PROTEUS

WWF Treatment

미처리 하수 Zero

BKT
Innovation
Beyond Waste

기술 소개

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하수처리장의 숨겨진 부지를
찾아주는 부지집약 솔루션

적용처 :

CSOs 처리,

일차처리,

초기우수처리,

고속유기물제거(Carbon Diversion)

: **상향류식 고속여과공정**으로 부유 여재를 투입한 여과지를 높은 선속도로 통과시켜 유입 수 내 고형물 및 유기물 제거

*프로테우스 : 변신이 자유로운 그리스 신화 속 신.
기술적으로 다양한 적용이 가능하고, 절감된 부지를 다양한 용도로 활용한다는 특징을 고려하여 기술명을 프로테우스라고 명명

주요 적용처

간이공공하수처리시설

강우 시 초과유량에 대한 적정 처리 후 수계로 방류

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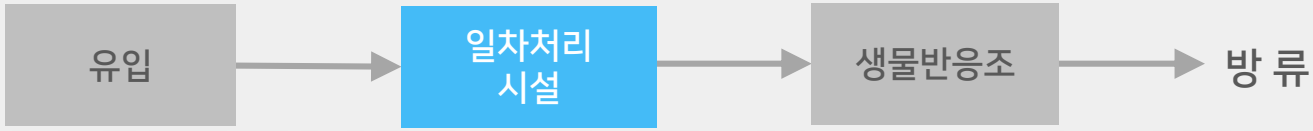
일차처리

생물반응조 유입전 고형물 제거, 부하변동에 의한 영향 최소화 에너지원 회수



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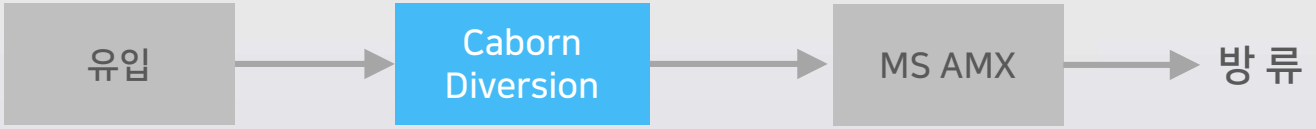
Carbon Diversion

후속 공정 최소화 및 에너지 절감



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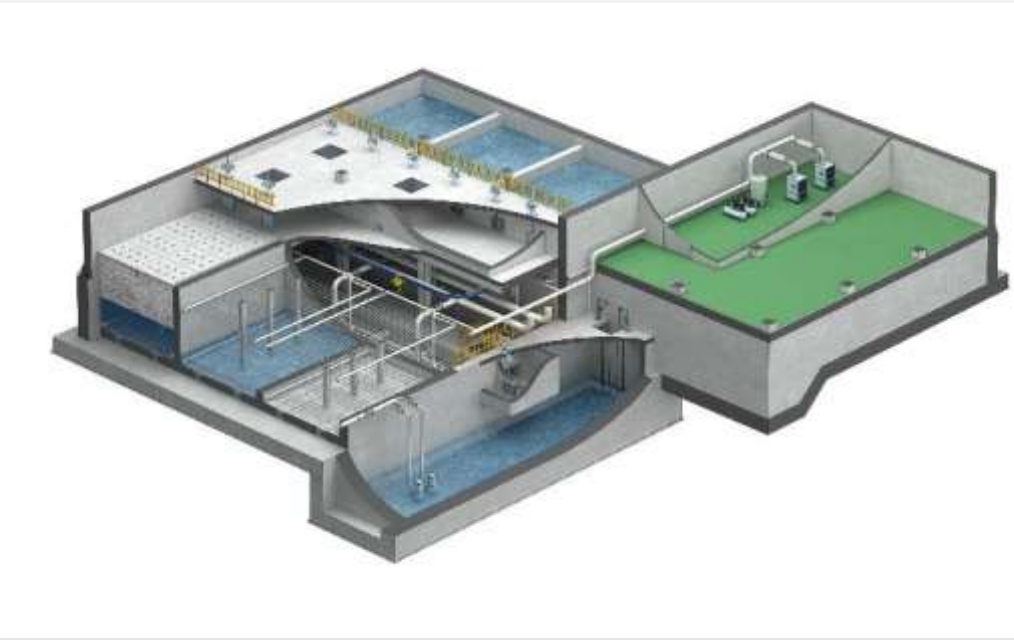
구조

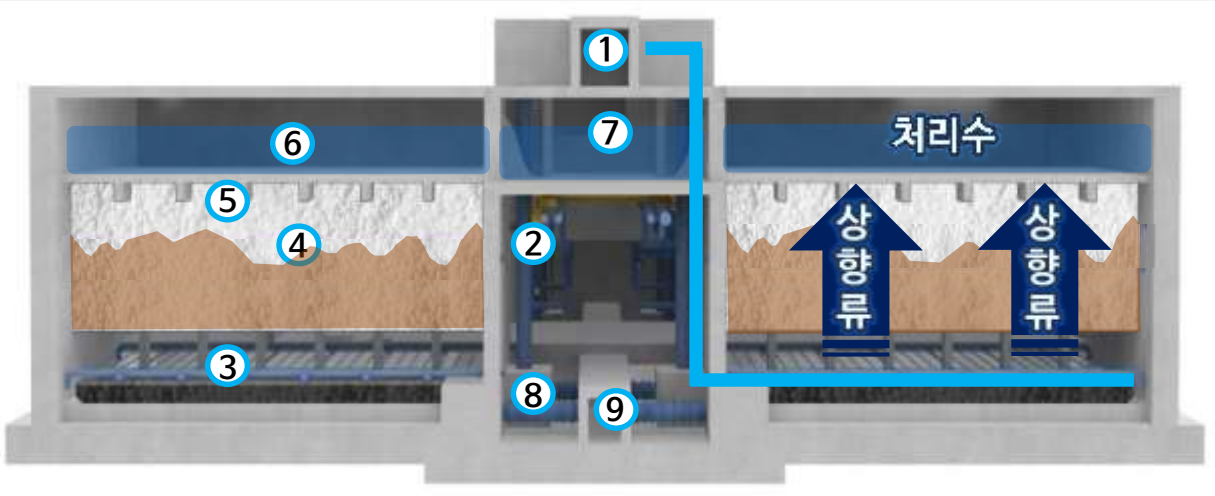
- 십자형 부상식 여재 부유여재 충진, 상향류식 고속여과공정
- 별도 역세척수 공급 불필요, 중력에 의한 무동력 역세척 수행으로 부대설비 최소화, 동력비 절감
- 여과지 상부 처리수 위치하여 악취발생 최소화
- 부지 여건에 따라 다양한 형태로 설치 가능(토목구조물, Steel 구조물 등 맞춤형 설계)
- 지별단독 제어, 모듈화로 용량 증설 및 부지활용도 증대

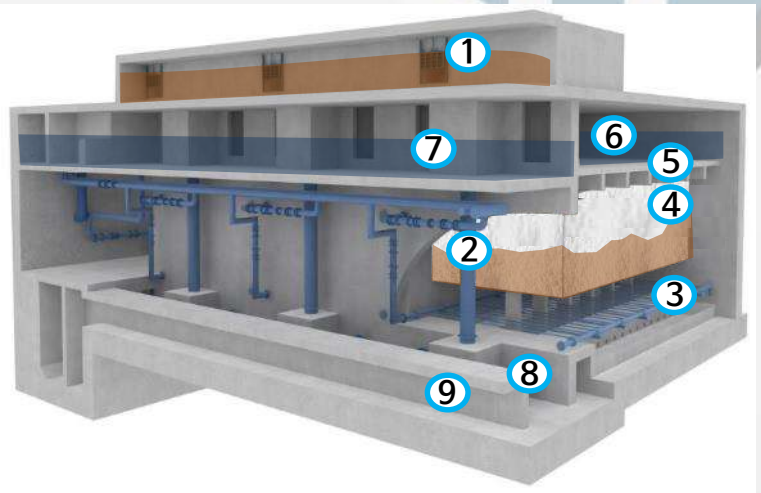


[R/C 구조물]

