Produced Water

Proceedings of the 1992 International Produced Water Symposium, San Diego, California, February 1992, held to provide a forum where scientists, regulators, industry, academia, and the environmental community could gather to hear and discuss the latest information related to the environmental conside

Produced biennially, The World's Water is the most comprehensive and up-to-to date source of information and analysis on freshwater resources. Each new volume examines critical global trends and offers the best data available on a variety of topics related to water. Volume 7 features chapters on U.S. water policy, transboundary waters, and the effects of fossil fuel production on water resources, among other timely issues. Water briefs provide concise updates on topics including bottled water, The Great Lakes Water Agreement, and water and security. The World's Water is coauthored by MacArthur "genius" Peter H. Gleick and his colleagues at the world-renowned Pacific Institute. Since the first volume was published in 1998, the series has become an indispensable resource for professionals in government agencies and nongovernmental organizations, researchers, students, and anyone concerned with water and its use.

Fundamentals, Water Chemistry, Emulsions, Chemical Treatment

Produced waterâ€"water from underground formations that is brought to the surface during oil and gas productionâ€"is the greatest volume byproduct associated with oil and gas production. It is managed by some combination of underground injection, treatment and subsequent use, treatment and discharge, or evaporation, subject to compliance with state and federal regulations. Management of these waters is challenging not only for industry and regulators, but also for landowners and the public because of differences in the quality and quantity of produced water, varying infrastructure needs, costs, and environmental considerations associated with produced water disposal, storage, and transport. Unconventional oil and gas development involves technologies that combine horizontal drilling with the practice of hydraulic fracturing. Hydraulic fracturing is a controlled, high-pressure injection of fluid and proppant into a well to generate fractures in the rock formation containing the oil or gas. After the hydraulic fracture procedure is completed, the injected fluid is allowed to flow back into the well, leaving the proppant in the newly created fractures. As a result, a portion of the injected water returns to the surface and this water is called "flowback water" which initially may mix with the naturally occurring produced water from the formation. The chemistry and volume of water returning to the surface from unconventional oil and gas operations thus changes during the lifetime of the well due to the amount of fluid used in the initial stage of well development, the amount of water naturally occurring in the geologic formation, the original water and rock chemistry, the type of hydrocarbon being produced, and the way in which production is conducted. The volume and composition of flowback and produced waters vary with geography, time, and site-specific factors. A workshop was conducted by the National Academies of Sciences, Engineering, and Medicine to highlight the challenges and opportunities associated in managing produced water from unconventional hydrocarbon development, and particularly in the area of potential beneficial uses for these waters. This publication summarizes the presentations and discussions from the workshop. Produced water contributes to the largest volume waste stream associated with oil and gas (O&G) exploration and production (E&P) operations. It is usually a complex mixture of inorganics and organics that is formed underground and brought to the surface during O&G production. Traditionally, produced water has been considered as a waste to the O&G industry. The conventional management strategies include disposal (typically by injection into depleted wells or permitted disposal wells), recycle (direct reuse within the E&P operation), and reuse (treatment and reuse offsite for food crop irrigation, livestock watering or industrial use). The O&G industry is going through a paradigm shift, where scarcity of water, economics of water management, declining oil costs, and increasing focus on environmental and ecological stewardship are shifting the focus toward integrated water management in E&P operations. Water is no longer a problem to be delegated to a third-party disposal or treatment vendor, but is becoming a cornerstone of O&G production. In this review, we summarize produced water characteristics, regulations and management options, produced water treatment fundamentals, and a detailed discussion of process equipment and advantages/disadvantages of currently available treatment processes. These results in peer-reviewed publications could provide a guide for the selection of appropriate technologies based on the desired application. Major research efforts in the future could focus on the optimization of current technologies and use of combined treatment processes of produced water in order to comply with reuse and discharge limits, under more stringent environmental regulations.

