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Restoring the Nature of Kuwait

Dr. Samira Omar & Waleed Roy

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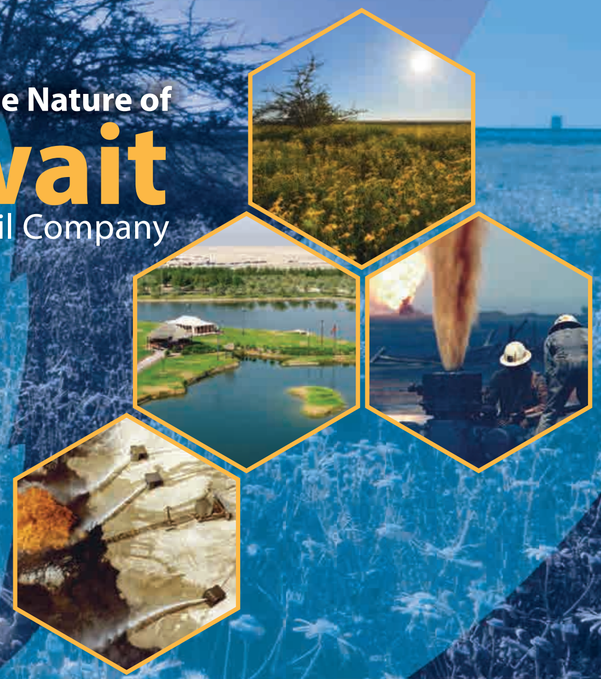
by Kuwait Oil Company



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His Highness Sheikh Sabah Al-Ahmad Al-Jaber Al-Sabah, Amir of the State of Kuwait

His Highness Sheikh Nawaf Al-Ahmad Al-Jaber Al-Sabah, Crown Prince of the State of Kuwait

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CONTENTS

FOREWORD

The government of Kuwait has recognized the practical and ethical imperative to halt the current rapid rate of biodiversity decline and loss of species. Habitat degradation continues to be the main global driver of biodiversity loss. While efforts to prevent habitat decline remain of paramount importance, the restoration of damaged and degraded terrestrial ecosystems will play an increasingly important role in the conservation and sustainable use of biodiversity, especially in light of the escalating impacts of the Iraqi invasion and overall global climate change. Now more than ever, it is clear that achieving our shared vision for a world in which nature is valued and conserved requires enhanced action, not only to protect what remains, but also to recover what has been lost.

The Kuwait Municipality has advocated for the development of a system of National Parks/Nature Reserves, where the national government reserves certain areas for the preservation of plants, animals, landscapes, or combinations of these, in their natural or improved state for the purpose of biodiversity conservation and public recreation. It is worth mentioning that many interacting social, legal, and political factors usually hinder conservation efforts; hence, all these factors are taken into consideration by lawmakers.

By establishing protected areas, such as national parks, wilderness areas, and nature reserves, it is possible to conserve biodiversity. Strategic interventions of this kind have an ancient history in the Arabian Gulf, stretching back to the HIMA (areas set aside for conservation of nature which is prohibited from grazing by livestock) that were already flourishing a thousand years ago as a traditional way of maintaining rangeland. Protected areas offer opportunities to maintain or restore natural vegetation patterns and to conserve the habitats of wildlife species that are endangered, either because of deliberate human interference, such as overhunting, or an accidental by-product of development such as disturbance or pollution. The survival of some of the rare and more sensitive wild species of the region are now dependent on setting aside dedicated areas for their protection.

As we increase our efforts to restore protected area values, however, we must also act with caution and humility, recognizing that ecological restoration is a complex and challenging process and that our intervention can have unforeseen consequences.

Industrial organizations in Kuwait, such as Kuwait Oil Company (KOC) realized the importance of remediation and restoration of damaged ecosystems within their premises and supported the establishment of oases and protected areas for conservation of natural resources and biodiversity. The restoration program developed by KOC is unique and significant in converting damaged land into productive land for biodiversity conservation. The approach involves restoring damaged areas that were contaminated with crude oil pollution from the explosion and detonation of oil wells, as well as controlling land use and access to areas that have special ecological importance.

KOC is pleased to present this book that highlights its efforts in conservation and restoration of areas that were severely damaged during the Iraqi invasion of Kuwait from August 1990–February 1991, including the destruction caused by the detonation of over 700 oil wells. Although many years have passed since liberation day, the environmental damages have had a long-term impact on air, soil, and groundwater. Remediation and restoration programs have been implemented by KOC in collaboration with other local and international organizations to bring nature back to its original state before the invasion. KOC has developed a comprehensive program known as the *Total Remediation Solution*, which includes several remediation and rehabilitation projects that span across the affected areas of KOC's operations and are expected to be completed in less than a decade. KOC has been realizing its strategic objectives relating to environmental affairs by applying the following initiatives and measures:

- KOC has pioneered an Air Quality Management Program that monitors and manages air quality and emissions.
- Significant projects have been completed that have successfully reduced gas (e.g., CO_2 and H_2S) emissions/flaring to less than 1%. In 2014, KOC received the top environmental award from the Council of Arab Environmental Affairs Ministers for their commitment towards preservation of the environment, improving air quality, and reducing gas emissions/flaring.
- KOC has also started to implement specialized programs to manage effluent water and control emissions.
- In addition to restoring the environment, many initiatives have been implemented aimed at increasing social responsibility awareness.

KOC, and by extension, the State of Kuwait, designates great importance to issues dealing with conservation and the environment. Naturally, matters related to sustainability and energy efficiency also play an important role in KOC's outlook and strategic plans.

At KOC, we have long been aware of the fact that our responsibility is not simply limited to the development of our business or increasing oil production. That is why we strive to fulfill our obligations to the community in which we operate. Naturally, this includes making every possible effort to protect and preserve our environment and create greater environmental efficiencies wherever possible.

Jamal Abdul Aziz Jaafar
Chief Executive Officer and Member of the Board
Kuwait Oil Company (KOC)

PREAMBLE

Preserving the environment is an issue of worldwide resonance, one in which the Kuwait Institute for Scientific Research (KISR) has played a pioneering role since its foundation in 1967. Throughout the years, addressing the variety of environmental challenges in Kuwait and the Gulf Region has been one of KISR's key directives. Today, the accumulated experience during those years are housed at KISR's Environment & Life Sciences Research Centre (ELSRC), where experts with multidisciplinary backgrounds develop sustainable food production strategies for Kuwait's agricultural and fish industries, assess and manage the risks of pollution to the environment and population, and directly address the challenges of restoring the country's damaged ecosystem while preserving its natural resources.

Kuwait's terrestrial and marine ecosystems are two of the most sensitive and compromised systems in the world. Problems include poor air quality, primarily due to dust storms arising from mobile sand movement, and the impact of pollution. Understanding the dynamics and impact of terrestrial and coastal biodiversity on Kuwait's population is where ELSRC's key competency lies.

Protected areas have long been established by KISR to conserve the wildlife species of Kuwait. One of the first protected areas in Kuwait was established in 1975 by KISR in the Kabd area known as the *KISR Station for Research & Innovation*, which is a 40-square kilometer area located to the southwest of Kuwait City. In the early 1980s, KISR provided its consultation to Kuwait Municipality to establish the Kuwait National Park/Nature Reserve that was inaugurated in 2004 and re-named the *Sabah Al Ahmad Nature Reserve*. Many more areas were later established to protect different types of ecosystems and to conserve the biodiversity of the country.

In addition, KISR contributed to the development of project and phasing plans of the Kuwait Environmental Remediation Program (KERP), the largest remediation and restoration program in the world that was awarded to Kuwait by the United Nations Compensation Commission (UNCC). One of the projects that relates to this program is the restoration of damaged terrestrial environments by establishing protected areas. These areas are under the jurisdiction of the Public Authority for Agriculture and Fish Resources (PAAFR). Other projects deal with the remediation of the damaged environment due to soil contamination with crude oil from the detonation of over 700 oil wells during the Iraqi invasion of Kuwait. The remediation and restoration program of the oil lakes and contaminated oil piles are being implemented by Kuwait Oil Company (KOC) in collaboration with the Kuwait National Focal Point (KNFP) for environmental claims. KOC is contributing to the conservation of biodiversity within its oil production areas and has embarked on a large-scale remediation and restoration program to allow recovery of damaged ecosystems.

Kuwait would make an interesting case study regarding how to establish a system for protected areas within a country that was badly impacted by war and burdened by additional environmental constraints. The designation of protected areas and restoration programs by KOC will enhance Kuwait's environmental conditions and allow ecosystem recovery.

Dr. Samira Omar
Director General
Kuwait Institute for Scientific Research

Eng. Waleed Roy observing sand dunes at Wadi Umm Al Rimam, Sabah Al Ahmad Nature Reserve

Dr. Samira Omar taking notes at the Sabah Al Ahmad Nature Reserve

INTRODUCTION

Over the past decades, the problem of land degradation in dry land regions has accelerated to an extreme pace, leading to the loss of vegetation cover and fertile topsoil, increased dust storms, and increasing desertification. Kuwait, like any other arid country, is confronted with similar problems, among others, in its dry land ecosystems. Today, Kuwait faces a variety of natural and human-induced challenges that threaten the country's unique and highly diverse coastal and marine environment.

With a growing population, expansion of urban development, and growth in the industrial sector, the environment resource base in Kuwait is under serious pressure. This is in addition to the increase in utilization of water resources and energy consumption, which are due to growing population and economic activities. The environmental degradation is further manifested by the first Gulf War and the accompanying unique exposure to oil pollution. This has already affected hundreds of square kilometers of the country both through the occurrence of residual *oil lakes* and the presence of thick oil residues left from burning that forms a mat over much of the country. Since then, other forms of degradation have occurred, caused by overgrazing, use of four-wheel drive vehicles in fragile habitats, wildlife hunting, camping, and unsustainable development. In effect, these forms of degradation are not only creating an escalating range of difficulties for human inhabitants, but also posing serious threats to wild plant and animal communities. This is further aggravated by current global climatic changes and their negative impact on natural resources and consumption of such resources. Altogether, these factors are negatively affecting ecosystem integrity and the livelihood of the people of Kuwait.

These environmental concerns have alerted all sectors in Kuwait to think of effective measures that would resolve these problems without negatively affecting the country's development. In 2002, ten years after the Convention on Biological Diversity of the United Nations, Kuwait ratified and developed a Biodiversity Strategy and Action Plan aimed at conserving renewable natural resources and restoring/rehabilitating damaged habitats. In order to protect habitat, fencing of large areas is considered the most appropriate approach to natural habitats recovery. Although the costs of fencing construction and maintenance demand a high price, the return is priceless to the people of Kuwait.

The United Nations Compensation Commission (UNCC) awarded the State of Kuwait about 3 billion USD to restore and remediate the environmental damages due to the Iraqi invasion that lasted from August 1990–February 1991. It took six years for the Public Authority for Assessment of Compensation Damages resulting from the Iraqi invasion to assess and monitor the environmental damage caused by the Iraqi troops and to present the scientific evidences to the UNCC. In 2005, Kuwait was awarded the environmental remediation program to initiate project and phasing plans as per UNCC Decision 258. The awards were implemented under the umbrella of the Kuwait Environmental Remediation Program (KERP) by governmental entities including Kuwait Oil Company (KOC) and supervised by Kuwait National Focal Point (KNFP). Kuwait Institute for Scientific Research (KISR) worked as the technical arm for KNFP for almost three years (2011–2014) to assist in the development of project and phasing plans, and to set up quality control measures for the implementation of the environmental awards. KERP is currently implemented by KOC, the Public Authority for Agriculture and Fish Resources, the Ministry of Electricity and Water, and, more recently (2017), by KISR. Several protected areas in the marine and coastal environments are being developed as part of the KERP program.

The UNCC supported Kuwait's enhancement strategies based on the understanding that the conservation of vegetation, wildlife species, and habitats is vital to maintaining a healthy environment that can withstand harsh climatic conditions. In setting aside areas for conservation of habitats and vegetation, mobile sand and dust storms will be less frequent, and thus, less damaging to roads and infrastructure, and would pose less of an impact on public health.

In summary, this book details KOC's contribution to the restoration and remediation of damaged ecosystems for the purpose of conserving wildlife and vegetation of vulnerable terrestrial and marine environments. It documents the extended efforts to remediate and restore contaminated soils due to the detonation of oil wells and explores future plans for ecosystem recovery and ecological functioning after remediation and restoration implementation.

Samira Omar
Waleed Roy

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1

THE KUWAIT OIL COMPANY

INTRODUCTION

The petroleum industry in Kuwait is the largest industry in the country. Oil reserves are approximately 104 billion barrels (bb), estimated at 7–8% of the world's reserves. Kuwait's oil reserves are the fourth largest in the world and the Burgan oil field is the second largest oil field.

In 1934, the Kuwait Oil Company Ltd. (KOC) was established by the Anglo-Persian Oil Company, now known as British Petroleum (BP), and Gulf Oil Corporation, now known as Chevron Corporation. KOC, under the umbrella of the Kuwait Petroleum Corporation (KPC), is the sole authority responsible for oil production in Kuwait. Its main responsibility involves the onshore and offshore exploration, drilling, and production of crude oil and natural gas within the State of Kuwait as well as storage of crude oil and delivery to tankers for export. Therefore, KOC has a vital role in sustaining development and the environment in its operations.

Early dates of oil explorations revealed commercial quantities of crude oil at the Burgan oil fields that were expanded to provide exportation facilities. In June 1946, His Highness Sheikh Ahmad Al-Jaber Al-Sabah (see Figure 1.1), the late Amir of Kuwait, inaugurated the export of Kuwait's first crude oil shipment. As part of its role to improve the economic status of the country and to manage its natural resources, the State of Kuwait took full control over KOC in 1975 and, in 1980, the KPC was established to bring all state-owned oil companies under one entity.

Figure 1.1 Sheikh Ahmad Al-Jaber Al-Sabah, the late Amir of Kuwait (1921–1950)

The Iraqi invasion of 1990 devastated KOC facilities and the Kuwait environment (see Figures 1.2–1.6). However, within months of Kuwait's liberation in February 1991, production gradually returned to full capacity.

Figure 1.2 Oil well fires in 1991

Figure 1.3 A Cormorant in an oil lake formed by gushing oil from detonated oil wells

Figure 1.4 H.H. Sheikh Jaber Al-Ahmad Al-Jaber Al-Sabah, the late Amir of Kuwait, putting out the last oil well fire at the Burgan oil fields in November 1991

Figure 1.5 Damage to the infrastructure at the Burgan oil fields after extinguishing the oil fires in November 1991

Figure 1.6 Oil lakes formed after the detonation of oil wells during the Iraqi invasion of Kuwait from 1990–1991

Super light crude oil was discovered at the Sabriya Field in 2005. The discovery of the API 52 crude oil represented a great leap forward for the company's exploration abilities.

In 2006, gas was discovered in the deep Jurassic reservoirs at Rahalyah, Mutriba, Umm Niqa (see Umm Niqa in Figure 1.7), and other fields throughout Kuwait. These discoveries fulfilled a long-standing Kuwaiti dream of becoming self-sufficient in gas that can be used for power generation.

In 2011, KOC successfully achieved its goal of reducing gas emissions of CO_2 and H_2S and flaring from oil wells to approximately 1%. Gas flaring is the combustion of flammable gases produced and extracted at oil and gas production sites and industrial plants. This is done for safety purposes to reduce excess pressure build-up on industrial plant equipment. Compared to gas flaring levels of as high as 17% just a few years earlier, this represented a major accomplishment for KOC.[1]

Today, KOC continues to live up to its stated mission of exploring, developing, and producing Kuwait's hydrocarbon resources for its customers around the world in a way that is environmentally sound and economically viable.

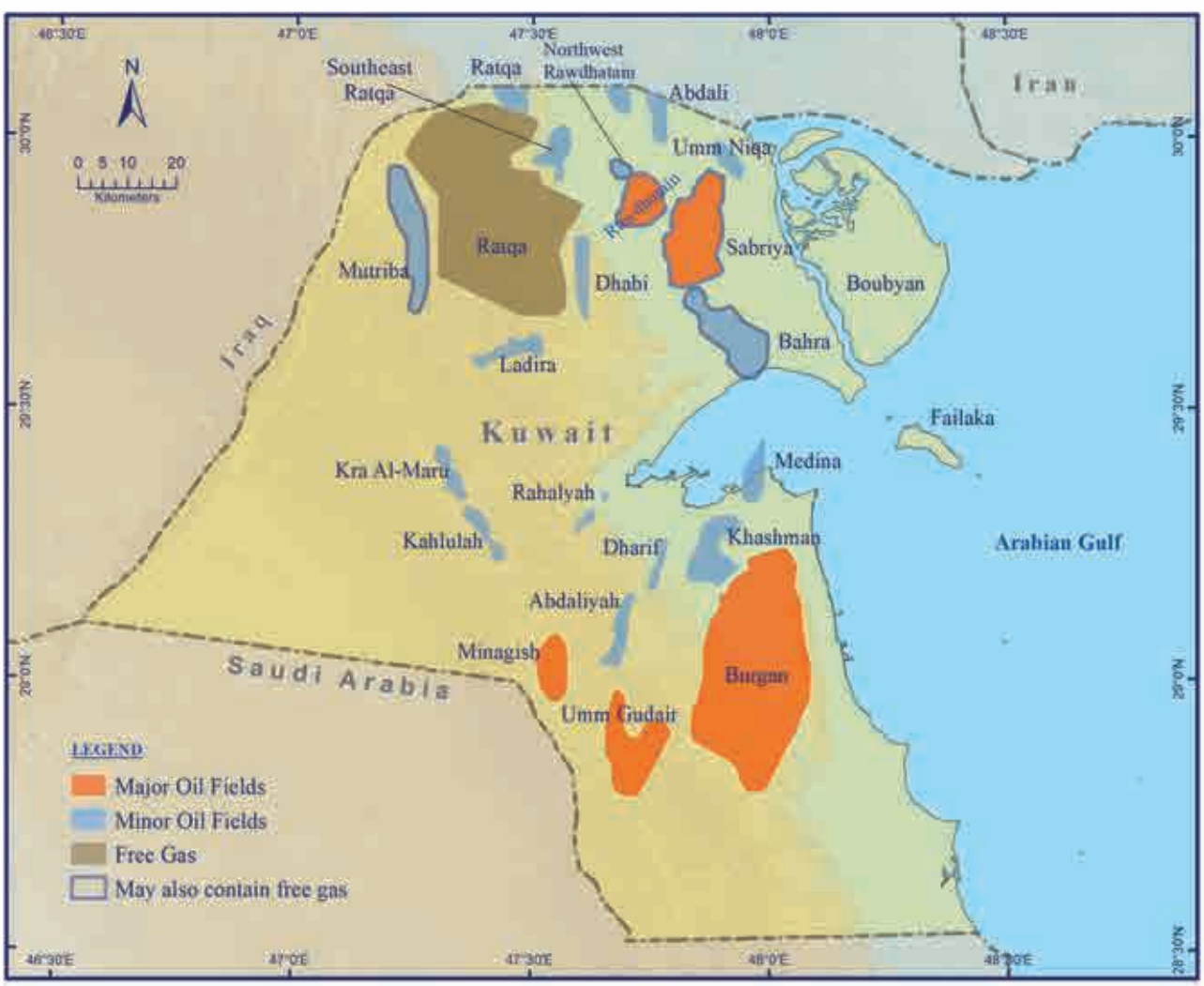

Figure 1.7 Oil fields in Kuwait based on size

THE OIL FIELDS

The oil fields of Kuwait are broadly classified into two categories: Greater Al Burgan and North Kuwait (Figure 1.8).

Greater Al Burgan

The Greater Al Burgan oil field area, situated in the south of Kuwait, is the second largest oil reserve and oil-producing complex in the world. It is comprised of the oil fields of Al Burgan, Al Ahmadi, Al Maqwa, and Al Minaqish. The Greater Burgan field is the world's largest sandstone oil field.[2]

The discovery of the Burgan oil field dates to the early twentieth century when Kuwait was in the domain of British influence. After the 1908 discovery of oil in Iran and the subsequent formation of the Anglo-Persian Oil Company (APOC), British attention was drawn to the nearby land of Kuwait which was also rich in bitumen seeps. In 1912, a party of geologists commissioned by the British Admiralty visited the Burgan area, and one of the geologists from the Geological Survey of India, Edwin Pascoe, reported the existence at Burgan of a gently dipping structural dome with bitumen seeps on the surface. In 1913, the Amir of Kuwait, Sheikh Mubarak bin Sabah, also wrote to the British Political Resident

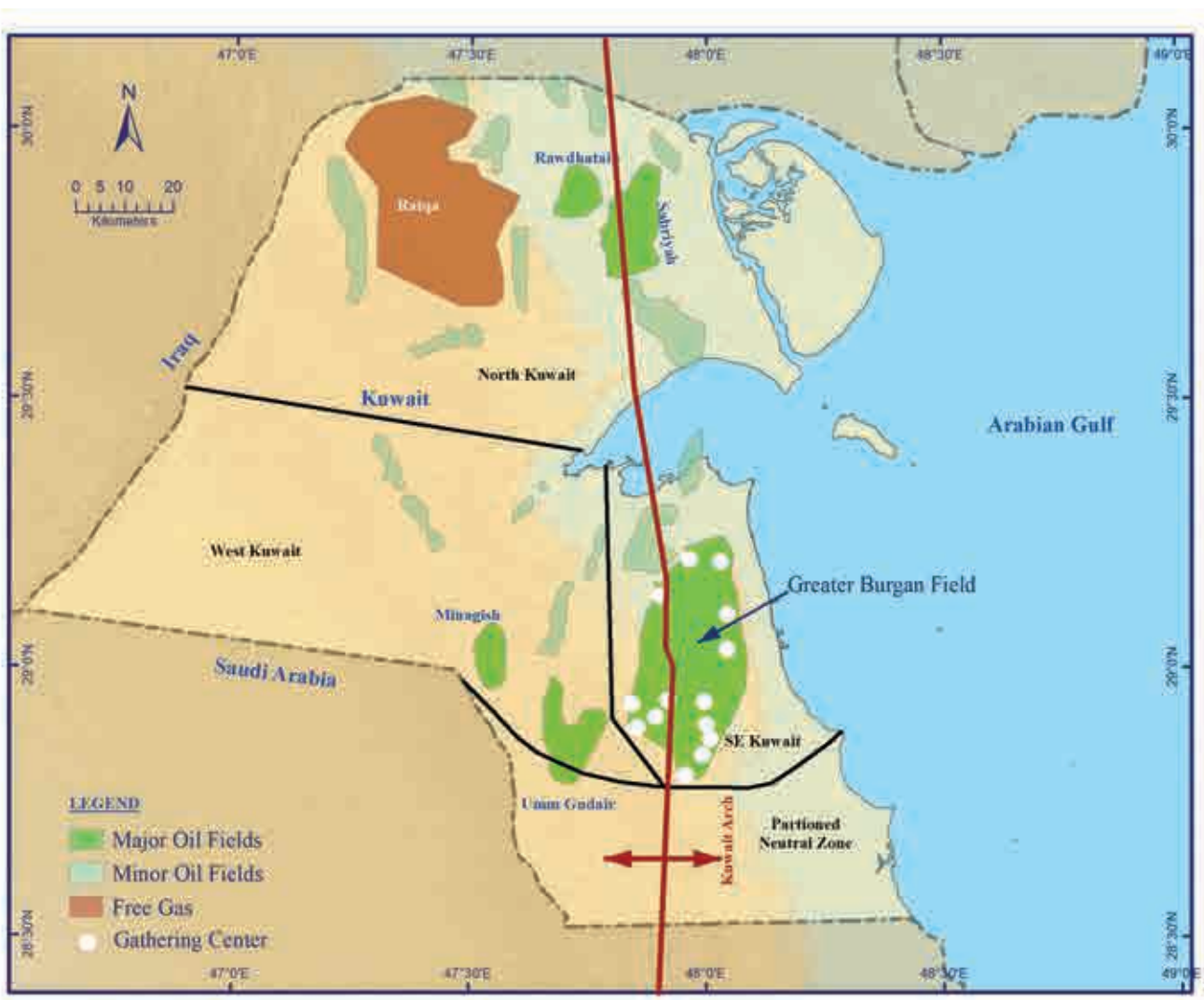

Figure 1.8 The Oil Fields of Kuwait and the Neutral Zone

in Kuwait about the famed abundant seepages in Kuwait and the possibility of an oil concession for a British entity. APOC dispatched the geologist S. Lister James in 1914 and again in 1917 to survey the seepages in the villages of Bahrah and Burgan, located respectively north and south of Kuwait Bay. James recommended drilling at the sites but it took two decades of on-and-off negotiations before any well could be drilled.

