



Desk Study on the Environment in Iraq



United Nations Environment Programme

First published in Switzerland in 2003 by the United Nations Environment Programme.

Copyright © 2003, United Nations Environment Programme.

ISBN 92-1-158628-3

This publication may be reproduced in whole or in part and in any form for educational or non-profit purposes without special permission from the copyright holder, provided acknowledgement of the source is made. UNEP would appreciate receiving a copy of any publication that uses this publication as a source.

No use of this publication may be made for resale or for any other commercial purpose whatsoever without prior permission in writing from the United Nations Environment Programme.

United Nations Environment Programme

PO Box 30552

Nairobi

Kenya

Tel: +254 2 621234

Fax: +254 2 624489/90

E-mail: cpiinfo@unep.org

Web: <http://www.unep.org>

DISCLAIMER

The contents of this volume do not necessarily reflect the views of UNEP, or contributory organizations. The designations employed and the presentations do not imply the expressions of any opinion whatsoever on the part of UNEP or contributory organizations concerning the legal status of any country, territory, city or area or its authority, or concerning the delimitation of its frontiers or boundaries.

Cover Design and Layout: Matija Potocnik

Maps: UNEP/PCAU and UNEP/DEWA/GRID-Geneva

Cover Photo: Caren Firouz - Reuters

Printer: Imprimerie Chirat, France

Printed on Recycled Paper



Desk Study
on the Environment
in Iraq

Table of Contents

Foreword	6
1. Introduction	8
1.1 Overview	8
1.2 Background and objectives	8
1.3 UNEP's role in post-conflict environmental assessment	9
2. Background information	10
2.1 Overview	10
2.2 Country maps	10
2.3 Geographical features	11
2.4 Key social issues	13
2.5 Key economic issues	17
2.6 Chronology of key events up to and including the 2003 conflict	24
3. Summary of chronic environmental issues	28
3.1 Overview	28
3.2 Water resources	28
3.3 Waste management	34
3.4 Oil industry	37
3.5 Ecosystem degradation	39
3.6 Biodiversity	46
3.7 Institutional and administrative issues	49
4. Environmental impacts of military conflicts	52
4.1 Overview	52
4.2 Iran-Iraq war, 1980-1988	52
4.3 Gulf War, 1991	56
4.4 Environmental impacts and risks from the conflict of March/April 2003	70
5. Next Steps	84
5.1 Overview	84
5.2 Next steps	84
Appendices	
Appendix A References and Internet sources	88

Foreword

Every conflict generates risks to human health and to the environment. The post-conflict situation in Iraq compounds a range of chronic environmental issues, and presents immediate challenges in the fields of humanitarian assistance, reconstruction and administration. Now that major military combat operations have ended, the United Nations Environment Programme (UNEP) is addressing post-conflict risks to the environment and to human health, and promoting long-term environmental management.

Timeliness is paramount. Lessons learned from earlier conflicts show that the immediate environmental consequences must be addressed as soon as possible to avoid a further deterioration of humanitarian and environmental conditions. For this reason, UNEP, as a part of the wider UN family, integrated its post-conflict activities into the UN Humanitarian Flash Appeal launch on 28 March 2003.

Earlier UNEP post-conflict studies also demonstrate that the environment can have major implications for human livelihoods and for sustainable economic development. As such, environmental issues must be integrated across all sectors in post-conflict situations. Following this most recent conflict, Iraqi citizens may have fears about environmental threats from military activities, such as air pollution, drinking water contamination, and the presence of hazardous substances, including heavy metals and depleted uranium. Objective and reliable information will help set aside such fears where the risk is minimal, and will help to target measurement and clean up activities in areas where the risk is higher. For these reasons, and based on this study and the information currently emerging from Iraq, UNEP is recommending that field research and analysis be carried out in Iraq at the earliest possible time.

The approach of this Desk Study is environmental and technical. The intent is not to attach blame for various environmental problems. Rather, it is to provide an overview of chronic and war-related environmental issues, and to identify the steps needed to safeguard the environment. Top priorities include environmental issues that have a direct link with easing the humanitarian situation, especially the restoration of water, power, sanitation networks and ensuring food security.

Identifying, assessing and cleaning up possible pollution 'hot spots' that pose immediate risks to human health, will also be important. These sites could include targeted industrial and/or military sites, damaged sewage treatment systems, and places where municipal or clinical waste has accumulated in the heart of towns and cities. Potential health risks from air pollution, due, for example, to burning oil wells and trenches, or fires at targeted sites, also need to be assessed.

While priority should be given to urgent humanitarian needs related to the environment, there will also be longer-term health and environment problems with consequences for the future of Iraq and its people. In order to address these effectively, the environment should be integrated into all reconstruction and development plans and operations. This will require building a sound knowledge base and strong national institutions and capacities for sustainable environmental management.

This Desk Study of the environmental situation in Iraq was initiated at a humanitarian meeting convened by the Government of Switzerland in Geneva in February 2003. As a consequence of the ongoing conflict, it has not been possible to work in the field, to obtain early

results from environmental measurements, or to contact Iraqi scientists and scientific institutions. For these reasons, and because the study was conducted during a limited period of just six weeks, it is not a comprehensive work covering all environmental issues facing Iraq, and does not purport to be a complete inventory of all war-related environmental damage. Therefore, it should be treated as background information for future work on the environment in Iraq.

UNEP hopes the report will give clear guidance on the next steps for addressing key environmental concerns, and that it will catalyze action to meet both the immediate and long-term needs of the Iraqi people.

Geneva 24 April 2003

Introduction

1.1 Overview

This Desk Study has been prepared by UNEP as a contribution to tackling the immediate post-conflict humanitarian situation in Iraq, and the subsequent rebuilding of the country's shattered infrastructure, economy and environment. It is intended for a wide audience and includes information likely to be of value to many of the stakeholders involved in shaping the future of Iraq.

The study focuses on the state of Iraq's environment against the context of decades of armed conflict, strict economic sanctions and the absence of environmental management principles in national planning.

Attention is drawn to possible next steps, including urgent measures to minimize, mitigate and remediate immediate environment-related threats to human health (e.g. from disrupted or contaminated water supplies, and from inadequate sanitation and waste systems). Suggestions are also made for wider measures, including field missions at an early stage to address the key environmental vulnerabilities and risks identified, and to prepare appropriate action plans, including clean-up and risk reduction measures. At the time of writing (22 April), restoring law and order is a key priority and a prerequisite for dealing effectively with humanitarian and environmental problems.

It is important to underline the scope and limitations of this report, which has been prepared on the basis of a rapid assessment of published and on-line information sources. The section of Chapter 4 that deals with the conflict of March and April 2003 in particular draws heavily on media reports and military briefings.

1.2 Background and objectives

Prior to the outbreak of the conflict of March/April 2003 the government of Switzerland convened in Geneva a 'Humanitarian Meeting Iraq' to provide a platform for expert dialogue between relevant actors. The Swiss delegation proposed the establishment of an 'environmental assistance stand-by group', and explicitly asked UNEP to be part of such a group. Subsequent to this request, UNEP initiated this Desk Study to assess environmental vulnerabilities in Iraq.

The objectives of the Desk Study are to:

- provide a rapid overview and preliminary assessment of the environment in Iraq;
- identify the most significant environmental challenges confronting Iraq as it enters a new chapter in its history;
- identify possible responses to these challenges, including humanitarian actions to avoid or reduce immediate risks to human health;
- indicate potential next steps toward environmentally sustainable reconstruction in Iraq, including measures for institutional strengthening, capacity building, and greatly enhanced participation in global and regional environmental processes.

UNEP has also conducted the following activities in support of the Desk Study:

- Observing environmental conditions during the conflict of March/April 2003, using satellite imagery and other data sources, to identify immediate risks to human health and the environment;

- Marshalling of international scientific expertise to assess environmental risks and provide timely advice on public safety, risk reduction and remediation;
- Conducting round-table discussions and other consultations with relevant expert organizations to gather and share information on environmental issues in Iraq;
- Contributing to the environment-related activities within the UN humanitarian framework by promoting exchange of information between agencies, investigating opportunities for cost sharing, joint training initiatives, joint field missions, and integration of results and findings from other UN agencies into UNEP's ongoing work.

UNEP's proposed activities in Iraq have been included within the UN Flash Appeal for the Humanitarian Requirements of the Iraq Crisis, launched on 28 March 2003.

This report and extensive supporting material has been posted on the website of UNEP's Post Conflict Assessment Unit (<http://postconflict.unep.ch>) to facilitate public access. The Desk Study has been supported financially by the government of Switzerland.

1.3 UNEP's role in post-conflict environmental assessment

UNEP is the United Nations body with specialized environmental expertise and with a mandate to address environmental concerns. Since the 1991 Gulf War, UNEP has been conducting post-conflict environmental assessments in order to:

- identify significant risks to the environment and human health;
- set out recommended priorities and options for environmental reconstruction;
- integrate environmental issues into the reconstruction process;
- build national and local capacities for environmental governance and sustainable resource use;
- study linkages between chronic environmental degradation and human livelihoods.

Between 1999 and 2001, UNEP conducted post-conflict environmental assessments in Kosovo, Serbia and Montenegro, in the former Yugoslav Republic of Macedonia, and in Albania. These assessments included pollution hotspots from the bombing of industrial sites, damage to biodiversity, environmental impacts from refugee flows, and institutional capacities for environmental management. UNEP also conducted a depleted uranium field study in Kosovo in 2000, with subsequent DU studies in Serbia and Montenegro in 2001, and in Bosnia and Herzegovina in 2002.

UNEP's most recent post-conflict assessment, conducted in 2002, included Afghanistan, and the Occupied Palestinian Territories. The full reports of all these assessments can be downloaded from the UNEP Post-Conflict Assessment Unit website at <http://postconflict.unep.ch>

Lessons learned from UNEP's post-conflict assessments demonstrate that environmental contamination and degradation have critical humanitarian consequences requiring consideration at an early stage in relief and recovery operations. Failure to do so can lead to additional degradation of air, soil and water resources, causing long-term threats to both human health and sustainable livelihoods. Furthermore, the assessments have revealed the critical need to build institutional capacities for environmental management immediately after the conflict in order to screen the potential environmental impacts of reconstruction and development projects, and to ensure their sustainability.

2

Background information

2.1 Overview

This chapter presents basic geographical, geo-political and socio-economic background information to provide a context for the environmental issues discussed in subsequent chapters. This information is not intended to be fully comprehensive, but sources are given for readers wishing to obtain further details.

2.2 Country maps

Map 1 shows Iraq, its six neighbouring states, major cities and the Tigris and Euphrates Rivers. Iraqi territory covers an area in excess of 430,000 km², while the Gulf coastline is just 58 km in length.

► Map 1. Iraq and neighbouring region



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

As shown in Map 2, there are currently 18 provinces or governorates. Since 1970, three of the northern governorates (Dahuk, Sulaymaniyah and Arbil) have been officially designated as a Kurdish autonomous region, with a separate elected legislature. This region came under UN and coalition protection after the 1991 Gulf War, to prevent the Iraqi regime from taking military action against the Kurdish population.

► Map 2. Iraq is divided into 18 provinces or governorates



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

2.3 Geographical features

Iraq can be roughly divided into four major geographical zones.^{1,2} These are described briefly below and shown in Map 3.

- (a) **Desert plateau:** Approximately 40% of Iraqi territory consists of a broad, stony plain with scattered stretches of sand, lying west and southwest of the Euphrates River and sparsely inhabited by pastoral nomads. A network of seasonal watercourses – or wadis – runs from the country’s western borders towards the Euphrates River.

2

- (b) **Northeastern highlands:** Covering approximately 20% of the country, this region extends south of a line between Mosul to Kirkuk towards the borders with Turkey and Iran, where mountain ranges reach up to 3,600 m in altitude.
- (c) **Uplands region:** About 10% of Iraq comprises a transitional area between the highlands and the desert plateau, located between the Tigris north of Samarra and the Euphrates north of Hit, and forming part of a larger natural area that extends into Syria and Turkey. Much of this zone may be classified as desert because watercourses flow in deeply cut valleys, making irrigation far more difficult than in the alluvial plain (see below).
- (d) **Alluvial plain:** Approximately 30% of Iraq is composed of the alluvial plain formed by the combined deltas of the Tigris and Euphrates Rivers. This region begins north of Baghdad and extends south to the Gulf coast bordering Iran. The once extensive wetlands of the region have been decimated by damming and diversion of the Euphrates in Turkey and Syria, and by large-scale drainage works carried out by the Iraqi regime.

► Map 3. Elevation and principal geographical regions of Iraq



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

2.4 Key social issues

The 1997 census recorded a total population of 22.3 million with a national average population density of 51 persons per sq km.^{3,4} However, actual density varied from 5 inhabitants/km² in the western desert province of Al Anbar (Anwar), to more than 170 inhabitants/km² in the fertile lowlands of Babil (Babylon). Seventy-five per cent of the population was concentrated in urban centres. Average population growth was estimated at 3.6% in the period 1980-1990, but emigration of foreign workers and severe economic hardship have reduced that rate since 1990,⁵ with estimated growth of 2.8% in 2002. In the same year, infant mortality was estimated at 57.6 deaths/1,000 live births, with a life expectancy at birth of 67.4 years. Women were expected to bear an average of 4.6 children.

► Urban Growth (2002)



SPOT Image 27 August 2002: False color composite, Bands 4, 3 and 1

Image courtesy of Digital Globe

The population of Baghdad grew from 3.8 to 5.6 million between 1987 and 2002

Over the last decade, Iraq's urban and rural society has been expanding and undergoing rapid social change. The main urban centres of Baghdad and Basra, for example, have grown at tremendous speed. The accelerated process of urbanization throughout the country (see Table 1) reflects the concentration of trade, construction, and real estate activities based on oil revenues and has resulted in a dramatic population decrease in rural areas.⁶

Prior to the 1991 Gulf War, Iraq enjoyed a high standard of living, with a majority of the population making up a relatively wealthy middle class.⁷ In fact, in 1990, the United Nations Develop-

ment Programme (UNDP) listed Iraq as 67th on its Human Development Index based on the country's (then) high levels of education, access to potable water and sanitation, as well as low infant mortality figures.⁸ However, when revenues from the oil industry fell dramatically due to the application of UN sanctions (see page 21) the humanitarian situation deteriorated, with dwindling food and water supplies and greatly reduced access to healthcare and education.⁹

Table 1. Population figures for major cities of Iraq (those with estimated 2002 population in excess of 500,000)⁷

City	Governorate	1987	2002
Baghdad	Baghdad	3,841,268	5,605,000
Kadhimiya		521,444	not available
Adhamiya		464,151	not available
Mamoon		244,545	not available
Karradah Sharqiyah		235,554	not available
Mosul	Nineveh (Ninawa)	664,221	1,739,000
Basrah	Basrah	406,296	1,337,000
Kirkuk	At-Ta'mim	418,624	728,000
Najaf	An-Najaf	309,010	563,000
Karbala	Karbala	296,705	549,000
Nasriyah	Dhi-Qar	265,937	535,000
Hilla	Babylon(Babil)	268,834	524,000
Kurdish autonomous region			
Irbil	Arbil	485,968	839,000
Sulaymaniyah	As-Sulaymaniyah	364,096	643,000

Health

The country's medical infrastructure is in a very poor state. Many facilities are only partially operational because of inadequate maintenance of buildings and equipment, and a lack of vital spare parts. Prior to the outbreak of renewed military conflict in March 2003, essential medicines and equipment had been made available under the oil-for-food programme (see page 21), contributing to an improvement in the overall situation, but there were still shortages of antibiotics, anaesthetics and intravenous fluids, as well as detergents and disinfectants.¹⁰ Health problems faced by the Iraqi population include malnutrition, nutritional anaemia, deficiencies of vitamin A and iodine, malaria, acute respiratory infections, leishmaniasis, and measles. Morbidity rates among children under five are very high, with acute respiratory tract infections and diarrhoeal disease representing over 70% of deaths.¹¹

In August 1999, UNICEF and the government of Iraq released the results of the first study of child mortality conducted since 1991. The survey showed that mortality among children under five years old had more than doubled, from 56 deaths per 1,000 live births in 1984 to 131 deaths in the period 1994-1999.¹² Following the 1991 Gulf War, chronic malnutrition among under-fives soared to 30% in 2000, from 18.7% in 1991. The average under-five suffered 14 episodes of diarrhoea per year – a three-fold increase since 1990.¹³

By 2002, the trend of malnutrition among children under the age of five, albeit still at a relatively high level, had been arrested and reversed in the centre and south of Iraq. Malnutrition rates in these regions in 2002 were half those of 1996, while in the three northern governorates there was a 20% reduction in acute malnutrition, a 56% reduction in chronic malnutrition and a 44% reduction in the incidence of underweight children in the under-five age group.¹⁴



EQUILIBRE - LAZAREVSKI - CORBIS

Distribution of food aid to Iraqi citizens. Meeting basic humanitarian needs is a top priority and will be assisted by securing a healthy environment.

Water supply and sanitation

Recent statistics for the north of Iraq have shown a fall in the number of cases of typhoid, cholera and malaria – diseases linked to the absence of clean water supply and adequate sanitation systems. By contrast, the situation remains critical in the centre and south of the country. Over the last decade, the water distribution system has steadily deteriorated, due mainly to a lack of spare parts and maintenance. As a consequence, the amount of water available for distribution has fallen by more than half, and much of the remaining resource never reaches the final consumer because of leakages. Furthermore, the rivers that most Iraqis rely on for their water are increasingly contaminated with raw sewage, as waste treatment plants fall into disrepair.¹⁵

It has been estimated that 5 million people (19% of the total population) are at risk from lack of access to safe water and sanitation. The supply of potable water in southern and central Iraq is dependent on the continuing operation of water treatment plants in urban areas and compact units in rural areas – all of which require electricity from the main power distribution grids. Any disruption of electrical power stemming from the current conflict would therefore exacerbate an already serious situation.¹⁶

Food supply

As of early 2003, UNICEF reported that close to 60% of Iraqis were fully dependent on the monthly government-distributed food ration. Although the nutritional value of the ration had increased under the oil-for-food programme, it still did not reach the minimum threshold set by the UN Secretary General. Over 18 million people were considered by UNICEF as being ‘food insecure’ and therefore highly vulnerable during a conflict.¹⁷ The situation in the three northern Kurdish governorates, where food distribution and administration were managed by the United Nations, has been somewhat better than in other regions of the country.¹⁸

On 17 April 2003 the World Food Programme (WFP) stated that it had received no reports of extreme food shortages in Iraq, but the agency was expecting reserves to be exhausted by

early May. To avert a humanitarian catastrophe, WFP is implementing a US\$1.3 billion Iraq emergency operation plan to re-establish the Public Distribution System (PDS) - a vast network that delivered food aid to the Iraqi people under the UN oil-for-food programme (see page 21). To replenish the PDS, WFP will need to import an estimated 480,000 metric tons of food commodities each month into Iraq.

Income, employment and education

Since economic sanctions were first imposed (see panel on page 21), most Iraqi families have exhausted their assets, selling possessions to meet urgent day-to-day needs.¹⁹ Prior to the outbreak of the conflict in March 2003, at least 50% of the labour force was unemployed or underemployed, GDP had fallen further from a 1995 estimate of US\$715 per capita, and a shortage of basic goods, compounded by drought, had resulted in rampant inflation (120% in 2000).²⁰

The most recent estimates of literacy rates are for 1997. At that time, 57% of the total adult population was considered literate (males 69.5%, females 42%).²¹

At the start of 2003, UNICEF reported that one-third of all children no longer attended school due to economic hardship. Non-attendance by boys was higher than for girls, whereas, prior to 1990, attendance and educational standards were approximately the same for both boys and girls.²² Orphanages are confronted with increasing numbers of abandoned children, without the resources to care for them properly. In Baghdad and other large cities, there is a growing problem of homeless children living on the streets.²³

Refugees and internally displaced persons

There were more than 128,100 refugees and about 700,000 internally displaced persons in Iraq in 2001. Displacement and redistribution was a policy pursued by the regime, which has resulted in crowded and ethnically unbalanced cities both in the north as well as in western



Approximately 40,000 Marsh Arabs are living in refugee camps in Khuzestan province Iran



PETER TURNLEY - CORBIS

Northern Iraq is home to hundreds of thousands of internally displaced Kurds

and southern parts of the country. The refugees included about 23,700 from Iran and 13,100 from Turkey (in both cases mostly Kurds), about 90,000 Palestinians, and about 1,300 refugees of other nationalities.²⁴ An estimated 600,000 internally displaced persons in the Kurdish-controlled northern governorates included more than 100,000 people expelled by the Iraqi regime from Kirkuk and surrounding districts. At least another 100,000 persons were internally displaced elsewhere in Iraq, mostly in the southeastern marshlands.²⁵ In 2001, an estimated one to two million Iraqis living outside Iraq were believed to be at risk of persecution if they returned, although only about 300,000 had any formal recognition as refugees or asylum seekers.²⁶

2.5 Key economic issues

Energy supplies

Twenty power stations and up to 90% of Iraq's electricity distribution grid was damaged or destroyed in the 1991 Gulf War. By 1998, the Iraqi authorities estimated that about 45% of the maximum pre-war generation capacity had been restored, with a report in November 1999 indicating that this figure may have increased to around 65%. Nevertheless, power continued to be rationed throughout the country.²⁷ Prior to the 2003 conflict, electricity was available for less than 12 hours per day in parts of the country, resulting in the degradation of public services, ranging from water supply and sanitation systems, to educational and health facilities, as well as a substantial drop in overall living standards.²⁸

Economy – oil industry

Iraq's economy is dominated by the oil sector, which has typically provided 95% of foreign exchange earnings. It was the first country in the Middle East region to strike oil and, at peak production, prior to the 1990 invasion of Kuwait, had an output of 3 million barrels of oil per day. Iraq has the second largest proven oil reserves in the world (some 112 billion barrels), next only to Saudi Arabia, with an estimated 220 billion barrels of potential reserves.