[Vessel Type]

구조





1. 공동유입수로
2. 유입배관 및 밸브
3. 역세용 산기관
4. 부상식 여재
5. 스트레이너 블럭
6. 처리수조
7. 공동처리수로
8. 역세척슬러지 배출밸브
9. 역세슬러지 배출수로

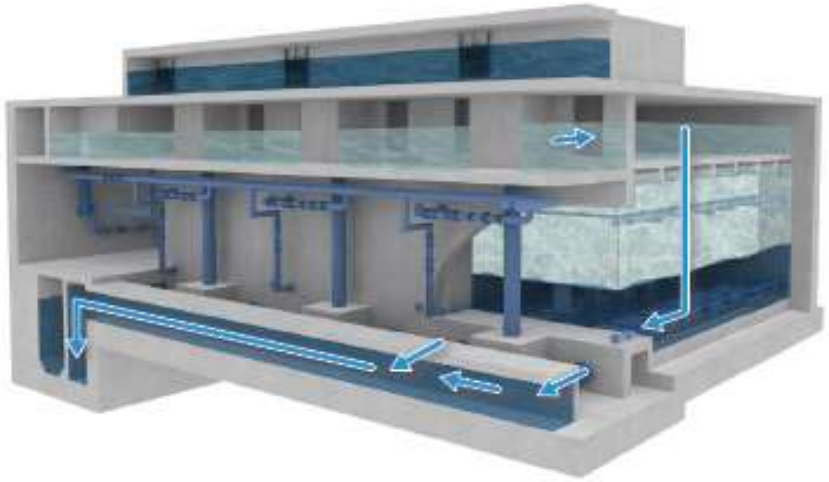
- 부상식 여재 : 물리적 여과에 의한 고형물 제거, 생물학적 처리에 의한 유기물 제거
- 스트레이너 블록 : 부상 여재 지지 및 유실 방지
- 역세용 산기관 : 손실 수두 회복을 위한 역세척 시 산기에 의해 역세척 효과 강화(비상시 사용)
- 역세슬러지 배출 밸브 : 부상 여재층 역세척시 역세슬러지 배출 제어

구조

여과 단계 (Filtration state)

- 유입수를 여과지 하부에서 상부로 유입시켜 여과 진행
- 부상 여재층 하부에 유입 하폐수내 부유물질이 여과되어 축적
- 고형물이 여재층내에 폐색되면서 여과지 내부 압력(수두손실) 증가

역세척 단계 (Backwashing state)



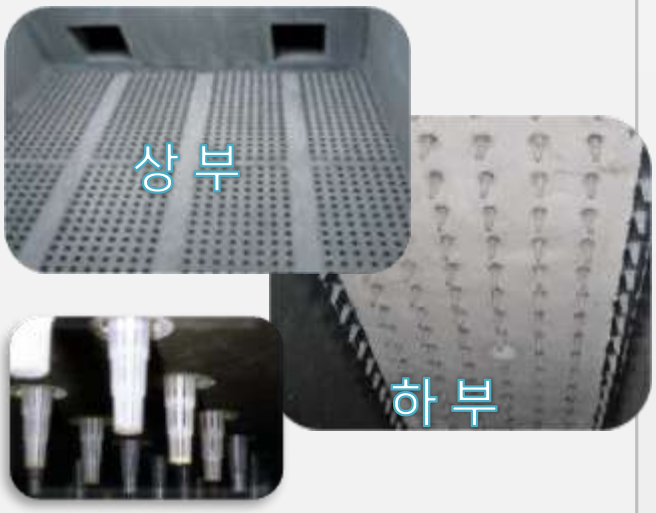
- 하부 배출시행으로 여과지내 수류가 중력에 의해 하향으로 이동하면서 여재층을 팽창시킴
- 처리수가 팽창된 부상 여재층을 통과하면서 부상 여재층 내 축적된 고형물과 함께 외부 배출
- 밀폐공간에서 이동됨에 따라 악취발생 최소화

구조

부상 여재

- 십자형 EPP(Expanded Poly-Propylene)
- 반영구적 재질(교체 불필요)
- 역세 손실분 보충 필요(1% 미만)
- NSF ANSI 61 취득으로 안전성 검증
- 목표수질에 따라 크기 조정

스트레이너 블럭



- 스트레이너 블록 : 철근 콘크리트
- 노즐 : PE(Poly-Ethylene)
- 스트레이너 블록 설치 후 노즐 체결

산기관(option)

- Stainless Steel Pipe
- 본관 : 150~200 ㎜
- 지관 : 32 ㎜
- 레이저 천공에 의해 제작

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간이공공하수처리?

강우시 하수처리장의 용량을 초과하여 유입되는 하수를 신속히 일정 수준까지 처리하여 방류하는 시설

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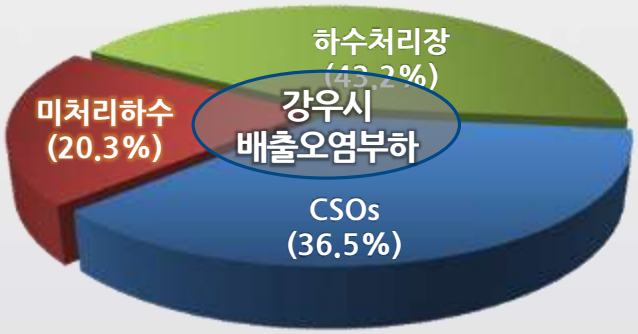
필요성

- 합류식 하수도 월류수(CSOs) 및 초기우수(Wet Weather Flow) 에 의한 방류수계 오염 증가
  → 초기우수로 인한 처리장 유입 농도 2~3배, 대장균군수 2~6 배 상승
- 강우시 발생된 총 배출오염부하량 중 CSOs(20.3%)와 미처리하수(36.5%) 가 대부분 차지
  → 강우시 하수처리장 용량초과 유량에 대한 처리 필요

적용 고려사항

- 불특정 강우시 하수처리장 시설용량 초과분에 대한 **신속한 처리 가능한가**
- 신속한 처리에도 **수질기준의 준수가 가능한가**
- **비강우시에도 시설의 효과적인 활용이 가능한가**



강우시 배출오염 부하율

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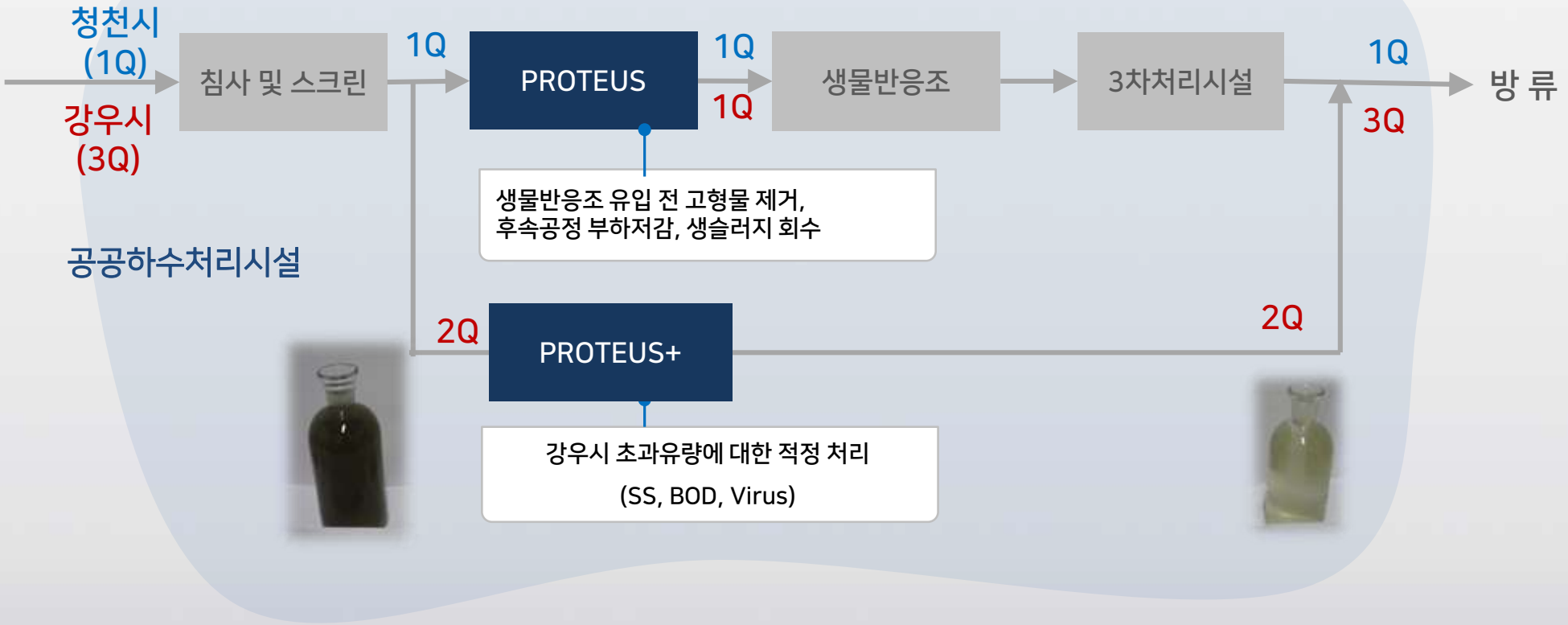
초기우수처리시설 분야
환경신기술
(환경신기술 지정 401호)

