Sewerage Treatment System in Seoul

Nov 2013

Hunmo Jeong

Seoul Metropolitan Government

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Introduction of Seoul
Seoul, the capital city of Korea, is located in the middle of the Korean Peninsula linking China and Japan, the largest consumer markets of Asia.
The Era of Destruction: the 1950s

- Reconstruction and Demographic Concentration after the Korean War (1950-1953)
- Urban problems such as poverty, housing shortages, and waste management and so on.
“Miraculous growth over half a century”

- Population rose exponentially after the Korean War, stabilized after the 90s.
- Income level: with the national economic development (1960s~), also rose after 1980s.
- From being a receiver of ODA, to an ODA donor country (1.17 billion, in 2010)
- 2012 Global Power City Index: World’s 6th in Ranking

※ Mori Memorial Foundation Institute for Urban Strategies
Sewerage System in Seoul

Present Status of Sewerage System

History of Sewage treatment in Seoul

Development Plans

Future Policy Direction
Present Status of Sewerage System
Overview of the Sewerage System

- Area Served: 605.33 km²
- Population: 10.44 million
- Drainage area: 4 big areas
- Sewer length: 10,297km
- Treatment Centers: 4
- Served ratio: 100%
85% of Seoul is served by the Combined Sewer System. During rainfall, runoff and domestic sewage are collected in the same sewer until combined water volume reaches 3 times of the hourly maximum sewage flow.
## Overview of the Sewer in Seoul

### Length by Type

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<tr>
<th></th>
<th>Total Length</th>
<th>Circular</th>
<th>Rectangular</th>
<th>Open channel</th>
<th>U-shape gutter</th>
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<td>10,297</td>
<td>8,704</td>
<td>1,198</td>
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### Length by Function

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<th>Combined sewer system</th>
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<td>10,297</td>
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### Subsidiary Facilities

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<td>486,767</td>
<td>918</td>
<td>1,340</td>
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Present Status of Sewage Treatment Plants

- **Capacity**: 5,810,000 ㎥/d
  - Night soil & Septic: 10,500 ㎘/d
- **Sludge Treatment**: 1,700 t/d
  - In Site: Sludge Drying 400, Incineration 300
  - Other Site (Sudokwon Landfill Area): 1000 t/d
- **Process**
  - Before Jan, 2012: Standard Activated Sludge
  - After Jan, 2012: MLE + Chemical Treatment
- **Total Man Power**: 547 Persons
Jungnang Water Reclamation Center

- Site: Chajangteo 5-gil 10, Seongdong-gu
- Area: 791,000 m²
- Construction Cost: USD 370 million
- Sewage Treatment Capacity: 1,710,000 m³/d
- Night Soil & Septic: 4,000 kl/d
- Sludge Drying Furnace: 200t/d
- Manpower: 137 persons
- 2011 Budget: USD 52.9 million
Nanji Water Reclamation Center

- Site: Jayu-ro 116, Goyang-si, Kyeongki-Do
- Area: 929,000㎡
- Construction Cost: USD 214 million
- Sewage Treatment Capacity: 1,000,000㎥/d
- Night Soil & Septic: 4,500㎘/d
- Sludge Incinerator: 150t/d
- Manpower: 116 persons
- 2011 Budget: USD 37.8 million
Tancheon Water Reclamation Center

- Site: Nambusunhwan-ro 6610, Kangnamgu
- Area: 385,000 м²
- Construction Cost: USD 332 million
- Sewage Treatment Capacity: 1,100,000 м³/d
- Sludge Drying Furnace: 200t/d
- Manpower: 122 persons (Private Sector Operation)
- 2011 Budget: USD 33.5 million
Seonam Water Reclamation Center

- **Site**: Yangcheon-gil 546, Kangseo-gu
- **Area**: 1,091,000㎡
- **Construction Period**: 1984 ~ 1999
- **Construction Cost**: USD 429 million
- **Sewage Treatment Capacity**: 2,000,000㎥/d
- **Night Soil & Septic**: 2,000㎘/d
  (increase capacity to 4,000㎘/d by 2015)
- **Sludge Incinerator**: 150t/d
- **Manpower**: 176 persons
  (Private Sector Operation)
- **2011 Budget**: USD 49.8 million
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<th>Description</th>
<th>Total (㎥/day)</th>
<th>Jungnang</th>
<th>Nanji</th>
<th>Tancheon</th>
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<tr>
<td>Digestion Gas Generation</td>
<td>201,934(㎥/d)</td>
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<td>35,801</td>
<td>17,028</td>
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<td>Night Soil &amp; Septic</td>
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Present Status of Sewage Treatment (Average, 2012)

• Regional Classification by Effluent Quality Standard (Han River Area)