This book outlines the technologies and techniques used in the oil & gas industry's shift from treating produced water as a "waste stream" to an integrated water management approach. Produced water is formed underground and brought to the surface during oil & gas (O&G) production and exploration and production (E&P) operations. It is usually a

complex mixture of inorganics and organics and contributes to the largest volume waste stream of O&G and E&P operations. Traditionally, produced water has been considered a waste and conventional management strategies include disposal (typically by injection into depleted wells or permitted disposal wells), recycling (direct reuse within the E&P operation) and reuse (treatment and reuse offsite for food crop irrigation, livestock watering or industrial use). The O&G industry is going through a paradigm shift where scarcity of water, economics of water management, declining oil costs, and increasing focus on environmental and ecological stewardship are shifting the focus toward integrated water management in E&P operations. Water is no longer a problem to be delegated to a third-party disposal or treatment vendor, but is becoming a cornerstone of O&G production. This is a summary of produced water characteristics, regulations and management options, produced water treatment fundamentals, and a detailed discussion of process equipment and advantages/disadvantages of currently available treatment processes. It provides a guide for selecting appropriate technologies for the desired application and points toward the optimization of current technologies and the use of combined treatment processes to meet reuse and discharge limits and critically, more stringent environmental regulations.
Produced water handling has been an issue of concern for oil and gas producers as it is one of the major factors that cause abandonment of the producing well. The development of effective produced water management strategies poses a big challenge to the oil and gas industry today. The conversion of produced water into irrigation or fresh water provides a cost effective tool to handle excessive amounts of the produced water. In this research we proposed on-site produced water treatment units configured to achieve maximum processing

throughput. We studied various advanced separation techniques to remove oil and dissolved solids from the produced water. We selected adsorption as the oil removing technique and Reverse Osmosis (RO) as the dissolved solids removing technique as being the best for our purpose. We performed experiments to evaluate operating parameters for both adsorption and RO units to accomplish maximum removal of oil and dissolved solids from the produced water. We compared the best models fitting the experimental data for both the processes, then analyzed and simulated the performance of integrated produced water treatment which involves adsorption columns and RO units. The experimental results show that the adsorption columns remove more than 90% of the oil and RO units remove more than 95% of total dissolved solids from the produced water. The simulation results show that the proper integration and configuration of adsorption and RO units can provide up to 80% efficiency for a processing throughput of 6-8 gallons per minute of produced water. From an oil and gas producer's viewpoint output from the produced water treatment system is a revenue generating source. The system is flexible and can be modified for the applications such as rangeland restoration, reservoir recharge and agricultural use.
The US Environmental Protection Agency (EPA) establishes controls on produced water discharges into US waters through effluent limitations guidelines (ELGs), and general and individual discharge permits. Over the past 20 years, produced water controls have become much stricter, and in some areas, no discharge of produced water is allowed. In setting discharge standards, EPA considers vast amounts of data, makes assumptions regarding which data and what approaches are representative, selects the most appropriate analytical methods, and interprets the analytical results. Despite EPA's considerable efforts to accurately understand

and characterize the economic and environmental impacts of produced water discharges before proposing and adopting ELGs and issuing permits, current US produced water controls may be overly restrictive and not cost-effective. This paper summarizes several studies that have reviewed in detail EPA's data, assumptions, and analytical methods for earlier proposed regulations and general permits. These include the offshore oil and gas ELGs, EPA's Region 6 general permit for coastal waters, and most recently, the proposed ELGs for the coastal oil and gas industry. By substituting different data, using revised assumptions, and reanalyzing data that are equally or more valid, the studies reach alternate conclusions on the cost-effectiveness of current produced water controls.

A system and method were used to treat produced water. Field-testing demonstrated the removal of contaminants from produced water from oil and gas wells.

Environmental interest, regulation changes, and costs have motivated the oil and gas industry to begin recycling produced water in high concentrations during new well stimulation. Accordingly, the potential impact of this practice on production should be investigated. In this thesis paper, tests were conducted to determine whether Marcellus produced water would cause incompatibilities in the Utica and Point Pleasant formations. A multivariate statistical analysis was then completed using a historical dataset of over 300 Marcellus wells to measure the effect of produced water used in stimulation had on well production. The results indicate that recycling produced water in high proportions, even from the Marcellus, should have no measurable impact on the productivity of Utica and Point Pleasant wells. This conclusion supports the use of recycled water not only to comply with regulations and address environmental concerns, but also as a method to reduce water management costs by at least 40 percent.

