Water Supply Secured and No Drought for HSIP
Drought Prevention and Emergency Measures for Hsin-Chu Science-Based Industrial Park in Taiwan

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ABSTRACT

The objective to establish Hsin-Chu Science-based Industrial Park(HSIP) is to build up a humanistic environment in Taiwan for high-quality R&D, manufacturing, work, life, and leisure, so it can attract high-tech talents, introduce high-tech technologies, establish high-tech industrial development base and promote industrial upgrade for Taiwan. Since it was founded in 1980, Taiwan 's government has invested around $30.8 billions NT in HSIP's software and hardware infrastructure. As of the year of 2001, HSIP has developed 625 hectares of land and Chunan Base has developed 118 hectares of land. 312 high-tech companies have been introduced to base in HSIP.

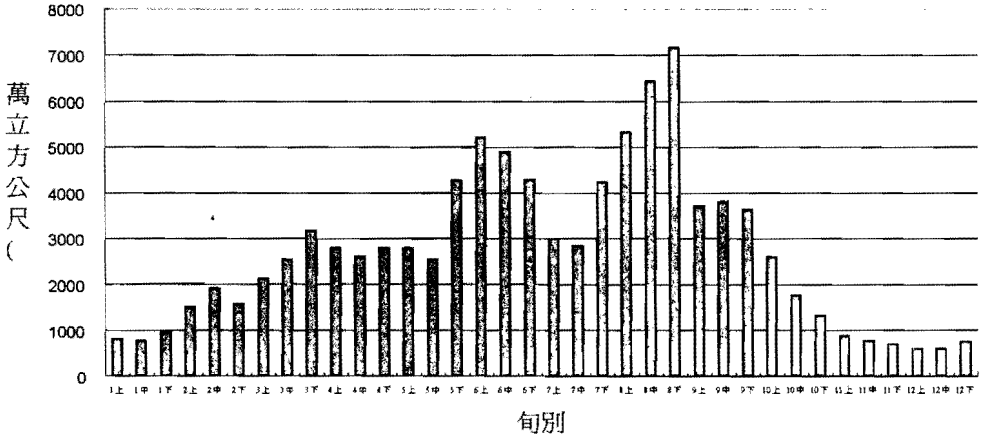
Taiwan's government has been devoted to a well-rounded environment for developing high-tech industry. It is essential to provide and maintain a long-term secured quality water supply. Presently, HSIP has the maximum daily water consumption of 103,000 tons. In 2004, the water consumption will reach 175,000 tons. To cope with the increasing demand of industrial water, HSIP expanded water purification plant and water supply line in 2001 to increase daily water supply up to 160,000 tons. In addition, Water Resources Agency of MOEA is planning on a second reservoir in Paoshan Hsin-Chu, water allocation program from irrigation water to industrial water for the drought period and building a seawater desalination plant. Meanwhile, HSIP is also implementing a program to increase water reuse rate to 85%.

This water shortage crisis for HSIP was caused by insufficient spring rainwater in February (the year of 2002) for Hsin-Chu area and reduced river water in Touchen River. The local farmers blocked the upstream of Touchen River to divert water for irrigation. As a consequence, the water retrieved from the downstream of Touchen River by Water Supply Corporation was sharply reduced from 20 tons per day to 3 tons per day. Therefore, Hsin-Chu Paoshan the First Reservoir and Yungho Shan Reservoir could only supply water to Hsin-Chu area for thirty days. Water Supply Corporation also decided to cut water supply to HSIP by 7%. Since the happening of water shortage crisis for HSIP, the government decided to stop supplying water for all the land irrigated by Touchen River. Water Supply Corporation also added emergency water supply line to deliver water from other areas and secure HSIP's water supply. Afterward, the crisis was relieved.

