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REPORT AND RECOMMENDATIONS MADE BY THE PANEL OF COMMISSIONERS CONCERNING THE THIRD INSTALMENT OF "F4" CLAIMS

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Introduction

1. The Governing Council of the United Nations Compensation Commission (the "Commission"), at its thirtieth session held from 14 to 16 December 1998, appointed the "F4" Panel of Commissioners (the "Panel"), composed of Messrs. Thomas A. Mensah (Chairman), José R. Allen and Peter H. Sand to review claims for direct environmental damage and depletion of natural resources resulting from Iraq's invasion and occupation of Kuwait. This is the third report of the Panel. It contains the recommendations of the Panel to the Governing Council on the third instalment of "F4" claims (the "third 'F4' instalment"), submitted pursuant to article 38(e) of the Provisional Rules for Claims Procedure (the "Rules") (S/AC.26/1992/10).

2. The third "F4" instalment consists of three claims by the Government of the State of Kuwait ("Kuwait") and two claims by the Government of the Kingdom of Saudi Arabia ("Saudi Arabia") (collectively the "Claimants"). The three claims of Kuwait are claim Nos. 5000452, 5000256 and 5000450. The two claims of Saudi Arabia are claim Nos. 5000451 and 5000360. The claims were submitted to the Panel in accordance with article 32 of the Rules on 20 March 2002.

3. By Procedural Order No. 5 dated 28 March 2003, the Panel deferred a portion of claim No. 5000451 of Saudi Arabia to the fourth instalment of category "F4" claims ("the fourth 'F4' instalment"). By Procedural Order No. 6 dated 9 July 2003, the Panel deferred portions of claim No. 5000450 of Kuwait to the fourth "F4" instalment. The total compensation sought in the claims reviewed in this report is 10,004,219,582 United States dollars (USD).

4. The claims reviewed in this report are summarized in table 1. The "amount claimed" column shows the compensation sought by the Claimants (with amendments, where applicable) expressed in United States dollars and corrected, where necessary, for computational errors.

Table 1. Summary of third "F4" instalment claims

Country	Claim No.	Amount claimed (USD)
Kuwait	5000256	185,167,546
	5000450	5,050,105,158
	5000452	52,471
Saudi Arabia	5000451	4,748,292,230
	5000360	20,602,177
Total		10,004,219,582

I. OVERVIEW OF THE THIRD "F4" INSTALMENT

5. The claims in the third "F4" instalment are for expenses resulting from measures already taken or to be undertaken in the future to clean and restore environment alleged to have been damaged as a direct result of Iraq's invasion and occupation of Kuwait.

6. The Claimants seek compensation for expenses resulting from cleaning and restoration measures undertaken or to be undertaken by them to remediate damage from:

(a) Oil released from damaged oil wells in Kuwait;

(b) Pollutants released from oil well fires and firefighting activities in Kuwait;

(c) Oil spills into the Persian Gulf from pipelines, offshore terminals and tankers;

(d) Laying and clearance of mines;

(e) Movements of military vehicles and personnel; and

(f) Construction of military fortifications.

II. PROCEDURAL HISTORY

A. Article 16 reports

7. Significant factual and legal issues raised by the claims in the third "F4" instalment were included in the Executive Secretary's twenty-ninth report, dated 28 October 1999; the thirty-first report, dated 28 April 2000; and the thirty-seventh report, dated 18 October 2001, issued pursuant to article 16 of the Rules. These reports were circulated to the members of the Governing Council, to Governments that have filed claims with the Commission and to the Government of the Republic of Iraq ("Iraq"). In accordance with article 16(3) of the Rules, a number of Governments, including Iraq, submitted information and views in response to these reports.

B. Article 34 notifications

8. Pursuant to article 34 of the Rules notifications were sent to Kuwait and Saudi Arabia requesting additional information and documentation to assist the Panel in its review of the claims in the third "F4" instalment.

C. Classification of claims and transmittal of claim files

9. On 30 July 2001, the Panel issued Procedural Order No. 1, classifying the claims in the third "F4" instalment as "unusually large or complex", within the meaning of article 38(d) of the Rules. Procedural Order No. 1 directed the secretariat to send to Iraq copies of the claim files, comprising the claim form, the statement of claim and associated exhibits, for each of the claims in the third "F4"

instalment. The secretariat transmitted copies of the claim files to Iraq. The secretariat also transmitted copies of Procedural Order No. 1 to Iraq and the Claimants.