Major Frank Holmes, a New Zealander who had helped set up the Eastern and General Syndicate in London, was the moving spirit behind oil explorations on the Arabian Peninsula during the 1920s and '30s. He even had an Arabic title, 'Abu Naft' (Father of Oil). In 1924–25, Holmes hired a Swiss geologist, Arnold Heim, to survey Kuwait and eastern Arabia, but Heim's geological report was discouraging. Then, in 1925–26, APOC sent its geologists to Kuwait, and they also gave it a low ranking for oil prospects. In 1927, the American company Gulf Oil bought Holmes' concessions (although Holmes still retained his job); this motivated APOC to enter the oil game in Kuwait afresh. For several years, both Gulf Oil and APOC held separate and competing negotiations with Sheikh Ahmad Al-Jaber Al-Sabah of Kuwait, and the Amir was willing to play one side off against the other to get a better deal. Those were the days of the Great Depression: global demand for oil was low and the rulers in the Arabian Gulf region were in dire need of new revenues to offset the diminishing pearl industry. In 1933, APOC and Gulf Oil decided to put aside their rivalry and act as a single entity. They registered a joint venture, the Kuwait Oil Company, in London, and offered a new deal to the Amir of Kuwait. In December 1934, Sheikh Ahmad Al-Jaber signed an oil concession for the entire 16,000 km^2 of Kuwait for a period of 75 years in return for royalties.

A team of geologists started working in Kuwait in the hot summer of 1935. They recommended drilling at Bahrah, but a 2,423 m well into the Cretaceous sediments drilled during 1936–37 yielded minor oil shows only. Meanwhile, gravity, magnetic, and seismic surveys were conducted in the Burgan area, and on October 16, 1936, Burgan No. 1 was spudded at a seepage. Sediments below 1,000 m had oil shows, and finally, on February 23, 1938, the well hit a high-pressure sandstone unit at a depth of 1,120 m. It was a gusher that at last put Kuwait on the world oil map. From 1938 to 1942, eight additional wells drilled in the Burgan field were all productive and yielded new payzones in the underlying Burgan Formation. However, World War II put an end to these operations.

Figure 1.9 Early days of oil discovery in Kuwait by British geologists

In June 1946, a year after the War had ended, the Amir of Kuwait inaugurated the first shipment of Burgan's crude from the Mena Al-Ahmadi terminal, some 24 km east of Burgan. By the end of 1950, there were 99 productive wells in Burgan pumping 344,000 barrels of oil per day (bopd). Also in 1950, oil was discovered at Magwa; two years later, a well hit oil at Ahmadi from the same Cretaceous sand units. In 1953, wells at Magwa and Ahmadi came online, and by 1955, production from the entire field stood at 1 million bopd. Both Magwa and Ahmadi are located on subsidiary domes of the mega-anticline on which the Burgan field is situated. These three structural culminations constitute the Greater Burgan field with similar oil-water contacts at depth.

Figure 1.10 Wara hill at Burgan in the early 1950s

Figure 1.11 Housing facilities at the Burgan oil fields after oil discovery

Figure 1.12 British geologists senior staff at the Wara area of the Burgan oil fields in the early days

Figure 1.13 Wara camp

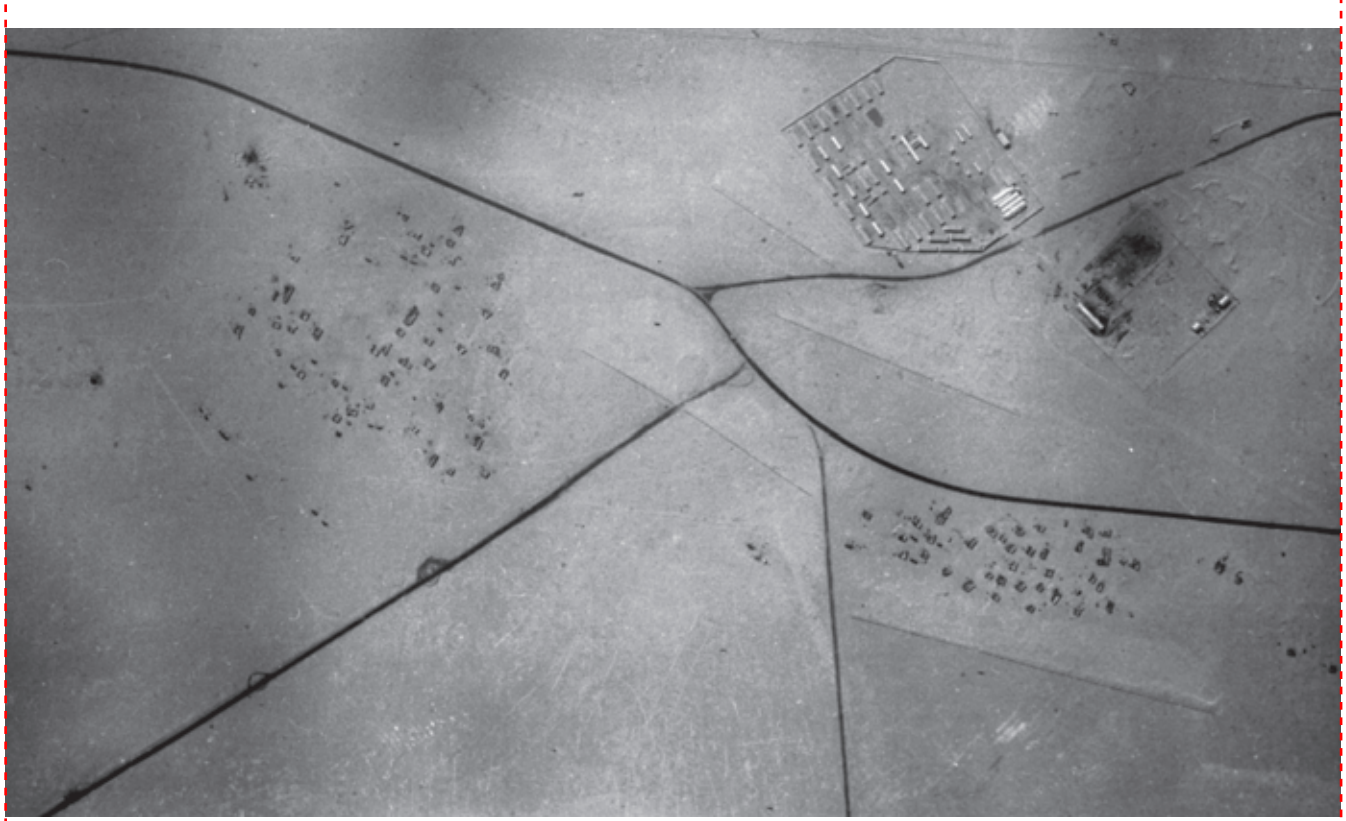

Figure 1.14 Aerial shot of the Wara area in 1950

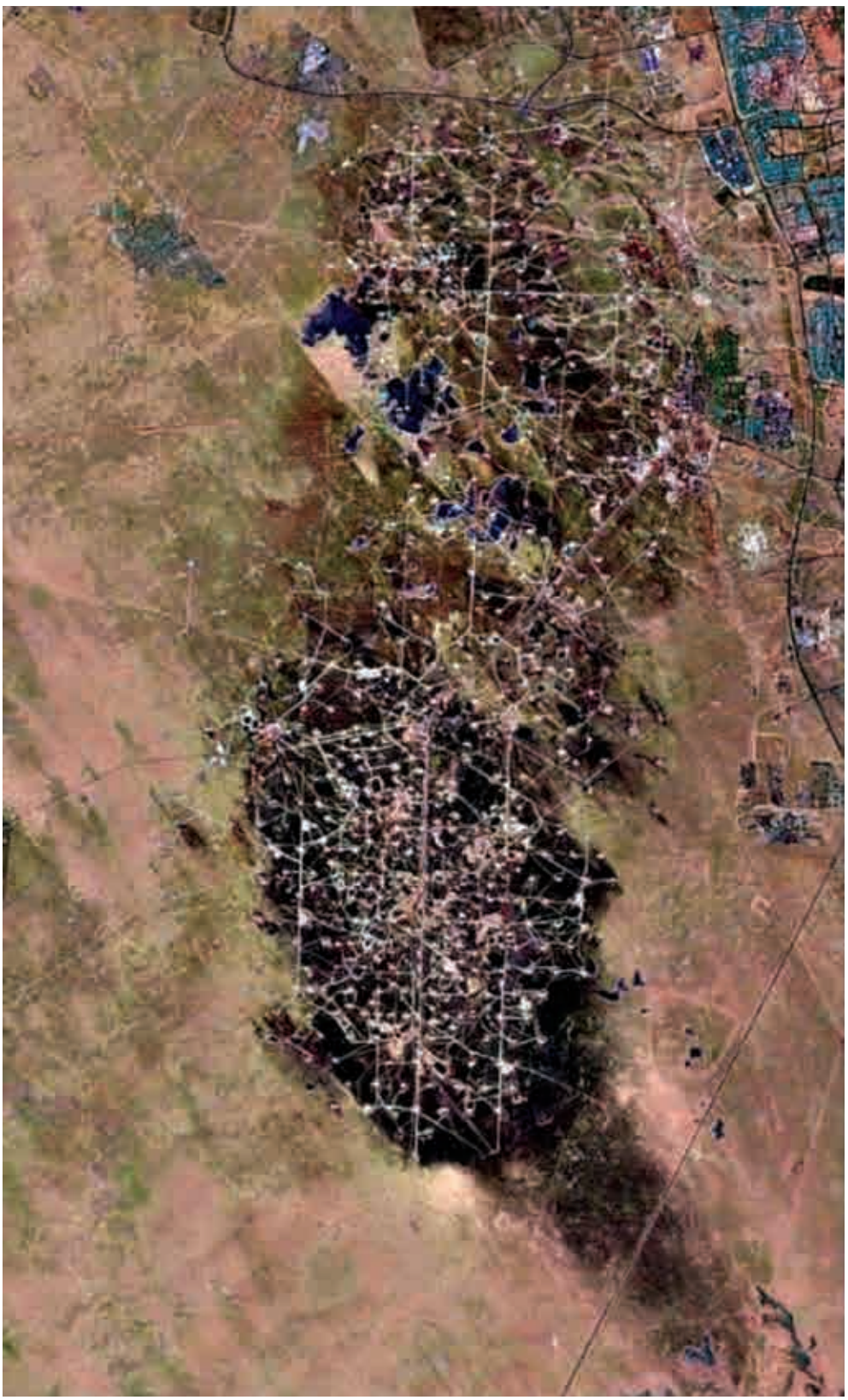

Figure 1.15 The Greater Burgan oil field after extinguishing all oil fires in 1992

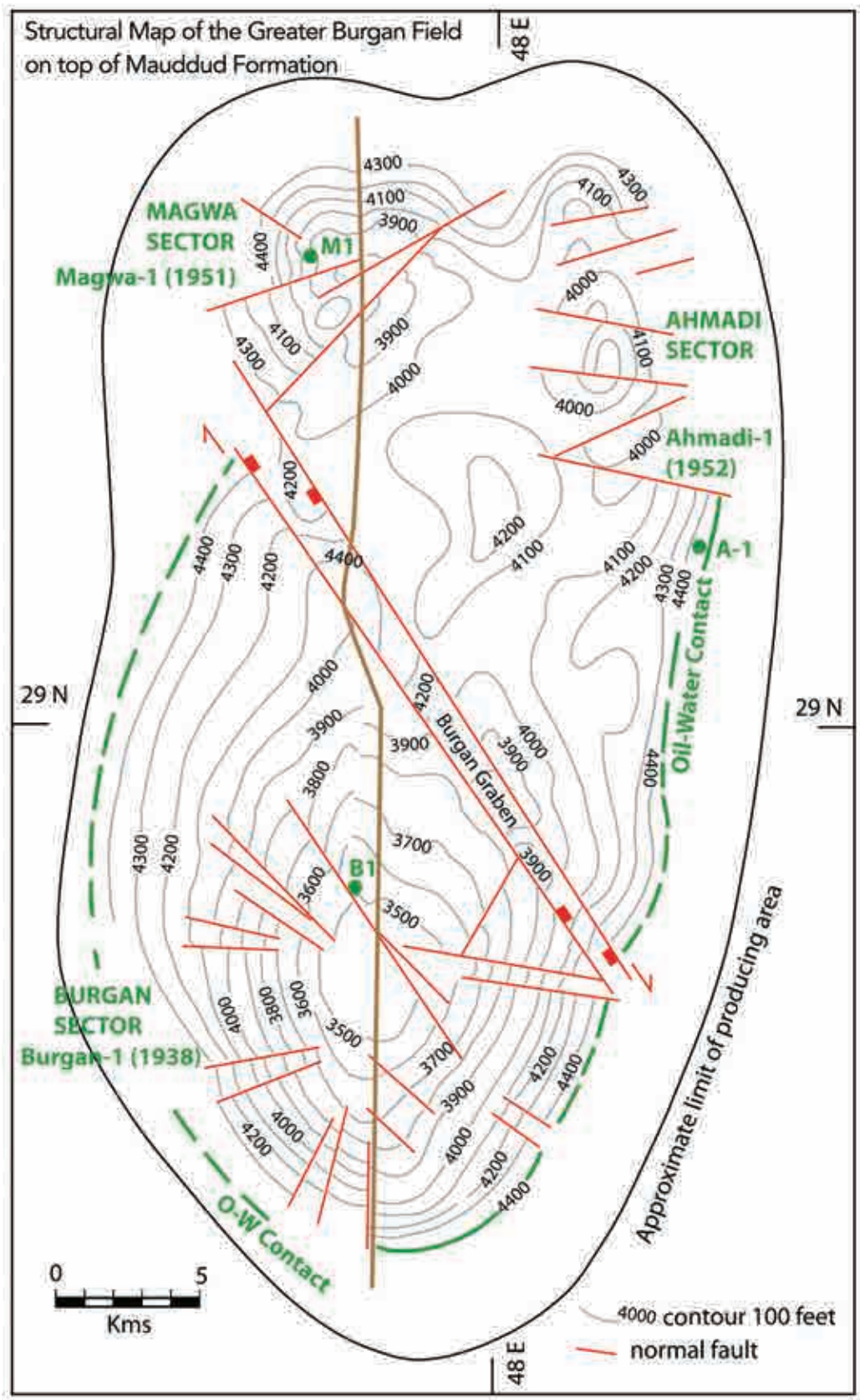

Figure 1.16 A structural map of the Greater Burgan oil field on top of the Mauddud Formation (modified after M. Adasani, 1965, Fifth Arab Petroleum Congress; P. Brennan, 1999, AA PG, Structural Traps I. A description of the structure has also been given by G. Carman, 1996, GeoArabia, 1)[3]

North Kuwait

Heavy oil has accumulated in North Kuwait and is found above the major oil fields in the area. The North Kuwait oil field was discovered in the late 1970s and subsequently 104 wells were drilled. Two Cyclic Steam Stimulation pilots were carried out in the 1980s. One pilot consisting of four wells was conducted in 1982, and another pilot featuring four wells was done in 1986. Both pilots were very successful. A third pilot for steam flood was designed in 1989, but due to the Iraqi invasion it did not materialize. During the Gulf War, these wells were destroyed. Drilling activity resumed in mid-2006 after a gap of about 17 years. Subsequently, over 1,030 wells have been drilled.

In North Kuwait, the Heavy Oil Reservoir covers a vast area of 1,411 km^2. It consists of Miocene unconsolidated, shallow, quartzose sand that is overlain by a 20- to 40-foot thick shale barrier that acts as the sealing unit for the reservoir system. There is no obvious structural closure. It is a simple North-East plunging monocline.

The reservoir broadly consists of two sandstone units separated by a mid-shale unit. However, intervening cemented siltstone and shale units often divide the two sandstone units into four stratified reservoir units. Each zone varies in pay thickness from about 10 to 30 feet. The pool shows significant variation in the north and south areas of the field, and viscous oil property shows considerable variation both laterally as well as vertically. As an average, API gravity varies from 10 to 18 and reservoir oil viscosity varies from 100 cp to 1,800 cp. Average permeability is in the range of 2–3 Darcy and porosity is more than 30% with a high oil saturation (70–80%). Reservoir pressure is 50 to 275 psi; temperature is in the 85- to 100-degree Fahrenheit range (about 29–38°C).

RESERVES AND PRODUCTION[3]

How much of Kuwait's proven oil is in Burgan? According to the annual data published in the BP Statistical Review of World Energy, OPEC's Annual Statistical Bulletin, and the Oil & Gas Journal, Kuwait's proven oil reserves stand at 101.5 bb, excluding the Partitioned Neutral Zone with proven oil reserves of about 5 bb which Kuwait shares with Saudi Arabia on a 50-50 basis. This figure accounts for 7–8% of the world's proven reserves. Assuming Burgan's recoverable oil to be 70 bb, it seems that this supergiant field holds about 70% of Kuwait's proven oil.

Production data from Burgan, even when they are known, cannot be taken at face value to assess the life span of the Burgan field because the production is subjected to not only geological storage but also reservoir management and political-economic considerations. The maximum production from Burgan was 2.2 to 2.4 mm bopd from 1970–73 (with 1972 standing at 2,415,068 bopd). The field's production has declined since then, partly because of market considerations (for example, the production was between 0.5 to 1.0 mm bopd between 1980–86) and partly because of optimal reservoir management practices. In a 2005 interview, Farouk Al-Zanki, former chairman of KOC, was reported as saying: "[To boost oil supply] Burgan itself won't be enough because we have exhausted that with its production capacity now much lower than what it used to be. We tried 2 million barrels a day, we tried 1.9 million, but 1.7 million is the optimum rate for the facilities and for the economy."[4] In 2010, Sami Rushaid, former Chief Executive of KOC, remarked that Burgan produced half of Kuwait's oil.[5] Kuwait's oil production from 2000 to 2010 varied between 2.0–2.8 mm bopd. In 2010, production was 2.5 mm bopd, including about 200,000 barrels of non-crude liquids. According to the 2011 country briefing on Kuwait by the U.S. Energy Information Administration, Burgan's recent production is between 1.1 and 1.3 mm bopd, about half of Kuwait's total production, but the field has a production capacity of 1.75 mm bopd.

Thanks to the rich oil endowments of Burgan and other fields, Kuwait, one of the smaller and less populous countries, is now one of the high-income economies in the world. Burgan has been pumping oil for 65 years or so, and like any other oil field, be it large or small, it will eventually be abandoned, but that day will probably be several decades hence. The Cretaceous play in Burgan is still a supergiant field. And with the application of improved recovery techniques, more of the oil in place can be produced. Moreover, the deeper Lower Cretaceous (Thamama Group) and Jurassic oil and Permian (Khuf) gas plays, which are proven and rich productive horizons in the Persian Gulf region, are yet to be rigorously explored in the Greater Burgan field.[6]

KOC 2040 STRATEGY

2040 Upstream Mission

Optimize the value of Kuwait's hydrocarbon resources through exploration, development, and production to ensure sustainability.

2040 Upstream Vision

To be an upstream leader recognized globally for excellence.

2040 Upstream Values

Innovation: Developing and embracing new ideas, methods, and approaches to solving challenges that create value

Excellence: Encouraging high performance, continuous improvement, and a customer focus

Caring for People: Creating a culture where people develop and grow, and are positively motivated to contribute to the success of others

Pride: Creating employee satisfaction on an individual level and promoting a sense of loyalty and belonging to KPC

One Team: Caring for the interests of KPC and ensuring alignment to achieve corporate and State goals

Partnership: Building and sustaining relationships that support growth and enhance operational excellence

Integrity: Acting in a trustworthy manner with the highest standards of ethics, respect, and honesty

Commitment to HSSE: Respecting the environment and ensuring safety, security, and the promotion of a healthy workplace wherever KPC operates

2040 Domestic Upstream Strategic Objectives

1. **Strive for World-class Operational Excellence:** Achieve world-class operational excellence to maximize upstream profitability
2. **Optimize Portfolio Management:** Optimize resource allocation to maximize strategic fit and return on investment for each type of hydrocarbon
3. **Achieve Sustainable Crude Oil Production Capacity:** Ensure meeting current and future demand by achieving a sustainable crude oil production capacity in the State of Kuwait, including production from the Partitioned Zone.
4. **Achieve Sustainable Non-associated Gas Production:** Ensure meeting current and future demand by achieving a sustainable production of non-associated natural gas in the State of Kuwait, including production from the Partitioned Zone
5. **Replace Reserves to Sustain Production:** Replace produced hydrocarbons by improving recovery factors for known resources and by discovering new reserves
6. **Facilitate Technology and Capability Transfer:** Ensure mechanisms and platforms are in place and pursue to capture and transfer technologies to and from K-companies and promote opportunities that support the development of Kuwaiti capabilities
7. **Actively Manage Stakeholders to Satisfy Kuwait Energy Demand Efficiently:** Efficiently provide energy security to the State of Kuwait by achieving and maintaining solid alignment with stakeholders including government entities, partitioned zone partners, service providers, and suppliers

HSSE

KOC is fully committed to protecting the health and safety of its employees, including contractors, visitors, and the environment in the communities where it operates. KOC recognizes that by integrating health, safety, and environmental leadership into all aspects of its business, the methods of exploring for and producing Kuwaiti oil and gas resources can be improved for the benefit of the state of Kuwait, its employees, and its customers. KOC will achieve this through:

1. Meeting or exceeding all applicable health, safety, and environmental legislation and requirements of the State of Kuwait. Where adequate laws or regulations do not exist, KOC will adopt its own standards to safeguard human health and protect the environment.
2. Designing, managing, and operating its facilities to demonstrate effective health and safety management and promote pollution prevention, energy conservation, and optimization.
3. Assigning clear roles and responsibilities for all employees, providing necessary training, and emphasizing the belief that HSSE management is everyone's responsibility.
4. Providing adequate resources and knowledge to implement HSSE policies and programs.
5. Advocating the adoption of all relevant HSSE policies and requirements by contractors, visitors, vendors, and suppliers with the aim to prevent/minimize all types of incidents, injuries, occupational illnesses, and pollution.
6. Learning and implementing industry-best HSSE practices by participating in industry-wide associations, and by investigating and learning from incidents and historical practices.
7. Encouraging and strengthening communication within the Company and with suppliers, customers, visitors, and the community.
8. Recognizing good HSSE performance as a core value and promoting a positive HSSE culture to ensure sustainable development and business success.
9. Evaluating HSSE performance by monitoring ongoing performance results, proactively responding through periodic management review, and continually improving in the implementation of the HSSE Policy and Management System.

2

THE ARID ENVIRONMENT OF KUWAIT

Dry lands cover about 41% of global terrestrial areas. Like most deserts in the region, Kuwait is characterized by hyper-arid harsh climatic conditions particularly during summer that extends from May to September. The piercing sunlight with extreme temperatures and hot dry air make it impossible for humans to remain outdoors. Most homes and buildings are air-conditioned and outdoor plants are heavily watered to survive heat stress. When the dry wind accelerates, dust begins to blow, making it difficult to breathe or see the surroundings for several meters. However, surprisingly dust has some positive "value" for slightly dropping the temperature when it shields the sun's radiation (see Figure 2.1). Nevertheless, winter is mild and cool with rainfall that occasionally exceeds 100 mm.

Figure 2.1 A dusty day with low visibility in Kuwait

A general description of the area setting, climate, drainage basins, land degradation, and natural resources are presented in the following sections.

AREA SETTING

Located in the northeastern part of the Arabian Peninsula, Kuwait is a gently undulating small, flat desert country extending between latitudes 28°33′ and 30°05′ N and longitudes 46°33′ and 48°30′ E. It has approximately 1.78 million *ha* of land (17,818 km^2) including nearly 100,000 *ha* in large urban and industrial areas of the country and an equal area of island land.[1] Kuwait is situated within two main physiographic regions: to the south and southwest, there is a sequence of sedimentary rocks, whereas to the north and northwest, there is the Mesopotamian plain with the Euphrates and Tigris River deltas at the head of the Gulf. The surface topography is rather flat and includes gently rolling desert plains, broken by occasional low hills, scarps, and wadis. The ground slopes from about 300 m near Salmi in the southwestern corner to sea level at Khor Al-Sabiya in the north. The continuous northwestern slopes in the northern part of the country are interrupted by a very wide shallow inland depression with internal drainage systems, followed by a very gentle dome-shaped elevation acting as a local watershed (see Figure 2.2).

Figure 2.2 Low altitude aerial photo of the Northwestern part of Umm Al Rimmam Depression

DRAINAGE BASINS

The Northern and Western parts of Kuwait are intensively dissected by drainage basins of different features (see Figure 2.3). The deep sandy soils of several basins (e.g., Wadi Al Batin (see Figure 2.4a) and Wadi Al Auja) support the growth of dense vegetation cover (see Figure 2.4b).

