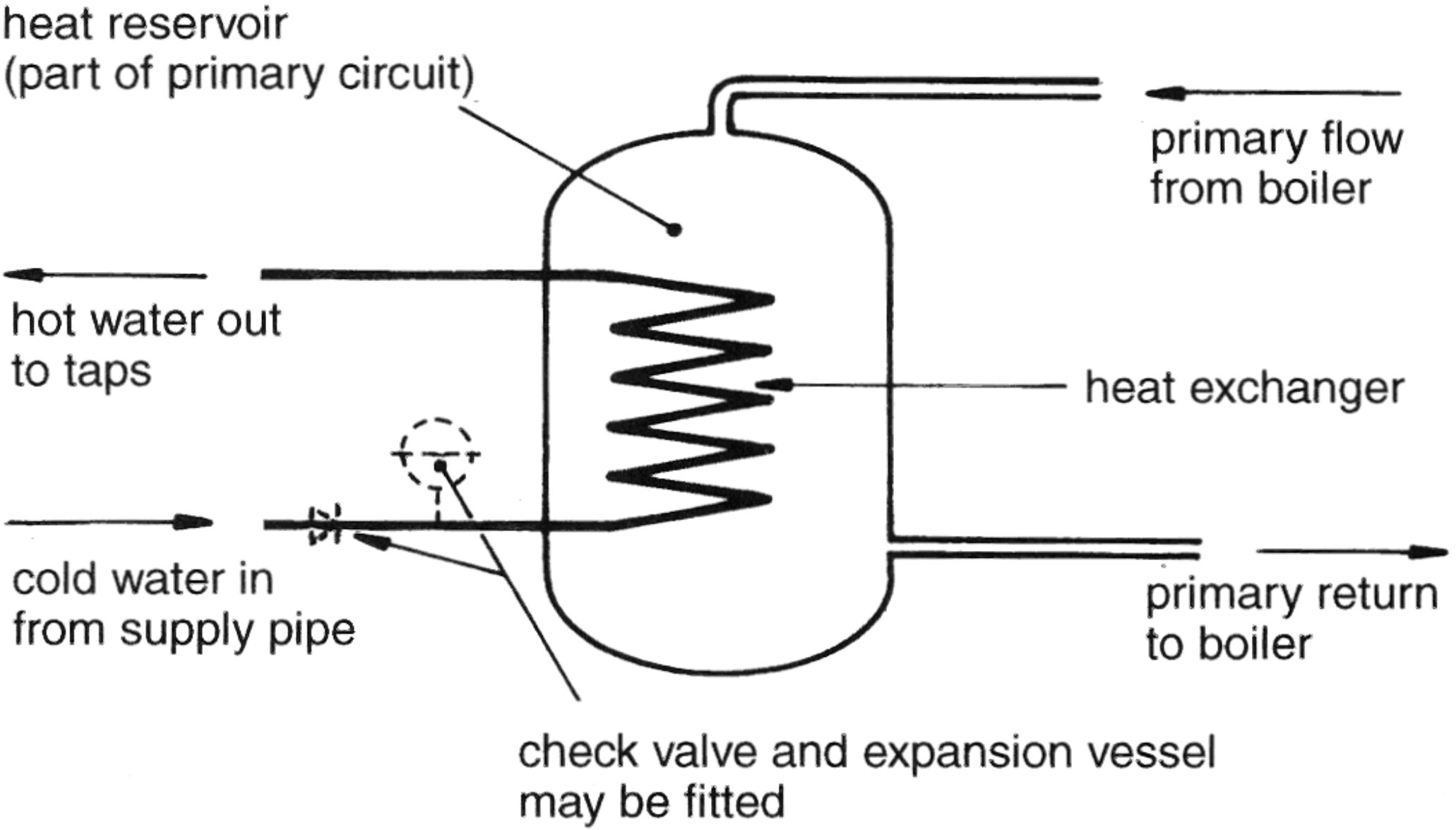
(Source: http://magicwaterheaters.com)

