INVESTIGATOR'S SUMMARY[1]

Nomination 2005-19

Investigator: Rasha M. Stino[2], Ph.D.

WetSep Wastewater Filtration System

The Innovation

Introduction

WetSep is a patented in-situ filtration system designed to extract dissolved and suspended solids from construction and factory wastewater. Water that has been treated by WetSep meets the environmental requirements, expressed as effluent discharge limits, of several countries, including the United States of America, Singapore, Hong Kong, Thailand, Japan and France. As a result, the treated water can be re-used, directly discharged into the urban storm water system, or, discharged into a natural body of water, such as a river, lake, or ocean.

WetSep was invented in 1998 primarily to treat construction and industrial wastewater. However, its simple, flexible design concept has allowed it to evolve, through the incorporation of different water treatment technologies, into more specialized models for limited, specific applications. For example, in 2003 a solar powered model of WetSep that uses bio-degradable additives was developed to provide potable water in developing countries and remote regions.

How WetSep Works

WetSep has been described by the Far Eastern Economic Review as the "Wastewater Washing Machine for the Construction Project". In the most basic terms, the WetSep wastewater treatment steps are as follows:

- pump influent wastewater into a vertical static mixer and inject with flocculent, coagulant and pH adjusting chemicals to begin primary treatment
- spin in a washing machine-like centrifugal device containing stacked cones to separate solid waste and water
- collect sedimentation at the bottom and accumulate floating particles and oil at the top
- pass water through a chamber for secondary treatment to produce clean effluent

WetSep: Overview

The WetSep system is essentially a two stage wastewater treatment process. Primary treatment involves Chemically Enhanced Precipitation Treatment (CEPT) and the Impinging Stream Reaction (ISR). CEPT is generally the process by which chemicals, typically metal salts and/or polymers, are used to cause suspended particles (e.g., solids and organic matter) to clump together via the processes of coagulation and flocculation

[1] August 3rd, 2005

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and settle faster. The ISR is an innovative washing machine-like mixer that enhances the CEPT process.

Secondary treatment takes place in a Universal Processing Chamber (UPC) that can use any of a variety of technologies such as Lamella Plate Separation, Physical Adsorption or Advanced Oxidation Process, depending on the specific treatment requirements and application. For most construction projects, Lamella Plate Separation is used in the Universal Processing Chamber. The lamella principle uses several parallel inclined plates to maximize the available settling area for any available floor area. Particles between lamella plates migrate to each plate surface along the resultant vector of two forces, fluid drag and gravity. Once on the plates, the particles slide down to a hopper.

CEPT and the technologies used in secondary treatment in the UPC have existed as stand-alone items in petrochemical plants, mining, urban treatment works and large scale factories. The conventional applications often require a very large footprint and consist of a series of pumps and mixers, sophisticated control panels and require monitoring by experienced engineers and chemists.

WetSep's innovation lies in its simple overall design, its unique Impinging Stream Reactor design (washing machine-like mixer), and, the merging of several existing technologies into a highly effective wastewater treatment process that flows along a single critical path. WetSep's two-stage treatment has a high suspended solid removal efficiency that meets the strictest environmental standards in many countries. WetSep has no transfer pumps or mixing motors, it can be operated by unskilled labor, and, it has a standardized, compact, one-piece design that can be easily handled, transported and stored.

<u>WetSep: A Closer Look</u>

For the purpose of this Investigation Summary, only the WetSep model used for treatment of construction runoff and most industrial types of wastewater will be examined in detail. This is by far the most commonly manufactured and used version of WetSep. Variations of this model that are used for specific, limited applications, such as removal of total petroleum hydrocarbon and heavy metals, or providing potable water, will be mentioned only briefly in this report. Nevertheless, the two stage WetSep treatment process, basic design concept and components are essentially the same for all WetSep models, regardless of the application. This is proof of WetSep's flexible and efficient design.

Details of WetSep's design and the flow of wastewater are illustrated in Exhibit 1 at the end of this report and can be described as follows:

Primary Treatment: Vertical Static Inline Mixer
Wastewater (construction runoff) carrying a large amount of suspended solids is pumped, using a submersible pump, into the Impinging Stream Reactor (ISR) through a vertical static inline mixer. Within the vertical static inline mixer, the wastewater is injected with two chemicals, a flocculant and a coagulant, for the Chemically Enhanced Precipitation Treatment. The WetSep system is equipped with two chemical preparation and dosing systems for this purpose. The coagulant destabilizes suspended solids by neutralizing their negative charges. The flocculation agglomerates the destabilized particles into

larger particles (flocs) that can be effectively removed. See Exhibit 2 at the end of this report for Chemical Data Sheets of the flocculant and coagulant agents used in WetSep.

If necessary, WetSep can be fitted with a pH adjustment system for optimization of the Chemically Enhanced Precipitation Treatment process. Acid is automatically injected into the vertical inline mixer of the WetSep system when the pH value of wastewater is above 9.

Primary Treatment: Impinging Stream Reactor (ISR)
The ISR is the innovative washing machine of the wastewater treatment process. The influent driving force is provided either by gravity or the pump that feeds the wastewater into the Vertical Static Inline Mixer. Suspended particles, binding with the injected chemicals, tangentially impinge on the inner surface of the reactor tank and follow a spiral path down to the bottom. By both the centrifugal and gravitational forces, the flocculated particles settle to the bottom while the water continues to move upward and enters a vertical central shaft. The central shaft contains a stack of cone-shaped plates to increase the surface area for efficient sedimentation. As the process continues, the impinging stream separates particles with different densities. Oil and grease rise to the top and are discharged through an oil skimmer while heavier sludge falls to the bottom hopper. Water is discharged from the opening of the central shaft to the Universal Processing Chamber (UPC) for secondary treatment (see Exhibit 3 at the end of this report).

Secondary Treatment: Universal Processing Chamber (UPC)
Different technologies can be applied in the UPC, depending on the application and treatment objectives. Lamella plate separation is commonly employed for construction activities. The lamella plates increase the available settling area for further removal of the suspended solids and oil residue. After treatment, water that now meets environmental standards is discharged through an outlet.

Sludge Handling/Automatic Sludge Discharge: The sludge generated from the primary and secondary treatments settles to the bottom hoppers and is automatically drawn off via electric valves.

Power Supply: WetSep is powered by a single phase source (120 or 240 V A.C., 300 W). It can also be powered by portable solar panels and wind turbines that are mounted on top of WetSep.

<u>WetSep: Key Innovations</u>

As stated earlier, WetSep's innovation lies in its simple design, the unique Impinging Stream Reactor (ISR) and the merging of several existing technologies into an effective wastewater treatment process that flows along a single critical path. WetSep offers several features that distinguish it from conventional and competing treatment methods:

- *Efficient mixing*: The Vertical Static Inline Mixer and Impinging Stream Reactor reduce the number of mixers, enhance mixing of influent and chemicals and reduce vessel size.

