

# Why Go Underground ?

For hundred of thousands of years,  
our natural domain has been  
mainly a two-dimensional space



# Nature, and not mankind, is at the origin of the first underground works



# Cave dwellings were an important landmark in the use of underground space by mankind (France)





Since the dawn of human endeavor,  
numerous reasons have encouraged  
mankind to use and develop  
underground space

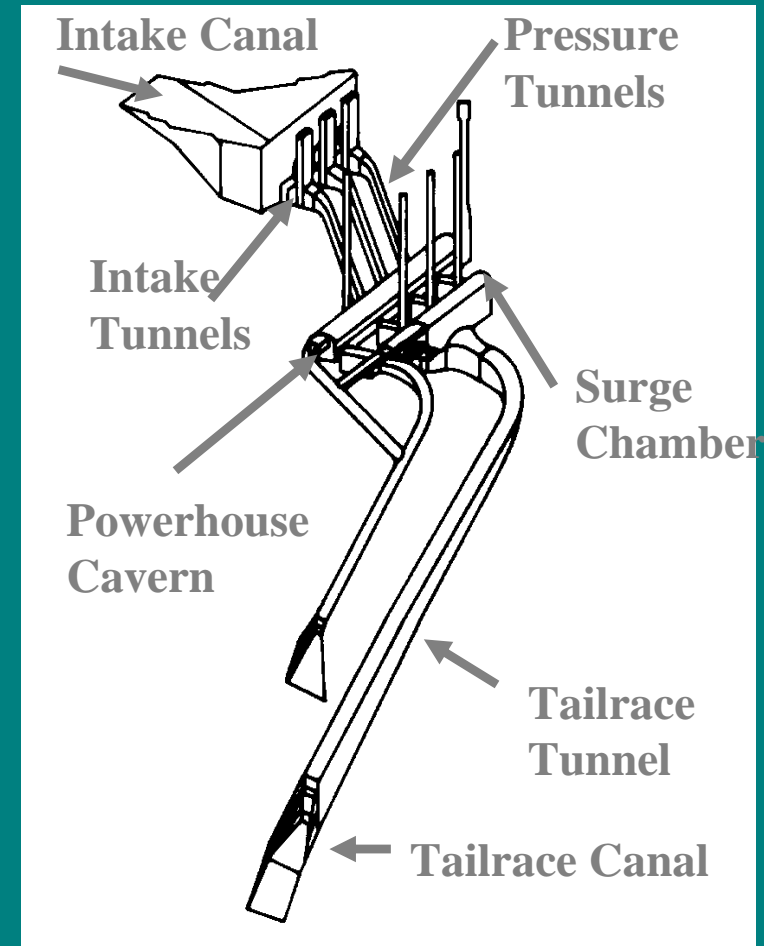
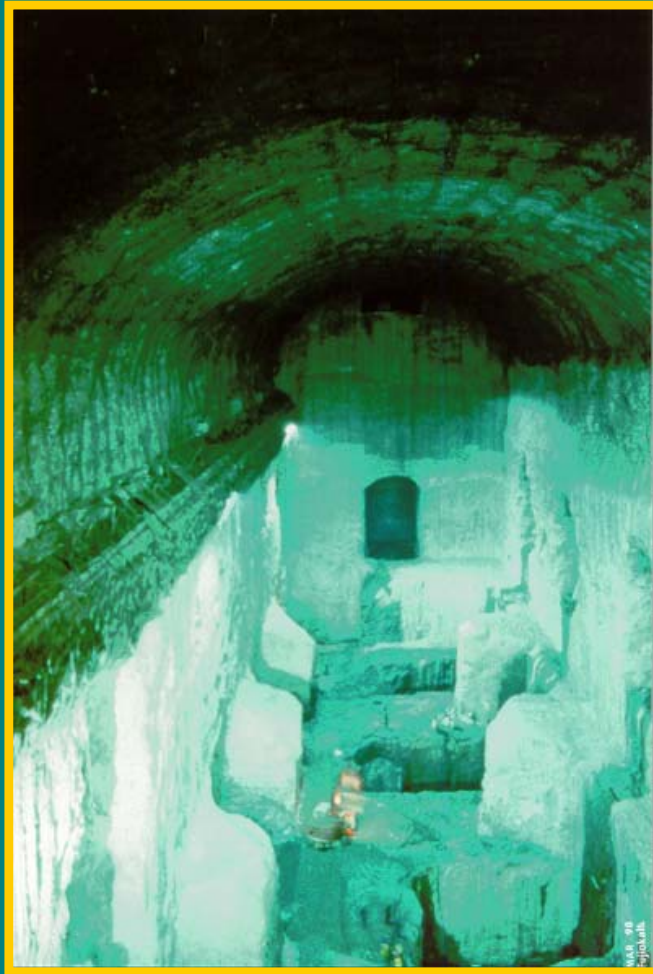
# The Malpas Tunnel on the Canal du Midi (France - late 17th Century)



# The Saint Gothard Tunnel (Switzerland - Late 19th Century)



# Powerhouse of the Serra da Mesa hydroelectric power plant (Brazil)





# Fundamental characteristics of underground space

- Underground medium is a space that can provide the setting for activities or infrastructures that are difficult, impossible, environmentally undesirable or less profitable to install above ground.
- Underground space offers a natural protection to whatever is placed underground
- The containment created by underground structures protects the surface environment from the risks / disturbances inherent in certain types of activities
- Underground space is opaque : an underground structure is only visible at the point(s) where it connects to the surface.

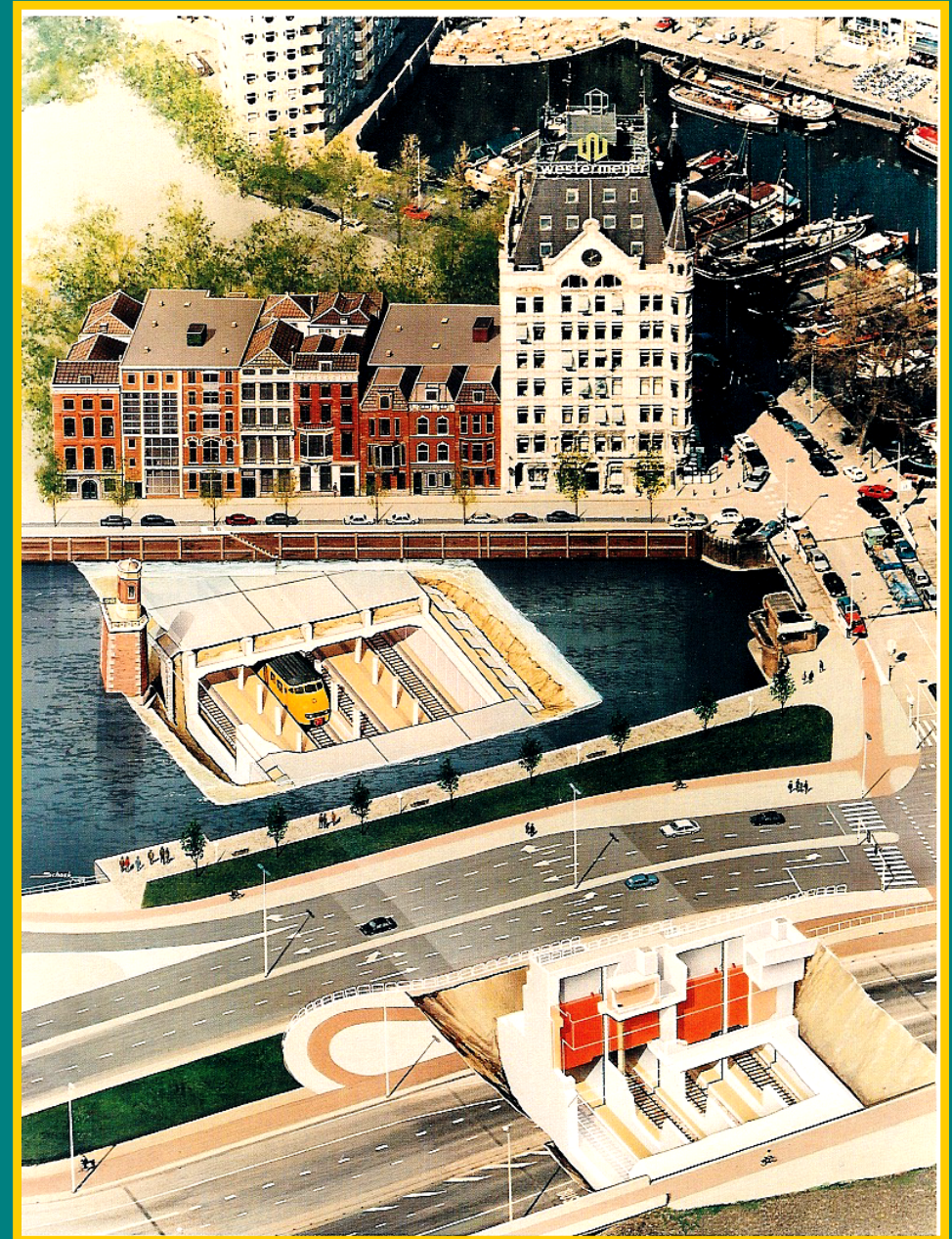
# Reasons for going underground

- Land use and location reasons
- Isolation considerations
- Environmental protection
- Topographic reasons
- Social benefits