강우시 미처리 하수 제로화

강우시 용량 초과분의 하수의 신속한 처리 → **미처리 하수 제로화 달성**

- 유입유량, SS 및 유기물 부하 급격한 변동에 유량 변동에 신속하고 안정적인 처리
- 지역별 유입 특성, 목표수질에 따라 적정 공정 적용



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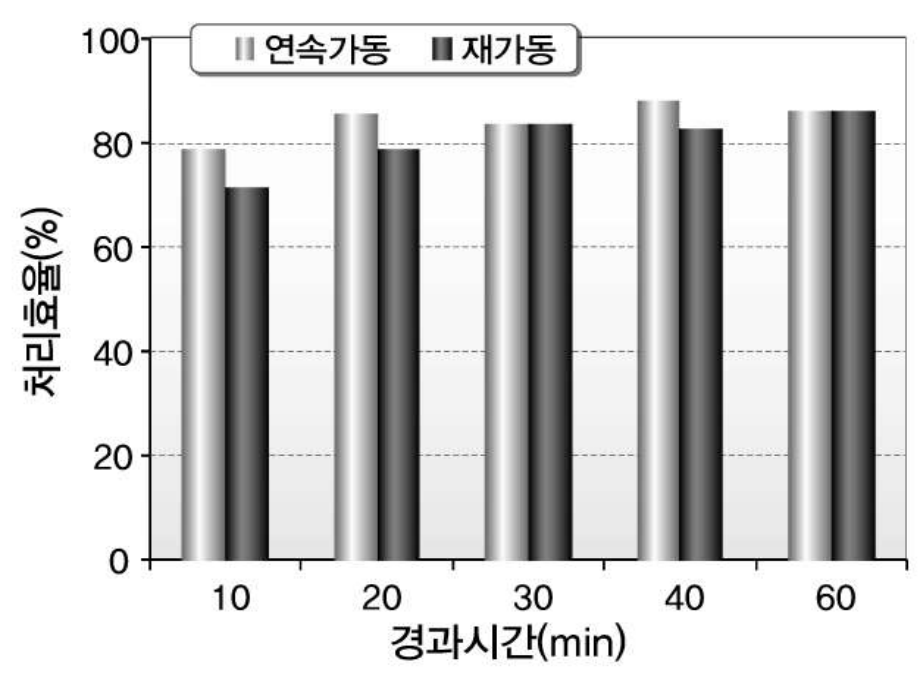
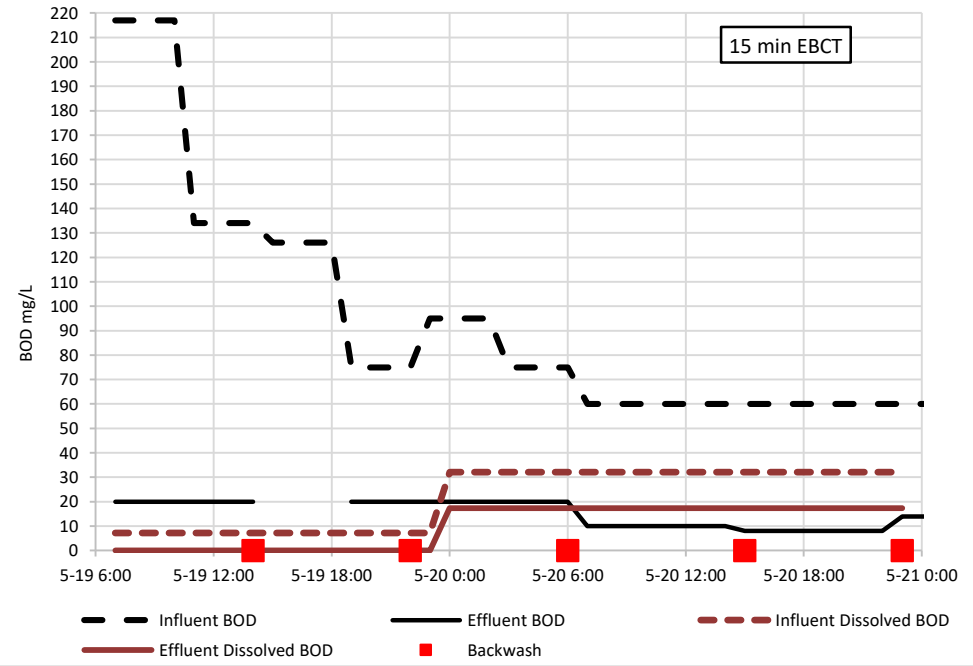
강우시 신속한 대응

- 장기간 휴지 후 재가동 시에도 신속한 여과 효율 확보
- 미생물 활성 최대 2주 이상 유지 가능(활성 유지위한 최소량 유입 조건)