- *Motor elimination:* There are no motors, moving parts or transfer pumps in the treatment and there is no need to stop system operation and empty or service tanks.
- *Easy operation:* The system is fully automated and can be operated by unskilled labor.
- *Fast setup and small footprint:* The system is a "plug and play unit" that can be set up within a day. It is fabricated in standard 20"or 40"containers that contain all components, electric measuring and automatic control systems.
- *Easy handling:* Its mobile, standardized design makes it easy to transport from site to site and reduces handling and delivery costs.
- *Minimum power requirements:* WetSep is powered by a single phase source (120 or 240 V A.C.) and is rated at no more than 300 W.
- *Flexible design and application:* A wide variety of advanced technologies can be selected for secondary treatment in the Universal Processing Chamber. The system is capable of treating wastewater in different settings (e.g., construction, contaminated soil clean-up, potable water treatment) and meets with the most stringent environmental standards.
- *Effective two-stage wastewater treatment:* It has higher suspended solid removal efficiency (99.8%) than conventional and competing systems due to its unique two-stage treatment method.

Conventional and Competing Technologies

Conventional wastewater treatment for construction activities has been characterized by large spatial requirements, complicated structures, poor efficiency and high capital and maintenance costs.

Conventional systems that WetSep replaces:

- *Ponds*: Despite low capital cost, ponds occupy enormous space making them unfeasible for urban and underground tunnel construction. Other limitations are long retention time, costly, labor-intensive sludge extraction and impracticable pH adjustment.
- *Rectangular sedimentation tanks:* The series of sedimentation tanks occupy a large amount space and performance (water treatment quality) is usually unsatisfactory. It has similar limitations to ponds.
- *Truck away:* Despite low capital cost, running cost is high due to frequent transportation.

Competing and Alternative systems:

- *Sand filters:* Require frequent backwash and pretreatment due to heavy solid loading. A sand filter cannot handle influent solid content higher than 500mg/l, (milligrams per liter) limiting its application.
- *Typical Chemically Enhanced Precipitation Treatment (CEPT) plant:* Occupies a large footprint consisting of a series of mechanical mixers and numerous pumps that are needed to complete the chemical reaction. The system has to be shut down during servicing of the mixers. Maintenance cost and energy consumption are high.

WetSep: Performance

WetSep's key innovations and performance compared to conventional and competing technologies can be translated into specific cost, time, safety, quality, spatial and environmental benefits:

WetSep Reduces Cost and Time

- Capital Cost: WetSep costs approximately USD 30,000 versus traditional methods that can be three to four times more expensive (e.g., a sedimentation tank plus one sand filter by companies such as 'Baker Rent', 'Rain for Rent' or 'US Filter').
- Mobility: can be lifted by light truck and shipped by most economical modes of transportation.
- Installation and Startup: "plug and play" system that can be setup within one day. No civil works required (e.g., foundations, support framework).
- Operation and Maintenance: system is fully automatic, simple and safe to operate by unskilled labor. No moving parts in the system results in reduced servicing time and cost.
- Running Unit Cost for Wastewater Treatment: conventional/competing systems cost on average USD 0.5/ m^3 (U.S. dollars per cubic meter). WetSep's running cost is one tenth, USD 0.05/ m^3, due to its low energy consumption and chemical usage (see Table 1).
- Energy Consumption: WetSep's is lower than the typical CEPT plant that requires numerous mixers and pumps.
- Water Reuse: treated effluent is clear and reusable, reducing the demand on water supplies as well as the cost of drainage discharge.
- Reuse of the system: WetSep is easy to transport from site to site.
- Compliance with Environmental Standards: WetSep's superior wastewater treatment saves companies the fines that they would normally pay for exceeding effluent discharge limits.

WetSep Improves Quality:

- WetSep removes more than 99.8% of suspended solids from the influent, offering much better results than conventional treatment methods and satisfying most of the established discharge standards. The effluent complies with the most stringent discharge limits (see Table 2).
- For a bore piling project generating wastewater at a rate of 100 m^3/hr (cubic meters per hour), the suspended solids level was reduced from 25,000 mg/l to 30 mg/l. The suspended solid level of storm water runoff on a residential project was reduced from 10,400 mg/l to 20 mg/l. Using conventional sedimentation tanks, the suspended solid level would only be brought down to 300 mg/l. Of the conventional methods, only a sand filter can meet a discharge standard of 30 mg/l, however, a sand filter is not designed to handle a high influent solid content and is limited to a maximum of 500 mg/l.

WetSep Improves Safety:

- Sludge Removal: traditionally, accumulated sludge is regularly excavated from sedimentation tanks. The excavator is likely to ruin the tank wall because of the powerful scraping arm. Furthermore, the excavator bucket is not versatile enough to completely clean the tank and often needs a worker alongside it, inside the tank. These unsafe conditions caused the death of a worker in Hong Kong's To Kwa Wan construction project in February, 1999. In contrast, WetSep automatically drains the accumulated sludge via electric valves without any risk to workers.
- Safety Features: WetSep is equipped with eyewash, secondary containment for chemicals, warning signs and a sampling point.

WetSep Reduces Spatial Requirements: WetSep incorporates existing treatment technologies, such as CEPT, but, due to its innovative design, takes up two-thirds less space than traditional tanks and methods. This has significant implications for construction sites with limited space, remote/inaccessible sites such as tunnels, and, handling and transportation requirements.

WetSep Helps the Environment:

- WetSep encourages sustainable energy by using little energy and running on solar and wind power, ideal for remote regions and developing countries, especially where providing potable water is challenging. The solar-powered WetSep has received the Silver Asian Innovation Awards in 2003 for its use of technology and its potential impact on the quality of life.
- WetSep complies with the World Summit's Integrated Water Resource Management Plan by producing treated effluent that can be reused and lowering the demand on water supplies.

Application of the Innovation

The WetSep system has been applied for treatment of wastewater generated from a variety of construction activities ranging from storm water run off, building construction, tunnel grouting, piling, and, highway construction. Following are examples of three types of construction applications.

Bore Piling / Foundation Work

Among the common construction activities, bore piling generates the greatest volume of effluent. Water is used as a medium and coolant to extract and bring out the soil from underground. The flow ranges from 40 m^3/hr to 50 m^3/hr for a 2.8 meter diameter pile and the suspended solid in the wastewater can reach 25,000 mg/l. With conventional treatment methods, an extremely long rectangular tank is used for sedimentation. This occupies a large footprint, necessitates the excavation of sludge out of the tank, requires intense labor and poses safety concerns. Furthermore, the treated water quality results are rarely satisfactory. WetSep's small footprint and efficient suspended solid removal (solids are reduced to 30 mg/l) has been proven to be the most cost effective system for

bore piling applications, tunnel grouting, piling, and, highway construction. Following are examples of three types of construction applications.