10. On 28 January 2002, the Panel issued Procedural Order No. 2, directing the secretariat to send to Iraq copies of the claim file for claim No. 5000452. This claim had been transferred by the Executive Secretary to the "F4" category of claims from the "F3" category and was allocated to the third "F4" instalment on 5 December 2001. The secretariat transmitted a copy of the claim file to Iraq. The secretariat also transmitted copies of Procedural Order No. 2 to Iraq and Kuwait.

11. The Commission received written comments from Iraq on the claims on 1 October 2002, 21 February 2003, 25 February 2003 and 7 April 2003.

D. Monitoring and assessment data

12. On 13 September 2002, the Panel decided that monitoring and assessment data should be made available to Iraq.[1] This decision was intended to further one of the objectives of Governing Council decision 124, namely "assisting the 'F4' Panel of Commissioners in the conduct of its tasks, through ensuring the full development of the facts and relevant technical issues, and in obtaining the full range of views including those of Iraq" (S/AC.26/Dec.124 (2001), annex, para. 2).

13. On 13 September 2002, the Panel issued Procedural Order No. 3, by which it requested the Claimants to identify previously submitted monitoring and assessment data and to provide any other monitoring and assessment data that they considered to be relevant to their claims in the third "F4" instalment.

14. In accordance with the decision of the Panel, the monitoring and assessment data referred to in paragraph 13 were transmitted to Iraq.

E. Oral proceedings

15. On 24 January 2003, the Panel issued Procedural Order No. 4 by which it informed the Claimants and Iraq that oral proceedings on the third "F4" instalment would be held on 25 and 26 March 2003. The procedural order listed the issues to be considered at the oral proceedings as follows:

(a) On what basis should the Panel determine whether and to what extent environmental damage resulted from causes other than the effects of Iraq's invasion and occupation of Kuwait?

(b) What should be the appropriate objectives of remediation measures?

(c) What standards should be applied in determining remediation goals in particular circumstances?

(d) To what extent will remediation goals and standards be affected where there is evidence that the environment was not in "pristine condition" prior to Iraq's invasion and occupation of Kuwait?

16. Procedural Order No. 4 invited the Claimants and Iraq to identify any other legal, factual or scientific issues that they wished to address at the oral proceedings. After considering the responses received from the Claimants and Iraq, the Panel decided that the following additional issues would be addressed at the oral proceedings:

(a) How appropriate is high temperature thermal desorption as a method for remediation of the types of damage for which it is proposed to be used in the "F4" third instalment of claims?

(b) To what extent is damage resulting from remediation measures compensable?

17. Oral proceedings were held at the Palais des Nations in Geneva on 25 and 26 March 2003. Representatives and experts of Iraq and the Claimants attended the oral proceedings and presented their views.

III. LEGAL FRAMEWORK

A. Mandate of the Panel

18. The mandate of the Panel is to review the "F4" claims and, where appropriate, recommend compensation.

19. In discharging its mandate, the Panel has borne in mind the observations of the Secretary-General of the United Nations, in his report to the Security Council of 2 May 1991, that:

> "The Commission is not a court or an arbitral tribunal before which the parties appear; it is a political organ that performs an essentially fact-finding function of examining claims, verifying their validity, evaluating losses, assessing payments and resolving disputed claims. It is only in this last respect that a quasi-judicial function may be involved. Given the nature of the Commission, it is all the more important that some element of due process be built into the procedure. It will be the function of the commissioners to provide this element."[2]

B. Applicable law

20. Article 31 of the Rules sets out the applicable law for the review of claims, as follows:

> "In considering the claims, Commissioners will apply Security Council resolution 687 (1991) and other relevant Security Council resolutions, the criteria established by the Governing Council for particular categories of claims, and any pertinent decisions of the Governing Council. In addition, where necessary, Commissioners shall apply other relevant rules of international law."