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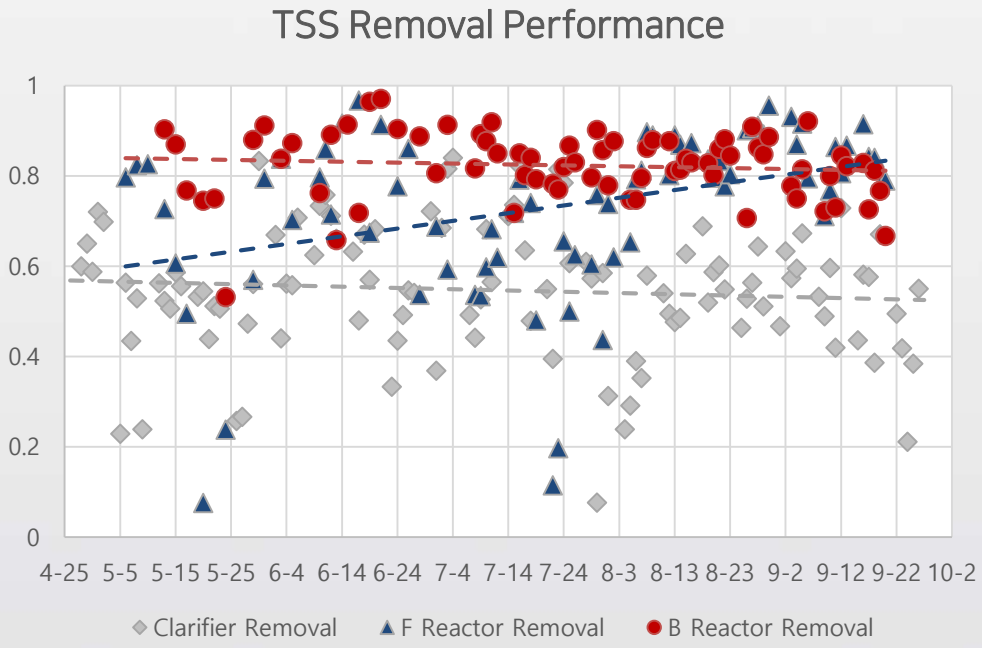
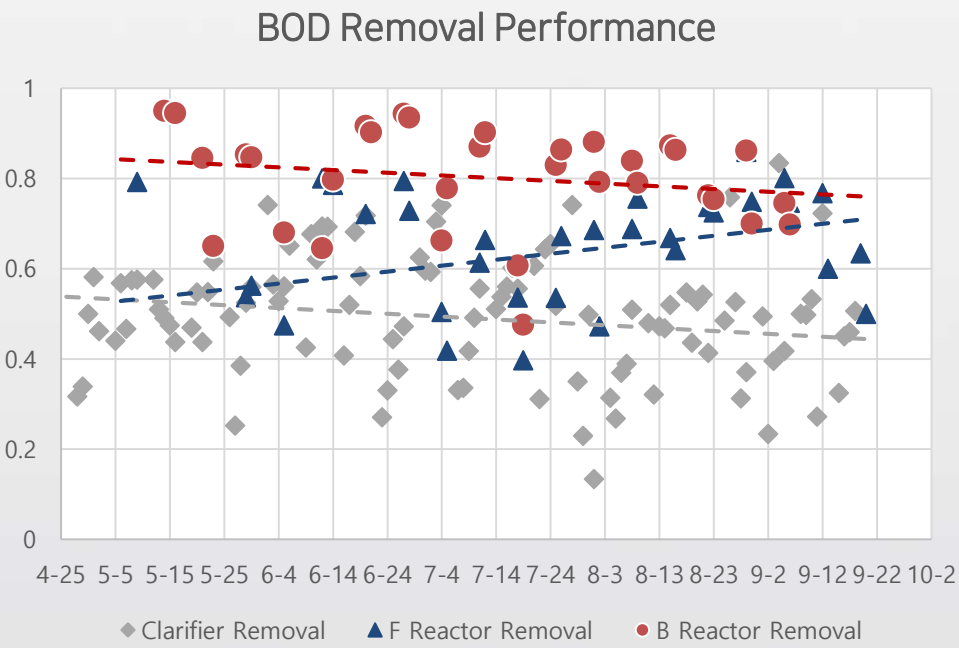
높은 처리효율

- 중력식 침전지 대비 처리효율

구 분	PROTEUS	PROTEUS +
TSS 제거효율	20% 이상 ↑	30% 이상 ↑
TBOD 제거효율	20% 이상 ↑	50% 이상 ↑ (SBOD 제거효과)





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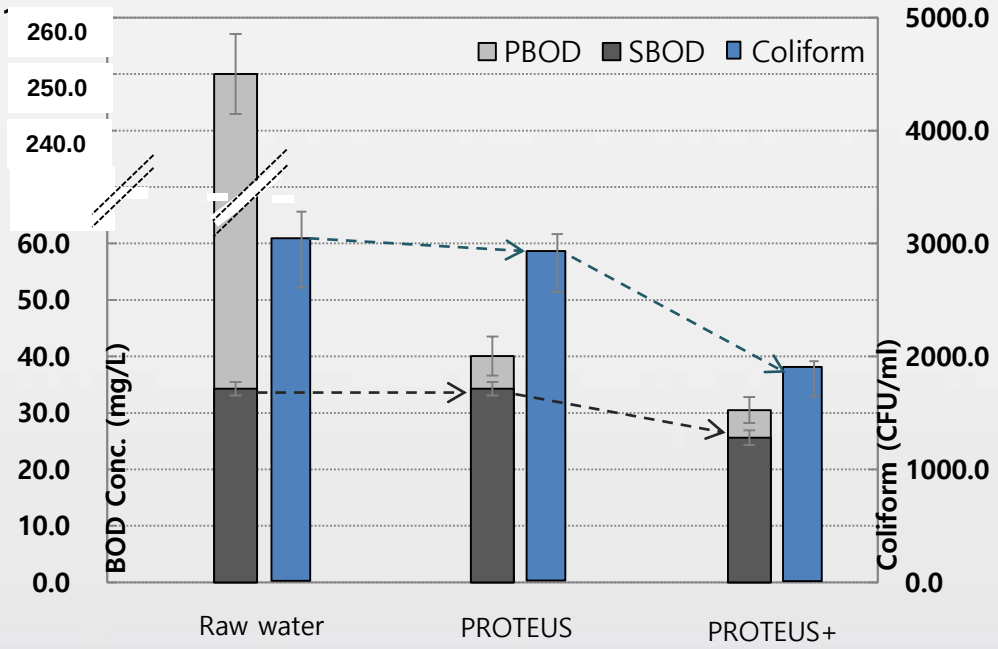
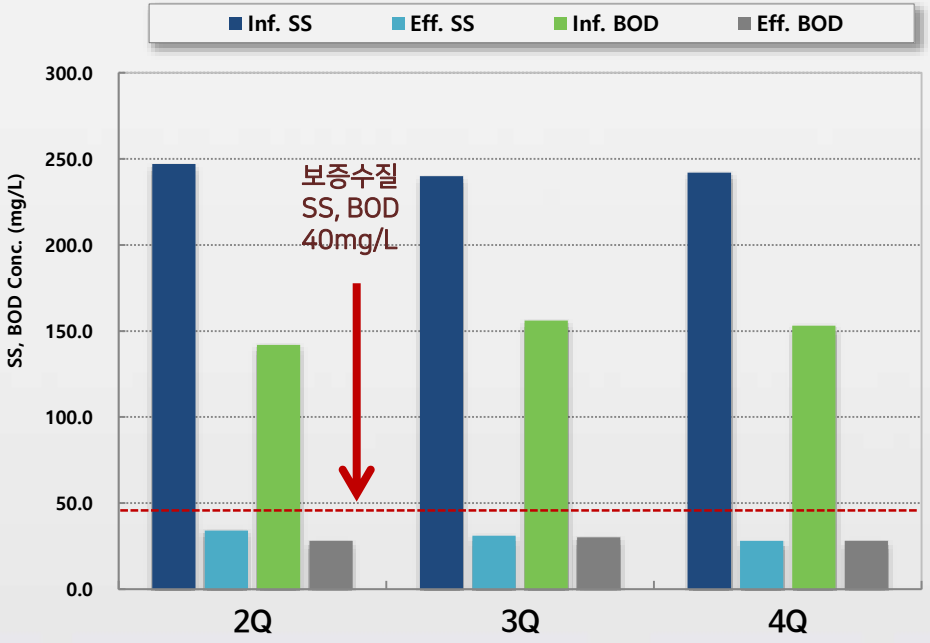
강력한 부하변동 대응성

- 용존성 유기물 및 대장균 제거



- 부하 변동시 역세주기 조절로 수질 확보 가능



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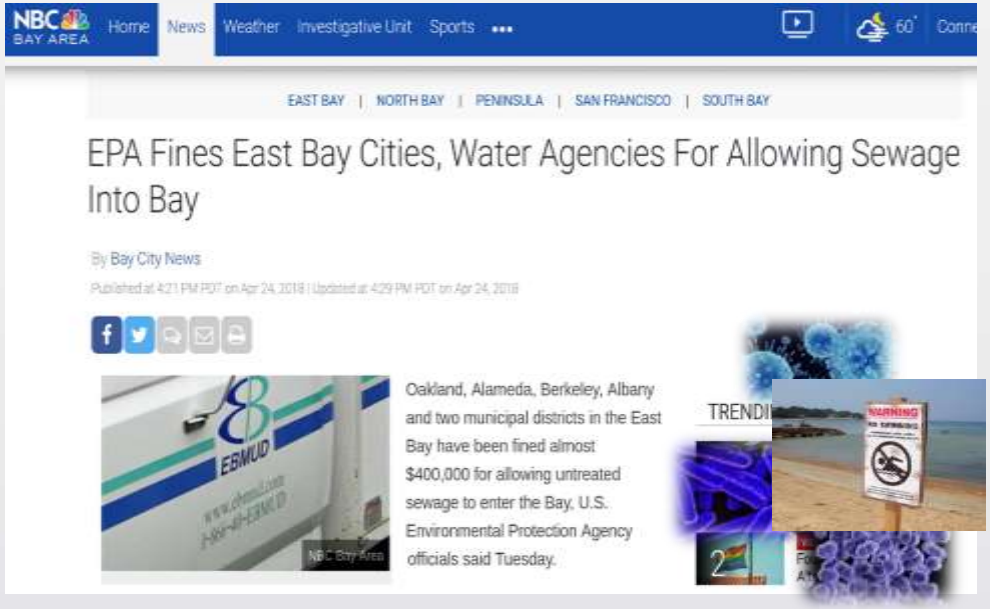
강력한 수질 확보 – Virus 제거