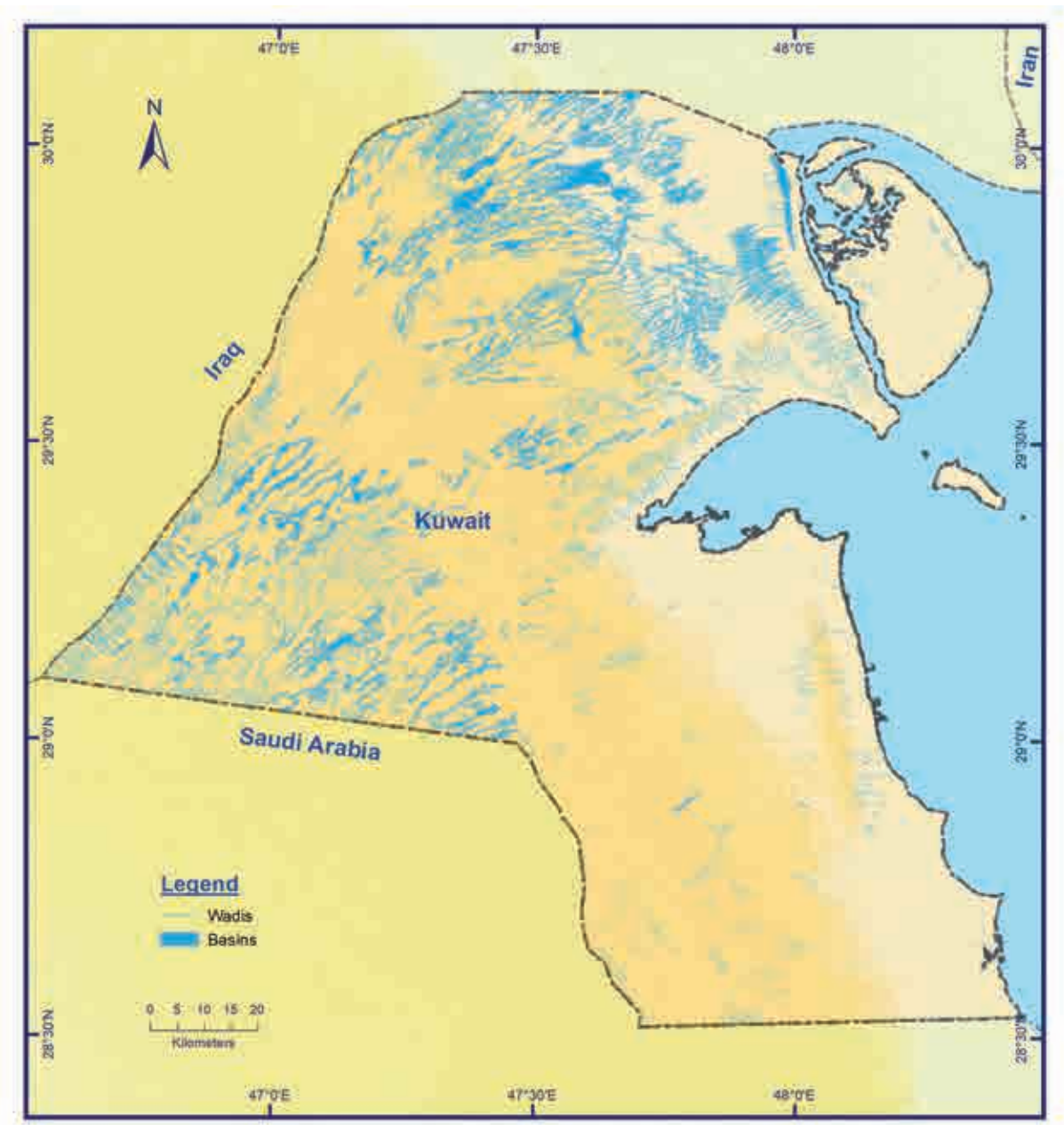

Figure 2.3 Drainage basins in Kuwait and adjacent areas[2]

Figure 2.4a Dense vegetation cover (mainly *Haloxylon salicornicum*) in Wadi Al Batin

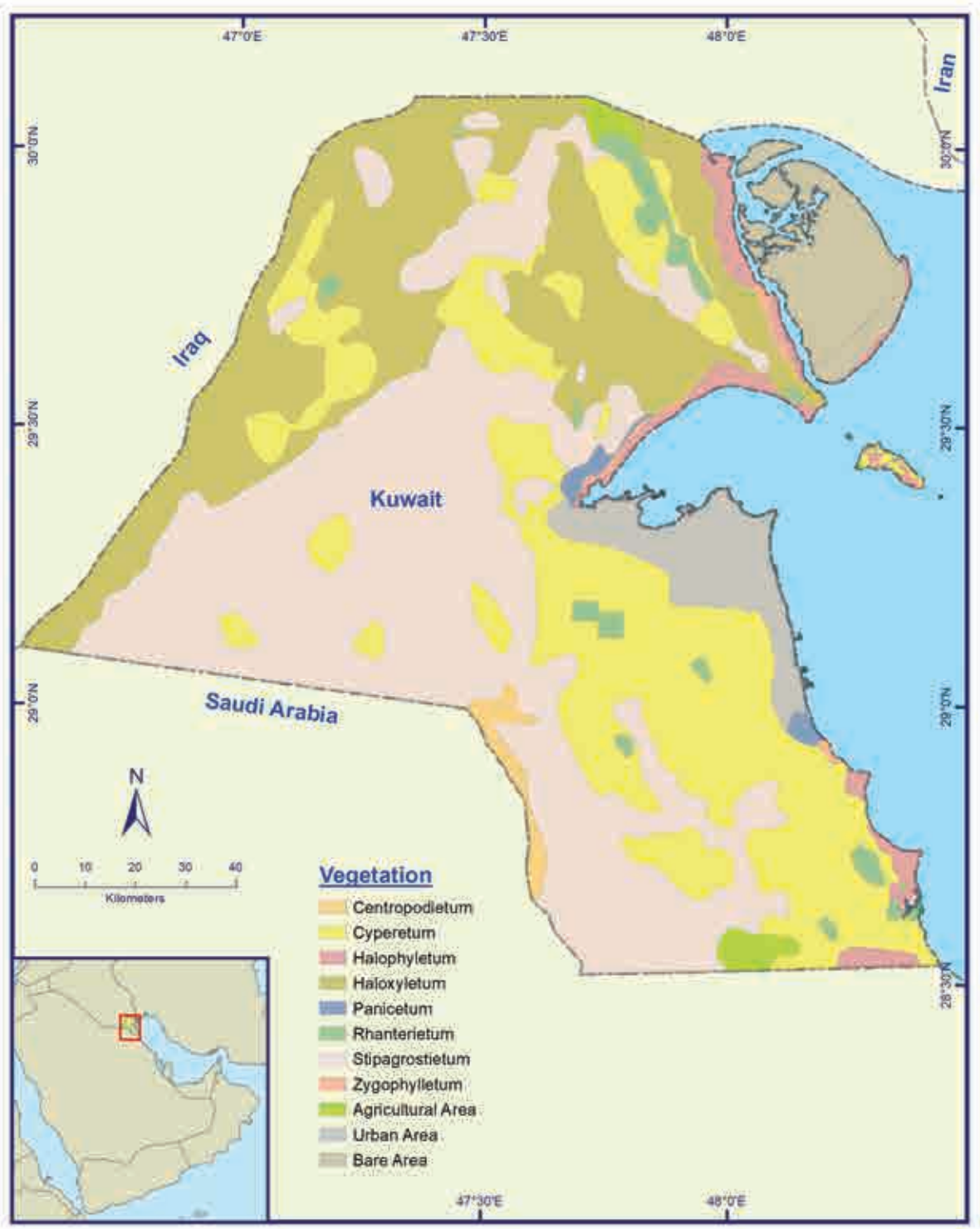

Figure 2.4b Vegetation map of Kuwait[3]

LAND DEGRADATION

Land degradation processes prevail in the majority of the terrestrial environment of Kuwait (Figure 2.5). Three classes of land degradation are identified. These are almost non-degraded, moderately degraded, and severely degraded. Land degradation processes include: soil salinization and water logging (Figure 2.6), loss of topsoils (through both wind and water erosion), soil crusting, sealing and compaction, vegetation degradation, and loss of biodiversity. As indicated in Table 2.1, about 11,330 km^2 of the terrestrial environment of Kuwait representing 72% of the country are degraded. For agricultural areas that cover 470 km^2 (2.6% of Kuwait), about 80 km^2 (17%) are degraded, while the rest (390 km^2) are non-degraded. Land degradation in agricultural areas is represented by soil salinization and loss of agricultural production.

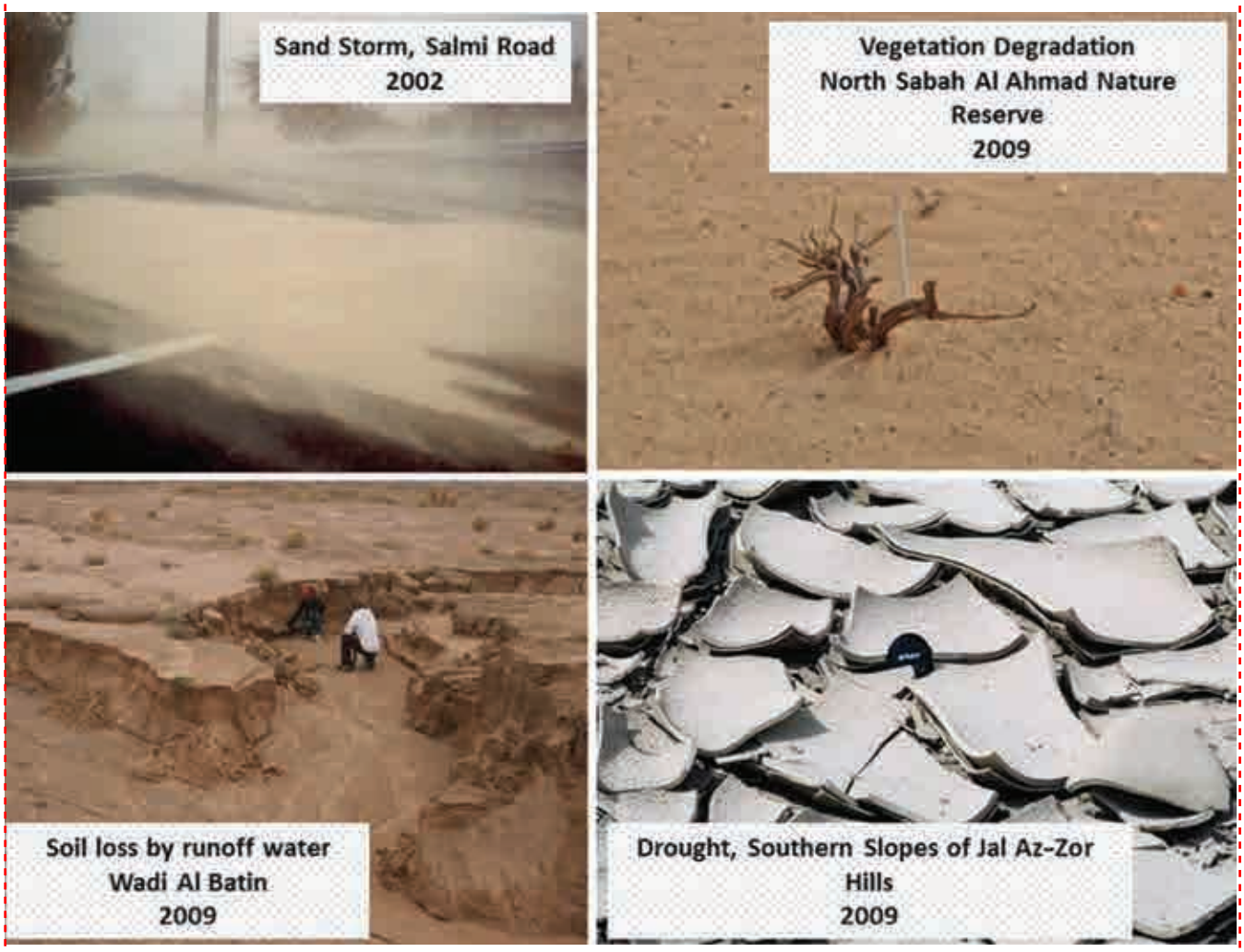

Figure 2.5 Indicators of land degradation and drought

Figure 2.6 Soil salinization and waterlogging, Wafra Farms, 2010

Table 2.1 Degraded and Non-Degraded Terrains, Terrestrial Environment of Kuwait (National Committee for Combating Desertification in Kuwait, 2015)

Land Use	% of Kuwait	Area (km^2)	Degraded	Non-degraded	Remarks
Livestock grazing	43	7,644	7,644 (100%)	0%	Loss of topsoils (by winds and water), degradation of vegetation cover, and loss of biodiversity are prevalent
Protected areas	18	3,242	1,679 (52%)	1,563 (48%)	1,679 km^2 are under protection (still opened)
Spring camping and recreation	8	1,479	1,479 (100%)	0%	Total area 1,479 km^2 for the year 2014, severe soil compaction and soil mining
Oil operations	6.6	1,177	114 (10%)	1,063 (90%)	114 km^2 of oil lakes
Military uses	4	688	100 (15%)	588 (85%)	Surface disruption in areas of maneuvers
Agriculture	2.6	470	80 (17%)	390 (83%)	Soil salinization and loss of topsoil (by wind and water) are prevailing in parts of several farms
Abandoned gravel quarries	2.1	383	203 (53%)	180 (47%)	Severe degradation at watershed areas especially in the northwestern wadis
Other uses	4	657	31 (5%)	626 (90%)	—
Total	**88**	**15,740**	**11,330 (72%)**	**4,410 (28%)**	

Soil Erosion

In Kuwait, soil erosion by wind (wind erosion) is the most widespread form of land degradation, contributing to at least 70% of the degraded lands. Soil erosion by wind widely occurs in the main northwestern sand corridor (Figure. 2.7). The consequences of wind erosion on roads can be seen in Figure 2.8.

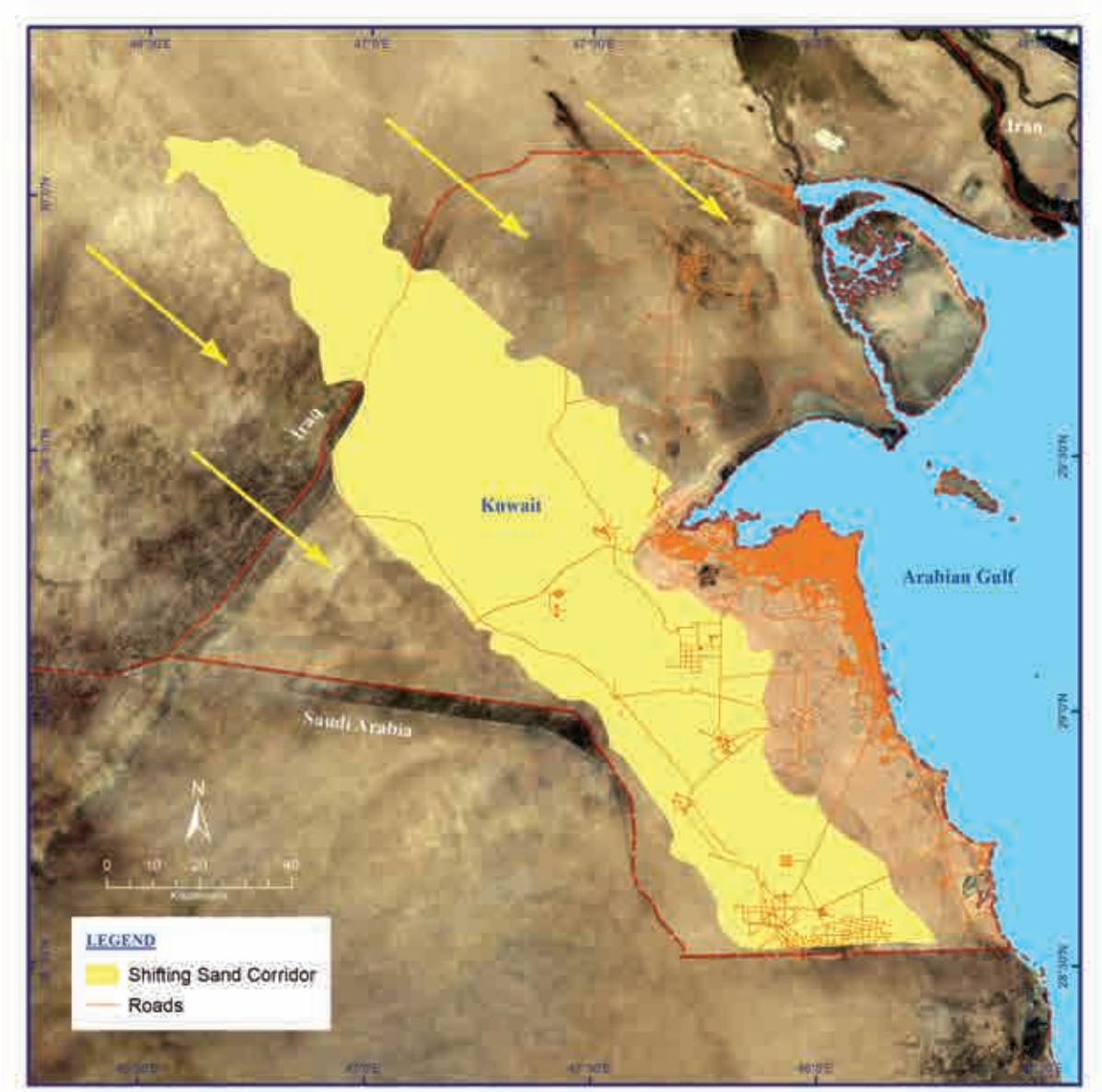

Figure 2.7 Main northwestern sand corridor[2]

Figure 2.8 Consequences of soil erosion by wind (top is Sabiya Road; bottom is Wafra, Mina Abdallah Road) (June 2015)[2]

CLIMATE

The climate is extremely hot and dry during the summer with long, intense sunshine hours and moderately cool short winters with occasional rain. The average daily maximum temperatures varied from 18.9°C (10-year average from 1996–2004) during January to 46.8°C in July. Rainfall, which occurs anytime between mid-October and late April, is minimal; averaging about 115 mm.y^{-1} (fluctuates between 25 and 250 mm), but evaporation is very high, ranging from 3.1 to 21.6 mm.d^{-1} (see Tables 2.2 and 2.3). Low relative humidity and strong, dry, and hot northwesterly winds prevail during summer, particularly in June and July. The annual rainfall from 1999–2004 increased by 18.67 mm.y^{-1}, whereas the evaporation increased 0.97 mm.d^{-1}. Therefore, the climate of Kuwait and most Gulf Cooperation Council (GCC) countries can be classified as hyper-arid.

Table 2.2. Maximum, average, and minimum air temperatures from 1962–2014 (in Celsius)

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum	16.7	18.2	23.6	29	34.3	38.6	40	39.6	35.6	30.2	22.2	17.5
Average	12.9	15.1	19.6	25.5	32.1	36.7	38.3	37.5	34	27.8	20.2	14.4
Minimum	7.6	11.9	16.4	22.9	27.9	33.4	36.6	35.1	32.1	24.6	16.5	10.8

Table 2.3 Monthly rainfall (mm) from 1960–2013

Month	Maximum	Minimum	Average
January	126	0.9	26
February	54.1	0.5	10
March	29.9	0.2	10.4
April	26.4	0.2	7.1
October	2.8	0.1	0.36

Drought

During the last five decades, Kuwait experienced a number of dry seasons during which rainfall was below 110 mm/year (average level). A period of drought was recorded between the 2007/2008 and 2012/2013 seasons. During these seasons the rainfall ranged between 35–65 mm. As a result, severe soil and vegetation degradation prevailed even in several protected areas.

SOILS

Kuwait's soils are generally poorly developed, mainly sandy, and low in organic matter and water retention capacity. Aridsols (70.8%) and Entisols (29.2%) are the main soil orders. According to the soil taxonomy procedures recommended by the United States Department of Agriculture, the soils of Kuwait are identified and characterized into eight great soil groups: 1) Aquisalids, 2) Calcigypsids, 3) Haplocalcids, 4) Haplogypsids, 5) Petrocalcids, 6) Petrogypsids, 7) Torriorthents, and 8) Torripsamments (see Figure 2.9). Of these, Petrogypsids and Torripsamments are the most common. The Petrogypsids occur on level to gently sloping plains formed on the sand and gravel deposits of the Dibdibah Formation. The Torripsamments, on the other hand, normally occur on extensive sand sheets in the central and southeast part of the country.

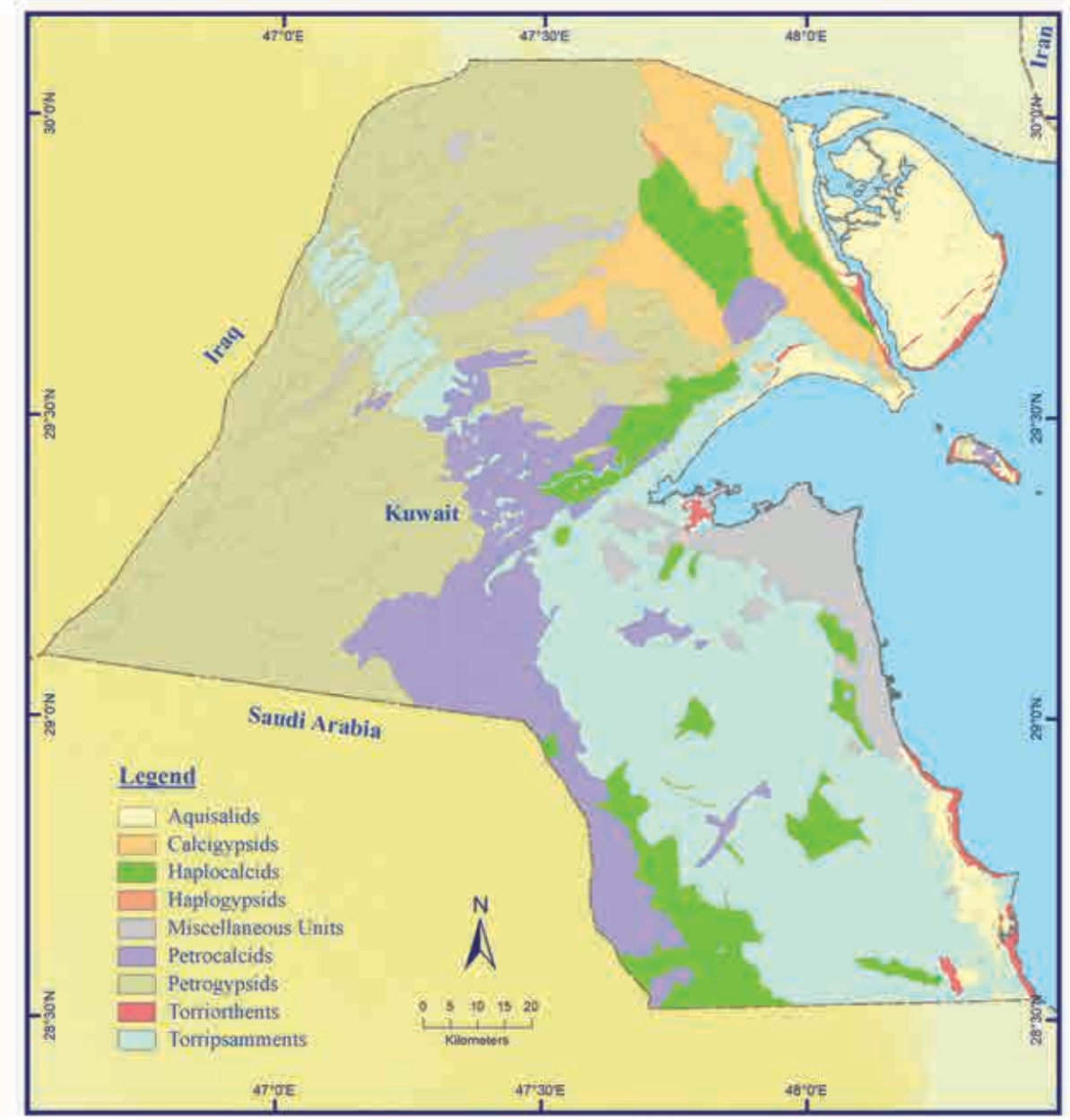

Figure 2.9 Soil types of Kuwait[4]

WATER RESOURCES

Kuwait is an extremely hot and arid country that lacks any freshwater lake or river system. Even the country's groundwater supply is mostly saline, with only two relatively small areas in the country being tapped for their groundwater supplies (Figure 2.10). Rainfall in the country varies on average between 75–110 mm per year. However, rainfall in Kuwait is extremely unpredictable—as little as 22 mm of rain may be measured one year while the next it may be significantly higher.