1. INTRODUCTION OF TOUCHEN RIVER WATER RESOURCES UTILIZATION

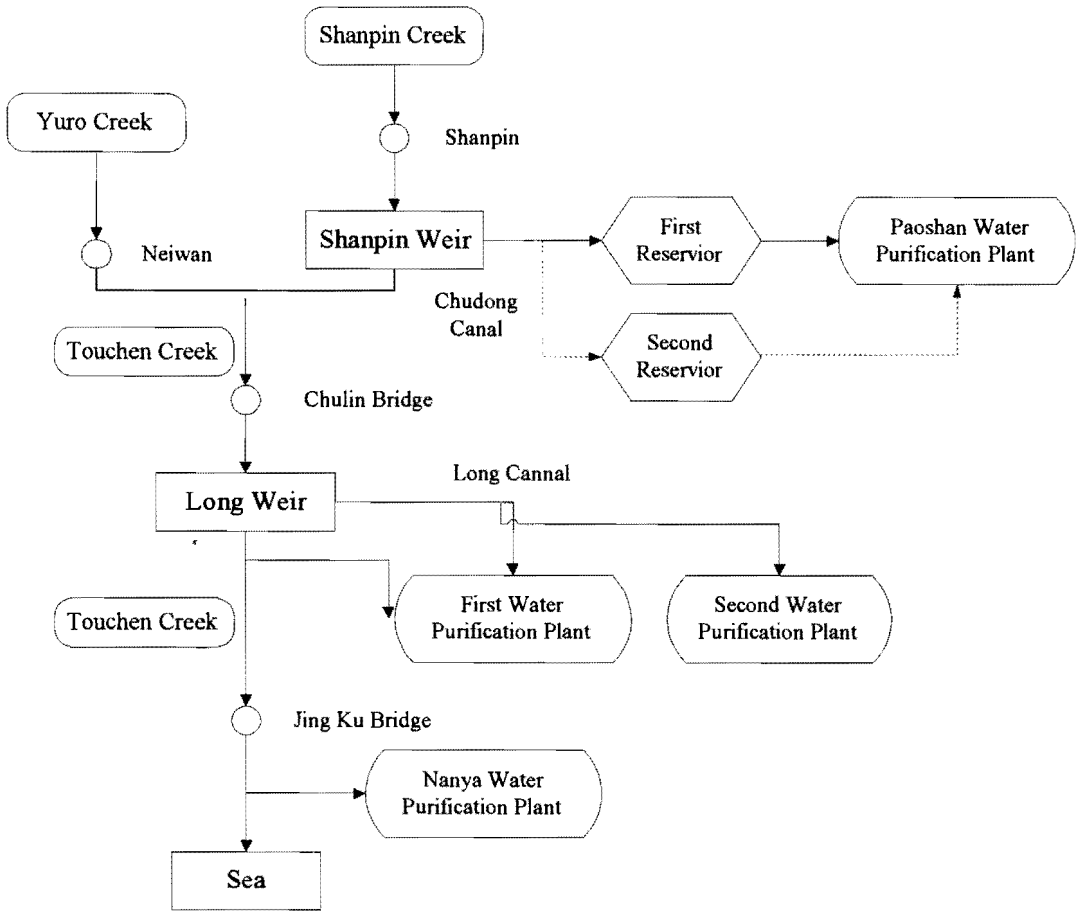
Hsin-Chu Touchen River is 63 kilometer long and covers land area of 566 square kilometers. The river has an average annual flow of 975.2 million cubic meters. In dry season (from October to March), it is about 252.5 million cubic meters, 25.9% of annual flow. The flow ratio for rainy season vs. dry season is 3:1. The 10 days runoff in the historical record (1971-1997) for Touchen River is shown in Figure 1.

Figure 1 Historical Record (1971-1997) for Water Flow for Touchen River watershed



The water resources in Touchen River area are utilized as follows: agricultural land area of 5,198 hectares irrigated by the system managed by Hsin-Chu Irrigation Association consumes 169,515 million cubic meters of water annually on average; water for public use is managed by the third district administrative office of Water Supply Corporation and serves a population of about 402 thousands; in 2001 average water consumption for daily life is 189.8 thousand tons and the annual water demand is 69.27 million cubic meters; the water for industrial use is supplied to the main industrial areas like Hsin-Chu Industrial Park, HSIP and HsinMiao Industrial park, in 2001 the daily water demand is 165.8 thousand tons and the annual water demand is 60.51 million cubic meters. In general, the combined daily water demand for Touchen River area for public use and industrial use is about 360 thousand tons and the annual water demand is 129.79 million cubic meters. The watershed has water weirs in upstream Shanping Creek, Paoshan the First Reservoir and downstream Long Weir. For details about locations, refer to Figure 2.

Figure 2 Water Resources Utilization Chart for Hsin-Chu Touchen River



Presently, the daily water supply capacity for Touchen River includes 50~80 thousand tons for Paoshan the First Reservoir, 90~140 thousand tons for the First, Second and Nanya Water Purification Plant and 30 thousand tons for Yuandon Water Purification Plant. The total is about 170~250 thousand tons. It still lacks 100~190 thousand tons of water, which is supplied from other areas like Miaoli Yungho Shan Dam and Taoyan Shihmen Dam. Currently HSIP consumes 125 thousand tons of water per day, which is supplied by Shin-Chu the Second Water Purification Plant .