Water heaters



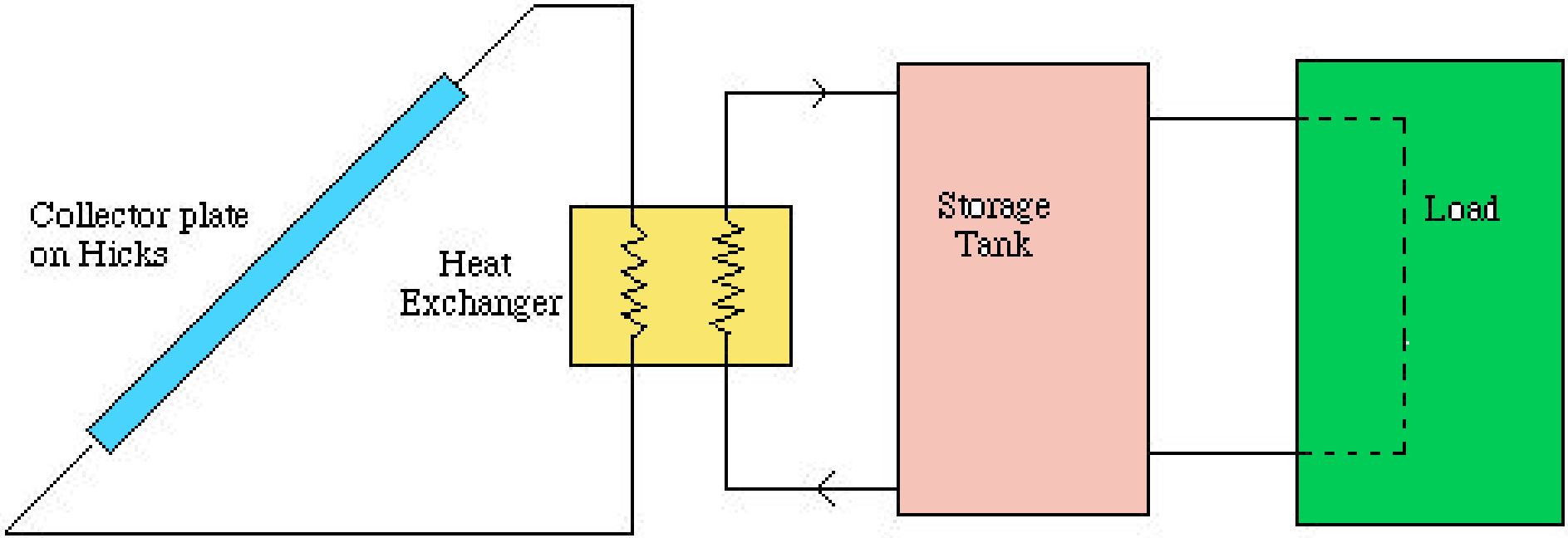
- Water-jacketed tube heaters
  - Usually as a form of instantaneous heater
  - Heat exchanger in a reservoir of primary hot water
  - Cold water feeds may be from the mains or from a water tank
  - Primary circuit may be vented or sealed system
  - Heat exchanger warms secondary supply water