Large volumes of produced water are generated and discharged to the coastal and ocean waters worldwide from offshore oil and gas production facilities. There is concern that the chemicals in the produced water may harm marine ecosystems. This book summarizes the bioavailability and marine ecotoxicology of metal and organic contaminants that may occur in oil well produced water at concentrations significantly higher than those in ambient seawater. The contaminants of concern include arsenic, barium, cadmium, chromium, copper, lead, mercury, radium isotopes, zinc, monocyclic aromatic hydrocarbons, polycyclic aromatic hydrocarbons, phenols, and bis(2-ethylhexyl)phthalate. The first part of the book is a detailed discussion of the chemical composition of produced water from offshore oil wells worldwide and its fates following discharge to the ocean. The remaining chapters of the book summarize the current scientific literature on the sources and distributions in the ocean of each of the contaminants of concern and their bioaccumulation and toxicity to marine organisms. This book will be of value to: environmental scientists in the oil and gas industry; marine toxicologists and ecological risk assessors in academia, government, and industry; government regulatory agencies concerned with marine environmental protection. The book advances the concept that bioavailability evaluation must be included in all ecological risk assessments and other environmental assessments of chemical contaminants in marine and freshwater ecosystems.

This book represents the proceedings of the first major international meeting dedi cated to discuss environmental aspects of produced water. The 1992 International Pro duced Water Symposium was held at the Catamaran Hotel, San Diego, California, USA, on February 4-7, 1992. The objectives of the conference were to provide a forum where scientists, regulators, industry, academia, and the enviromental community could gather to hear and discuss the latest information related to the environmental considerations of produced water discharges. It was also an objective to provide a forum for the peer review and international publication of the symposium papers so that they would have wide availability to all parties interested in produced water environmental issues. Produced water is the largest volume waste stream from oil and gas production activities. Onshore, well over 90% is reinjected to subsurface formations. Offshore, and in the coastal zone, most produced water is discharged to the ocean. Over the past several years there has been increasing concern from regulators and the environmental commu nity. There has been a quest for more information on the composition, treatment systems and chemicals, discharge characteristics, disposal options, and fate and effects of the produced water. As so often happens, much of this information exists in the forms of reports and internal research papers. This symposium and publication was intended to make this information available, both for open discussion at the conference, and for peer review before publication.

Individual equipment is described with performance data. Process configuration (process lineup) is discussed. Various applications of produced water, and water treatment strategies are given.

Hydraulic fracturing is a process adopted by the oil and gas industry to extract natural gas out of shale rock formations from depth ranging from 2,440 to 3,048 meters below the surface. Produced water is the largest by product of hydraulic fracturing. The composition of produced water can be toxic due to the presence of oil, grease, suspended and dissolved solids, heavy metals, chemicals that are part of fracturing fluid mixture which is injected to enhance gas production. The composition may vary significantly based on the geological formation. Safe disposal or treatment of produced water has been a challenge to the oil and gas industry both from an economic and environmental perspective. Over the last several years, many companies in the water treatment industry have developed technologies to treat produced water for safe disposal or for reuse in drilling new wells. The objective of this research is to characterize produced water samples collected from the Eagle Ford shale play region in Texas, and to assess the efficiency of treatment processes using the reactor developed by Elequa LLC, San Antonio, Texas which works on the principle of electro-coagulation. The reactor performance is then assessed based on the removal efficiency of various constituents. This method of treatment has been around since early 21 st century but has not been implemented to its full potential. A review of various other technologies developed and implemented for treatment of produced water is included in this report. The electro-coagulation reactor is tested for its efficiency in reducing the turbidity, total dissolved solids, total suspended solids and inorganic chemicals (i.e., cations) of major concern present in water produced from hydraulic fracturing. Based on test results, it is observed that there were significant levels of total suspended solids, total dissolved solids and inorganic cations present in produced water and that treatment with the electro-coagulation reactor decreased the values. There was a 75% to 97% reduction in these levels after the treatment. There were no additional pre-treatment methods used. Based on the research outcomes recommendations for modifying Elequa's Electro-coagulation reactor/technology to improve performance and an assessment of the efficiency of cathodes and anodes are provided.