2. DROUGHT LEVEL AND PREVENTION AND EMERGENCY RESCUE ORGANIZATION IN TAIWAN

2.1 Drought Level Classification

The drought disaster in Taiwan is classified to three different levels according to the water supply status for public use and agricultural use：

Classes for Drought Disaster

System	Level	Status description
Public Water Supply	1st	Water shortage rate above 30%
	2nd	Water shortage rate between 20% and 30%
	3rd	Water shortage rate between 10% and 20%
Agricultural Water Supply	1st	Water shortage rate above 50%
	2nd	Water shortage rate between 40% and 50%
	3rd	Water shortage rate between 30% and 40%

1. The water shortage rate for public use in the responsible area of Taiwan Water Supply Corporation(including Kingmen and Machu) is calculated based on the difference between actual water supply and water demand.

   Daily water shortage for public use(%)= (1−actual water supply／water demand) ×100

   The main water supply areas for public use are classified to fifteen districts according to Water Supply Corporation's business areas:

   1) Keelong Area: the First Administration District for TWSC
   2) Taipei Area: Taipei Water Department District
   3) Shihmen Area: the Second Administration District for TWSC
   4) HsinMiao Area: the Third Administration District for TWSC
   5) Taichung Nantou Area: the Fourth Administration District for TWSC
   6) Yunlin and Chayie Area: the Fifth Administration District for TWSC
   7) Tainan Area: the Sixth Administration District for TWSC
   8) Kaohsiung and Pingdon Area: the Seventh Administration District for TWSC
   9) Ilan Area: the Eighth Administration District for TWSC
   10) Hwalian Area: the Ninth Administration District for TWSC
   11) Taidong Area: the Tenth Administration District for TWSC
   12) Chunghwa Area: the Eleventh Administration District for TWSC
   13) Panhsin Area: the Twelveth Administration District for TWSC
   14) Kingmen Area: Kingmen main island
   15) Machu Area: Nankan, Peikan, Tongyin and Chukwong

2. The water shortage rate for agricultural use in the responsible areas of local irrigation associations is calculated based on the difference between the available water supply and the irrigation water demand.

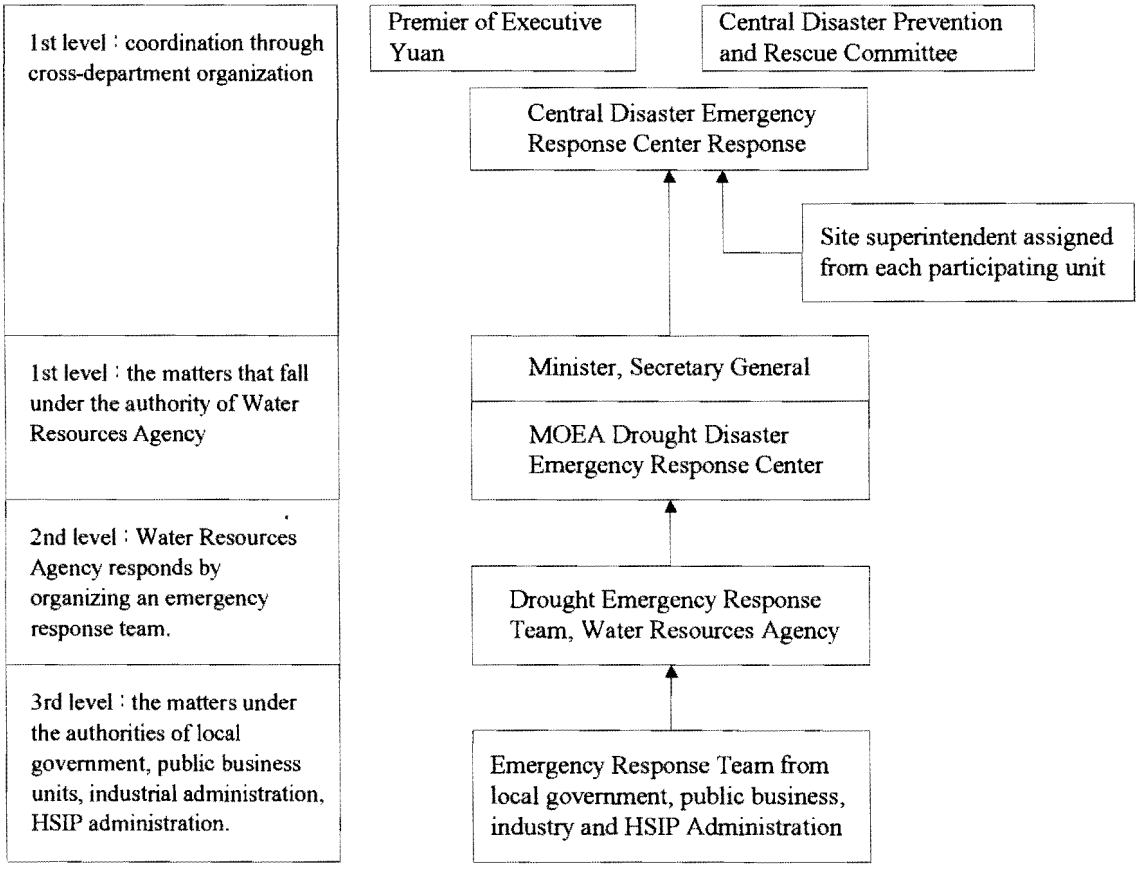
   10 days water shortage rate for agricultural use (%) = (1−available water supply／water demand) ×100