	Canada	Georgia	Denmark	France	WetSep
Treatment cost (USD per cubic meter)	0.70	0.36	0.30	0.90	0.05

Table 1. Typical unit cost of traditional wastewater treatment in various countries versus typical unit cost of wastewater treatment using WetSep (Source: Waste and Environmental Technologies Ltd. 2005)

	U.S.A.[3]	Singapore[4]	Hong Kong[5]	Thailand[6]	Japan[7]	France[8]	WetSep
Suspended Solids (mg/L)	30	50	30	50	150	35	10 – 25
Biological Oxygen Demand (BOD) (mg/L)	25	20	20	30	20	30	15 – 20
Chemical Oxygen Demand (COD) (mg/L)	-	60	80	100	120	125	60 – 100
Heavy Metals (ppb)	Monitor and report	500	1000	1000	1000	1000	< 100
pH	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9

Table 2. Effluent discharge limits in different countries versus effluent quality produced by WetSep (Source: Waste and Environmental Technologies Ltd. 2005)

[3] National Pollution Discharge Elimination System, U.S.A.
[4] http://app.nea.gov.sg/cms/htdocs/article.asp?pid=1644
[5] Technical Memorandum, Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters, Environmental Protection Department, Hong Kong
[6] http://www.pcd.go.th/Information/Regulations/WaterQuality/Effluents.htm
[7] http://www.env.go.jp/en/lar/regulations/nes.html
[8] http://aida.ineris.fr/textes/arretes/text3105.htm

Bore Piling / Foundation Work
Among the common construction activities, bore piling generates the greatest volume of effluent. Water is used as a medium and coolant to extract and bring out the soil from underground. The flow ranges from 40 m^3/hr to 50 m^3/hr for a 2.8 meter diameter pile and the suspended solid in the wastewater can reach 25,000 mg/l. With conventional treatment methods, an extremely long rectangular tank is used for sedimentation. This occupies a large footprint, necessitates the excavation of sludge out of the tank, requires intense labor and poses safety concerns. Furthermore, the treated water quality results are rarely satisfactory. WetSep's small footprint and efficient suspended solid removal (solids are reduced to 30 mg/l) has been proven to be the most cost effective system for bore piling applications.

Concrete Works
Concrete used for building construction is highly alkaline. Construction runoff (influent) at such sites has a high pH that requires effective treatment before discharge. In addition to reducing the suspended solid content, WetSep automatically brings the influent pH down to the correct level for optimal Chemically Enhanced Precipitation Treatment (CEPT).

Tunneling
In most tunneling projects, underground runoff, grouting, and, the water used to cool and flush tunnel boring machines generate an enormous amount of contaminated effluent. Due to space limitations, conventional sedimentation tanks cannot be installed inside the tunnel. Contractors often resort to costly and, sometimes, ineffective solutions, such as installing numerous high lifting pumps to pump wastewater to the ground level for treatment. WetSep's compact design allows it to fit inside a tunnel without disturbing the excavation works and eliminates the need for pumping. WetSep has been used for many tunneling projects around the world, including the world's fourth largest tunnel in Taiwan, and has become the standard for tunneling projects in Hong Kong.

WetSep has been successfully applied on over 100 projects worldwide. According to Waste and Environmental Technologies Ltd. (WetSep creator), sixteen of the top fifty international civil contractors use WetSep. For a partial list of projects where WetSep has been used and details of WetSep's successful use on the Pinglin Tunnel Project in Taiwan (world's fourth longest tunnel) see Exhibit 4 at the end of this report. Specialized versions of WetSep that are used for limited, unique applications are briefly described under "Background of the Innovation: Special Applications, 1999-Present".

Background of the Innovation

The WetSep system was invented by Mr. Leung Wai-On, Managing Director of Waste & Environmental Technologies Ltd., in Hong Kong in 1998. Mr. Wai-On was inspired by the washing machine and his observation that most people would like to "push a button and walk away from environmental clean-ups".

Mr. Leung Wai-On had been serving in the construction and processing industries for 30 years when he designed the WetSep system. His objective was to cater to the everyday conditions on a construction site and to maximize performance at a minimum energy consumption rate and cost. WetSep was designed as a compact, mobile system that needed no mixing motors, transfer pumps or skilled labor to operate. The submersible pump, found on most construction sites, became the only device needed to pressurize the influent wastewater (construction runoff entering the system).

WetSep has obtained patents in over twenty countries, including Australia, Europe (European Union countries), Canada, United States of America, Japan, Hong Kong, Taiwan and China.

Following is a brief timeline of WetSep's development and highlights of its expansion to the international construction market:

- 1999: The first WetSep was applied in the construction industry for Hong Kong's Pak Tim Housing Building project. It achieved an effluent quality of 30 mg/l suspended solid as required by Hong Kong Environmental Protection Department. Due to its excellent performance, it was successfully installed on many types of construction projects, including, railways, highways, site formation, buildings and underground tunnels. WetSep soon dominated the pollution control market in the Hong Kong construction sector. WetSep received the CMA Certificate of Merit in Machinery and Equipment Design by the Hong Kong Awards for Industry.
- 2000: WetSep was used by Gammon Skanska for their USD 74 million sewage tunnel construction project in Hong Kong. WetSep received the Silver Award of the Hong Kong International Invention EXPO2000.
- 2001: WetSep was used for construction of the Taiwan Pinglin Tunnel, the world's 4th longest car tunnel. It was installed inside the tunnel at a depth of 250 meters for the treatment of 320 m^3/hr (cubic meters per hour) of wastewater. Twenty percent (20%) of the treated effluent was reused and the remaining was discharged to the potable water control zone.
- 2002: WetSep was successfully applied to cleaning up reservoirs. Silt laden water was pumped to the WetSep system for filtration and dechlorination before discharge. WetSep received three awards from the New Techniques and Products of Geneva 30th International Exhibition of Inventions, *Salon International Des Inventions Geneve*, (Silver Award, Metal, and, Environmental Prize).
- 2003: WetSep was integrated with Advanced Oxidation Process (AOP) technology for a contaminated soil remediation project. It reduced total petroleum hydrocarbon levels to environmentally acceptable ppb (parts per billion).
- 2003: WetSep was further modified and equipped with solar powered capabilities for use in remote regions with potable water problems. The Solar WetSep model received the Silver Award of the 6th Asian Innovation Awards in 2003. The Solar WetSep model also received the CMA Certificate of Merit in Machinery and Equipment Design by the Hong Kong Awards for Industry.
- 2004: WetSep rapidly expanded its overseas construction market to many regions and countries including Macau (China), Australia, Singapore and France. The Solar

WetSep model was a finalist of the World Technology Awards in City Hall, San Francisco, U.S.A.