21. Paragraph 16 of Security Council resolution 687 (1991) reaffirms that Iraq is "liable under international law for any direct loss, damage, including environmental damage and the depletion of

natural resources, or injury to foreign Governments, nationals and corporations, as a result of Iraq's unlawful invasion and occupation of Kuwait".

C. Compensable losses or expenses

22. Governing Council decision 7 (S/AC.26/1991/7/Rev. 1) provides guidance regarding the losses or expenses that may be considered as "direct loss, damage, or injury" resulting from Iraq's invasion and occupation of Kuwait, in accordance with paragraph 16 of Security Council resolution 687 (1991).

23. Paragraph 34 of Governing Council decision 7 provides that "direct loss, damage, or injury" includes any loss suffered as a result of:

(a) Military operations or threat of military action by either side during the period 2 August 1990 to 2 March 1991;

(b) Departure of persons from or their inability to leave Iraq or Kuwait (or a decision not to return) during that period;

(c) Actions by officials, employees or agents of the Government of Iraq or its controlled entities during that period in connection with the invasion or occupation;

(d) The breakdown of civil order in Kuwait or Iraq during that period; or

(e) Hostage-taking or other illegal detention.

24. Paragraph 35 of Governing Council decision 7 provides that "direct environmental damage and the depletion of natural resources" includes losses or expenses resulting from:

(a) Abatement and prevention of environmental damage, including expenses directly relating to fighting oil fires and stemming the flow of oil in coastal and international waters;

(b) Reasonable measures already taken to clean and restore the environment or future measures which can be documented as reasonably necessary to clean and restore the environment;

(c) Reasonable monitoring and assessment of the environmental damage for the purposes of evaluating and abating the harm and restoring the environment;

(d) Reasonable monitoring of public health and performing medical screenings for the purposes of investigation and combating increased health risks as a result of the environmental damage; and

(e) Depletion of or damage to natural resources.

25. As the Panel observed in its report on the second instalment of "F4" claims (the "second 'F4' report"), paragraph 35 of Governing Council decision 7 does not purport to give an exhaustive list of the activities and events that can give rise to compensable losses or expenses; rather it should be

considered as providing guidance regarding the types of activities and events that can result in compensable losses or expenses.[3]

D. Evidentiary requirements

26. Article 35(1) of the Rules provides that "[e]ach claimant is responsible for submitting documents and other evidence which demonstrate satisfactorily that a particular claim or group of claims is eligible for compensation pursuant to Security Council resolution 687 (1991)". Article 35(1) also provides that it is for each panel to determine "the admissibility, relevance, materiality and weight of any documents and other evidence submitted".

27. Article 35(3) of the Rules provides that category "F" claims "must be supported by documentary and other appropriate evidence sufficient to demonstrate the circumstances and amount of the claimed loss". In addition, Governing Council decision 46 (S/AC.26/Dec.46 (1998)) states that, for category "F" claims, "no loss shall be compensated by the Commission solely on the basis of an explanatory statement provided by the claimant".

28. When recommending compensation for environmental damage or loss that has been found to be a direct result of Iraq's invasion and occupation of Kuwait, the Panel has in every case assured itself that the applicable evidentiary requirements regarding the circumstances and amount of the damage or loss claimed have been satisfied.

E. Legal issues

29. In reviewing the claims in the third "F4" instalment, the Panel considered a number of legal issues relating to the claims. Some of these issues were raised by Iraq in its written responses or in submissions during the oral proceedings and were commented upon by the Claimants during the oral proceedings.

1. Amendment of claims based on results of monitoring and assessment activities

30. The Claimants have submitted amendments to some of the claims based on results of monitoring and assessment activities. In some cases, these amendments increase the amount of compensation claimed, while others decrease the claimed amounts.

31. Iraq has questioned these amendments. It contends that the amendments and the data on which they are based should not be accepted by the Panel because they were submitted after the expiry of the applicable time limits.

32. In its report on the first instalment of "F4" claims (the "first 'F4' report"), the Panel anticipated that the results of some monitoring and assessment activities would assist its review of related substantive claims.[4] The Panel recalled that "the Governing Council's decision to authorize expedited review of monitoring and assessment claims was, in large part, intended to make funds available to claimants to finance activities that might produce information to support their substantive 'F4' claims".[5] In the view of the Panel, the possibility that the amounts claimed might increase or decrease

in the light of data and information obtained from monitoring and assessment activities is implicit in the decision of the Governing Council to authorize separate funding for monitoring and assessment activities prior to the review of related substantive claims. The Panel, therefore, finds that it is appropriate to receive and consider amendments to the amounts claimed, provided that such amendments are based on information and data obtained from monitoring and assessment activities.