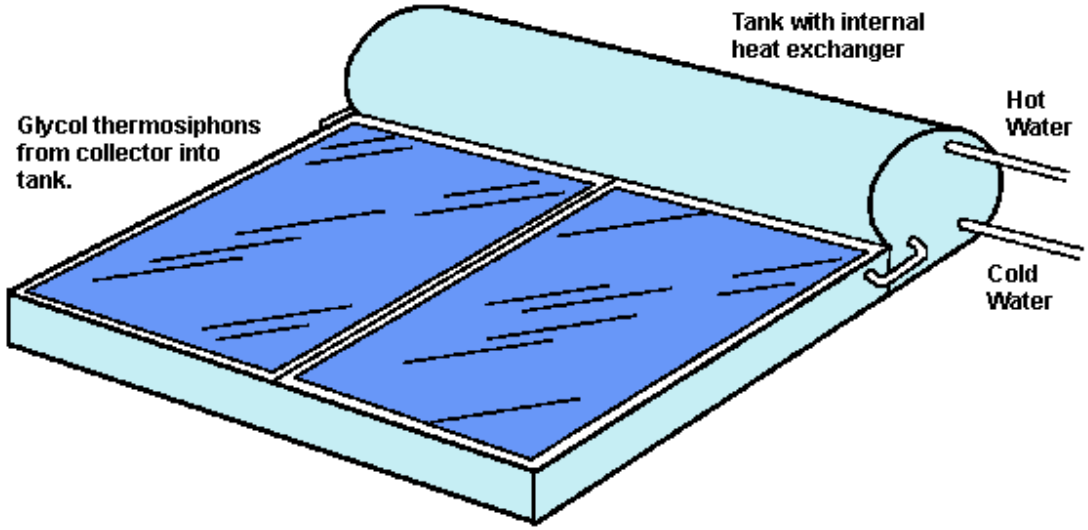
Water-jacketed tube heater



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

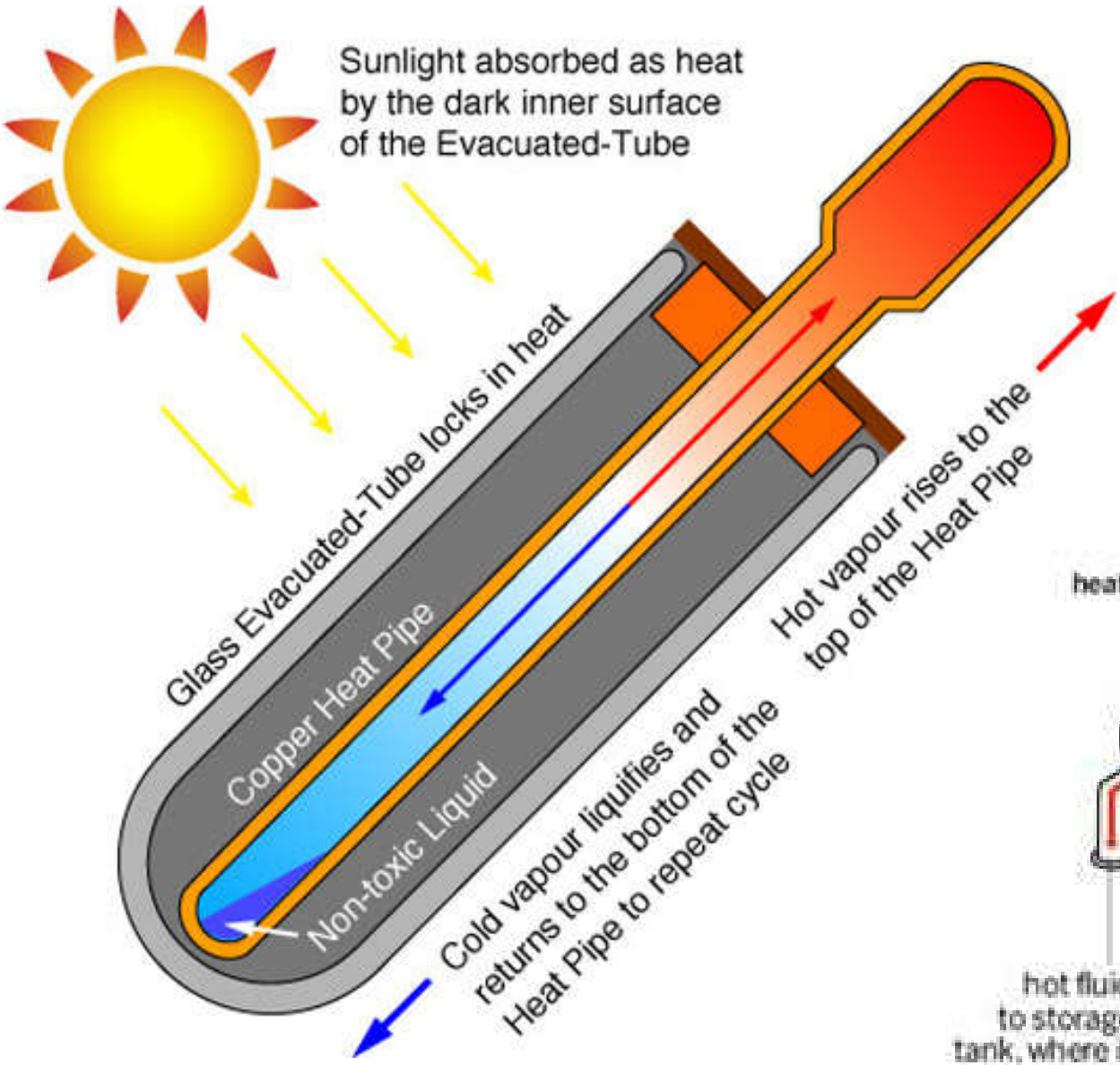
Solar hot water systems