This report summarizes the work performed from 1 April 2003 to 30 September 2003 and recommends the tasks to be performed during Phase II (Pilot Evaluation). During this period discussions were held with various water agencies regarding use of the treated produced water either directly or indirectly through a water trading arrangement. In particular, several discussions were held with Monterey County Water Resources Agency, that has been charged with the long-term management and preservation of water resources in Monterey County. The Agency is very supportive of the program. However, they would like to see water quality/cost estimate data for the treated produced water from the pilot study prior to evaluating water use/water trade options. The agency sent a letter encouraging the project team to perform the pilot study to evaluate feasibility of the project. In addition, the regulations related to use of the treated water for various applications were updated during this period. Finally, the work plan, health and safety plan and sample analyses plan for performing pilot study to treat the oilfield produced water were developed during this period.

A state-of-the-art review of scientific knowledge on the environmental risk of ocean discharge of produced water and advances in mitigation technologies. In offshore oil and gas operations, produced water (the water produced with oil or gas from a well) accounts for the largest waste stream (in terms of volume discharged). Its discharge is continuous during oil and gas production and typically increases in volume over the lifetime of an offshore production platform. Produced water discharge as waste into the ocean has become an environmental concern because of its potential contaminant content. Environmental risk assessments of ocean discharge of produced water have yielded different results. For example, several laboratory and field studies have shown that significant acute toxic effects cannot be detected beyond the "point of discharge" due to rapid dilution in the receiving waters. However, there is some preliminary evidence of chronic sub-lethal impacts in biota associated with the discharge of produced water from oil and gas fields within the North Sea. As the composition and concentration of potential produced water contaminants may vary from one geologic formation to another, this conference also highlights the results of recent studies in Atlantic Canada.

Water, in all its forms, may be the key to an environmentally friendly energy economy. Water is free, there is plenty of it, plus it carries what is generally believed to be the best long-term source of green energy—hydrogen. Water for Energy and Fuel Production explores the many roles of water in the energy and fuel industry. The text not only discusses water's use as a direct source of energy and fuel—such as hydrogen from water dissociation, methane from water-based clathrate molecules, hydroelectric dams, and hydrokinetic energy from tidal waves, off-shore undercurrents, and inland waterways—but also: Describes water's benign application in the production of oil, gas, coal, uranium, biomass, and other raw fuels, and as an energy carrier in the form of hot water and steam Examines water's role as a reactant, reaction medium, and catalyst—as well as steam's role as a reactant—for the conversion of raw fuels to synthetic fuels Explains how supercritical water can be used to convert fossil- and bio-based feedstock to synthetic fuels in the presence and absence of a catalyst Employing illustrative case studies and commercial examples, Water for Energy and Fuel Production demonstrates the versatility of water as a provider of energy and fuel, conveying the message that as energy demand and environmental concerns grow, so should our vigilance in pursuing the role of water in the energy landscape.

The purpose of this study is to evaluate produced water as a supplemental source of water for the San Juan Generating Station (SJGS). This study incorporates elements that identify