Kuwait's groundwater resources are negligible. Due to extremely high evaporation losses and the high deficit in Kuwait's soil moisture, only a small percentage of the limited precipitation that the country receives infiltrates into the groundwater supply. According to information published by the Public Authority of Agriculture Affairs and Fish Resources (2006), Kuwait's groundwater can be divided into three categories according to its salt content. The first is fresh groundwater, with a content of soluble salt of less than 1,000 mg/l. This water, which is found in the Rawdhatain and Umm Al-Aish fields, is not used for agriculture and is considered as a strategic freshwater reservoir for drinking. The second is brackish groundwater with a soluble salt content ranging from 1,000 to 7,000 mg/l. This water is produced from the Al Shigaya, Umm Qadeer, Sulaibiya, Wafra, and Abdali fields and used mostly for agriculture and domestic purposes and as drinking water for cattle. The last category of Kuwait's groundwater supply is saline water with a soluble salt content between 7,000 to 20,000 mg/l. This water is not appropriate for agricultural or domestic use.

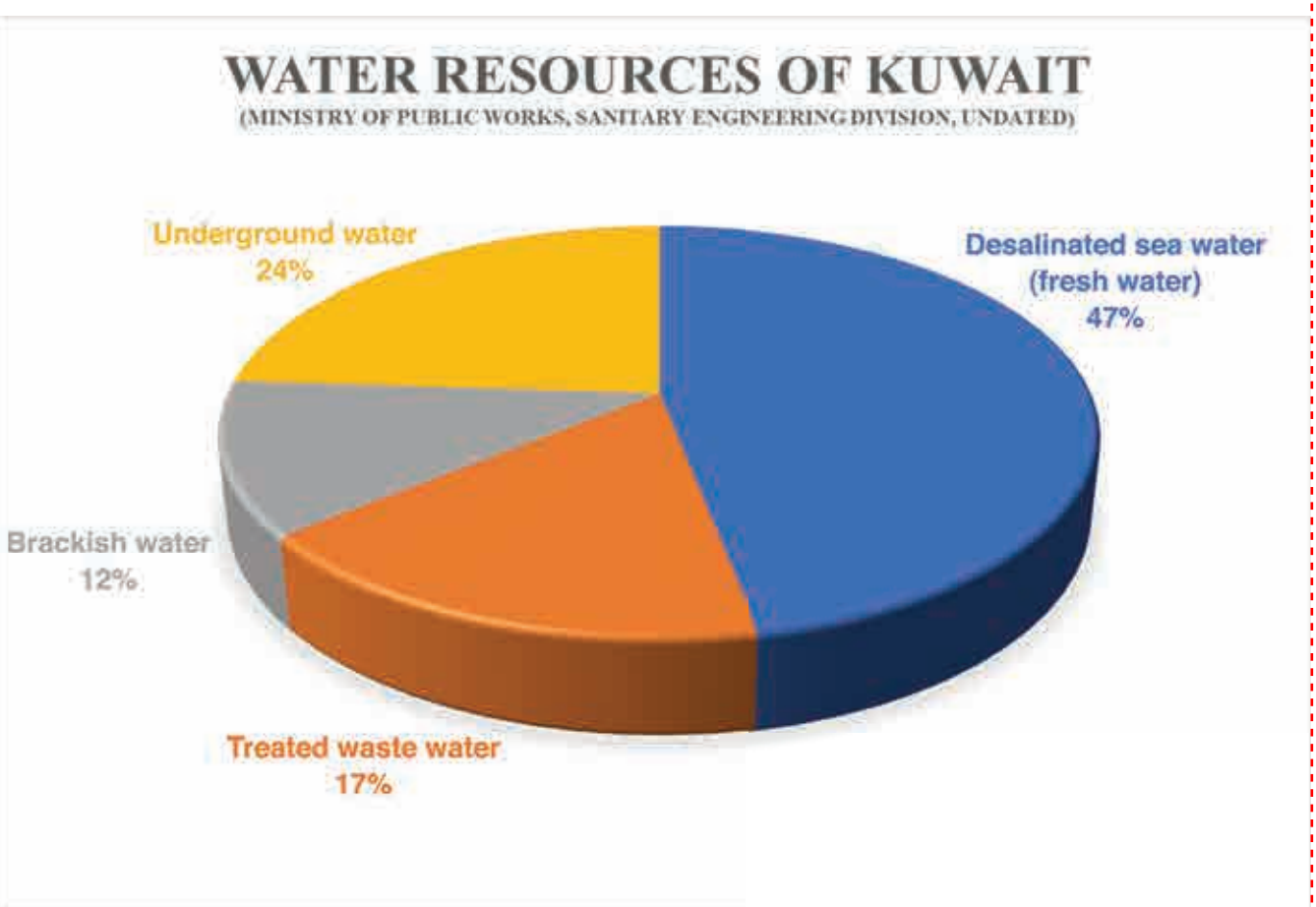

Figure 2.10 Water resources of Kuwait

VEGETATION

Based on variations in habitat landform and soil characteristics, the floristic composition, and the dominant species, six ecosystems have been identified:

1. Coastal plain and lowland
2. Desert plain
3. Alluvial fan
4. The escarpment, ridge, and hilly
5. Wadi and depression
6. Barchan dunes, nebkas, and sand sheets

The **coastal plain** and **lowland** ecosystem covers areas along the coastline from the north to the south and the islands of Kuwait (Figure 2.11). It includes salt marsh and saline depressions and contain halophytic species, such as *Halocnemum strobilaceum* and *Nitraria retusa* in salt marshes and *Halocnemum strobilaceum*, *Bienertia cycloptera, Cressa cretica*, and *Zygophyllum qatarense* in saline depressions.

Figure 2.11 Coastal plain and lowland ecosystem

The **desert plain** ecosystem is located west of the coastal plain and extends to the southwestern borders and into the northeastern part of Kuwait. This ecosystem is characterized by the aeolian deposits in the form of sand sheets, wadi fill, sand dunes, and sand drifts. The dominating plant communities of this ecosystem are: *Cyperatum*, *Rhanterietum*, *Haloxyletum*, and *Panicetum*.

The **alluvial fan** ecosystem occurs in the western, central, and northern parts of the country (Figure 2.12). The soils in this ecosystem vary considerably with gypsic cemented hardpans (locally known as "gatch") occurring at various depths in the soil profile. Clumps of *Haloxylon salicornicum* are present on sand accumulations.

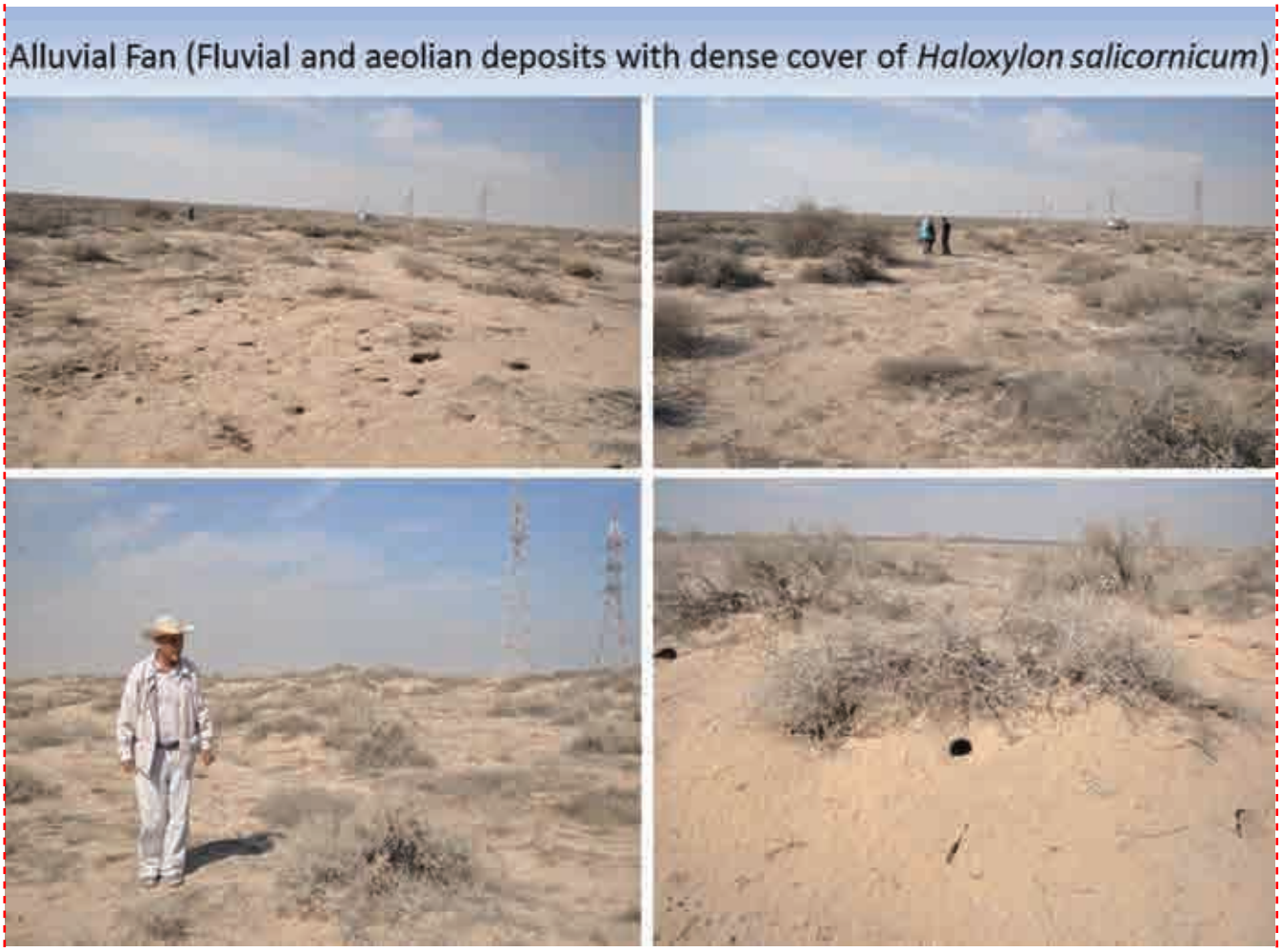

Figure 2.12 Alluvial fan ecosystem

The **escarpment**, **ridge**, and **hilly** ecosystem, which includes the most prominent geomorphological features of Kuwait known as the Jal Az-Zor escarpment, runs parallel to the northern shores of Kuwait bay and is dominated by mixed strands of vegetation (Figure 2.13).

Figure 2.13 Escarpment, ridge, and hilly ecosystem

The **wadi** and **depression** ecosystem is scattered within the drainage systems and includes two major wadis, the Wadi Al-Batin and Wadi Umm Ar. Rimam (Figure 2.14). The main species of Wadi Al-Batin are *Astragalus sieberi* and *Haloxylon salicornicum*, whereas Wadi Umm Ar. Rimam is inhabited by *Ochradenus baccatus*, *Calligonum polygoides*, *Chrozophora* sp., *Savignia parviflora*, *Trigonella anguina* and *Gynandriris sisyrinchium*.

Figure 2.14 Wadi and depression ecosystem in the buffer zone on the Kuwait-Iraq border

Barchan are **sand crescent/arc-shaped sand dunes** formed along the direction of the wind. They can change their shape and location when the wind direction changes. Each of these ecosystems consists of a dominant plant community and several associated species (see Figure 2.15).

Figure 2.15 Barchan dunes, nabkas, and sand sheets

LAND USE AND LAND COVER

Rangeland covers 75% of the total area and is mainly used for grazing and recreational (camping) activities—the dominant land use. Part of Kuwait's land has been designated as protected areas (about 18%). Other significant land uses include: oil fields (7%), military activities (4%), built-up urban areas (4%), agriculture (3%), and quarries, borrow pits, landfill sites, communication facilities, power stations, racetracks, park lands, and unused areas (7%) (Figure 2.16). In Kuwait, land resources are used for livestock grazing, water production, oil production, sand and quarrying, agricultural production, and camping/bird hunting during the winter season.

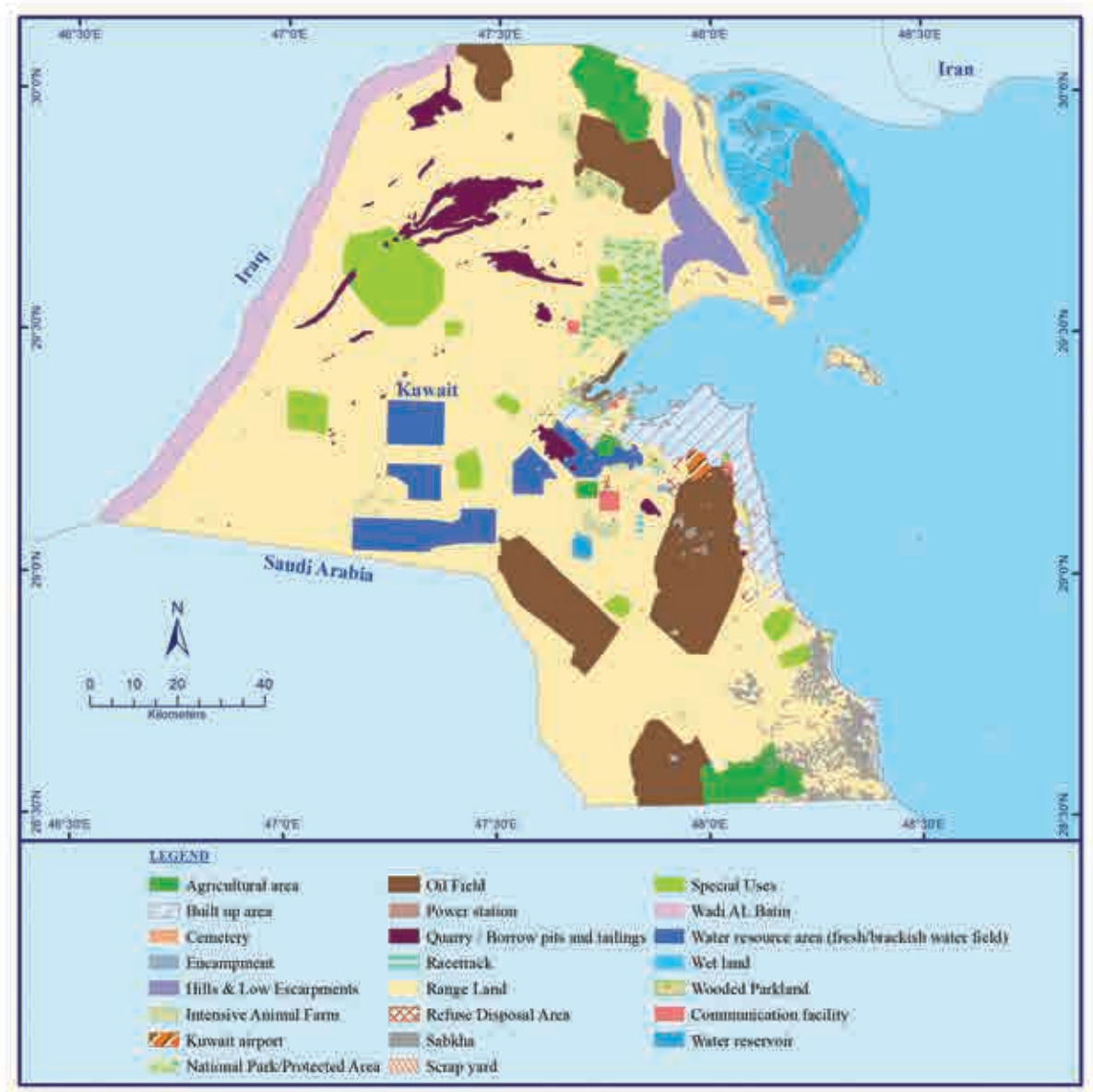

Figure 2.16 Land use/land cover in Kuwait[5]

3

BIODIVERSITY AND PROTECTED AREAS

Kuwait's biodiversity includes 374 types of plants of which annuals make up 256 species. There are also 28 mammalians, 40 reptilians, and 300 bird species (see Figures 3.1–3.23). Vegetation is an open scrub of shrublets (34 species) that extend from the southwestern deserts of Iraq to the northern deserts of the Kingdom of Saudi Arabia. For many centuries across the Arabian Peninsula, the desert rangelands have provided important forage for wildlife and livestock grazing by camels, sheep, and goats as well as offering a valuable gene pool and plant material for food, medicine, and fiber. Native plants, however, are highly vulnerable to modern human-induced changes providing a valuable indicator of human perturbation.

Figure 3.1 Rumex vesicarius (*Hummayd*)

Figure 3.2 *Bromus* species

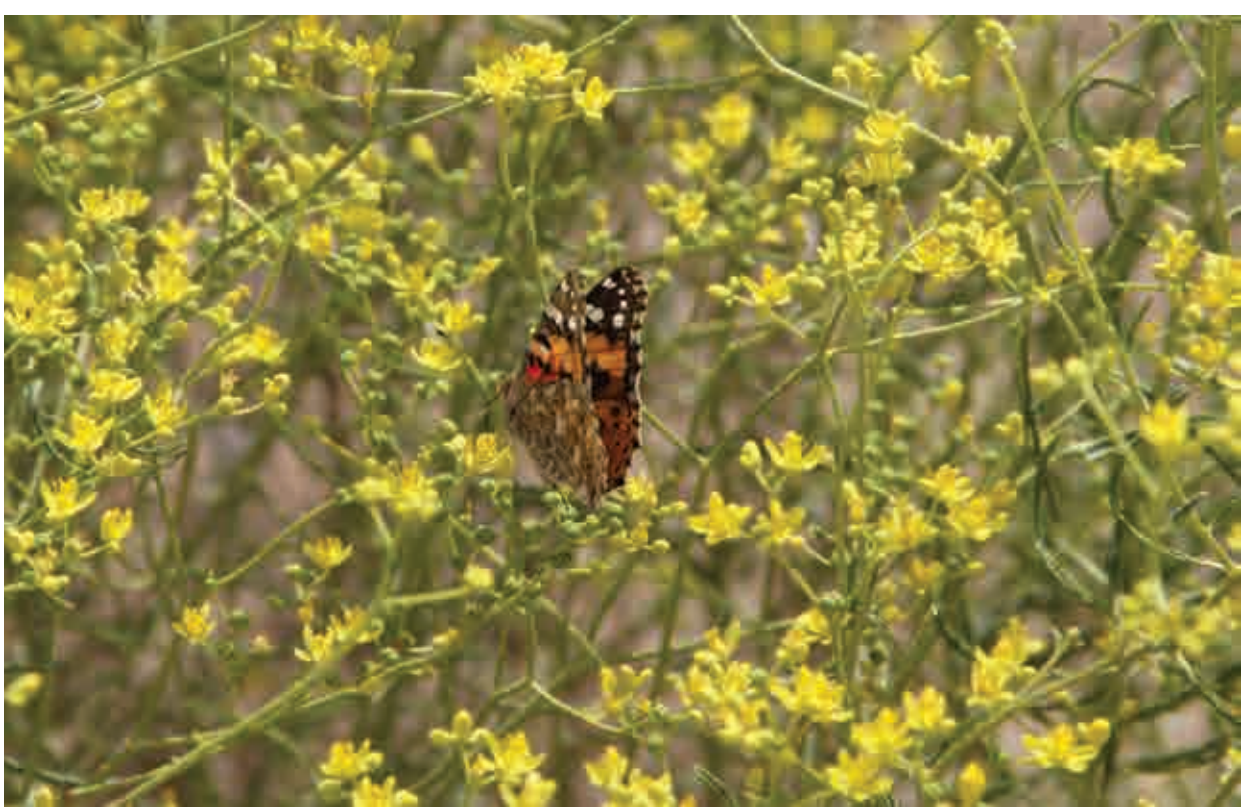

Figure 3.3 *Haplophyllum tuberculatum* (Al Musaikah)

Figure 3.4 *Anisosciadium lanatum* (dry fruit)

Figure 3.5 *Asphodelus tenuifolius* (Barwag)

Figure 3.6 *Echium rawolfii* (Kahil)

Figure 3.7 *Carthamus Oxyacantha* (Zafaran, Usfur)

Figure 3.8 *Carduus pycnocephalus* (Shadq Al-Jamal)

Figure 3.9 *Calligonum polygonoides* (Artah)

Figure 3.10 Wildflowers of Kuwait

Figure 3.11 *Anthemis deserti* (Iqhowan)

Figure 3.12 *Allium Sphaerocephalum* (Khurait)

Figure 3.13 Woodchat Shrike (*Lanius senator*)

Figure 3.14 Red-backed Shrike (*Lanius collurio*)

Figure 3.15 Steppe eagle and greater spotted eagle (*Aquila nipalensis* and *Clanga clanga*)

Figure 3.16 European bee-eater (*Merops apiaster*)

Figure 3.17 Steppe eagle (*Aquila nipalensis*)

Figure 3.18 Rufous-tailed Rock Thrush (*Monticola saxatilis*)

Figure 3.19 Steppe buzzard (*Buteo buteo vulpinus*)

Figure 3.20 Rüppell's fox (*vulpes Rueppellii*)

Figure 3.21 *Uromastyx aegyptius* (dhub lizard)

Figure 3.22 *Acanthodactylus-scutellatus* (fringe-fingered lizard)

Figure 3.23 Camels grazing in the desert of Kuwait

Despite the intensive heat and low rainfall, protected areas in arid lands can offer immediate benefits to human society by maintaining a range of critical ecosystem services. For example, they help to maintain the following:

- Water supply: protects essential water supplies for domestic and agricultural needs
- Food security: protects crop's wild relatives and local cultivars, both of which can play vital roles in crop breeding programs
- Disaster reduction: native vegetation stabilizes dry land soils, reducing erosion, dust storms, dune formation, and desertification
- Carbon storage: conserves or restores vegetation and soil humus in dry land areas
- Drought resilience: protects against the effects of drought by maintaining natural vegetation as emergency food and livestock fodder
- Cultural survival: natural ecosystems are also important for local cultures and faiths

AREAS OF HIGH BIODIVERSITY IMPORTANCE IN KUWAIT

Kuwait is committed to building a comprehensive protected area system and developing tools and systems to facilitate this process. In doing so, the country can draw both on existing conservation prioritization processes and on gap analyses specifically developed for Kuwait; both options are described as follows.

- Global Prioritization Processes: There are at least ten global conservation prioritization exercises in existence.[1] The large majority do not cover the Gulf States because they are focused on areas either of high biodiversity or of rapid ecological change. For example, Kuwait is not listed in the World Wildlife Fund/International Union for Conservation of Nature (WWF/IUCN) Centres of Plant Diversity analysis.[2] There is a proposal for developing a list of important plant areas for the Arabian countries, which include Kuwait, but there is no evidence that this process has been completed. Similarly, Kuwait does not feature in the conservation international biodiversity hotspots or its high biodiversity wilderness area analysis. There are three exceptions to the information gaps around the Gulf States: the WWF global eco-regions analysis; the Birdlife International assessment of important bird areas; and a collaborative effort between the Ramsar Convention and IUCN to identify wetlands of international significance in the Middle East.
- Global 200 Eco-Regions: Part of Kuwait is included in the Global 200 eco-regions analysis[3] within the freshwater *Mesopotamian Delta and Marshes Eco-region*.[4] The eco-region covers 100,000 km^2 of the deltas from the Euphrates, Tigris, and Karun Rivers in Iraq, Iran, and Kuwait. Kuwait is included within the eco-region, but it falls outside the main delta. Ecological conditions on the north of Boubyan Island most closely resemble those within the eco-region and, therefore, it is possible to say that Boubyan Island falls into the eco-region.
- Important Bird Areas: Birdlife International has two important prioritization processes: endemic bird areas (EBA) and important bird areas (IBA). Kuwait falls just outside the Mesopotamian Marshes EBA identified by Birdlife International[5] although one of the restricted range species triggering the EBA, the Iraq babbler (*Turdoides altirostris*), is recorded as being from Kuwait. However, Kuwait is included in the IBA analysis with eight sites (some existing and some planned) identified in the country as listed below:
  - Al-Doha Nature Reserve
  - Al-Abraq Al-Khabari
  - Al-Batin Park
  - Al-Jahra Pool Nature Reserve (see Figure 3.24)
  - Dawhat Kazima
  - Jal Az-Zor
  - Kubbar Island
  - Sulaibikhat Bay
- Directory of Middle East Wetlands: an initiative to identify important wetlands of the region[6] listed five sites from Kuwait as follows:
  - Al-Jahra Pool Nature Reserve
  - Dawhat Kazima
  - Sulaibikhat Bay and Doha Peninsula
  - Kubbar Island
  - Al Khiran

Figure 3.24 Al-Jahra Pool Nature Reserve

PROTECTED AREAS IN KUWAIT

Kuwait's protected area system has been planned to include both sites of known ecological interest and some sites requiring ecological restoration. This mixture is needed because of the wide-ranging war damage and the need to restore ecological services. The national system would therefore, at least initially, be rather unusual in featuring both relatively pristine and seriously degraded areas. Selection would nonetheless be focused on key ecological principles.