Region Ⅰ
BOD₅: 5 mg/l
T-P: 0.2 mg/l

Region Ⅱ
BOD₅: 5 mg/l
T-P: 0.3 mg/l

Region Ⅲ
BOD₅: 10 mg/l
T-P: 0.5 mg/l

Region IV
BOD₅: 10 mg/l
T-P: 2 mg/l
Organization of Sewerage Management System

Seoul Metropolitan Government

Urban Safety Headquarter

Water Management Bureau

Water Management Policy Division
Water Reclamation Planning Division
River Management Division
Water Reclamation Facilities Division

Jungnang, Nanji, Tancheon, Seonam

25 District Offices

Construction and Traffic Bureau

Sewerage Planning Division, Flood Control Division
25 Gu, 10 persons each

4 Sewage Treatment Centers, 547 persons
Budget for Sewerage System

- Special accounting scheme for sewerage works

- Budget (2013)
  - Revenue : 603 billion won (USD 541 mil)
    Tariff : 496 billion won (82.3%)
    Others : 107 billion won (17.7%)
  - Expenditure : 603 billion won (USD 541mil)
    Sewer Maintenance : 306 billion won (50.8%)
    Operation and Maintenance of Sewage Treatment Centers(STC) : 198 billion won (32.8%)
    Facility Modernization and Others : 99 billion won (16.4%)
History of Sewage Treatment in Seoul
Development of Sewerage Management in Seoul

Before 1960s

- National Income: Below USD 80/capita in GNI
- Area: 268㎢, Population: 2.4 million
- Reconstruction and extension of sewers (225 km) built before Korean War (1950~1953)
- No treatment plants. Sewage and night soil were discharged into streams and Han River
Shabby Houses along the Cheonggye Stream ('50s)

Flooded Downtown Area ('57)

Dye Works along the Stream ('50s)

Han River in the Winter

Han River in the Summer ('68)
Development of Sewerage Management in Seoul

1960s ~ 1970s: Background

- National Income: USD 82 → 1,645 in GNI
- Seoul’s administrative district expanded twofold
  - Area: 268㎢ ⇒ extended to 605㎢ (1973)
  - Population: 2.5million → 8.3million

- Sewage conditions
  - Increased wastewater due to rapid population growth,
    More industrial wastewater resulting from economic growth
  ⇒ Pollution of the Han river and its tributaries began from the 1960s
  ⇒ Necessary to establish a division which oversees the sewage treatment policies, build sewage treatment facilities, and improve sewage pipes

- During the two decades, streams in Seoul were severely contaminated.
  All 36 streams were regarded as dangerous and 24 streams were covered up.
Development of Sewerage Management in Seoul

1960s ~ 1970s: Seoul’s Policy

1. Institutional arrangements & Organization reform
   - Enactment of the Sewerage Act (1966)
   - Change in organizational structure: Sewerage Division originally under the Construction Management Bureau → Elevate to Sewerage Management Bureau (1976) and newly establish Sewerage Administration Division

2. Improve and expand the coverage of sewer pipelines (Significant expansion since 1960s)
   - Expansion of culvert pipes rather than openly exposed pipes
   - Construction of 5,940km sewers in newly constructed areas (840 in 60s, 5,096 in 70s)
     ※ Service rate 27.9% (1970) → 64.8% (1980) with total 6,588km sewers

3. Unsanitary, open sewer lines → Covered-up roads
   - From late 1950s to late 1970s, 19 streams including Joonghakcheon and Chunggyecheon (total length 19,207m) were covered up.

* Perception of covered roads: More hygiene, looks better, addresses traffic problems
4. Construction of Sewage Treatment Facilities

- Lack of funding and technology: Loan from AID, Planning by a foreign company (Cheonggyecheon Sewage treatment plant, etc.)
- Construction of 4 septic soil sanitary disposal plants (2,930t/d) during 1972~1976
- Completion of first sewage treatment plant (Jungnang, 360,000 m³/d) in 1979

※ Sewage treatment rate of 1980: 15% of total 2,400,000 m³/d sewage
Development of Sewerage Management in Seoul

**‘Cheonggyecheon Sewage Treatment Plant’ - The very first in Korea**

- **Background:** Serious contamination of the Han River in the early 1960s
- **Snapshot of the facilities in 1979 (Upon completion)**
  - Area: 362,670㎡
  - Treatment capacity: 150,000㎥/day
    - To treat the domestic sewage from the Cheonggyecheon basin (5,600ha, 1.30m people)
  - Treatment method: Activated sludge method (Advanced treatment)
  - Treatment efficiency: BOD average 330ppm -> Below 19ppm
  - SS average 330ppm -> Below 30ppm
  - Discharge to Han River

- **Construction process:** Utilized loans due to lack of funding and technology,
  Received technical service from a foreign company