produced water volume and quality, infrastructure to deliver it to SJGS, treatment requirements to use it at the plant, delivery and treatment economics, etc. SJGS, which is operated by Public Service of New Mexico (PNM) is located about 15 miles northwest of Farmington, New Mexico. It has four units with a total generating capacity of about 1,800 MW. The plant uses 22,400 acre-feet of water per year from the San Juan River with most of its demand resulting from cooling tower make-up. The plant is a zero liquid discharge facility and, as such, is well practiced in efficient water use and reuse. For the past few years, New Mexico has been suffering from a severe drought. Climate researchers are predicting the return of very dry weather over the next 30 to 40 years. Concern over the drought has spurred interest in evaluating the use of otherwise unusable saline waters.
Produced water is generated nationally as a byproduct of oil and gas production. Seven states generate 90 percent of the produced water in the continental US. About 37 percent of the sources documented in the US Geological Survey's (USGS) Produced Waters Database have a TDS of less than 30,000 mg/l. This is significant because produced water treatment for reuse in power plants was found to be very costly above 30,000 mg/l TDS. For the purposes of this report, produced water treatment was assessed using the technologies evaluated for the San Juan Generating Station (SJGS) in Deliverable 3, Treatment and Disposal Analysis. Also, a methodology was developed to readily estimate capital and operating costs for produced water treatment. Two examples are presented to show how the cost estimating methodology can be used to evaluate the cost of treatment of produced water at power plants close to oil and gas production.
Natural gas and oil production from stripper wells also produces water contaminated with hydrocarbons, and in most locations, salts and trace elements. The hydrocarbons are not

generally present in concentrations that allow the operator to economically recover these liquids. Produced liquids, (Stripper Gas Water) which are predominantly water, present the operator with two options; purify the water to acceptable levels of contaminates, or pay for the disposal of the water. The project scope involves testing SynCoal as a sorbent to reduce the levels of contamination in stripper gas well produced water to a level that the water can be put to a productive use. Produced water is to be filtered with SynCoal, a processed sub-bituminous coal. It is expected that the surface area of and in the SynCoal would sorb the hydrocarbons and other contaminates and the effluent would be usable for agricultural purposes. Test plan anticipates using two well locations described as being disparate in the level and type of contaminates present. The loading capacity and the rate of loading for the sorbent should be quantified in field testing situations which include unregulated and widely varying liquid flow rates. This will require significant flexibility in the initial stages of the investigation. The scope of work outlined below serves as the guidelines for the testing of SynCoal carbon product as a sorbent to remove hydrocarbons and other contaminants from the produced waters of natural gas wells. A maximum ratio of 1 lb carbon to 100 lbs water treated is the initial basis for economic design. While the levels of contaminants directly impact this ratio, the ultimate economics will be dictated by the filter servicing requirements. This experimental program is intended to identify those treatment parameters that yield the best technological practice for a given set of operating conditions. The goal of this research is to determine appropriate guidelines for field trials by accurately characterizing the performance of SynCoal over a full range of operating conditions.

In some coalbeds, naturally occurring water pressure holds methane--the main component of natural gas--fixed to coal surfaces and within the coal. In a coalbed methane (CBM) well, pumping water from the coalbeds lowers this pressure, facilitating the release of methane from the coal for extraction and use as an energy source. Water pumped from coalbeds during this process--CBM 'produced water'--is managed through some combination of treatment, disposal, storage, or use, subject to compliance with federal and state regulations. CBM produced water management can be challenging for regulatory agencies, CBM well operators, water treatment companies, policy makers, landowners, and the public because of differences in the quality and quantity of produced water; available infrastructure; costs to treat, store, and transport produced water; and states' legal consideration of water and produced water. Some states consider produced water as waste, whereas others consider it a beneficial byproduct of methane production. Thus, although current technologies allow CBM produced water to be treated to any desired water quality, the majority of CBM produced water is presently being disposed of at least cost rather than put to beneficial use. This book specifically examines the Powder River, San Juan, Raton, Piceance, and Uinta CBM basins in the states of Montana, Wyoming, Colorado, New Mexico, and Utah. The conclusions and recommendations identify gaps in data and information, potential beneficial uses of CBM produced water and associated costs, and challenges in the existing regulatory framework.