2.2 Drought Prevention and Emergency Rescue Organization System

When drought happens, each level of government's water resources administration and the relevant authorities form different emergency rescue organizations according to the classification of disaster level (Drought Prevention and Emergency Rescue Organization System as in Figure 3):

1. 1st level：MOEA calls to form a「MOEA Drought Emergency Response Team」and「Central Drought Disaster Emergency Response Center」if coordination among different departments required.
2. 2nd level：Water Resources Agency calls to form 「Water Resources Agency Drought Emergency Response Team」
3. 3rd level：MOEA subdivisions, reservoir administrations, local government, Water Supply Corporation, industrial park administration and HSIP call to form a emergency response team.

Figure 3 Drought Emergency Response Organization Chart



3. GOVERNMENT'S RESPONSIVE MEASURES TO COPE WITH WATER SHORTAGE FOR HSIP

Hsin-Chu area did not have sufficient rainwater for Touchen River due to less rainfall than normal in winter and spring. After the Chinese New Year in February, farmers built dam at upstream of Touchen River, so the river to Long Weir, which was the origin for the water supply to the First and Second Water Purification Plants for the Third Administration District for Water Supply Corporation, was blocked. This caused a terrible shortage and misallocation for the water for the public use in Hsin-Chu area. The immediate impact was the daily demand of 125 thousand tons of water for the high-tech companies in HSIP. This was purely personal behavior of those farmers. They have stopped after being advised by Hsin-Chu County Government. Afterward, the drought did not go away. The daily water intake from Touchen River on February 19th dropped from 200 thousand tons to 30 thousand tons. Meanwhile, the water storage in Paoshan the First Reservoir and Yungho Shan Reservoir could supply to Hsin-Chu area for public use and industrial use for only thirty days. The water shortage had reached the third level of drought classification. Following the emergency response measures, Water Supply Corporation made an emergency report to Water Resource Agency (formerly Water Resources Bureau) to call for assistance in solving the water shortage problem. On

February 22nd, the local farmers had another competition for water. Again, the water shortage crisis happened for Hsin-Chu area and HSIP.

3.1 Actions taken by water resources administrative authorities

1. On the same day as February 22nd when the farmers had another competition for water, North Water Resources Bureau of Water Resource Agency called Water Supply Corporation and Hsin-Chu Irrigation Association to negotiate a plan on water allocation. It was decided that since February 23rd Shihmen Reservoir would supply 55 thousand tons of water per day to Hsin-Chu area and gradually increase the supply to 80 thousand tons per day to relieve the water shortage pressure.
2. On February 25th, to respond to the water shortage to domestic use and industrial use in Hsin-Chu area, North Water Resources Bureau of Water Resource Agency called Hsin-Chu Irrigation Association, Hsin-Chu County Government and HSIP Administration for a meeting, which agreed to stop farming. This resolution was reported to MOEA later.
3. On February 27th, Vice Premier of the Executive Yuan Hsin-I Lin called MOEA and Council of Agriculture for a meeting about stopping farming and water delivery line from north to south. On the same day, Water Resource Agency of MOEA held "Responsive Meeting for Water Shortage in Taoyan and Hsin-Chu areas", which decided to stop farming for 14,778 hectares of farmland in Shihmen and Touchen irrigation areas and allocate irrigation water to HSIP and domestic use in Hsin-Chu area.
4. On March 1st, to prepare for the drought development further to the second level, Water Resource Agency organized a drought emergency response team. The team was in charge of all emergency measures, including water allocation and cloud seeding.
5. After fallow paddy field, the agricultural irrigation water from Touchen River was allocated for public use and increased water supply for Paochan the First Reservoir by 60 thousand tons, Hsin-Chu the First and Second Water Purification Plants by 260 thousand tons, Nanya Water Purification Plant by 50 thousand tons. The total increase of 370 thousand tons of water can satisfy the demand for Hsin-Chu area. Since March 14th, the spring rain and plum rain season started to bring back the water level for Touchen River. Therefore, the water storage for Paoshan the First Reservoir gradually approached to its full line, which relieved the water shortage pressure from HSIP.