2. Threshold for compensable damage

33. Security Council resolution 687 (1991) provides that Iraq is "liable under international law for any direct loss, damage, including environmental damage and the depletion of natural resources … as a result of Iraq's unlawful invasion and occupation of Kuwait". According to Iraq, this means that the Panel must have regard to the applicable rules of international law in determining whether any environmental damage or loss alleged to have resulted from "Iraq's invasion and occupation of Kuwait" qualifies for compensation in accordance with Security Council resolution 687 (1991). Specifically, Iraq argues that damage resulting from the invasion and occupation of Kuwait is not compensable unless it reaches the "threshold" that is generally accepted in international law for compensation in cases of state responsibility for transboundary environmental damage. According to Iraq, the applicable threshold is that the damage must be at least "significant", and no compensation should be awarded for damage that is below this threshold.

34. As noted in paragraph 20, the primary sources of the law to be applied by the Panel in the review of claims for compensation are listed in article 31 of the Rules. These are "Security Council resolution 687 (1991) and other relevant Security Council resolutions, the criteria established by the Governing Council for particular categories of claims, and any pertinent decisions of the Governing Council". "[O]ther relevant rules of international law" are to be applied "where necessary". In the view of the Panel, this means that recourse to "other relevant rules of international law" is necessary where the Security Council resolutions and the decisions of the Governing Council do not provide sufficient guidance for the review of a particular claim.

35. For the claims in the third "F4" instalment, the Panel finds that Security Council resolution 687 (1991) and the relevant decisions of the Governing Council provide sufficient guidance. Resolution 687 states clearly that compensation is payable for "any direct loss, damage … or injury" that resulted from Iraq's invasion and occupation of Kuwait. In addition, paragraph 35 of Governing Council decision 7 states that "direct environmental damage and the depletion of natural resources" include losses or expenses resulting from "reasonable measures already taken to clean and restore the environment or future measures which can be documented as reasonably necessary to clean and restore the environment". In the view of the Panel, the key issues for decision in connection with the claims in the third "F4" instalment are: (a) whether the environmental damage for which compensation is sought resulted directly from Iraq's invasion and occupation of Kuwait; (b) whether measures already taken by a claimant to remediate environmental damage were "reasonable"; and (c) whether measures proposed to be undertaken by a claimant qualify as "future measures which can be documented as reasonably necessary to clean and restore the environment".

36. In considering the reasonableness of remediation measures, it is appropriate to have regard to the extent of the damage involved. However, in the view of the Panel, this is not the only factor to be considered. Other factors, such as the location and nature of the damage and its actual or potential effects on the environment may also be relevant. Thus, for example, where damage that might otherwise be characterized as "insignificant" is caused to an area of special ecological sensitivity, or where the damage, in conjunction with other factors, poses a risk of further or more serious environmental harm, it may not be unreasonable to take remediation measures in order to prevent or minimize potential additional damage.

3. Parallel or concurrent causes of environmental damage

37. Iraq contends that some of the damage for which compensation is sought by the Claimants cannot be attributed solely to "Iraq's invasion and occupation of Kuwait". It alleges that some of the damage resulted from other factors that existed before and after the invasion and occupation of Kuwait. According to Iraq, the environment in the claimant countries was not in "pristine condition" prior to the invasion and occupation. In particular, Iraq refers to exploration for oil, the operation of refineries and petrochemical industries and the large number of oil tankers operating in the Persian Gulf as sources of environmental damage both before and after the invasion and occupation. With respect to Kuwait's claim for damage to its terrestrial resources from military activities, Iraq asserts that any damage still remaining is the result of mismanagement and destructive land use, especially the failure to control livestock grazing and the use of off-road vehicles in sensitive areas of the desert. Iraq maintains, therefore, that "it is impossible to limit the causes of environmental pollution in a particular region to one cause and hold one state liable for that and oblige it to compensate the damages, especially when many factors and states contributed to the pollution".