FRANCOISE DE MULDER - CORBIS

Iraqi power station bombed by coalition forces during the 1991 Gulf War

The country's true resource potential may be far greater than this, since up to 90% of Iraqi territory is unexplored by modern seismic techniques. Deep oil-bearing formations located mainly in the vast western desert region, for instance, could yield large additional oil resources (possibly another 100 billion barrels). Overall, only about 2,000 wells have been drilled in Iraq (of which about 1,500-1,700 are actually producing oil), compared to around one million wells in Texas, for example. Furthermore, oil production costs in Iraq have been amongst the lowest in the world, presenting a highly attractive commercial prospect.²⁹

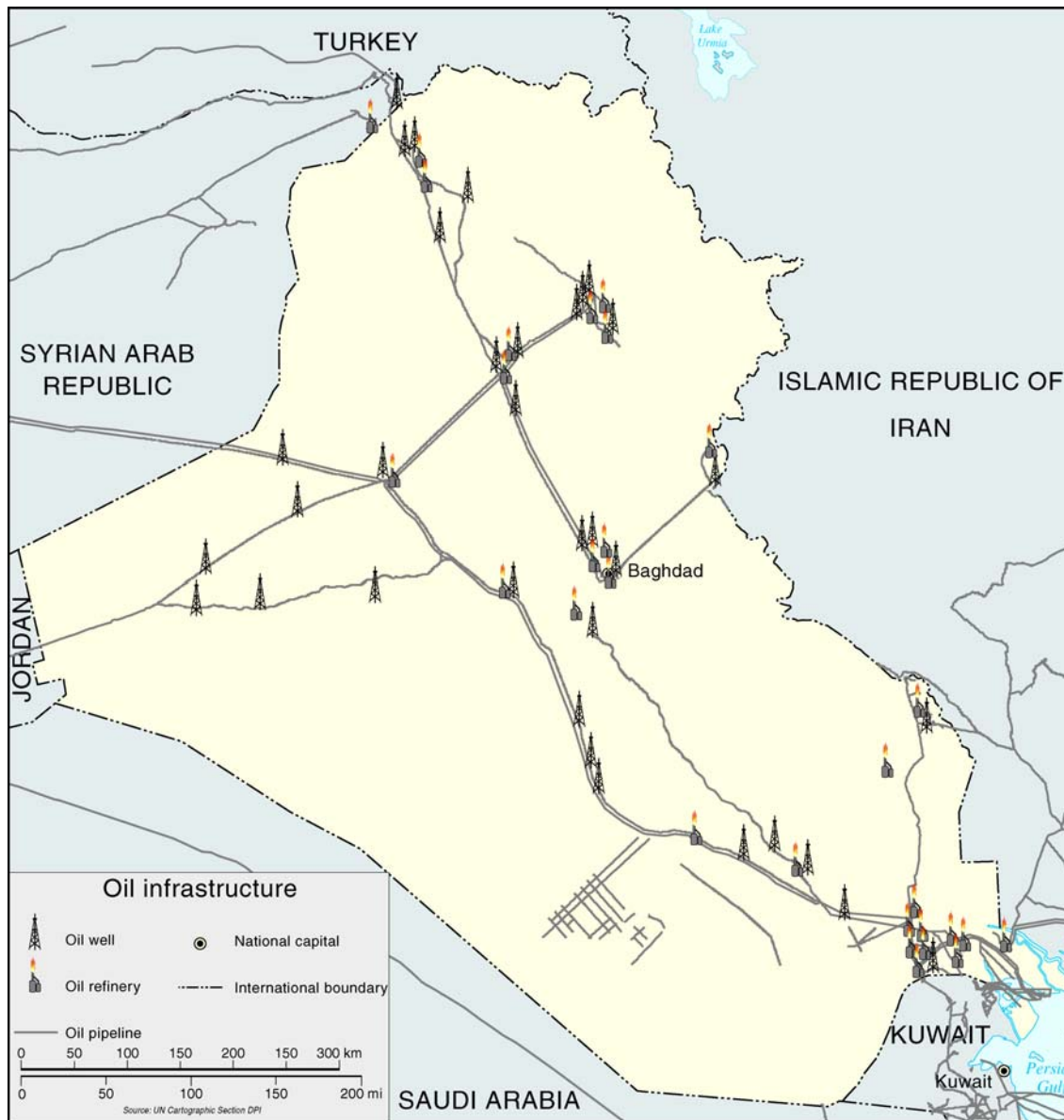
Production is concentrated in two main areas, namely northern Iraq in and around Kirkuk, and, in the south, around Basra (see Map 4 and Table 2). Under the oil-for-food programme (see page 21) most production from the north has been exported via pipeline through Turkey, though 180,000 barrels per day (bpd) were being piped to Syria without UN supervision.³⁰

Table 2. Iraqi oil production capacity

Location	Number of wells	Estimated production capacity (thousand barrels per day)
Northern oil fields		
Kirkuk	96	800
Bai Hassan	57	100
Jambur	30	45
Khabbaz	29	30
Saddam	84	15
Others	202	15
Southern oil fields		
Rumaila	436	1250
Al Zubair	56	150
West Qurna	15	50
Others	100+	75

The country's second most important production centre after Kirkuk is the southern field of Rumaila (1.25 million bpd), while other large southern fields include Al-Zubair and West Qurna. Production from the southern oil fields is exported via a pipeline to northern Iraq, and from there to Turkey, as well as via the offshore terminal of Mina al-Bakr in the Gulf.³¹

► Map 4. Distribution of principal Iraqi oilfields



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

The war with Iran in the 1980s cost Iraq an estimated US\$100 billion, wiping out official foreign exchange reserves and leading the government to implement a range of austerity measures. After the cessation of hostilities, oil exports gradually recovered to approximately 3.5 million bpd. The 1991 Gulf War and UN sanctions caused a renewed slump, although very high levels of government military and security spending have also harmed the economy. Under the oil-for-food programme, oil exports in early 2003 had reached more than 75% of their pre-Gulf War levels, though per capita output and living standards were still well below the pre-war level.³² At the same time, Iraq had reportedly signed several multi-billion dollar deals with foreign oil companies, mainly from China, France and Russia, aiming to increase its production capacity to six million barrels or more per

day, though ongoing UN sanctions had inhibited ‘on-the-ground’ implementation of these agreements.³³

Also as a consequence of economic sanctions, Iraq had little or no access to state-of-the-art oil industry technology, spare parts, or basic investment through most of the 1990s. This means that outmoded technology and unsustainable practices (such as over-pumping, and injection of contaminated waste water into the ground) have reportedly been used to maintain production. There is evidence that this may have caused long-term damage to some reserves. The Iraqi government indicated in early 2002 that only 24 of 73 Iraqi oil fields were in production, while an international oil consulting company recently highlighted the risk of a 5%-15% annual decline in production capacity at potentially damaged oil fields.³⁴

Iraq’s southern oil industry was badly affected by the 1991 Gulf War, with production capacity falling to 75,000 bpd in mid-1991, while an estimated 60% of facilities in northern and central Iraq were also damaged. In general terms, oilfield development plans have been on hold since 1990, with efforts focused on maintaining production at existing fields.

In March 2000, the UN Security Council agreed to raise the spending cap for oil sector spare parts and equipment, allowing Iraq to spend up to US\$600 million every six months on repairing oil facilities. According to the *Middle East Economic Survey* (MEES), problems at Iraqi oil fields include *inter alia*: years of poor oil reserve management, corrosion problems at various facilities, deterioration of water injection facilities, lack of spare parts, and damage to oil storage and pumping facilities. MEES estimates that Iraq could reach production capacity of 4.2 million bpd within three years at a cost of US\$3.5 billion, and 4.5-6.0 million bpd within seven years.

■ Natural gas

Iraq has 3.114 trillion m³ of proven natural gas reserves, and approximately 4.25 trillion m³ in probable reserves. About 70% of Iraq’s natural gas reserves are ‘associated’ (meaning that the gas occurs with oil reserves). In 2001, Iraq produced 2.75 billion m³ of natural gas, down drastically from peak output levels of 19.82 billion m³ in 1979. Iraq has had a long-term strategy of increasing its domestic consumption of natural gas to free as much oil as possible for export. Options for constructing a gas export line from Iraq to serve the European market have been developed and costed.

■ Oil refining

Iraq’s refining capacity as of January 2003 was believed to be over 417,000 bpd, compared to a pre-Gulf War capacity of 700,000 bpd. The country has ten refineries and topping units, the largest of which are the 150,000 bpd Baiji North, 140,000 bpd Basra, and 100,000 bpd Daura plants. During the Gulf War, both Baiji in northern Iraq along with the refineries at Basra, Daura, and Nasiriyah were severely damaged. Refineries have also been hit hard by sanctions, due to shortages of supplies and spare parts.

■ Oil export pipelines and tanker terminals

Currently, the 960 km Kirkuk-Ceyhan pipeline, linking Iraq with Turkey, is the largest operable crude export pipeline, with a fully operational capacity of 1.1 million bpd (though reports indicate a current capacity of around 900,000 bpd). A second, parallel pipeline has an optimal capacity of 500,000 bpd, but is reportedly inoperable.

In 1998, Iraq and Syria signed a memorandum of understanding concerning the possible reopening of the 50-year-old, rusting pipeline from Iraq’s northern Kirkuk oil fields to the

Syrian port of Banias. The facility was reportedly in use in October 2002 and discussions were being held with a view to building a parallel replacement pipeline.

In order to optimize export capabilities (i.e. to allow oil shipments to the north or south), in 1975 Iraq constructed a reversible, 1.4-million bpd 'Strategic Pipeline' consisting of two parallel 700,000 bpd lines. This north-south system allows for export of northern Kirkuk crude from the Gulf and for southern Rumaila crudes to be shipped through Turkey. During the Gulf War, the Strategic Pipeline was disabled by the destruction of pumping stations.

Iraq has three tanker terminals in the Gulf: at Mina al-Bakr, Khor al-Amaya, and Khor az-Zubair. Mina al-Bakr is the largest, with four 400,000 bpd capacity berths capable of handling very large crude carriers. Gulf War damage to Mina al-Bakr in 1991 appeared to have been repaired in large part prior to the 2003 conflict and the terminal was able to handle 1.2-1.3 million bpd. Khor al-Amaya was destroyed during the Gulf War, with partial repairs completed by the end of 2001. Its projected future capacity was 1.2 million bpd.

UN sanctions against Iraq and the oil-for-food programme

In August 1990, the UN Security Council (UNSC) responded to Iraq's invasion of Kuwait by adopting Resolution 661, which placed a ban on all imports and exports except for "supplies intended strictly for medical purposes, and, in humanitarian circumstances, foodstuffs." The sanctions were maintained after the Gulf War as a means of enforcing Iraqi compliance with a number of new conditions imposed by UNSC cease-fire resolutions, primarily aimed at destroying Iraq's capacity to produce weapons of mass destruction (see Chapters 3 and 4).

Due to declining humanitarian conditions, an oil-for-food programme (OFFP) was established in 1997 under UNSC resolution 986, enabling Iraq to sell limited quantities of oil to purchase humanitarian supplies. The ceiling on oil sales was eased during 1998 and finally lifted in 1999, enabling the programme to move from a focus on food and medicine alone, to repairing essential infrastructure, including the oil industry.

The Office of the Humanitarian Coordinator for Iraq (UNOHC/I) is an integral part of the UN Office of the Iraq Programme (UNOIP). The Humanitarian Coordinator has been responsible for the management and implementation of the OFFP in the field, involving nine other UN agencies and programmes.

Under the terms of UNSC resolution 1330 of December 2000, 72% of Iraqi oil revenues were used to fund the humanitarian programme in Iraq (59% for the centre and south of the country and 13% for the three northern governorates); 25% was remitted to the UN Compensation Commission in Geneva, while 3% covered UN administrative costs for running both UNOIP and the weapon inspection programme. The government of Iraq was responsible for the purchase and distribution of supplies in the centre and south (subject to UN monitoring), while the UN itself undertook these tasks in the three Kurdish governorates.

As of early 2003, some US\$26 billion in humanitarian supplies and equipment had been delivered to Iraq under the programme, including US\$1.6 billion of oil industry spare parts and equipment. An additional US\$10.9 billion worth of supplies were due for delivery. However, the OFFP was suspended shortly before the outbreak of hostilities in March 2003.

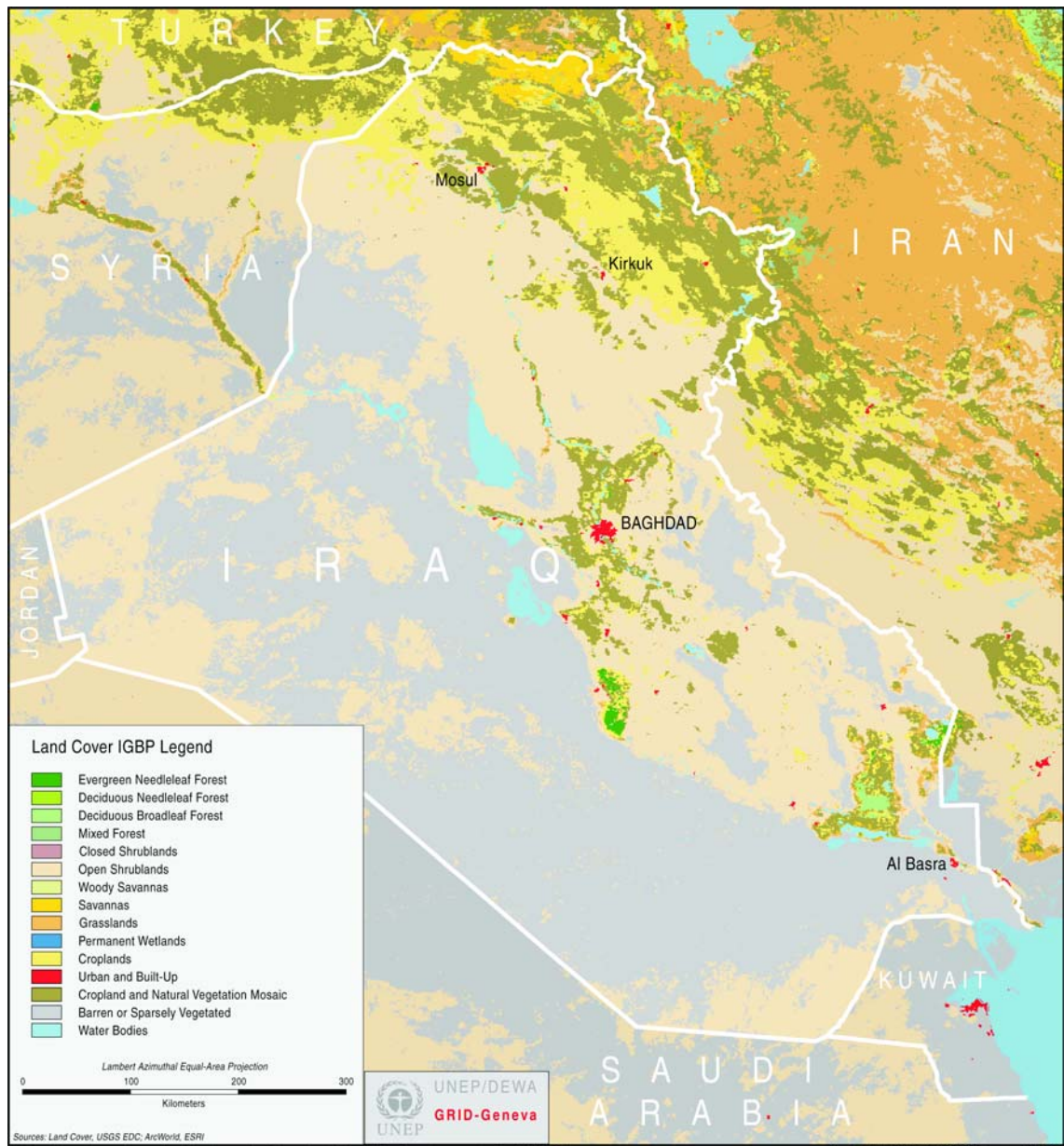
On 28 March 2003 the UNSC adopted resolution 1472 making temporary and technical adjustments to the OFFP. This resolution gave the Secretary General authority to use certain funds from OFFP accounts for limited purposes included in the Flash Appeal. The Secretary General was also authorized to review, as a matter of urgency, already approved contracts and to determine the relative priorities for providing medical supplies, food and other commodities to meet essential civilian needs. The resolution limited this mandate to contracts only that could be shipped within a period of 45 days (by 12 May 2003).

As of 31 March 2003 there were US\$10.15 billion of approved and funded contracts in the pipeline and an additional US\$5.8 billion had been approved but not yet funded. At the time of writing, the respective UN agencies are evaluating and renegotiating contracts with the aim of providing immediate assistance under the mandate given to the Secretary General. By 22 April, some US\$ 455 million worth of supplies had been identified.

Agriculture

Although the agriculture sector contributed relatively little to the economy before the Gulf War, it has played an increasingly important role in recent years. Given serious import supply constraints, the government has implemented a number of measures aimed at achieving greater self-sufficiency in food. However, economic sanctions have limited access to foreign investment and imported supplies, including spare parts for farm machinery as well as fertilizers, pesticides and herbicides. In addition, the country suffered a major drought at the end of 2000.³⁵ Unsustainable water management practices, including construction of large dams and irrigation schemes, have resulted in deterioration of the quality of soil and land productivity.

► Map 5. Principal landcover types in Iraq



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Created at UNEP/DEWA/GRID-Geneva; April 2003



NIK WHEELER

Grazing buffalo

The desert plateau provides the country's main rangeland grazing, as well as limited dryland cultivation. The uplands and mountains yield acorns, almonds, walnuts and pine nuts, with additional grazing and dryland cultivation. Irrigated agriculture occurs mainly in the alluvial plain.³⁶ It is estimated that about 11.5 million ha, or approximately one quarter of the country's total area, are cultivable. However, due to land degradation (see page 45), the practice of leaving some land uncultivated, and the recent unstable political situation of recent years, it is



DAVID BUTOW - CORBIS

Farmers gathering hay

estimated that only 3 to 5 million ha are currently cultivated annually.³⁷ The principal crops include dates, wheat, barley, maize, rice and cotton, as well as a wide variety of fruit and vegetables.³⁸

The UN Food and Agriculture Organization (FAO) has recently expressed concerns that the 2003 harvest (due in May/June) could be at risk from continuing instability and fuel and manpower shortages.

Other key industries

Iraq's industrial infrastructure was heavily damaged during the 1991 Gulf War and little information has been made publicly available on the situation since then. Apart from armaments and oil/gas production, petrochemical industries make up the most important sector, with products including agricultural chemicals, pharmaceuticals, and fibres. Other manufacturing industries include textile and paper mills, furniture factories, electronics plants, and iron and steel production. All of these industries use raw materials and/or generate waste that may pose risks to the environment and human health, particularly given the country's absent or rudimentary waste collection and treatment systems (see page 34).

2.6 Chronology of key events up to and including the 2003 conflict

The following table summarizes key events in Iraq from the country's independence in 1932 to the military conflict of March/April 2003.³⁹

From independence to the succession of Saddam Hussein to the Presidency

1932 3 October – Iraq becomes an independent state.

1958 14 July – the monarchy is overthrown in a military coup and Iraq is declared a republic.

1963 8 February – the government is overthrown in a coup led by the Arab Socialist Ba'ath Party.

1979 16 July – Saddam Hussein becomes President.

Iran-Iraq war

1980 4 September – war breaks out between Iran and Iraq.

1983-1988 – Iraq deploys chemical weapons.

1988 20 August – a ceasefire comes into effect, to be monitored by the UN.

Iraq invades Kuwait

1990 2 August – Iraq invades Kuwait and is condemned by United Nations Security Council (UNSC) Resolution 660 which calls for full withdrawal.

1990 6 August – UNSC Resolution 661 imposes economic sanctions on Iraq.

1990 29 November – UNSC Resolution 678 authorizes states cooperating with Kuwait to use "all necessary means" to uphold UNSC Resolution 660.

The Gulf War

1991 16-17 January – war breaks out when the US-led coalition of 34 countries begins aerial bombing of Iraq in Operation 'Desert Storm'.

1991 24 February – the start of coalition ground operations which results in the liberation of Kuwait on 27 February.

1991 February-April – more than 600 Kuwaiti oil wells are on fire.

1991 3 March – Iraq accepts the terms of a ceasefire.

1991 3 April – UNSC adopts resolution 687, which, *inter alia*, establishes UNSCOM, the United Nations Special Commission responsible for inspecting and supervising the destruction of Iraq's weapons of mass destruction.

1991 Mid-March/early April – Iraqi forces suppress rebellions in the south and the north of the country.

1991 10 April – the US-led coalition orders Iraq to end all military activity north of latitude 36 degrees north, aiming to establish a 'safe-haven' for the protection of the Kurds.

1991 20 May – the United Nations Compensation Commission (UNCC), a subsidiary organ of the UNSC, and the UN Compensation Fund are established to process claims and pay compensation for losses, including environmental damage, resulting from Iraq's invasion and occupation of Kuwait.

1992 26 August – the coalition imposes a second no-fly zone, excluding flights of Iraqi aircraft, in southern Iraq, south of latitude 32 degrees north.

1994 10 November – the Iraqi National Assembly recognizes Kuwait's borders and its independence.

Oil-for-food programme

1995 14 April – UNSC Resolution 986 allows the partial resumption of Iraq's oil exports to buy food and medicine (the 'oil-for-food' programme – see text box on p. 21 for further details). However, the resolution is not recognized by Iraq until May 1996 and is not implemented until December 1996.

1996 31 August – Iraqi forces launch an offensive into the northern no-fly zone, in response to a call from Kurdish leaders for international aid.

1996 3 September – the US extends the northern limit of the southern no-fly zone to latitude 33 degrees north, just south of Baghdad.

1998 31 October – Iraq ends all forms of cooperation with UNSCOM.

Operation Desert Fox

1998 16-19 December – after UN staff are evacuated from Baghdad, the US and UK launch a bombing campaign, Operation 'Desert Fox', against Iraqi nuclear, chemical and biological weapons facilities.

Establishment of UNMOVIC

1999 17 December – UNSC Resolution 1284 creates the UN Monitoring, Verification and Inspection Commission (UNMOVIC) as the successor body to UNSCOM. The resolution is rejected by Iraq.

2000 1 March – Dr Hans Blix becomes Executive Chairman of UNMOVIC.

2000 October – Iraq resumes domestic passenger flights, the first since the 1991 Gulf War. Commercial air links re-established with Russia, Ireland and Middle East.

2001 – free-trade zone agreements set up with neighbouring countries. Rail link with Turkey re-opened in May for first time since 1981.

2001 February – US and UK carry out bombing raids attempting to disable Iraq's air defence network.

2002 April – Baghdad suspends oil exports in protest against Israeli incursions into Palestinian Territories. Despite calls by Saddam Hussein, no other Arab countries follow suit. Exports resume after 30 days.

2002 May – UNSC agrees to overhaul the sanctions regime, replacing a blanket ban on a range of goods with ‘smart’ sanctions targeted at military and dual-use equipment.

Weapons inspectors return

2002 12 September – US President George Bush tells world leaders gathered at a UN General Assembly session to confront the “grave and gathering danger” of Iraq.

2002 November – UNMOVIC inspectors return to Iraq (for the first time since UNSCOM inspections were halted in 1998) backed by UNSC Resolution 1441 that threatens serious consequences if Iraq is in “material breach” of its terms.

2003 March – the Executive Chairman of UNMOVIC reports that Iraq has accelerated its cooperation but says inspectors need more time to verify Iraqi compliance.

2003 17 March – following the failure of intensive deliberations among Security Council members on possible next steps to ensure Iraqi compliance, the UK’s ambassador to the UN says the diplomatic process on Iraq has ended; UN Secretary General orders the evacuation of arms inspectors from Iraq; President Bush gives Saddam Hussein 48 hours to leave Iraq or face war.

2003 19 March – UN Secretary General addresses UNSC, expressing regret and disappointment at the imminence of war.

Renewed conflict

2003 20 March – missiles hit targets in Baghdad, marking the start of a US-led campaign to topple the Iraqi regime. In the following days US and British ground troops enter Iraq from the south and numerous targets are struck in Baghdad and other key cities.

2003 24 March – UN Secretary General calls for “urgent measures” to restore electricity and water in Basra.

2003 25 March – coalition forces cross the Euphrates at Nasiriya.

2003 28 March – UNSC adopts resolution 1472 adjusting the oil-for-food programme, authorizing the Secretary General to use limited OFFP funds for the UN Humanitarian Flash Appeal launched the same day.

2003 1 April – coalition forces are within 45 km of Baghdad.

2003 4 April – power is cut to most of Baghdad.

2003 6 April – coalition forces enter Basra, taking control the next day.

2003 7 April – coalition forces take control of key sites in Baghdad.

2003 9 April – coalition forces sweep into central Baghdad. Widespread looting breaks out.

2003 11 April – coalition forces move to secure Kirkuk oil field.

2003 14 April – the Pentagon says that all major combat operations are probably at an end, following the fall of Tikrit, Saddam Hussein’s home town.



STEVEN B. LEHMANN - UNEP - TOPHAM

Blazing oil fire in Kuwait in 1991

3

Summary of chronic environmental issues

3.1 Overview

Iraq is confronted with a range of environmental problems that are both immediate and severe. Some can be directly linked with the effects of recent military conflicts. Others have been triggered by internal Iraqi policies and actions, and exacerbated by factors such as the impact of economic sanctions and limited regional cooperation on the management of shared natural resources.

Critical long-term environmental vulnerabilities and risks are particularly associated with:

- water resource management, including groundwater
- waste management, including hazardous waste
- the oil industry
- ecosystem degradation, including the desiccation of the Mesopotamian Marshes, desertification and deforestation, and loss of biodiversity.

3.2 Water resources

Main problems:

- the adverse downstream impact of large dams in the upper Tigris and Euphrates basin
- deliberate drainage of Iraqi wetlands
- severe contamination of surface water by sewage and other waste
- inadequately maintained and war-damaged water distribution network
- land salinization and waterlogging due to unsustainable irrigation practices and poor maintenance
- potential contamination of groundwater by oil spills.

■ The significance of the Tigris and Euphrates Rivers to Iraq

Iraq is traversed by two major rivers, the Tigris and the Euphrates, both of which rise in the eastern mountains of Turkey and enter Iraq along its northwestern borders. Before their confluence just north of Basra, the Euphrates flows for about 1,000 km and the Tigris for some 1,300 km within Iraqi territory.¹ Downstream from this point, the combined rivers form the tidal Shatt al-Arab waterway, which flows 190 km into the Gulf. The southern Shatt al-Arab forms the border between Iraq and Iran and represents the symbolic boundary of Arab culture and language.^{2,3}

The Euphrates basin (579,314 km²) embraces parts of Iraq (roughly 49% of the basin), Turkey (21%), Syria (17%) and Saudi Arabia (13%).⁴ The Euphrates River does not receive water from permanent tributaries within Iraqi territory and is fed only by seasonal runoff from wadis.⁵



Euphrates River fringed by date palm trees

The Tigris basin (371,562 km²) covers parts of the territories of Iran (47.2% of the basin), Iraq (38%), Turkey (14%) and Syria (0.3%). Within Iraq, the Tigris River receives water from four main tributaries, the Khabour, Great Zab, Little Zab and Diyala, which rise in the mountains of eastern Turkey and northwestern Iran and flow in a southwesterly direction until they meet the Tigris. A seasonal river, Al Authaim, rising in the highlands of northern Iraq, also flows into the Tigris, and is the only significant tributary entirely within Iraq.⁶

The great alluvial plains of the Tigris and Euphrates Rivers comprise more than a quarter of Iraq's surface area. Topographically, the region is extremely flat, with a fall of only 4 cm/km over the lower 300 km of the Euphrates and 8 cm/km along the Tigris. Under natural conditions, the region was rich in wetlands and subject to annual flooding of up to 3 m. In recent years, this seasonal flooding has occurred on a much smaller scale because of dams constructed upstream, particularly on the Euphrates in Turkey and Syria,⁷ and due to large-scale drainage works in Iraq itself (page 30).⁸

Until the mid-20th century, most efforts to regulate the Tigris and Euphrates were primarily concerned with irrigation, but development plans in the 1960s and 1970s were increasingly devoted to reduction of flooding, though expansion of irrigation in upstream parts of the river basins was also an important goal.