3.2 Actions taken by agricultural administrative authorities

On March 1st, Council of Agriculture Executive Yuan announced that Daojun Irrigation District of Shihmen Irrigation association and Touchen Irrigation District of Hsin-Chu Irrigation Association to stop the first term farming activity for 2002 and the relevant instructions as follows：

1. Compensation standard for fallow paddy field is based on $46,000 NT per hectare. Additional $9,100 NT per hectare would subsidize for farmland already seeded. Additional $11,000 NT per hectare would be subsidized for farmland already cultivated. Additional $7,000NT per hectare would be subsidized for farmland already planted.
2. The designated non-irrigation area should not ask for irrigation water. The government would not assist with any buying plan. No other compensation would be given if natural disasters arise.
3. The farmers in the designated fallow area should register at the office of their Irrigation Association within the effective period.
4. The follow-up inspection for the fallow area would be carried out by the Irrigation Association.
5. The designated fallow area is required to stop farming accordingly.

The total compensation was around $1.05 billion NT, which was agreed on the meeting called by MOEA on March 5th among the Directorate General of Budget Accounting and Statistics Executive Yuan, the Council for Economic Planning and Development, the National Science Council(NSC), the Council of Agriculture, Water Supply Corporation and HSIP administration: the part under the compensation standard announced by the Council of Agriculture was $680 million NT, which was prepared by the administrative authorities. As to the compensation to the farmland already seeded, pudding or planted, it was around $370 million NT, which was prepared evenly by HSIP and Water Supply Corporation.

3.3 Actions taken by Water Supply Corporation:

1. Implement the first stage of water limitation on unnecessary domestic use and night-time reduced water pressure to maintain daily water supply of 370 thousands for the public use and the industrial use in Hsin-Chu area.
2. Manage water supply from outside area to have daily water delivery of 55 thousand tons from the Second Administration District of Water Supply Corporation (Taoyuan) to Hsin-Chu area.
3. Prepare pumping operation for dead storage level. Floating pumping equipment was completed for Paoshan the First Reservoir and Yungho Shan Reservoir, so pumping will start when the water drops below dead storage level.
4. Implement construction project for water delivery from north to south. Connect water lines from Pingchen Water Purification Plant to Hsin-Chu the Second Water Purification Plant and from Shihmen Water Purification Plant to Yungmei Water Purification Plant. The increase of allocated water was up to 130 thousand tons per day, which could be supple to Hsin-Chu area on a flexible plan.
5. Implement no-vacation plans for the relevant personnel and enhance public services. Strengthen the coordination among the water purification plants for water allocation.

3.4 Actions taken by HSIP:

1. HSIP Administration exchanged water supply information with Water Supply Corporation and water-utility team of HSIP union and monitored and assessed the water supply status.
2. Form a drought emergency response team as a contact channel with central water resources administrative authorities, local government, Irrigation Associations and Water Supply Corporation to assure a secured water supply.
3. Work with HSIP Industrial Association to coordinate with Water Supply Corporation about flexible water supply schedule. If necessary, assist the companies at water line terminal to maintain normal operation by implementing a flexible water supply plan based on locations and time. To cope with water shortage, coordinate with Water Supply Corporation to provide information about locations that offer truckload of water.
4. Establish HSIP water utilization data network and supervise instantly the companies that have large water consumption and their wastewater drainage. Advise the companies to strengthen waster reuse plan. Especially for semiconductor companies, the reuse rate should reach 85%. The water reuse rate for the entire plant should be over 70%. Assess the water utilization efficiency for each manufacturing unit for each company.
5. Work with HSIP industrial association and Industry Technology Research Institute (ITRI) to organize "Water Conservation Corps" to help the companies conserve and reuse water.

4. HSIP WATER CONSERVATION PLAN

4.1 HSIP Water Conservation Measures

1. Request, advocate or assist the companies to add reuse equipment or rainwater catchment system.
2. Award the companies that have achieved significant water conservation.
3. Put the companies that do not perform well in water conservation on top priority for assistance to bring up improvement plan.
4. The performance in water conservation would be used as a key factor for water allocation during water shortage period.