# Reasons for going underground

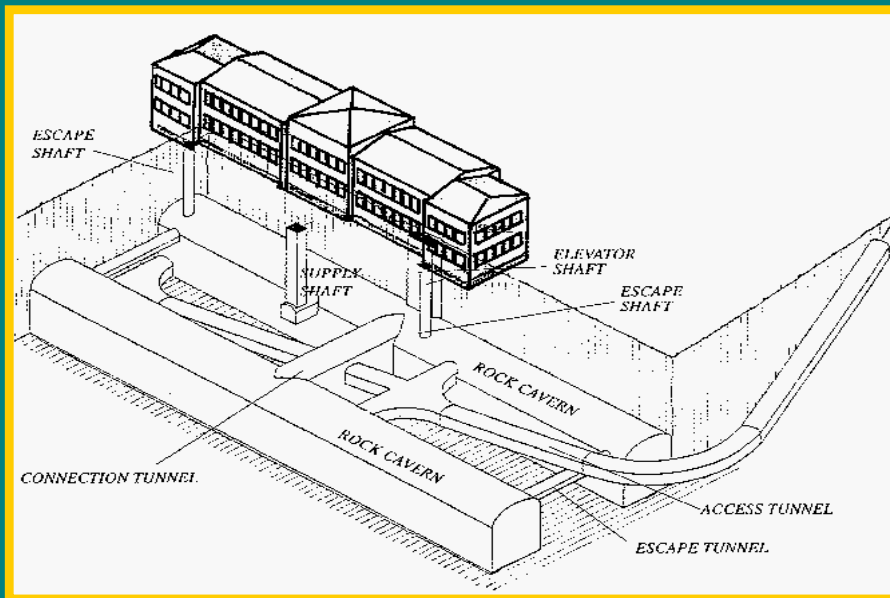
(I) Land use and location reasons

# Blaak Station (Rotterdam - The Netherlands)

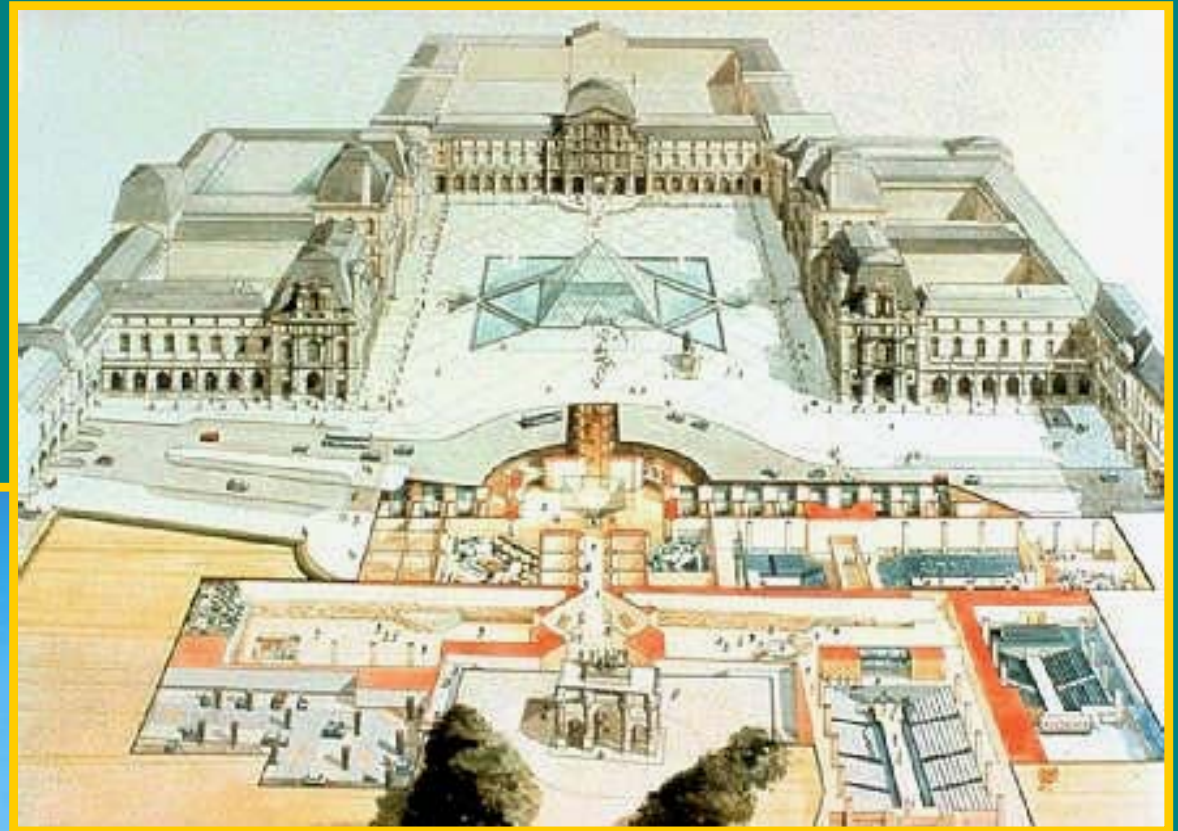




# Underground expansion of the Swedish Royal Library (Stockholm - Sweden)

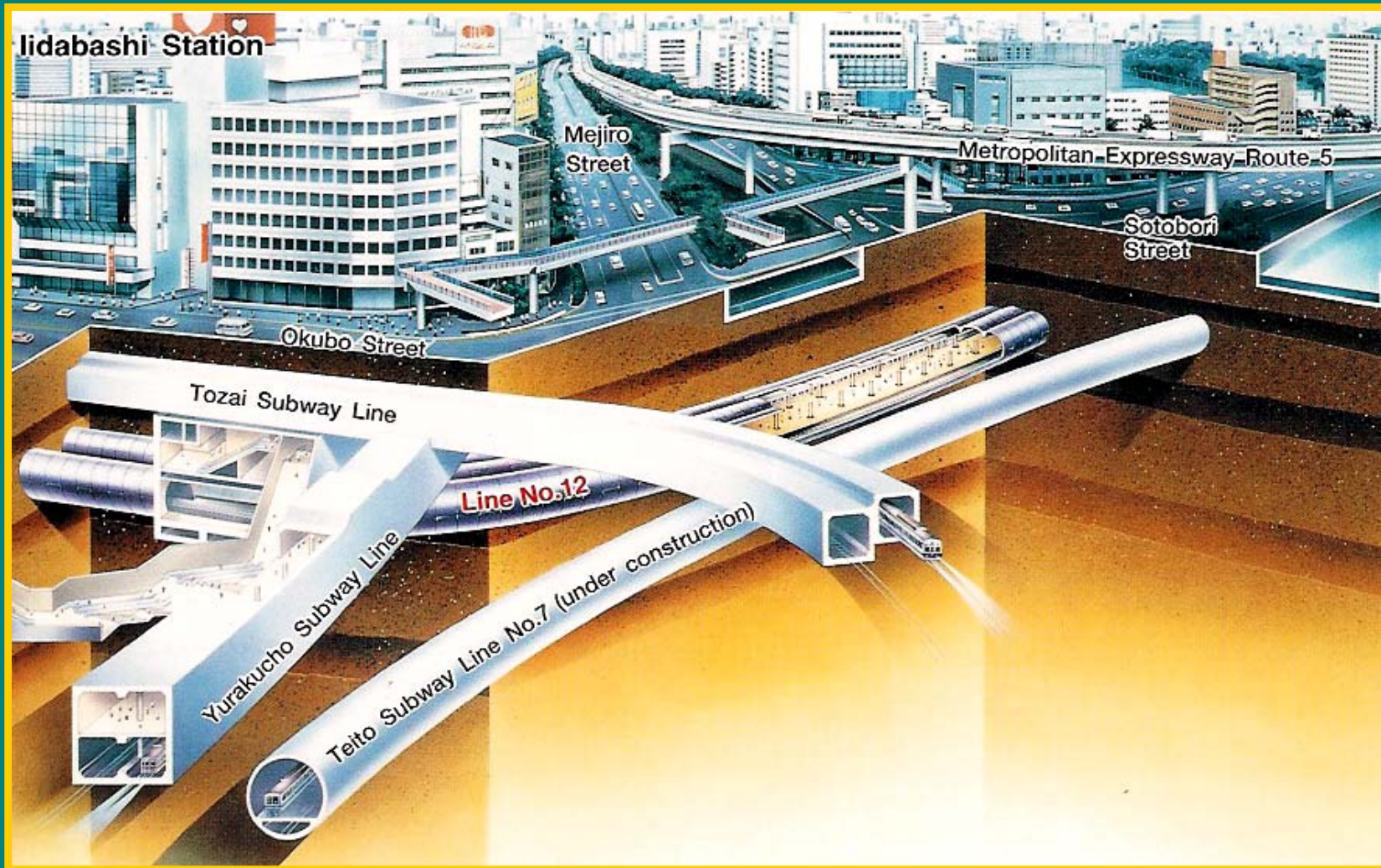


# Le Grand Louvre (Paris - France)



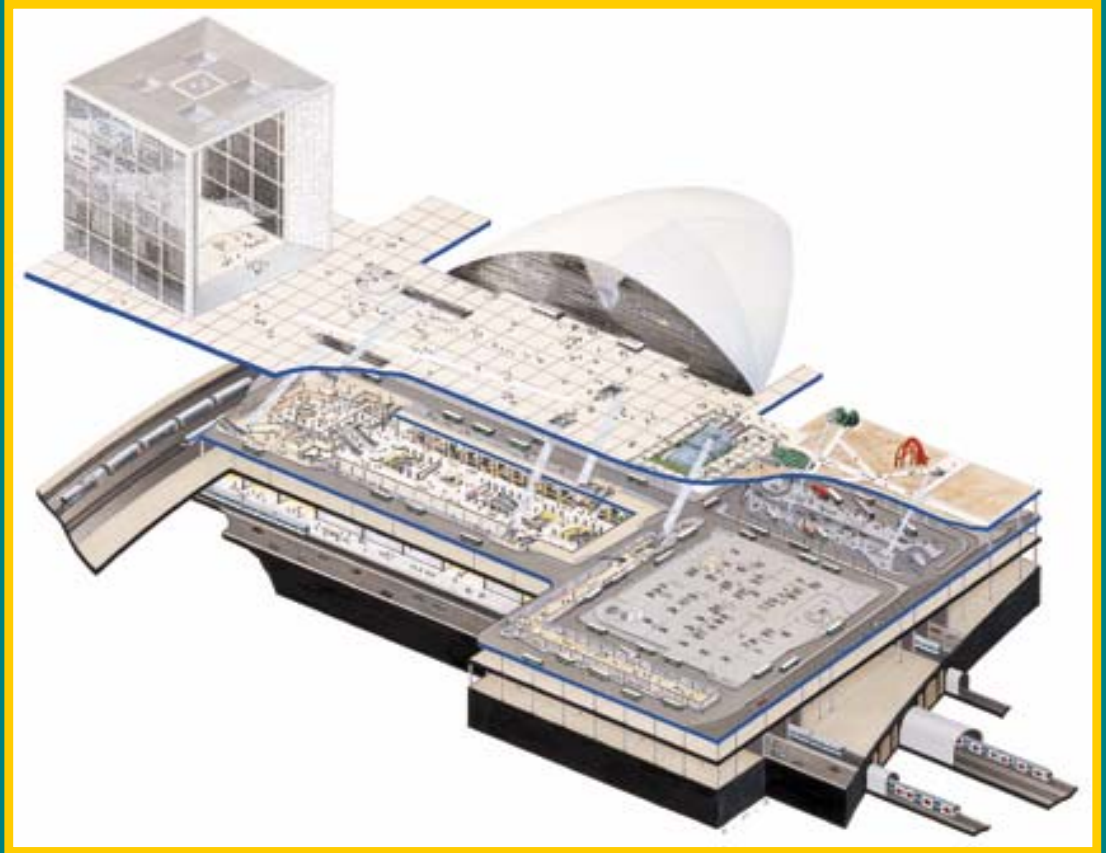


# Tokyo Subway - Iidabashi Station (Tokyo - Japan)





# La Defense Urban Hub (Paris - France)



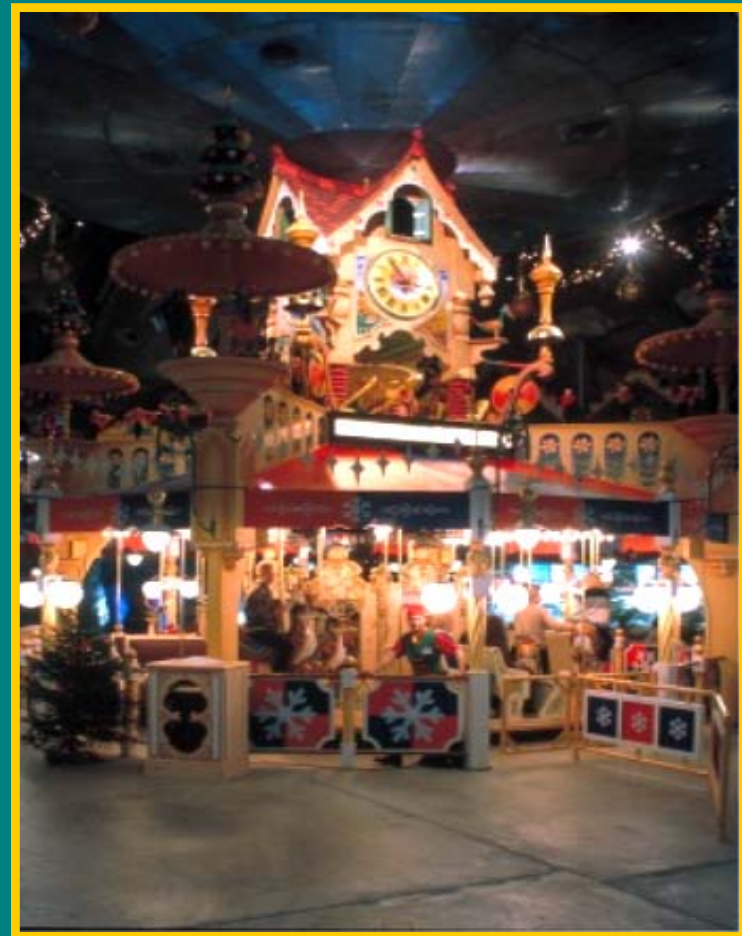
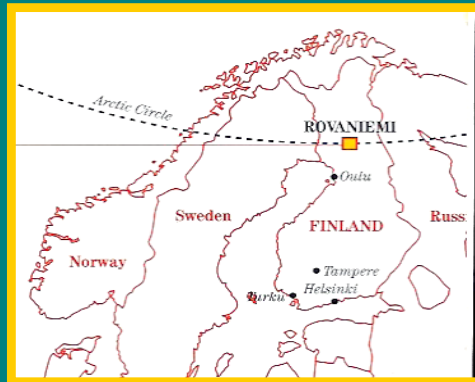