38. With regard to Iraq's liability for environmental damage where there are parallel or concurrent causes, the Panel recalls that in its second "F4" report it notes that "Iraq is, of course, not liable for damage that was unrelated to its invasion and occupation of Kuwait, nor for losses or expenses that are not a direct result of the invasion and occupation. However, Iraq is not exonerated from liability for loss or damage that resulted directly from the invasion and occupation simply because other factors might have contributed to the loss or damage. Whether or not any environmental damage or loss for which compensation is claimed was a direct result of Iraq's invasion and occupation of Kuwait will depend on the evidence presented in relation to each particular loss or damage".[6]

39. In reviewing each of the claims in the third "F4" instalment, the Panel has considered whether, and if so to what extent, the evidence available indicates that the damage for which compensation is sought was wholly or partly the result of factors unrelated to Iraq's invasion and occupation of Kuwait. It has also considered whether the claimant has aggravated or otherwise contributed to the damage, either by failing to take appropriate steps to mitigate damage or by negligent or other improper action. Where, on the basis of the evidence, the Panel finds that damage resulted from causes wholly unconnected with Iraq's invasion and occupation of Kuwait, no compensation is recommended for such damage or loss. Where the evidence shows that damage resulted directly from Iraq's invasion and occupation of Kuwait but that other factors have contributed to the damage for

which compensation is claimed, due account is taken of the contribution from such other factors in order to determine the level of compensation that is appropriate for the portion of the damage which is directly attributable to Iraq's invasion and occupation of Kuwait.[7]

4. Duty of the claimant to prevent and mitigate environmental damage

40. Iraq also argues that some of the damage for which the Claimants seek compensation has been caused or contributed to by the Claimants themselves, either because they failed to take steps to mitigate damage resulting from the invasion and occupation of Kuwait or because the damage had been aggravated by the acts or omissions of the Claimants after the invasion and occupation. For example, Iraq claims that Saudi Arabia's failure to remove oil from its coastal areas over 12 years after the end of the invasion and occupation constitutes a breach of Saudi Arabia's obligation under international law to mitigate the damage. Iraq claims that Saudi Arabia's failure to act has allowed a sediment layer to form over the oil contamination, thus doubling the quantity of material to be remediated. Iraq also alleges that any damage to Kuwait's groundwater resources must be attributed to the negligence of Kuwait. It claims, first, that Kuwait was negligent in constructing oil recovery pits in areas above its aquifers and, secondly, that Kuwait should have taken action to remove oil recovery pits and oil lakes from above the aquifers as soon as it became aware that they had the potential to contaminate groundwater.

41. According to Iraq, failure by a claimant to take reasonable and timely measures to mitigate damage from the invasion and occupation of Kuwait amounts to contributory negligence and justifies rejection of the claim for compensation or a corresponding reduction in the compensation to be awarded to the claimant. Iraq also contends that action by a claimant that causes additional damage or aggravates damage from the invasion and occupation constitutes an intervening factor that breaks the chain of causation so that the damage involved can no longer be attributed to "Iraq's invasion and occupation of Kuwait".

42. The Panel stresses that each claimant has a duty to mitigate environmental damage to the extent possible and reasonable in the circumstances. Indeed, in the view of the Panel, that duty is a necessary consequence of the common concern for the protection and conservation of the environment, and entails obligations towards the international community and future generations. The duty to mitigate damage encompasses both a positive obligation to take appropriate measures to respond to a situation that poses a clear threat of environmental damage as well as the duty to ensure that any measures taken do not aggravate the damage already caused or increase the risk of future damage. Thus, if a claimant fails to take reasonable action to respond to a situation that poses a clear threat of environmental damage, the failure to act may constitute a breach of the duty to mitigate and could provide justification for denying compensation in whole or in part. By the same token, where a claimant takes measures that are unreasonable, inappropriate or negligent in the circumstances and thereby aggravates the damage or increases the risk of damage, the claimant may be required to bear some responsibility for the portion of the loss or damage that is attributable to its own acts or omissions.