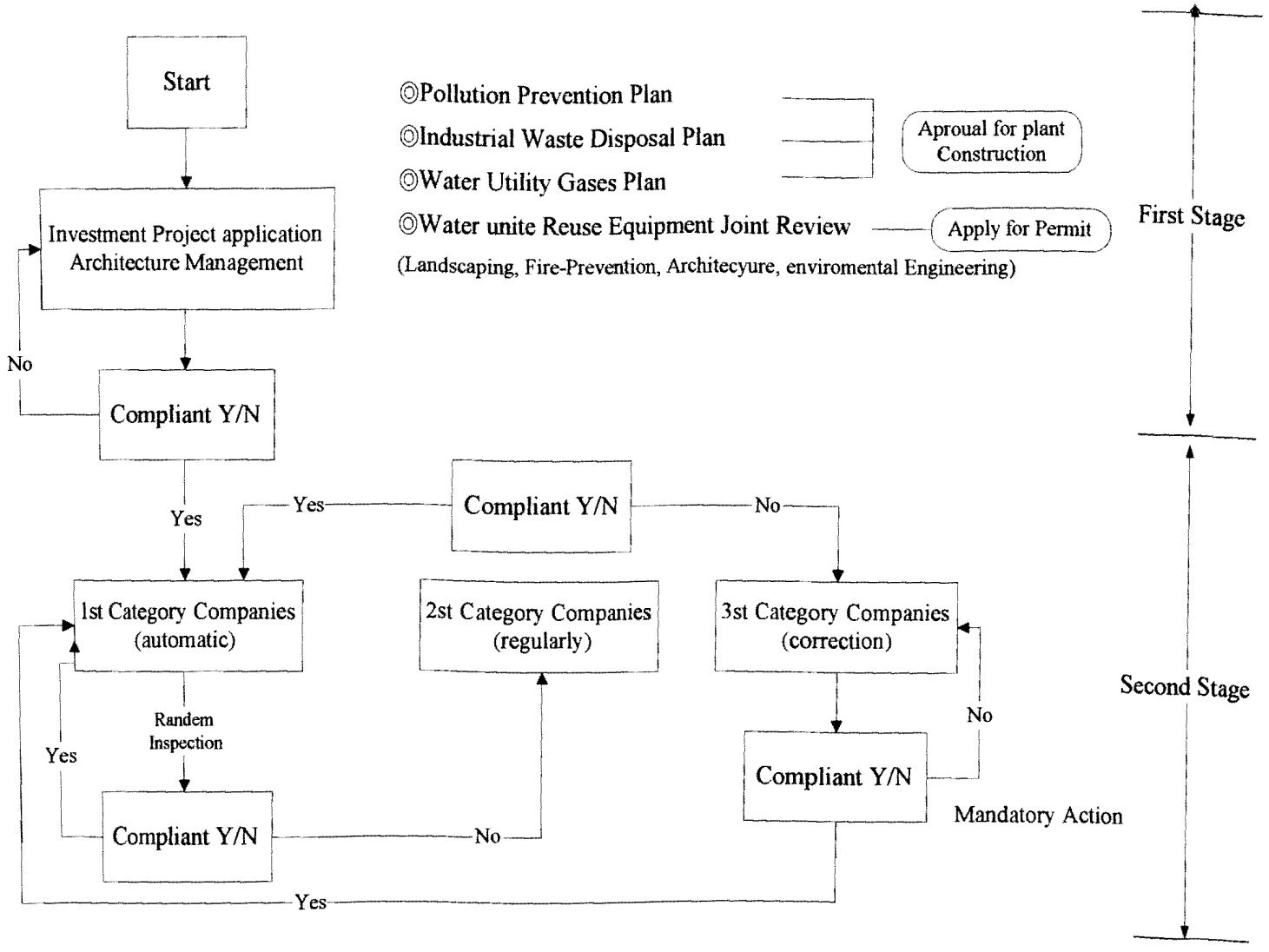
4.2 Implement Inspection and Assistance for HSIP Companies regarding Water Conservation Plan

1. Put together monthly data for water use and drainage for each company. Examine against the water utilization standard.

2. According to the plant construction time, HSIP Administration helps the companies to meet the following standards:
   1)The plants built before 1994 should meet the process reuse rate standard larger than 50% and the entire plant should have reuse rate larger than 30% and drainage rate smaller than 80%.
   2)The plants built between 1994 and 1999 should meet the process reuse rate standard larger than 70% and the entire plant should have reuse rate larger than 50% and drainage rate smaller than 80%.
   3)The plants built after 1999 should meet the process reuse rate standard larger than 85 % and the entire plant should have reuse rate larger than 60% and drainage rate smaller than 70%.
3. The above-mentioned plants, if rebuilt, should be considered as newly built; if only remodeling, should comply with the original water utilization plan. For definitions and calculation equations for so-called process reuse rate, entire plant reuse rate and drainage rate, please refer to Attachment 2 - 「Specification for HSIP Water Reuse Rate Calculation」
4. For unfaithful declaration about water utilization and drainage, intensive on-site assistance and inspection will be implemented for the company. Advice regarding water use and installing certified meter would be given.