  Devise a plan(1962) → Submit the loan contract plan to the Construction Management Bureau(1964.8) → Apply for government-guaranteed loan to USOM in Korea(1965.10) → Approval by the National Assembly(1966.4) → Conclude loan contract with AID for $3.5m → Conclude technical service agreement with D.M.J.M(1967.9) → Complete the design(1969.9) → Obtain approval for the design from USAID in Korea(1969.11) → Begin construction(1970.6) → Sign a contract for an additional loan of $2.8m(1974.4) → Complete construction(1976.9)
Development of Sewerage Management in Seoul

'Jungnang Sewage Treatment Plant'

◆ Snapshot of the facilities in 1979 (Upon completion)
  - Treatment Capacity: 210,000 m³/day
  - Treatment method: Activated sludge method (Advanced treatment)
  - Treatment efficiency
    - BOD average 250 ppm -> below 20 ppm
    - SS average 300 ppm -> below 30 ppm

※ Note: Digestion gas produced during the treatment process is used to produce 1,400 kw of electricity (Account for 60% of the electricity consumption)

◆ Construction process
  Loan from the UK Gradley Brant Bank (10.15 billion won)
  Construction started in December 1975 and ended in September 1979

※ Established the Office for the Management of Jungnang Sewage Treatment Plant
  ⇒ Oversee both the Cheonggyecheon plant and the Jungnang plant

⇒ Discharge to Han River
Development of Sewerage Management in Seoul

Covering of the Cheonggye Stream ('58~'66)
Development of Sewerage Management in Seoul

Covered Cheonggye Stream (1968)

Construction of the Cheonggye Highway ('68-'71)
Development of Sewerage Management in Seoul

1980s ~ 1990s: Background

- National Income: USD 1,800 → 10,841 in GNI
- Population: → 10.3 million

- Sewage conditions
  - Increase of sewage generation volume, Serious environmental pollution
  - Greater public awareness of the lack of sewage treatment volume and the importance of sewage treatment

![Graph showing treatment rate and sewage generation volume](image)
1. Institutional arrangements

- Drastic revision of the Sewerage Act(1982), Master Plan for Sewage and Drainage in Seoul
  ※ Revision: Mandate the establishment of a master plan, Charge fees to public sewerage users

  • Establish a Master Plan for Sewage and Drainage in Seoul(1983):
    To be devised every 20 years, revised every 5 years
  • Enact the Ordinance on Sewerage Usage(1983) & Collect public sewerage user fee

  ⇒ To secure funds to manage the sewerage system

  ※ Annual tax revenue 49.5 billion (1985) → 132.2 billion (1994)
Development of Sewerage Management in Seoul

**Master Plan for Sewage and Drainage in Seoul (1983)**

- Target year: 2011
- Estimated population: 1,041,700
- Major contents
  - Expand sewage pipes: Add existing pipes 7,059,650m + integrated pipes 1,967,249m, waste water pipes 555,289m
  - Facility Size: Daily sewerage generation volume per capita 235L, Current capacity 36,000m³/day
    + Increase of 3,191,900m³/day → Final Target: 4,551,900m³/day
  - Build 4 large-scale sewage treatment facilities

Divide Seoul into four areas (Jungnang, Tancheon, Gayang, Nanji) to build sewage treatment facilities

※ Revision to the Master Plan

Flood in 1988 → Revision to incorporate the revised run-off coefficient and rainfall intensity (1992) → Revision to accommodate decreased estimate of population and reclassify the drain areas (1996)
Development of Sewerage Management in Seoul

1980s ~ 1990s: Seoul’s Policy

2. Expansion of the Sewage Treatment Facilities
   - Establish a plan to expand the sewage treatment facilities ahead of the 1986 Asian Games and 1988 Summer Olympics
   - Increase the treatment capacity of all four existing sewage treatment plans as part of the 'Comprehensive Development Plan of the Han River'
     ※ Construction of 4 sewage treatment plants (total 5,810,000 m³/d)
     ⇒ 1998. Achieved 99.8% sewage treatment service rate
     ⇒ 1999. Sewage generation volume 5.65mil m³/day, Treatment capacity 5.81mil m³/day

3. Introduction of separate pipes (1981) to separate rain water and waste water
   - Introduce separate pipes in new built-up areas
   - Start with areas such as Gaepo, Garak, Godeok, Mokdong, Sanggye, Junggye
     ※ Intercepting sewers (413km) during 1984 ~ 1999
Development of Sewerage Management in Seoul

Intercepting Sewers
(413km, 1984 ~ 1998)
Development of Sewerage Management in Seoul

4. Rehabilitation of existing pipes: Examine the pipes & Devise a maintenance plan (1992)
   - Examine the existing pipes in each drain area
   - Devise a systematic plan to repair decrepit or damaged pipes