Produced water volume generation and management in the United States are not well characterized at a national level. The U.S. Department of Energy (DOE) asked Argonne National Laboratory to compile data on produced water associated with oil and gas production to better understand the production volumes and management of this water. The purpose of this report is to improve understanding of produced water by providing detailed information on the volume of produced water generated in the United States and the ways in which produced water is disposed or reused. As the demand for fresh water resources increases, with no concomitant increase in surface or ground water supplies, alternate water sources, like produced water, may play an important role. Produced water is water from underground formations that is brought to the surface during oil or gas production. Because the water has been in contact with hydrocarbon-bearing formations, it contains some of the chemical characteristics of the formations and the hydrocarbons. It may include water from the reservoir, water previously injected into the formation, and any chemicals added during the production processes. The physical and chemical properties of produced water vary considerably depending on the geographic location of the field, the geologic formation, and the type of hydrocarbon product being produced. Produced water properties and volume also vary throughout the lifetime of a reservoir. Produced water is the largest volume by-product or waste stream associated with oil and gas exploration and production. Previous national produced water volume estimates are in the range of 15 to 20 billion barrels (bbl; 1 bbl = 42 U.S. gallons) generated each year in the United States (API 1988, 2000; Veil et al. 2004). However, the details on generation and management of produced water are not well understood on a national scale. Argonne National Laboratory developed detailed national-level information on the volume of produced water generated in the United States and the manner in which produced water is managed. This report presents an overview of produced water, summarizes the study, and presents results from the study at both the national level and the state level. Chapter 2 presents background information on produced water, describing its chemical and physical characteristics, where it

is produced, and the potential impacts of produced water to the environment and to oil and gas operations. A review of relevant literature is also included. Chapter 3 describes the methods used to collect information, including outreach efforts to state oil and gas agencies and related federal programs. Because of the inconsistency in the level of detail provided by various state agencies, the approaches and assumptions used to extrapolate data values are also discussed. In Chapter 4, the data are presented, and national trends and observations are discussed. Chapter 5 presents detailed results for each state, while Chapter 6 presents results from federal sources for oil and gas production (i.e., offshore, onshore, and tribal lands). Chapter 7 summarizes the study and presents conclusions.
Produced Water Treatment Field Manual presents different methods used in produced water treatment systems in the oil and gas industry. Produced water is salty water that is produced as a byproduct along with oil or gas during the treatment. Water is brought along with the oil and gas when these are lifted from the surface. The water is then treated before the discharge or re-injection process. In the introduction, the book discusses the basic terms and concepts that describe produced water treatment. It also presents the different methods involved in the treatment. It further discusses the design, operation, maintenance, and sizing of the produced water treatment systems. In the latter part of the book, the ways to remove impurities in water are discussed, including choosing the proper filter, filtering equipment, filtering methods, and filtering types. The main objective of this book is to provide information about proper water management. Readers who are involved in this field will find this book relevant. Present a description of the various water treating equipment that are currently in use Provide performance data for each unit Develop a "feel" for the