43. In the view of the Panel, whether an act or omission of a claimant constitutes failure to mitigate damage depends on the circumstances of each claim and the evidence available. The test is whether

the claimant acted reasonably, having regard to all the circumstances with which it was confronted. Where a claimant fails to respond to a crisis that presents a clear threat of environmental damage, such inaction should rightly be considered as a breach of the claimant's duty to mitigate damage. On the other hand, a claimant confronted with a situation that poses multiple threats of serious environmental damage may not be able to deal with all the threats at the same time or in the same way. In such a situation, a decision by the claimant to take or not to take measures, based on its judgment of the urgency of the various threats, would not necessarily constitute a violation of the duty to mitigate damage. As previously noted by the Panel, the reasonableness or appropriateness of the measures taken or not taken by a claimant in such a situation must be evaluated by reference to the circumstances in which the decision was taken. For example, in its second "F4" report, the Panel found that the decision taken by the contractors engaged by Kuwait for mine clearance to detonate some unexploded ordnance where it was found, instead of recovering and storing the ordnance in an appropriate facility, was reasonable in the circumstances, given the dangerous conditions present at the time.[8] The Panel also found that the decision of Kuwait "to select contractors from a limited number of specially designated countries was … not unreasonable, particularly in view of the special circumstance in which the decision was taken".[9] The same considerations apply to the decisions of claimants regarding measures to prevent or mitigate environmental damage resulting from Iraq's invasion and occupation of Kuwait.

5. Remediation objectives

44. The Claimants state that the objective of the remediation measures taken or proposed by them is to restore the environment to the condition in which it would have been if Iraq's invasion and occupation of Kuwait had not occurred.

45. While accepting this objective in principle, Iraq argues that, in determining the appropriate objectives of remediation, due account should be taken of the fact that the environment in the claimant countries was not in "pristine condition" prior to the invasion and occupation of Kuwait. According to Iraq, it should not be held responsible for expenses to remediate damage that predated the invasion and occupation of Kuwait. Consequently, Iraq maintains that any compensation awarded for remediation should be limited to the damage that resulted directly from the invasion and occupation. According to Iraq, compensation should not be awarded for measures to restore the environment to a "pristine condition", because that would result in "unjust enrichment" for the Claimants.

46. Iraq further argues that, in any case, remediation is justified only where environmental assessment, risk assessment and analysis of alternatives show that the risks posed by the environmental damage exceed the potential risks posed by the proposed remediation measures. In particular, due consideration should be given to the possibility of natural recovery. Furthermore, Iraq maintains that remediation measures that involve "grossly disproportionate costs" are unreasonable and should be rejected in favour of less expensive measures.

47. With respect to the claims in the third "F4" instalment, the Panel considers that the appropriate objective of remediation is to restore the damaged environment or resource to the condition in which it would have been if Iraq's invasion and occupation of Kuwait had not occurred. In applying this

objective to a particular claim, regard must be had to a number of considerations. These include, inter alia, the location of the damaged environment or resource and its actual or potential uses; the nature and extent of the damage; the possibility of future harm; the feasibility of the proposed remediation measures; and the need to avoid collateral damage during and after the implementation of the proposed measures. In the view of the Panel, such an approach is appropriate even where there is evidence that the environment was not in pristine condition prior to Iraq's invasion and occupation of Kuwait. The contribution of any pre-existing or subsequent causes of damage (where such causes can be identified) should be considered, not in determining the restoration objective to be achieved by remediation, but in determining the proportion of the costs of remediation that can reasonably be attributed to Iraq's invasion and occupation of Kuwait.

48. The Panel considers that, in assessing what measures are "reasonably necessary to clean or restore" damaged environment, primary emphasis must be placed on restoring the environment to pre-invasion conditions, in terms of its overall ecological functioning rather than on the removal of specific contaminants or restoration of the environment to a particular physical condition. For, even if sufficient baseline information were available to determine the exact historical state of the environment prior to Iraq's invasion and occupation of Kuwait, it might not be feasible or reasonable to fully recreate pre-existing physical conditions.

6. Duty to consider transboundary impacts of remediation measures

49. Iraq asserts that, in considering remediation measures proposed by the Claimants, account should be taken of the potential impacts of such measures in third States. According to Iraq, remediation measures with potential transboundary impacts are subject to the requirements of international law relating to notification to the States concerned, and the Claimants have the obligation to consult with such third States, with a view to preventing or minimizing any adverse transboundary impacts.