5. Introduction of Trenchless Pipe Lining in pipe maintenance (1995)
   - Problems of excavation: Compromise aesthetic feature of the city, traffic congestion, road wear due to hardening of site, inconvenience for residents, etc.
   - Introduce CIPP method which does not require excavation to rehabilitate a pipeline
   ※ Cured in place pipes lining (CIPP): Liner is installed inside the pipes to build new pipes and repair the existing ones (First applied to pipes in Shingye-dong, Yongsan-gu)
Despite the development of the sewerage system, streams were still left as dead spaces until the late ’90s. The downtown areas near the covered streams became dilapidated with unpleasant conditions like hateful stench coming from the streams below.
## Development of Sewerage Management in Seoul

### Construction of Sewage Treatment Plants in Seoul

<table>
<thead>
<tr>
<th>Plants</th>
<th>Year</th>
<th>Volume (100m³/d)</th>
<th>Construction Cost (Million Won)</th>
<th>Cost (Converted to 2012 price)</th>
<th>Treatment Rate (Primary)</th>
<th>Treatment Rate (Secondary)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jungrang I</td>
<td>1976</td>
<td>150</td>
<td>6,143</td>
<td>32,452</td>
<td>7.0%</td>
<td>7.0%</td>
</tr>
<tr>
<td>Jungrang II</td>
<td>1979</td>
<td>210</td>
<td>9,632</td>
<td>35,203</td>
<td>15.0%</td>
<td>15.0%</td>
</tr>
<tr>
<td>Tancheon I</td>
<td>1987</td>
<td>500</td>
<td>129,595</td>
<td>268,304</td>
<td>77.3%</td>
<td>36.8%</td>
</tr>
<tr>
<td>Seonam I (primary)</td>
<td>1987</td>
<td>1,000</td>
<td>35,456</td>
<td>73,406</td>
<td>77.3%</td>
<td>36.8%</td>
</tr>
<tr>
<td>Nanji I (primary)</td>
<td>1987</td>
<td>500</td>
<td>23,676</td>
<td>49,017</td>
<td>77.3%</td>
<td>36.8%</td>
</tr>
<tr>
<td>Jungnang III</td>
<td>1988</td>
<td>750</td>
<td>130,323</td>
<td>262,724</td>
<td>92.8%</td>
<td>54.2%</td>
</tr>
<tr>
<td>Tancheon I Expantion</td>
<td>1991</td>
<td>100</td>
<td>851</td>
<td>1,549</td>
<td>79.4%</td>
<td>47.3%</td>
</tr>
<tr>
<td>Jungnang I,III Expantion</td>
<td>1992</td>
<td>350</td>
<td>48,101</td>
<td>85,712</td>
<td>85.1%</td>
<td>53.7%</td>
</tr>
<tr>
<td>Tancheon II</td>
<td>1994</td>
<td>150</td>
<td>45,803</td>
<td>78,281</td>
<td>79.4%</td>
<td>79.4%</td>
</tr>
<tr>
<td>Seonam I (Secondary)</td>
<td>1994</td>
<td>1,000</td>
<td>118,219</td>
<td>202,046</td>
<td>79.4%</td>
<td>79.4%</td>
</tr>
<tr>
<td>Nanji I (Secondary)</td>
<td>1994</td>
<td>500</td>
<td>57,406</td>
<td>98,112</td>
<td>79.4%</td>
<td>79.4%</td>
</tr>
<tr>
<td>Jungnang III Expantion</td>
<td>1997</td>
<td>250</td>
<td>65,263</td>
<td>99,440</td>
<td>87.5%</td>
<td>87.5%</td>
</tr>
<tr>
<td>Nanji II</td>
<td>1997</td>
<td>500</td>
<td>102,368</td>
<td>155,976</td>
<td>87.5%</td>
<td>87.5%</td>
</tr>
<tr>
<td>Tancheon II Expantion</td>
<td>1998</td>
<td>350</td>
<td>50,349</td>
<td>68,369</td>
<td>99.8%</td>
<td>99.8%</td>
</tr>
<tr>
<td>Seonam II</td>
<td>1998</td>
<td>1,000</td>
<td>208,096</td>
<td>282,572</td>
<td>99.8%</td>
<td>99.8%</td>
</tr>
</tbody>
</table>
Development of Sewerage Management in Seoul

Han River Water Quality
(Gayang point, BOD$_5$ annual average)

BOD (mg/l)

- 10.4: Jungnang I, II Completion
- 8.3: Jungnang III, Tancheon I Completion, Seonam I, Nanji I Primary Treatment Start
- 8.2: Jungnang III, Tancheon I Completion, Seonam I, Nanji I Primary Treatment Start
- 6.9: Jungnang I, III, Expansion, Tancheon II Completion, Seonam I, Nanji I Secondary Treatment Completion
- 5.5: Jungnang I, III, Expansion, Tancheon II Completion, Seonam I, Nanji I Secondary Treatment Completion
- 3: Jungnang, Tancheon Expansion, Seonam II, Nanji II Completion