4.3 Form water-conservation advisory committee for providing on-site assistance (as in the attached figure4)

Figure 4. Advisory Process for Company to Implement Water Conservation Plan



5. PLANT WATER-CONSERVATION AND WATER-LIMITING EMERGENCY RESPONSE MEASURES

Many factors can affect the water utilization. They include product characteristics, manufacturing process, equipment condition, operation method, operation condition, reuse rate and water management etc. "Review operation method, operation condition" "Increase reuse rate" and "Enhance water management". During water shortage time, the benefits from water conservation become evident. The water utilization analysis in Taiwan indicates indirect cooling water for 82.28%, then process water for 15.48%, boiler water, household water and others for 1.47%, 0.37% and 0.40%, respectively. Regarding reuse rate, Taiwan started water conservation and reuse implementation relatively late, so the overall reuse rate was about 32%, far less than 76% for the industrial water reuse rate in Japan. Compared with other countries, the reuse rate was apparently low, indicating a potential for the companies to conserve water. Water Resource Agency made improvement suggestions on water utilization based on many years of on-site investigation and assistance. The information can be found at http://wcis.erl.itri.org.tw/index.htm.

5.1 Effective Water Management

1. Install water meter, record and inspect the water utilization status (work with various kinds of water management software and hardware facilities)
2. Establish reasonable water use index for each type of water use in plant
3. Use the index to examine the water use and manage to reduce water consumption.
4. If abnormal water consumption arises, find the cause immediately.
5. Implement a reward and penalty system regarding water conservation efforts.
6. Conduct propaganda education on water conservation, proper water use and operation habits.

5.2 Water Minimization

1. Improve cooling water system (increase concentration, by-pass treatment, air cooling etc.)
2. Adopt water conservation manufacturing equipment (with flow stabilizer)
3. Reassess manufacturing process and seek water conservation opportunities (such as equipment layout, production sequence etc.)
4. Review manufacturing methods (such as reversal cleaning, dry cleaning, use of oil as thermal medium)
5. Adjust operation condition (such as shorten cleaning cycle, reduce water change frequency, minimize water flow etc.)
6. Avoid or minimize pollution (such as leaking prevention, cleaning liquid residue minimization)
7. Cultivate good operating habits

5.3 Enhance Reuse Rate

1. Reuse the used water according to drainage characteristics (for old plants, consider using conductivity meter and electromagnetic valve to differentiate water on quality)
2. Prioritize the water to be reused according to water purity or concentration and assess the reuse rate (such as waste liquid containing suspended solid or diluted inorganic waste liquid can be reused first)
3. Assess the locations of water use and supply for water reuse (potential water conservation locations: RO concentrate, condensate water, cooling tower drainage, cleaning water in final stages and drainage from wastewater treatment plant: water use locations: make-up water for cooling tower, toilet water, gardening water, cleaning water, process cleaning water in initial stages, local scrubber and cooling water).

5.4 Seek Substitute Water Source

Seek other water sources, like rainwater, spring water, seawater, underground water and even allocated water from farmland and other industrial plants, water treatment plants etc.