In 1980, a Joint Technical Committee on Regional Waters was created by Turkey and Iraq, on the basis of a 1946 protocol concerning the control and management of the Euphrates and the Tigris. Syria joined the committee in 1982.^{9,10}

Transboundary issues concerning the Euphrates are critical to Iraq's water strategy as more than 90% of the river's water comes from outside the country (as opposed to 50% for the Tigris). Under the terms of a 1990 agreement between Syria and Iraq, Iraq shares the Euphrates' waters with Syria on a 58% (Iraq) and 42% (Syria) basis, based on the flow received by Syria at its border with Turkey. Since Turkey has unilaterally promised to provide a minimum flow of 15.8 km³/year at its border, this agreement would *de facto* represent approximately 9.2 km³/year for Iraq. However, there is not yet any trilateral binding agreement between the three countries.¹¹

■ The adverse downstream impacts of large dams in the upper Tigris/Euphrates system¹²

As of 1997, there were 32 major dams on the Euphrates and Tigris Rivers, with eight more under construction and at least 13 more planned. The total storage value of all the dams that had been constructed on the Euphrates in Turkey was 90.9 billion cubic metres (BCM), but was projected to rise to 94.78 BCM when all planned works had been completed. In Iraq and Syria, the combined storage capacity of all dams was 22.88 BCM. Overall, the gross storage capacity of all existing hydraulic works on the Euphrates was 143.19 BCM, or five times the river's average annual flow. Although retention along the Tigris was lower than on the Euphrates, it was nonetheless considerable. Iraq exercised the greatest control on Tigris waters, with the massive Tharthar diversion reservoir accounting for 69% of the country's 105.95 BCM gross storage capacity, or double the average annual flow of the Tigris. Turkey's storage capacity was 3.95 BCM, but this is due to rise to 17.6 BCM. The planned dams in Turkey alone would be able to retain volumes equivalent to 137% of the Euphrates' average annual discharge and 92% of that of the Tigris.¹²

The diversion of floodwaters into seasonal lakes and natural depressions along the middle courses of both rivers during the 1950s signalled the first major change in river management. This was followed in the early 1960s by the initiation of major dam-building projects in the middle and upper parts of the basins, in both Iraq and Iran, to store water for irrigation and hydroelectricity generation. Thereafter, dam construction intensified rapidly in both basins. In 1975, Turkey brought the Keban hydroelectric dam on line and Syria inaugurated the Tabaqa dam, setting the scene for large-scale developments in the upper Euphrates. Two years later, Turkey initiated its Southeast Anatolia Development project, re-launched in 1989 as a controversial integrated regional development programme, based on construction of 22 dams in the upper Tigris and Euphrates.¹²

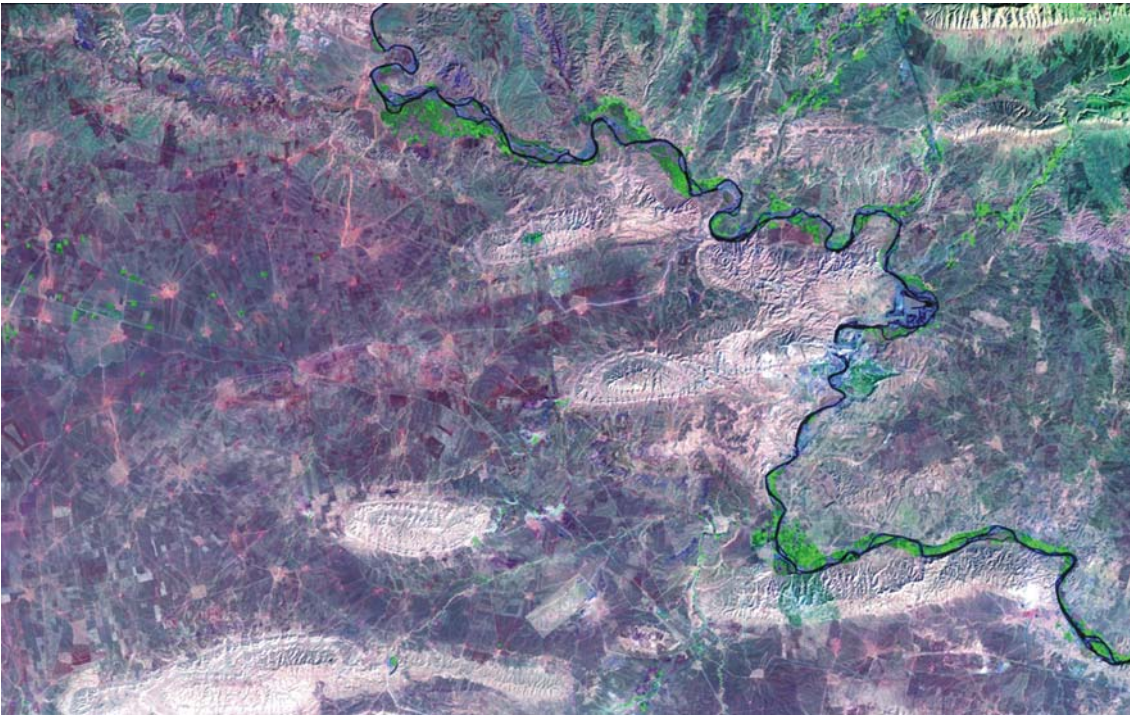
In the mid-1990s, Iran embarked on a multi-billion water management scheme on the Karun River (which flows into the Shatt al-Arab) comprising a series of dams and related irrigation and hydroelectric power schemes.¹³ In April 2001, Iran inaugurated a major dam on the Karkheh River (also a tributary of the Tigris), intended to irrigate 320,000 ha of land.¹⁴ However, plans are also underway to transfer water from this dam to the coast of southern Kuwait via a 540 km pipeline. The US\$2 billion scheme should eventually supply Kuwait with 760,000 m³ of freshwater per day.

The hydrograph of Euphrates flow at Hit-Husaiba in Iraq graphically illustrates how dams have effectively eliminated the spring floodwaters on which the wetlands in the lower basin were dependent for their survival. For the period 1938-1973, prior to intensive dam construction, the hydrograph showed a peak water flow of 2,594 m³/second in May. By contrast, maximum May flow for the period 1974 to 1998 had dropped by more than two-thirds to 831 m³/second. Furthermore, maximum discharge has shifted from spring (April-May) to winter (January-February). With the dam-induced decline of the snowmelt floods – and accompanying fertile sediment – that formerly sustained the Mesopotamian marshlands, some experts predicted that these changes alone would probably lead to a considerable reduction in the size of the marshlands and eventually to their disappearance.¹⁵ However, the demise of these once vast wetlands has been hastened through deliberate drainage by the Iraqi regime (see page 39), and a general decline in water quality due to sewage pollution and saline irrigation waste water. Upstream changes have also reduced the volume of fresh water and sediments reaching the Gulf, adversely affecting coastal ecology.

■ Sanitation (see also page 15)

Due to the collapse of sewage treatment systems, huge quantities of raw sewage, mixed with industrial waste (as there is no separate system for industrial discharges) are being discharged into water bodies every day, with a large part of this being released into the Tigris in Baghdad,

► Mosul Aski dam (1984/2002)



1984 and 2002 images: Landsat TM bands 7,4,2 taken during October

Images courtesy of UNEP/DEWA/GRID-Geneva

This pair of landsat images shows a dramatic change in the landscape following the construction of the Mosul Aski dam in the upper Jazirah (located approximately 60 km northwest of Mosul city). The red tones in the 1984 image (top) show uncultivated areas in a traditional dryland farming system dependent on rainfall. The image on the right from 2002 shows that the water supply from the new dam reservoir has enabled the implementation of modern irrigated agriculture. This is revealed by the large size of irrigated blocks and the straight line patterning of modern irrigation schemes. The dark green areas in the 2002 image (bottom) are presently cultivated lands, while the light green areas are mainly fallow lands.

the city's only source of water.¹⁶ The pumping of wastewater to sewage treatment plants relies on a network of pumping stations in the city, and few of these stations have backup generators for operation in the event of disruption to the main electricity supply. In the north of the country, most sewage disposal takes place through a system of cesspools and septic tanks that are not dependent on power supplies.¹⁷

■ Water supply

Prior to the 1991 Gulf War, potable water was supplied to all urban centres, but only 54% of rural areas. The situation has deteriorated subsequently, due *inter alia* to poor maintenance and the banning of chlorine imports – required for water treatment – under UN sanctions for potential ‘dual use’ substances.¹⁸ This has led to the spread of a wide range of water-borne illnesses such as typhoid, dysentery, cholera and polio, the latter re-emerging after nearly being eradicated prior to the sanctions.¹⁹ Significant quantities of water are lost through leakages.

■ Irrigation and salinity

Irrigation in what is now Iraq dates back some 7,500 years to the time when the Sumerians built a canal to irrigate wheat and barley on land between the Tigris and the Euphrates. It was estimated in 1990 that over 5.5 million ha of Iraqi territory are potentially suitable for irrigation, with 63% of this land occurring in the Tigris basin, 35% in the Euphrates basin, and 2% along the Shatt al-Arab. However, irrigation development depends to a large extent on the volume of water released by the upstream countries.²⁰

The risk of elevated soil salinity and waterlogging as a consequence of poor irrigation practices has long been a priority concern in the country, and was already recorded as a cause of crop yield reductions some 3,800 years ago. It is estimated that in 1970 half the irrigated areas in central and southern Iraq were degraded in this way. In 1978, a land rehabilitation programme was initiated, comprising concrete lining for irrigation canals and the installation of field drains and collector drains. By 1989, a total of 700,000 ha had been rehabilitated at a cost of around US\$2,000/ha.²¹



Pollution of surface waters is a major problem throughout Iraq



ED KASHI - CORBIS

The cultivation of wheat in Iraq depends on irrigation



ED KASHI - CORBIS

Recent studies indicate that around three-quarters of Iraq's irrigated land suffers from some degree of elevated salinity

However, continuing use of unsustainable practices, damage to infrastructure during the 1991 Gulf War, and poor maintenance exacerbated by sanctions, have caused a further deterioration. Recent estimates showed that 4% of irrigated areas were severely saline, 50% moderately saline and 20% slightly saline (i.e. a total of 74% of irrigated land suffered from some degree of elevated salinity). Irrigation of date palms with highly saline water has been practised since 1977, while the use of brackish groundwater for tomato irrigation has also been reported in the south of the country.²²

■ Groundwater

Groundwater with acceptably low salinity levels (below 1.0 mg/l) has been found in two regions of Iraq.²³ The aquifer in the foothills of the northeastern mountains has an estimated sustainable discharge of between 10 and 40 m³/s, at depths of 5 to 50 m, while those on the right bank of the Euphrates River are found at depths up to 300 m, and have an estimated discharge of 13 m³/s. Elsewhere, groundwater salinity always exceeds the 1.0 mg/l threshold.

There is concern that groundwater may be vulnerable to spillages of oil and oil-contaminated water, and possibly to contamination by depleted uranium and other hazardous substances released into the environment as a consequence of military conflict (see also Chapter 4).

3.3 Waste management

There is very little information available on waste management practices in Iraq. However, among the main areas for concern are considered to be the following:

- absent or poorly functioning systems for the collection, treatment and disposal of all types of waste, exacerbated by the ongoing conflict and the impact of sanctions
- risks to human health from accumulations of domestic, demolition and clinical waste

- possible health and environmental risks from uncontained domestic landfills and hazardous industrial waste (especially from the oil industry)
- large quantities of military waste (UXO, destroyed vehicles, packaging) and possible risk of contamination at former chemical, biological and nuclear facilities.

■ **Domestic waste**

It has been estimated that in 1997 Iraq produced 285 kg per capita of municipal waste per year,²⁴ (compared to a 1999 average for EU Member States of 540 kg per capita)²⁵ which is equivalent to approximately 6,327,000 metric tons per year (estimated 1997 population of 22.2 million). Waste generation rates are closely related to economic prosperity and, hence, since Iraq's GDP adjusted for inflation fell by 75% during 1991-1999, it can be assumed that Iraq's domestic waste generation rates have also fallen. Prior to the first Gulf conflict, Iraq's main cities had efficient collection systems, which deposited waste in basic landfills on the perimeter of the cities. However, since the imposition of UN sanctions, waste collection and disposal has been significantly reduced. For example, truck tyres and other replacement parts were not available. In 1990, Baghdad had 800 garbage collection trucks, while in 1999-2000 there were only 80 trucks, and even with reduced generation rates this would have resulted in approximately two-thirds of the domestic waste not being removed.²⁶ Anecdotal evidence



FRANÇOISE DE MULDER - CORBIS

The accumulation of waste in urban areas, as here in Basra, poses a direct threat to human health

indicates that waste was only collected from wealthy residential areas and government buildings, with the remaining population carrying waste by hand to informal dump sites within the city.²⁷ Rural communities had no formal collection systems and either burnt their waste or deposited it in a wadi or village dump.

■ **Clinical and veterinary waste**

There is no information available on clinical or veterinary waste procedures in Iraq, though it can be assumed that such waste is either co-disposed with domestic waste or burnt in crude incinerators.

In 1999, it was reported that a disease outbreak in livestock, due to vaccination restrictions, had resulted in the death of 1 million sheep and 150,000 cattle.²⁸ However, the disposal route for the carcasses is unknown.

■ Hazardous industrial waste

The principal sources of hazardous waste are likely to include oil and petrochemical complexes, fertilizer plants, refineries and chemical plants, as well as small and medium-sized industries such as electroplating facilities, tanneries, workshops and garages. Although there are no reliable data on the quantities of hazardous waste generated in Iraq, some Gulf countries do publish hazardous waste inventories and it is possible to use this information to make estimates for non-reporting countries using comparative GDP as an indicator.²⁹ The official reported data from Gulf oil-producing countries indicate that they generate between two and eight times more hazardous waste per capita than the United States.

The oil industry (see also pages 17-21) produces a range of hazardous wastes including: bottom sludge from oil storage tanks, oiled mud from the drilling of wells, contaminated soils from oil spills, waste lubricating oil from pumps and other machinery, chemical wastes and low level radioactive waste. In addition, in the Middle East, non-potable saline groundwater, slightly contaminated with oil, is frequently removed with the crude oil at a ratio of two to four barrels of water per barrel of oil. It is not known if this contaminated wastewater is treated, re-injected or allowed to evaporate in holding lagoons. Prior to the conflict of March/April 2003, Iraq's oil refineries had reported a lack of equipment and spare parts, due to UN sanctions, for treating industrial waste. For example, the North Refineries Enterprise at Baiji was estimated to be producing 600 m³ of industrial waste per hour, without treatment because spare parts were unavailable. Before the application of sanctions, four waste-processing units at the Baiji complex isolated chemical by-products and treated this waste using bio-reactors.³⁰ It has been reported that many refineries currently deposit hazardous waste into depleted wells or canals specifically dug for the purpose.³¹



JON MILLIS - REUTERS

Waste collection, treatment and disposal systems are rudimentary. This picture shows a huge informal disposal site for scrap metal near Umm Qasr in southern Iraq.

■ **Military waste, including waste from chemical, biological and nuclear weapons programmes**

The multiple military conflicts during the past quarter of a century have resulted in large and widespread quantities of military debris (including unexploded ordnance, spent cartridges/shells/penetrators, military vehicles etc), toxic and radioactive material (depleted uranium), contaminated soils and demolition waste (e.g. containing chemicals or asbestos), human and animal remains (leading to elevated disease risks, especially in urban areas), and packaging from military and humanitarian supplies.



PETER TURNLEY - CORBIS

Numerous destroyed and damaged military vehicles were abandoned in Kuwait after the 1991 Gulf War, posing a major clean-up challenge

As described in Chapter 4.3, Iraq had extensive programmes for the production of weapons of mass destruction. In addition to waste from research and production processes and destruction of weapons by the Iraqi authorities and by UN weapons inspectors, many facilities were targeted during the Gulf War. The potential remaining environmental risks of toxic and/or radioactive waste materials from these weapons programmes are unknown.

3.4 Oil industry

Main problems:

- likely widespread oil contamination of surface water and groundwater due to poor environmental controls;
- oil industry maintenance standards fell due to a lack of spare parts under the UN sanctions regime, increasing the likelihood of pollution incidents.

Routine oil operations may result in environmental degradation due to:

- acquisition of land and resulting land use changes;

- surface and subsurface disturbance;
- creation of access corridors (roads, pipelines etc) in pristine and/or sensitive areas;
- groundwater pollution (drilling through freshwater aquifers, leaking wells, re-injection of oil-contaminated water);
- disposal of drilled material;
- disposal of chemicals;
- operational waste such as tank bottom sludge, lube oils etc;
- disposal of Technologically Enhanced Radioactive Materials – TERM (well heads, pipes etc);
- disposal of mercury-contaminated pipes, vessels etc;
- normal non-hazardous wastes (e.g. wood, tyres, plastics).

In addition to these impacts is contamination of land and water bodies due to accidental oil spills, while well blowouts, though infrequent, may result in large-scale contamination of land, surface and ground water and air pollution.

At many oil fields, excess natural gas is burnt-off by operational flares. This may result in locally elevated levels of sulphur dioxide and nitrogen oxides and greenhouse gases (unburnt hydrocarbons and carbon dioxide).

In any well-managed oil field, controls will be in place to address all the issues listed above, including contingency plans for dealing with oil leaks and spillages, gas recovery plans, and measures to reduce total greenhouse gas emissions.

Due to the impact of economic sanctions, Iraq's oil sector has been starved of resources for proper maintenance. This is likely to have resulted in:

- increased number of oil spills and leaks due to infrastructure degradation;
- lack of technology for leak detection and prevention;
- environmentally unacceptable disposal of drill cuttings and tank bottom sludge;
- flaring off associated gas;
- little or no protection of aquifers;
- disposal of oil-contaminated water to shallow aquifers or to land (cheaper alternatives than deeper injection or treatment).

In any case, it can be anticipated that environmental concerns would have been low among the priorities of the state-owned oil industry, such that even routine waste management may not have met industry standards in the region.

It can be expected that oil field operations in Iraq during the 1990s have resulted in significant degradation of soil and ground water, air pollution and major greenhouse gas production. Dumping areas for waste oil, water and chemicals are likely to be scattered across affected parts of the country. It is therefore important that a comprehensive survey of all oil field operations is conducted.

The environmental consequences of conflict-related damage to the oil industry are dealt with in Chapter 4.

3.5 Ecosystem degradation

Main problems:

- destruction of the Mesopotamian Marshes and degradation of the Shatt al-Arab;
- mismanagement of wetlands in general;
- high risk of desertification exacerbated by unsustainable agricultural practices, and overgrazing, as well as by land degradation from military movements and use of munitions;
- lack of information on the current status of Iraq's natural forest cover.

■ Destruction of the Mesopotamian Marshes

The destruction of the Mesopotamian marshlands has been documented in a UNEP report *The Mesopotamian Marshlands: Demise of an Ecosystem*.³² This study reveals that the wetlands in the middle and lower basin of the Tigris and Euphrates Rivers in Iraq were, until recently, the most extensive wetland ecosystems in the Middle East. In their lower courses, the rivers created a vast network of wetlands – the Mesopotamian Marshes – covering up to 20,000 km². These comprised a complex of tall reeds, seasonal marshes, dominated by desert shrub and grasses, shallow and deep-water lakes, slightly brackish seasonal lagoons, and regularly inundated mudflats. The wetlands extended from Basra in the south to within 150 km of Baghdad, but the core of the system was located around the confluence of the Tigris and Euphrates rivers.

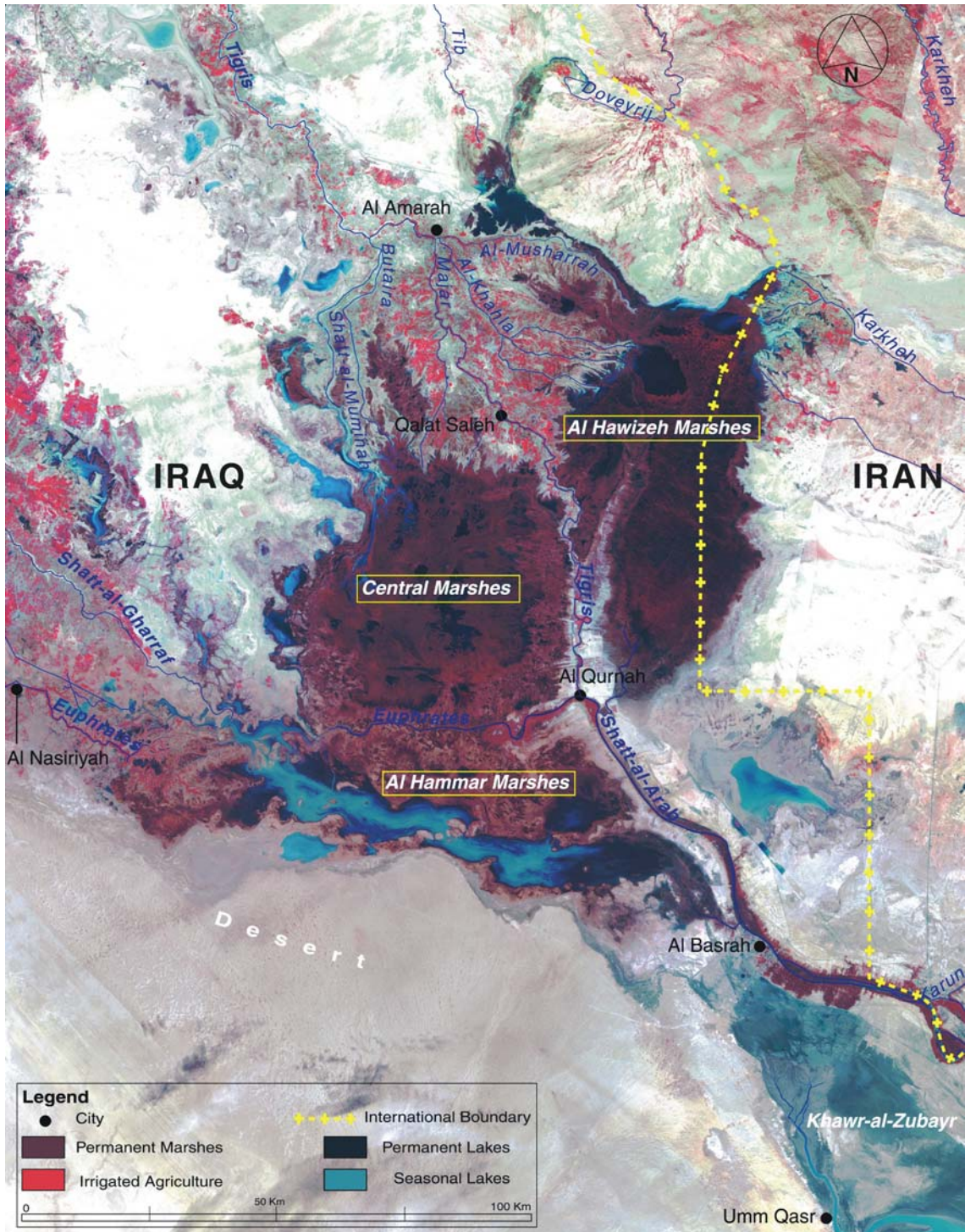


NIK WHEELER

Marsh Arab settlements prior to the drying out of the wetlands

Massive drainage works in southern Iraq in the late 1980s and early 1990s, together with the effects of major upstream damming (see page 30) devastated the wetlands (overall loss of 90%), such that only minor and fragmented parcels remain today. Satellite images taken in 1973-1976 reveal that the wetlands were then more or less intact. However, the UNEP study shows that

► Mesopotamian Marshlands (1973)

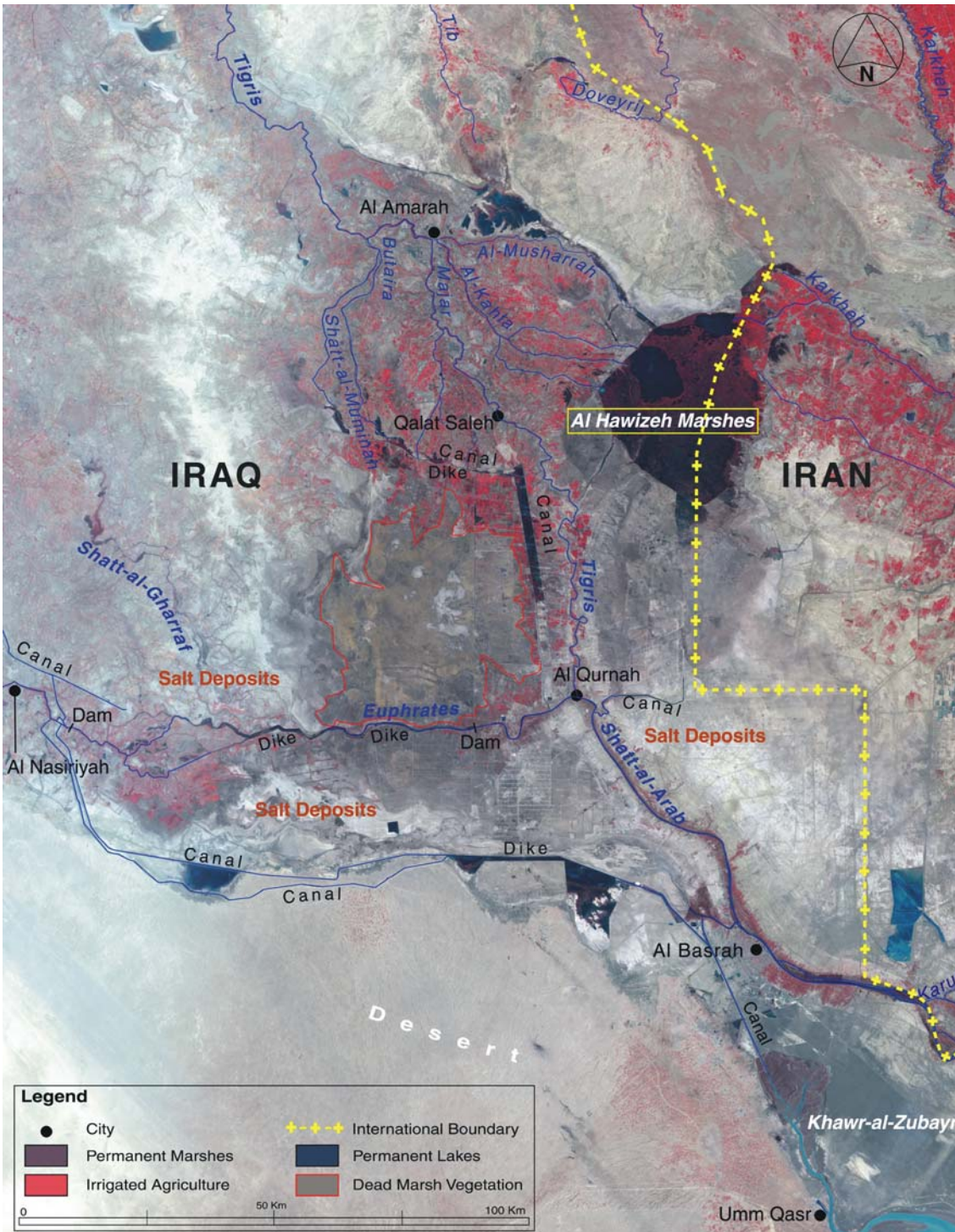


Landsat image: MSS Bands 4, 2 and 1, taken on 16 February 1973, 14 February 1975 and 27 May 1976.