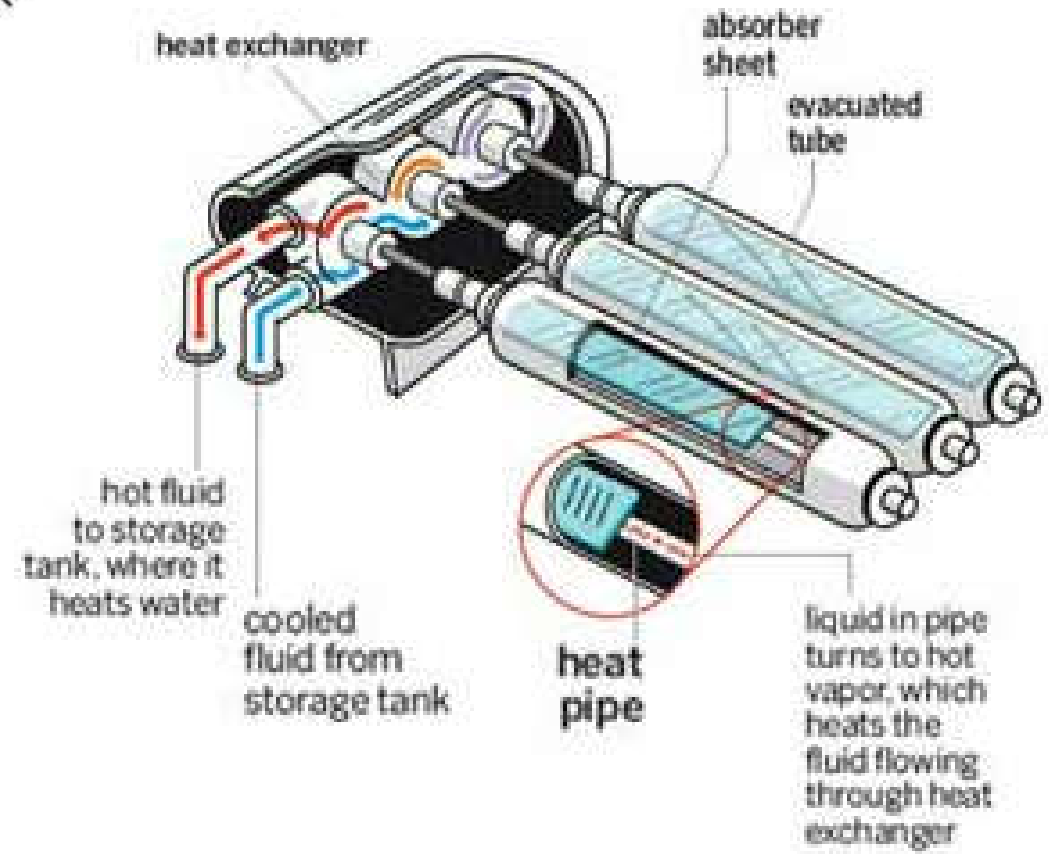




Simple domestic system
(with integral storage tank)

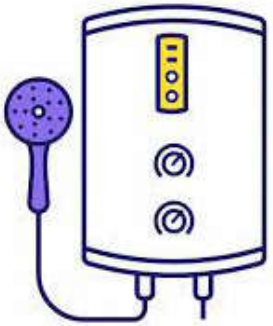
Heat pipe evacuated-tube solar collector