# Reasons for going underground

## (2) Isolation considerations

# The Santa Claus Village

Unique Christmas theme park on the Arctic Circle in Finnish Lapland



# Underground hospital in a potash salt mine for allergy treatment (Ural - Russia)





# Underground swimming pool (Finland)





# Gjovik Olympic Mountain Hall (Norway)





# Above-ground structures are more sensitive to earthquake than underground ones

## Kobe Earthquake (Japan - 1995)

Severe damage to the Kobe City Hall

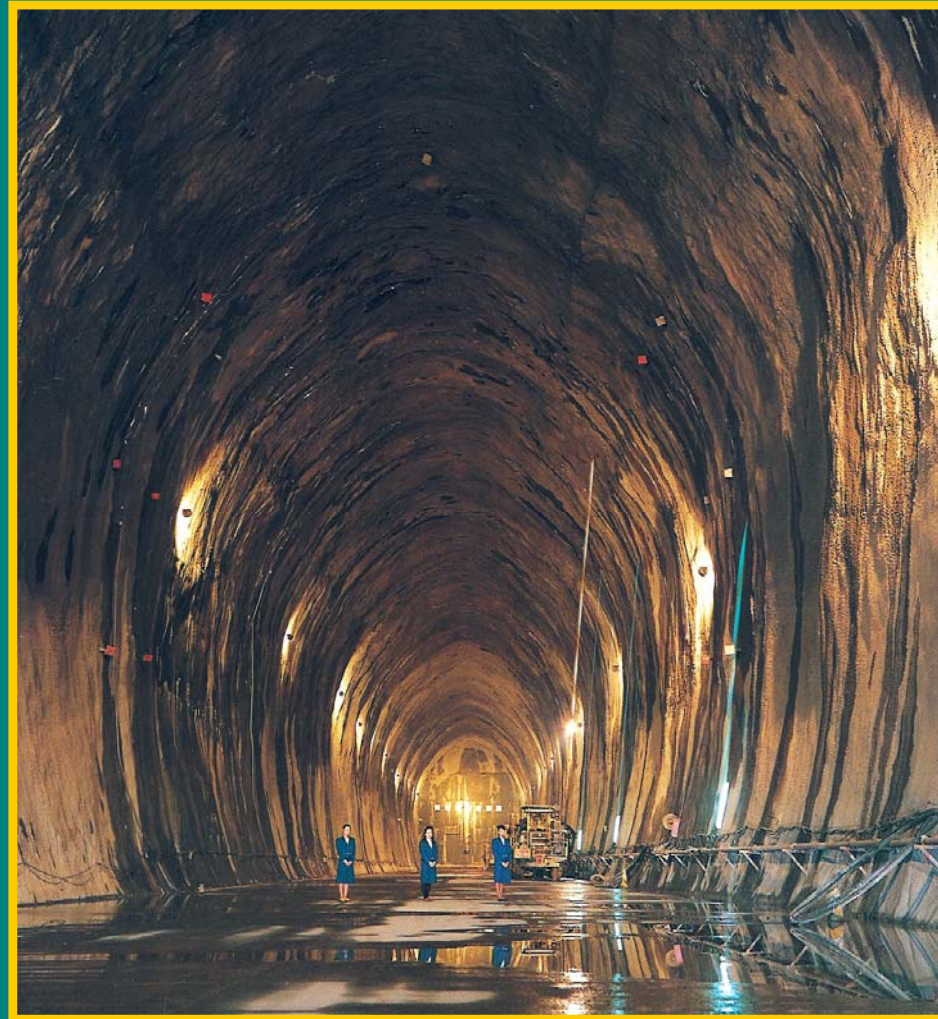


No damage to the underground shopping mall located below



# Underground crude oil storage facility

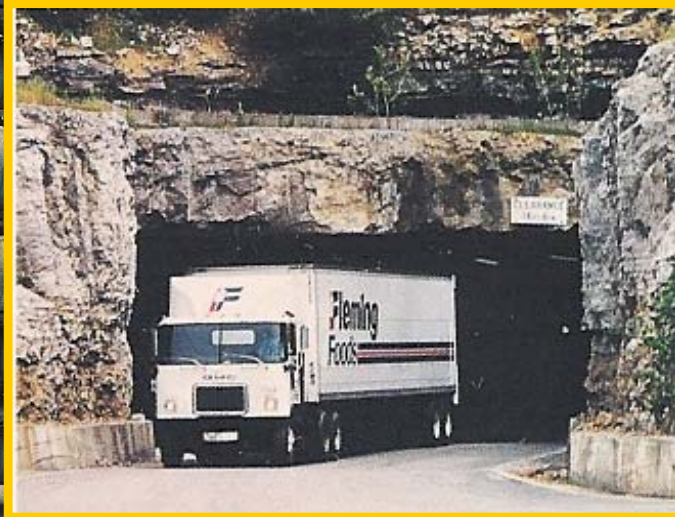
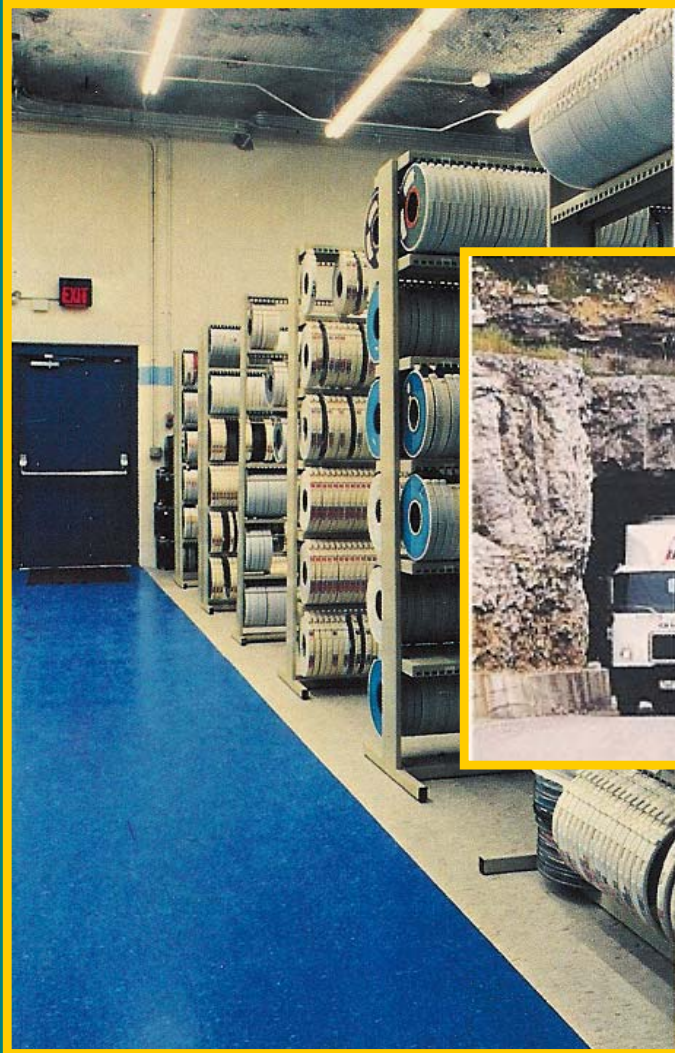
## Kuji Plant (Japan)