- 2004-2005: Waste & Environmental Technologies Ltd. was invited by the Mexican government to examine Mexico City's water pollution.
- Special Applications, 1999-Present: WetSep continued to improve and meet with the most stringent environmental standards and evolved into more specialized models by incorporating other treatment technologies that could be used on unique projects:
  - *Early development:* WetSep switched from the centrifugal effect of vortex to the more effective Impinging Stream Reaction (ISR) and started using Computational Fluid Dynamics (CFD) instead of AutoCAD software as the design tool for treatment optimization.
  - *Electrostatic Coagulation:* For applications where only biodegradable additives are allowed during the coagulation process (e.g., a salmon farm/factory in Canada), coagulation is achieved by generating a high voltage electrostatic field inside the vertical static mixer. This method requires neither coagulants nor flocculants and has very low energy consumption (24V D.C., 30W).
  - *Ozonation:* Ozone is injected into WetSep's vertical static inline mixer to reduce the chemical oxygen demand (COD) and disinfect wastewater. The mixing process inside the ISR increases the solubility of ozone from about 25% to 80%-85%. Higher ozone solubility increases the dissolved oxygen (DO) level and, thus, the quality of the effluent. It also reduces the operating cost due to efficient use of ozone. This specialized version of WetSep has been adopted by the Leisure and Cultural Services Department Office at Approach Beach, Hong Kong for greywater treatment and disinfection.
  - *Advanced Oxidation Process and Physical Adsorption:* WetSep utilizes the physical adsorption property of activated carbon during secondary treatment to remove harmful substances such as dioxins and hydrocarbons on soil remediation projects. By coupling this process with ozone injection as an Advanced Oxidation Process, persistent pollutants are reduced to an acceptable ppb (parts per billion) level. Hydrogen Peroxide is injected into the connection between the ISR and Universal Processing Chamber to react with the organic contaminants. Activated carbon replaces lamella plates in the Universal Processing Chamber to further treat the wastewater up to a tertiary level. The Kowloon Motor Bus (KMB) in Hong Kong adopted WetSep to solve its hydrocarbon pollution problem that needed to be reduced to the required ppb level.
  - *Microsand:* Also called micro silica, is injected into the vertical static inline mixer in order to weigh down and speed the settlement of light-weight suspended solids down to the hopper. If needed, a hydrocyclone is added to WetSep to recover the microsand by separating it from the sludge. The recovered microsand is injected back into the WetSep system.

Responsibility for the Innovation

The following individuals are responsible for the creation and success of WetSep:

Mr. Leung Wai-On – (Inventor of WetSep)

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Opinions of Persons Contacted

Nine industry references were asked the following questions through both electronic mail and facsimile (first contact made on August 3rd, 2005).

1. How did you become familiar with the WetSep Wastewater Filtration System?
2. What components of WetSep are innovative? Please be specific.
3. Is WetSep truly innovate or an evolution of existing concepts and technologies?
4. What, in your opinion, are the tangible benefits of WetSep when used on construction projects?
5. For what types of projects is WetSep suited: a wide variety or a narrow niche?
6. Is WetSep applicable / acceptable / adaptable in many countries, with different environmental requirements?
7. Does WetSep make some projects possible / practical that otherwise would not be?
8. What are the practical constraints and limitation of WetSep?
9. Are there any competing/alternative technologies in the industry? If so, name them and state how they compare in terms of time, cost and quality.
10. What would you suggest for improvement / future research of WetSep?
11. Any other comments?

There was clear consensus among the interviewees that WetSep is a one-of-a-kind wastewater treatment system with many benefits that can successfully be applied to a wide range of construction projects in different countries. The advantages of WetSep stated in this report were confirmed by the interviewees based on their personal experiences. These included, cost savings, highly satisfactory wastewater treatment results, speed and ease of use, compact size, portability, adaptability to different treatment problems, and, low energy consumption. Furthermore, interviewees noted that there are no competing or alternative treatment technologies in the industry that compare to WetSep in terms of time, cost, quality and spatial requirements. One Senior Project

Manager noted, “I found a relatively inexpensive solution to what was a serious problem. I had a relatively small work area and needed to treat 10 cubic meters of water per minute. We easily achieved full compliance with discharge licenses using [WetSep]. Since that initial project, the same equipment has been used on several other projects with only minor renovation cost. It is a cost effective solution for temporary construction sites.” Another Senior Project Manager from the same construction company stated that by using WetSep, they won the Eco-Business Award’s Green Contractor Award for 2004.

Investigator's Comments

I believe that WetSep is an innovative wastewater treatment system due to its simplicity, adaptability and portability that translate to lower cost, higher quality and improved safety. In its short life, WetSep has had and will continue to have a significant impact on construction wastewater treatment. It has evolved into many specialized models that can address unique water treatment needs. Its benefits extend beyond the immediate realms of construction and manufacturing to the global environment and the potential improvement of the quality of life in rural, remote and developing regions. As Mr. Leung Wai-On put it, “after 5 years of successful case studies, we believe it can be beneficial to the rest of the world no matter a construction run off in Long Island, New York or the drinking water supplies for Bangladesh to treat the naturally-occurring arsenic that is threatening the health of as many as 70 million people.”

The main challenge in preparing this report was getting the inventor and references to really explain in the most basic terms what was innovative about WetSep and how it worked. It took a great deal of effort and time and much back and forth communication to sift through the masses of information that was sent to me, much of which was too superficial, and to produce a meaningful description of WetSep’s design, components and process. There was also a language barrier to some degree that required editing, review and deciphering of data that was sent to me.

I would like to acknowledge Mr. Leung Wai-On and his staff at Waste and Environmental Technologies Ltd. for their extreme helpfulness and for providing the figures, tables and data needed to produce this challenging report.

SELECTED INTERVIEW SUMMARIES

General note: The complexity of this technology required more than one telephone and e-mail interview per each industry contact.

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Response Date: **August 26th, 2005**

Dear Dr. Rasha Stino,

Thank you very much for your interest at the WetSep Wastewater Filtration. It is my pleasure to answer you as much as I could.

1. How did you become familiar with the WetSep Wastewater Filtration System?
I am the Chairperson of the Environmental Affairs Panel of the Legislative Council and normally I am quite aware of the latest technology and equipment available for Environment Prtection Works in Hong Kong. I also know that our public works have employed many WetSep systems and as far as I know, they found this technology satisfactory especially effluent quality. I also read about the performance of the WetSep from the report published by the Environmental Protection Department of Hong Kong.

2. What components of WetSep are innovative? Please be specific.
The system consists of no motor driven process and is different to the other existing method being used n Hong Kong. To me, the simplicity of the WetSep is an innovation.

3. Is WetSep truly innovate or an evolution of existing concepts and technologies?
I understand that the WetSep system received patents worldwide and have made applications in Asi and Europe for varies type of effluent. All these must be good proof for the outstanding performances in technologies and concept. It could be the only system driven by PV Panel.

4. What, in your opinion, are the tangible benefits of WetSep when used on construction projects?
I feel that the system turns the concept for wastewater treatment from cost base into profit-based polutants. The cost saving would be the most tangible benefit for construction projects.

5. For what types of projects is WetSep suited: a wide variety or a narrow niche?
From the records I know, they show that the WetSep system could fit into different kinds of Construction Projects in Hong Kong.

6. Is WetSep applicable / acceptable / adaptable in many countries, with different environmental requirements?

The job reference reflected the installation of the WetSep in other countries were acceptable.

7. Does WetSep make some projects possible / practical that otherwise would not be?

Subject to the job reference, the SSDS tunnel project in Hong Kong and the Ping Ling Tunnel Project in Taiwan, the work design did not allow the wastewater treatment system initially to handle the construction run off.