Because Kuwait is in the early stages of establishing a national protected areas system, it has an ideal opportunity to do so in the context of international norms and standards, rather than attempting to retrofit these later onto an existing system. This means confirming to the IUCN definition and management categories of protected areas. According to IUCN,[7] a protected area is: "A clearly defined geographical space, recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values."

Kuwait already has some protected areas allocated in the Kuwait Master Plan Review. The current World Data on Protected Areas (WDPA) list for Kuwait was analyzed, and the data have been taken both from the new Protected Planet site and the 'old' WDPA site. Table 3.1 lists all protected areas on the WDPA with details from the website and in some cases also from the authors' experience.

The WDPA records for Kuwait are clearly no longer accurate. The list is far too long, and some existing protected areas are omitted while many *potential* protected areas have been listed for a long time without further progress being made. Many do not match current plans for new protected areas. The location of the protected areas is shown in Figure 3.25.

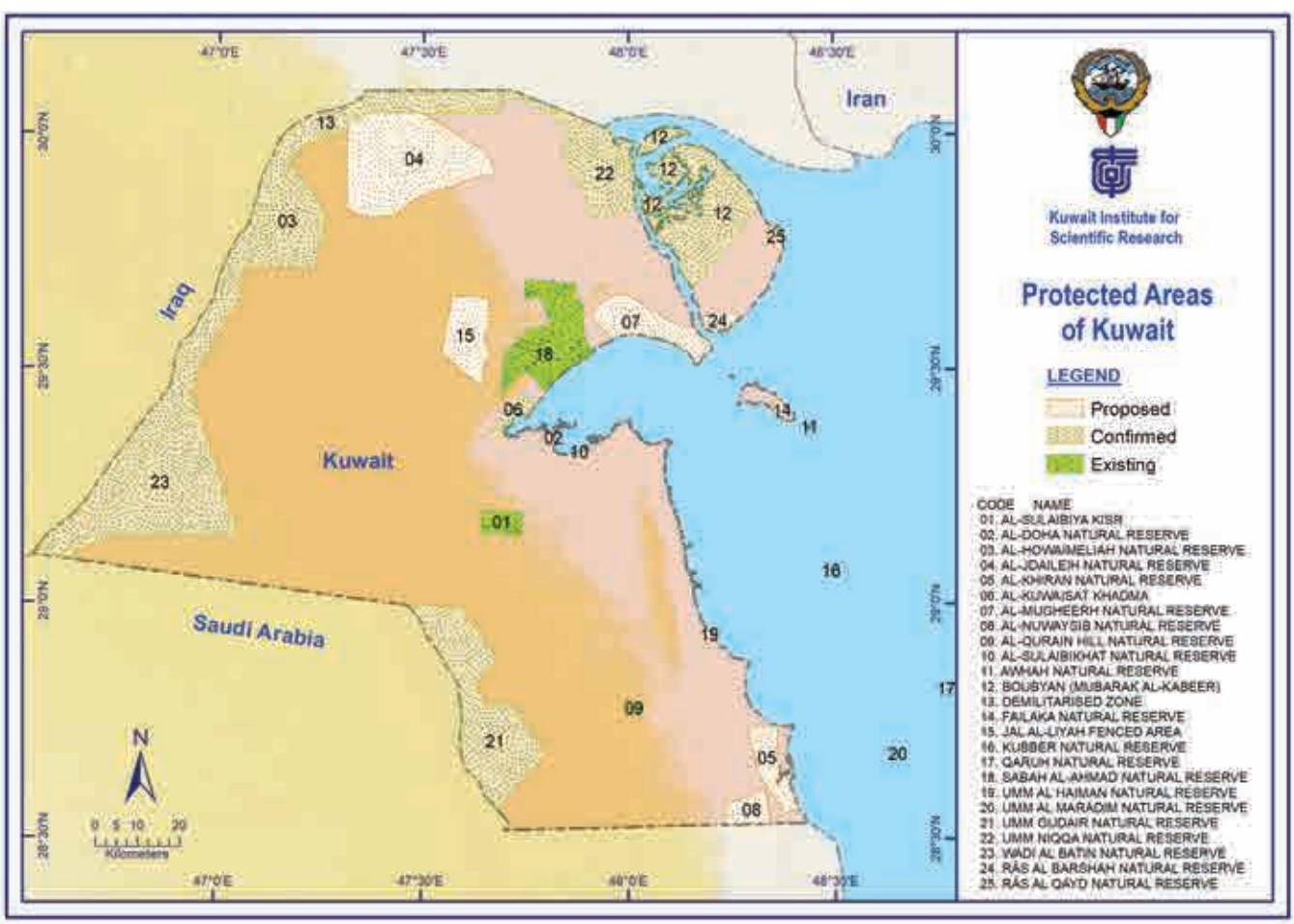

Figure 3.25 Protected Areas of Kuwait 2017

Table 3.1 Updated List of Current and Proposed Protected Areas from the World Database on Protected Areas (2012). (MPA: Marine Protected Area, IBA: Important Bird Area)

Name	Size (ha)	Other Details
Sabah Al Ahmad Nature Reserve/ Jal Az-Zor National Park (see Figures 3.26 and 3.27)	33,000	Status: Legally designated in 1990. Inaugurated in 2004.
Al-Doha Nature Reserve	450	Sandy sabkhah flooded by exceptional tides, important for wading birds, particularly crab plover (*Dromas ardeola*) and Eurasian curlew (*Numenius arquata*) (data from IBA website). Salt-tolerant plants. Bisected by road, near power station. Status: Legally designated, no date given.
Kubbar Island	18	Listed as an MPA. Important breeding colony for terns: lesser crested (*Sterna bengalensis*), bridled (*S. anaethetus*), white-cheeked (*S. repressa*), and great crested (*S. bergii*). Status: Proposed.
Mughayrah	Terrestrial and marine	Coastal sabakha and mudflat area. Archaeological site. Status: Proposed.
Al Batin Security Area	57,500	Western and northern border with Iraq. IBA because of Eastern Imperial Eagle (*Aquila heliaca*). Large area but impacted by grazing and camping, important water source (data from IBA website). Status: Officially designated as Protected Security Area by the Council of Ministers in 2011.
Al-Liyah	19,000	Designated by the Council of Ministers in 2005. Rehabilitated gravel quarry area by the Kuwait Institute for Scientific Research (KISR).
Al Kuwaisat Khadma	Terrestrial and marine	Sabkha area. Status: Proposed.
Umm Niqqa Desert Nature Reserve	21,620	Listed as MPA on WDPA, but this seems unlikely. Status: Proposed—pending legal designation by Municipality Council in 2012.
Al-Huwaymillyan	27,300	Status: Legal designation by the Council of Ministers in 2011.
Umm Al-Judaliyat	Unknown	Status: Proposed.
Boubyan Island and Warba Island with surrounding marine areas. (Mubrak Al Kabeer Reserve)	66,000	Coastal and MPA. Important migratory birds breeding island and lagoons. Status: Designated by the Council of Ministers in 2011.
Khawr Mufattah Protected Area	No data	Mentioned as a proposed protected area in 1991 following the first Gulf War in southern Kuwait and on the WDPA, but no details available. Listed as an MPA. Status: Designated 1990. This area is unlikely to be established as an MPA due to recent developments at Al Khiran area.
Al Khiran Desert Park	No data	No data. Status: Proposed but unlikely to be developed due to recent developments at Al Khiran Area.
Umm Gudair	54,570	Terrestrial
Jahra Pool Nature Reserve	250	The only significant area of non-marine wetland in the country, man-made by effluent coming from Al-Jahra town and flowing across sandy sabkhah to the sea, forming stagnant, open, shallow pools and extensive beds of *Phragmites*. There are scattered halophytes on the sabkhah. Listed as an IBA on the basis of lesser kestrel (*Falco naumanni*) and imperial. Status: Legally designated, 1990.
Qit'at Uraifjan Nature Reserve	No data	Status: Proposed.

Getty Reef Nature Reserve	No data	MPA. Status: Proposed.
Umm Al Maradim Marine Reserve	No data	MPA—offshore island and marine turtle nesting site. Status: Designated in 1977 according to the WDPA, but also listed as a potential site[8] (and as a potential site by KISR).
Qaruh Marine Reserve	No data	Offshore atoll, marine turtle nesting site, mentioned as a project focus of the Kuwait Marine Turtles Organization. Status: Proposed.
Naval Base Reef Nature Reserve	No data	Status: Proposed.
Sulaybia Experimental Station	4,000	Incorrectly listed as an MPA on the WDPA. Desert plain ecosystem dominated by the *Rhanterium epapposum* plant community. Status: Legally designated in 1979 for research and development. Renamed in 2015 by KISR as KISR Station for Research and Innovation (KSRI).
Dawhat Al Zorq Nature Reserve	No data	Not listed as an MPA, but location and other information suggested that it is a marine area. Status: Proposed.
Idries Rock Nature Reserve	No data	Status: Proposed.
Umm Al Aish Rock Nature Reserve	No data	Marine area. Status: Proposed.
Oit'at Mudayrah Nature Reserve	No data	Not marked as an MPA but location map suggested that it is a marine area. Status: Proposed.
Failaka Island Nature Reserve	No data	Status: Proposed on WDPA and both proposed and designated in 1990 on MPA database. Not officially designated.
Al Qurain	No data	Established in 2011.

Figure 3.26 Sabah Al Ahmad Nature Reserve ridges and plains

Figure 3.27 Lake at Sabah Al Ahmad Nature Reserve

4

ENVIRONMENTAL DAMAGE FROM THE IRAQI INVASION

AGGRESSION AGAINST THE ENVIRONMENT

At the end of the Gulf War in 1991, the retreating Iraqi soldiers detonated more than 700 oil-producing wells in Kuwait. The gushing oil wells created numerous oil lakes and tar mat areas that extended for more than 49 square kilometers.[1] The oil well fires produced an enormous amount of smoke and tons of soot that plunged the area into darkness (see Figure 4.1).

Effects of Oil Pollution on Soil

The detonation and damage of oil wells and oil infrastructure resulted in contamination of the soil surface and, in some areas, deep penetration of oil into the soil. Contamination occurred from: 1) oil spreading over the land surface and penetrating the soil to varying depths, 2) aerial fallout from oil spray and combustion products from oil fires, and 3) formation of oil lakes (see Figure 4.2) in depressions on the surface of the land. Field surveys identified four types of oil-contaminated soil layers (soot, tar mat, oily soil, liquid oil) plus a *clean* soil type. The contaminated layer types and the organization of these layers provided information on the overall contamination category, which were labeled as oil lake, dry oil lake, tar mat, soot, or clean (with no visible contamination).

The contaminated volume of soil was estimated to be 26 million cubic meters out of which the Al Burgan area contaminated soil volume was 24.4 million cubic meters. The bulk of the contaminated soil occurred in the dry oil lake and oil lake areas, and oily soil is the dominant contaminated soil layer type (see Figures 4.3–4.5).

Effects of Oil Pollution on Groundwater

The elevation of groundwater in Kuwait varies from 100 m above sea level in the southwest corner of the country to sea level at the Arabian Gulf in the northeast. The quality varies from brackish in the south and central areas to saline in the north. Fresh groundwater sources are mainly found in the northern parts of Kuwait at Raudhatain and Umm Al-Aish, which are within the oil production areas that were detonated during the Iraqi invasion to Kuwait.

An elaborate study was completed by Kuwait Institute for Scientific Research (KISR) in early 2016, where the hydrocarbon and salt contamination of the freshwater fields of the Raudhatain and Umm Al-Aish areas in North Kuwait were investigated. The study concluded that 1) significant contamination of groundwater by hydrocarbon and salts has taken place in the neighborhood of the main oil lake in the Umm Al-Aish water field; 2) good correlations between the total dissolved solids and petroleum hydrocarbon concentrations suggest that there is simultaneous movement of hydrocarbons and salts that are leached from the surface soil by the infiltration of surface runoff;[2] 3) contamination in the Raudhatain water field is at a much lower level and is mainly confined to the southeastern part of the field; 4) similar assemblages of microbes were detected in the groundwater of both contaminated and uncontaminated sites, though contaminated sites had a somewhat higher relative abundance of hydrocarbon degrading bacteria;[3] 5) some biodegradation of the hydrocarbon contaminants is taking place in the western fringe of the Umm Al-Aish oil lake where a possible presence of a body of nonaqueous phase petroleum liquid (NAPL) nearby has been inferred;[4] and 6) the attenuation of contamination along a northeast trending transect away from the Umm Al-Aish oil lake is mainly due to dilution.

Figure 4.1 Oil wells set ablaze and destroyed by retreating Iraqi troops

Figure 4.2 Oil spread over fields created large oil lakes

Figure 4.3 Contaminated soil due to oil trenches

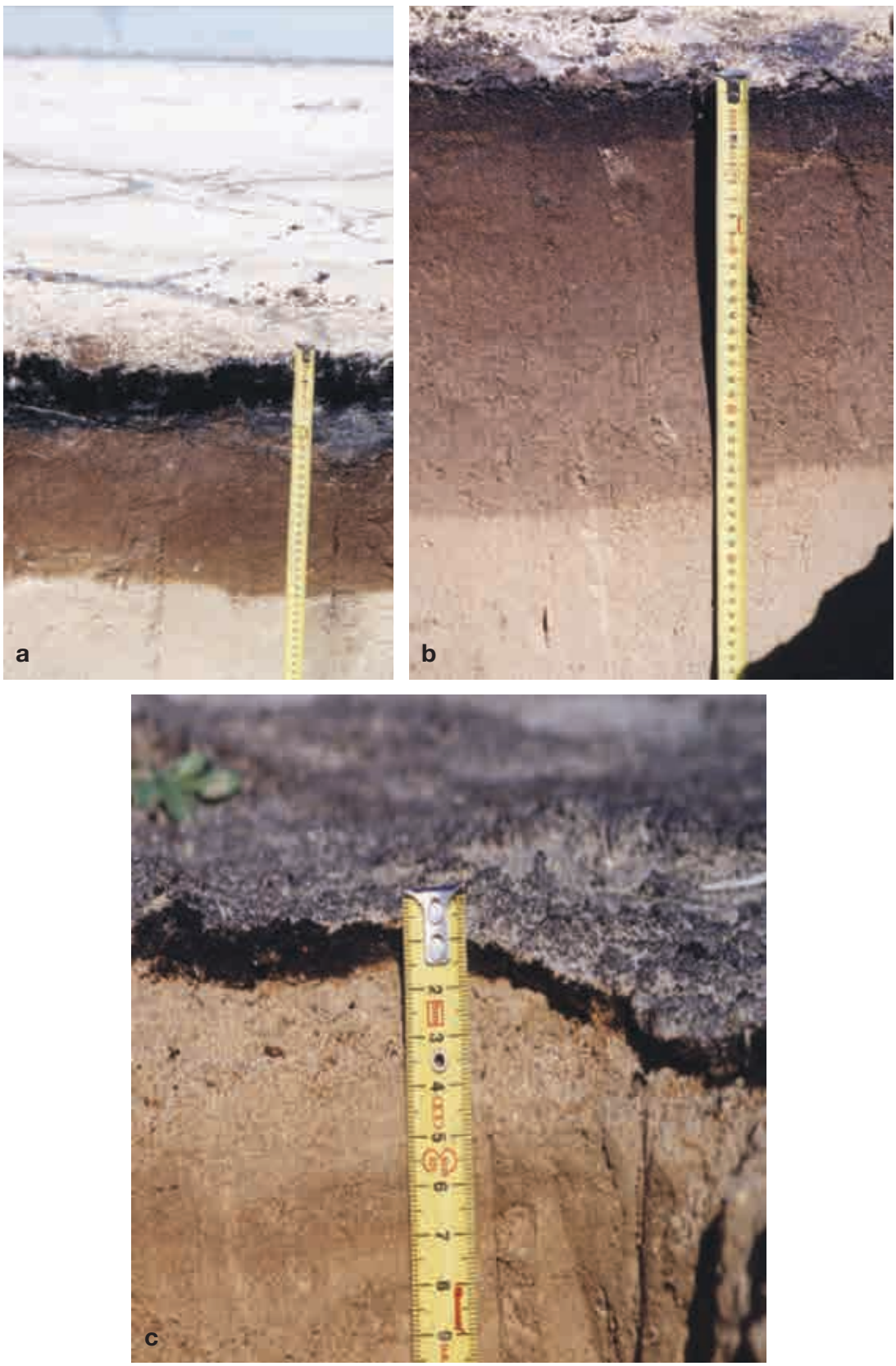

Figure 4.4 Various types of oil pollution to the soil: a) the oil lake category consists of a liquid or semi-solid oil layer over an oily soil; b) the dry oil lake category consists of a tar mat layer over an oily soil that has a dark brown color, oily smell, and friable consistency; and c) the tar mat category consists of a tar mat layer that has a hard consistency and can be peeled off the underlying *clean* soil

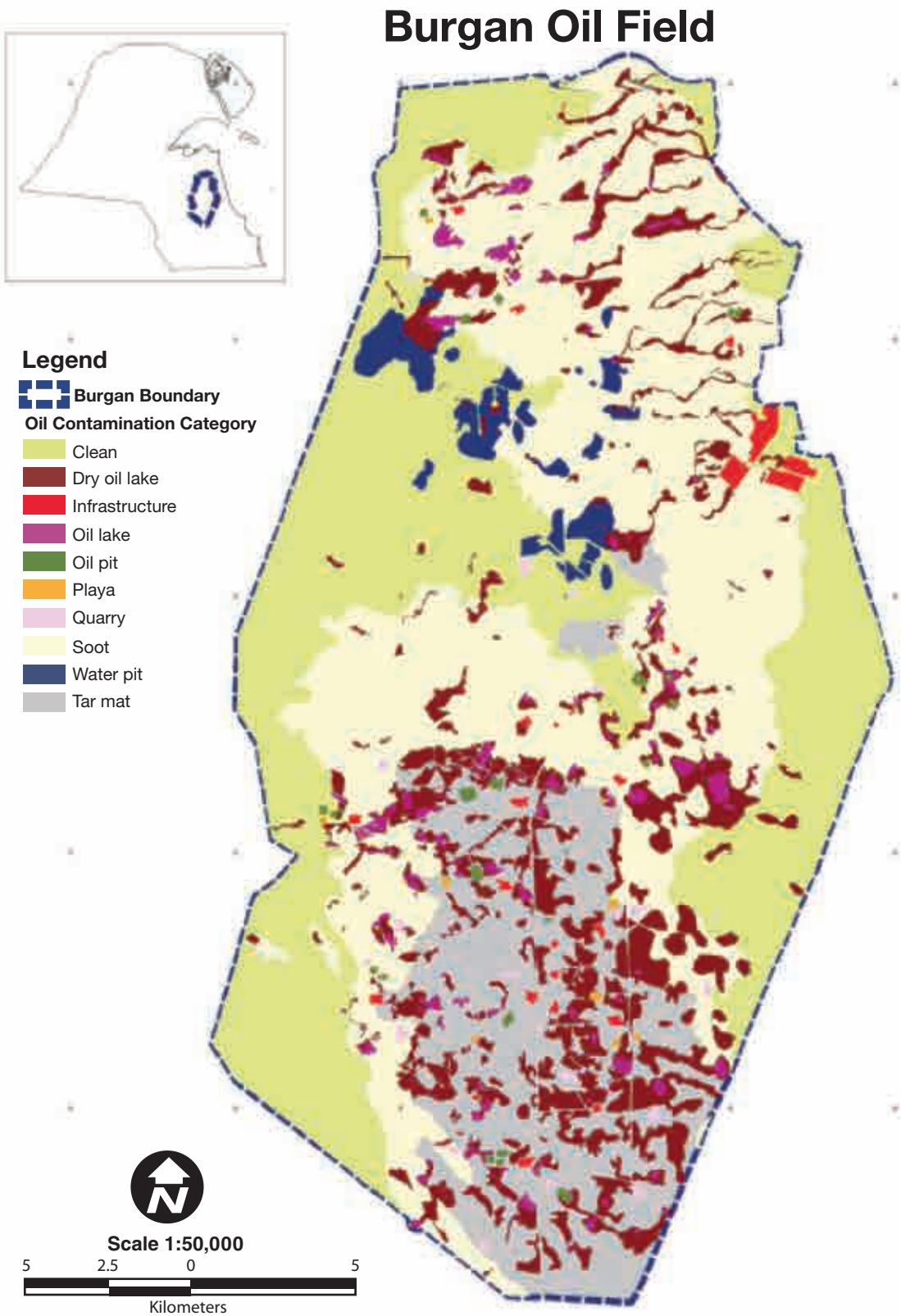

Figure 4.5 Reduced version of the 1:50,000 scale map showing distribution of the four oil contaminated map unit categories (oil lake, dry oil lake, tar mat, soot), a *clean* map unit category, and five miscellaneous map unit categories (oil pit, water pit, quarry, infrastructure, playa)

Effects of Oil Pollution on Wildlife

The effects on wildlife were severe as can be seen by the handful of images presented as Figures 4.6–4.12. This section is based on an actual field survey conducted in 2001 by KISR.

Figure 4.6 *Ardeola ralloides* (Squacco Heron) stuck in oil

Figure 4.7 Unidentified parrot species carcass trapped in oil

Figure 4.8 Multiple carcasses of desert hedgehogs at dry oil lake

Figure 4.9 Bonelli's eagle (*Aquila fasciatus*) covered in oil

Figure 4.10 Carcass of a species of a dhub

Figure 4.11 Bird species having eyes treated and cleaned from oil residue

Figure 4.12 Remains of large avian species in dry oil lake

On October 28, 2001, a reconnaissance survey was performed by KISR[5] at the Al Burgan oil field, and a wildlife survey and monitoring commenced with the installation of drift fences with pitfall traps in the different study site areas (see Figures 4.13 and 4.14). Ten study sites were selected inside the Al Burgan oil field using the following criteria: 1) they must be accessible via a four-wheel drive vehicle; 2) representative of the different categories of oil-contaminated soils; 3) studied in earlier research work by KISR; and 4) declared by the military to be safe from unexploded ordnance.