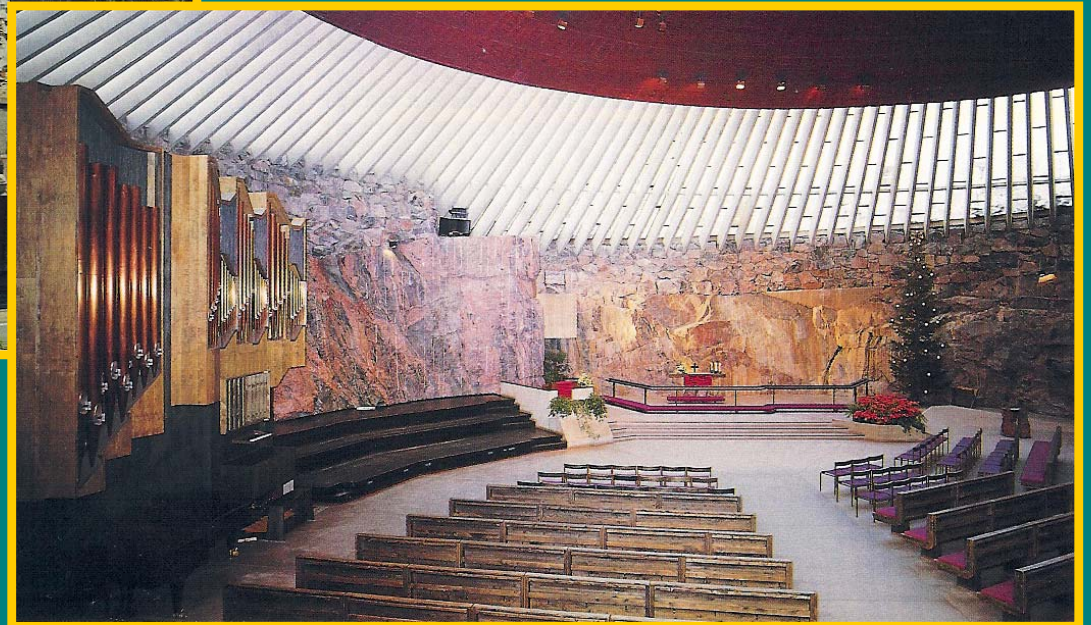
# Underground storage facilities

## Kansas City (USA)



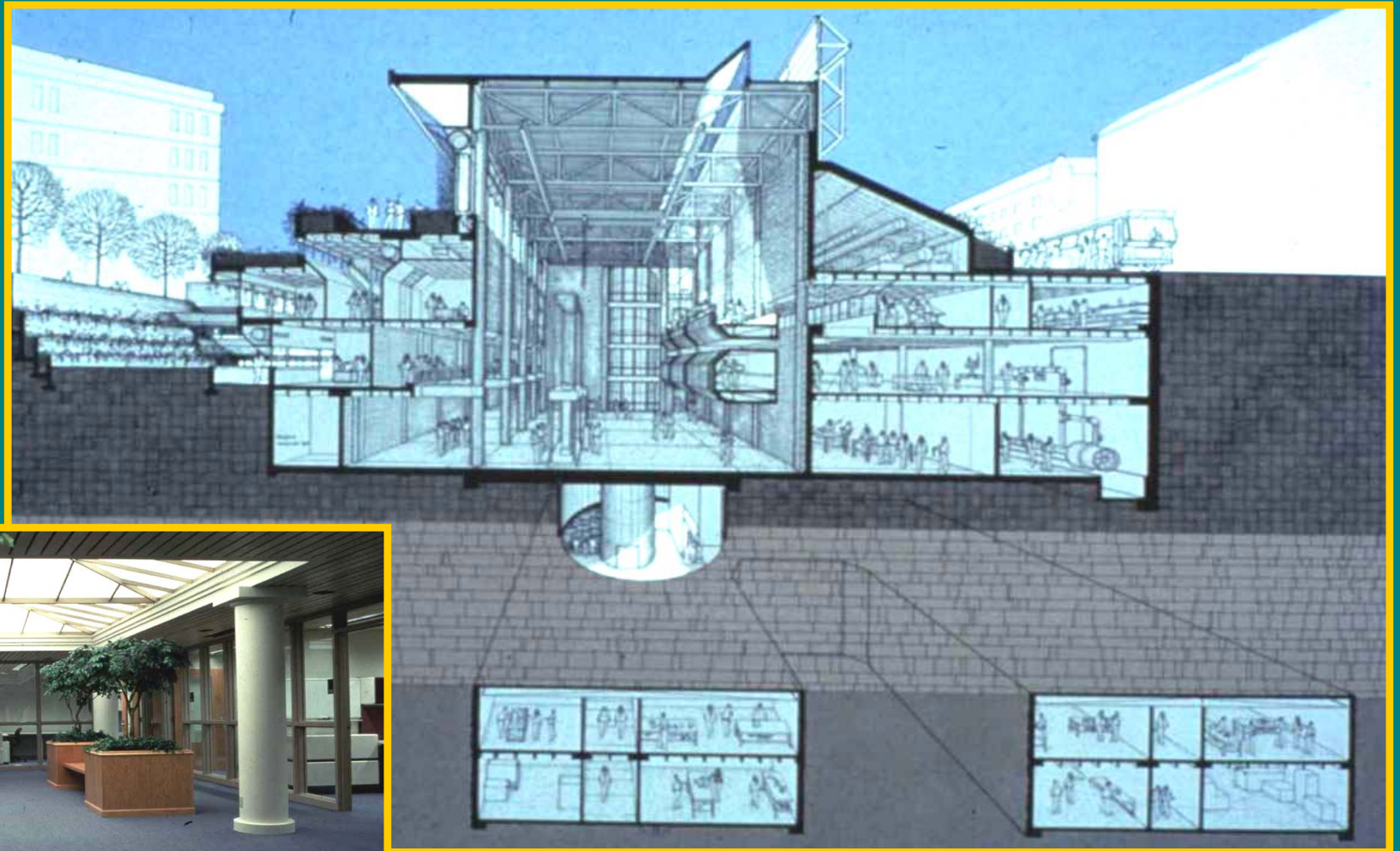


# Underground Church in Rock (Helsinki, Finland)

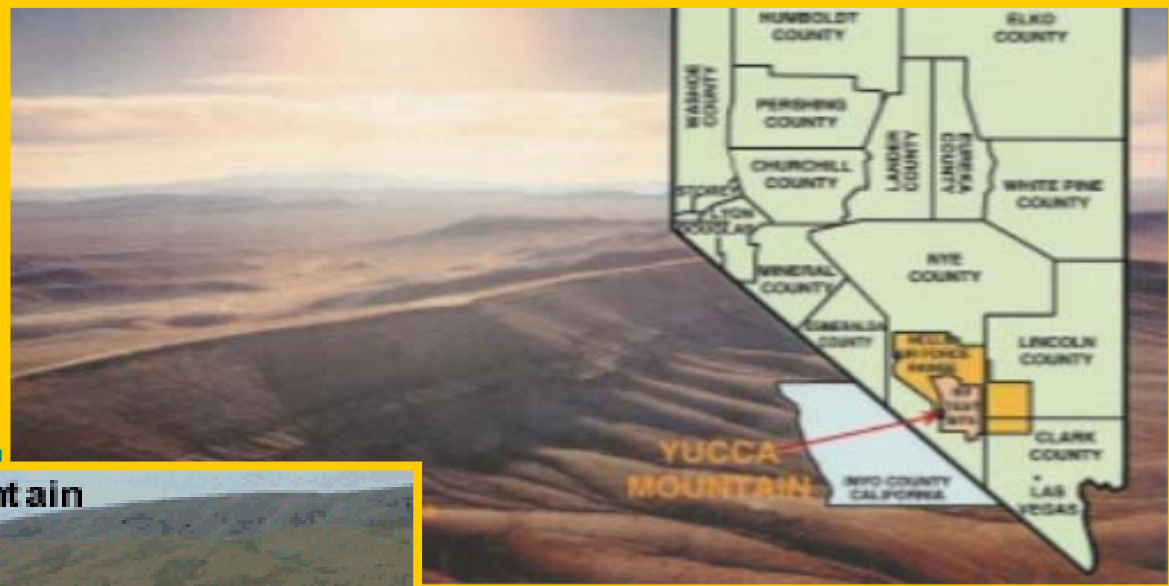




# University of Minnesota (USA)



# Yucca Mountain Site characterization project (Nevada - USA)



North Pad of Yucca Mountain





# Reasons for going underground

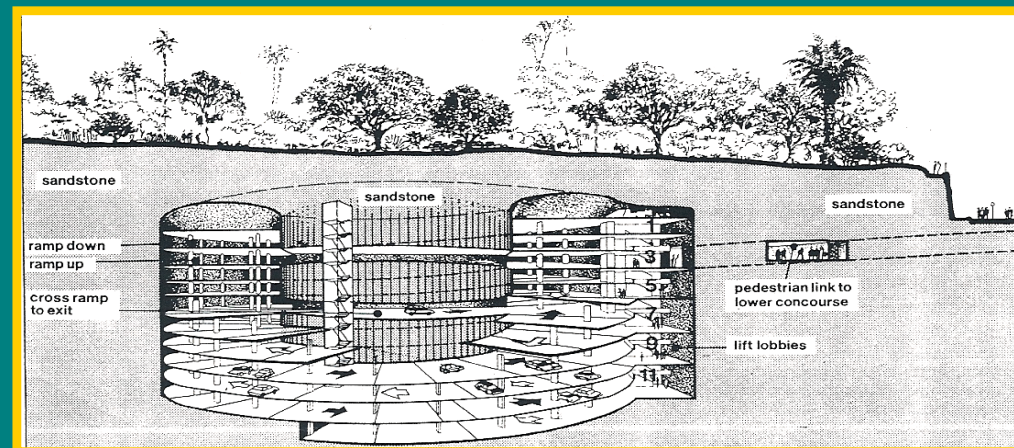
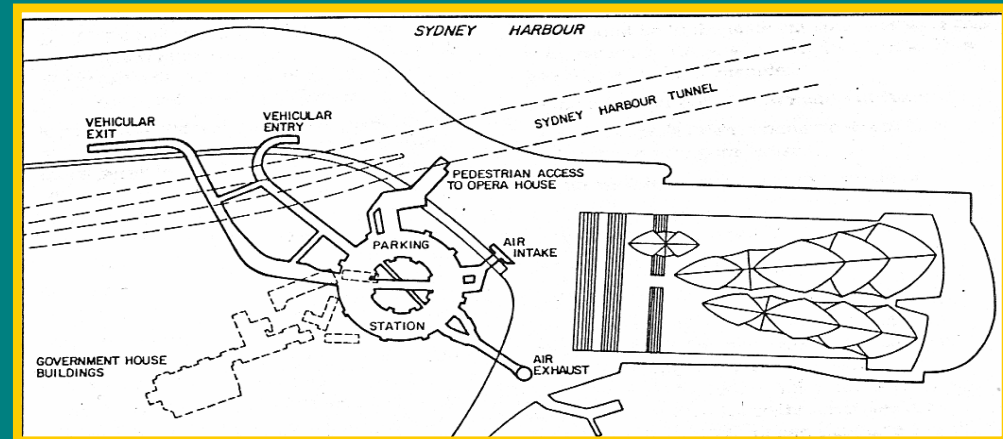
(3) Environmental protection

# Car park at the square Estienne d'Orves in Marseilles (France)

Situation «before» and «after» the construction of  
the underground car park



Thanks to the use of subsurface, a car park could be located in the very proximity of the Sydney Opera House (Australia)





# Variety of the underground infrastructure in a city





A motorway tunnel forming a green bridge,  
providing a free range for people, animals, and  
even vegetation (Finland)





# The Green Heart Tunnel (The Netherlands)

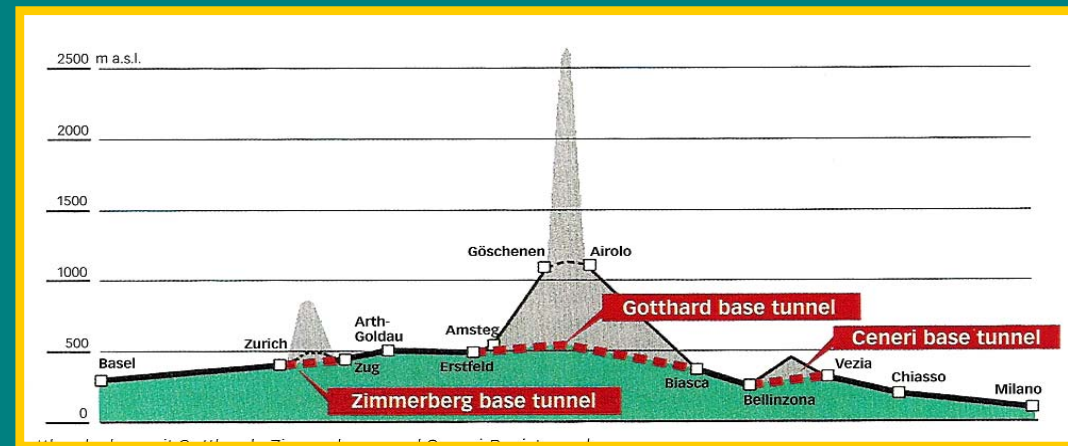
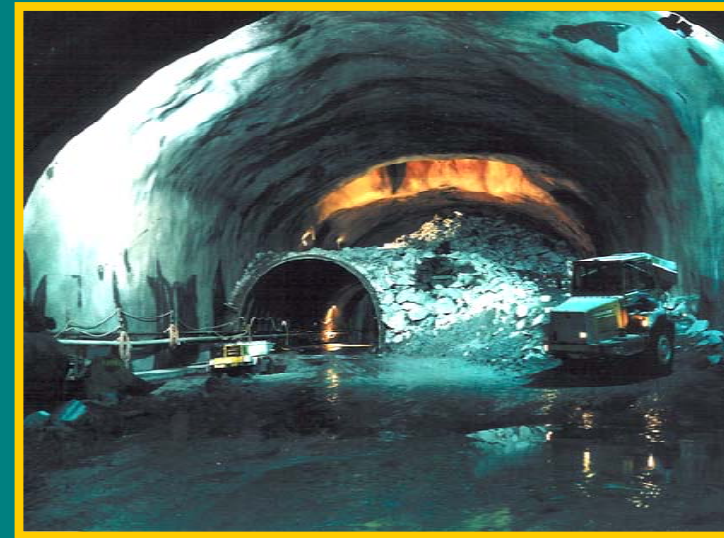