The employment of the WetSep was a cost effective solution to the project and making the water can be reuse or even the collected underground water filled with cement grouting. The waste supply cost in Hong Kong is US$1.00 per cuM and the treatment cost for the WetSep is less than US$0.10 per cuM.

8. What are the practical constraints and limitation of WetSep?

Not to my knowledge

9. Are there any competing/alternative technologies in the industry? If so, name them and state how they compare in terms of time, cost and quality.

I understand that there could be convenional holding tanks or sand filter systems. However, whether or ot they are as cost effective and s easy to handle as the WetSep is another story and of course it is up to the practices of the users.

10. What would you suggest for improvement / future research of WetSep?

I believe it could be xtended to the application of emrgency water or wastewater treatment.

11. Any other comments?

I highly recommend this new, simple and innovative technology that is developed by a Hong Kong Company.

Name	**Mr. James P. Clark**
Position	**Chairman**
	The World Technology Network
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	London NW3 6B1, UK
Tel.	**+ 44 (0) 208 953 4333**
Fax	**+ 44 (0) 208 953 6333**
E-mail	**jpclark@wtn.net**

Response Date: **August 17th, 2005**

Dear Dr. Stino,

Although I am pleased that Mr. Leung Wai On listed me as a reference for the NOVA Awards nomination, I cannot fulfill that responsibility I do no have enough personal and detailed experience with the technology to answer the questions I read on list you sent to me.

I can, however, say, that Waste and Environmental Technologies Ltd was elected as a corporate member of the World Technology Network (WTN) by being selected as one of

only five finalists for the 2004 World Technology Award for Environment (in our corporate category due to the WetSep technology.

The way the World Technology Awards process works is as follows: Current individual WTN members (winners and finalists of previous annual World Technology Award cycles in the individual categories) nominate those individual and companies they feel are doing the work of the greatest likely long-term significance. We then contact each of the nominees and request further background information. We then provide all of the nominee profiles back to the individual WTN members so that they can vote their preferences. That is how the Waste and Environmental Technologies Ltd made it to the finals and was elected a WTN member. To even be nominated is an honor, but to be selected as a finalist is an even greater honor.

I hope you find this background helpful and supportive of the WetSep nomination for the 2005 NOVA Award.

The World Technology Network
http://www.wtn.net

Name	**Mr. Tesuika**
Position	**Pinglin Tunnel Project**
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Response Date: **August 15th, 2005**

1. *How did you become familiar with the WetSep Wastewater Filtration System?*

The WetSep system had been employed for our previous tunnel project in Hong Kong, the run off treatment from the Tunnel Bolting Machine and also the drill and blast section. The project was a Joint Venture with Leighton Contractor from Australia. Again, we employed the WetSep system for our Ping Ling Tunnel in Taiwan.

We had used the WetSep system for a Yinlan traffic tunnel construction project. The tunnel is extended from Taipei to Yinlan at 250 m underground and total length of 12.9 km. The tunnel went through a lot of lakes and reservoirs. The project had to overcome spring during the construction and discharge to the country side.

2. What components of WetSep are innovative? Please be specific.

The WetSep system was different from the existing equipment available in Taiwan. It was a modular type and could be transported into the deep tunnel without a long erection period to setup.

3. Is WetSep truly innovate or an evolution of existing concepts and technologies?

It is innovative. We have previously employed a traditional wastewater treatment plant. However, due to its footprint, it became a wastewater treatment project that required large capture and zero return after the project completion.

4. What, in your opinion, are the tangible benefits of WetSep when used on construction projects?

It is small in size, easy to transport and set up, mobility. It can be setup within an hour. Low operation and maintenance cost

5. For what types of projects is WetSep suited: a wide variety or a narrow niche?

It has been used in our projects for tunnels. Among the Japanese construction companies, it had been applied for marine, highway and building construction and foundation which generated wastewater with heavy solids.

6. Is WetSep applicable / acceptable / adaptable in many countries, with different environmental requirements?

Our project in Taiwan adopted for the WetSep system and met the local legislative requirements. The standard of discharge in our site is stricter as there is a reservoir next to our site. However, after using the WetSep system, most of the effluent can meet to the discharge requirement.

7. Does WetSep make some projects possible / practical that otherwise would not be?

Due to the small size, the system can be installed inside the tunnel, which reduce the installation of pipe works, reduce pump capacity and hence reduce energy consumption. The saved cost can be further investigated in our project construction.

8. What are the practical constraints and limitation of WetSep?

The modular size should be larger for large capacity project.

9. Are there any competing/alternative technologies in the industry? If so, name them and state how they compare in terms of time, cost and quality.

In Taiwan, there are many suppliers or contractors providing wastewater treatment facility, however, all of them are designed for permanent installation which requires large spacing and low feasibility. After the WetSep system overcomes the above mentioned problems

10. What would you suggest for improvement / future research of WetSep?

The WetSep system can be smaller and designed to capture larger water capacity.

11. Any other comments?

Name	**Mr. Colin Foster**
Position	**Senior Project Manager**
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Response Date: **August 13th, 2005**

1. How did you become familiar with the WetSep Wastewater Filtration System?
I attended a trade exhibition in Hong Kong out of general interest approx 6 years ago. I was having some problems with large quantities of discharge water with high solid and high alkali content on my construction project and saw a possible solution with this system.

2. What components of WetSep are innovative? Please be specific.
It is an all-in-one compact and easily portable solution which can be adapted easily to solve differing problems.

3. Is WetSep truly innovate or an evolution of existing concepts and technologies?
I think that it is mainly an evolution of existing technology. Separation and dosing technologies already existed

4. What, in your opinion, are the tangible benefits of WetSep when used on construction projects?
It's basic simplicity (No very High –Tech components), adaptability (Can be set up in parallel to cope with varying discharge quantities and water quality) and portability. It can be set up quickly and re-used many times for follow on projects. It can be particularly economical for short duration projects.

5. For what types of projects is WetSep suited: a wide variety or a narrow niche?
A wide variety of projects requiring reduction of suspended solids content and ph balance before discharge of waste or naturally occurring water.

6. Is WetSep applicable / acceptable / adaptable in many countries, with different environmental requirements?
Yes

7. Does WetSep make some projects possible / practical that otherwise would not be?
No

8. What are the practical constraints and limitation of WetSep?
I don't believe it would be totally effective or economic for very high, fine solids such as drilling fluids, bentonite etc. although I have not tried or tested those conditions. Primary settlement is advisable when coarser material is present.

9. Are there any competing/alternative technologies in the industry? If so, name them and state how they compare in terms of time, cost and quality.
Many techniques exist, but they may need large settling tanks and other devices (Hydrocyclones etc.), usually involve higher set up costs and more space.

10. What would you suggest for improvement / future research of WetSep?
Possible incorporation of drying/caking press to reduce water content of residual fines

11. Any other comments?
I found a relatively inexpensive solution to what was a serious problem. I had a relatively small works area and needed to treat up to 10 cubic meters of discharge water per minute. We easily achieved full compliance with discharge licenses using this system. Since that

initial project, the same equipment has been used on several other projects with only minor renovation cost. It is a cost effective solution for temporary construction sites.