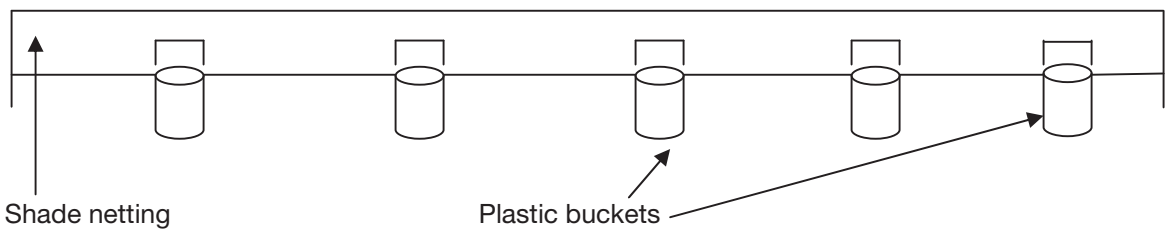

Figure 4.13 Schematic design of the drift fence with pitfall traps used for the study

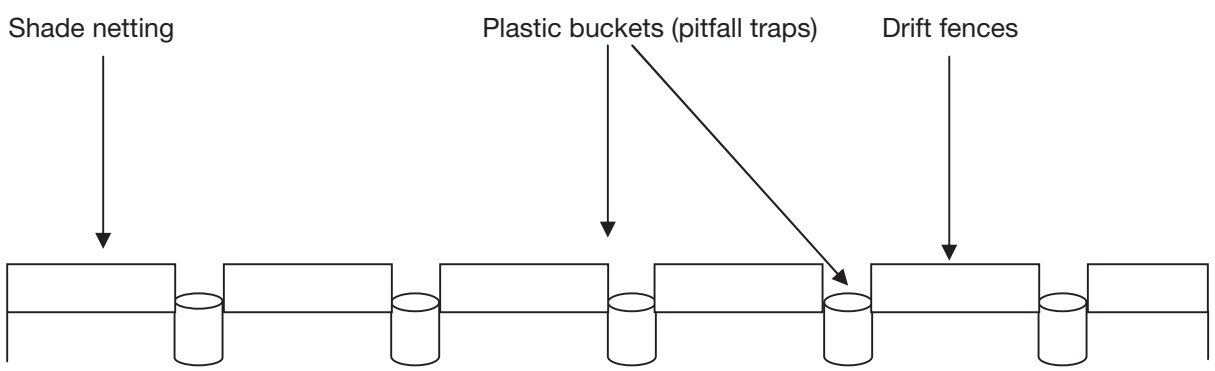

Figure 4.14 Schematic design of the drift fence with pitfall traps described by Clarke[5]

Results and Discussion

Line transects: data collected from the two line transects (*clean* and *polluted*) are presented in Table 4.1. There were 250 animals observed during the 11 transect exercises performed in the "clean" and "polluted" areas. The clean area had a total of 136 (54.4%) wild animals observed. On November 18, 2001, the polluted area had the highest animal count with 43 (17.2%) individuals (see Figure 4.15), which were mostly migrating larks, although on the 6th exercise (March 4, 2002), 24 Hoopoe Larks (*Alaemon alaudipes*) dominated the number of animals observed. Other observations recorded during this preliminary line transects exercises were as follows:

- The daily total number of observed animals in both transects varied significantly, especially on the second exercise when a high number (75.8%) of birds were observed that day in the *polluted* area.
- Out of the 21 animal species observed, 17 species were birds and 3 species were reptiles. Two species of birds dominated the list, Hoopoe Lark (*Alaemon alaudipes*) and the Crested Lark (*Galerida cristata*). However, 24 individuals of *A. alaudipes* out of the total of 40 were observed in a flock in one transect (November 18, 2001), suggesting that the birds were on an (autumn) migration passing through the study site. For comparison, on the next day, only a single specimen of that species was observed in the area. Likewise, this also might be true for the Crested Larks *Galerida cristata* (21), the pair of Collard Dove (*Streptopella* spp), and the 11 Black-crowned Sparrow Larks (*Eremopterix nigriceps*), which were also seen in flocks in the *polluted* area.
- The dhub (*Uromastyx aegyptius microlepis*) dominated, with 18 individuals observed in both line transects. Fourteen were noticed along the clean area and the rest along the polluted area.

- Seven drift fences with 5 pitfall traps each were installed at different categories of oil-contaminated soils inside the Al Burgan oil field.
- A total of 20 trapping exercises were conducted using drift fences with pitfall traps. There were more than 1,386 invertebrates and ground-crawling animals trapped (Table 4.2). Of these, more than 720 (52%) were either giant desert ants (*Camponotus xerxes Forel*) or small black desert runner ants (*Cataglyphis niger Andre*). Red colored ants caught in the traps might have been the worker species of *Camponotus xerxes*. Sample specimens were collected for later identification.
- Beetles (*Adesmia* spp) ranked second in number (152) of all the invertebrates caught in the pitfall traps. Three species of *Adesmia* (pitted beetle, *A. cancellata*; elevated stalker beetle, *A. stoeckleini*; and the variable stalker beetle, *A. cothurnata*) were identified.
- Fifty lizard specimens were caught in the pitfall traps. Equal numbers of lizards were caught in the soot covered and clean areas. This fringe-toed lizard, *Acanthodactylus* spp, was recaptured at both soot-covered sites.

Table 4.1 Animals observed during the 5 km line transects (clean: BCTR1, polluted: BPTR1) inside the Al Burgan oil field

Animal species observed during transects			
Common Name/Scientific Name	**Total BCTR1**	**Total BPTR1**	**Grand Total**
Hoopoe lark/*Alaemon alaudipes*	15	25	40
Crested lark/*Galerida cristata*	25	26	51
Desert lark/*Ammonanes deserti*	0	1	1
Short-toed lark/*Calandrella brachydactyla*	0	11	11
Black-crowned s. lark/*Eremopterix nigriceps*	0	14	14
Lark species	12	0	12
Stonechat/*Saxicola torquata*	4	4	8
Isabelline wheatear/*Oenanthe isabellina*	8	4	12
(Northern) wheatear/*Oenanthe oenanthe*	28	3	31
White-crowned wheatear/*Oenanthe leucopyga*	4	7	11
Wheatear species	13	4	17
Great grey shrike/*Lanius excubitor*	1	3	4
Isabelline shrike/*Lanius isabellinus*	0	1	1
Collard dove/*Streptopelia decaocto*	0	2	2
Kestrel/*Falco tinnunculus*	2	1	3
Sparrowhawk/*Accipiter nisus*	0	1	1
Hen harrier/*Circus cyaneus*	1	1	2
Short-eared owl/*Otus otus*	1	0	1
Black kite/*Milvus. Nigrans*	0	1	1
Dhub/*Uromastyx microlepis*	14	4	18
Fringe-toed lizard/*Acantudactylus* spp.	6	0	6
Short-nosed lizard/*Mesalina brevirostris*	1	0	1
Adesmia species	1	1	2
Total animals observed	**136**	**114**	**250**

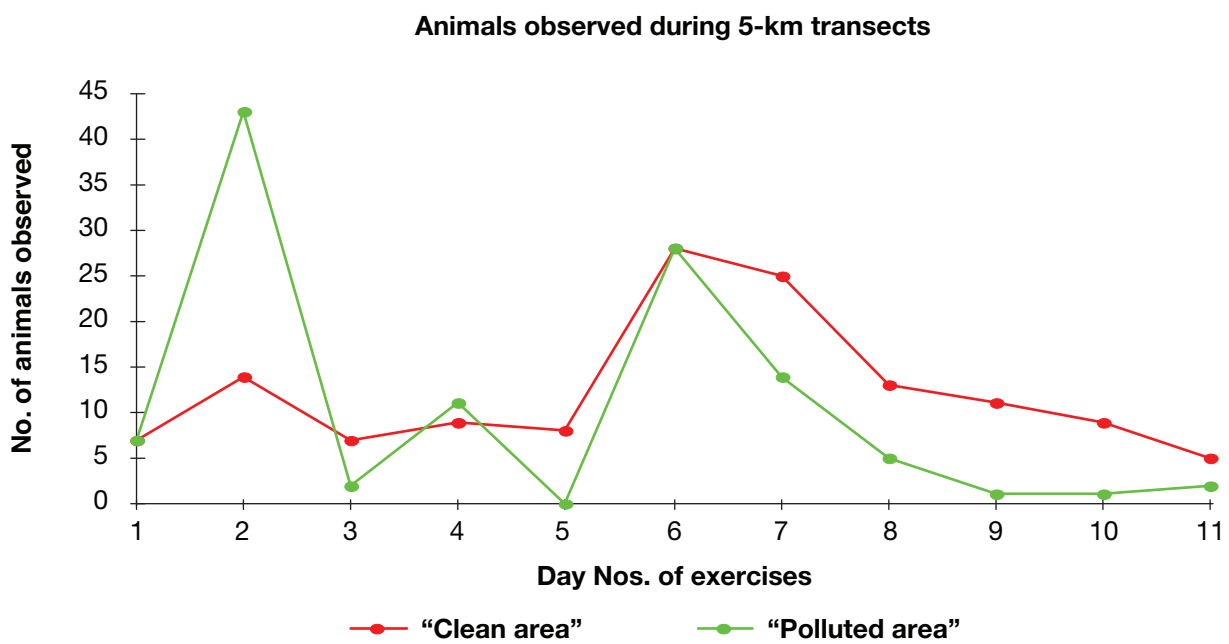

Figure 4.15 Number of animals observed during the 5-km line transects conducted in the Al Burgan oil field: clean (BCTR1) and polluted (BPTR1)

Table 4.2a List of animals caught in pitfall traps at the Al Burgan oil field

Animals caught during 4 days of pitfall trapping exercises at the two *clean* sites.									
Species caught in pitfall traps	**Site BCAR1**				**Site BCAR2**				
Common Name/Scientific Name	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**Total**
Churchyard beetle/*Blaps* spp	2	1	0	3	6	0	3	4	19
Stalker beetle/*Adesmia* spp	1	13	0	0	2	9	0	2	27
Arabian darkling beetle/*Pimelia* spp	1	3	0	12	3	7	13	8	47
Urchin beetle/*Prionotheca* spp	0	0	0	1	1	0	1	0	3
Opossum beetle/*Mesostema* spp	0	8	16	3	0	0	>20	6	>53
Crowned beetle/*Akis elevata*	1	0	0	3	0	0	8	7	19
Short-nosed lizard/*Mesalina brevirostris*	2	0	0	2	1	0	1	4	10
Fringe-toed lizard/*Acanthodactylus* spp	2	0	0	1	0	1	0	1	5
Agamid lizard/*Trapelus* spp	0	0	0	0	0	0	0	1	1
Sand gecko/*Stenodactylus* spp	0	0	0	0	0	0	0	1	1
Silverfish/*Thermobia* spp	0	0	0	3	0	0	0	1	4
Sand swimmer/*Zophosis* spp	0	0	0	1	0	0	0	0	1
Wolf spider/*Lycosid* spp	1	2	0	0	1	0	0	0	4
Sand spider	0	0	2	4	0	0	2	5	13
Desert giant ant/*Camponotos* spp	2	11	>100	0	1	0	0	3	>117
Black (small) ant/*Cataglyphis* spp	0	0	2	2	0	0	.10	14	>28
Red ant (workers?)	0	>10	5	0	0	0	0	1	>16
Centipede	0	2	0	0	0	0	1	0	3
Daily Total	**12**	**>50**	**>125**	**35**	**15**	**17**	**>59**	**58**	**>371**

Note: Date of pitfall trapping exercises: 1 = 19 Nov. 01; 2 = 26 Nov. 01; 3 = 23 Oct. 02; 4 = 28 Oct. 02.

Table 4.2b List of animals caught in pitfall traps at the Al Burgan oil field

Animals caught during 4 days of pitfall trapping in the two tar mat-covered sites.									
Species caught in pitfall traps	**Site BTMR1**				**Site BTMR2**				
Common Name/Scientific Name	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**Total**
Churchyard beetle/*Blaps* spp	5	3	3	2	0	1	0	3	17
Stalker beetle/*Adesmia* spp	10	10	2	0	4	59	0	0	85
Arabian darkling beetle/*Pimelia* spp	3	2	12	8	0	0	0	12	37
Urchin beetle/*Prionotheca* spp	0	0	0	1	0	0	0	1	2
Crowned beetle/*Akis elevata*	0	0	1	1	0	0	0	3	5
Opossum beetle/*Mesostema* spp	0	0	12	14	0	0	16	3	45
Short-nosed lizard/*Mesalina brevirostris*	0	0	0	2	0	0	0	2*	4
Fringe-toed lizard/*Acanthodactylus* spp	0	0	0	2	0	0	0	1	3
Sand gecko/*Stenodactylus* spp	0	1	1	0	1	0	0	0	3
Silverfish/*Thermobia* spp	0	0	0	1	0	0	0	3	4
Sand swimmer/*Zophosis* spp	0	0	0	0	0	0	0	1	1
Wolf spider/*Lycosid* spp	0	1	0	0	0	5	0	0	6
Sand spider	0	0	2	8	0	0	2	4	16
Desert giant ant/*Camponotus* spp	>50	>20	>40	21	0	3	>100	2	>236
Black (small) ant/*Cataglyphis* spp	0	0	7	5	0	0	2	0	14
Red ant (workers?)	7	>60	0	0	0	0	5	0	72
Unidentified wingless wasp-like insect	0	0	0	1	0	0	0	0	1
Daily Total	**>75**	**>97**	**<80**	**66**	**5**	**68**	**>125**	**35***	**551**

Note: * = 1 recapture

Table 4.2c List of animals caught in pitfall traps at the Al Burgan oil field

Animals caught during 4 days of pitfall trapping in the two soot-covered sites.									
Species caught in pitfall traps	**Site BSCR1**				**Site BSCR2**				
Common Name/Scientific Name	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**Total**
Churchyard beetle/*Blaps* spp	1	1	1	9	3	0	2	9	26
Stalker beetle/*Adesmia* spp	0	2	0	1	0	30	0	2	35
Arabian darkling beetle/*Pimelia* spp	1	0	0	3	3	16	10	8	41
Urchin beetle/*Prionotheca* spp	0	0	0	0	3	0	1	0	4
Crowned beetle/*Akis elevata*	0	0	1	0	0	0	14	5	20
Opossum beetle/*Mesostema* spp	0	0	11	10	1	0	4	0	26
Fringe-toed lizard/*Acanthodactylus* spp	0	1	2	2*	0	0	2	3*!	10
Short-nosed lizard/*Mesalina brevirostris*	0	0	2	3	0	0	0	0	5
Stone gecko/*Stenodactylus* spp	0	0	1	1	0	1	1	0	4
Silverfish/*Thermobia* spp	0	0	0	0	0	0	2	1	3
Wolf spider/*Lycosid* spp	5	0	0	0	0	3	0	0	8
Camel spider/*Galeodis* spp	1	0	0	0	0	0	0	0	1
Sand spider	0	1	2	1	0	0	0	0	4
Black scorpion	0	0	0	0	0	0	1	0	1
Yellow scorpion	0	0	0	0	0	0	0	1	1
Desert giant ant/*Camponotus* spp	0	>20	0	0	0	0	0	4	24
Black (small) ant/*Cataglyphis* spp	0	0	3	11	0	>50	0	1	65
Red ant (workers?)	0	0	13	10	>30	0	0	0	53
Unidentified wingless wasp-like insect	0	0	2	1	0	0	0	0	3
Daily Total	**8**	**>25**	**38**	**52**	**>40**	**>100**	**37**	**34*!**	**334**

Note: * = 1 recapture; ! = 2 predated

Table 4.2d List of animals caught in pitfall traps at the Al Burgan oil field

Animals caught during 4 days of pitfall trapping in the dry lake site.					
Species caught in pitfall traps	**Site BDLR1**				
Common Name/Scientific Name	**1**	**2**	**3**	**4**	**Total**
Churchyard beetle/*Blaps* spp	1	0	1	3	5
Stalker beetle/*Adesmia* spp	4	0	0	1	5
Arabian darkling beetle/*Pimelia* spp	0	5	0	9	14
Urchin beetle/*Prionotheca* spp	2	0	0	0	2
Crowned beetle/*Akis* elevata	0	0	1	0	1
Opossum beetle/*Mesostema* spp	0	0	0	1	1
Fringe-toed lizard/*Acanthodactylus* spp	0	0	2	0	2
Short-nosed lizard/*Mesalina brevirostris*	0	0	0	1	1
Sand gecko/*Stenodactylus* spp	0	0	0	1	1
Wolf spider/*Lycosid* spp	3	0	0	0	3
Long-legged spider	0	0	0	1	1
Sand swimmer/*Zophosis* spp	0	0	0	2	2
Desert giant ant/*Camponotus* spp	4	1	>50	>20	>75
Small black ant/*Cataglyphis* spp	0	0	0	>20	>20
Daily Total	**14**	**6**	**>54**	**>59**	**>133**

Ground Searches and Oil Lake Survey

Six ground searches were performed on demarcated 8 m × 8 m plots (Table 4.3). The tar mat covered areas (BTMR1 and BTMR2) were shown to be the most active for ground frequenting species. BTMR1 had three large active ant colonies and more than 11 other burrows. It also had the highest number of ants observed during the pitfall trapping exercises. The occurrence of numerous ants, beetles, and other vertebrates in this area may have been due to the microbial *bloom* and *dieback* (as the petroleum hydrocarbon source is depleted), resulting in more soil organic matter and improved *tilth* (favorable soil structure and workability) because of oil biodegradation by microbes in the area.[6] This could also be due to the fact that tar mat sites are better areas for collecting seeds and other detritus; and, therefore, attract large numbers of detritavous and granivores, such as ants, beetles, and birds (larks). One soot covered area (BSCR1) had two old fox (*Vulpes* sp.) stools whitish in color and well dried. This site also had many burrows, probably rodents, near the demarcated plots. Rodent (small mammal) traps were set at this site, but gave no results. It would be interesting to know the species and population dynamics of the rodents or other mammals present in the area by undertaking trapping and using other methods, such as spotlighting.

Table 4.3 Ground searches on demarcated 8 m × 8 m plots

Site Location No.	Soil Category Type of Contamination	Ground Searches Findings					
		Nov. 19, 2001	Nov. 26, 2001	March 6, 2002	Mar 11, 2002	Oct. 22, 2002	Oct. 27, 2002
BCAR1 Easting (mE) 782551 Northing (mN) 3213450 UTM Zone 38	*Clean* area	Cold & windy morning. One large ant mound; 8 small burrows with lizard tracks	Ground soft from rain overnight; no animal signs observed	Vegetation green and starting to flower; 5 burrows with lizard tracks; 2 small ant mounds; 1 large burrow probably dhub or bigger reptile; bird droppings on all demarcation posts	Rained intermittently last night; no animal signs observed today	Hot (Env. 32°C, ground 36°C); no recent rain; 1 large ant colony; 1 dhub burrow and 1 rodent burrow, both active with animal tracks; 3 *M. brevirostris*; 4 predator stools	Still hot (Env. 35°C, ground 41°C). Active dhub and rodent burrows; 5 active small burrows, probably lizards and beetles; ant mounds and/or termite colonies
BCAR2 Easting (mE) 782500 Northing (mE) 3219400 UTM zone 38	*Clean* area	3 rodent burrows near shrubs; 9 active lizard burrows	No animal signs seen; rained overnight	Vegetation green and flowering; bird droppings on all demarcation posts; no new animal signs observed	No new animal signs observed; had rained last night	Termite mound; 7 small burrows with lizard tracks; dried predator stools	Hot (Env. 35°C, ground 39°C); No new animal signs observed
BSCR1 Easting (mE) 785950 Northing (mN) 3198450 UTM zone 38	Soot covered area	No new animal signs except for the 2 old and dried predator stools; 7 lizard or beetle burrows	No animal signs seen; rained overnight	Scattered flowering vegetation; one butterfly feeding on flowers; bird droppings on demarcation posts	Rained overnight; no animal signs noticed	Hot and windy (Env. 36°C, ground 43°C); 1 large termite colony; 11 small burrows with lizard and beetle tracks	Env. 30°C, ground 34°C; 12 small (rodents and lizards) active burrows
BSCR2 Easting (mE) 791460 Northing (mN) 3224600 UTM zone 38	Soot covered area	2 large ant colonies; 6 small burrows (lizard?); no animal tracks	No animal signs observed	Green vegetation inside demarcated plots; no animal signs observed	Demarcation posts gone		

Continued

Table 4.3 Ground searches on demarcated 8 m × 8 m plots (*continued*)

Site Location No.	Soil Category Type of Contamination	Ground Searches Findings					
		Nov. 19, 2001	Nov. 26, 2001	March 6, 2002	Mar 11, 2002	Oct. 22, 2002	Oct. 27, 2002
BTMR1 Easting (mE) 786510 Northing (mN) 3206040 UTM zone 38	Tar mat covered area	3 large ant colonies; 11 small burrows with lizard and beetle tracks	No animal signs observed	No animal signs observed	One ant colony; 1 active lizard burrow; vegetation flowering	Numerous termite and ant mounds; 12 ant burrows with beetle and lizard tracks; 3 active rodent burrows	Predator (probably fox) stools
BTMR2 Easting (mE) 789110 Northing (mN) 3198670 UTM zone 38	Tar mat covered area	4 burrows with lizard tracks	No signs of animal activity; ground soft from rain overnight	Scattered green vegetation; no animal signs	One butterfly passed over the demarcated plots	Small burrows with lizard and beetle tracks	Lizards and beetle burrows were active
BDLR1 Easting (mE) 786970 Northing (mN) 3209700 UTM zone 38	Dry lake	No animal signs	No animal signs	No animal signs	No animal signs	No animal signs	No animal signs

The oil lake survey was conducted at study site BWOLR1 (Figure 4.16). At the time of the survey (November 19, 2001), most of the oil lakes at the Al Burgan oil field were drying up. Deaths of wild animals caught in oil lakes were observed on October 22 and 23, 2002. A hooded malpolon (*Malpolon moilensis*) was observed trapped in an oil lake near study site BDOLR1 and the next day a hen harrier (*Circus cyaneus*) was observed floating dead in an oil lake. This juvenile raptor was observed the previous day during the line transect exercise at BPTR2. One important observation was of a Houbara bustard (*Chlamydotis undulata*) seen near BSCR2. Other interesting observations were a short-nosed lizard (*Mesalina brevirostris*) and a darkling beetle (*Blaps* spp) observed preying on ants. Also, a short-nosed lizard was observed eating a moth.

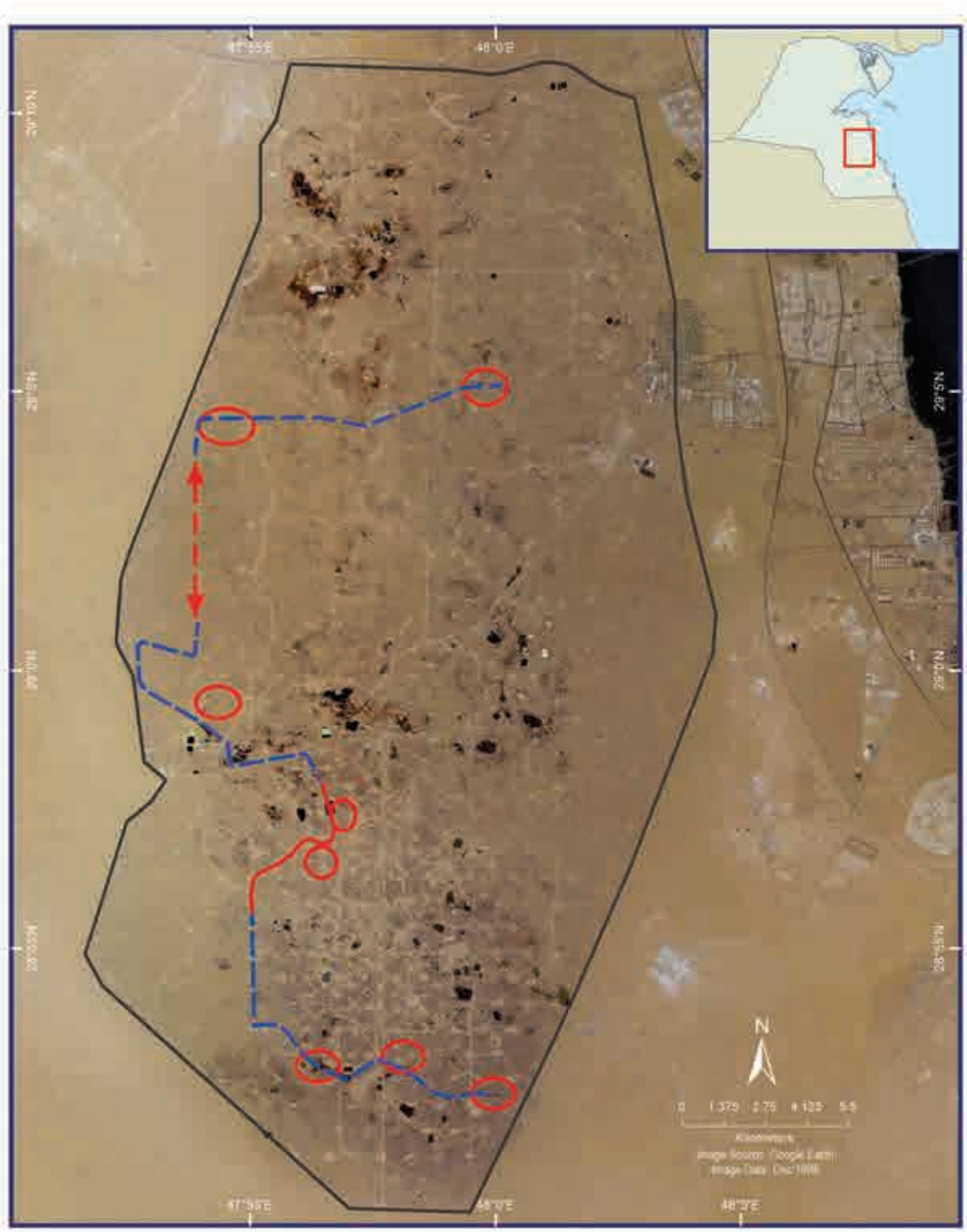

Figure 4.16 Preliminary wildlife survey and monitoring study sites at the Burgan oil field. The red circles and lines are the different wildlife survey and monitoring sites. The blue dotted lines are the wildlife survey routes taken during study exercises.