# Reasons for going underground

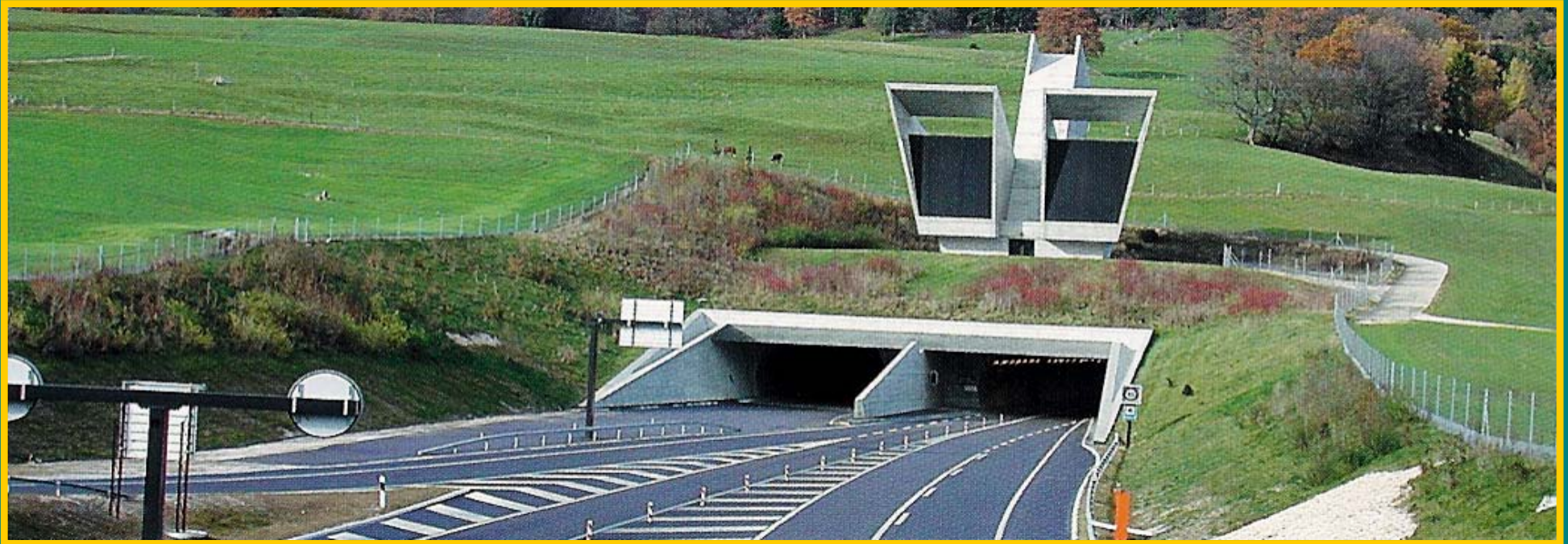
## (4) Topographic reasons

# The Gotthard Base Tunnel (Switzerland)





# Mont Russelin Tunnel on National Highway A16 (Switzerland)

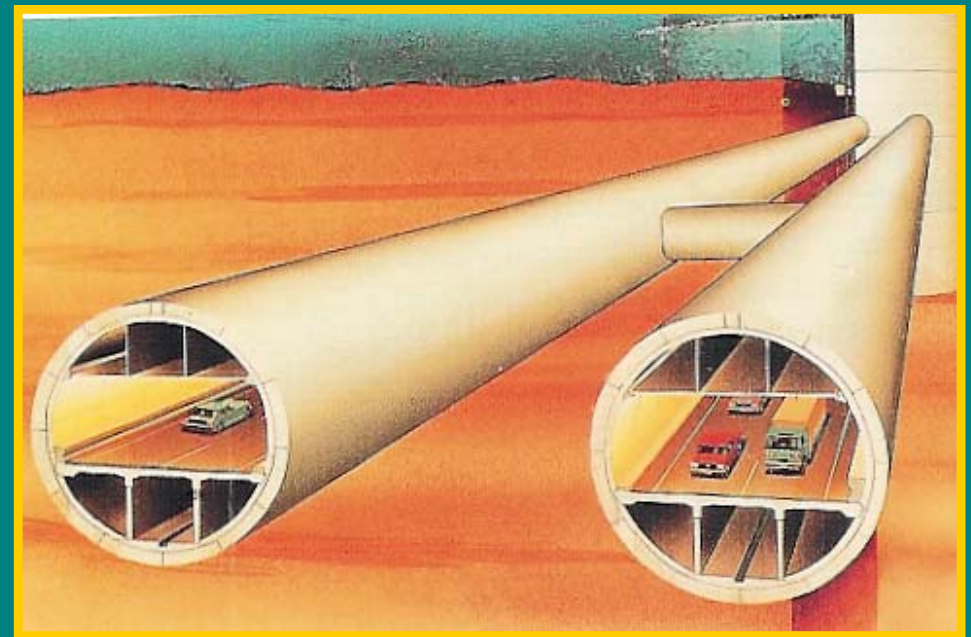




# High speed railway tunnel (Germany)

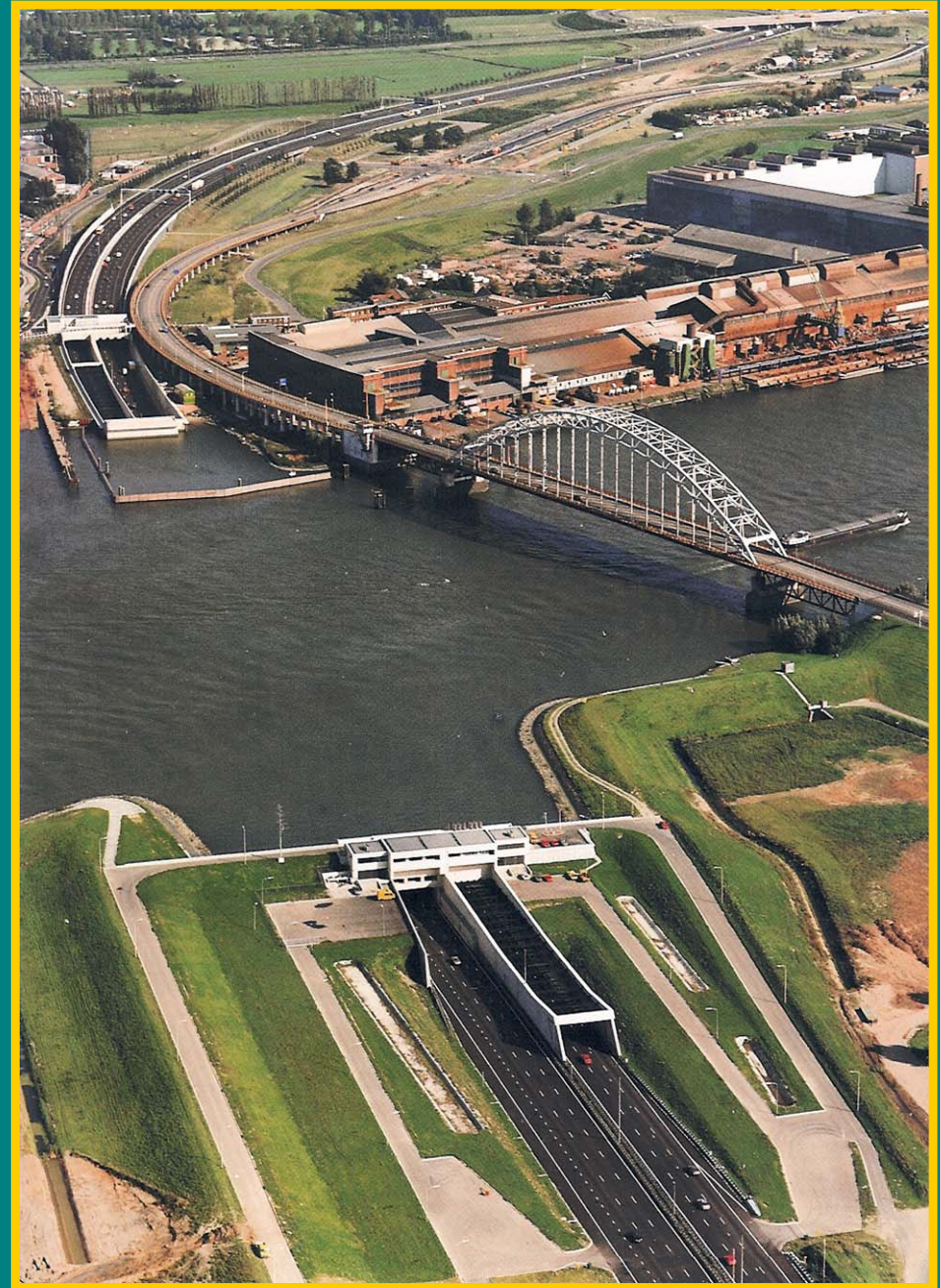


# Trans Tokyo Bay Highway (Japan)

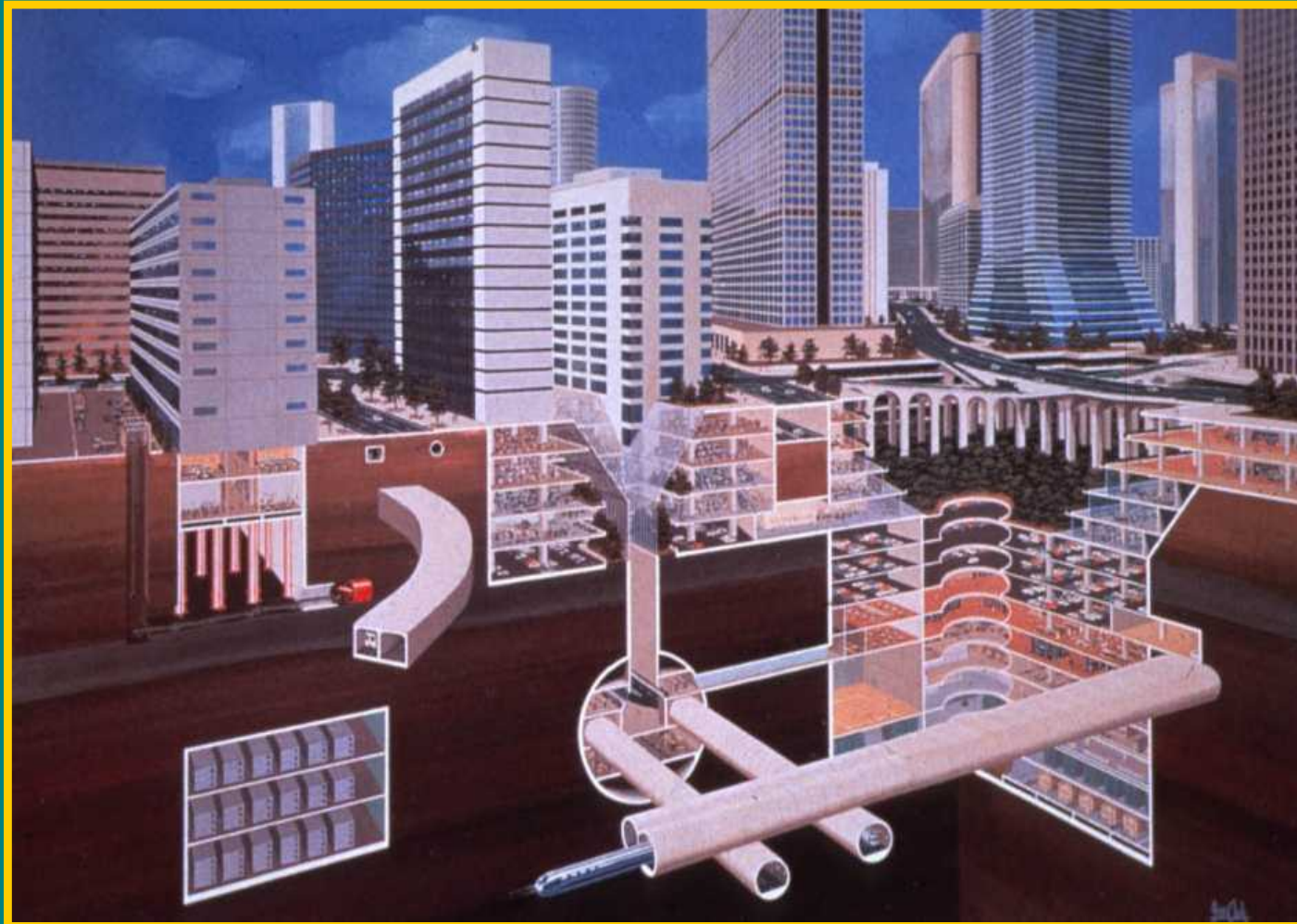




# The Noord Tunnel Amsterdam (The Netherlands)

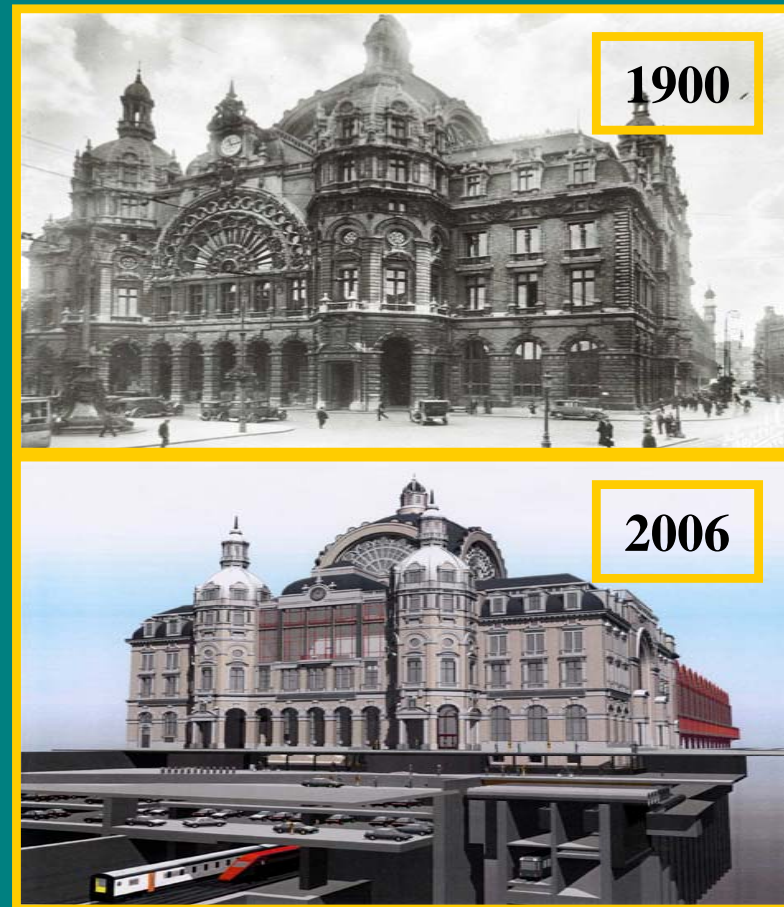


# Expanded use of underground space





# The new Antwerp Central Station on the Paris-Amsterdam high speed rail link (Antwerpen - Belgium)



# Reasons for going underground

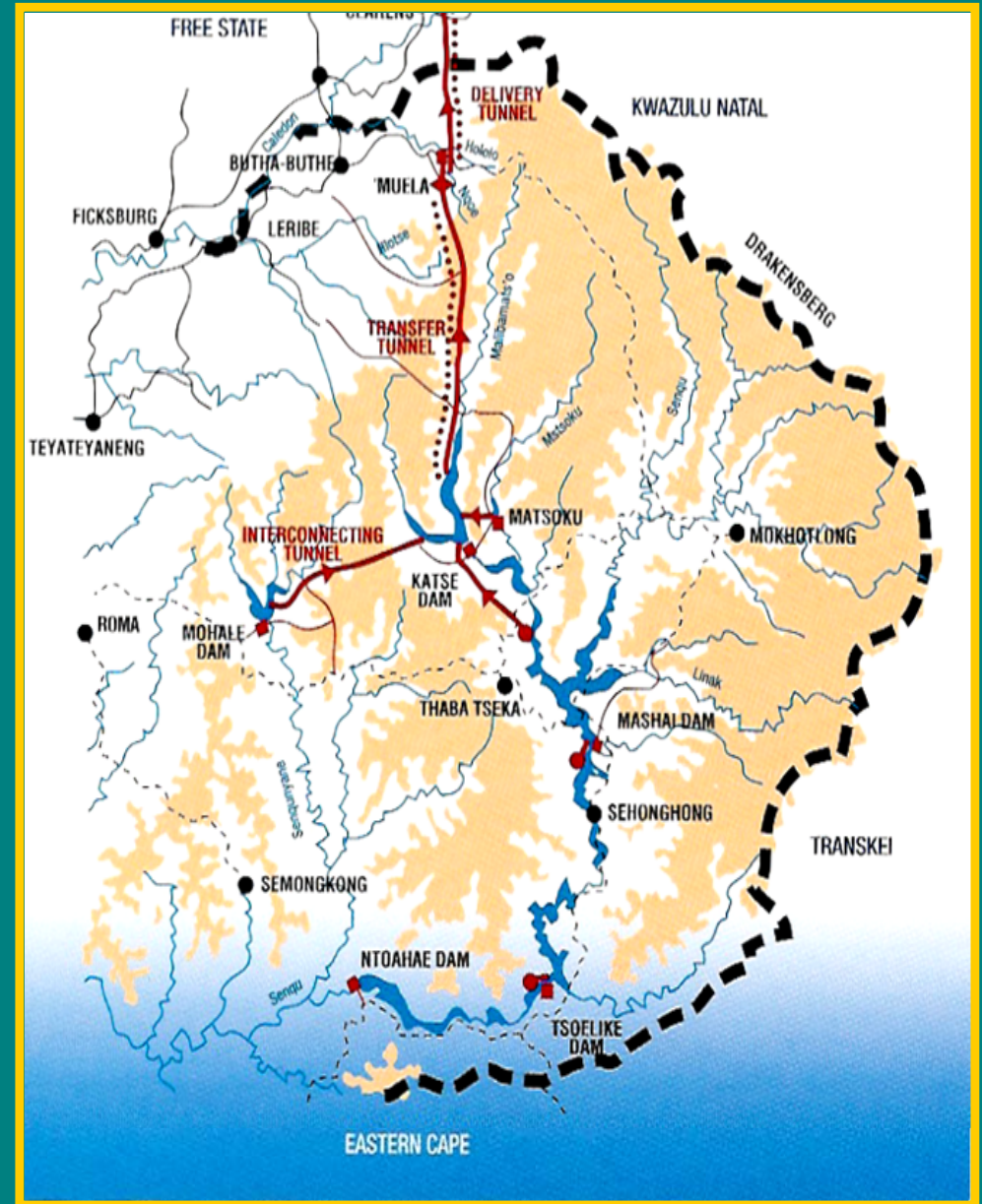