Images courtesy of UNEP/DEWA/GRID-Geneva
Source: The Mesopotamian Marshlands – the Demise of an Ecosystem.

Space view of the Mesopotamian Marshlands taken by the earth observation satellite Landsat in 1973-76. Dense marsh vegetation (mainly *Phragmites* reeds) appears as dark red patches. Black reflects deep open waters, while shallow brackish lakes range from blue to very light blue. In the lower right corner, the Shatt al-Arab begins where the Tigris and Euphrates join and transports their waters southwestward into the Persian Gulf.

► Mesopotamian Marshlands (2000)



Landsat image: ETM Bands 4, 3 and 2, taken on 26 March and 4 May 2000.

Images courtesy of UNEP/DEWA/GRID-Geneva
Source: The Mesopotamian Marshlands – the Demise of an Ecosystem.

In this Landsat 7 Enhanced Thematic Mapper (ETM) mosaic taken in 2000, most of the Central Marshes appear as olive to grayish-brown patches (red outline) indicating low or dead vegetation on moist to dry ground. Very light to grey patches are bare areas with no vegetation and are largely covered by salt evaporites from former lakes. Red blocky patches indicate irrigated agriculture, mainly wheat and barely. The Main Outfall drain is visible running along the lower margin of the image, while the North-South Canal cuts across the Central marshes. East of the Tigris, lies the northeastern section of the Al-Hawizeh marshes which is all that remains of the wetlands.

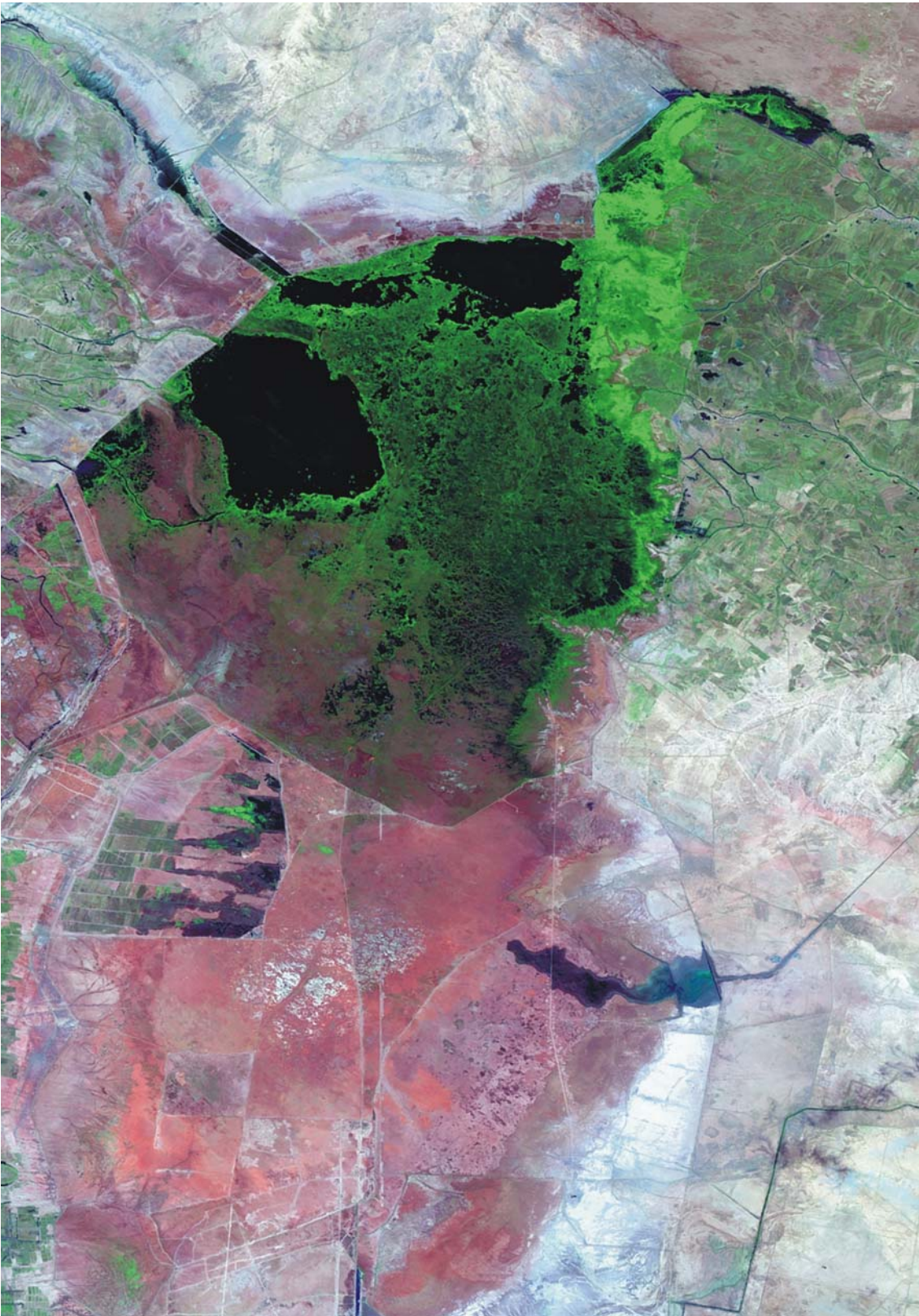
► Zoom of remaining Marshland areas (Hawr Al-Hawizeh/Al-Azim, 2000)



Landsat image: ETM+ Bands 7,4 and 2

Images courtesy of UNEP/DEWA/GRID-Geneva

► Zoom of remaining Marshland areas (Hawr Al-Hawizeh/Al-Azim, 2002)



Landsat image: ETM+ Bands 7,4 and 2

Images courtesy of UNEP/DEWA/GRID-Geneva

Analysis of Landsat satellite imagery shows that the surviving Mesopotamian marshlands declined by 30% from 1,084 square kilometers in 2000 (see opposite page) to 759 square kilometers in 2002 (above). At this rate of loss, the marshes are likely to totally vanish within the next five years.

3

massive loss and degradation had taken place by 2000, with the greatest change occurring between 1991 and 1995. The central and Al Hammar marshlands had been almost completely destroyed, with 97% and 94% of their respective cover transformed into bare land and salt crusts. The water-filtering role of the marshland had ceased and the remaining drainage canals carried polluted irrigation wastewater directly toward the Gulf, with potentially harmful impacts on local fish resources.

The entire Marsh Arab community has suffered huge social and economic upheaval as a result of the marshlands' destruction, with about 40,000 people forced to flee to southwest Iran and hundreds of thousands internally displaced within Iraq.³³

The impact on biodiversity has also been catastrophic (see also section 3.6, page 46). Prominent losses include possible extinction of the endemic smooth-coated otter *Lutra perspicillata maxwellii*, bandicoot rat *Nesokia bunnii*, long-fingered bat *Myotis capaccinii* and an endemic species of barbel fish *Barbus sharpeyi*. Several waterbirds are critically threatened, including African darter *Anhinga rufa* and sacred ibis *Threskiornis aethiopica*, which may now be extinct in the Middle East. A further 66 bird species are considered to be at risk. A wide range of migratory aquatic species have been affected – including penaeid shrimp, and Hilsa shad *Tenulosa ilisha* (a fish), which migrate between the Gulf and nursery grounds in the marshlands – with serious economic consequences for coastal fisheries. Increasing salinity in the Shatt al-Arab estuary (due to upstream hydrotechnical works) has also damaged the breeding grounds of another important fish species, silver pomfret *Pampus argenteus*.

A new study conducted by UNEP indicates that, of the remnant wetlands surviving in 2000, one-third had disappeared by 2002. UNEP experts predict that unless urgent action is taken to reverse the trend and rehabilitate the marshlands, the entire wetland system is likely to be lost within three to five years.³⁴ This will only be feasible through regional cooperation.



An entire way of life for Marsh Arabs was systematically destroyed

■ Desertification and drought

Desertification is the process of land degradation in arid, semi-arid and dry sub-humid areas. It is caused primarily by human activities and climatic impacts. Desertification occurs because dryland ecosystems are extremely vulnerable to over-exploitation and inappropriate land use. Poverty, political instability, deforestation, overgrazing and poor irrigation practices can all undermine land quality and productivity.³⁵ The impact of war, internal policies and external sanctions combine to confront Iraq with a high risk of desertification. This has been exacerbated by drought and the destruction of the Mesopotamian Marshes (see page 39). Degradation of rangelands will have particularly adverse effects on nomadic pastoralists.

The World Bank completed its first regional environment strategy for the Middle East and North Africa in 1995. This highlighted the regional threat of shrinking croplands due to serious land degradation and recurrent droughts.³⁶ Four years later, Iraq experienced its worst drought in decades, which devastated the 1999 winter harvest. In most areas, rainfall during the main season from October to March was about 30% of normal precipitation while the level of water in main rivers fell by more than 50%. It was estimated that more than 46% of total cultivated area was severely damaged by the drought. The livestock sector, which had already been extensively affected by foot and mouth disease, was also seriously damaged through lack of fodder and water.³⁷ Rural communities experienced severe shortages of potable water. The overall impact of the drought was exacerbated by economic sanctions that restricted imports of agricultural goods, including fertilizers.³⁸

Desert ecosystems are particularly vulnerable to physical damage from vehicle movements, which result in loss of plant cover and disaggregation of soil particles. Iraq's deserts have therefore been at risk of widespread degradation during the military conflicts of recent decades. Extensive desert crust damage from vehicle movements was detected by BirdLife International in Kuwait following the 1991 Gulf War.³⁹

The desert crust is a layer of algae, mosses, lichens, fungi, bacteria and cyanobacteria that occupies the top one millimetre of the desert soil. These organisms are dormant when dry, but become active when wetted. The crust has major ecological value in the desert ecosystem as a protector of the thin desert soil against wind erosion, as an absorber of water (from fog and dew as well as rain), as a suitable bed for seed germination, and as a photosynthetic layer that adds a significant amount of organic carbon and organic nitrogen into the desert ecosystem, thus increasing its productivity. The crust is known to be fragile and easily damaged by vehicles⁴⁰ and seems to be very slow to repair itself, with scientists estimating recovery over decades rather than months or years. One study of tank tracks in the Arizona desert suggested full recovery only after 1,000 years.⁴¹

■ Deforestation

As part of its *Global Forest Resources Assessment 2000*, the UN Food and Agriculture Organization (FAO) estimated Iraq's total forest cover (including both natural forests and plantations) to be 799,400 ha. A much older FAO assessment, from the 1970s, included a figure of more than 1.8 million ha. Although the degree to which these two figures are directly comparable is unknown, there is a clear suggestion of extensive deforestation during the 1980s and 1990s. The only Iraqi report available to FAO for the 2000 assessment was dated 1990 and did not provide information on forest change. A UNEP assessment of the world's closed forests (where tree cover is greater than 40% of the land surface) gives a figure for Iraq of just 1,100 ha, showing that most of the country's forest consists of scattered trees.⁴² The only major areas of natural forest occur on the slopes of the northeast mountain ranges, with a few remnant patches of riverbank scrub along the Euphrates and Tigris and their main tributaries. The remainder of the country is treeless except for plantations, including crops such as date palms (see above).



H. PARTOW/UNEP/GRID-GENEVA

Burnt date palms show the devastating footprint of war. Large tracts of forest along the Shatt al-Arab were levelled during the Iran-Iraq war to reduce potential cover for attacking forces.

There does not appear to be any readily available data concerning risks to Iraq's natural forest cover, though the combination of conflict and sanctions will have increased pressure on forest resources and there is a need for an up-to-date assessment.

During the 1980s and 1990s, 80% of the 17-18 million date palms lining the Shatt al-Arab estuary – once the largest area of date palms in the world and yielding an economically important crop – was destroyed, particularly as a consequence of damage during the Iran-Iraq war, but also due to increased water salinity in the estuary because of upstream dam and irrigation schemes. The remaining, weakened palms have been susceptible to pest infestations, further degrading the quality of the forest.⁴³

3.6 Biodiversity

Main problems:

- lack of institutional or legal framework for conservation of biodiversity;
- lack of any effective protected areas network;
- lack of a national biodiversity strategy, or action plan;
- many species under threat from ecosystem degradation, especially loss of the Mesopotamian Marshes.

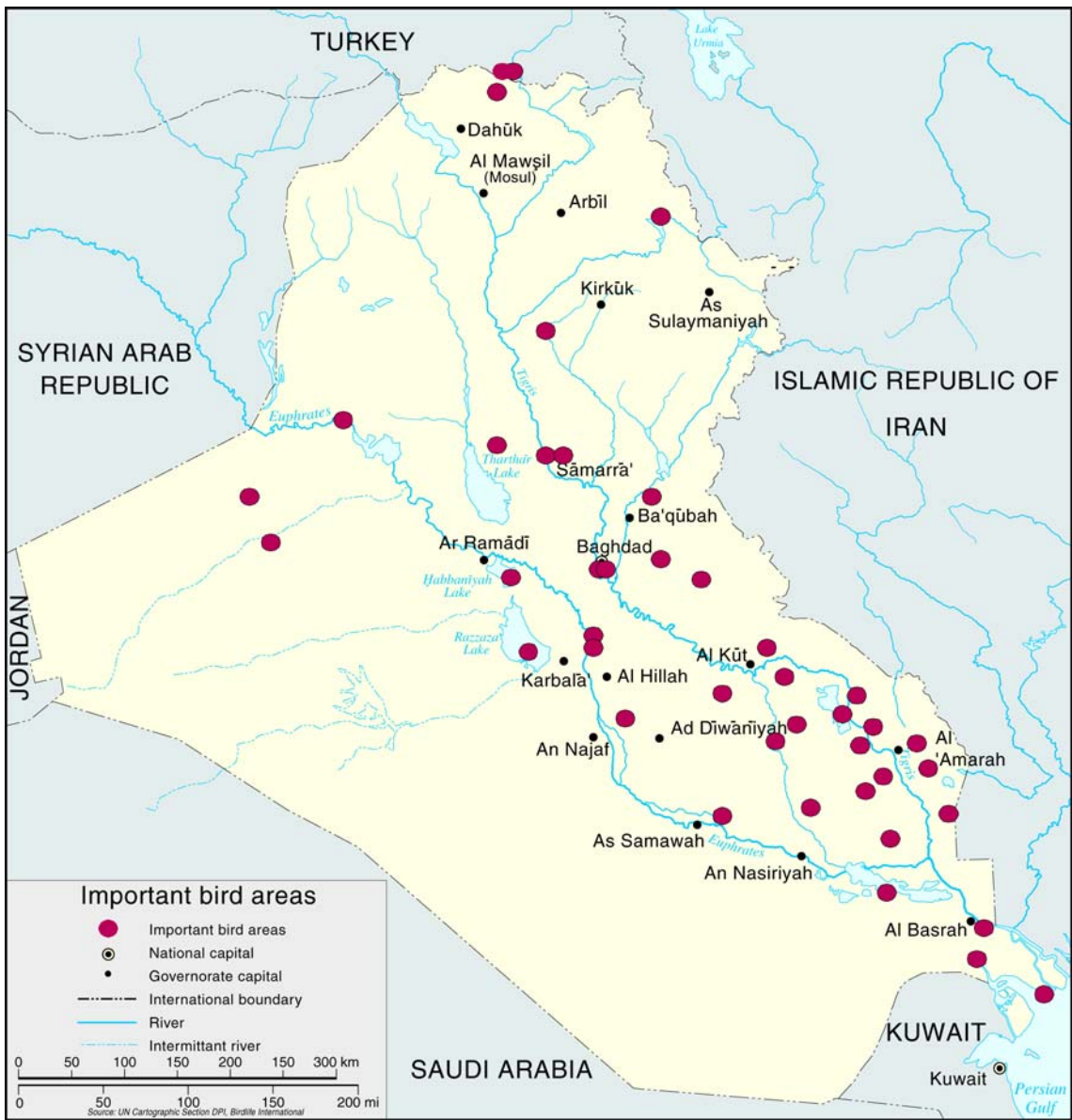
■ Protected areas

The UNEP-WCMC Protected Areas Virtual Database lists just eight small protected areas (none bigger than 110 ha) in Iraq.⁴⁴ None of these qualifies for inclusion in the official UN List of Protected Areas maintained by UNEP-WCMC, which only covers sites larger than 1,000 ha.

The majority of sites important for biodiversity conservation have no protected area status, although many have been recommended for designation. For example, BirdLife International has recognized a total of 42 sites as ‘Important Bird Areas’ (IBAs). These cover a combined area of c.35,000 km², or about 8% of the country’s surface area (see Map 6).⁴⁵

However, none benefits from any legal protection from a biodiversity perspective and many of the wetlands, in particular, are critically threatened by flood control, irrigation and drainage projects being carried out in Iraq and in neighbouring countries (see page 30). Monitoring of IBAs and their internationally important biodiversity is weak or absent.

► Map 6. Important Bird Areas



■ Species

The UNEP-WCMC Species Database lists 73 terrestrial mammal species (plus a further three species known to be extinct).⁴⁶ Of these, three bat species, Eurasian otter *Lutra lutra* and smooth-coated otter are listed as ‘vulnerable’ in the 2002 IUCN Red List.^{47,48}

A large number of reptiles occur in Iraq, but information on their distribution and conservation status is limited. The 2002 IUCN Red List ranks the Euphrates soft-shelled turtle *Rafetus euphraticus* as ‘endangered’, and common tortoise *Testudo graeca* as ‘vulnerable’.

Over 400 species of birds have been recorded in the northern Gulf Region (comprising Kuwait, Iraq, eastern Saudi Arabia and western Iran). Among the species occurring in Iraq, white-headed duck *Oxyura leucocephala* is listed as endangered in the 2002 IUCN Red List, while Socotra cormorant *Phalacrocorax nigrogularis*, marbled teal *Marmaronetta angustirostris*, greater spotted eagle *Aquila clanga*, imperial eagle *Aquila heliaca*, lesser kestrel *Falco naumanni*, corncrake *Crex crex*, and sociable lapwing *Vanellus gregarius* are listed as vulnerable. A further nine species are listed as ‘conservation dependent’ or ‘near threatened’.^{249,50} The region is especially important as part of the intercontinental flyways used by huge numbers of birds moving between Africa and Eurasia. It has been estimated that some two to three billion migrants move south across Arabia each autumn.^{51,52}

In a generally arid to semi-arid region, Iraq’s wetlands are of immense importance for the maintenance of biodiversity. Until their virtual disappearance (see page 39), the Mesopotamian Marshes were of global conservation value. In central and northern Iraq, most of the natural freshwater lakes and marshes have long since been drained for agricultural purposes, although significant remnants still survive. The valleys of the Tigris and Euphrates themselves have been extensively modified for agricultural purposes. Most of the original riverine forest which once lined the banks of the two rivers has been replaced by orchards and other cultivated land, although some significant stands of forest still exist, especially on small islands. The surviving patches of forest provide important breeding habitat for a wide variety of birds, notably regional specialities such as the grey hypocolius *Hypocolius ampelinus*, Iraq babbler *Turdoides altirostris* and Dead Sea sparrow *Passer moabiticus*, and are used as staging areas by large numbers of migratory passerines. Other important natural wetlands in central Iraq include two large brackish to saline lakes, Shari Lake to the east of the Tigris north of Samarra, and Haur Al Shubaicha on the plains to the east of the Tigris southeast of Baghdad.⁵³

Reports prepared by BirdLife International detail the organization’s fears concerning the possible impacts of the current conflict on birds and biodiversity in general.



The marshlands of southern Iraq, now virtually dry, were once an important site for pelicans and many other migratory waterbirds

There is very limited information available on fish diversity in Iraq, although the World Resources Institute (WRI) states that the combined Euphrates and Tigris watershed supports 71 native fish species (plus a further 21 introduced species) of which 28 are endemic to the basin. None is indicated as being under threat.⁵⁴

3.7 Institutional and administrative issues

Main problems:

- no effective institutional or administrative infrastructure for environmental management or sustainable development;
- inadequate legislation;
- lack of participation in global and regional environmental agreements and processes.

■ Context and limitations

It will be important to identify existing national expertise on environmental issues so that these experts can work alongside international and regional agencies involved in the post-conflict clean-up and reconstruction process. At present, however, there is little readily available information, although it can be assumed that institutional capacity related to the environment is likely to have been weakened by the policies of the Iraqi government (e.g. restrictions on international communications) as well as by the impact of UN sanctions (difficulties in obtaining equipment or participating in international environmental processes). Early efforts will be needed to address this information gap.

A new administration has yet to be established following the conflict of March/April 2003 and the fall of Saddam Hussein's government. It is clear that the former administration for environment and natural resource issues will have included skilled professionals whose knowledge will be used within the new administrative structures, once established.

■ Government

In 2002, the key sustainable development coordination mechanism in Iraq was the Planning Commission, with the Environment Protection and Improvement Council, National Human Settlements Commission, the Regional and Rural Planning Centre, the General Federation of Iraq Women, and the Iraq Economists Society also involved in this field.⁵⁵ Regulation and protection of the environment came under the jurisdiction of the Ministry of Health, Labour and Social Affairs, through the Higher Council for Environmental Protection and Improvement.⁵⁶ The Ministry of Irrigation was responsible for coordinating water resource management and development, while Irrigation Directorates undertook management and development at the state or district level. Information on the use of water by agricultural, household and industrial sectors was the responsibility of the Central Statistical Organization within the Planning Commission. Information was distributed through the Agriculture Planning Directorate, the Construction, Housing and Services Planning Directorate, and the Industrial Planning Directorate.

The Ministry of Irrigation implemented various projects related to desertification, including the stabilizing of sand dunes to prevent them from encroaching on river systems. The Ministry of Irrigation, in cooperation with the Ministry of Agriculture, also undertook a wide array of water development projects.⁵⁷

■ Agriculture institutions

The Ministry of Agriculture was responsible for organizing ownership of agricultural lands, contracts with farmers, cooperatives and agricultural companies, in addition to enhancing

agricultural investment activities. In particular, the ministry was responsible for providing agricultural inputs to all farmers, and for marketing agricultural commodities.