Name	**Mr. Rayland C. F. Lee**
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Response Date: **August 13th, 2005**

1. *How did you become familiar with the WetSep Wastewater Filtration System?*

We had first used the WetSep system for our sewage tunnel project in Tsing Yi Island. Since then, this system has been employed for many of our construction projects such as building & road construction for wastewater treatment.

2. *What components of WetSep are innovative? Please be specific.*

The system does not require any motor for mixing of the chemicals and wastewater, which makes it simple for our operators to operate and reduces maintenance cost.

3. *Is WetSep truly innovate or an evolution of existing concepts and technologies?*

Yes, it is truly an innovative product. Before this system has launched to the construction industry, we were using sedimentation tanks for wastewater treatment. The tank size is enormous and the effluent quality was hardly satisfied, not to mention water reuse.

4. *What, in your opinion, are the tangible benefits of WetSep when used on construction projects?*

Benefits: Water reuse, small in footprint, easy to transport and operate. It can be setup within a day. Less operation and maintenance cost. Reliable

5. *For what types of projects is WetSep suited: a wide variety or a narrow niche?*

This system can be used for wide variety of construction jobs. It has been adopted in our projects for bore piling, tunnels, marine, highway and building construction and foundation.

6. *Is WetSep applicable / acceptable / adaptable in many countries, with different environmental requirements?*

The treated water after the WetSep system meets the legislative requirements. It can even be recycled for wheel washing and dust suppression. Our company has employed the WetSep system for a construction project in Singapore.

7. *Does WetSep make some projects possible / practical that otherwise would not be?*

Due to the small footprint, the system had been used in most construction jobs even for the busiest roads like Nathan Road in Hong Kong. Moreover, our company has won Eco-Business Award – Green Contractor Awards 2004 in Hong Kong. Most of our projects have employed the WetSep systems for wastewater recycling to meet our water management objectives.

8. What are the practical constraints and limitation of WetSep?
For marine construction project, the system shall require special coating for anti-corrosion.

9. Are there any competing/alternative technologies in the industry? If so, name them and state how they compare in terms of time, cost and quality.
After the WetSep system, Aquarsed and Pure Sources systems came into market for wastewater filtration treatment. However, both systems require motors to drive and the effluent quality has to be discovered.

10. What would you suggest for improvement / future research of WetSep?
We would like the new version of WetSep system to be suitable for bentonite treatment.

11. Any other comments?

Name	**Mr. Tang Kin Fai**
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Response Date: **August 10th, 2005**

Thanks for the message. While I have attempted to provide below information based on my best knowledge and personal opinions, I must submit that I have no hand-on experience in using the technology. Presumably, you have also contacted some construction work contractors that have purchased and used the system to provide you with their experience. My responses to the questions following the same numbering system are as follows:

1. How did you become familiar with the WetSep Wastewater Filtration System?
The system was made known to me while I was involved in enforcing the water pollution control law in Hong Kong. One of the major problems faced by the construction industry at the time was muddy discharges from construction sites and the lack of onsite cost effective and compact wastewater treatment systems on the market to treat the wastes.

2. What components of WetSep are innovative? Please be specific.
The system is compact, simple to operate, and suitable for use in congested construction sites. Being sized in the form of a container, it can be easily transported from sites to sites.

3. Is WetSep truly innovate or an evolution of existing concepts and technologies?
It is at least an evolution of existing technologies. It is claimed that the impinging stream reactor system is innovative but I have no information to verify this.

4. What, in your opinion, are the tangible benefits of WetSep when used on construction projects?

The tangible benefits of the system for construction projects are its compactness and effectiveness in treating muddy water discharges at affordable costs. The system is particularly suited to small construction sites and can be moved from sites to sites.

5. For what types of projects is WetSep suited: a wide variety or a narrow niche?
I think the system is suitable for various types of projects that produce muddy waste discharges, though its application to small sites is particularly impressive.

6. Is WetSep applicable / acceptable / adaptable in many countries, with different environmental requirements?
I think it can be adapted for used in many countries with different environmental requirements in terms of suspended solid removal.

7. Does WetSep make some projects possible / practical that otherwise would not be?
It would enhance the feasibility of projects that produce muddy discharges and have tight physical site constraints.

8. What are the practical constraints and limitation of WetSep?
Although it is relatively easy to operate, it would still require manual supervision especially if flows are time varying. I am not sure about its effectiveness in terms of removal of organic and other pollutants.

9. Are there any competing/alternative technologies in the industry? If so, name them and state how they compare in terms of time, cost and quality.
In Hong Kong, there is at least one alternative and similar technology used in the construction industry. The technology is developed by the Hong Kong Productivity Council. You may find some more details from their website.

10. What would you suggest for improvement / future research of WetSep?
I guess there may be room for improvement of its automation in handling highly variable flows and lowering its operating cost.

11. Any other comments?
I came across the system some years ago and I understand that the system has been enhanced and improved over the last few years. Comments from latest users or wastewater treatment design experts on the system would be useful for your assessment.

Hope you find the above useful.

Name	**Mr. Olof Thoren**
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Response Date: **August 9th, 2005**

Dear Dr Rasha Stino,

Unfortunately we are still to take delivery of the wet sep to site. Cannot answer your questions until it has been up and running for a while.

REFERENCES

Wai-On, L. "Drainage Service Department: Integrated Wastewater Treatment with CEPT" (Presentation), Hong Kong, May 2005.

Waste and Environmental Technologies Limited. "An Innovative Water and Wastewater Treatment System", Hong Kong (no date provided).

Waste and Environmental Technologies Limited. "Wastewater Recycling for Construction Site", Hong Kong, April 2005.

SUPPORTING EXHIBITS

Exhibit 1. Figure of WetSep design and wastewater treatment flow (1 page).

Exhibit 2. Figure of Impinging Stream Reactor (ISR) (1 page).

Exhibit 3. Chemical Data Sheets of the flocculant and coagulant agents used in WetSep (2 pages).