(5) Social benefits



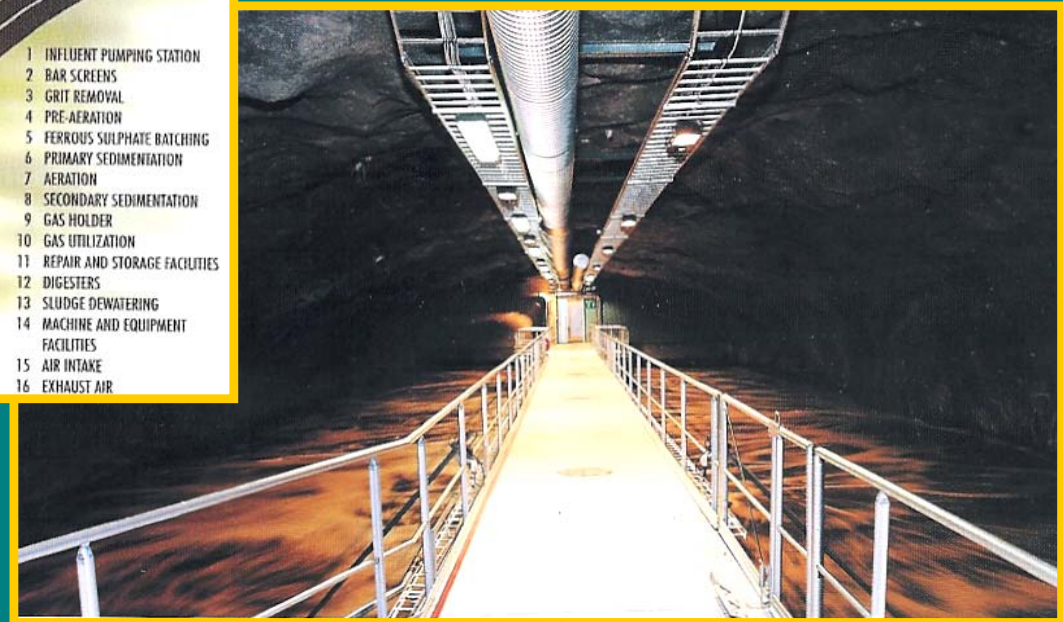
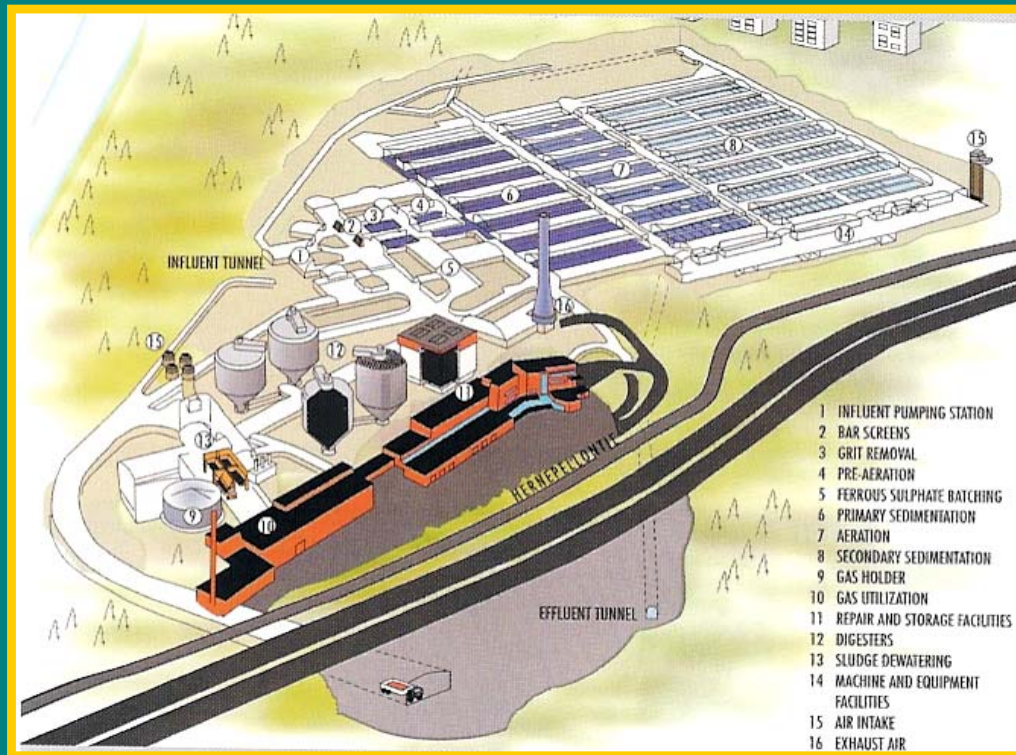
*« Tunnels play a vital environmental role by conveying clean water to and by conveying wastewater out from urban areas »*

\*\*\*\*\*

## The Lesotho Highlands Water Project



# Waste water treatment plant in Helsinki (Finland)





*« Tunnels provide  
safe, environmentally  
sound, fast, and  
unobtrusive urban  
mass transit systems »*

*\*\*\*\*\**

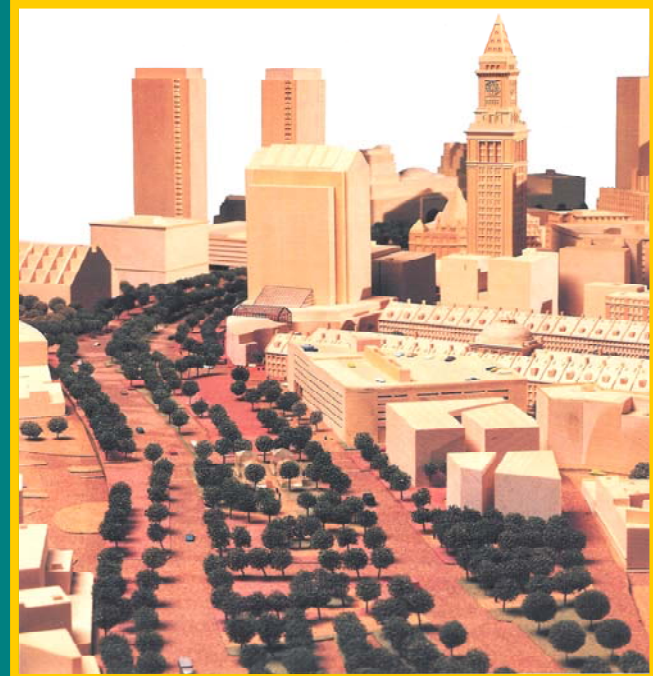
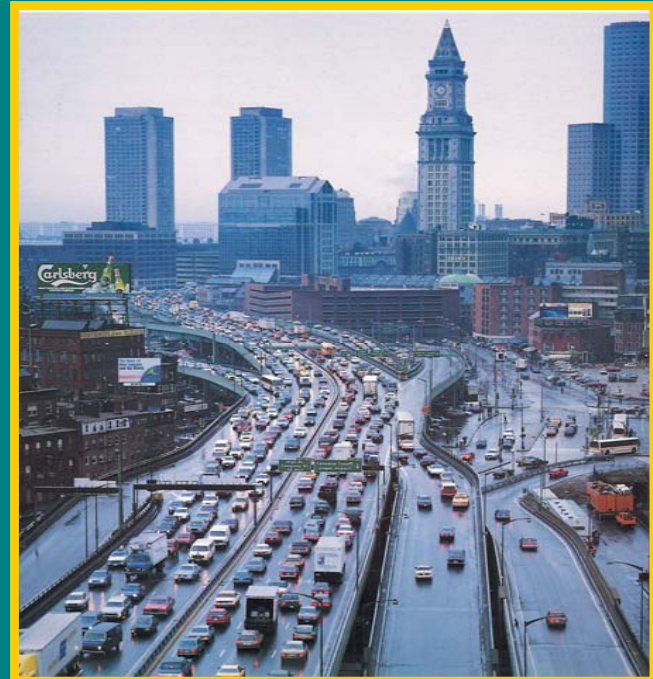
**Paris Metro  
Line 14 - «Meteor»  
(France)**