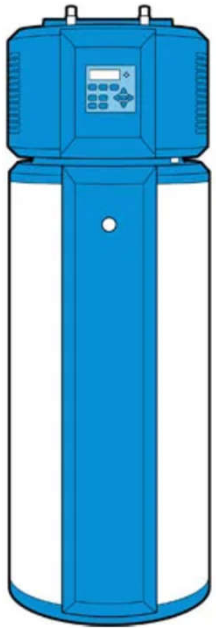


Evacuated-tube solar hot water system

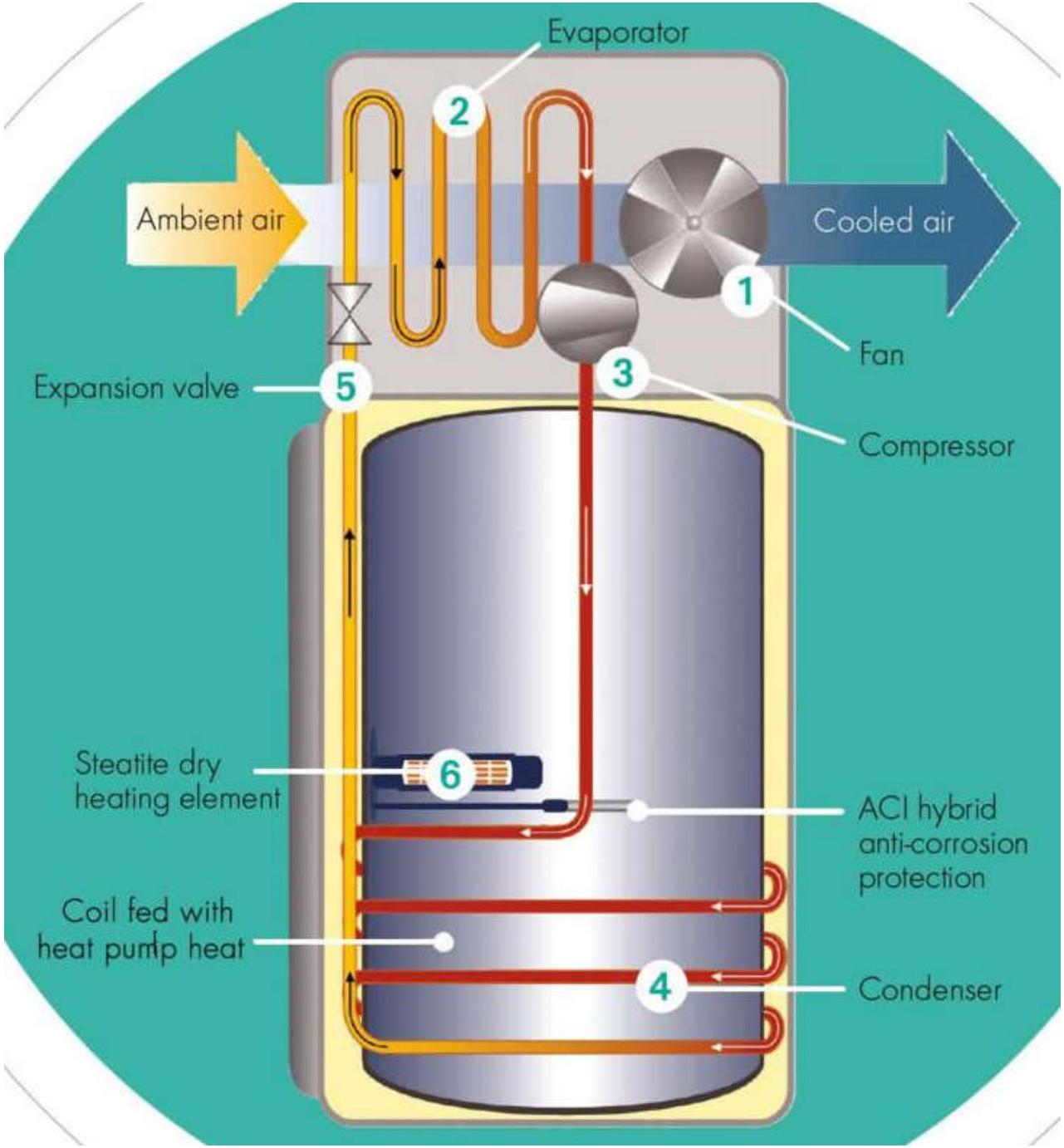
Water heaters



- Heat pump water heaters (HPWH)
  - An effective tool to produce hot water
  - Extract energy from ground, water, or ambient air
  - Typical applications:
    - To preheat conventional hot water systems
    - To augment existing systems
    - To supply full hot water
  - Reverse of the normal refrigeration cycle