The Ministry of Irrigation was in charge of water resources development, irrigation and drainage development, as well as its operation and maintenance. Its major functions were to assess water requirements and resources, control running water, reservoirs, wetlands and marshes, underground water, the construction of dams, canals and drainage systems, soil conservation, classification, land evaluation and use, and research and studies on land and water. The ministry executed most of the water resources development projects with the assistance of a number of state companies.⁵⁸

■ Universities

Baghdad is home to a number of centres of higher education including Baghdad University, Saddam University, Mustansiriyah University, the University of Technology and the Federation of Technical Institutes.⁵⁹ There are also universities in Basra, Mosul, Tikrit, Babylon, Anbar and Kufa. Within each university there are areas of specialization. For example, the University of Baghdad has experience in the fields of health and engineering. The University of Basra is specialized in water sciences and aquatic ecology, while the University of Mosul, one of the largest educational and research facilities in the Middle East, has a college of medicine⁶⁰ and also undertakes agricultural research including water resource conservation and management for agricultural production in dry areas,⁶¹ as well as work on dryland management.⁶²

■ Research organizations

There are various research organizations in the country. These include:

- The Federation of Arab Scientific Research Councils, located in Baghdad.
- The Agricultural Research Centre, Baghdad.⁶³
- Many Technical Institutes (including the Agriculture Institute in Mussaiab), most of which belong to the Ministry of Higher Education.
- The following marine/aquatic research organizations:⁶⁴
 - Fish Research Centre, Baghdad;
 - Marine Science Centre, Basra;
 - Fishery Research Department of the Agriculture Research Centre (IPA), Baghdad;
 - Central Hatchery, Swairah;
 - Fisheries and Marine Resources Department, College of Agriculture, University of Basrah.

■ Overview of participation in international organizations/agreements

Iraq belongs to the following international organizations: United Nations and certain of its specialized agencies, including the World Bank, International Monetary Fund (IMF), and International Atomic Energy Agency (IAEA). It is also a member of the Organization of the Islamic Conference, the League of Arab States, Organization of Petroleum Exporting Countries (OPEC), Organization of Arab Petroleum Exporting Countries, INTELSAT, Interpol, the G-19 and the G-77. Iraq is also a party to a range of global and regional treaties, of which the more recent agreements having a strong environmental relevance are listed in Table 3. Iraq is not a party to any of the conventions dealing with desertification, wetlands, biological diversity, climate change, or migratory species.

Within UNEP, Iraq is covered by the Regional Office for West Asia (ROWA) in Bahrain with representatives of Iraq’s Environmental Protection and Improvement Office participating in a wide range of UNEP-led activities. Iraq has also participated in UNEP’s Regional Seas Programme for the Kuwait Region, through the Regional Organization for the Protection of the Marine Environment (ROPME) – the secretariat for the Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution.⁶⁵

Table 3. Chronological list of global and regional environment-related conventions and agreements to which Iraq is party

Title	Entry into force
Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare	1931
International Plant Protection Convention	1954
Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water	1964
Treaty on the Non-Proliferation of Nuclear Weapons	1970
Agreement for the Establishment for Arab Centre for the Studies of Dry and Barren Land	1971
Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Sea-Bed and the Ocean Floor and in the Subsoil thereof	1972
Convention concerning the Protection of the World Cultural and Natural Heritage	1975
Protocol Concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency	1979
Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution	1979
Convention on Early Notification of a Nuclear Accident	1988
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	1988
Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf	1990
Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction	1991
Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources	1993

■ **Overview of international agencies**

Until the outbreak of the 2003 conflict, there were many international agencies with a humanitarian focus present in Iraq, some of which were working in environment-related issues such as healthcare.

The UN system was by far the largest humanitarian entity operating in the country. Nearly all UN agencies (particularly UNDP, UNICEF, WHO, WFP) were represented in Iraq and, while the larger agencies had their own funds for long-term assistance programmes, most funding was arranged under the oil-for-food programme. The United Nations Office of the Humanitarian Coordinator (UNOHC) coordinates all UN agencies in the humanitarian sector. The International Committee of the Red Cross (ICRC), International Federation of Red Cross and Red Crescent Societies (IFRC), and CARE have been the major non-UN international organizations present, while the Iraq Red Crescent Society (IRCS) is the coordinator of international relief assistance for non-governmental organizations working in the country. All of the non-UN agencies, except for ICRC, have received important funding from the European Community Humanitarian Aid Office (ECHO) over the last four years. Priority activity areas for all humanitarian agencies are the provision of food and medicine, and rehabilitation of the infrastructures for healthcare, water supply and sanitation. The UN has also been involved in electricity, agriculture, education and mine clearance.

4

Environmental impacts of military conflicts

4.1 Overview

This chapter summarizes some of the principal environmental consequences of the three major armed conflicts that have involved Iraq since 1980, drawing on a wide range of sources. The information provided is not intended as a comprehensive study, but rather, as a means of highlighting the key risks that now need detailed assessment as Iraq enters a post-conflict phase.

4.2 Iran-Iraq war, 1980-1988

The Iraq-Iran War began in September 1980. Iraq commenced a ground assault on Iran, and launched air strikes on strategic targets.¹ However, Iranian resistance proved strong, and all Iraqi troops had withdrawn from the occupied portions of Iran by early 1982. Iran then initiated a series of offensives that Iraq responded to with the deployment of chemical weapons in 1983.²

Following continuing use by Iraq of chemical weapons and missile attacks against civilian areas, Iran accepted the provisions³ of a cease-fire agreement in July 1988.

Overall, the eight-year war resulted in heavy losses on both sides, with an estimated 600,000 Iranian and 400,000 Iraqis dead, over one million refugees and a total cost running into billions of dollars.⁴

No formal independent studies have been conducted to determine the long-term environmental impacts and risks to human health from the Iran-Iraq War. For example, little is known about the consequences of major oil spills into the Gulf from the targeting of oil industry infrastructure (e.g. at the Nowruz oil field where almost two million barrels were spilled).⁵

Chemical and biological weapons

The Organisation for the Prohibition of Chemical Weapons (OPCW) states that “During the Iran-Iraq war....there were various unconfirmed reports that Iraq had used chemical weapons, but the international community was slow to react at first. Eventually, however, UN fact-finding teams confirmed that Iraq was indeed using chemical weapons on a massive scale and that Iran had suffered thousands of casualties as a result of these attacks”.⁶

Iraq’s use of chemical weapons during the war can be divided into three distinct phases:⁷

- 1983 to 1986 – use against advancing Iranian forces. In 1984, Iraq became the first country known to have used a nerve agent on the battlefield when it deployed aerial bombs filled with the nerve agent tabun. Some 5,500 Iranians were killed by this means between March 1984 and March 1985. Some 16,000 Iranians were reported killed by the toxic blister agent mustard gas between August 1983 and February 1986.
- 1986 to early 1988 – use adapted to target the preparation of Iranian offensives.
- Early 1988 to conclusion of the war – integration of large nerve agent strikes into Iraq’s overall offensive operations.

The most well documented cases are listed in Table 4 and the locations indicated in Map 7. The chemical weapons deployed by Iraq reportedly included mustard gas and the nerve gases sarin, tabun and GF, which have environmental persistence times ranging from thirty minutes, in the case of tabun, to as much as two years in the case of mustard gas.⁸ At the time of the attacks, both countries were parties to the 1925 Geneva Protocol, a treaty banning the use of chemical weapons against another contracting party (Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous, or other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on 19 June 1925). A UN expert team, which conducted investigations between 1984 and 1988, confirmed that chemical weapons had been used by Iraq.⁹



Mustard gas rounds

The degree of environmental contamination and the extent of deaths and injuries, both during and after a chemical weapons attack, depend on the following factors:

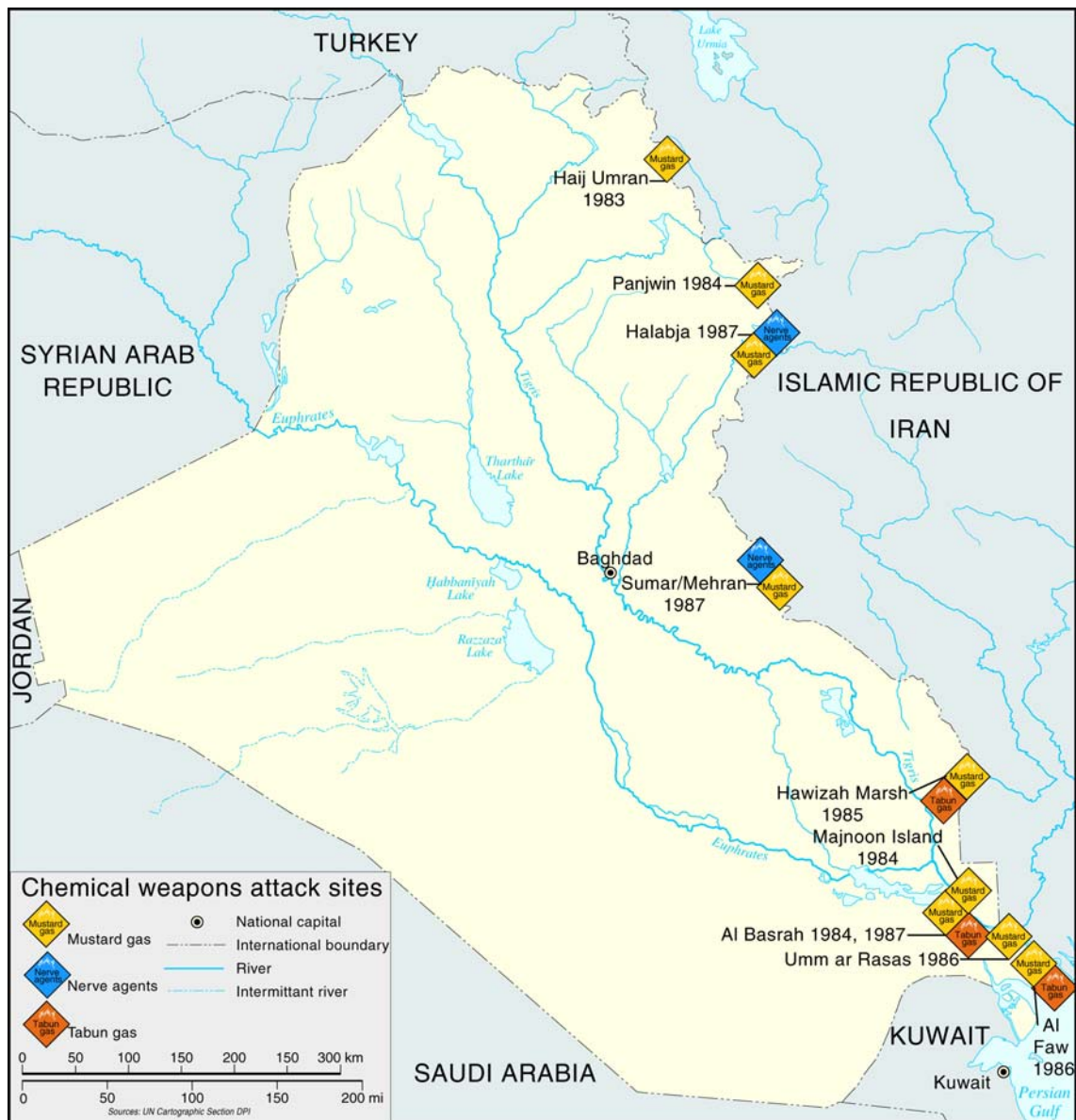
- Method of weapon deployment
- Toxicity and persistence of the agent used
- Toxicity and persistence of possible breakdown products
- Intensity of solar radiation
- Wind velocity and air turbulence
- Temperature, precipitation and humidity
- Topography and soil conditions.

Table 4. Well-documented cases of Iraqi use of chemical weapons during the Iran-Iraq war

Date	Area	Type	Approximate casualties
August 1983	Haji Umrans	Mustard	< 100
Oct-Nov 1983	Panjwin	Mustard	3,000
Feb-Mar 1984	Majnoon Island	Mustard	2,500
March 1984	Al Basrah	Tabun	50 to 100
March 1985	Hawizah Marsh	Mustard/Tabun	3,000
February 1986	Al Faw	Mustard/Tabun	8,000 to 10,000
December 1986	Um ar Rasas	Mustard	Thousands
April 1987	Al Basrah	Mustard/Tabun	5,000
October 1987	Sumar/Mehran	Mustard/Nerve agents	3,000
March 1988	Halabjah	Mustard/Nerve agents	5,000

(Source: *Iraq Weapons of Mass Destruction Programs, U.S. Government White Paper, February 13, 1998*)¹⁰

► Map 7. Well-documented use of chemical weapons during the Iran-Iraq war



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Towards the end of the war, Iraq's use of chemical weapons was not confined to military targets. During 1987 and 1988, it was alleged that numerous chemical attacks had been launched against Kurdish villages in the north of the country. Clinical evidence and soil samples confirmed the use of mustard gas and the nerve agent tabun against the Kurdish population in 1987. The most infamous attack occurred on 16 March 1988 in the town of Halabja, where up to 5,000 Kurdish civilians and Iranian soldiers died from the effects of sarin nerve gas and mustard gas. Later that year, chemical weapon agents were again used against the Kurds, forcing many thousands to flee to Iran and Turkey. The UN Secretary-General requested Iraq's permission for a UN investigation but this was denied.¹¹



KURDISH REGIONAL GOVERNMENT

Up to 5,000 Kurdish civilians and Iranian soldiers died from the effects of sarin nerve gas and mustard gas at the town of Halabja in March 1988

Some reports indicated that anthrax bacteria had been found among hospitalized Iranians, suggesting that Iraq may also have used biological weapons. Furthermore, according to some toxicological tests, mycotoxins were found in samples of body fluids taken from Iranian gas victims. However, neither of these reports was verified, and the use of biological weapons by Iraq against Iran remains unconfirmed.¹²

The most likely biological agents to be used as weapons agents are:

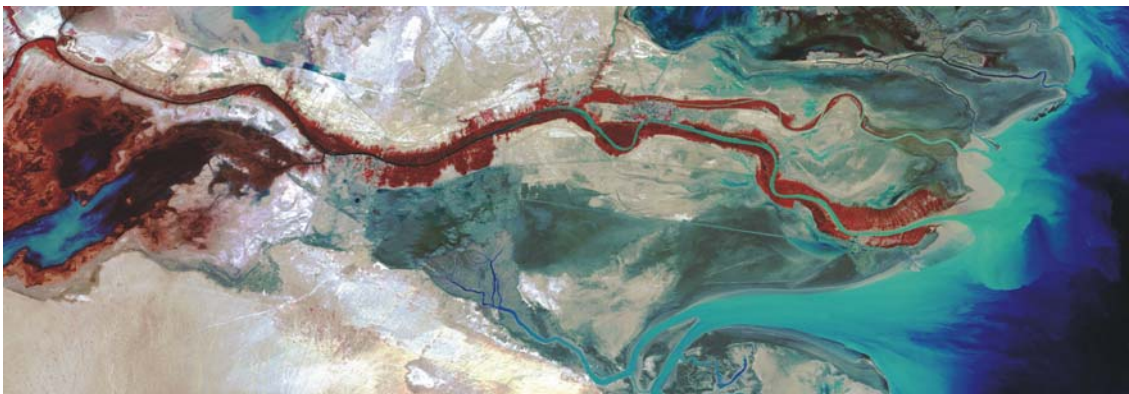
- Anthrax
- Botulin toxin
- Plague
- Smallpox
- Tularaemia

Beyond the immediate concerns for the health of affected individuals, livestock and crops, the potentially longer-term ecological implications associated with the use of biological weapons represent an important risk element.¹³

Environmental degradation along the Shatt al-Arab estuary

As indicated in Chapter 3, the destruction of the once extensive date palm forests along the Shatt al-Arab estuary was also largely due to the Iran-Iraq War. The satellite images below contrast the situation in 1975 with that in 2002.

► Date Palm Deforestation – Shatt al-Arab (1975/2002)



1975 image: Landsat MSS bands 4,2,1
2002 image: Landsat TM bands 4,3,2

Images courtesy of UNEP/DEWA/GRID-Sioux Falls and GRID-Geneva
Source: Atlas of Global Change, UNEP/DEWA/GRID-Sioux Falls

In the pair of infrared Landsat images above, the date palm belt skirting the 190 km long Shatt al-Arab appears as a dark red hue in 1975. Healthy vegetation is characterized by a distinctively strong reflectance in the near infrared represented by red tones in these satellite images. In 2002, the intensity of infrared emittance in the date belt had considerably diminished denoted by a pallid red brown indicating stressed and dead vegetation, and the replacement of palms by reeds and desert scrub.

4.3 Gulf War, 1991

Background

Kuwait was invaded by Iraq on 2 August 1990. On 29 November 1990, the UN Security Council adopted resolution 678 authorizing the use of “all necessary means” unless Iraq withdrew from Kuwait by 15 January 1991. On 17 January, a US-led coalition of 26 nations, with a combined military force of more than 600,000 troops, initiated Operation ‘Desert Storm’ against Iraq. A massive air campaign targeted Iraqi military forces and infrastructure, including nuclear, biological and chemical weapons facilities, as well as numerous other sites including oil refineries, electrical power stations, and petrochemical facilities.^{14,15} The coalition declared a ceasefire on 28 February, and on 3 April the UN Security Council adopted resolution 687 setting out provisions for the cease-fire, including neutralization of Iraqi weapons of mass destruction through the creation of a Special Commission (UNSCOM), and the establishment of a compensation mechanism (United Nations Compensation Commission – UNCC), confirmed the following month by resolution 692.¹⁶

■ Assessing environmental consequences

During and after the war, the international community expressed serious concerns over possible environmental impacts and associated risks to human health. In response to this concern, UNEP convened an inter-agency meeting in February 1991 with a view to developing an environmental action plan.

The outcome of the inter-agency meeting, and of meetings of the Regional Organization for Protection of the Marine Environment (ROPME) was the formulation of an Inter-Agency Plan of Action to address the environmental impacts of the war. The document identified four distinct areas of activity:

- **Coastal and marine environment:** oil pollution response and clean-up; oil pollution assessment and monitoring; oceanographic observations; coastal and marine ecological assessment; living marine resources; coastal infrastructure; remote sensing and database support.
- **Atmosphere:** air quality and human health effects; air/sea exchange; meteorology and long-range air pollution.
- **Terrestrial:** terrestrial ecosystems and desertification, food, soil and agriculture assessment; food safety and drinking water; shelter and welfare.
- **Hazardous waste management:** assessment of damage to industrial sector and risk of release of hazardous wastes.

UNEP released three reports entitled *Rapid Assessment of the Impacts of the Iraq-Kuwait Conflict on Terrestrial Ecosystems in Kuwait, Iraq and Saudi Arabia*. A summary consolidated report of the inter-agency assessment missions and action plan entitled *Updated scientific report on the environmental effects of the conflict between Iraq and Kuwait* was also released in May 1993.

In addition to UN activities, a number of NGOs, research institutions and universities also conducted independent evaluations on the potential environmental impacts. These include:

- Greenpeace 1991: *On Impact – Modern Warfare and the Environment – A Case Study of the Gulf War*.
- Greenpeace 1991: *The Environmental Legacy of the Gulf War*.
- Green Cross International 1998: *An Environmental Assessment Of Kuwait Seven Years After the Gulf War*.
- First International Conference on the Environmental Consequences of War, June 10-12 1998.

The UNCC is also dealing with claims relating to compensation for environmental damage from the war. On 21 June 2001, the UNCC F4 panel awarded US\$243 million to Iran, Jordan, Kuwait, Saudi Arabia and Syria to undertake 69 different monitoring and assessment studies of the environmental impacts of the conflict. The preliminary results of each country study have not been released publicly.

Drawing on available information, the principal components of the environmental consequences of the Gulf War are as follows:

Targeted nuclear facilities

Three Iraqi nuclear research sites were targeted (see map 8):¹⁷

- **Tuwaitha Nuclear Research Centre:** Located 18 km SSE of Baghdad. Main site for Iraqi nuclear programme. Activities included: several research reactors (including a smaller French 500 kW Tammuz-2 unit and a larger Russian 5000 kW IRT-5000 unit), plutonium separation and waste processing, uranium metallurgy, neutron initiator development and work on a number of methods of uranium enrichment. Tuwaitha was also the location of the Osiraq reactor bombed by Israel in 1981. All nuclear fuel at this site was removed under IAEA monitoring and equipment directly tied to the nuclear weapons programme was destroyed in place.
- **Tarmiya (Project 411):** Located 30 km NW of Baghdad. Main site for electromagnetic isotope separation (EMIS) programme for the enrichment of uranium. Site included both 1200 mm and 600 mm separators. Much of the equipment at this site was disassembled unilaterally by Iraq, and the components hidden from IAEA inspection teams, before eventually being handed over to IAEA personnel and destroyed in place.
- **Al Fajar (Facility 555):** Designed to be a duplicate of Tarmiya for enriching uranium to weapons grade, Facility 555 had almost no equipment in it at the time of the 1991 air strikes.

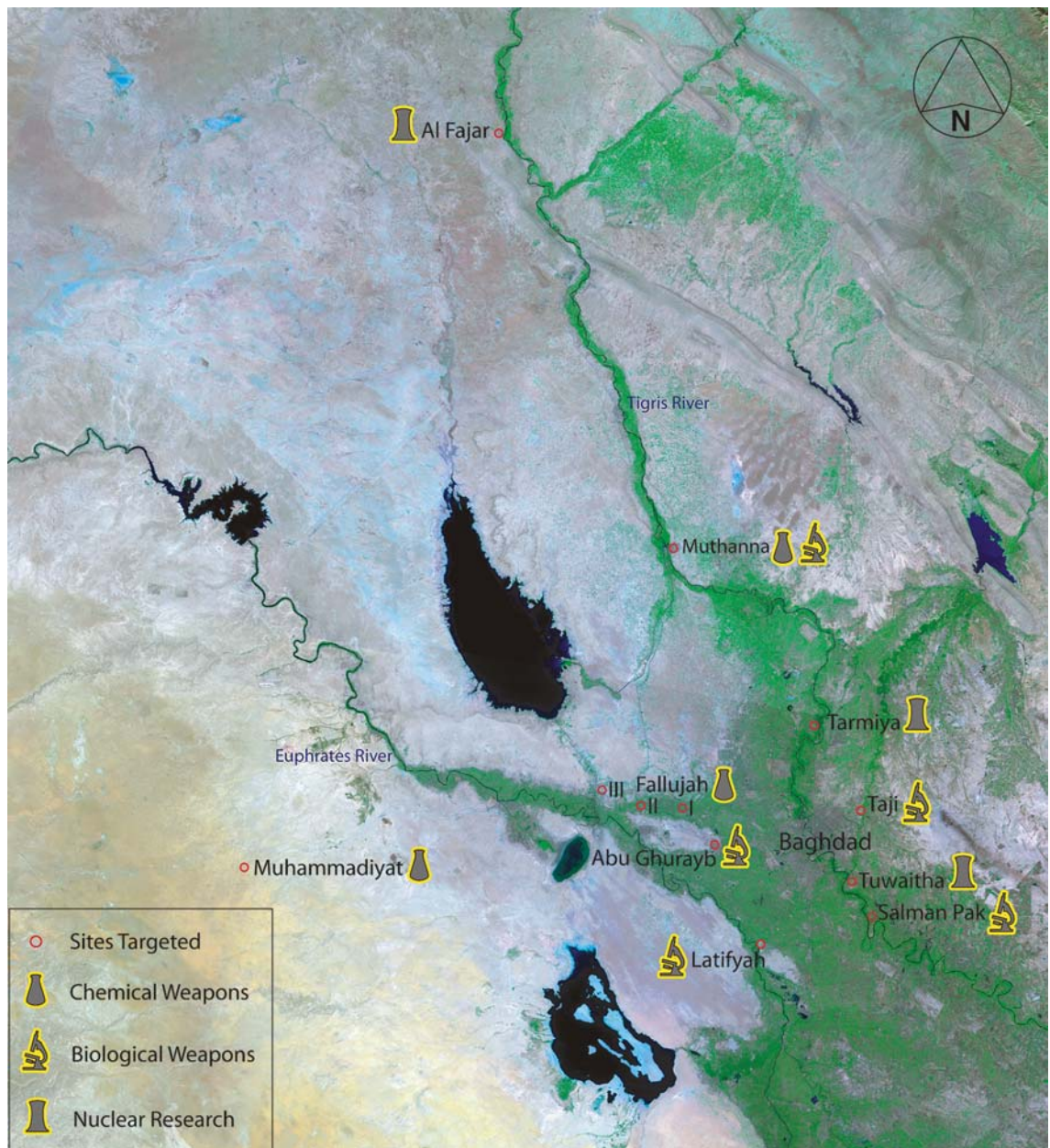
The US has argued that nuclear sites had been targeted with precision-guided weapons to minimize possible fallout and provided assurances that no environmental contamination occurred.¹⁸

Iraqi declarations to IAEA/UNSCOM indicated the following inventory of enriched and/or weapons grade uranium:

- Highly Enriched Uranium (HEU) from the IRT-5000 reactor:
 - 68 fuel assembly with 80% enrichment of U-235, equal to 10.97 kg of U-235;
 - 10 fuel assembly with 36% enrichment of U-235, equal to 1.27 kg of U-235.
- Tammuz-2 reactor:
 - some fuel assembly with 93% enrichment of U-235 balanced, equal to 0.372 kg of U-235.
- Other enriched materials – not weapons grade:
 - balanced with 35.58 kg U-235.