*« City traffic tunnels clear vehicles from surface streets, traffic noise is reduced, air becomes less polluted and the surface street areas may partially be used for other purposes »*

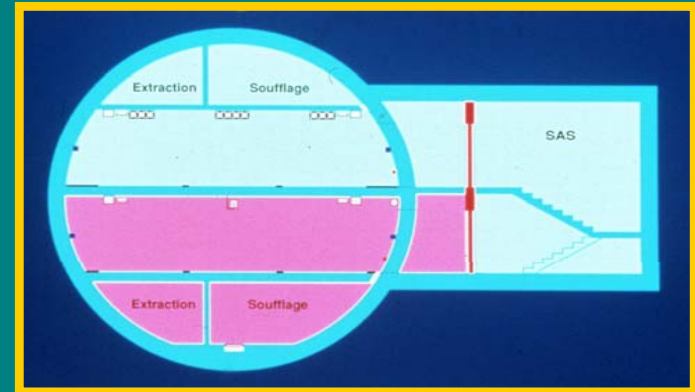
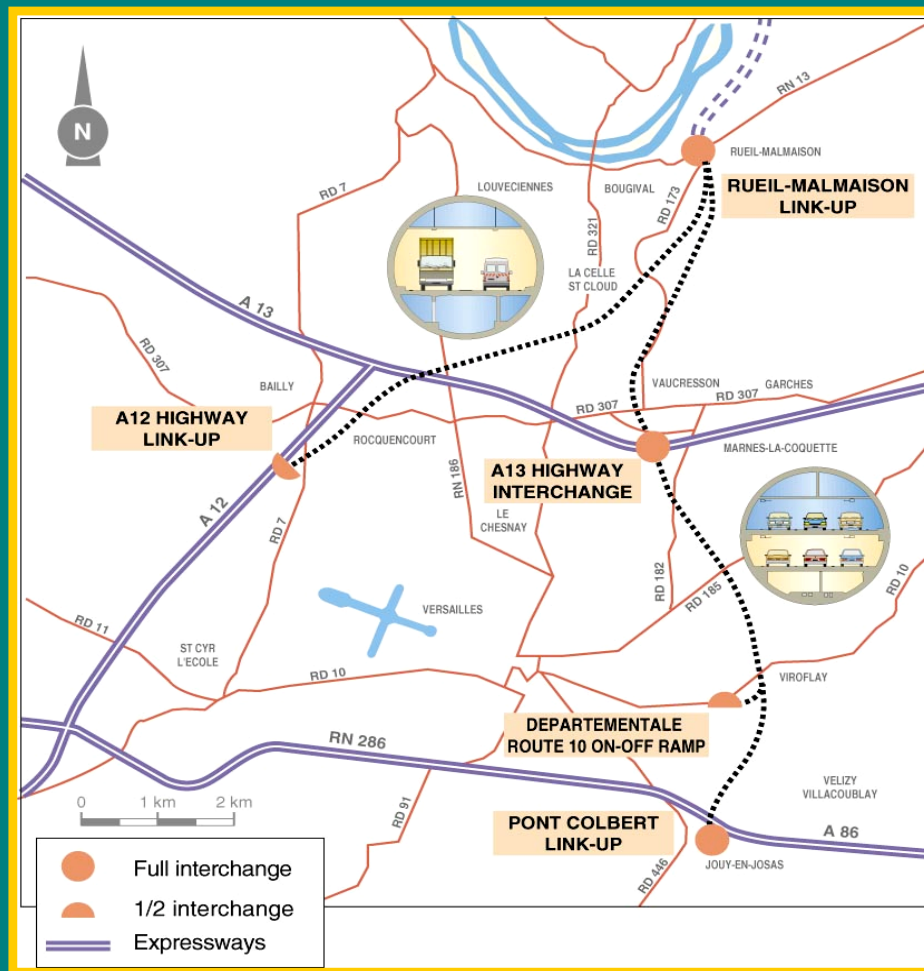
\*\*\*\*\*

*The Central Artery  
in Boston (USA)*





# The A86 West Underground Link-up (Paris Region - France)



*« Underground car parks  
in city centres leave room  
for recreation areas and  
playground above  
ground »*

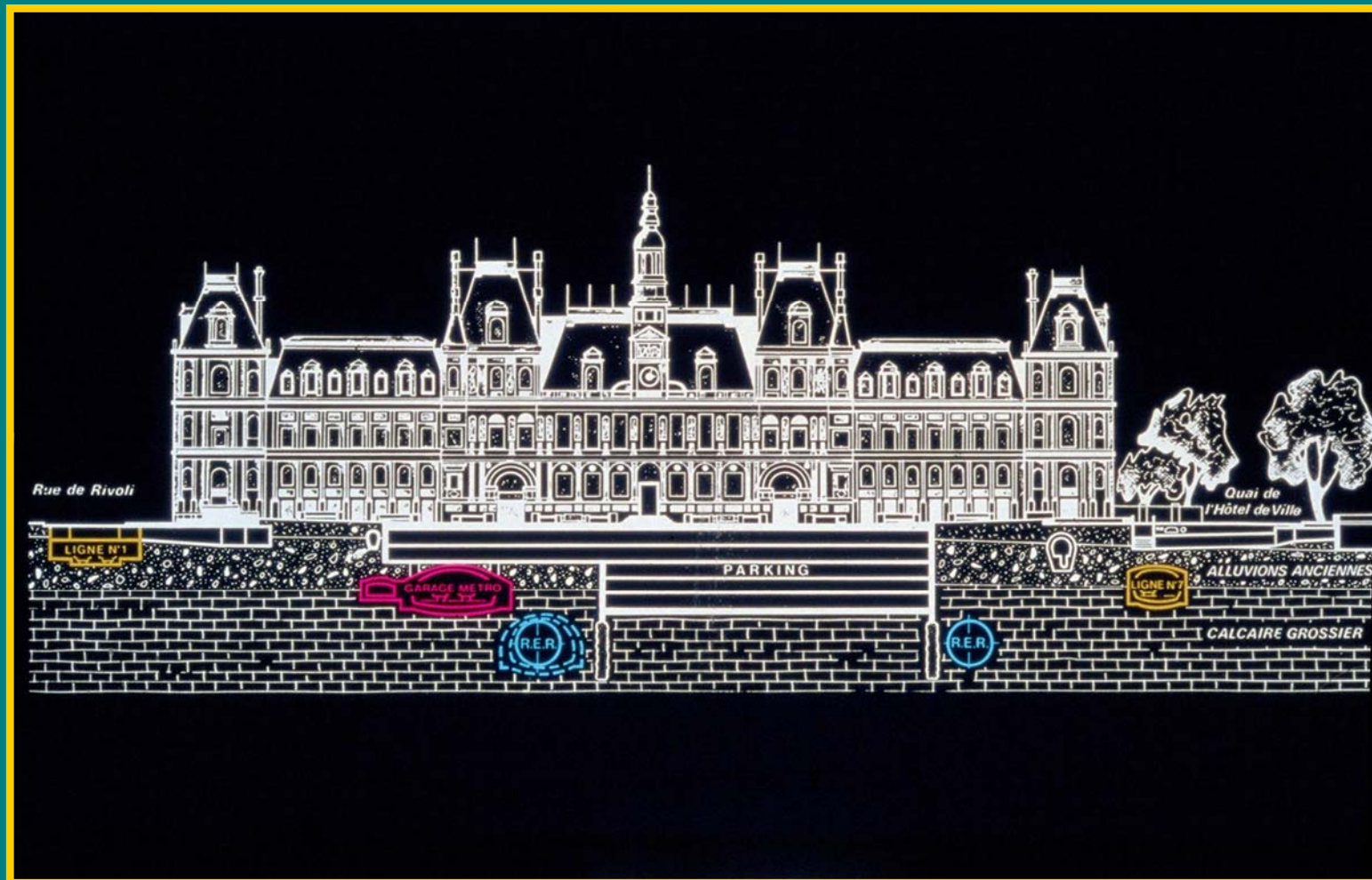
\*\*\*\*\*

Underground car park  
below a schoolyard  
(Stockholm - Sweden)





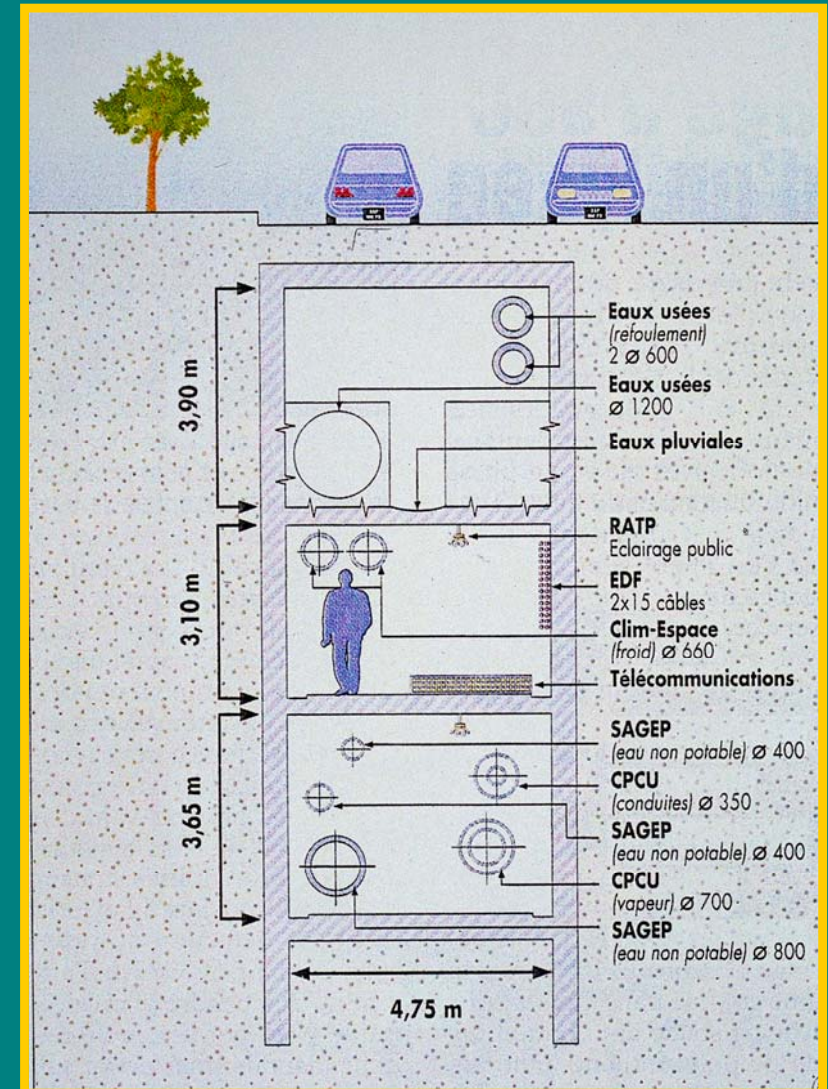
# The Paris Town Hall underground car park (France)