Full Years:
- 1980
- 1982
- 1987
- 1989
- 1997
- 1999
- 2004
- 2006
- 2008
- 2010
- 2012

Gayang monitoring point
2000s ~ Present: Background

- National Income: USD 10,159 → 20,250 in GNI

- Sewage conditions
  - Greater demand for improvement in the surrounding environment (ex. eliminate odor) with the increase of residential buildings in the vicinity
  - 21,400 households reside within 300m (Tancheon 12,644, Jungnang 1,367, Seonam 7,219, Nanji 177)
  - Mandatory onshore treatment of sludge following the ban on ocean disposal (2005)
    - BOD 20 → 10 mg/l, T-P 2 → 0.5 mg/l
Development of Sewerage Management in Seoul

2000s ~ Present: Seoul’s Policy

   - Construction of Sludge treatment facilities (700t/d)

2. Introduce Advanced Sewage Treatment Facilities (2007 ~)
   - Construct advanced sewage treatment facilities at the Jungnang Sewage Treatment Center
     (Capacity 46,000 ton/day)
   - Improve the existing facilities at the four centers

3. Transform into a facility that produces new and renewable energy
   - Install solar panels
   - Initiate the project to use congestion gas fuel

4. Ensure transparent management of the sewage treatment facilities & consultation with the residents for community support programs (2012)
   - Set up a steering committee for each center (composed of 7~10 members, selected by the administrative district council), Invite residents to participate in consultation and debates
Development of Sewerage Management in Seoul

**2000s ~ Present : Seoul’s Policy**

5. Eliminate sewer plant odor and build convenience facilities for the residents
   - Construction of offensive odor prevention facilities and creation of parks, sports utilities, play grounds, etc for resident use (308,000 m³ of 4 sewage treatment plants)

Tancheon Park

Seonam Environment Park (in Seonam Center)
Development of Sewerage Management in Seoul

Effects of 100% Sewage Treatment

- Transformation of the covered-up roads into eco-friendly spaces

Opening of newly restored Cheonggye Stream (Oct. 1st, 2005)
After the completion of 100% sewage treatment service in 1999, over 17 streams have been restored as echo spaces, walking paths and playgrounds.

- Transformation of the streams into ecological parks

Effects of 100% Sewage Treatment

- Seongbuk Stream
- Danghyeon Stream
- Dorim Stream
Development of Sewerage Management in Seoul

Impact of 100% Sewage Treatment

- The downtown area near the restored streams in Gangbuk regained a competitive advantage.

- Existing markets in the area regained their vitality and a lot of buildings have been repaired or newly constructed, too.
• **CSO(Combined Sewer Overflow) Problem**

  - Seoul's sewers were mostly designed to discharge the mixture of sewage and storm water into streams at 1,140 CSO discharge points when the flow volume exceeds 3 times the hourly maximum flow of sewage in the event of heavy rain.

  - The runoff condition and volume of sewage generation in some drainage areas have changed, thus in need of bigger intercepting sewers than the already installed ones.

  - Combined Sewer Overflows from discharge points usually contain a lot of pollutants, thereby threatening public health. Such negative impact of CSOs can be minimized by installing pollutants reduction facilities with storm water detention facilities at discharging points and increasing the capacity of intercepting sewers in some drainage areas.

  - However, these measures require huge expenses (about USD 360 mil) and a long time for planning and execution.
Problems of the Sewerage System in Seoul

- **Sewer Repair & Replacement**
  - 18.8% of sewers in Seoul were constructed 30 years ago and 57.9% were built 20 years ago. Many of them have problems like decrepitude, leakage from bad joints and insufficient discharge capacity. The total forecast expenditure during next 10-year period for sewer repair and replacement purpose is over USD 4.4 billion.

- **Strengthening of Effluent Standards**
  - In an effort to prevent water pollution, the national effluent standards have been continuously strengthened for the last 20 years. BOD limitation was lowered to 10mg/l in 2008 from 20mg/l. Total phosphorus concentration limitation, which was 8, has been strengthened to 2 in 2008 and 0.5 in 2012.
  - In addition, the national environmental law will soon mandate the local governments to implement total water pollution load management system and first flush control system. Therefore, local governments will need to not only secure additional budget but also spaces to build the new facilities.
Problems of the Sewerage System in Seoul

- Public’s Complaint about the Sewage Treatment Plants

  Three sewage treatment plants are located in the residential areas of Seoul and a lot of households are adjacent to the plants. Another plant is located in the suburb of Seoul but several small towns are located near the plant. Therefore, since the beginning of the plant operation, many citizens complained of offensive odor and property value depreciation.