- 최근 강우시 미량유해오염물질, 바이러스 유입 등으로 규제 강화 추세

  → 강우 시 초기우수로 인한 공공하수처리시설 유입수 대장균군수 2~6 배 상승
- 초기우수 내 박테리아 및 박테리아 제거를 위한 소독효과 증대(소독시설 최소화)
- 생물처리공정에서 60% 이상 사멸, 후단 소독 공정에서 대부분 사멸



E. Coliorm (대장균)
60~70% 제거

Fecal Coliform
(분변대장균)
70~80% 제거

염소사용량
70~80% 감소

- 보스턴, 샌프란시스코 등 근해 어장, 굴 양식에 영향으로 강우시 Virus 포함하여 규제
- 강우시 Viruses 대한 규제 내륙지방으로 확대 검토 중

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현장여건에 따른 다양한 적용

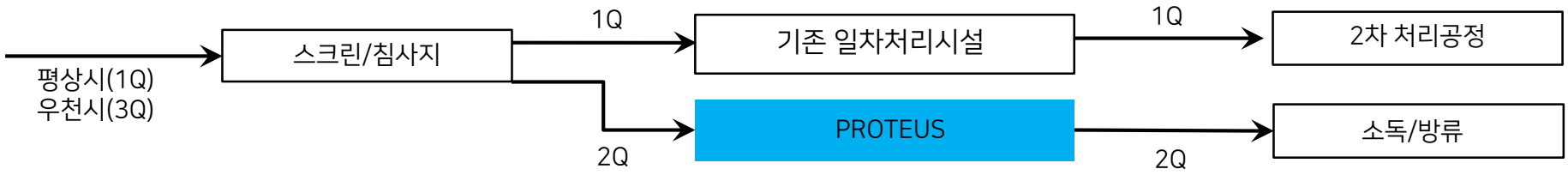
- 일차처리시설이 없는 경우(사례 : 서남물재생센터)

저류 및 간이공공처리를 위한 다목적 처리시설 구성

- 강우시 약품주입 및 고속여과로 수질기준 준수
- 평상시 무약주 일차처리시설로 활용 : 기존 생물반응조의 부하 저감, 유입유량 조정,
  수질 제어로 부하변동 대응성 향상 및 처리장 성능개선

- 일차처리시설이 있는 경우(사례 : 중랑물재생센터)

별도 간이공공처리시설 설치



- 강우시 별도 간이처리시설 운영으로 일차침전지 유입량 유지, 처리장 운영 안정성 확보 및 수질기준 안정적 준수
- 평상시 유량 및 부하변동 대처용 시설로 운영(재가동시 효율변동 최소)

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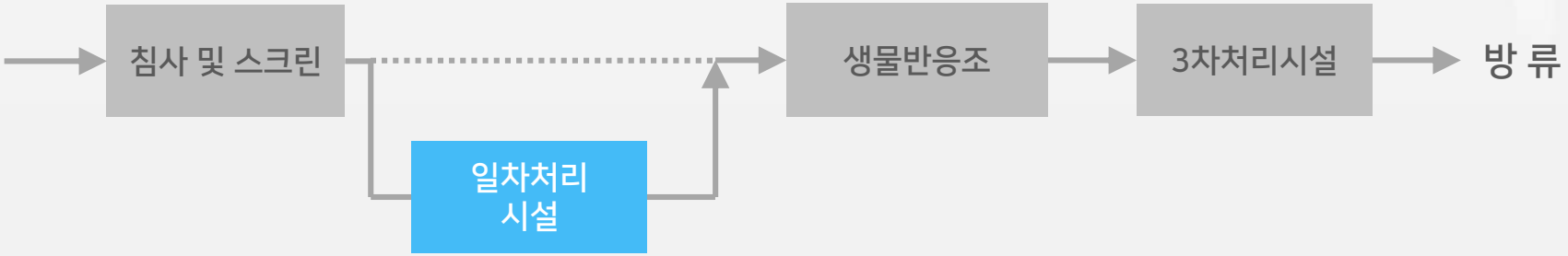
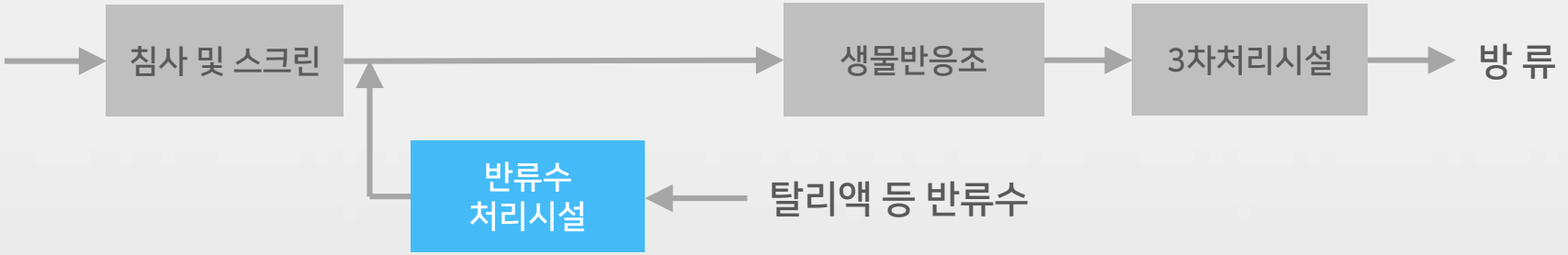
비 강우 시 다양한 활용 가능

- 일차처리시설 또는 부하저감시설



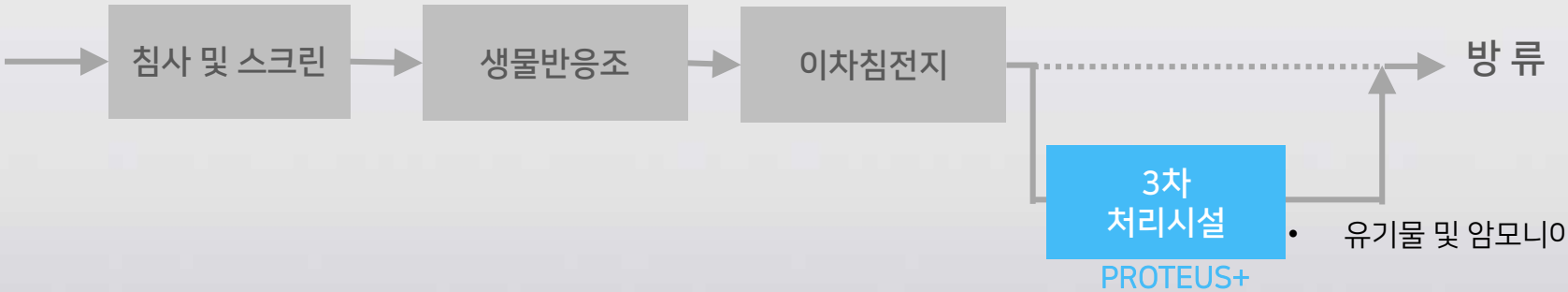
PROTEUS • 비상시 부하저감 기존 공정 운영비 저감

- 반류수처리 시설



PROTEUS+ • 반류수 내 질소저감, 기존 공정 안정성 확보

- 3차처리시설



• 유기물 및 암모니아성 질소 제거

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대표 사례

중랑물재생센터(PROTEUS, w/chemical)