Under IAEA supervision, enriched material was removed to Russia for reprocessing towards the end of 1991.^{19,20}

► Map 8. Chemical, biological and nuclear sites near Baghdad targeted in 1991



Landsat 7 ETM, October 2002, Bands 7,4,2

Image courtesy of UNEP/DEWA/GRID-Geneva

This image depicts the chemical and biological weapons facilities and nuclear research sites near Baghdad that were targeted by coalition forces during the 1991 Gulf War.

Targeted chemical weapons facilities and post-war activities of UNSCOM

The six chemical weapons facilities targeted in 1991 are described briefly below.²¹

- Muthanna State Establishment:** 120km NW of Baghdad. This 25km² site housed Iraq's primary chemical weapons research, development, and production facility. The site operated continuously from 1983 to 1991, producing thousands of tons of nerve agents (sarin, tabun, and VX), mustard gas and 'precursors' (chemicals that can be used to produce the toxic agents for chemical weapons). The site was heavily bombed during the Gulf War. From 1992 to 1994 the UNSCOM Chemical Destruction Group eliminated remaining precursor materials, destroyed production plants and equipment, and hydrolysed or burned remaining chemical warfare agents.

- **Fallujah I:** 60km WNW of Baghdad. Intended to be an additional precursor production facility for the chemical weapons programme. The facility was in the initial phases of construction at the time of the Gulf War.
- **Fallujah II:** 65 km WNW of Baghdad. Produced chemical weapons precursors destined for the Muthanna site. Products included chlorine, phosphorous trichloride and oxychloride, thionyl chloride, and it is highly probable that two direct nerve agent precursors were also produced. Following bombing during the Gulf War, remaining precursors and equipment were transferred to the Muthanna site for destruction under the supervision of the UNSCOM Chemical Destruction Group.
- **Fallujah III:** 70km WNW of Baghdad. In the late stages of construction at the time of the Gulf War. The facility, intended to support the Muthanna site, contained multi-purpose production plants. All these were destroyed during the coalition bombing of 1991. The intended products of this site remain unclear, but may be connected with the VX programme.
- **Muhammadiyah:** 140km W of Baghdad. The primary storage area for filled chemical weapons. At the time of the Gulf War the site contained numerous chemical weapons munitions, many filled with chemical agents. The site was heavily damaged during the war. The UNSCOM Chemical Destruction Group completed elimination of chemical weapons that survived the bombardment.
- **Khamisyah:** A very large site, covering nearly 40km² and including approximately 100 ammunition storage bunkers, 88 ammunition storage buildings, and numerous other structures. The site contained munitions filled with blister agent mustard, and the nerve agents sarin and cyclosarin.

Twenty-two suspected chemical weapons storage bunkers at 13 separate locations, and 8 bunkers at another single location were also attacked.²² There is no independent information available on the chemical agents that may have been released.

► 1991 bomb damage of chemical weapons bunkers at Al Muthanna (2002)



Image courtesy of Digital Globe

Following the Gulf War, UNSCOM confirmed, based on chemical weapons inspections, the following Iraqi chemical weapons facilities:

Production sites:

- Al Muthanna production complex
- Al Fallujah: 3 precursor facilities
- Al Fallujah: Proving ground.

Storage sites:

- Al Muhammediyat: Munitions storage
- Dujayl: Al Hussein warheads
- Al Bakr air base: 250 & 500 gauge aerial bombs
- Al Taji: unfilled containers for 122 mm warheads
- Al Fallujah general headquarters: CS grenades
- Khamisiyah: 122 mm rockets.

UNSCOM supervised destruction of Iraq's declared chemical weapons during the period June 1992 to June 1994. This involved the following munitions and agents:

- 46,000 chemical munitions
- 17,657 metric tons precursor chemicals
- 4,340.5 metric tons of chemical weapons agents (about 3,000 tons of mustard gas; more than 200 metric tons GA; about 800 metric tons of GB; 3.3 metric tons of VX; and a few metric tons of CS)

In his Second Report to the UN Security Council, the Chairman of UNSCOM reported that Al Muthanna had been designated by UNSCOM as the central destruction site and that the process of moving chemical munitions from various sites around the country to Al Muthanna for storage prior

to destruction had been initiated. It was planned that actual destruction of field munitions and bulk agents would begin early in 1992 and was expected to continue into 1993. It was also reported that 11,829 unfilled chemical munitions had already been destroyed by Iraqi personnel under the supervision of UNSCOM at different sites.

The third report of the Executive Chairman of UNSCOM, made in June 1992, said that with regard to chemical weapons, although verification survey activities continued, there had been a shift in empha-

► Fallujah facilities (2002)



Image courtesy of Digital Globe



UNSCOM - CORBIS

Destruction of mustard gas rounds under UNSCOM supervision at Al Muthanna

sis, with relatively more time and resources being devoted to issues directly related to the destruction of Iraq's identified chemical weapons assets. At Khamisiyah, UNSCOM had supervised the destruction of 122 mm rockets, which were too unsafe to be moved to Al Muthanna. A total of 463 rockets (389 filled with GB/GF, 36 partially filled and 38 unfilled, and a total of 2.5 tons of GB/GF mixture) were destroyed on site.



UNSCOM - CORBIS

UNSCOM chemical weapons destruction facility at Al Muthanna



Destroyed chemical weapons bunker at Al Muthanna

The seventh report of the Executive Chairman of UNSCOM (24 June 1994) said that the work of the Chemical Destruction Group at Al Muthanna had been concluded on 14 June 1994. The group destroyed over 480,000 litres of chemical warfare agents (including mustard agent and the nerve agents sarin and tabun), over 28,000 chemical munitions (involving eight types of ammunition ranging from rockets to artillery shells, bombs and ballistic missile warheads), and nearly 1.8 million litres, over 1,040 metric tons and 648 barrels of some 45 different precursor chemicals for the production of chemical warfare agents. No damage to the environment could be recognized.



Iraqi 155 mm mustard rounds at Khamisiyah

Targeted biological weapons facilities and post-war activities of UNSCOM

The biological weapons facilities targeted in 1991 are described briefly below and their locations are shown in Map 8.²³

- **Salman Pak:** Located 40km SE of Baghdad. Conducted laboratory-scale research on anthrax, botulinum toxin, clostridium, perfringens (gas gangrene), mycotoxins, aflatoxins, and ricin. Researchers at this site carried out toxicity evaluations of these agents and examined their growth characteristics and survivability.
- **Taji Single Cell Protein Plant:** Located 10km NW of Baghdad. This site was converted for the production of hundreds of litres of botulinum toxin in the late 1980s.

- **Muthanna State Establishment:** Located 170km NW of Baghdad. The initial location for Iraq's biological weapons programme in 1985/86. Researchers at this site carried out toxin evaluations of several biological weapon agents and examined their growth characteristics and survivability. Agents investigated include anthrax, botulinum toxin, aflatoxin, and ricin. Muthanna also conducted small-scale production of botulinum toxin. Biological weapons equipment was moved to Salman Pak in 1987 and Muthanna was heavily damaged during the Gulf War. Muthanna also provided weaponization expertise to the biological weapons programme – primarily chemical weapons munition technology and testing.
- **Latifiyah:** Information available indicated that the area served as a botulinum toxin weapons fill facility. The biological weapons facility is located at the eastern end of the complex, which is part of an overall complex known as the Latifiyah Explosives and Ammunition Plant al Qa Qaa.
- **Abu Ghurayb Vaccine Plant:** The Abu Ghurayb plant in Al-Kindi had been identified by American intelligence as a suspected biological warfare facility since 1988.
- **Abu Ghurayb (Project 600):** Project 600 was known as the 'baby milk factory' and was located on the main road from Baghdad to Fallujah. Although some equipment for a milk factory was installed, the high level of security (armed patrols of the compound, a concrete fence and embankment, anti-aircraft artillery emplacements) indicated another use. The facility was thought to have been converted to a biological munitions filling plant.

Other suspected storage bunkers for biological weapons were also attacked. There is no independent information available on the agents that may have been released.^{24,25}

Iraq's sixth Full Final and Complete Disclosure (FFCD) of its biological weapons programme, presented to UNSCOM in September 1997 (see Table 5). However, the Chairman of UNSCOM reported to the Security Council that this version of the FFCD was not acceptable, because it did not differ in substance from the previous version (June 1996), which had itself been rejected.²⁶ Al Hakam, the main production site for biological agents, was destroyed by UNSCOM in 1996. Other sites had already been destroyed by coalition forces in 1991.

Post-war assessments of chemical and biological agent releases

UNSCOM investigated the possible release of chemical and biological agents from key military targets. Only at Muhammadiyat and Al Muthana did UNSCOM find evidence that would lead them to conclude that chemical weapons were released as a result of coalition bombing. However, the long-term potential environmental consequences of the releases were not assessed.

Table 5. Iraq's Full Final and Complete Disclosure (FFCD) of its biological weapons programme, as presented to UNSCOM in September 1997

	Total production (litres)	Inactive (litres)	Weaponized (litres)	Destroyed by Iraq (litres)	R-400 bombs (number)	Rocket warheads (number)
<i>Clostridium Botulinum (toxine)</i>	25,000	6,000	11,500	7,500	100	16
<i>Bacillus anthracis</i>	95,000	10,000	50,000	35,000	50	5
<i>Aflatoxine</i>	2,400	-	1,150	1,250	7	4
<i>Clostridium perfringens</i>	3,400			3,400		

A variety of studies have been conducted by the US military to determine the potential risks to coalition troops from fallout from the bombing of chemical, biological and nuclear sites. Releases of chemical agents have been confirmed from Muhammadiyat and Al Muthanna, as well as from Khamisiyah. Potential chemicals released from the sites include blister agent mustard and a mixture of the nerve agents sarin and cyclosarin.²⁷ While attempts have been made to link Gulf War syndrome to possible exposure to chemical weapons from these sites, there is still no clear link. The long-term potential environmental consequences of the releases were not assessed. The Armed Forces Medical Intelligence Centre (AFMIC) also conducted monitoring for indications of possible disease outbreaks within the local Iraqi population from possible biological weapons exposure.²⁸ To date, there have been no such indications.²⁹

Scud missiles

Thirty fixed sites and 100 mobile facilities for Iraqi 'scud' missiles were struck by coalition forces.³⁰ Nevertheless, 90 scuds were launched by Iraq,³¹ of which 25%³² were intercepted by US patriot missiles. Given that the regime had stated publicly that scud missiles could be adapted to carry nuclear, chemical or biological warheads, serious concerns were raised about the potential fallout from the destruction of scud facilities and the missiles themselves.

Targeting of oil industry infrastructure

Five oil refineries (Southern Oil Company, Basrah refinery, North Oil Company, Dawrah/Dora Refinery and Bayji/Beiji Refinery) and numerous tankers and ports were targeted.^{33,34} Iraqi officials estimated that approximately 15 million barrels of oil and 1.5 million m³ of petroleum products were burnt.³⁵



Iraq's Dora oil refinery, bombed during the 1991 Gulf War

FRANÇOISE DE MULDER - CORBIS

Targeting of power supplies

A number of electrical plants and related facilities were attacked, rendering 25% of Iraq's electricity generating facilities inoperative and an additional 50% heavily damaged. Some electrical transformers contained PCBs (polychlorinated biphenols) that may have burnt or otherwise been released into the environment.³⁶ PCBs are extremely toxic and pose a serious risk to human health.

The loss of electrical production facilities had cascading effects on water supply, sanitation and refrigeration. By March 1991 the water supply in Bagdad was operating at only 10% of its pre-war capacity. The loss of electricity severely disrupted systems for pumping saline water from irrigated lands in the southern floodplain, leading to widespread water logging and salinization.^{37,38}

Targeting of industrial facilities

Industrial research, development and production facilities were targeted, including chlorine, phosphorus and vaccine plants. A complete list of the targeted industrial sites is not available.³⁹

Bombing of chemical and industrial plants led to the release of numerous toxic chemical compounds into the atmosphere, soil and local waterways. An assessment of the chemical risks and levels of environmental contamination has not been conducted.⁴⁰

The livestock and agriculture sectors in Iraq were devastated by disease epidemics due to a lack of vaccines caused by the destruction of production plants, and by a lack of pesticides and fertilizers as a result the bombing of chemical plants (and also the impact of import sanctions). In some cases, production was reduced by up to 40%.⁴¹

Damage to water supply and treatment systems

Damage from coalition bombing disrupted water distribution and treatment plants (Sarafiya), sewage related facilities (Rustumiya) and hospitals (Adan).⁴²

Kuwait's water supply and sewage treatment facilities were damaged by retreating Iraqi troops.⁴³ Over 50,000 m³ of sewage were released per day into Kuwait Bay.⁴⁴

Oil well fires

Seventy-six Kuwaiti wells were uncapped by Iraq forces and allowed to flow freely onto land.⁴⁵ Another 99 wells were deliberately damaged.⁴⁶ Approximately 60 million barrels were released.⁴⁷ Over 246 oil pools were formed, covering an estimated area of 49 km²⁴⁸ to a depth of 30-50 cm. Estimates of the total quantity of oil accumulated in the pools ranged from 25 to 50 million barrels.⁴⁹ The major toxicological components of the oil included mercury, benzene, toluene, ethylbenzene, xylenes (BTEX) and polyaromatic hydrocarbons (PAHs).⁵⁰

More than 600 Kuwaiti oil wells were set on fire by retreating Iraqi troops, burning between 2.5 and 6 million barrels of oil per day.^{51,52} Wells burned continuously from the end of February to the beginning of April 1991,⁵³ and the smoke plume extended over several hundred kilometres in width.⁵⁴ It was estimated that the total amount of oil-related pollutants generated by the fires, including sulphur dioxide, carbon monoxide, soot and carcinogenic combustion products such as benzopyrene, PAHs and dioxins, was 500,000 metric tons per day. By early May, fire-fighting teams had capped 80 gushing wells and extinguished 70 fires. The last fire was extinguished in November 1991.^{55, 56}

4



PETER TURNLEY - CORBIS

Burning oil wells in Kuwait in 1991

Widespread degradation of grazing land occurred in Saudi Arabia as a result of soot fallout and deposition of oil droplets (oil 'mist'). This increased the density of grazing in unaffected areas, leading to soil erosion and to the further loss of perennial plants.⁵⁷

► Kuwait Fires



Kuwait - 31 August 1990

Kuwait - 23 February 1991

Kuwait - 14 November 1991



Kuwait - 31 August 1990

Kuwait - 23 February 1991

Kuwait - 14 November 1991

Pre-Fire Image: August 1990, Landsat 4 TM bands 4 3 2

Fire Image: February 1991, Landsat 4 TM bands 4 3 2

Post-Fire Image: November 1991, Landsat 5 TM bands 4 3 2

All images courtesy of USGS.

In addition, some 6-8 million barrels of oil were intentionally spilled into the Gulf from three major sources: sunken or leaking vessels, and terminals in both Kuwait and Iraq.⁵⁸ The size of the initial oil slick – the largest in history – was estimated to be 56 km by 16 km (almost 900 km²). By February 1991 the slick had grown to 120-130 km long and 5-25 km wide.⁵⁹ A total of 707 km of Saudi Arabian coastline were estimated to have been oiled, of which 366 km were heavily affected.⁶⁰ The total amount of oily sediment was estimated at more than 1.25 million m³.

The environmental damage in Kuwait was estimated at US\$40 billion⁶¹ (out of a total loss of US\$250 billion). Similar estimates are not available for Iraq, Saudi Arabia or Iran.

Total emission of carbon dioxide from the oil fires was estimated to be 3×10^8 tonnes – about 1.5% of worldwide annual emissions from fossil fuels and biomass burning. The emissions may have also contained small quantities of mercury, benzene, toluene, ethylbenzene, xylenes (BTEX), and polyaromatic hydrocarbons (PAHs). It is possible that the oil fires could have also produced dioxins due to the introduction of chlorine from the use of salt water for extinguishing the fires.⁶²



OLIVIERO TOSCANI - BIRDLIFE INTERNATIONAL

The release of oil during the 1991 Gulf War caused severe and widespread contamination of soil, surface/groundwater, and coastal waters

Within the smoke plume, peak concentrations of sulphur dioxide exceeded health standards, while peak concentrations of carbon monoxide, ozone and nitrogen oxides were below health standards. Overall, however, the possible long-term health effects of the atmospheric pollution are uncertain, and it was recommended that additional studies be conducted on the pollutants themselves and on the exposed population.⁶³

At ground level the concentrations of total suspended particulates (TSP) and particulate matter below 10 micrometres (PM-10) often exceeded local and other recognized health standards in the region. However, high occurrences of TSP and PM-10 were common in the region, making it difficult to determine the contribution from the oil fires without

chemical analyses. Such analyses were not conducted.⁶⁴ In some cases, ground level concentrations of sulphur dioxide exceeded local health standards, but the levels were not persistently high.⁶⁵ Available hospital attendance records suggest there was a temporary increase in upper respiratory tract and asthmatic symptoms. More investigation is needed to determine long-term health complications and risks, including increases in chronic bronchitis and mortality rates.⁶⁶

Acidic precipitation may have increased in Iran during the period of the fires. There is no firm evidence that acidic precipitation occurred on the Arabic Peninsula or outside the region.⁶⁷

The soot and oil mist emanating from the burning oil wells in Kuwait covered the soil surface and vegetation over large areas, in particular in the Burgan oil field and along the Ahmadi–Wafra road towards the south.⁶⁸ Approximately 953 km² of desert area were oiled from the fallout of the fires,⁶⁹ of which 100 km² were considered to be heavily affected.⁷⁰ The annual flora failed to set seed and much of the perennial vegetation was either killed or severely damaged.⁷¹

In some of the areas where fires were fought, extensive salination of the soil occurred due to the use of salt water in fire-fighting equipment. This has resulted in mortality of native plant species, and a shift to more salt-resistant coastal species.⁷²

Fallout of soot and unburnt oil products formed slicks on the surface of the ocean. Polycyclic aromatic hydrocarbons and heavy-metal-laden soot were released into the water column.⁷³ Although analyses of water samples indicated that heavy metal concentrations had not increased as a consequence of the oil spill,⁷⁴ there was no information available on how concentrations may have increased in bottom sediments, which were affected by widespread, low-level oil contamination.

It was not possible to identify the impacts of the oil spills and oil fires on fisheries.⁷⁵ The possible risks to human health from ingesting fish that may have been exposed to hydrocarbons and related breakdown products were not investigated thoroughly since it was believed that the fish resources did not constitute a health hazard.

Some 30,000 wintering seabirds died as a result of oil spills.^{76,77}

Use of depleted uranium (DU) ordnance by coalition forces

A total of just over 290 metric tons of DU projectiles were fired by the US during the Gulf War (compared to 9 tons in Kosovo and 3 tons in Bosnia and Herzegovina), with DU remaining in the environment as dust or small fragments.^{78,79} The DU munitions were deployed by:

- US Air Force A-10 Thunderbolt II ('warthog' or 'tankbuster') aircraft – approximately 81% of the total DU fired;
- US Marine Corps AV-8 Harrier aircraft – about 3% of the total;
- US Army and Marine Corps M60 and M1A1 Abrams tanks – about 16% of the total.



A-10 Thunderbolt aircraft accounted for more than 80% of the depleted uranium rounds fired in the Gulf War

The World Health Organization (WHO) had agreed in August 2001⁸⁰ to investigate the possible health impacts of DU in Iraq.

The study was to cover three areas – surveillance of diseases (especially cancers and congenital malformations), measurements of DU in potentially affected people, and prevention/research activities. However, due to the prevailing political context, no such investigation took place. In 1995, a preliminary study was conducted in Kuwait to determine the possible risks from DU. It was calculated that the total per capita intake of DU via inhalation by Kuwaiti inhabitants was 0.05 Becquerel, which is less than 0.2% of the recommended annual intake limit for the general population.⁸¹ Kuwait requested the IAEA to assist with verifying results of DU studies conducted at a national level. Consequently, the IAEA laboratories analysed 30 samples containing air filters, water, soil and DU penetrator fragments from various regions of Kuwait.⁸²

Unexploded ordnance (UXO)

US military officials estimate that 3-5% of bombs, rockets and shells fail to explode, although soft sand may have increased this rate to 15% in some cases. The total number of unexploded ordnance may range from 10,000 to 40,000 individual pieces.⁸³ Up to 1.6 million landmines were laid inside Kuwait by Iraq, consisting of 1 million anti-personnel mines and 0.6 million anti-tank mines.⁸⁴

Unexploded/capture ordnance was destroyed predominantly through open-air burning and/or detonation by coalition forces, potentially releasing contaminants into the air and the soil of Iraq, Kuwait and Saudi Arabia.

Hazardous waste

It can be assumed that the conflict generated significant quantities of hazardous waste that may still have significant consequences for the environment and human health – for example around targeted industrial and military facilities. While information is lacking on the amounts, types and locations of such waste, its possible presence should be taken into account in post-conflict clean-up and reconstruction.

Physical degradation of landscapes

A total of 375,000 bunkers, trenches and weapons pits were installed in Kuwait, and an unknown number in Iraq.⁸⁵ A total of 3,500 tanks and 2,500 armoured personnel carriers were in operation causing significant disruption of desert sand and soil layers.⁸⁶

Pulverization of the surface soil by off-road military vehicles, troop movements and disturbance by bunker and road construction and bombings increased its vulnerability to erosion by wind and water⁸⁷. Remote sensing analyses suggest that up to 50% of the desert surface in Kuwait was compacted.⁸⁸

Physical destruction to beaches by the digging of trenches and laying of mines, barbed wire and other defence installations caused serious impacts on coastal landscapes and biodiversity, in addition to the obvious direct threats to people.⁸⁹

Waste disposal systems in both Iraq and Kuwait were severely disrupted during the conflict, leading to widespread illegal dumping and burning. Illegal dumpsites may have created risks to groundwater, and burning may have produced dioxins.^{90 91}

Due to a shortage of fuel, illegal clearing of woodland in Iraq damaged approximately 160 km² of land.⁹² In Kuwait, disruption of irrigation systems caused severe damage to young plants in afforested areas.⁹³ An estimated 20% of the country's cultivated trees were lost.⁹⁴

Rehabilitation and compensation of environmental damage

Compensation for environmental damage from the conflict is also contained within the mandate of the United Nations Compensation Commission (UNCC). The 'F4' Panel of Commissioners was established by the Governing Council of the UNCC to review claims presented by governments or international organizations with respect to direct environmental damage and the depletion of natural resources. The environmental claims are divided into five instalments:

- First: monitoring and assessment projects (awarded in July 2001);
- Second: past work – abatement of damage, prevention works, past mitigation and remediation work (awarded summer 2002);
- Third and Fourth: future remediation and restoration works (mid 2002 – end 2003);
- Fifth: natural resource damage and public health (end 2003 – end 2004).

4.4 Environmental impacts and risks from the conflict of March/April 2003

For obvious reasons, it has not yet been possible to undertake field research in Iraq. This section is therefore based primarily on media reports and military briefings to journalists and the general public. At the time of writing, the level and intensity of conflict is much reduced but not yet at an end, and limited information is available on actual environmental impacts and risks. When reviewing this preliminary summary it is essential to keep in mind that Iraq's environment was already subject to a range of both chronic and acute environmental problems arising from:

- impacts of the Iran-Iraq War and 1991 Gulf War, as summarized in sections 4.2 and 4.3;
- low priority attached to the environment by the Iraqi government;
- unintended effects of UN sanctions (imports of many spare parts and chemicals required for maintaining essential environmental services such as sanitation and water supply were restricted because of their 'dual use' nature; only in May 2002 were new procedures set in place by Security Council resolution 1409 for the processing of contracts for humanitarian supplies).

In addition to the key issues outlined below, it can be expected that additional risks will arise from unexploded ordnance and land mines. At the time of writing, there have been no reports of any major marine pollution incidents in the Gulf, nor have there been mass movements of displaced persons across international borders. However, all these, and additional potential environmental stresses, will need to be kept under continual review.

► Bomb Explosion in Baghdad (2003)



Date: April 9, 2003

Image courtesy of Digital Globe

Explosion in Eastern Suburbs of Baghdad.

The US air force stated that, as of 15 April 2003, coalition air forces had used 18,275 precision-guided munitions (67% of all munitions deployed) and around 8,975 unguided munitions.⁹⁵ Over 800 Tomahawk cruise missiles had been fired as of 12 April.⁹⁶ This compares with 288 fired during the 1991 Gulf War.

Disruption of power supplies, water and sanitation

As discussed in Chapter 2, the Iraqi population has become highly urbanized in recent years, meaning that most citizens are dependent on municipal power, water and sanitation services. Baghdad, Basra and other cities have experienced extended power cuts, with serious impacts on already inadequate water distribution and sanitation systems that have been subject to further degradation during the conflict. Millions of civilians have been deprived of basic services and there is likely to be an elevated risk of disease epidemics, as well as an increased pollution burden on the Tigris River.