5.5 Suggestions for Companies to Cope with Water Limitation during Drought Period

Water limitation status (%)	Responsive Measure	Description
30	1.Call a meeting about implementing "emergency response plan for water shortage and outage "	1.The responsible person calls the meeting to determine the "emergency response plan for water shortage and outage ".
	2. Strengthen water conservation management, education and crisis consciousness	2. Educate the employees on water management and serious consequence of water shortage. Each individual can contribute the goal of water conservation.
	3. Lower the household water use in industry	3. Use water conservation equipment. Use drainage from cooling tower or RO waste liquid for toilet.
	4. Increase high price water	4. For example: increase water reuse rate, purchase water from other sources
	5. Assess process water minimization	5. For example: reduce cleaning agent concentration, lower cleaning flow, shorten cleaning time or cycles to achieve the objective of process water minimization.
	6. Seek other water resources and elevate water storage level	6. Use established database to seek alternative water sources and increase storage tank capacity by elevating the level control to increase the tolerance for water shortage.
	7. Review the response plan by reducing production	7. Review the possibility of reducing production or limiting production to certain products. Prepare for the possible coming disaster of water shortage.
40	1.Continue to advocate water conservation and strengthen crisis consciousness for water shortage	1. Water management and education are always effective ways for water conservation. When still under water shortage condition, consider limiting bathing water. Use reuse water for toilet flushing and irrigation. Use electric fans for Office air conditioning.
	2. If possible, manufacture products with low water consumption.	2. Seek customer's approval to manufacture products with low water consumption.
	3. In-house water allocation	3. Reallocate in-house water for all production lines.
	4. Reassess the increase of reuse water rate	4. Increase the capacity for water reuse equipment (water quality may deteriorate or equipment life may be affected)
	5. Seek Customer Support	5. Seek customer support to extend delivery date or quantity.
	6.Implement production reduction plan	6. Consider production reduction for certain products
	7. Review production shutdown plan	7. If water shortage continues, review the possibility of production shutdown plan.
50	1.Lower water quality requirement or use less quality water to increase water reuse rate	1. Lower water quality requirement or use less quality water to increase water reuse rate. But watch for the quality change.
	2. Implement production reduction plan	2. Some products are subject to production reduction. Shifts should be rescheduled.
	3.Consider implementing shutdown emergency plan	3. This is an undesirable condition. But this is not plant shutdown. It is to stop production on certain products or close certain lines according to careful plans. Some products can be moved to plant locations where have no water shortage problem or toll-manufactured. Consider all aspects including partner companies, employees and customers.

6. EMERGENCY RESPONSE PLAN FOR WATER SHORTAGE AND SUPPLY LIMITATION FOR WAFER FOUNDRY INDUSTRY

Wafer foundry industry plays a critical role in the process for Taiwan to develop into a high-tech island. Generally, the wafer foundry industry has already adopted many water reuse equipments. Thus, it is recommended to enhance water reuse equipment capability during drought period and increase the number of reuse points and reuse quantity. Normally, wastewater is classified to organic and inorganic. Most has been separated for reuse. The less quality wastewater is directly delivered to wastewater treatment plant. However, such type of wastewater still can be treated to become useful for cooling tower and scrubber with a reuse rate of 10~15%. When it is under an abnormal condition of water shortage and no negative effect is posed to production yield, the following measures can be taken for further water conservation:

Table1 Companies Emergency Response Plan for Water Shortage

Water shortage limitation status (%)	Response measure	Water conservation potential (%)	Description
30	1.Emission from water purification system is used for toilet flushing.	20~30	1.Emission from water purification system is concentrate of tap water. Reuse of such water can save 5~10% of water consumption. But pay attention to for scaling problem. ◦
	2.Process cleaning water is reduced to lower safety limit.		2.Considering safety cleaning quantity, the cleaning water is slightly larger than the safety standard. During water shortage, it can be dropped to lower safety limit and save around 2~5% of water consumption.
	3.Increase capacity for water reuse equipment		3. Change operation parameters or add pretreatment equipment to increase capacity for reuse equipment.
40	1.After treatment of process emission, the water is used for scrubber and cooling tower.	10~15	1.After separation and recycle for process water, fair quality water is subject to active carbon membrane treatment and used for secondary process. It saves water by 10~15%.
50	2.Add physical or chemical equipment to increase concentration for cooling tower.	5~10	1.Use chemicals or by-pass treatment to increase concentration cooling tower.
	3.Assess the possibility for water consumption reduction or production reduction		1.Minimize the number of cleaning and quantity of cleaning water or reduce production.

7. CONCLUSION

The water shortage crisis for HSIP in 2002 was relieved under the drought emergency response system operated among HSIP Administration, HSIP labor union, Water Supply Corporation, Irrigation Associations, National Science Council, the Council of Agriculture and Water Resources Agency of MOEA. Afterward, the high-tech industry in HSIP was back to normal operation.

It was learned from this crisis that the water resources administrative authorities should expedite the construction of Hsin-Chu Paoshan the Second Reservoir and hopefully complete the project by 2004. This will assure the secured water supply for Hsin-Chu area and HSIP. Besides, seawater desalination plant should be also on the list of major national construction projects. The plan includes building a seawater desalination plant along Hsin-Chu coast to produce 70 thousand tons of plain water per day and implementing a network of bi-directional water lines to effectively minimize the risk of water shortage when drought arises.

In addition to hardware construction, Water Resource Agency will put together the disciplines of climate, radar and hydrology forecast to work on early monitoring and warning model. It is also important to improve the accuracy of precipitation forecast and prepare for plan on water resource allocation. Besides, further review and improvement will be given to current drought classification, water limitation procedures and regional water allocation mechanism.