- 시설용량 : 500,000 m^3/일

구 분		BOD(mg/L)	SS(mg/L)
파일럿	유입수질	152~171	80~120
	처리수질	17~36	5~12
신뢰성운전	유입수질		40~170
	처리수질	15	36
	목표수질	40	40

서남물재생센터 (PROTEUS, w/chemical)

- 시설용량 : 720,000 m^3/일

구 분		BOD(mg/L)	SS(mg/L)
설계	유입수질	150	250
	처리수질	40이하	40이하
신뢰성운전	유입수질	84	190
	처리수질	8.5	11.8

대표 사례

화도하수처리장(PROTEUS, w/o chemical)

- 시설용량 : 63,000 m^3/일
- PROTEUS

구 분		BOD(mg/L)	SS(mg/L)
신뢰성 운전	유입수질	141.9~242	62~458
	처리수질	3.9~45.9	13~48
운영	유입수질	69.0~172.8	70~224
	처리수질	17.4~51.4	11.7~52.6
	목표수질	60	60

탄천물재생센터 (PROTEUS+, w/ chemical)

- 시설용량 : 100 m^3/일
- PROTEUS

	TBOD(mg/L)	SBOD(mg/L)	SS(mg/L)
유입수질	89.0 ~ 231.8 (149.2)	38.7 ~ 86.4 (60.8)	63.0 ~ 420.0 (155.8)
처리수질	26.1 ~ 45.0 (37.3)	4.4 ~ 18.3 (11.5)	7.0 ~ 44.0 (32.9)
목표수질	40이하	-	40이하

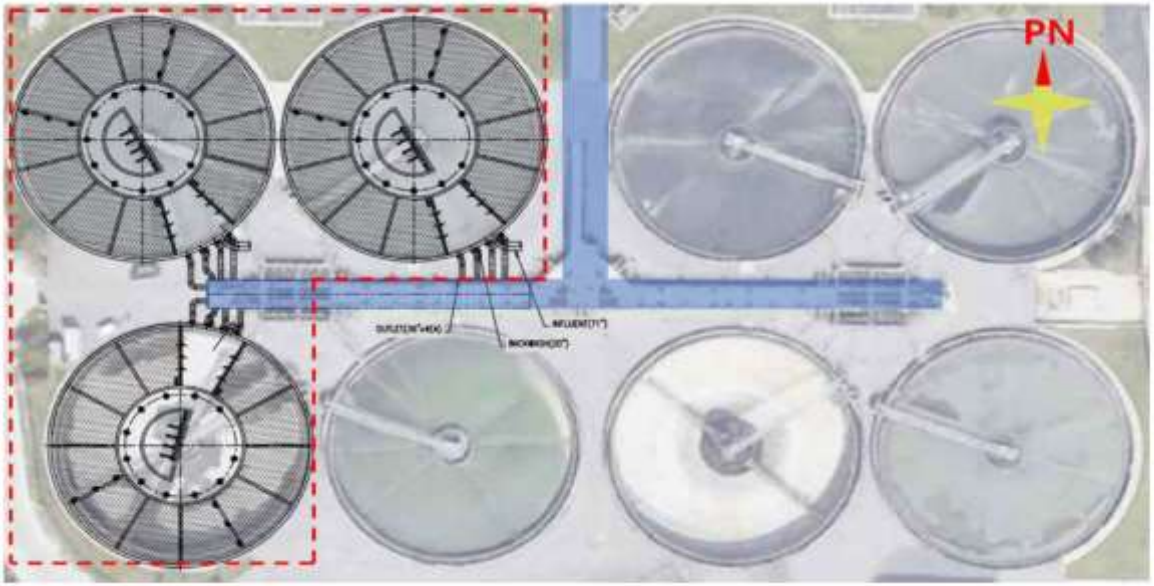
대표 사례

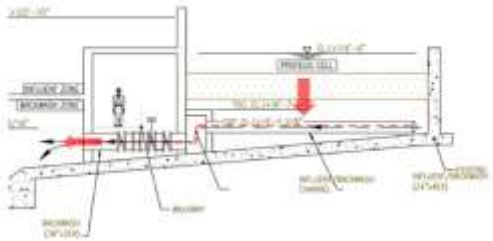
The Anthony Ragnone Treatment Plant (ARTP) in Genesee County, MI (PROTEUS+, w/ chemical))

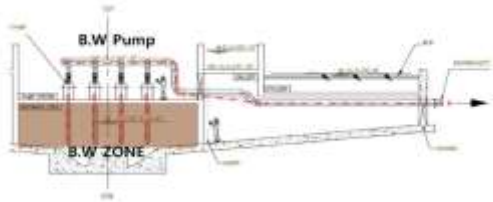
	TBOD(mg/L)	SBOD(mg/L)	SS(mg/L)	E. Coli
유입수질	50~450	30~50	50~550	-
처리수질	10~100	10~15	10~90	-
제거효율	60~95% (평균 81%)	50~80% (평균 74%)	70~95% (평균 84%)	60~70% (평균 66%)

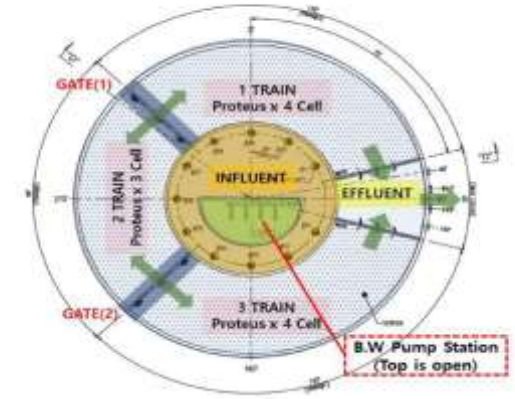
대표 사례 | Jones Island WRF

- 320,000m³/d (Peak 1,300,000m³/d)의 원형침전지를 Proteus로 개조, 일차처리 및 초기우수 대응
- 확보된 부지 활용하여 에너지 생산설비 구축, 유량조정조 설치(Black & Veatch)