  Seoul Metropolitan Government has achieved great success in eliminating the odor but there are still civil complaints about inconvenience.
Development Plans for Sewerage System
Sewer Reconstruction Plan

**Purpose**

- **To Secure Optimal Flow Velocity**: To prevent sedimentation and bad smell
- **To Secure Discharge Capacity**: To ensure civil safety and protect property against flooding
- **To Secure Water Tightness**: To prevent contamination of soil & stream; To protect sewers from infiltration/inflow
- **To Enhance Durability**: To extend sewer lifespan; To prevent the occurrence of negligent accident

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**Images and Captions**

- [Image 1]: Description of optimal flow velocity
- [Image 2]: Description of discharge capacity
- [Image 3]: Description of water tightness
- [Image 4]: Description of durability
Sewer Reconstruction Plan

Overview of the Repair and Replacement Plan

- Construction Period: 2010 ~ 2020
- Budget: USD 4,460 million
- Target: 3,705 km of decrepit sewers with leakages from bad joints and insufficient discharge capacity

Policy Direction

- Planning by drainage area unit – Starting with lower drainage areas first
- Citizen-friendly construction
  - Application of trenchless technology
  - Lightweight lining with temporary facility for open-cut
### Construction of Advanced Treatment Facilities

**Background**
- Necessary to meet the newly strengthened standard of phosphorus: 0.5 mg/ℓ in 2012
- Safe treatment of phosphorus to prevent eutrophication

**Construction Plan**
- Construction Period: 2009 ~ 2013
- Budget: USD 270 million
- Target: 4 Centers
- Stricter standard on treatment process and efficiency

<table>
<thead>
<tr>
<th>Process</th>
<th>Standard Activated Sludge (Before 2012)</th>
<th>MLE (Modified Ludzack-Ettinger) + Chemical Treatment (After 2012)</th>
</tr>
</thead>
</table>
| Treatment Efficiency | • 93% BOD Removal Rate : 150mg/ℓ→10mg/ℓ  
                         • 93% SS Removal Rate : 150mg/ℓ→10mg/ℓ  
                         • Phosphorus (Effluent) : ≤ 2.0 mg/ℓ | • 96% BOD Removal Rate : 170mg/ℓ→ 7mg/ℓ  
                                                                 • 95% SS Removal Rate : 131mg/ℓ→ 7mg/ℓ  
                                                                 • Phosphorus (Effluent) : ≤ 0.5 mg/ℓ |
Construction of Advanced Treatment Facilities

**Water Treatment Process**
- After Jan, 2012
  - Influent Pumping Station
  - Primary Sedimentation Tank
  - Reaction Tank (MLE Method)
  - Final Sedimentation Tank
  - Filtering Facility
- Sewage Inflow
- Raw Sludge
- Chemical (Coagulants)
- Discharge
- Raw Sludge Thickener
- Excess Sludge
- Centrifugal Sludge Thickener

**Sludge Treatment Process**
- Before Jan, 2012
  - Grit Chamber
  - Influent Pumping Station
  - Primary Sedimentation Tank
  - Aeration Tank
  - Final Sedimentation Tank
  - Chlorine Contact Tank
- Sewage Inflow
- Raw Sludge
- Sludge Thickener
- Mixing Sludge Reservoir
- Sludge Digester
- Digested Sludge Thickener
- Sludge Dehydrator
- Sludge Cake
- Desulfurizer
- Gas Storage Tank
- Landfill or Drying Process (Recycling)
- Boiler
- Gas Storage Holder
- Supplies Current to a Blower
- Boiler Heats up Sludge Digester
Construction of Advanced Treatment Facilities

**Applied Method**

**A2O Process**
- Inflow
- Anaerobic
- Anoxic
- Oxic
- Return Sludge
- Effluent
- Primary Sludge
- Excess Sludge

*(Jungrang 460,000 Ton/Day, In Operation)*

**MLE Process**
- Inflow
- Sub. Mixer
- Diffuser
- Aeration
- Returned Sludge
- Sedimentation Tank

*(Jungrang 880,000 Ton/Day, Seonam 1,270,000 Ton/Day, Nangi 860,000 Ton/Day, Tancheon 900,000 Ton/Day) → 3,910,000 Ton/Day (By 2012.12)*

**SBAF Process**
- Inflow
- Inclined Multilayer clarifier
- Bio Filter
- Effluent
- Primary Sludge
- Denitrification Tank
- Nitrification Tank

*(Jungrang 250,000 Ton/Day, By 2014.01)*

**4-Stage BNR Process**
- Inflow
- 1st clarifier
- 150%
- Pre-anoxic
- Anoxic
- Oxic #1
- Oxic #2
- RAS/DO
- Bio-Reactor
- 2nd clarifier

*(Seonam 360,000 Ton/Day, By 2015.8)*
Expansion of Sludge Treatment Facilities

**Background**

- Prohibition of ocean dumping with the enforcement of the London agreement 「96 protocol」 and revision of the Sea Contamination Prevention Law (from Feb. 2012)
- Preparation for increase of sludge from newly adopted phosphorus treatment process