Electricity supplies to central Baghdad were cut at approximately 17.00 GMT on 3 April⁹⁷ and, at the time of finalizing this report (22 April), have not been re-established. The cause of the blackout is unknown, with coalition forces saying that they had not deliberately targeted the city's power supply. On 9 April, the ICRC estimated that only 20% of Baghdad's five million citizens had access to electricity, while the following day the organization was planning to visit the Medical City hospital complex (650 beds), which was "still experiencing water shortages". The ICRC was also attempting to fill public water tanks in areas of the capital currently not connected to the water-supply network.⁹⁸ On 16 April, ICRC reported that Al-Rashad hospital in the east of Baghdad "lacks sufficient drinking water, has no water for washing or cleaning...and only limited food is available for patients". ICRC provided 30,000 litres of water for drinking and cleaning.⁹⁹

In Basra, the ICRC and coalition forces had partially reconnected the city's water supply by the end of March. However, on 10 April the ICRC stated that "the water supply to parts of Basra and reportedly also to most towns in southern Iraq remains disrupted". A week earlier, the BBC reported the water and humanitarian situation in the southern town of Umm Qasr to be "a shambles".¹⁰⁰ The ICRC, working with local technicians, restored supplies to the Al-Sadr region of Baghdad on 17 April¹⁰¹, coinciding with a call from the UN Secretary General for coalition forces to do everything possible to ease the humanitarian situation.

Waste management and disease

The conflict will have exacerbated an already critical waste management situation. The long-term consequences of inadequate waste systems will be supplemented by acute health and safety risks associated with the accumulation of waste in populated areas, especially major town and cities. These risks include disease vectors (vermin, insects, dogs, pathogens) sourced to human remains, clinical waste, and food waste, and exposure to dust and debris potentially containing asbestos and other hazardous materials.

Oil-well fires in southern Iraq and oil-filled trenches around Baghdad

Reports of oil wells having been deliberately set on fire in the Rumeila oilfield of southern Iraq began to emerge on 20 March, while a thick haze of dark smoke could be seen from Kuwait City the following day. Pentagon officials indicated that the fires were at wellheads, rather than from oil-filled trenches. Initial reports of up to 30 fires were later scaled back to nine. On 25 March Reuters stated that three of the fires had been extinguished, while on 27 March the Associated Press reported "as many as five fires were still burning", although a spokesperson for the Kuwaiti oil industry said that only three fires remained. Specialist contractors from Canada and the US were preparing to tackle these sites. British forces cast

► Bomb damage to Republican Palace, Baghdad, 1 April 2003



Images courtesy of Space Imaging

doubt on initial claims that many of the wellheads had been sabotaged, reporting only very limited evidence of tampering. Only two fires were still burning on 3 April¹⁰², while the last fire was reportedly extinguished on 15 April.¹⁰³

Oil-filled trenches in and around Baghdad were set alight in an attempt to impede coalition weapons and prevent aerial and satellite surveillance. These fires, together with fires at targeted sites, generated large quantities of dense black smoke, containing a range of toxic substances, with potential health risks for local people. The trenches also cause soil pollution and potentially threaten contamination of groundwater bodies and drinking water supplies.

The number, extent and intensity of oil fires (whether from wells or trenches) were far smaller than during the 1991 Gulf War, and it can be expected that damage to the environment and/or human health has been at a lower level. However, further studies are needed to confirm this tentative conclusion.

As of 22 April, there have been no reports of any major oil (or petroleum product) spills, either on land or into water bodies (including offshore waters). This again contrasts with the severe environmental damage that occurred during the 1991 Gulf War.

■ Environmental impacts of oil fires

Crude oil is a mixture of about one thousand different hydrocarbons, with exact composition (notably the ratio of heavy and light components) varying from one reserve to another. The products of uncontrolled oil fires, whether at a wellhead, a storage area or in trenches, will depend on the type of crude oil, local climate conditions, the content of hydrogen sulphide (H_2S), water and/or natural gas, and the presence of naturally occurring radioactivity, especially dissolved radon isotopes as products of the natural uranium decay series.

The broad categories of contaminants from oil fires are:

- extreme heat
- carbon monoxide
- unburned hydrocarbons
- poly aromatic hydrocarbons (PAHs)
- polychlorinated-dibenzo-dioxins and furans
- carbon soot
- oxides of sulphur
- oxides of nitrogen
- carbon dioxide
- radon

► Bomb damage in Dawrah area of Baghdad, 1 April 2003



Images courtesy of Space Imaging

Of these, the first two are lethal, capable of causing immediate death upon exposure, even for a short duration. However, this would happen only within the immediate vicinity of the fire. The other pollutants have more chronic effects and some (PAHs, carbon soot) are carcinogenic.

Other than potential impacts on human and animal health, the contaminants from oil fires may also damage vegetation (including crops), landscapes, and human artefacts (including buildings and archaeological sites).



Fighting well fires in the Rumaila oil field, 27 and 28 March 2003



A normal oil-well fire will generally have only a limited footprint, though damage within this area may be very severe. However, many Iraqi oil fields are high producers (>5,000 bpd) by industry standards, and liable to generate very substantial quantities of pollutants. Plumes can potentially extend hundreds of kilometres and possibly enter neighbouring countries, depending on wind direction. Multiple large well fires, as occurred in Kuwait in 1991, may result in large-scale regional impacts, reduced penetration of sunlight, accumulated tar on ground surface, exposure of the general populace to pollutants, and widespread damage to vegetation.

Assuming that a typical well produces 5,000 bpd, and that there may be up to ten fires burning simultaneously, the level of fuel load could have been around 50,000 bpd. This equates to the pollution from 8 million diesel cars burning fuel at 99% efficiency.

■ Environmental impacts of unburned oil from wells and trenches

The impacts of unburnt crude oil spilled onto the ground will depend on the type of crude (light/heavy), the presence of hydrogen sulphide, microclimatic conditions (temperature and wind direction) and the permeability of the ground. In the case of light crude oil (or its products), an explosive mixture of volatile hydrocarbons is soon formed in the area, putting people and the environment at risk. Hydrogen sulphide has the potential to cause instant death at concentrations above 500 ppm and high concentrations are known to occur at many oil and gas wells in the region.

The broad categories of contaminants from unburnt oil leaks/pools are as follows:

- volatile hydrocarbons, including aromatics (BTEX)
- hydrogen sulphide
- highly saline water
- naturally occurring radioactivity.

Since the aromatic hydrocarbons (benzene etc.), which are known carcinogens, are the most volatile of hydrocarbons, exposure even at low levels can be very harmful. Exposure can occur some kilometres from the point of the leak/pool depending on the prevailing wind conditions.

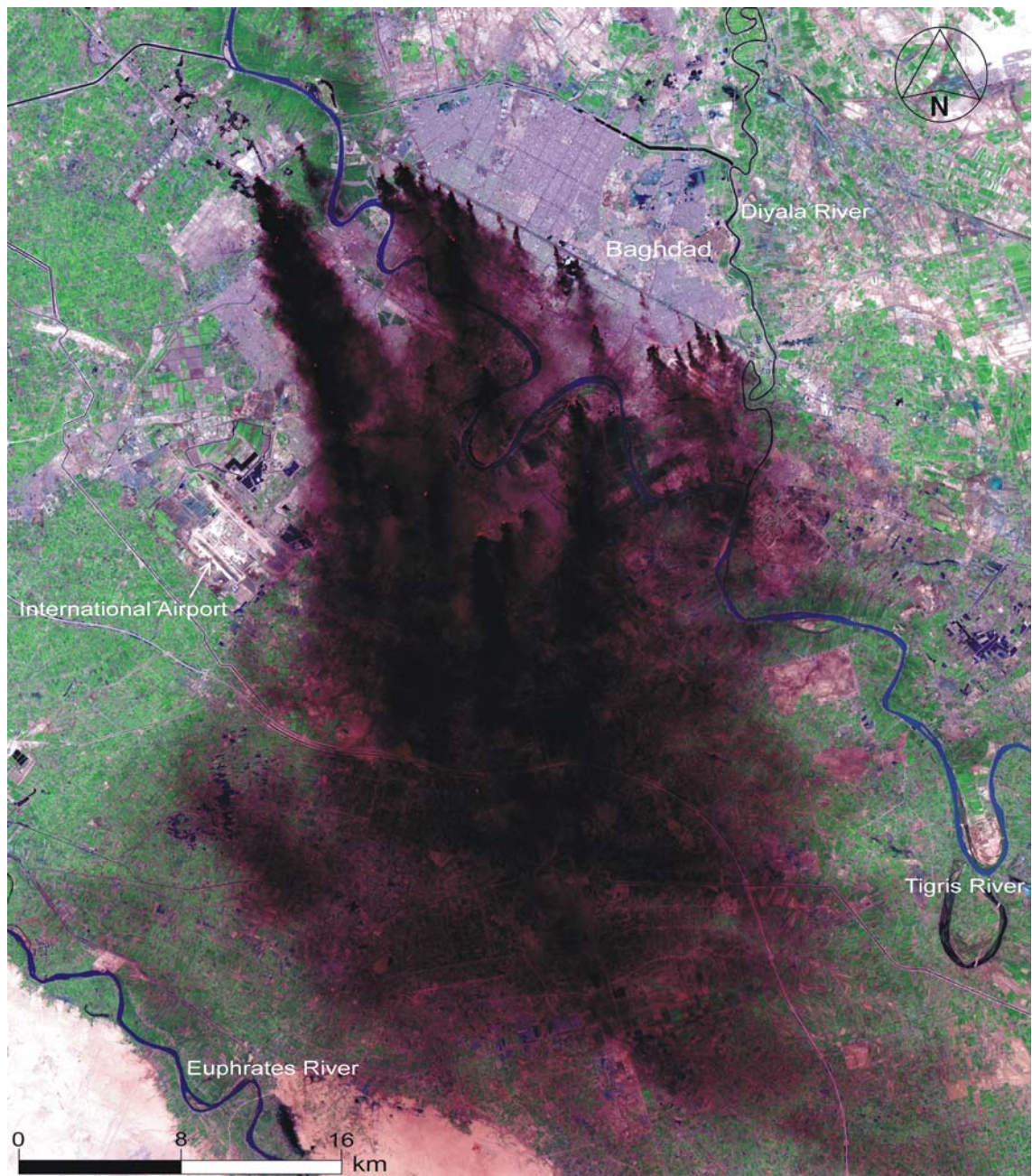
► Oil Trench Fires around Baghdad (2003)



IKONOS satellite on 1 April 2003

Image courtesy of Space Imaging

► Oil Trench Fires around Baghdad (2003)



This image is derived by merging of panchromatic ETM Band 8 with Bands 7,4 and 2.

Image courtesy of UNEP/DEWA/GRID-Geneva

This image of black smoke plumes over Baghdad was acquired by Landsat's Enhanced Thematic Mapper (Bands 7,4,2) on 2 April. The plumes, stretching along major roads and canals, originate mainly from burning oil trenches and pools. Large sections of the city are blanketed by thick, almost black smoke, containing chemical and particulate components that pose a serious hazard to the health of Baghdad's 5 million residents and their environment. The smoke columns extend for about 60 kilometers south of the city, and cover a 36 kilometer wide swath. Urban areas are grey and the vegetated cover, mainly irrigated agriculture, appears green.

Oil trench fire near fuel tanks and industrial area, south Baghdad, 27 March (next page, top)

Oil trench fire near the monument of the unknown soldier, central Baghdad, 1 April (next page, bottom)



Image courtesy of Digital Globe

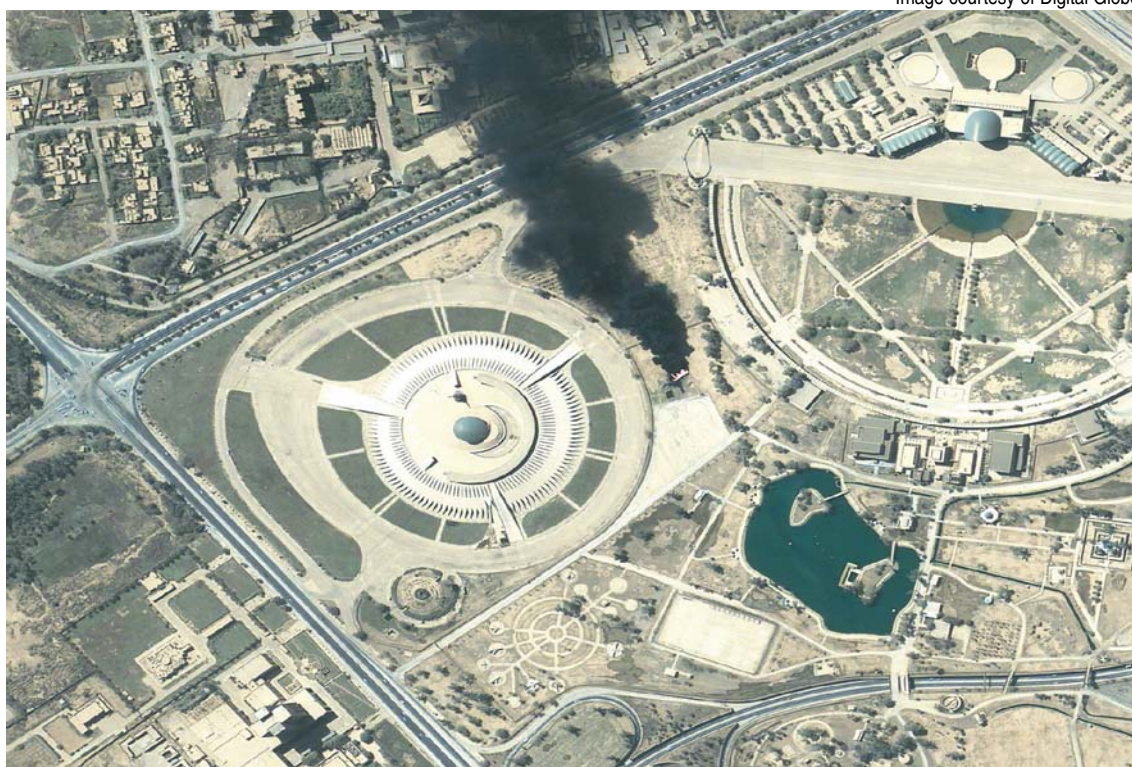


Image courtesy of Digital Globe

► Oil Well Fires from the Rumaila oil fields (2003)



MODIS Image: Bands 1, 4, 3 (true colour)

Image courtesy of UNEP/DEWA/GRID-Sioux Falls and GRID-Geneva

This image taken on 21 March 2003 shows thick black plumes billowing out from Rumaila oil wells on the Iraq-Kuwait border and on the outskirts of Al-Basrah. The last of up to nine burning wells was extinguished on 15 April 2003.

Hydrocarbons may be very mobile in the ground especially in fractured/permeable soil (though percolation of crude is typically slower than that of oil products such as petrol and diesel), with a risk of widespread aquifer contamination, which is very expensive and time-consuming to remediate. There was significant aquifer contamination in Kuwait as a result of oil released during the Gulf War.

Oil mist can be carried for a few hundred metres before dropping back to ground, causing smothering of plant leaves, damage to buildings and artefacts, and depriving oxygen from ground microfauna.

Tackling deliberate and accidental oil spillages is extremely difficult, the more so in a conflict situation. If hydrogen sulphide is present, it will not be advisable to approach the area without special breathing apparatus. Secondly, due to the potentially explosive mixture of volatile hydrocarbons, it may not be safe for people to work in the area, either with or without breathing apparatus. Overall, therefore, oil trenches that have not been burnt, though less spectacular in terms of media imagery, are probably more damaging from a health and environment control and clean-up perspective.

Damage to industrial sites

UNEP's experience in the Balkans showed that direct or indirect damage to industrial sites can threaten human health and the environment. However, as of 22 April, no detailed information was available concerning the impacts of the recent conflict on industrial sites and potential releases of hazardous substances into the environment.

On 29 March, a coalition airstrike on a factory close to Al Rasheed water treatment plant caused damage to buildings within the treatment plant compound.

Targeting of military sites, including sites related to the production of chemical, biological and nuclear weapons

The coalition targeted numerous Iraqi military facilities, including ammunition storage sites and the logistical supply chains for Iraqi forces. Any of the sites targeted could present hazards to the environment and/or human health from a range of risk factors, including possible presence of unexploded ordnance, toxic or radioactive substances, and pollutants such as oil and petroleum products.

Several military targets were identified during coalition media briefings. For example, on 31 March it was reported that the Al-Kindi rocket and missile development site, located at Mosul near the Tigris River some 400 km north of Baghdad, was targeted by a coalition airstrike.¹⁰⁴ This site had been visited by IAEA and UNVOMIC inspectors on four occasions between December 2002 and February 2003.

On 1 April, the Pentagon stated that a "former terrorist training camp" believed to have been "developing poisons for use against civilians in Europe and the United States" at Khurmal in northeastern Iraq had been targeted with Tomahawk cruise missiles during the last week of March.¹⁰⁵

Several media reports raised concerns about the security of nuclear material at a storage facility near the Tuwaitha Nuclear Research Centre entered by US forces during the conflict, although it was unclear how, when and by whom the site had first been entered.¹⁰⁶ The US subsequently provided assurances to IAEA that the nuclear material located there would be properly protected and access to the site restricted.¹⁰⁷



Mosul missile facility, pre-strike

During weapons inspections in Iraq from November 2002 until March 2003, IAEA inspectors visited the Tuwaitha Centre many times. In some buildings, the inspectors had documented higher than normal radiation levels, attributable to Iraq's past nuclear weapons programme and the presence of radioisotopes.

Speaking on 11 April 2003, IAEA's Director General said that, "as soon as circumstances permit, IAEA should return to verify that there has been no diversion of this material".

IAEA has also underlined that radiation levels remain high and that great care must be taken when entering the facility.¹⁰⁸

As of 22 April, the potential environmental consequences at any of the above-mentioned sites of possible releases of toxic/hazardous substances, including chemicals and heavy metals, are unknown.

Physical degradation of ecosystems

Intensive military activities will have caused widespread degradation of fragile desert ecosystems that may take many decades to recover (see Chapter 3, page 45). This will increase erosion, loss of top soil, and vulnerability to sand storms.

Depleted uranium

Depleted uranium, a by-product from the process that enriches natural uranium ore for use as fuel in nuclear reactors and nuclear weapons, has both defensive and offensive military applications.¹⁰⁹ Its high density makes it suitable as a component of armour plating (e.g. for part of the turrets of US Abrams M1 main battle tanks), as well as for piercing armour plating. DU munitions are currently manufactured for use by aircraft (including helicopters) and tanks.

Many Iraqi tanks and armoured personnel carriers (APCs) were targeted during the conflict by US A10 Thunderbolt ('warthog' or 'tankbuster') aircraft, used throughout the military campaign. Use of DU by coalition forces was confirmed by US Central Command on 26 March.¹¹⁰



Mosul missile facility, post-strike

A10s are equipped with conventional missiles, but also with guns that fire rounds of depleted uranium (DU). Television pictures broadcast by media on 8 April showed A10 aircraft attacking both the Planning and Information Ministries in Baghdad. Expert observers considered that DU munitions were used in these attacks. In other incidents, US Abrams tanks are known to have burned, with likely releases of DU to the environment.

- Overall, it is likely that significant amounts of DU rounds have been fired (around 290 metric tons were reportedly fired during the 1991 Gulf War¹¹), with additional DU released into the environment from the burning of armour plating. This may involve any or all of the following potential risks to the environment and human health, based on UNEP's findings in the Balkans:¹²
 - Inhalation of DU dust at the time of munition impact, leading to a potentially serious additional health risk to anyone in the immediate vicinity who survived the initial blast and subsequent fire;
 - Widespread, low-level contamination of the ground surface by DU;
 - Presence of intact DU penetrators buried in soft ground (which might be dug up and handled by unprotected individuals, leading to a low-level but unnecessary beta radiation dose to the skin);
 - Presence of DU penetrator fragments on the ground surface (which might be picked up and handled by unprotected individuals, including 'souvenir' hunters, leading to a low-level but unnecessary radiation dose);
 - Possible migration of DU into ground water (and from there into drinking water supplies), through corrosion and dissolution of penetrators and penetrator fragments.



30 mm depleted uranium round

FEDERATION OF AMERICAN SCIENTISTS



GORAN TOMASEVIC - REUTERS

Iraqi soldiers stand on top of a destroyed US tank in the southern outskirts of Baghdad



FALEH KHEIBER - REUTERS

Iraqi Planning Ministry during an A-10 air strike

However, it must be stressed that UNEP's work in the Balkans was undertaken some years after conflict had occurred, during which time dispersion of DU dust had occurred. Currently, in Iraq, there will be fresh surface contamination around sites targeted with DU in March and April 2003. UNEP experts expect there to be a high risk of inhaling DU dust when entering within a radius of about 150 m of such sites, unless high quality dust masks are worn. Inhalation of DU dust within this radius could result in health risks due to both the potential chemical toxicity of uranium, and to its radioactive nature.

It is also important to underline that the environmental conditions in Iraq (especially climate, soil, geology and vegetation) are very different to those prevailing in the Balkans and there may be important differences in the rates of corrosion and in the environmental pathways for DU. Consequently, it is important that independent scientific investigations are made if local people, military personnel, and those otherwise present in affected areas in the weeks, months and years ahead are to be given appropriate and accurate advice concerning risks to human health and the environment.

DU was reportedly used extensively in the vicinity of Basra during the 1991 Gulf War, so it is likely that future field investigations may detect sites where DU contamination is present from two conflicts 12 years apart. DU was also used in Kuwait in 1991 and IAEA conducted a study of affected sites in 2002.

Chemical and/or biological weapons

As of 22 April 2003, there is no evidence that chemical or biological weapons have been used at any time during the conflict, though the discovery of protective clothing at Iraqi military positions, and – in a Nasiriya hospital – of drugs used to counteract the effects of chemical weapons, led to coalition speculation that the Iraqi regime was prepared to deploy such weapons. Several reported finds by coalition forces of chemical weapons facilities were later discounted. On 22 April, the US stated that no weaponized chemicals, biological agents or any

nuclear devices had so far been found. Some potential ‘dual use’ materials had been located, but the quantities and substances did not indicate weaponization.

Speaking on 10 April, the UN Secretary General stated his view that the mandate of UN weapons inspectors was still valid, having only been suspended because of the war. He expected that inspectors would be able to return as soon as possible to resume their work.¹¹³ The Chairman of UNMOVIC has also indicated his belief that UN weapons inspectors can play a key role.¹¹⁴ Effective weapon inspections will be an important element in safeguarding Iraq’s future environment.

Unexploded Ordnance (UXO)

As in the 1991 conflict, it can be expected that significant quantities of UXO are present, especially in and around heavily targeted areas such as Baghdad and Basra. One recent media report detailed the removal of an unexploded smart bomb from the grounds of Basra’s main hotel.¹¹⁵ Unless strictly controlled and monitored, the open burning and detonation of UXO could pose risks to the environment and human health.



SIMON WALKER - REUTERS

Destroyed Iraqi tank

Next steps

5.1 Overview

The post-conflict situation in Iraq, following the events of March and April 2003, presents immediate challenges in the fields of humanitarian assistance, reconstruction and administration. The humanitarian consequences of the conflict, including the disruption of water, sanitation and power supplies, mean that environmental issues must be accorded high priority.

This report has highlighted many of the environmental risks and vulnerabilities now confronting Iraq. However, as a consequence of the ongoing conflict, it was not possible to gather information at the field level – an essential precondition for preparing effective post-conflict environmental assistance. This is why UNEP advocates that early steps should be taken towards assembling more detailed knowledge of the current situation on the ground, through a series of specialized field missions. However, restoring security and the rule of law will be needed before these activities can be undertaken.

The environmental situation in Iraq was already of serious concern prior to the most recent outbreak of conflict. This had resulted from a combination of successive wars, the low priority attached to environmental concerns by the former Iraqi government, and the unintended impact of UN sanctions, such as restrictions on the import of chemicals used for treating drinking water.

The conflict of March and April 2003 has been markedly different from the 1991 Gulf War, having been focused on major urban areas in Iraq, especially Baghdad and Basra. As result, the environmental consequences have also been very different, with the most obvious problems being air pollution from oil-trench fires and the damage to essential services such as water and electricity supplies.

This does not mean, however, that the consequences have been negligible. Among the known categories of impacts are physical damage to environmental infrastructure, (e.g. water and sanitation systems), targeting of military and industrial infrastructure, and consequent releases of potentially hazardous substances, air pollution from oil-well and oil-trench fires, damage to ecosystems and landscapes from military activities and use of depleted uranium (DU) ordnance, which is likely to have resulted in widespread environmental contamination of as yet unknown levels or consequences.

With the conflict not yet formally ended, it is too early to reach detailed or definitive conclusions on these issues. Key information is currently lacking – for example, the exact types and locations of targeted sites, such as industrial complexes, that might present environmental risks. It will also be essential to maximize knowledge of the pre-conflict state of the environment and chronic environmental stresses, such as inadequate hazardous waste management, that have confronted Iraq and its citizens for decades. Addressing these concerns will require the establishment of cooperative links with in-country sources of environmental expertise.