Exhibit 4. (2 pages)

- Partial list of projects where WetSep has been used
- Case Study of WetSep's successful use on the Pinglin Tunnel Project in Taiwan

EXHIBIT 1:- Figure of WetSep Design and Wastewater Treatment Flow

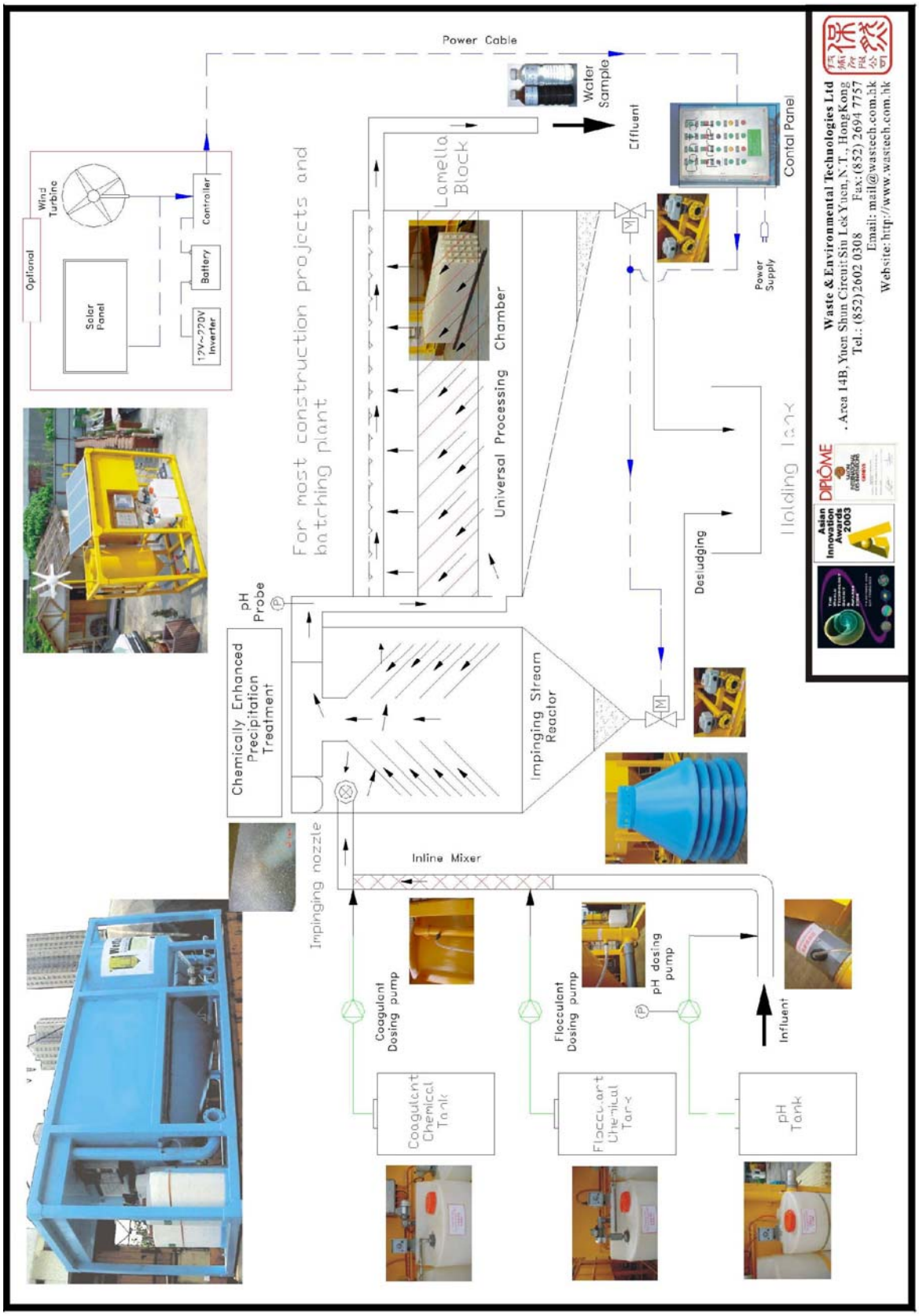
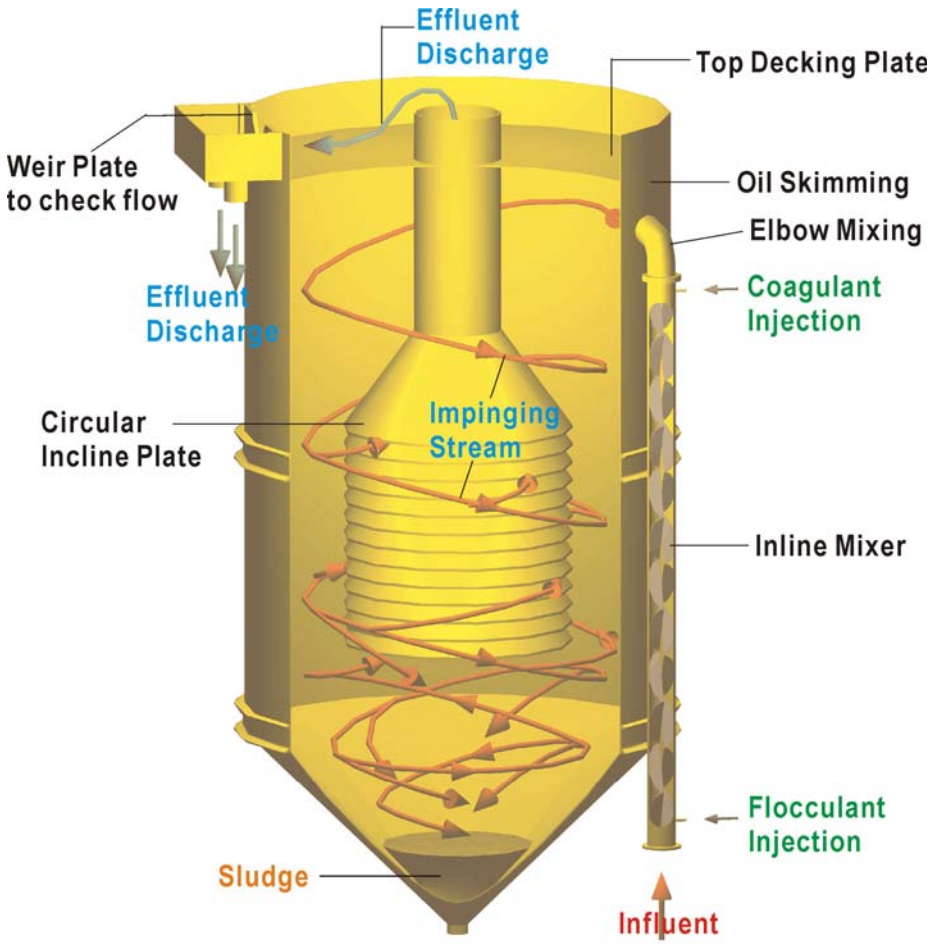
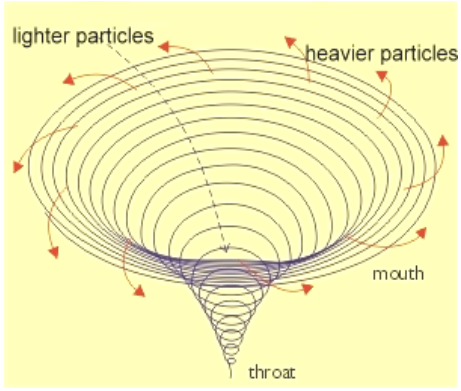


EXHIBIT 2:
Figure of Impinging Stream Reactor (ISR)





Impinging Stream Reactor

EXHIBIT 3: - Chemical Data Sheets of the flocculant and coagulant agents used in WetSep

CHEMICAL DATA SHEET: FLOCCULANT AGENT # 26AS

DESCRIPTION

Flocculent Agent #26AC is an anionic potato starch modified for use in water purification processes. It is fully soluble in cold water giving solutions of a low viscosity.