**Construction Plan**

- Construction Period: 2011 ~ 2013
- Budget: USD 40 million
- Newly constructed facilities: 450t/d (present 1,700 → 2,150t/d (after Jan. 2014))
  - Jungnang: 100t/d, Drying facility
  - Nanji: 150t/d, Drying facility
  - Sudokwon Landfill Area: 200t/d (part of 1000t/d), Drying facilities
Expansion of Sludge Treatment Facilities

2011 (1567 ton/day)

- Solidification: 634
- Ocean Dumping: 245
- Drying: 383
- Incineration: 267

2014 (1700 ton/day)

- Solidification: 800
- Drying: 620
- Incineration: 250
- Others: 30

Drying Facility

Sudokwon Landfill Facility
Future Policy Direction
Modernization Plan for Jungnang & Seonam

• What is Modernization of Sewage Treatment Plants in Seoul?
  - Integrating and laying facilities underground
  - Adopting advanced technology for new facilities
  - Creating parks and recreation areas on the ground

• Target Centers: Jungnang, Seonam
  - 3-stage construction (2007~2027)
Modernization Plan for Jungnang & Seonam

• Modernization of Jungnang Center

- Scope of modernization: 1,130,000 m³/d (Extra 460,000 m³/day – Previously retrofitted)
- Period: 2007 ~ 2026 (20 years)
- Budget: USD 853 million

[1st Stage of the Project (250,000 m³/d)]
- 2007 ~ 2015, USD 188 million
- Above-ground structures: Sports areas, Water museum, Ponds and...
Modernization Plan for Jungnang & Seonam

- **Modernization of Seonam Center**
  - Scope of modernization: 1,630,000 m³/d
  - Period: 2008 ~ 2027 (20 years)
  - Budget: USD 1,210 million

[1st Stage of the Project (360,000 m³/d)]
- 2008 ~ 2016, USD 269 million
- Above-ground structures: *Water science museum, Water garden*
Resident-Friendly Sewage Treatment Center

**Purpose**

- Build "Resident-friendly facilities"
  - by changing STCs to "Parks or Eco-friendly space"

1. Creation of Covered Parks at Tancheon Center

- Site area: 392,671㎡, Covered area: 109,381㎡
- Project Cost: USD 63.3 billion
- Project Period: 1999~2015
- Facilities: Park, Forest zone, Sports areas, Children’s playground, Parking lot, etc
- Future Plan: 4th Stage 33,798㎡ (2013~2015, about 45 billion won)
Resident-Friendly Sewage Treatment Center

Tancheon Center Area View

3rd Stage

4th Stage
(Constructing)

2nd Stage

1st Stage
2. Creation of Resident-Friendly Space around Seonam & Nanji

- Forest park and Sports facilities at **Seonam center**
  - Total Area: 188,500 m²
  - Project Cost: USD 8.1 million
  - Project Period: 2008 ~ 2011.6
  - Facilities: Walking trail, Forest, Tennis courts, Golf course, etc.

- Sports Facilities at **Nanji center**
  - Total Area: 10,000 m²
    (Football field, Basketball court, etc)
  - Project Cost: 1,000 million won, 2010~2011.2

3. Future Project

- **Nanji Modernization Plan**
  - Project Cost: USD 49.3 million
  - Project Period: 2013 ~ 2020
  - Facilities: Walking trail, Forest, Sports facilities, etc
Use of New & Renewable Energy

- **New & Renewable Energy**
  - Energy that comes from sources that are continually replenished such as sunlight, wind, tides, waves, and geothermal heat

- **Use of New & Renewable Energy in STCs**
  - Sewage Treatment Systems are basically energy-intensive facilities; however, there is a huge potential to produce new & renewable energy at STCs using digestion-gas, sewage heat recovery, photovoltaic power generation, and etc.

Goal of Energy Self-Sufficiency Rate for 4 STCs in Seoul

<table>
<thead>
<tr>
<th>Year</th>
<th>2011</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Energy Self-Sufficiency Rate for STCs</td>
<td>• 25%</td>
<td>• 50%</td>
</tr>
<tr>
<td>Energy Consumption of 4 STCs</td>
<td>• 129,842 TOE/Year (mostly Electricity)</td>
<td>• 140,436 TOE/Year (increase with advanced treatment facilities)</td>
</tr>
<tr>
<td>Energy Production at 4 STCs</td>
<td>• 39,079 TOE/Year (mostly digestion gas)</td>
<td>• 80,626 TOE/Year (digestion gas increase, construction of sewage heating pump and photovoltaics)</td>
</tr>
</tbody>
</table>
한글이 "소화가스 증가, 열펌프 건설, 태양전지 설치"가 맞는지?
Use of New & Renewable Energy