For all these reasons, a presence on the ground will be needed before environmental priorities can be assessed in full.

5.2 Next steps

Based on these considerations, UNEP has identified steps for action in the immediate post-conflict period, which can be divided into two broad categories. Steps 1 and 2 address environmental concerns that pose risks for human health and further environmental degradation. Steps 3-5 set

out the longer-term measures needed to strengthen environmental management, build effective environmental institutions and ultimately to restore the country's life support system. It will be essential to integrate Iraqi scientists into all steps from the outset.

Step 1. Assess the situation on the ground and identify technical priorities for mobilizing environmental assistance

- Organize scientific field assessments to establish the precise post-conflict situation of the environment in Iraq, for example by conducting field measurements and observations, and taking samples for laboratory analysis.
- Identify principal environmental 'hot spots' including areas subject to direct targeting, where releases of hazardous substances into the environment may have occurred, and other major polluted areas, that may threaten human health.
- Identify sites targeted with DU by obtaining information on their locations from coalition governments.
- Measure and assess levels of pollution at such 'hot spots' and plan corresponding environmental protection and clean-up actions.



GORAN TOMASEVIC - REUTERS

Palls of black smoke from raging oil fires billow over Baghdad

Step 2. Relieve environmental threats to human health and wellbeing

- Restore water supply and sanitation systems, including the provision of basic chemicals and other maintenance supplies, and the identification and remediation of major pollution sources.
- Implement immediate action to collect and safely dispose of solid waste, including hazardous waste from targeted sites, to reduce the risk of disease epidemics from accumulated municipal and medical waste.
- Conduct other clean-up measures to avoid, minimize or mitigate further risks to the population.
- Provide guidelines to military personnel, civilian administrators, and to the general public, on precautions to minimize the risk of accidental exposure to chemicals, other pollutants and depleted uranium at potentially contaminated locations.

Step 3. Integrate environmental protection into the wider post-conflict reconstruction process

- Apply international environmental ‘good practice’, including Environmental Impact Assessment, internalization of pollution costs, and the preferential use of ‘clean’ technologies to all major reconstruction projects and programmes, with particular attention to development of the oil industry.
- Maximize the exchange of information between key stakeholders to ensure that accidental further risks to human health and/or damage to the environment are avoided.
- Establish a register of contaminated sites, to be used by the authorities in charge of future planning and land use, to minimize the environmental and health risks that could arise from uninformed disturbance of such sites.



People collecting water in Basra

Step 4. Create the knowledge base for addressing the chronic environmental problems confronting Iraq

- Assemble appropriate national and international expertise.
- Address the issue of hazardous waste and emissions by identifying major sources, including military, industrial, nuclear and medical facilities, whether or not these were directly targeted.
- Identify measures needed for environmentally sustainable water resource management within Iraq, in the context of wider river basin management.
- Give high priority to preparing rehabilitation of degraded ecosystems, especially the Mesopotamian Marshes, through regional cooperation and international assistance, and create an effective biodiversity conservation infrastructure, including a strong protected areas network.
- When addressing the issue of depleted uranium, working in cooperation with IAEA and WHO, gather information from the 1991 Gulf War to complete the picture of DU use in the region.



NIK WHEELER

Steps towards possible rehabilitation of the Mesopotamian Marshes are needed

Step 5. Action to build strong national institutions and capacities for long-term sustainable management of the environment

- Ensure from the beginning that environment – because of its significance for human health and sustainable post-conflict economic development – is treated as a priority issue in the development of new governance and institutional structures.
- Identify existing environmental expertise within Iraq.
- Work with national and international experts to define the institutional, legislative, capacity building and resource needs for effective and sustainable environmental management.
- Promote and support Iraqi accession to key Multilateral Environmental Agreements and participation in regional environmental agreements and processes.



CAREN FIROUZ - REUTERS

Environmental protection will be a key ingredient of sustainable development in post-conflict Iraq

A

Appendix A

References and Internet sources

2 Background information

1. <http://www.unicef.org/media/publications/iraqsitan2002nationalcon.txt>
2. <http://lcweb2.loc.gov/frd/cs/iqtoc.html>
3. http://www.iq.undp.org/key_data.htm
4. <http://www.arab.de/arabinfo/iraq.htm>
5. <http://www.fao.org/ag/agl/aglw/aquastat/countries/iraq/index.stm>
6. <http://www.globalsecurity.org/military/world/iraq/city.htm>
7. <http://www.globalsecurity.org/military/world/iraq/city.htm>
8. <http://www.undp.org/rbas/ahdr/english.html>
9. http://www.care.ca/press/pr/iraq/030131_e.shtm
10. http://europa.eu.int/comm/echo/field/iraq/hum_needs_en.htm
11. <http://www.unicef.org/emerg/Country/Iraq/030114.pdf>
12. <http://www.iq.undp.org/PDF/REPORT.PDF>
13. http://www.care.ca/press/pr/iraq/030131_e.shtm
14. <http://ods-dds-ny.un.org/doc/UNDOC/GEN/N02/681/19/PDF/N0268119.pdf?OpenElement>
15. http://europa.eu.int/comm/echo/field/iraq/hum_needs_en.htm
16. <http://www.unicef.org/emerg/Country/Iraq/030114.pdf>
17. <http://www.unicef.org/emerg/Country/Iraq/030114.pdf>
18. <http://www.iq.undp.org/PDF/REPORT.PDF>
19. http://www.care.ca/press/pr/iraq/030131_e.shtm
20. <http://www.iq.undp.org/PDF/REPORT.PDF>
21. http://www.iq.undp.org/key_data.htm
22. http://www.care.ca/press/pr/iraq/030131_e.shtm
23. http://europa.eu.int/comm/echo/field/iraq/hum_needs_en.htm
24. <http://www.refugees.org/world/countryrpt/mideast/iraq.htm>
25. <http://www.refugees.org/world/countryrpt/mideast/iraq.htm>
26. <http://www.refugees.org/world/countryrpt/mideast/iraq.htm>
27. <http://www.eia.doe.gov/emeu/cabs/iraq.html>
28. http://www.care.ca/press/pr/iraq/030131_e.shtm

29. <http://www.eia.doe.gov/emeu/cabs/iraq.html>
30. http://www.rice.edu/projects/baker/Pubs/workingpapers/iraq/iraq_12.html
31. http://www.rice.edu/projects/baker/Pubs/workingpapers/iraq/iraq_12.html
32. <http://www.eia.doe.gov/emeu/cabs/iraq.html>
33. <http://www.eia.doe.gov/emeu/cabs/iraq.html>
34. <http://www.eia.doe.gov/emeu/cabs/iraq.html>
35. <http://www.fao.org/News/2000/000904-e.htm>
36. <http://www.fao.org/ag/agl/aglw/aquastat/countries/iraq/index.stm>
37. UNEP. 1991. A Rapid Assessment of the Impacts of the Iraq-Kuwait Conflict on Terrestrial Ecosystems.
38. <http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPS/Pgrfa/pdf/iraq.pdf>
39. Chronology based on http://news.bbc.co.uk/1/low/world/middle_east/737483.stm

3 Summary of key environmental issues

1. <http://www.fao.org/ag/agl/aglw/aquastat/countries/iraq/index.stm>
2. <http://www.fao.org/ag/agl/aglw/aquastat/countries/iraq/index.stm>
3. http://www.suite101.com/article.cfm/middle_east/21610
4. UNEP 2001. Partow, H. *The Mesopotamian Marshlands: Demise of an Ecosystem*. Division of Early Warning and Assessment, United Nations Environment Programme. Nairobi, Kenya.
5. UNEP 2001. Partow, H. *The Mesopotamian Marshlands: Demise of an Ecosystem*. Division of Early Warning and Assessment, United Nations Environment Programme. Nairobi, Kenya.
6. <http://www.wetlands.org/inventory&/MiddleEastDir/IRAQ1.htm>
7. <http://www.wetlands.org/inventory&/MiddleEastDir/IRAQ1.htm>
8. UNEP 2001. Partow, H. *The Mesopotamian Marshlands: Demise of an Ecosystem*. Division of Early Warning and Assessment, United Nations Environment Programme. Nairobi, Kenya.
9. <http://www.fao.org/ag/agl/aglw/aquastat/countries/iraq/index.stm>
10. <http://www.fao.org/ag/agl/aglw/aquastat/countries/turkey/index.stm>
11. <http://www.fao.org/ag/agl/aglw/aquastat/countries/iraq/index.stm>
12. Based on material contained in UNEP 2001. Partow, H. *The Mesopotamian Marshlands: Demise of an Ecosystem*. Division of Early Warning and Assessment, United Nations Environment Programme. Nairobi, Kenya.
13. Whitley, A and Gallagher, K (1995) Karun River Politics: Iran's Multi-Billion Dollar Hydroelectric Plans Lay in the Hands of Foreign Policy-Makers" in the Middle East Insight, Vol. XI, No. 5, pp. 33-35

14. *Tehran Times* 31; October 1999, 19 April 2001
<http://www.tehrantimes.com>
15. Pearce, F. (1993) "Draining Life from Iraq's marshes" in *New Scientist*, No. 1869, pp.11-12.
Pearce, F. (2001). "Iraqi wetlands face total destruction" in *New Scientist*, 2291, pp. 4-5.
Beaumont, P. (1998). "Restructuring of Water Usage in the Tigris-Euphrates Basin: The Impact of Modern Water Management Projects" in *Transformation of Middle Eastern Natural Environments: Legacies and Lessons*, edited by Jane Coppock and Joseph A. Miller. Yale University, New Haven.
16. http://www.care.ca/press/pr/iraq/030131_e.shtm
17. <http://www.unicef.org/emerg/Country/Iraq/030114.pdf>
18. <http://www.fao.org/ag/agl/aglw/aquastat/countries/iraq/index.stm>
19. <http://www.islamonline.net/english/science/2002/10/article04.shtml>
20. <http://www.fao.org/ag/agl/aglw/aquastat/countries/iraq/index.stm>
21. <http://www.fao.org/ag/agl/aglw/aquastat/countries/iraq/index.stm>
22. <http://www.fao.org/ag/agl/aglw/aquastat/countries/iraq/index.stm>
23. <http://www.fao.org/ag/agl/aglw/aquastat/countries/iraq/index.stm>
24. <http://www.grida.no/geo2000/english/0113.htm>
25. http://waste.eionet.eu.int/Publications/articles/Signals_2002
26. UN/UNICEF document: *Joint Government of Iraq (GOI) - UNICEF Programme Review 1990-2000, Water & Environmental Sanitation (WES) Sector Review Report*.
27. <http://www.iacenter.org/reportun.htm>
28. <http://www.casi.org.uk/discuss/1999/msg00264.html>
29. <http://www.grida.no/geo2000/english/0113.htm>
30. <http://www.iacenter.org/pollutn.htm>
31. <http://www.islamonline.net/english/science/2002/10/article04.shtml>
32. UNEP 2001. Partow, H. *The Mesopotamian Marshlands: Demise of an Ecosystem*. Division of Early Warning and Assessment, United Nations Environment Programme. Nairobi, Kenya.
33. AMAR (ICF) 2001; Iraqi Marshlands: Prospects (Draft Report)
UNHCR 1996; Background Paper on Iraqi Refugees and Asylum seekers
34. <http://grid.unep.ch/activities/sustainable/tigris/marshlands/index.php>
35. <http://www.unccd.int/convention/text/leaflet.php>
36. [http://lnweb18.worldbank.org/ESSD/essdext.nsf/41ByDocName/MiddleEastandNorthAfricaEnvironmentStrategy306KBPDF/\\$FILE/MNAEnvStrategy2001.pdf](http://lnweb18.worldbank.org/ESSD/essdext.nsf/41ByDocName/MiddleEastandNorthAfricaEnvironmentStrategy306KBPDF/$FILE/MNAEnvStrategy2001.pdf)
37. <http://www.fao.org/DOCREP/004/X2596E/X2596E00.HTM> - P232_6505
38. http://www.iq.undp.org/current_settings.htm

39. http://www.birdlife.net/news/sandgrouse93_part1.pdf
40. Moore, P.D. 1998. Desert ecology: Life in the upper crust. *Nature* 393: 419-420.
41. <http://www.earlham.edu/~biol/desert/crust.htm>
42. UNEP. 2001. An Assessment of the Status of the World's Remaining Closed Forests. UNEP Division of Early Warning and Assessment (DEWA), United Nations Environment Programme. Nairobi, Kenya
43. H. Partow. 2003. *Shatt al-Arab: Palm Forest Destruction*. In Atlas of Global Change. United Nations Environment Programme.
44. <http://www.unep-wcmc.org/cgi-bin/padb.p>
45. http://www.birdlife.net/news/iraq_iba_chapter.pdf
46. UNEP. 1991. A Rapid Assessment of the Impacts of the Iraq-Kuwait Conflict on Terrestrial Ecosystems.
47. <http://www.redlist.org/>
48. UNEP. 1991. A Rapid Assessment of the Impacts of the Iraq-Kuwait Conflict on Terrestrial Ecosystems.
49. <http://www.redlist.org/>
50. <http://www.birdlife.org/species/index.cfm?GeoRecID=102>
51. <http://www.wetlands.org/inventory&/MiddleEastDir/IRAQ1.htm>
52. UNEP. 1991. A Rapid Assessment of the Impacts of the Iraq-Kuwait Conflict on Terrestrial Ecosystems.
53. <http://www.wetlands.org/inventory&/MiddleEastDir/IRAQ1.htm>
54. http://pdf.wri.org/watersheds_europe_p2_62.pdf
55. <http://www.un.org/esa/agenda21/natlinfo/wssd/iraq.pdf>
56. <http://www.un.org/esa/agenda21/natlinfo/wssd/iraq.pdf>
57. "Combating Desertification in Iraq" *Desertification Control Bulletin* No. 33, 1998.
58. <http://www.fao.org/waicent/faoinfo/agricult/agl/aglw/aquastat/countries/iraq/index.stm>
59. <http://www.aaru.edu.jo/iraq.html>
60. <http://hometown.aol.com/mosuluniversity/>
61. <http://www.shared.de/iac/shared/asp/StrInstitutionSelected.asp?InstNummer=5011&InstCountry=125&all=1>
62. <http://www.wisard.org/cg2002/ICARDA/3.1.htm>
63. <http://www.shared.de/iac/shared/asp/generalinfoserver/intermediate.asp?InstitutionID=5001>
64. <http://www.infosamak.org/english/iraq.html>
65. <http://www.unep.ch/seas>

4 Environmental impacts of military conflicts

1. SIPRI. 1998. Stockholm International Peace Research Institute (SIPRI). Fact sheet on Iraq: the UNSCOM experience. <http://editors.sipri.se/pubs/Factsheet/unscom.html>
2. <http://www.encyclopedia.com/>
3. <http://ods-dds-ny.un.org/doc/RESOLUTION/GEN/NR0/524/70/IMG/NR052470.pdf?OpenElement>
4. Encyclopedia of the Orient.
5. Greenpeace. 1991. Modern Warfare and the Environment – A Case Study of the Gulf War.
6. <http://www.opcw.org/html/global/search.html>
7. <http://www.fas.org/nuke/guide/iraq/cw/program.htm>
8. Dwyer, A., Eldridge, J., Kernan, M. 2002 Jane's Chem-Bio Handbook, 2nd edition. Jane's Information Group.
9. OPCW 1997b. Investigations Of Alleged Use Of Chemical Weapons.
10. <http://www.fas.org/news/iraq/1998/02/13/whitepap.htm>
11. Staub. 1999. Arms Control and Disarmament Cluster. Implementation of Multilateral Arms Control Agreements: Questions of Compliance. Chemical Weapons. Heiner Staub. AC-Laboratorium Spiez, Switzerland. <http://www.gcsp.ch/e/research/ACCluster/Papers99-2000/Staub.htm>
12. SIPRI. 1998. Stockholm International Peace Research Institute (SIPRI). Fact sheet on Iraq: the UNSCOM experience. <http://editors.sipri.se/pubs/Factsheet/unscom.html>
13. United Nations. 1969. Chemical and bacteriological (biological) weapons and the effects of their possible use. Report of the Secretary-General, New York. United Nations Publication, No: E69.I.24.
14. <http://www.encyclopedia.com>
15. <http://www.un.org/Docs/scres/1990/scres90.htm>
16. <http://www.un.org/Docs/scres/1991/scres90.htm>
17. http://www.fas.org/news/un/iraq/s/971203_sites.htm
18. Greenpeace. 1991. Modern Warfare and the Environment – A case study of the Gulf War.
19. UN Security Council document S/1997/779
20. <http://www.iaea.org/worldatom/Programmes/ActionTeam/nwp2.html>
21. http://www.fas.org/news/un/iraq/s/971203_sites.htm
22. DOD intelligence report – Desert Storm Iraq's Chemical and Biological Warfare Facilities. 28 January 1991.
23. http://www.fas.org/news/un/iraq/s/971203_sites.htm
24. DOD intelligence report – Nuclear, Missile, Chemical and Biological Warfare Capabilities of Iraq, Before, During and After Desert Storm. Undated.
25. DOD intelligence report – Desert Storm Iraq's Chemical and Biological Warfare Facilities. 28 January 1991.

26. <http://www.un.org/Depts/unscom/sres97-774.htm>
27. http://www.gulflink.osd.mil/khamisiyah_ii/khamisiyah_ii_s07.htm#IV.%20ANALYSIS
28. DOD intelligence report. Collateral Risk Due to Allied Air Strikes on Iraqi Biological Warfare Facilities. Undated.
29. DOD intelligence report. Collateral Risk Due to Allied Air Strikes on Iraqi Biological Warfare Facilities. Undated.
30. Greenpeace. 1991. Modern Warfare and the Environment – A case study of the Gulf War.
31. <http://www.cnn.com/2002/US/11/11/hln.terror.hussein.scuds/>
32. <http://www.wsws.org/articles/2003/feb2003/cbc-f07.shtml>
33. Greenpeace. 1991. Modern Warfare and the Environment – A case study of the Gulf War.
34. Letter dated 26 October 1996 from the Permanent Representative of Iraq to the United Nations addressed to the Secretary General – Environment and Sustainable Development – The Environment in Iraq Following the Aggression.
35. Letter dated 26 October 1996 from the Permanent Representative of Iraq to the United Nations addressed to the Secretary General – Environment and Sustainable Development – The Environment in Iraq Following the Aggression.
36. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years after the Gulf War.
37. Greenpeace. 1991. Modern Warfare and the Environment – A case study of the Gulf War.
38. UNEP. 1991. A Rapid Assessment of the Impacts of the Iraq-Kuwait Conflict on Terrestrial Ecosystems.
39. Greenpeace. 1991. Modern Warfare and the Environment – A case study of the Gulf War.
40. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
41. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
42. Greenpeace. 1991. Modern Warfare and the Environment – A case study of the Gulf War.
43. Greenpeace. 1991. Modern Warfare and the Environment – A case study of the Gulf War.
44. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
45. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years after the Gulf War.
46. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years after the Gulf War.
47. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years after the Gulf War.
48. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years after the Gulf War.
49. UNEP. 1993. Updated scientific report on the environmental effects of the conflict between Iraq and Kuwait.
50. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years after the Gulf War.

A

51. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
52. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years after the Gulf War.
53. Greenpeace. 1991. Modern Warfare and the Environment – A case study of the Gulf War.
54. UNEP. 1991. Environmental Consequences of the Armed Conflict Between Iraq and Kuwait.
55. Greenpeace. 1991. Modern Warfare and the Environment – A case study of the Gulf War.
56. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years after the Gulf War.
57. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
58. UNEP. 1993. Updated scientific report on the environmental effects of the conflict between Iraq and Kuwait.
59. UNEP. 1991. Environmental Consequences of the Armed Conflict Between Iraq and Kuwait.
60. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years After the Gulf War.
61. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years After the Gulf War.
62. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years After the Gulf War.
63. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
64. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
65. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
66. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years After the Gulf War.
67. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
68. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
69. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years After the Gulf War.
70. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years After the Gulf War.
71. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
72. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years After the Gulf War.
73. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
74. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
75. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.

76. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
77. http://www.birdlife.net/news/pritem_display.cfm?NewRecID=789&NewType=p
78. http://postconflict.unep.ch/publications/du_final_report.pdf
79. <http://www.islam-online.net/english/Science/2002/03/article1.shtml>
80. <http://www.reliefweb.int/w/rwb.nsf/s/173D4094241F7592C1256AB1005B3B30>
81. Bourabee, F. 1995. "Estimating the concentration of uranium in some environmental samples in Kuwait after the 1991 Gulf War. Applied Radiation and Isotopes. Vol. 46, N4 (apr), p. 217-220.
82. http://www.iaea.or.at/worldatom/Documents/Anrep/Anrep2001/human_health.pdf
83. Greenpeace. 1991. Modern Warfare and the Environment – A Case Study of the Gulf War.
84. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years after the Gulf War.
85. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years After the Gulf War.
86. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years After the Gulf War.
87. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
88. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years After the Gulf War.
89. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
90. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years After the Gulf War.
91. Greenpeace. 1991. Modern Warfare and the Environment – A case study of the Gulf War.
92. Letter dated 26 October 1996 from the Permanent Representative of Iraq to the United Nations addressed to the Secretary General – Environment and Sustainable Development – The Environment in Iraq Following the Aggression.
93. UNEP. 1993. Updated Scientific Report on the Environmental Effects of the Conflict Between Iraq and Kuwait.
94. GCI. 1998. An Environmental Assessment of Kuwait, Seven Years After the Gulf War.
95. <http://www.af.mil/news/opscenter/index.shtml>
96. <http://www.defenselink.mil/transcripts/2003/tr20030412-0092.html>
97. <http://news.bbc.co.uk/2/hi/2912253.stm>
98. <http://www.icrc.org/Web/eng/siteeng0.nsf/iwpList550/C4F4D01059E327CFC1256D04004E2E42>
99. <http://www.icrc.org/Web/eng/siteeng0.nsf/iwpList4/A98A153313D6530CC1256D0B00422DF8>
100. http://news.bbc.co.uk/2/hi/middle_east/2915091.stm
101. <http://www.icrc.org/Web/eng/siteeng0.nsf/iwpList4/A98A153313D6530CC1256D0B00422DF8>

A

102. <http://www.washingtonpost.com/wp-dyn/articles/A15118-2003Apr2.html>
103. <http://www.centcom.mil/CENTCOMNews/Transcripts/20030415.htm>
104. http://www.defenselink.mil/news/Mar2003/t03312003_t0331asd.html
105. http://www.defenselink.mil/news/Apr2003/t04012003_t0401sd.html
106. <http://www.guardian.co.uk/international/story/0,3604,934486,00.html>
107. http://www.iaea.org/worldatom/Press/P_release/2003/prn0304.shtml
108. http://www.iaea.org/worldatom/Press/P_release/2003/prn0304.shtml
109. For background information on UNEP's work on depleted uranium, see <http://postconflict.unep.ch/activities.htm> - du
110. <http://www.centcom.mil/CENTCOMNews/Transcripts/20030326.htm>
111. http://www.deploymentlink.osd.mil/du_library/gulfwar.shtml
112. <http://postconflict.unep.ch/publications.htm> - du
113. <http://www.un.org/apps/sg/offthecuff.asp?nid=413>
114. <http://news.bbc.co.uk/2/hi/americas/2957905.stm>
115. <http://www.abc.net.au/news/newsitems/s834018.htm>

Further information

Copies of this report may be ordered from:

SMI (Distribution Services) Limited

P.O. Box 119

Stevenage

Hertfordshire SG1 4TP, UK

Tel: +44 1438 748111

Fax: +44 1438 748 844

UNEP also has an online bookstore at: <http://www.earthprint.com>

Further technical information may be obtained from the UNEP Post-Conflict Assessment Unit website at: <http://postconflict.unep.ch>

An aerial photograph of a city, likely Baghdad, Iraq, showing a river (the Tigris) winding through the urban landscape. Dark smoke plumes are visible rising from various points across the city, suggesting environmental damage or conflict. The city's grid-like street pattern is clearly visible.

www.unep.org

United Nations Environment Programme
P.O. Box 30552 Nairobi, Kenya
Tel: ++254-(0)20-62 1234
Fax: ++254-(0)20-62 3927
Email: cpinfo@unep.org



This UNEP Desk Study provides rapidly assembled information concerning the environment in Iraq. Based on this initial overview, UNEP believes that more thorough assessments should be carried out at field level, and that action to address environmental concerns should be an integral part of post-conflict clean-up and reconstruction efforts.

However, it is already possible to single-out specific environmental concerns in Iraq - particularly those aspects with a direct humanitarian link, such as water and power supplies, sanitation, and possible pollution from war-damaged sites.

Because of the close links between environmental degradation and human suffering, the United Nations Environment Programme's work on Iraq is part of the overall 'UN Humanitarian Flash Appeal for Iraq', launched in March 2003.