Total Water & Wastewater Management for Shale Gas Production

Treatment and Operation Solutions
Impact of Water and Wastewater from Shale Gas Fracturing Operations

As the number of shale gas fracturing operations increase, the demands on fresh water supplies are being strained. Disposal options for the higher TDS wastewater generated from both fracturing wells and producing wells are also becoming limited and less economical. These constraints have a negative effect on production activities as drilling projects are delayed or reduced.

Effective, cost-efficient methods to treat and supply the millions of gallons of water used for shale gas production are required to address the issues that impact development. The long-term sustainability of shale gas operations in a given region depends on several factors:

- Working closely with the local, state, and federal regulatory environment
- Coping with the stress placed on the local fresh water supplies
- Effective and economical wastewater management plans

Water Management Solutions & Technologies

Increasing disposal costs due to greater logistical requirements and a shortfall of available treatment capacity are issues that will require a comprehensive water treatment strategy. These challenges for future growth in the industry include:

- Limited alternatives to treat high TDS flowback and produced water
- Removal of free oil and grease
- Reducing overall waste volume
- Limited water re-use
- Management of the entire water cycle

Complete Produced Water Systems

Focus on High Water Recovery & Reuse

Veolia Water Solutions & Technologies (VWS) is a recognized, global provider of water and wastewater treatment systems design and operation.

Each system designed and installed for oil and gas production sites focuses on the issues facing the industry such as environmental compliance, waste reduction targets, and maximum recovery and reuse of water in the process.

VWS has supplied more than 300 installations with process technology, design-build water and wastewater plants, or facility operation expertise worldwide in the oil and gas industry.
Innovative Water & Wastewater Technologies

VWS has a wide variety of cost-effective, flexible, and proven processes and technologies available worldwide for pretreatment and primary treatment of water and wastewater specifically designed for oil and gas applications. These technologies focus on waste reduction, water recycle and reuse, and ZLD (Zero Liquid Discharge).

Each solution is designed for the specific water chemistry and production objectives of the client that optimize energy consumption, minimize operating costs, and simplify operations for central water plants or drill-site treatment facilities.

Primary and Secondary Oil/Grease Removal

**AutoFlot®** Induced Gas Flotation
- Free oil removal (<20mg/l)
- Low retention time (5 mins.)

**Power Clean™ ORF**
- Free oil removal (<2.0 mg/l)
- 95% Removal efficiency

Primary Hardness/TSS Removal

**Multiflo®** Chemical Softening
- High-rate package softening process
- High-quality effluent (TH<20, Turb<10)
- Package plants up to 1200 gpm
- Mobile units available for on-site testing

Biological Treatment for BOD/VOC Removal

**AnoxKaldnes™** Moving Bed Bio-Reactor (MBBR)
- High specific surface area for biofilm growth
- No backwashing required
- Good sludge settling characteristics
- Compact, flexible design for easy retrofit

**OPUS™ Technology**
- High System Recovery (90+% depending on TDS)
- Low CIP costs, infrequent cleaning intervals
- Effective fouling and scaling control
- Adapts to variation in feed water
- High salt rejection

Evaporation & Crystallization Systems

**Thermal treatment of flowback / produced water**
- Greater than 95% water recovery
- Zero Liquid Discharge (ZLD) system
- Little, if any, pretreatment required for high TDS wastewater
- Only waste is solid saltcake
Water Plant Operation and Maintenance

Veolia Water provides operation expertise for oil and gas production water treatment facilities and water recycling plants, often as Design, Build, Operate, and Maintain (DBOM) contracts.

Combining in-house technological solutions with operations, maintenance, and plant management expertise, provides the lowest life-cycle costs, minimizes risk, and achieves long-term performance objectives of the plant.

A full-service approach in both the supply of technology and plant operations allows production companies to focus on their core business.

Solid Waste Handling

A wide range of industrial solid waste handling capabilities is available through Veolia Environmental Services (VES). These include solid waste collection, non-hazardous industrial and special waste disposal (such as waste brines), and waste transportation.

Design-Build Project Execution

Design-build water and wastewater plants require a high level of expertise and focused coordination to execute projects from the early stages of development through commercial startup.

VWS provides single-source responsibility that combines the best available technical and process solutions with focused project management. This approach allows seamless integration with the client’s business objectives, operational targets, and other production activities whether supplying a central plant or a drill-site water and wastewater treatment facility.

A single point of contact also provides:

- Streamlined project execution
- Reduced schedule exposure
- Minimized associated risks and costs
- Performance and process guarantees
- Integrated safety plans
- System startup support

Permitting Assistance

Experience in all major industries, specifically in oil and gas field production, ensures that the proposed treatment facility will be in full compliance with local, state, and federal laws.

Veolia Water offers support in the permitting process to assist client in the development of water and wastewater facilities.
Produced Water Treatment Experience

Design, Build, & Operate Case Study
Steam-Enhanced Oilfield Production
Chevron Corp. - San Ardo California

The Chevron San Ardo project involves treatment of produced water for the purposes of discharge to recharge basins and production of Once Through Steam Generator (OTSG) make-up water. The project goal was to achieve water quality suitable for recharge basins discharge, while achieving 75% water recovery across the treatment system and minimizing the volume of produced water requiring re-injection.

The treatment process includes pretreatment for free oil removal followed by OPUS™ technology (patent pending) to achieve the discharge water quality and a Series Softening System for generation of OTSG make-up water.

The OPUS™ technology consists of multiple treatment steps such as heat exchange, degasification, chemical softening, media filtration, ion exchange softening, and a double-pass RO system to meet the effluent water quality requirements. The solids generated from the system are dewatered and disposed in a landfill.

The San Ardo project involved process design, basic engineering, equipment procurement, and construction management. The advanced water treatment system is operated by Veolia Water North America.

Technology & Process Expertise
Specific Treatment of Shale Gas Effluent

Flowback and produced water, in the case of the Marcellus Shale Gas Play, can be effectively treated utilizing evaporation and crystallization technology for both low and high TDS wastewater.

A proprietary process developed by Veolia Water Solutions & Technologies provides efficient removal of sodium and calcium chlorides as well as the heavy metals commonly found in effluent generated from the produced water. Based on the wastewater composition from this region, the process eliminates the need for often expensive pretreatment of the produced water, reducing capital, and operating costs.

Offered as a Zero Liquid Discharge (ZLD) system, this process recovers greater than 95% water recovery with the only waste as a solid saltcake suitable for landfill disposal.
Veolia Water Solutions & Technologies

Veolia Water Solutions & Technologies (VWS), a subsidiary of Veolia Water, is a leading global water and wastewater technology company and provider of a full range of services including engineering, project management, design-build, start-up, training and maintenance services.

VWS Oil & Gas is the global division of Veolia Water Solutions & Technologies dedicated to serving the oil and gas industry. VWS Oil & Gas supports developments onshore and offshore around the world.

### VWS Oil & Gas Centers

<table>
<thead>
<tr>
<th>Region</th>
<th>Office</th>
<th>Phone</th>
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<tbody>
<tr>
<td>North America</td>
<td>Houston, TX – USA</td>
<td>+1 281 227 0670</td>
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<td>South America</td>
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<td>Europe, Middle East &amp; Africa, Asia-Pacific</td>
<td>Paris – France</td>
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<td></td>
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### VWS Oil & Gas Regional Offices

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