5

THE KUWAIT ENVIRONMENTAL REMEDIATION PROGRAM

BACKGROUND INFORMATION

Following the aftermath of Iraq's devastating invasion of 1990/91, most of Kuwait's natural resources were severely damaged. Much of Kuwait's soil and water was contaminated by crude oil after retreating forces set fire to about 700 oil wells throughout Kuwait (see Figure 5.1). The oil lakes (see Figure 5.2) created by this has had a negative impact on Kuwait's soil, wildlife, and subterranean water resources (refer to Chapter 4). Terrestrial resources, such as native plants and animals were also affected by the movement of heavy military equipment over fragile desert areas that are sensitive to soil displacement. The work that needed to be done to help the country recover from this environmental catastrophe was vast to say the least, and today, over 28 years later, even more work needs to be done for Kuwait to fully recover from the devastation inflicted on the environment (see Figure 5.3).

Figure 5.1 An oil well fire from the Iraqi invasion

Figure 5.2 Wet oil lake at the Al Burgan area south of Kuwait

In the years following the liberation of Kuwait, many activities were conducted to assess the extent and magnitude of damage inflicted on Kuwait's environment. In 1994, the State of Kuwait, through its *Public Authority for the Assessment of Compensation Resulting from Iraqi Aggression* (PAAC), submitted six claims representing environmental damages to Kuwait's groundwater; terrestrial, marine, and coastal resources; and public health. These claims were known as the "Environmental Claims" and categorized under an "F4" designation.

From 2001–2007, PAAC conducted a Monitoring and Assessment Program (M&A)[1], which was designed to provide a clear understanding of Kuwait's environmental situation and the extent of damage that was inflicted on the country's natural resources. The study resulted in awarding the State of Kuwait with six environmental claims to remediate and restore environmental damages by the United Nations Compensation Commission (UNCC). To help restore the environment, the UNCC issued guidelines for a follow-up program that would monitor technical and financial progress of the planning and implementation of environmental remediation projects to ensure compliance with UNCC decisions, rules, and procedures. It would also establish a local Focal Point for the management and oversight of the Kuwait Environmental Remediation Program (KERP).

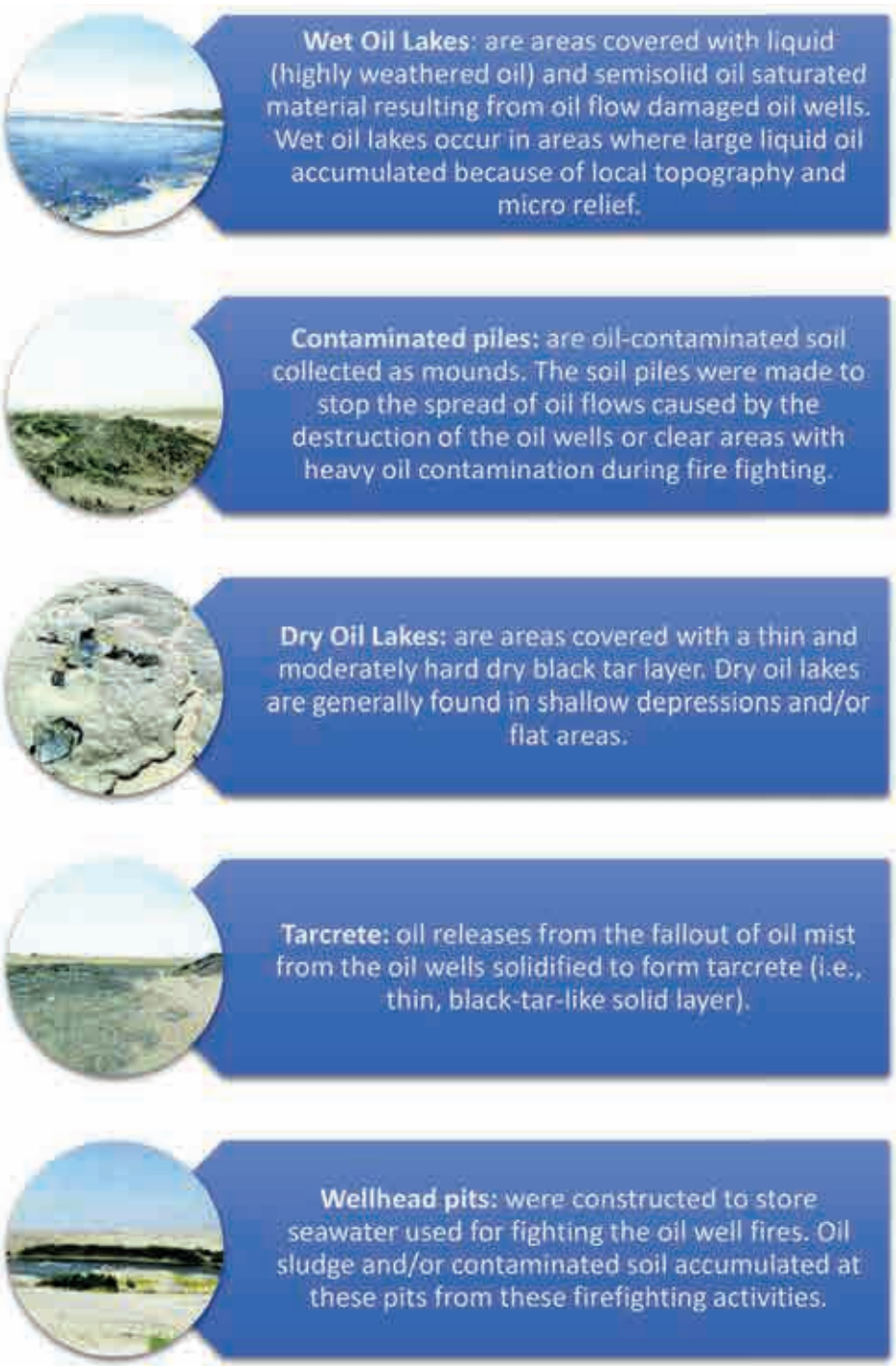

Figure 5.3 Types of oil-contaminated soil

UNCC ENVIRONMENTAL AWARDS

The United Nations issued resolutions after the end of the Gulf War in 1991, and the UNCC was established to oversee the reparations to injured countries, companies, and individuals. The UNCC issued Decision 258, which laid out the rules and guidelines for the planning and implementation of the environmental remediation projects in Kuwait and other counties affected by environmental damages. The UNCC environmental claims were designed to assist Kuwait to restore the damaged ecosystems in both land and sea. The Government of Kuwait established the Kuwait National Focal Point (KNFP) to supervise the implementation of several projects related to environmental remediation. These are:

1. Remediation of damage to groundwater
2. Remediation of damage to marine resources
3. Damage to terrestrial resources
4. Remediation of areas damaged by oil lakes, oil contaminated piles, oil trenches, and oil spills
5. Remediation of marine and coastal resources
6. Open-burning/open-detonation sites

Table 5.1 lists the UNCC awards to Kuwait for the environmental claims/projects covered in each decision together with a short description of each underlying environmental claim unit or project.

Table 5.1 List of environmental claims for which Kuwait was awarded compensation by the UNCC[2]

Claim number	Subject matter	Amount claimed (USD)	Amount awarded (USD)
Third Installment: Decision 212 (December 2003)			
5000256	**Damage to groundwater water resources**	**185,167,546**	**41,531,463**
5000450	**Damage to terrestrial resources**	**5,050,105,158**	**643,814,034**
	• Remediation of areas damaged by military fortifications	14,170,924	9,019,717
	• Remediation of areas in and around wellhead pits	34,276,192	8,252,657
	• Remediation of areas damaged by tarcrete	928,820,719	166,513,110
	• Re-vegetation of damaged terrestrial ecosystem	4,039,217,642	460,028,550
Fourth Installment (part 1): Decision 234 (December 2004)			
5000259	**Damage to marine resources**	**33,901,560**	**3,990,152**
5000466	**Damage to terrestrial resources (OD/OB)**	**695,119,160**	**162,259**
Fourth Installment (part 2): Decision 235 (December 2004)			
5000454	**Remediation of oil lakes**	**6,804,310,621**	**2,259,285,969**
	• Remediation of oil lakes, oil trenches, and oil spills	5,863,998,176	1,975,985,580
	• Re-vegetation of damaged terrestrial ecosystems	940,312,445	283,300,389
Fifth Installment: Decision 248 (June 2005)			
5000460	**Loss of natural resources (marine preserve)**	**967,831,391**	**7,943,030**
Total		**13,736,435,136**	**2,956,726,907**

KNFP assigned the Kuwait Institute for Scientific Research (KISR) as the technical arm for implementing a project entitled "Management and Supervision of the Kuwait Environmental Remediation Program (KERP)." The main objectives of this project were: 1) to guide KNFP in the implementation of KERP and to prepare clear project plans for all environmental claims and 2) phase-in plans of the two major claims (damage to terrestrial resources) and (remediation of areas damaged by oil lakes, oil contaminated piles, oil trenches, and oil spills). KISR's additional role was to oversee the execution of KERP projects in accordance with UNCC decisions and to design and implement a long-term environmental monitoring program to ensure restoring the ecological functioning of ecosystems. The execution of the project plans was the responsibility of several stakeholders, including the private sector. The role of research institutions, such as KISR, was vital in the planning, supervision, and monitoring of the environmental remediation program.

Role of KOC

> ***"Thick, black smoke surrounded Kuwait, turning day to night," former KOC CEO Abdul Malik Al-Gharabally said. "Poisonous gas emissions threatened life all around, and smoke from the burning oil wells extended 2,000 kilometers away."***

KOC put tremendous effort into putting out the oil fires in 1991. Both international delegations and Kuwait fire teams were instrumental in extinguishing the oil well fires that caused severe pollution to air and land. KOC, as a project stakeholder, was assigned the responsibility for the remediation program (KERP) relating to:

1. Claim No. 5000259 (coastal and marine resources): Remediation and restoration of damages to coastal and marine resources by oil contamination, excavation, transportation, and landfilling of oily contaminated material from coastal oil deposits, coastal oil trenches, and weathered oil layers.
2. Claim No. 5000450 (remediation of areas in and around wellhead pits and tarcrete): This claim has five elements and KOC was responsible for Element 2—oil-contaminated areas in and around wellhead pits and Element 3—tarcrete damage areas.
3. Claim No. 5000454 (remediation of areas damaged by oil lakes, oil-contaminated piles, oil trenches, and oil spills): This claim is focused on the remediation of areas damaged by crude oil contamination within 114 km^2 of KOC's oil fields in the firm (if dry) and wet lakes and oil-contaminated piles.

KOC developed a comprehensive program known as the "Total Remediation Solution," which includes several remediation and rehabilitation projects that span across the affected areas of the company's operations and are expected to be completed in less than a decade. During 2014, a KOC delegation met with UNCC, KNFP, and KISR officials to discuss the project plans for the environmental remediation program (see Figure 5.4).

Figure 5.4 A KOC implementation meeting with Kuwait Institute for Scientific Research (KISR) and Kuwait National Focal Point (KNFP) representatives in 2013

In 2015, a strategy had been presented by the Government of Kuwait and approved by the UNCC. Initial plans called for all contaminated soil to be disposed of in landfills (see Figure 5.5). However, after much deliberation, a new plan that was aimed at remediation was finalized that focused on the treatment and cleaning of soil that had been contaminated. Following the conclusion of an important event at KOC where the world's top remediation specialists were gathered in one place, the company was able to develop new solutions and move forward with a tangible plan that saw remediation of contaminated soil as the primary and preferred solution (see Figure 5.6).

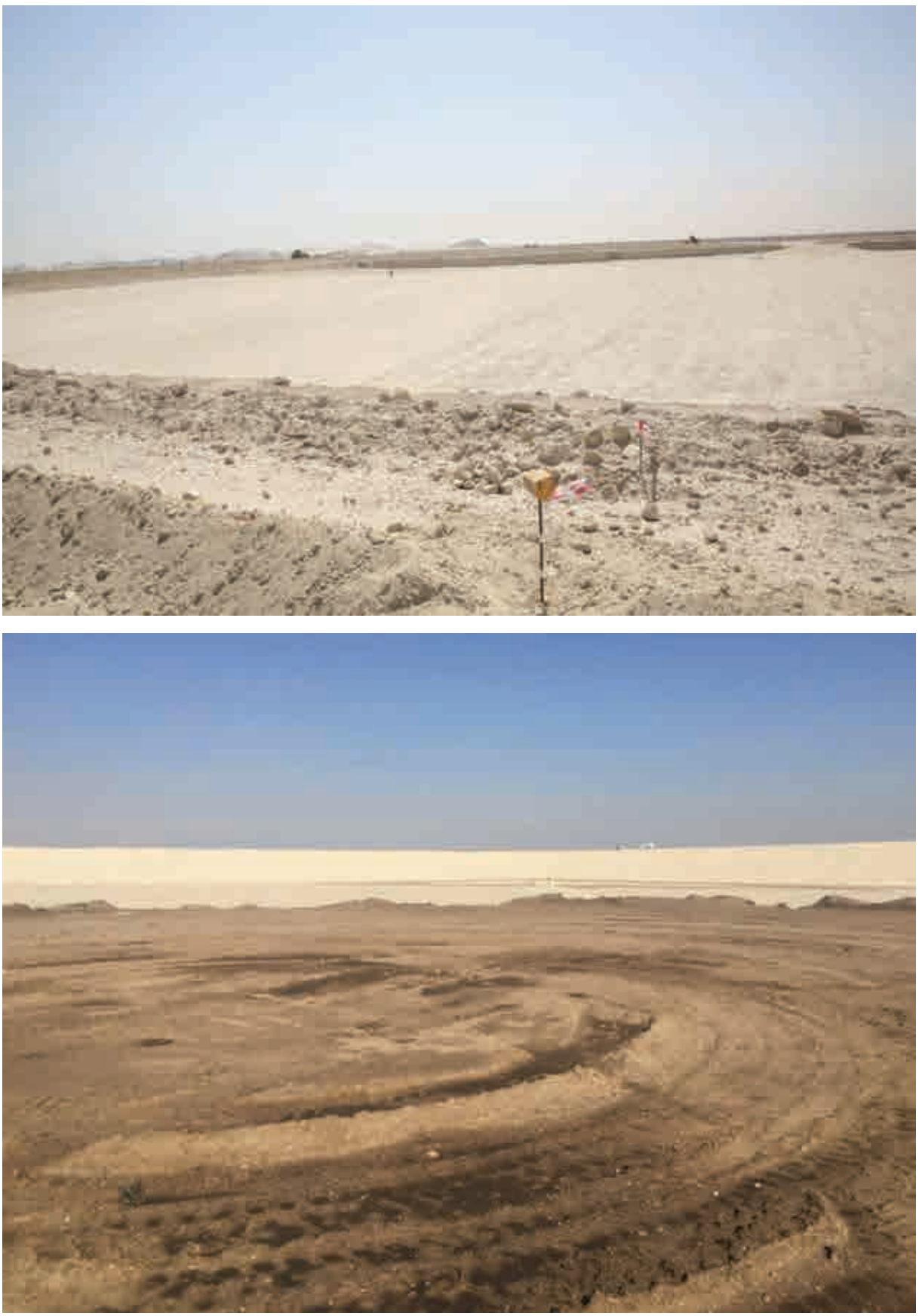

Figure 5.5 Landfill with contaminated soil transported from the oil lakes in the north of Kuwait (operation supervised by KOC)

Figure 5.6 One of the oil lakes remediated and restored by KOC at the Al Burgan area south of Kuwait

6

OPPORTUNITIES FOR RESTORING NATURE

The first Gulf War and the accompanying oil pollution took its toll on the environment. Along with the desertification of rangelands and a lack of proper conservation measures, these factors lead to the degradation of existing biodiversity. Under the sponsorship of the United Nations Compensation Commission (UNCC), Kuwait began to investigate, establish, and protect the most sensitive natural and semi-natural areas of the country, including its national parks, wilderness, and nature reserves. Eventually, the UNCC plan made it possible to select five new protected areas extending to about 1,679.5 km^2, which are to be used for restoring the lands damaged by military activities. The five protected areas include: Umm Niqa, Wadi Al Batin, Al-Huwainiliya, Al-Kuwaisat Khadma, and Umm Gudair (see Figure 6.1).

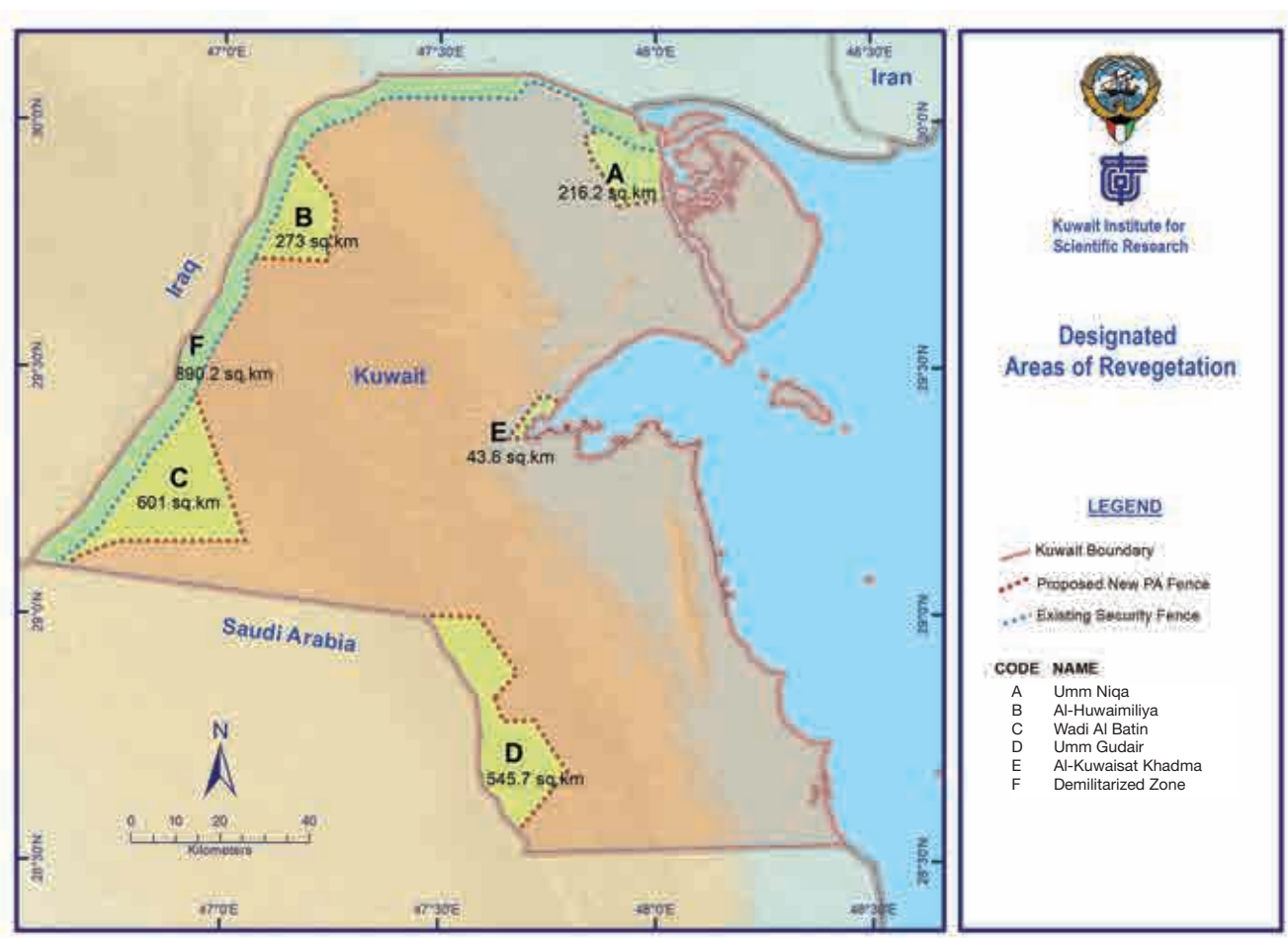

Figure 6.1 The five new protected areas for the restoration of damaged terrestrial ecosystems in Kuwait

These areas were planned to be used to maintain or restore natural vegetation patterns and conserve the habitats of endangered wildlife species. Moreover, the country's people can get immediate benefits through maintaining a range of critical ecosystem services; for example, sustainability of water supply, food security, disaster reduction, carbon storage, drought resistance, and cultural survival. The Public Authority for Agriculture and Fish Resources (PAAFR) will manage the newly protected areas in collaboration with the Kuwait National Focal Point (KNFP). Based on Geographic Information System (GIS) mapping, some areas within these protected areas have been designated to be re-vegetated with native plants of Kuwait. A re-vegetation plan, which considers soil and vegetation types from the GIS database, has already been conceived for mass restoration of the damaged areas (see Figure 6.2).

Figure 6.2 Native plants are grown in farms in collaboration with the Kuwait Institute for Scientific Research (KISR) for large-scale re-vegetation of damaged areas

RESTORATION OPTIONS

Kuwait is unusual in the amount of restoration that will be necessary within reserves. However, the situation is not unique, and the International Union for Conservation of Nature (IUCN), in association with the Society for Ecological Restoration (SER), has identified many important restoration options open to protected-area managers. Although these have not yet been fully explored, some options include:

- Restoration through natural processes as a result of protection; for example, through the removal of grazing pressure or the impacts of vehicles
- Restoration through time-limited interventions to undo past damage; for example, reintroduction of extirpated species
- Restoration as a continual process for biodiversity conservation; for instance, using domestic livestock grazing to maintain biodiversity values
- Restoration as a continual process for both natural resources and biodiversity; for example, recovering productivity after soil erosion

DESERT OASES OF KOC

As the Kuwait Oil Company (KOC) 2040 Strategy calls for new sustainability efforts to be implemented at the company, new environmental awareness campaigns were launched with the health, security, safety, and environment (HSSE) initiatives. Several oases were established in the Burgan oil fields to restore damaged areas and conserve biodiversity. In addition, KOC established protected areas of important wildlife habitats (migratory birds) within its premises. The following presents KOC's contribution to sustainable development and conservation of biodiversity.

The Subaihiya Oasis in the Al Burgan Area

KOC has established the Subaihiya Oasis in a historic location in South Kuwait with the stated goal of preserving the environment and protecting wildlife in the area. As part of efforts to promote the historical significance of the site, KOC constructed an informative exhibition that details the importance of Subaihiya in Kuwait's history. From an environmental standpoint, KOC teams were responsible for creating environmental conditions at the location that are suitable for the growth of desert plants and wildlife with special focus on making the location an attractive area for migratory birds. In addition, an artificial lake was created that supports aquatic life (see Figure 6.3).

Ahmadi Oasis

The location of the Ahmadi Oasis was partly chosen so that it could appear to air travelers on their approach to Kuwait. In coordination with Kuwait's Directorate of Civil Aviation, KOC ensured that the enormous KOC logo, a primary feature of the Ahmadi Oasis, could be seen by approaching aircraft (see Figure 6.4).

It should be noted that the construction of the Ahmadi Oasis was a voluntary effort that was accomplished with available and recycled resources and volunteers.

Originally, the project area was rough terrain with a natural topography that reached up to 12 m in height in some areas. In addition, a large amount of trash had accumulated throughout the area over the years. The location was cleaned up and the logo was drawn on an area of 120,000 m^2 using modern scanners and drones. The plan for the Ahmadi Oasis was drawn internally without the help of an engineering firm and external resources used to complete the project did not exceed 15%.

Construction of the Ahmadi Oasis began after plans were finalized. The first phase of the project took four years to complete. Several teams were formed and spread out through the desert to gather scrap (pipes, metal, wood, etc.) to use and recycle for the project. The best example of this recycled material at the Ahmadi Oasis is the main gate, which was engineered by forging and welding the recycled material before being painted. Moreover, at the main entrance, there is a burned bus that has been repurposed to serve as a rest area on the top deck. An artificial waterfall at the Ahmadi Oasis was also constructed with scrap material.

Figure 6.3 Three images of one of the oil lakes remediated and restored by KOC at the Subaihiya Oasis in the Al Burgan area

Figure 6.4 Aerial view of the Ahmadi Oasis

The Ahmadi Oasis features facilities for a number of sports, including football fields, basketball courts, and tennis courts. Furthermore, there are 36 rooms with small gardens attached that families can make use of. Playgrounds for children are also present. The rooms can also be used for fair pavilions to display products, which is very suitable for the company's spring season activities. A walking track also encircles the location.

Cars are not permitted into the Ahmadi Oasis. This was decided so that visitors could be protected from emissions. Instead, electric golf carts are used as an alternative.

Because an oasis could not exist without greenery and water, two lakes were constructed. The first artificial lake is fed by a waterfall that was made of scrap material. In the second stage of construction, a musical fountain will be added. The second lake is home to ducks with a small seating area beside the lake. The oasis also has a tent that can be used for meetings facing the lake (see Figure 6.5).