PRINCIPAL USES

Flocculent Agent #26AC is used throughout the water industry as a coagulant aid for potable water production. It is used on both clarification and filtration processes. It can also be used in the treatment of industrial waters and in some cases may be effective in sludge treatment processes.

It is approved by the Drinking Water Inspectorate for clarification and filtration processes in potable water treatment up to a level of $5g/m^3$.

TYPICAL PROPERTIES

Physical form	White to pale yellow flakes
Bulk density	Approx. $0.33g/cm^3$
Particle size	Max. 10% less than 250 microns
pH of 10% solution at 25^oC	10-11
Volatiles	Approx. 7.5%
Solubility in water (20^oC)	Fully soluble

APPLICATION & STORAGE

Solution preparation time	1-2 hours
Recommended solution concentration :	
Stock solution	5%
Feed solution	0.5-1%
Recommended storage period:	
Solid	Up to two years
Solutions	24 hours

Storage of the dry product for longer than the above period may be possible under certain conditions but some loss in product efficiency may occur. The solid should be stored in cool dry conditions.

CORROSIVE PROPERTIES

Corrosion towards most standard materials of construction is low. Stainless steel, polyethylene, polypropylene and rubberized surfaces are recommended.

PACKAGING

Flocculent Agent #26AS is supplied in 0.5kg polypropylene bottle.

SPILLAGES

Spillages of Flocculent Agent #26AS should be contained and disposed of accordingly to the local regulations.

HEALTH AND SAFETY

Flocculent Agent #26AS exhibits a very low order of oral toxicity and does not present any abnormal

problems in its handling and general use.

Detailed information on handling and any precautions to be observed in the use of the product(s) described in this leaflet can be found in our relevant Chemical Safety Data Sheet.

CHEMICAL DATA SHEET: COAGULANT AGENT # 27

STRUCTURE FORMULA

$[Al_2(OH)_nCl_{6-N}.XH_2O]m$

PRODUCT PROPERTY

Coagulant Agent#27 is a highly polymeric compound. It is somewhere between the $AlCl_3$ and $Al(OH)_3$ compounds. Its formation is based on the [OH] to be bonded together. It carries different number of [OH] group.

It is a yellowish powder. Its solution is colorless or slightly yellowish. Due to its highly ionized, it shows a good attractive property to the ionic ions. It is easy to dissolve into water. But when dissolving into water, a process of ionization, coagulation and precipitation will then be followed.

PRODUCT STANDARD

The standard follows the GB 337-64
Al_20_3% >=30
Fe_20_3% <=3
Base% <=70-75
Insoluble matter% <=0.5

USAGE

Its main use is in water treatment, such as removing the Iron ion, fluoride ion.

STORAGE

It should be stored without direct sunlight
Well ventilate warehouse
Avoid to be moist

PACKING

Powder Form ~ 10kg/bag or 25kg/bag

PRECAUTION

It is slightly corrosive. It should be handled with care. It is advisable to wear rubber gloves and wear eye-goggles during operation. If skin contacted, wash with plenty water. If eye contacted, wash with plenty water and seek medical advise.

EXHIBIT 4:

- **Partial list of projects where WetSep has been used.**
- **Case Study of WetSep's successful use on the Pinglin Tunnel Project in Taiwan**

Partial list of WetSep Projects

	Projects	Contractor	Application	Year of installation
1	Grands Goulets Tunnel, one drive from downhill (1.6 km) using drill/blast method and 100 m from the uphill entrance with a hydraulic breaker, France	Bouygues Construction	Tunnel Construction	2005
2	New Mercedes Benz Showroom, Singapore	Gammon Construction	Building and Foundation	2005
3	Tsing Yi Viaduct, 1.1 km 3-lane carriageway predominantly of pre-cast box girder segmental viaduct connecting the Stonecutters Bridge and the Nam Wan Tunnel in the south-eastern part of Tsing Yi Island, HKSAR, China	Bouygues Construction JV	Bridge Construction	2005
4	Wynn Resort, consisting of a 600-room hotel, a casino, seven restaurants, retail space, a spa, a salon and entertainment facilities, Macau, China	Leightion - China State JV	Building & Foundation	2004
5	Expansion project of Grand Lisboa Hotel, 44-floor mega-hotel comprising 800 hotel rooms and 30,000 square meters in casino space, Macau, China	Hip Hing Construction	Building & Foundation	2004
6	Highway Tunnel in Tsing Yi Island, HKSAR, China	Gammon Skanska	Tunnel Construction	2004
7	CEPT packaged plant at remote site, Tai O, HKSAR, China	HKSAR	Sewage Treatment Plant at Remote Area	2004
8	Route 8 Eagle's Nest Road Tunnel, twin 2.1 km, three-lane, HKSAR, China	Kumagai Gumi and Leighton JV	Tunnel and Building Construction	2004
9	Deep Bay Link, a 4-km dual three-lane linking Hong Kong and Shenzhen, HKSAR, China	Gammon Skanska	Bridge Construction	2003
10	HKSAR's Lok Ma Chau 3.6-km long railway tunnel for Kowloon Canton Railway Corporation (KCRC) East Rail Extension , HKSAR, China	Bouygues Construction	Railway Tunnel Construction	2003
11	Contaminated Soil Remediation at Retired Bus Depot, HKSAR, China	Sanfield (Management) Ltd	Contaminated Soil Remediation	2003
12	KCRC East Rail Extension West Section Alignment & Association Works, HKSAR, China	Maeda Corporation	Railway Construction	2002

13	Tai Lam Tunnel, 5.5 km long by drill and blast for KCRC West Rail Phase 1 , HKSAR, China	Nishimatsu Construction	Railway Tunnel Construction	2002
14	Cleaning of Sheung Chuen reservoir, HKSAR, China	HKSAR	Water treatment	2002
15	Pinglin Tunnel, 12.9 m by TBM, rank in the 4th largest in the world, Taiwan	Kumagai Gumi Co. Limited	Tunnel Construction	2001
16	Package plant for Laundry at Tai Lam Center for Woman, HKSAR, China	HKSAR	Laundry Wastewater Treatment	2001

Case Study: Tunnel Construction: Fourth longest tunnel in the world, Pinglin Tunnel Project, Taiwan

Challenge:

Enormous flow of underground water and large volumes of effluent were generated during excavation and grouting inside the world's fourth longest car tunnel, located in Taiwan. A small footprint treatment system had to be installed inside the tunnel at an underground depth of 250 meters with access only from the air shaft. Treated effluent would be discharged into the potable water control zone.

Solution and Results:
Four units of WetSep80 were installed for treatment of 320 m^3/hr of wastewater.

Treatment criteria	
Influent capacity	200 - 300 m^3/hr
Suspended solids	7,000 - 10,000 ppm
pH value	11-13
Allowable footprint	30m x 15m
Location	250 m underground
WetSep performance	
Treatment capacity	320 m^3/hr
System footprint	22m x 10 m
pH value	6 – 9
Suspended solids	< 30 ppm