*« Multipurpose utility tunnels  
are less vulnerable to external  
conditions than surface  
installations and will cause  
only insignificant disturbance  
above ground when installed  
equipments are repaired or  
maintained »*

\*\*\*\*\*

**Utilidor**  
(Paris - France)



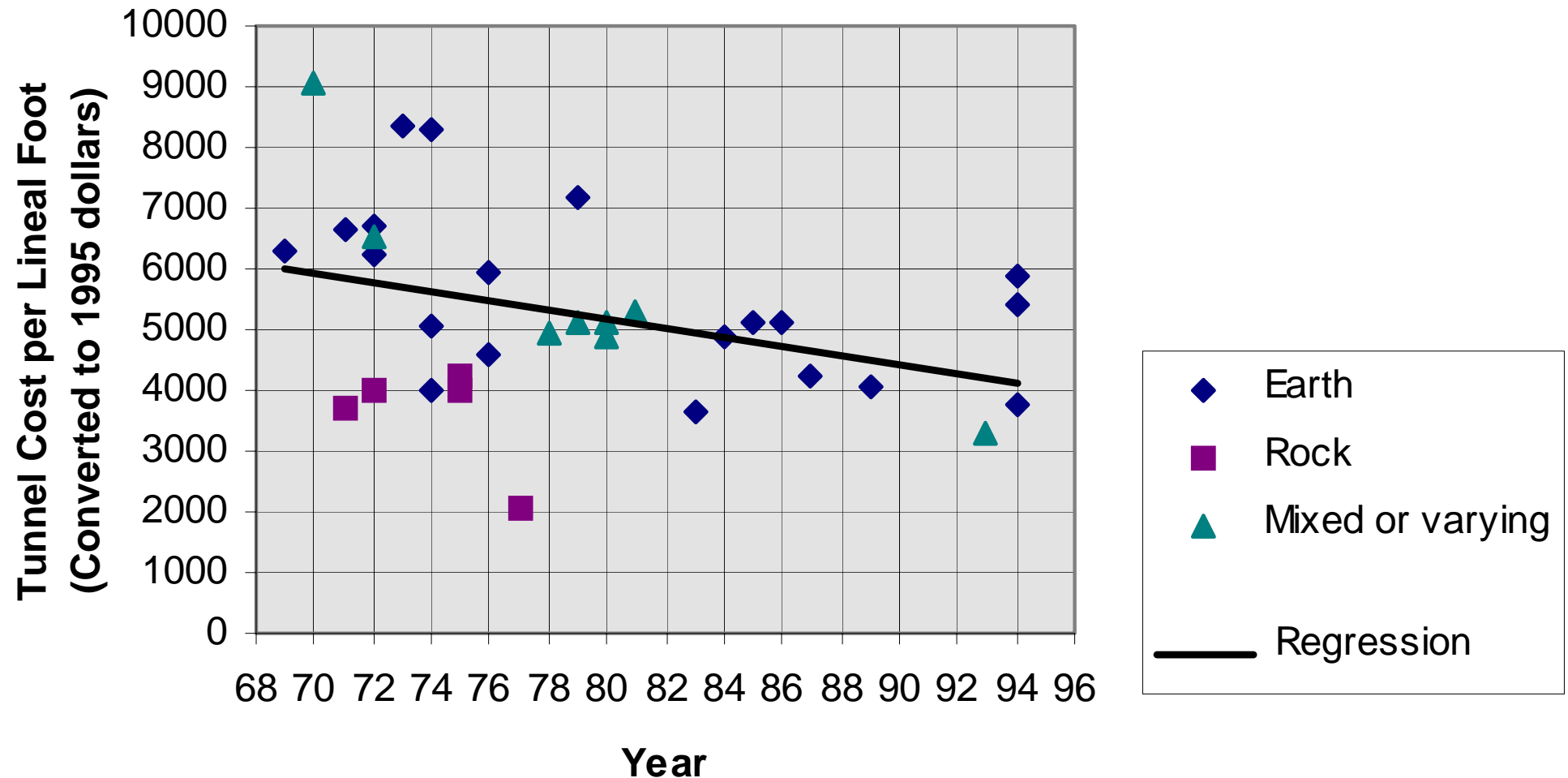


# Assessment of the underground structures

(I) Taking into account life-cycle  
costs

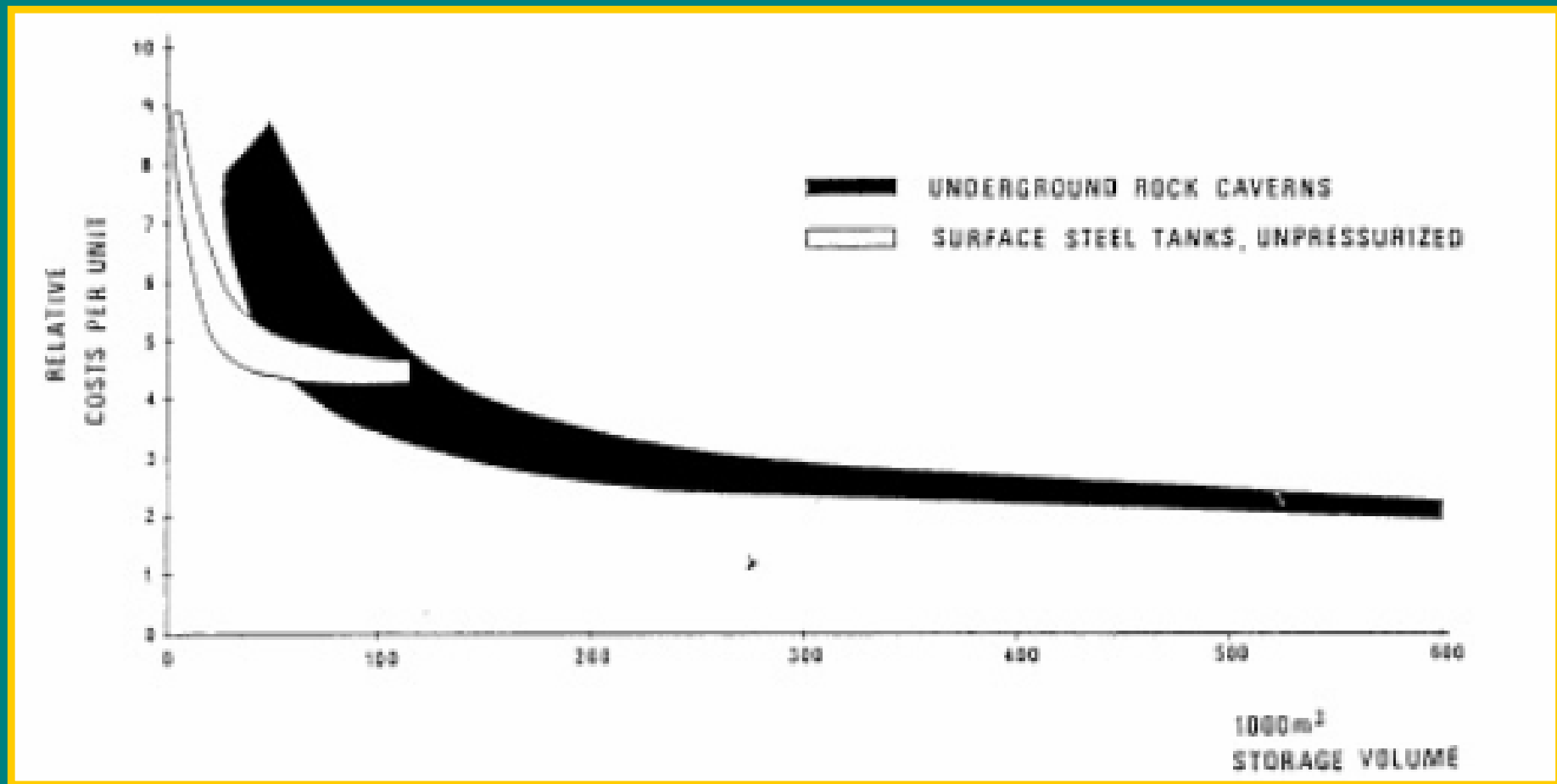
## Washington Metro Tunnel Costs 1969 - 1994

### Prices for mining & lining ~20' Dia. Tunnels





# Cost comparison between hydrocarbon storage in rock caverns and in steel tanks



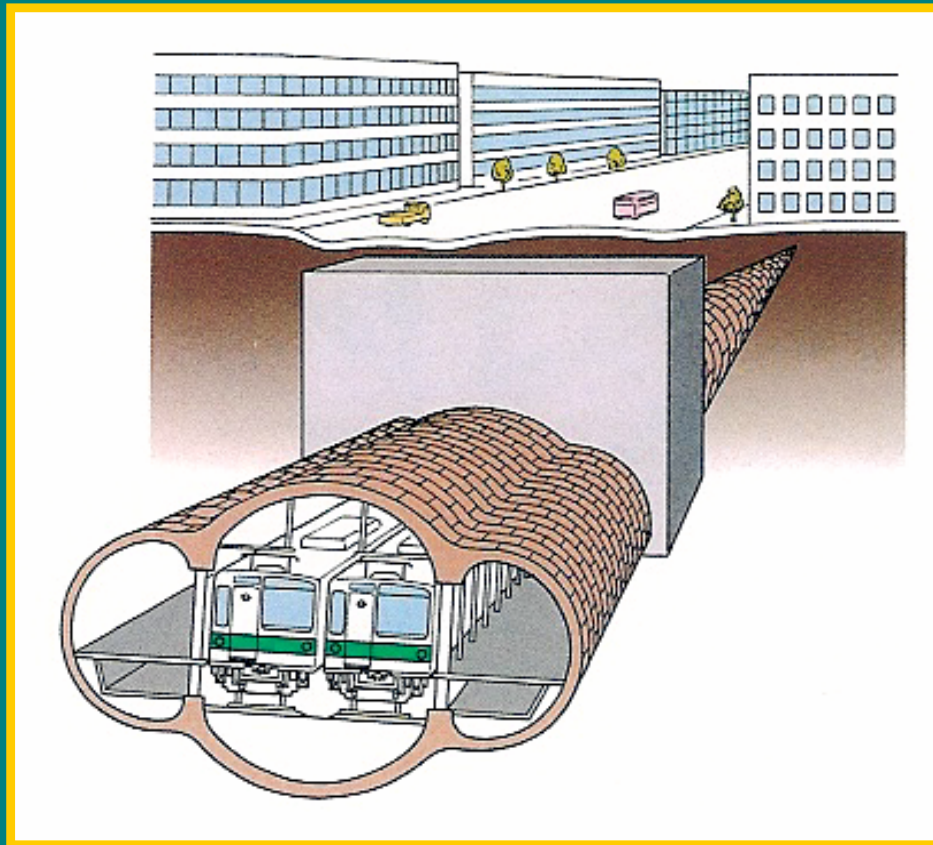
# Assessment of the underground structures

(2) Taking into the indirect benefits  
of the underground structures



# Risk analysis in underground works

# Three-Centered Station Shield Metro of Tokyo (Japan)





# ITA-AITES Working Groups

WG 2 Research

WG 3 Contractual practices in  
underground construction

WG 5 Health and safety

WG 6 Maintenance and repair of  
underground structures

WG 11 Immersed and floating  
tunnels

WG 12 Shotcrete use in  
tunnelling

WG 14 Mechanized tunnelling

WG 15 Environment

WG 16 Quality

WG 17 Long tunnels at great  
depth

WG 18 Training

WG 19 Conventional tunnelling

WG 20 Urban problems -  
Underground solutions

# http://www.ita-aites.org