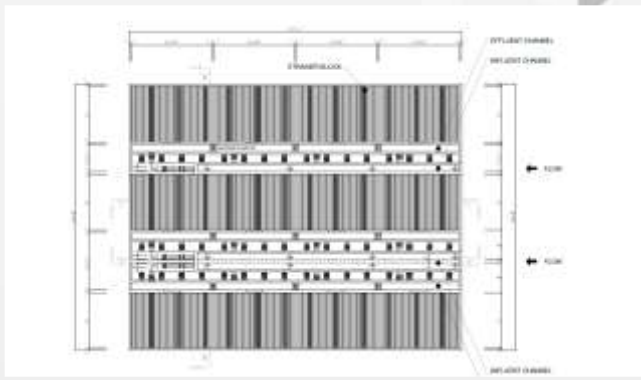


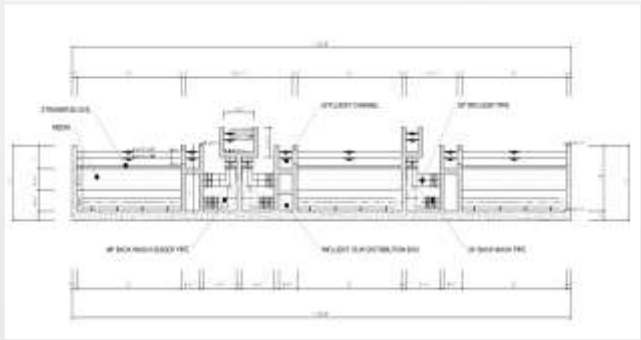




대표 사례 | South Shore WRF

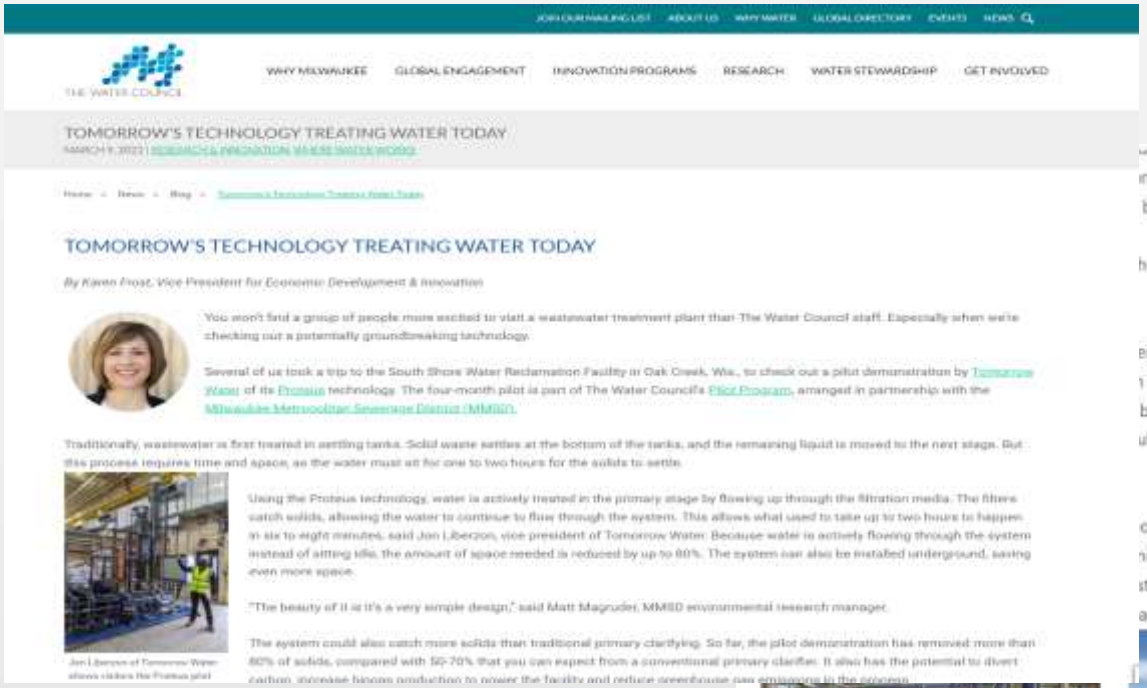
- 400,000m³/d (Peak 1,400,000m³/d)의 장방형침전지를 Proteus로 개조 일차처리 및 초기우수 대응
- 잔여 침전지 개조로 생물반응조 체류시간 확보(Black & Veatch)





대표 사례 | MMSD

- 밀워키 하수처리국 (MMSD; Milwaukee Metropolitan Sanitation District) 파일럿 테스트
- 경제성 평가, 지속 가능성 점수, 장기 운전 안정성이라는 3가지 지표를 기준 우수성 확인
- 평가 결과를 바탕으로 South Shore, John's Island 하수처리장 제안



WHY MILWAUKEE GLOBAL ENGAGEMENT INNOVATION PROGRAMS RESEARCH WATER STEWARDSHIP GET INVOLVED

TOMORROW'S TECHNOLOGY TREATING WATER TODAY

TOMORROW'S TECHNOLOGY TREATING WATER TODAY

By Karen Frost, Vice President for Economic Development & Innovation

You won't find a group of people more excited to visit a wastewater treatment plant than The Water Council staff. Especially when we're checking out a potentially groundbreaking technology.

Several of us took a trip to the South Shore Water Reclamation Facility in Oak Creek, Wis., to check out a pilot demonstration by Tomorrow Water of its Proteus technology. The four-month pilot is part of The Water Council's Pilot Program, arranged in partnership with the Milwaukee Metropolitan Sewerage District (MMSD).

Traditionally, wastewater is first treated in settling tanks. Solid waste settles at the bottom of the tanks, and the remaining liquid is moved to the next stage. But this process requires time and space, as the water must sit for one to two hours for the solids to settle.

Using the Proteus technology, water is actively treated in the primary stage by flowing up through the filtration media. The filters catch solids, allowing the water to continue to flow through the system. This allows what used to take up to two hours to happen in six to eight minutes, said Jon Liberzon, vice president of Tomorrow Water. Because water is actively flowing through the system instead of sitting idle, the amount of space needed is reduced by up to 80%. The system can also be installed underground, saving even more space.

"The beauty of it is it's a very simple design," said Matt Magruder, MMSD environmental research manager.

The system could also catch more solids than traditional primary clarifying. So far, the pilot demonstration has removed more than 80% of solids, compared with 50-70% that you can expect from a conventional primary clarifier. It also has the potential to divert

The visit included representatives of The Water Council, Milwaukee Metropolitan Sewerage District and others.

Because the Proteus technology can be installed underground, a plant in Seoul, South Korea was able to put a park above the treatment facility.

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GLOBAL WATER INTELLIGENCE

CTO

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MARKET MAP

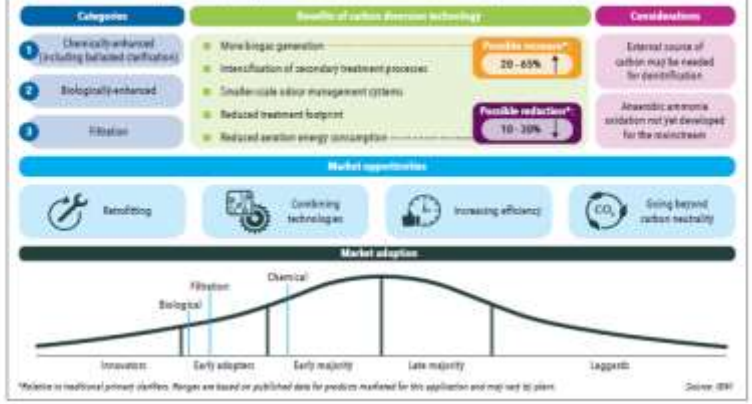
Carbon efficiency diverts interest towards enhanced primary treatment

Sustainably-minded utilities are hunting for ways to optimise the energy balance of their operations. Could enhanced primary treatment be the key to unlocking energy efficiency for wastewater treatment plants?

As more wastewater treatment plants transform from pollution busters into carbon management centres, the drive to reduce aeration energy consumption and increase biogas generation via carbon diversion is becoming more pronounced. Carbon diversion involves reducing the organic load on secondary systems by redirecting more biochemical oxygen demand (BOD) towards the sludge line at the primary treatment stage, which reduces the aeration requirements for aerobic biological processes downstream. The market for installing enhanced primary treatment for this application is rapidly growing, with a wealth of opportunities for chemical, physical and biological methods to prove they can save energy and reduce pressure on secondary treatment processes. Cloth media disc filters and compressible media are leading the way in filtration, while high-rate activated sludge processes, otherwise known as A-stage or adsorption/biooxidation (A/B) processes are also gain- ▶