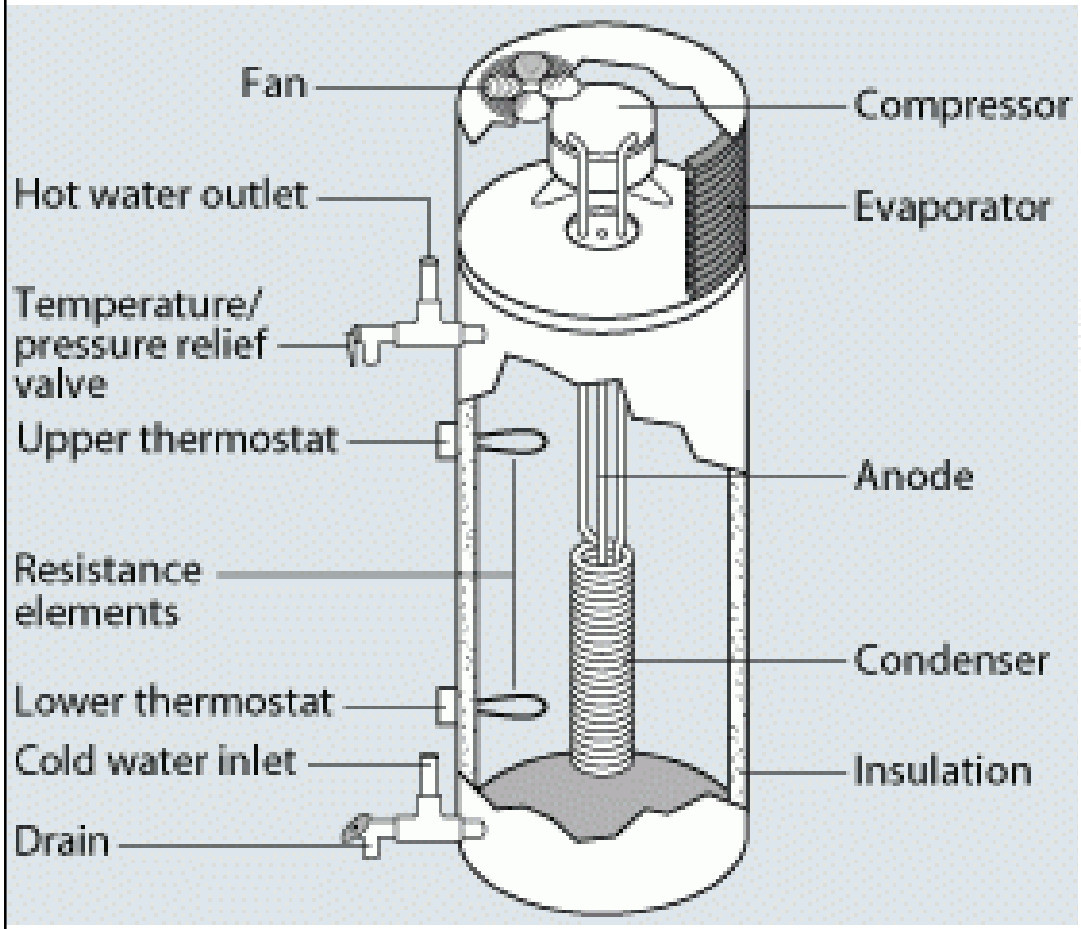


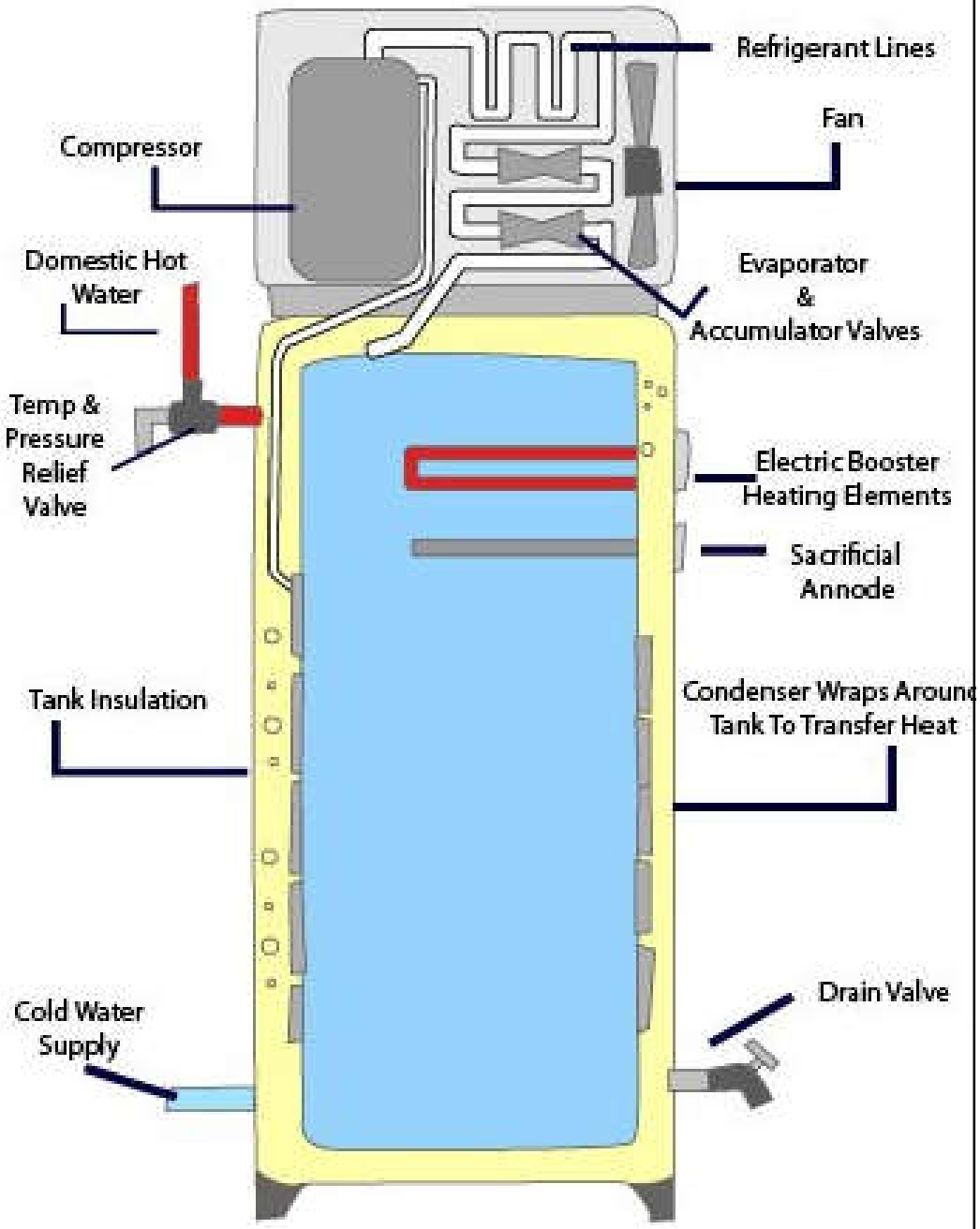
Working principle of heat pump water heater



(Source: https://www.atlantic-comfort.com/How-to-choose/Choosing-your-water-heater/Water-heating-technologies/Heat-pump-water-heaters-working-principle)

Heat pump water heaters

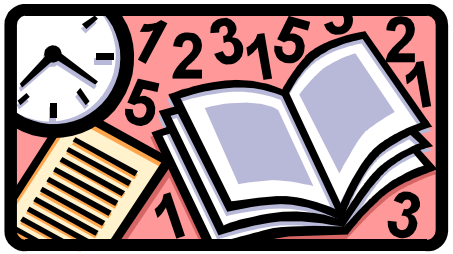




Video: How a Heat Pump Water Heater Works (2:01)
https://youtu.be/EMdZr-TAga0

(Image sources: https://www.energy.gov/energysaver/water-heating/heat-pump-water-heaters;
https://cdn2.hubspot.net/hubfs/91341/waterHeaterModals/waterHeater002a.html)

References



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