The Ahmadi Oasis also celebrates Kuwaiti culture. The Cultural Village from the Mishref Fair Ground gifted a traditional boom vessel, which KOC will maintain. The vessel will be a monument that will allow visitors to learn more about Kuwait's seafaring history as it features old diving tools such as nets, shellfish holders, and other equipment (see Figure 6.6). The Company established a passage to the vessel that has a resting area onboard and can hold a group of seven people.

The group also established a Kuwaiti *Fireej*, which is an old neighborhood with an antiquated Kuwaiti house that has three rooms: a kitchen, a diwaniya, and a bedroom, which were furnished with old cultural furniture obtained from local markets.

The Ahmadi Oasis also features an agricultural greenhouse that extends over an area of 3,000 m^2. It features a great number of trees, such as banana, mango, fig, and apple trees. It also has a small museum for school students that explains the various aspects of agricultural activity. It also has a rest area and a small waterfall. Part of the Ahmadi Oasis was constructed as an agricultural area so that various company teams can take part in annual competitions where different crops and plants are grown on dedicated plots of land. Visitors can also enjoy beautiful, tree-lined walkways (see Figure 6.7).

Figure 6.5 Two images of the second lake of the Ahmadi Oasis

The Ahmadi Oasis has a central hall for events. This hall was formerly a workshop at Ahmadi Port where forging, maintenance, and welding work took place. It has been repurposed to its current oval shape with glass windows so visitors can enjoy the oasis. In addition, approximately 3,000 empty soda cans were recycled to form an artwork that shows the Kuwaiti flag and Kuwait's Amir with its martyrs at night.

To minimize electricity consumption, power at the Ahmadi Oasis is generated through solar energy. Solar panels at the oasis illuminate all of the facility's walkways, in addition to operating the irrigation system. A plan has been made to generate all of the Ahmadi Oasis power needs through solar power by installing panels over the car parking lot, which has accommodations for 150 cars.

The oasis also features an "Environment Map" which is a map of Kuwait that features plants that used to be widespread in Kuwait 40 years ago. The plants have been replanted on this map and information about each plant is available through the push of a button.

Spirit of the Desert Oasis

The *Spirit of the Desert* Oasis is located approximately 4 km from the main gate of the Burgan oil field. The oasis was inaugurated in November 2004. The area began as a dumping ground dotted with minor bodies of water showing oil contamination. It was rehabilitated by KOC to cover more than 240,000 m^2 of land including 64,614 m^2 of watershed. The landscape design was developed by KOC in collaboration with KISR. The area is covered with different types of desert plants and trees, and migratory birds find good refuge and landing during mild winters (see Figure 6.8).

Figure 6.6 A traditional boom vessel

Figure 6.7 Two tree-lined walkways at the Ahmadi Oasis

Figure 6.8 Images of the *Spirit of the Desert* Oasis

Al Abdaliya Nature Reserve

Al Abdaliya Nature Reserve is an environmental preservation space located within one of KOC's operational areas in West Kuwait. The reserve is a notable accomplishment since the once polluted area has been cleared of all waste and environmental damage, thus restoring the wildlife and biodiversity of the area to its former glory.

The Al Abdaliya Nature Reserve project was implemented in three phases that cover an area of 7 million m^2 with work beginning in January 2011. More than 100,000 plants and trees from 30 different species were planted at the reserve. Suitable conditions that support plant and wildlife have been developed, such as the establishment of water resources and the formation of hills around the lakes for desert plants. See Figures 6.9–6.11 for more information.

Figure 6.9 Inauguration of Al Abdaliya reserve (February 2013)

Figure 6.10 Recovery of native plants (*Cyperus conglomeratus*) at Al Abdaliya reserve

Figure 6.11 Artificial lake at Al Abdaliya reserve

Restoration of an Artificial Reef

When retreating Iraqi forces ignited about 700 oil wells and flooded Kuwait's waters with crude oil, the magnitude of the damage was on a scale that had never been seen before. At the time, the long-term effects of such damage were uncertain. Wildlife on land and in the sea suffered greatly. The enormity of the impact was so severe that soil remediation projects continue to this day, some 28 years after the fact. Damage to Kuwait's marine environment was extensive. Over the years, wildlife in Kuwait's waters slowly recovered. However, the majority of Kuwait's coral reefs continue to be negatively affected by bleaching.

KOC initiated the Marine Colony Project in collaboration with KISR to help contribute to the important task of restoring harmony to the environment in which it operates. The Marine Colony, near Ahmadi's South Pier in the State of Kuwait (see Figure 6.12), is a place where hope is kept alive. In 2005, KOC constructed an artificial reef 4.3 nautical miles southeast of Al-Ahmadi Port. Consisting of 1,000 reef balls deployed in clusters, the reef covers an area of 48,500 m^2 (0.048 km^2) in depths from 7 to 9 m. The purpose of this reef was to provide additional reef habitat to enhance fish stocks, rehabilitate the marine environment, and contribute to conservation. Before approval from Kuwait's Environmental Public Authority (EPA) to create additional artificial reefs, evidence was needed to show that this artificial reef provided the intended benefits.

In addition, KOC commissioned KISR (Dr. Shaker Al Hazeem and his team from KISR) to conduct an ecological assessment of the Marine Colony. A joint diving team comprised of KOC employees and individuals from KISR monitored the Marine Colony throughout the seasons over the course of a year. Equipped with state-of-the-art technology, the team managed to gather critical data that helped KOC better understand and protect marine life in Kuwait's waters (see Figure 6.13). The outcome of this KISR research project is presented in the following section from Dr. Shaker Al Hazeem's report.[1]

Figure 6.12 Kuwaiti coastal map showing the site of the artificial reef

Figure 6.13 Joint KOC and KISR dive teams

Fish assemblages and epibenthic organisms associated with the KOC reef were compared quantitatively and qualitatively with those of an adjacent non-reef area and a natural nearby reef at Qit'at Uraifjan. Biweekly surveys from January 2011 through December 2012 at these three areas consisted of visual and video documentation of fish within a 5-m diameter "cylinder" from the sea bottom to the surface at 10 to 15 sites. Fish inside the reef balls were also recorded (Figures 6.14 and 6.15). Epibenthic surveys used both direct observation counts, fauna within a 0.25 m^2 quadrat, and photography to determine species present, percent cover, and number of individuals. Epibenthic surveys were conducted at eight locations on the artificial reef and adjacent non-reef area, and three stations on the natural reef. Physical and chemical properties of the waters around the study sites were recorded synoptically twice, and seasonally during spring and neap tides. Current speed and direction were measured at each of the study sites using acoustic Doppler current profilers.

Survey results differed substantially between years with totals of 17 and 44 species of fish and other motile species being observed in 2011 and 2012, respectively. All species observed in 2011 were also recorded in 2012 except the jellyfish *Catostylus mosaicus*. In 2011, species observed at the natural reef and the artificial reef were about equal (16 and 15, respectively). In 2012, however, 38 species were observed at KOC's artificial reef, whereas only 22 species were observed at the natural reef. This difference may be due, in part, to the number of surveys: 18 at the artificial reef vs. 10 at the natural reef. Eighteen species were common to both the natural reef and the artificial reef in 2012. Only one species was present in the area adjacent to KOC's artificial reef in 2011, and only 7 species in 2012, but surveys there were few. In general, numbers of any species averaged less than 1, but there were notable exceptions. In 2011, the damselfish *Neopomacentrus sindensis* averaged nearly 38 per natural reef survey, whereas on the artificial reef just over 1 specimen was observed per survey. For the seabream *Diplodus saergus*, each survey averaged 322 individuals on the artificial reef, but only 14 for the natural reef. Differences in 2012 were even greater. An average of 394 cuttlefish were recorded for the artificial reef, and none on the natural reef. The damselfishes *Abudefduf vaigiensis* and *Neopomacentrus sindensis* averaged 101 and 313, respectively, on the natural reef, but only 10 and 7 per survey on the artificial reef. Results for the 2012 surveys for *Diplodus saergus* were similar to those in 2011, i.e., this seabream highly favored the artificial reef (793 vs. 92/survey). Safi *Siganus javus*, a species not observed in 2011, was abundant on the artificial reef (278/survey), but not on the natural reef (0.5/survey).

Figure 6.14 Reef ball installation

Figure 6.15 Fish within and around the reef balls

Epibenthic cover documented both biotic and abiotic features of the reefs. Abiotic categories included sand and rubble because they can smother reef organisms. Twenty and 42 epibenthic categories were listed in 2011 and 2012, respectively. Categories ranged from group level (barnacles, bivalves, etc.) to species. In 2011, epibenthic cover included 13 to 15 categories on the artificial and natural reefs. Seven categories were listed for the area adjacent to the artificial reef with sand covering an average of 97% of the quadrats. Sand also covered 95% of the natural reef quadrats, but none of those surveyed for the artificial reef. Barnacles, green algae, sea slugs, and sponges covered 22, 73, 42, and 11%, respectively, of the artificial reef quadrats, but <2% of those of the natural reef. The urchins *Diadema setosum* and *Echinometra mathaei* dominated the epibenthic fauna of the natural reef covering 34 and 60% of the quadrats, respectively, but were almost absent on the artificial reef. Results of the 2012 surveys differed considerably from those of the previous year. Categories for the natural reef nearly doubled to 33, with dead coral and green algae covering 36 and 9% of the quadrats, respectively. Only 12 categories of cover were listed for the artificial reef, and green algae accounted for most (62%) of the cover. Barnacles and calcareous algae each accounted for 12% on average of the cover within each quadrat. A surprising number of categories were recorded in the area adjacent to the artificial reef. Of the 21 listed, the two most abundant in terms of average percent cover were sand (77) and dead coral (16). Except for the ophiuroid *Ophiothela venusta*, which ranked third at 2%, other categories were less than 1%.

Seawater parameters showed strong seasonal fluctuations of water temperature, higher salinity, lower dissolved oxygen, and higher turbidity at KOC's artificial reef compared to the natural reef. These results can be attributed to the artificial reef's location near the warm brine discharge from the Shu'aibah Industrial Area. This discharge results in an inverse-estuarine circulation. Additionally, prevailing winds increase the turbidity and temperature fluctuations. *Chlorophyl a*, an indicator of phytoplankton abundance, was low at both reefs. Total petroleum hydrocarbons (TPHs) were low at both reefs in the water column, but the sediments around KOC's artificial reef exhibited a higher TPH burden.

The survey results indicate that KOC's artificial reef ball clusters have created new habitats for a range of marine species, including commercially important fish. Creating new habitat for corals, however, has not been as successful. The low abundance of coral recruits on the reef balls is likely due to the location of the reef in turbid water at depths where light is insufficient, and sedimentation is high. Therefore, KOC's artificial reef has not created new coral reef habitat, and have lower ecological and biodiversity value than the natural coral reef. If additional reefs are to be constructed, it is recommended that the new reef be placed in waters less than 5 m in depth and located adjacent to Kuwait' natural offshore reefs.

The results of the surveys of KOC's artificial reef demonstrate that reef ball clusters have the potential to increase coral reef habitats and biodiversity (see Figure 6.16). To be effective, new reef habitats should be integrated into a larger reef-restoration project to rehabilitate Kuwait's ecologically important, but degraded, coral reef at Kubbar Island (see Figure 6.17) using new integrated research design and techniques.[3]

The Marine Colony has done much in the way of creating awareness about the importance of Kuwait's natural habitats. By protecting and promoting the well-being of the ecology of Kuwait's natural areas, the community at large can see firsthand how a clean and healthy environment can contribute to the overall well-being of the country. In addition, the wider community can recognize the role of KOC in restoring the environment in which it operates. This is done through projects like the Marine Colony and its many community outreach programs (e.g., awareness sessions at local schools, beach clean-up campaigns, a recycling program in Ahmadi, etc.).

KOC takes corporate social responsibility initiatives very seriously. The Company is constantly working on existing initiatives and it openly invites employees to suggest new programs for consideration. KOC is keen to maintain its protected natural reserves on land and the Marine Colony is a natural extension of the Company's interest in protecting natural areas offshore.

Figure 6.16 Wildlife at the artificial reefs show progress at rehabilitation sites

Figure 6.17 Aerial view of Kubbar Island

7

MAJOR KOC ENVIRONMENTAL ACHIEVEMENTS AND FUTURE PERSPECTIVE

NINE MAJOR KOC ACHIEVEMENTS[1]

Reduction of Gas Flaring

One of KOC's most remarkable achievements is continuing its effort to reduce gas flaring to less than 1%. These efforts have paid off with KOC achieving the lowest gas flaring percentage ever of 0.36% during April 2015. The Company also won the "Gas Flaring Reduction Excellence Award 2015" as part of the World Bank Global Gas Flaring Reduction (GGFR) initiative. The company succeeded in achieving a very high level of West Kuwait Associated Gas, and also succeeded in reducing West Kuwait gas flaring from 40% to less than 1% through the commissioning of several projects in West Kuwait related to gas sweetening, gas compression, gas re-injection, and other projects that are part of the strategic objective of KOC.

The Ahmadi Oasis

The Ahmadi Oasis is a primary display of KOC's efforts to incorporate elements of sustainability into its areas of operation. The project itself was an effort that was accomplished with available and recycled resources and volunteers. Originally, the project area was rough terrain with a natural topography that reached up to 12 m in height in some areas. In addition, a large amount of trash had accumulated throughout the area over the years. The location was cleaned up and the KOC logo was drawn on an area of 120,000 m^2 through the use of modern scanners and drones, which photographed the area from above for optimal accuracy. The plan for the Ahmadi Oasis was drawn internally without the help of an engineering firm and external resources used to complete the project did not exceed 15%.

New Ahmadi Hospital

KOC has a long history of caring for its employees and their families, which was exemplified, in part, in 1960 when the Company opened the Ahmadi Hospital. Later, in the 1980s, a decision was made to open Ahmadi Hospital's doors to the entire oil sector, a decision which greatly benefited a large number of individuals but also placed an increased amount of traffic and responsibility on the aging hospital. The New KOC Ahmadi Hospital and residencies will occupy a four-story building that has a combined floor space of approximately 80,000 m^2 which provides room for 300 beds with a provision for a 100-bed future expansion wing and a fully serviced medical facility that encompasses all services.

Ahmad Al-Jaber Oil & Gas Exhibition

Constructed as a successor to KOC's Display Center, the new exhibition is Kuwait's premier location for those interested in learning about oil and gas. The new Ahmad Al-Jaber Oil & Gas Exhibition, named after Kuwait's 10th ruler, H. H. the late Sheikh Ahmad Al-Jaber Al-Sabah, proudly displays KOC's historic legacy. A key aim of the exhibition is to encourage young people to explore careers in the oil industry. The exhibition accommodates a broad spectrum of visitors, ranging

from heads of state and VIPs to students and visitors from around the world with the common denominator being that everyone, regardless of age or status, can learn about Kuwait's story of oil (see Figure 7.1).

Solar Initiatives

Kuwait recently began operating its first-ever solar power plant as it seeks to diversify its sources of energy to meet fast-rising local demand (see Figure 7.2). The project, Sidrah 500, will produce 10 megawatts (MW) of electricity, half of which will be supplied to the public electricity network. The other half will be used to supply the oil field itself, which is owned by KOC. The opening of the plant follows increased interest in renewables in Kuwait and across the Gulf region in recent years as the scale of the consumption challenge has become clear. Kuwait announced plans to generate 15 percent of its energy needs via renewable sources by 2030. Sidrah 500 represents the country's first step toward that goal.

North Kuwait Production Progress

Heavy oil represents a significant portion of KOC's strategic plan, which requires the development of North Kuwait's heavy oil fields. In order for this development to take place, the first phase of an infrastructure project capable of producing 60,000 BPD must be completed. This first phase, which seeks to extract heavy oil from the Lower Fars Reservoir, will be completed by 2018/19. Heavy oil in the Lower Fars Reservoir at the South Ratqa Field represents a major challenge because of the difficulty associated with its extraction. In part, the process requires advanced forms of technology and a sophisticated heat treatment methodology for exploration and production.

Wastewater Treatment

At KOC, Company officials have long understood the importance of sustainable and efficient containment of waste that is generated in Ahmadi and within the Company's areas of operation. As a result, KOC has worked hard to help preserve and protect Kuwait's environment, which is one of the Company's top priorities. This has given rise to the creation of KOC's Environmental Waste Management Program, a pioneering project for Kuwait and KOC which was born out of the recognition of the importance of environmental custodianship.

The need for sewage treatment plants (STPs) was identified back in 2009. Three STPs were developed in compliance with KEPA standards and methods to handle the sewage generated from all KOC operational areas. The management,

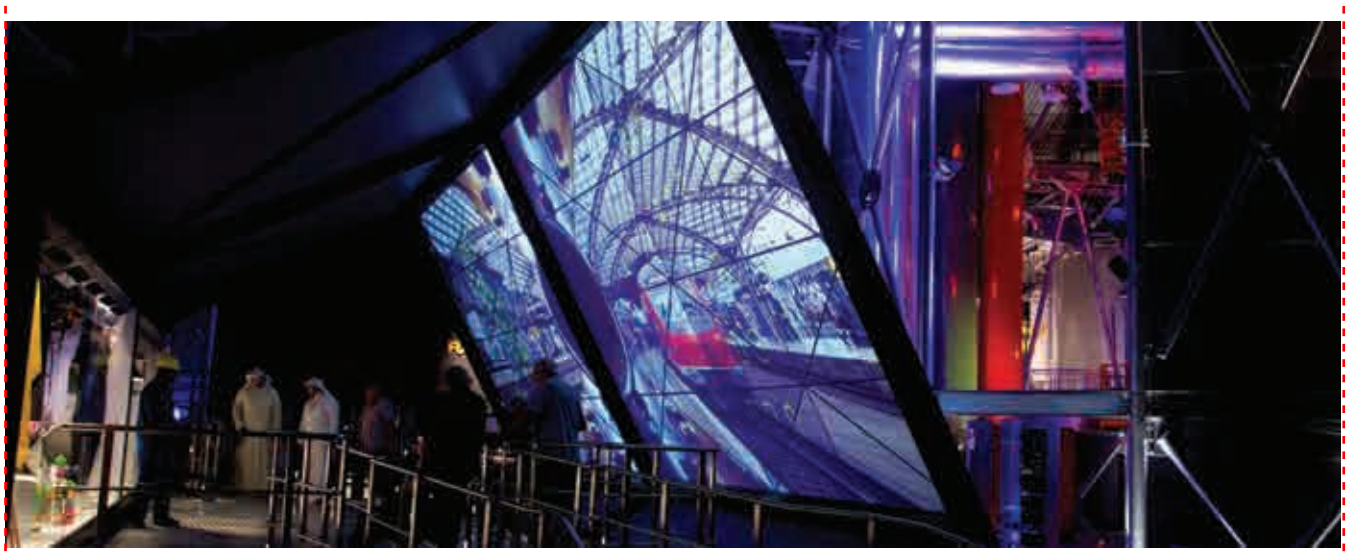

Figure 7.1 The Ahmad Al-Jaber Oil & Gas Exhibition

Figure 7.2 Solar panels at a KOC Oasis

treatment, and disposal of wastewater were developed at KOC to maintain a clean and healthy Kuwaiti environment ecosystem. Each plant has a capacity of 300 m^3/day. The benefits and values of wastewater treatment include:

- Reduced pollution due to transportation
- Reduced economic expenses
- Reduced fuel usage
- Reduced demand of freshwater for irrigation at KOC
- Reduced greenhouse gas emission

Zero Disposal to Pits

As part of efforts to live up to the Company's health, security, safety, and environment (HSSE) obligations, officials from KOC's North Kuwait Directorate recently announced that they have achieved an environmental milestone by successfully implementing the *Zero Disposal to Pits* effort at KOC through a successful commissioning of Effluent Water Injection Phase 1 and Sea Water Injection Phase 2 (EF-1071/EF-1082).

This recent achievement in North Kuwait is important because it safely and effectively disposes of effluent water that is associated with the production process. Safe and effective disposal of effluent water was achieved through the expansion of various North Kuwait facilities, such as Gathering Centers and the Central Injection Pumping Facility. The *Zero Disposal to Pits* effort involves collecting effluent water from KOC's Gathering Centers and safely disposing of the material in designated injection wells. Before the injection process begins, the effluent water is treated through new and specialized

Water Treatment Systems installed under EF-1071/EF-1082 in North Kuwait. In addition to the new systems procured for the water treatment process, KOC has installed a wide range of new facilities that ensure effluent water is disposed of in a safe and responsible manner. An added bonus of this project was a sustainable and subsequent rise of reservoir pressure which will enhance crude production.

Recycling at KOC

Studies indicate that Ahmadi produces approximately 25–30 tons of waste daily, and this is out of 2,500 tons of total waste production in Kuwait. Recent studies indicate that Kuwait is one of the largest producers of waste in the world per capita with most of this waste going to Kuwait municipality landfills.

Within this context, KOC has refocused its attention on environmental protection by dedicating a significant amount of money, time, and energy into developing the Environmental Waste Management Program for KOC residences and offices in Ahmadi.

This project took more than 10 years of research and experimentation until it reached its form today as an integrated system that helps preserve the environment by adequately disposing of and eliminating the risks associated with home and office waste. The project includes the transport, sorting, and primary treatment to transform these materials from undesired waste to raw materials that support local industries. In addition, this pioneering project has received recognition from the United Nations. The UN is a major supporter of environmental preservation systems and projects, and the recognition by the UN has done much in the way of bolstering confidence in this important KOC project.

Here are some interesting statistics (KOC *The Kuwaiti Digest* April–June 2017):

- Each plastic ton received by the recycling center allows for 700 kilograms of raw oil to be saved
- Each ton of received cardboard helps spare 2.5 tons of wood
- Each piece of received paper saves a liter of water in addition to 2.5 watts per hour of electricity and 15 grams of wood.

FUTURE CHALLENGES: THE WAY FORWARD

The Petroleum Industry and Environmental Challenges

The oil and gas industry is facing major challenges in meeting the world's rising hydrocarbon needs in an environmentally sound and socially acceptable way, while curbing its own energy consumption. Many new sources of hydrocarbons, including oil sands, gas-to-liquids, and biofuels are inherently more energy-intensive. Tougher standards for refined products and the growing shift towards lighter products are pushing up the energy intensity of refining. The greater distances over which oil and gas must be transported will boost fuel needs as would the introduction of carbon capture and storage. These challenges make it even more important to unleash the potential that still exists for the industry to save energy through efficiency gains and conservation. Energy efficiency is often the cheapest, fastest, and most environmentally friendly way of meeting the challenges of reducing the industry's own energy needs.

All stakeholders in the hydrocarbon sector—from producers to consumers—have a role to play, working together, to ensure energy is used efficiently and cleanly. The hydrocarbon industry is committed to stepping up efforts to seek out every opportunity for saving energy where it is economic to do so, and to helping policymakers formulate strategies and measures aimed at saving energy and reducing emissions. Policymakers, for their part, are responsible for establishing a stable and predictable policy framework that promotes planning and investment in more efficient energy options, and enhances market drivers to improve efficiency all along the supply chain.

Oil and gas companies will continue to invest heavily in research and development of more efficient technologies; many companies are augmenting their efforts substantially. Government-funded research will remain vital, especially for promising technologies that are not yet ready to be commercialized. Yet, public budgets for oil and gas research remain well below the levels reached after the oil shocks of the 1970s and have fallen in many cases over the past decade. There is a pressing need for the public and private sectors to work together to develop more efficient oil and gas technologies.

The oil and gas industry is responsible for ensuring efficient energy use and conservation in its own activities. But it also has an interest—and, in some cases, a legal obligation—to promote energy-efficient use of its products, particularly since the potential for saving energy there is considerably higher in absolute terms.

For example, a 10% improvement in the efficiency of oil use in transport and other end uses would save the equivalent of one-half of all the energy used by the oil and gas industry worldwide. The oil and gas industry is already helping final consumers of its products to save energy and will continue to do so. Another way in which the industry is seeking to reduce energy needs is through improvements in the quality of its products, such as advanced road fuels that improve mileage. Several European countries have implemented or plan to introduce white certificate schemes, involving obligations or voluntary commitments on the part of producers, suppliers, and distributors of oil, gas, and electricity to undertake energy-efficiency measures that ensure that their final users save an amount of energy equal to a pre-defined percentage of their annual energy deliveries. White certificates are documents certifying that a certain reduction of energy consumption has been attained. Great Britain was the first European country to introduce such a scheme, combining its obligations on suppliers to save energy with the possibility of trading those obligations and the certificates. Italy started a scheme in January 2005 and France a year later, while Denmark and the Netherlands are considering introducing them in the near future.

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Chapter 7

1. Information in this chapter was compiled from different sources by the KOC information team.

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