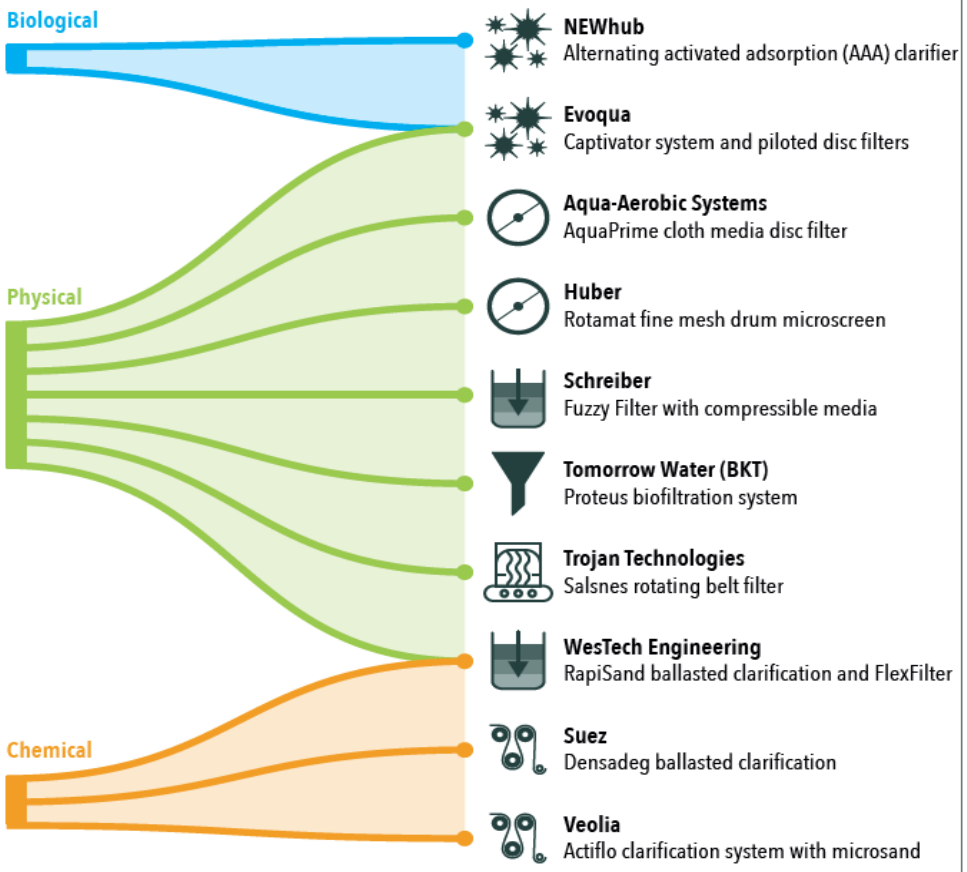
CARBON DIVERSION: AT A GLANCE

The carbon diversion market is expected to see rapid uptake over the coming years, with a host of technology options contributing to efficient utility operations.



PRIMARY TREATMENT PIONEERS

A handful of technology providers have established themselves as innovators in this space, with systems developed to span a range of treatment principles.



Source: GWI

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FEATURE ▶ Filtration

Level Up

Catch up on the newest tools in advanced primary treatment

Onder Caliskaner, John Dyson, Pete Lervoson, Sebastian Jaworski, Jon Libeson, Hailey Rowbotham, and Sina Tassitty

Editor's Note

The article follows on the work from September 2019 Water Environment & Technology article, "The New Frontier of Primary Clarifiers."

Water Environment & Technology editorial guidelines usually discourage listing specific product and company names. In this case, however, we feel the reader gains more by seeing the specific capabilities of each of the technologies and their names and nomenclatures.

Several advanced primary treatment (APT) technologies have recently emerged to provide a higher degree of primary treatment, reduced footprint, and decreased operational and maintenance requirements compared to conventional primary sedimentation (PS). These emerging APT technologies also may offer enhanced carbon diversion — that is, increased removal of carbon before biological treatment and routing of carbon to anaerobic digestion facilities — at water resource recovery facilities (WRRFs) resulting in additional savings in energy and costs. The overall cost savings is achieved from decreased aeration energy requirements in secondary treatment, increased digester biogas production, and reduced sizing of secondary treatment facilities or increased secondary treatment capacity of existing facilities. The APT technologies discussed in this article can be grouped into the general categories of primary effluent filtration (PEF), tri-media filtration (PF), rotating belt filter (RBF), and microscreens.

Different treatment filtration systems have been developed during the past 20 years that can be used to enhance the performance of or replace conventional primary treatment facilities. To enhance primary treatment performance, PS tank effluent can be filtered or further reduce the constituent concentrations sent to secondary treatment facilities. This form of primary enhancement is known as PEF. When a filter technology is used to replace primary sedimentation, the process application is known as PF. This article discusses the three filtration systems that can be used for PEF or PF. The microscreen and RBF systems included in this article are used to replace the PS system.

This article provides an overview of five APT technologies. Additional sweeping and promising APT technologies exist. Even though the removal performances of different APT systems can be similar, significant hydraulic and operational differences exist between these technologies when they are used for primary treatment. The advantages and challenges of different APT systems can vary considerably compared to conventional PS. Detailed evaluation of the treatment requirements, hydraulics, cost comparisons, and operational performances of different APT systems is essential when considering their application for different types of City/Rota.

▶ ▶ ▶ ▶ ▶ ▶ Filtration

Proteus and Proteus Plus Filter

Proteus from Tomorrow Water (BKT, Anaheim, California), is an advanced primary treatment technology based on the classic biological aerated filter (BAF) platform. Proteus captures solids using a packed bed, while the upgraded Proteus Plus configuration adds a layer of aerated biofilm for biological treatment. Using an innovative, cross-shaped media designed for high solids loads, Proteus allows this well-established core technology (BAF) to be utilized for primary and wet weather treatment for the first time.

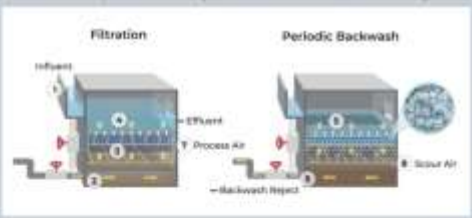
Operational Cycles

The system feeds influent by gravity from a header box into the bottom of each filtration cell, where it flows upward through a packed bed of floating synthetic media, which is retained by a strainer block. As influent is processed, solids are captured in the bed, causing differential pressure to rise until the system initiates an automatic backwash. At this point, effluent stored above the media bed flows down by gravity, unpacking the bed and carrying away excess solids in the reject line. Proteus Plus biological filters add process air to the center of the media bed and enhance backwashing efficiency with an air scour to control biofilm thickness.

Potential Benefits and Challenges

Proteus media's high void fraction allows the filter to process fast flow velocities with low head loss, maintaining high solids capture, long run times, and rapid backwashing. Proteus' high throughput allows significant footprint reduction compared to conventional settling basins, as demonstrated at the Jungnang and Seonam facilities in Seoul, South Korea. The system is proven as a reliable, cost-saving replacement for primary sedimentation, boosting TSS and BOD removal rates and reducing downstream aeration requirements. It also maintains consistent removal performance at peak flow rates.

As an auxiliary installation for peak wet weather flows, Proteus Plus provides a high-rate biological treatment option that does not require chemicals or redirection of biomass. The media's high specific surface area allows for a greater biofilm density and shorter contact times. Proteus' simple design and full automation simplify operation. The system is not designed to handle high levels of grease, however, which may necessitate pretreatment. Additionally, designers should consider that 2 m (6 ft) of available head is required to fit the process into a facility's hydraulic profile.



Tomorrow Water's Proteus advanced primary treatment technology is based on a biological aerated filter platform, which can be used for primary and wet weather treatment. Tomorrow Water

Existing Projects

Proteus primary filters are installed at two full-scale facilities with more than 4.3 years of combined operational experience. The Jungnang and Seonam facilities utilize Proteus as a replacement for primary clarifiers, processing daily flows up to 250,000 m^3/d and 350,000 m^3/d (66 and 93 mgd) respectively, according to 2021 proceedings of the Water Environment Federation (WEF, Alexandria, Virginia), titled "Development of world's largest dual-use high-rate Primary and Wet Weather Flow Filtration Process using Floating Media" and the 2012 proceedings titled "Primary Treatment of Domestic Wastewater and Wet Weather Flow Using High Rate Up-flow Filtration System with Floating Media in Mega City Seoul." These facilities also have additional Proteus wet weather filter capacity, for a total installed capacity of 1.2 million m^3/d (322 mgd). Both Proteus and Proteus Plus were recently piloted in Michigan, with reports published at WEFTEC and several regional conferences, according to WEF proceedings titled "Novel Integrated High-Rate Filtration & Fixed-Film Biological Reactor Demonstrates Simultaneous TSS & BOD Removal in Wet Weather Peak Flows." A new 300,000-m^3/d (79-mgd) Proteus primary filter is currently in design in Korea, and multiple U.S. pilots are scheduled for the coming months.

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