parameters needed for design and their relative importance Develop and understanding of the uncertainties and assumptions inherent in the design of the various items of equipment Outline sizing procedures and equipment selection U.S. Environmental Protection Agency (EPA) Region VI has issued a general permit for offshore oil and gas discharges to the Gulf of Mexico that places numerical limits on whole effluent toxicity (WEI) for produced water. Recently proposed EPA general permits for other produced water discharges in Regions VI and X also include enforceable numerical limits on WET. Clearly, the industry will be conducting extensive produced water WET testing. Unfortunately, the WET test may not accurately measure the toxicity of the chemical constituents of produced water. Rather the mortality of test organisms may be attributable to (1) the high salinity of produced water, which causes salinity shock to the organisms, or (2) an ionic imbalance caused by excesses or deficiencies of one or more of seawater's essential ions in the test chambers. Both of these effects are likely to be mitigated in actual offshore discharge settings, where the receiving water will be seawater and substantial dilution will be probable. Thus, the additional salinity of produced water will be rapidly assimilated, and the proper marine ionic balance will be quickly restored. Regulatory authorities should be aware of these factors when interpreting WET test results. Although the production of Coalbed Natural Gas (CBNG) is variable, a large amount of produced water continues to be brought to the surface. The produced water can be very useful in the water-limited regions of Wyoming, but beneficial uses may be hindered by potential water quality problems. To assess these problems a water quality monitoring study began in 1999. Nine years of water data from CBNG outfalls and discharge ponds was measured over the last eleven years and used for trend analyses. The CBNG produced water was measured on-site for pH, electrical conductivity (EC), oxidation-reduction potential, dissolved oxygen, and temperature. The water samples were later analyzed for alkalinity, Ca, Na, Mg, K, Fe, Al, Cr, Mn, Pb, Cu, Zn, As, Se, Mo, Cd, Ba, B, Cl, SO4, NO3, and PO4. In addition to the trend analyses of CBNG produced water, pond sediment samples were collected over the last four years. Sediment samples were analyzed with TCLP (Toxicity Characteristic Leaching Procedure) for As, Ba, B, Cr, Cu, Mn, Mo, and Se. Trends in CBNG outfalls are not always the same in CBNG discharge ponds: environmental factors play an important role in the water quality of these produced waters. pH is not significantly changing in outfalls of the Belle Fourche River, Cheyenne River, Little Powder River, or Powder River watersheds, but the pH in the Tongue River watershed outfalls is increasing by 0.18 per year. pH in the discharge ponds is increasing by 0.13 per year in all watersheds. Sodium adsorption ratio (SAR) showed no significant increasing or decreasing trends in outfalls or discharge ponds. Alkalinity is significantly decreasing in the outfalls and discharge ponds of the Belle Fourche River, Cheyenne River, and Little Powder River watersheds, and is increasing significantly in the Powder River and Tongue River watersheds. Iron, copper, and chromium concentrations are decreasing in all outfalls of all watersheds. Iron concentrations in the discharge ponds are increasing in the Belle Fourche River, Cheyenne River and Tongue River watersheds, and are decreasing in the Little Powder and Powder River watersheds. Copper and chromium concentrations are decreasing in all watersheds. Overall trend analyses suggest that CBNG outfall produced water in all watersheds of the Powder River Basin meet beneficial use criteria for aquatic life, livestock and wildlife watering, and irrigation except for SAR and to some extent EC. The discharge ponds across all watersheds meet all criteria for all uses except for pH, SAR, and to some extent EC for irrigation, aquatic life, and livestock and wildlife watering. Arsenic concentrations in discharge ponds also exceed aquatic life standard of 7 mcg/L in the Little Powder River and Powder River watersheds. All other water quality components (e.g. Ca, Mg, Na, K, NO3, PO4, SO4, Cl) and trace metals (e.g. Fe, Al, Cr, Mn, Pb, Cu, Zn, Se, Mo, Cd, Ba, B) meet criteria for all common beneficial uses such as, livestock and wildlife watering, aquatic life and irrigation. The results of trend analysis and sediment TCLP analysis discussed in this study could help the CBNG industry, ranchers and landowners, and the state and federal agencies manage CBNG produced water.

The exploration for and production of oil and gas to meet our nation's energy needs also results in the production of large quantities of water as a by-product. This water, which is produced from wells during exploration and production, is known as "produced water." Because produced water may contain a variety of contaminants, such as salts and minerals, it is often considered to be a waste stream that oil and gas producers must appropriately manage and treat before this water can be disposed of. If it is not appropriately managed or treated, the contaminants present in produced water discharged from oil and gas operations may threaten human health and the environment. This book explores the inextricable link between energy production and water with a focus on what is known about the volume and quality of produced water from oil and gas production; what practices are generally used to manage and treat produced water; and how the management of produced water is regulated at the federal level and in selected states.