Photovoltaic power generation

- Construction of solar cells on the treatment tanks and on the ground
  - Plan: 2,000kw (2012, Jungnang 400, Nanji 100, Seonam 1,300)
  - → 10,770kw (2015, Tancheon 2,280, Jungnang 690, Seonam 6,000)
  - Construction Cost: USD 46.6 million (invested by Electricity Generation Enterprises)
Use of New & Renewable Energy

Sewage Heat Recovery
- Recovery of heat from treated water
  - 5℃-Thermal energy recovery can be achieved by heat-pump installation
  - Plan: 52 TOE (2010, Jungnang 26, Seonam 26) → 19,000TOE (2014, Tancheon 19,000)
  → 30,000TOE (2015, Seonam 11,000)
- Construction Cost: USD 56.5 million (invested by the private sector)
**Use of New & Renewable Energy**

**Digestion Gas**

- Increase of gasification rate and enhancement of utility value
  - Plan: $201,900 \text{ m}^3/d (2012) \rightarrow 260,000 \text{ m}^3/d (2015)$
  - Cavitation and Ultrasonic Wave Treatment at the inlet line of sludge digester

- Present Gas Usage: Digester Heating 49%, Sludge Dry 22%, Generation 5.8%, Fuel for industry 7.7%, Burning 14.5%

  - By enhancing digestion gas values through refining and selling gas to cogeneration enterprises, over USD 8 million of revenue can be earned annually

**Refining**

- Earn 9 billion won of revenue
- CO2: 35%, CH4: 65%
- 78,000 \text{ m}^3/d After Feb. 2014
- 7,000 \text{ m}^3/d Since 2009
- Fuel for 270 vehicles
- Electricity, Heat for 20,000 Houses
- Seonam, Nanji
Re-use of Treated Water

Current: 5% (220,000 m³/d)
- Road Cleaning and Cooling water
- Subway Train Washing
- Others

Future Goal: 10% of discharge
- Maintenance water for streams
- Water for landscaping
- Cleaning water, etc.
Practical Use of Retarding Basins in Urban Areas

Function of Retarding Basins

Collect the torrents and slow it down to help reduce the impact of floods in built-up areas.

Total Area in Seoul: **1,820,000 m²**

Present Use

- Parking: 49%
- Sports Facilities: 16%
- Eco-Parks: 10%
- Not Use: 25%

Basic Plan for Practical Use

- Change to ecological space for residents
- Create a Cultural Complex
Practical Use of Retarding Basins in Urban Areas

Basin Concept of the Park

1. Water Way
   - Landscape on the cover of water way

2. Planting

3. Green Wall

4. Bicycle Parking

Cultural Complex
Recommendations
Why should we treat sewage?

- To secure pleasant living space
- To protect the water environment
- To increase the usability of water which is one of most important resources in our society
Combined sewer vs. Separate sewer

- Consider existing sewers and condition of planning drain areas.
  - Urban areas where sewers are already constructed:
    - Adopt storm overflow chamber and intercepting sewer in order to create a combined sewer system
  - New town sites: Separate sewer system is recommended
  - Rural areas: Incomplete separate sewer system is recommended
  - Separate sewer system: Be careful not to misconnect sewers
• Advantage of Centralized Treatment
  ➢ Large scale plant is feasible from the construction and operation expense aspect
  - Plant construction cost for 1 m³/d sewage in Korea (1985~2011)

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Over 300,000 m³/d</th>
<th>100,000 ~ 300,000 m³/d</th>
<th>10,000 ~ 100,000 m³/d</th>
<th>500 ~ 10,000 m³/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Cost (Won/1 m³ sewage)</td>
<td>21 sites USD 314</td>
<td>31 sites USD 762</td>
<td>135 sites USD 1,740</td>
<td>314 sites USD 4,789</td>
</tr>
</tbody>
</table>

• Disadvantage of Centralized Treatment
  ➢ Centralization of sewage makes the sewers larger and additional facilities like pump stations necessary → May incur greater expenses for sewer maintenance
  ➢ Centralization treatment may cause water in adjacent streams to run out
  ➢ Longer sewers may cause inflow/infiltration problems → Sewage volume may exceed design capacity and lead to decreased efficiency of treatment

• Should consider the distance between urban clusters and the possibility of complaints from residents living in adjacent areas.
Construction

- Prepare progressive expansion plans in line with the urban development plans
  - Decide the construction timing of the Primary, Secondary, Advanced treatment
  - Determine the order of priority of drain areas: upstream, downstream

- Install the sewer taking into account the future land use of drainage area
  - Consider the facility capacity, durability, and maintenance procedures

- Decide the treatment method by analyzing the local circumstances
  - Find low cost, highly efficient methods under local conditions
  - Consider the relationship with local residents.
  - Consider the disposal method of byproducts such as sludge and bio-gas, etc.
The sewerage system of Seoul shall largely contribute to the safe and comfortable lives of the citizens and the preservation of planet Earth.