This volume constitutes the proceedings of the Produced Water Seminar held in Trondheim, Norway, in September

1995. Hosted by Statoil Research and Development and IKU Petroleum Research, the seminar was an update of the 1992 seminar of the same title held in San Diego, California (Ray and Engelhardt, 1992). Produced water remains the largest volume waste stream from oil and gas production offshore. In the North and Norwegian Seas, produced water volumes are projected to increase significantly over the coming decades, as oil reservoirs near depletion. These releases are therefore the focus of continuing environmental concern. The purpose of this seminar was to provide a forum for scientists, legislators, and industrial and environmental representatives to share recent information and research results, and to encourage cooperative pursuit of solutions in the future. The success of the seminar, and the quality of this volume, are due in large part to the many authors from around the world who presented almost 50 posters and papers focused on environmental issues and mitigation technologies. In addition, we wish to acknowledge the contributions of the local and international organizing committees. Local Committee Asbj0fg 0verli and Heidi Torp, Statoil Egil Wanvik and Laila S. Olden, IKU Petroleum Research International Committee James P. Ray, Shell Chemical and Petroleum Products Companies Alexis E. Steen, American Petroleum Institute Theodor C. Sauer, Battelle Ocean Sciences Steven A. Flynn, British Petroleum Martin C. Th. Scholten, TNO Kjell Lohne, Statoil Ingvild Martinsen, Norwegian Pollution Control Authority. Produced water is typically the largest bi-product or waste stream volume accompanied with the oil and gas production. It is basically the waste product full of chemical contaminants; which cannot be utilized for any useful purpose. Produced water quality fluctuates considerably based on type of hydrocarbons produced, geographical location and the geochemistry of the generating reservoir. This book is helpful in selecting the most appropriate method for produced water

in oil & gas sector across the globe. Each of the produced water handling techniques has pros & cons with respect to their implementation at site depending upon the volumes of it generated each day, it's chemical and physical characteristics etc. This book also contains produced water data from oil & gas companies which is evaluated and analyzed in detail to reach at a conclusion that Forced Evaporation system is the most feasible and viable handling technique for controlled produced water productions. As for the higher produced water generation, definitely other handling techniques such as well injection, water treatment, down-hole injection for oil recovery are the alternate solutions to the problem.
Commercial scale oil shale and oil sands development will require water, the amount of which will depend on the technologies adopted and the scale of development that occurs. Water in oil shale and oil sands country is already in scarce supply, and because of the arid nature of the region and limitations on water consumption imposed by interstate compacts and the Endangered Species Act, the State of Utah normally does not issue new water rights in oil shale or oil sands rich areas. Prospective oil shale and oil sands developers that do not already hold adequate water rights can acquire water rights from willing sellers, but large and secure water supplies may be difficult and expensive to acquire, driving oil shale and oil sands developers to seek alternative sources of supply. Produced water is one such potential source of supply. When oil and gas are developed, operators often encounter ground water that must be removed and disposed of to facilitate hydrocarbon extraction. Water produced through mineral extraction was traditionally poor in quality and treated as a waste product rather than a valuable resource. However, the increase in produced water volume and the often-higher quality water associated with coalbed methane development have drawn attention to

potential uses of produced water and its treatment under appropriations law. This growing interest in produced water has led to litigation and statutory changes that must be understood and evaluated if produced water is to be harnessed in the oil shale and oil sands development process. Conversely, if water is generated as a byproduct of oil shale and oil sands production, consideration must be given to how this water will be disposed of or utilized in the shale oil production process. This report explores the role produced water could play in commercial oil shale and oil sands production, explaining the evolving regulatory framework associated with produced water, Utah water law and produced water regulation, and the obstacles that must be overcome in order for produced water to support the nascent oil shale and oil sands industries.

The latest edition of this best-selling title is updated and expanded for easier use by engineers. New to this edition is a section on the fundamentals of surface production operations taking up topics from the oilfield as originally planned by the authors in the first edition. This information is necessary and endemic to production and process engineers. Now, the book offers a truly complete picture of surface production operations, from the production stage to the process stage with applications to process and production engineers. New in-depth coverage of hydrocarbon characteristics, the different kinds of reservoirs, and impurities in crude Practical suggestions help readers understand the art and science of handling produced liquids Numerous, easy-to-read figures, charts, tables, and photos clearly explain how to design, specify, and operate oilfield surface production facilities