50. The Panel recognizes the need for claimants to consider the potential adverse impacts of remediation measures that they undertake to respond to environmental damage in their respective territories. In particular, the Panel emphasizes that claimants have the obligation under international law to ensure that the remediation measures that they take do not cause damage to the environment in other States or in areas beyond the limits of national jurisdiction. In the view of the Panel, it is the responsibility and right of each claimant to decide on the measures and procedures that are necessary and appropriate to ensure compliance with its international obligations.

IV. REVIEW OF THE THIRD "F4" INSTALMENT CLAIMS

51. Article 36 of the Rules provides that a panel of Commissioners may "(a) in unusually large or complex cases, request further written submissions and invite individuals, corporations or other entities, Governments or international organizations to present their views in oral proceedings" and "(b) request additional information from any other source, including expert advice, as necessary". Article 38(b) of the Rules provides that a panel of Commissioners "may adopt special procedures

appropriate to the character, amount and subject-matter of the particular types of claims under consideration".

52. In view of the complexity of the issues raised by the claims and the need to consider scientific, engineering and cost issues in evaluating the claims, the Panel sought the assistance of a multi-disciplinary team of independent experts retained by the Commission ("expert consultants"). Expert consultants were retained, inter alia, in the fields of desert ecology, desert botany, terrestrial and marine remediation techniques, marine biology, coastal ecology, coastal geomorphology, geology, hydrogeology, water quality, indoor air quality, health risk assessment, chemistry, water treatment engineering, coastal engineering, civil engineering and ordnance disposal.

53. At the direction of the Panel, the Panel's expert consultants undertook on-site inspections in Kuwait and in Saudi Arabia. The purpose of the inspections was to enable the expert consultants to obtain information that would assist the Panel to:

(a) Assess the nature and extent of environmental damage resulting from Iraq's invasion and occupation of Kuwait;

(b) Evaluate the technical feasibility, reasonableness and cost-effectiveness of the remediation measures proposed by the Claimants; and

(c) Identify possible remediation alternatives.

54. Where necessary, the Panel requested additional information from the Claimants to clarify their claims.

55. In reaching its findings and formulating its recommendations on the claims, the Panel has taken due account of all the information and evidence made available to it, including the evidence and information provided by the Claimants in the claim documents and in response to requests for additional information; the information and views submitted by Governments in response to article 16 reports; the written responses submitted by Iraq; the views presented by Iraq and the Claimants during the oral proceedings; and the reports of the Panel's expert consultants.

56. In order to avoid multiple recovery of compensation, the Panel instructed the secretariat to carry out cross-claim and cross-category checks of the claims. On the basis of these checks, the Panel is satisfied that there is no risk of duplication of awards of compensation.

57. In considering future measures proposed by a claimant to clean and restore the damaged environment, the Panel has evaluated the reasonableness of the measures by reference to, inter alia, the potential of the measures to achieve the remediation objectives set out in paragraphs 47 and 48; potential adverse environmental impacts of the proposed measures; and the cost of the measures as compared with other remediation alternatives. In some cases, the Panel has found that certain modifications to the measures proposed are necessary or desirable to take account of these considerations. Details of such modifications are set out in the relevant technical annexes to this

report. The amounts recommended for the claims are based on the proposed measures as modified. This is consistent with the approach adopted by the Panel in its previous reports.

58. The Panel's analysis of the third "F4" instalment claims is set forth in chapters V and VI of this report.

59. A glossary of scientific and technical terms is appended to this report.

V. CLAIMS OF THE STATE OF KUWAIT

A. Overview

60. In the third "F4" instalment, Kuwait submitted three claims for expenses for measures to remediate environmental damage that it alleges resulted from Iraq's invasion and occupation of Kuwait. Claim No. 5000256 is for future measures to remediate damage to groundwater resources. Claim No. 5000450 is for future measures to remediate damage to terrestrial resources. Claim No. 5000452 is for expenses incurred for the cleaning and restoration of the exterior of the Central Bank of Kuwait's building.

61. Kuwait alleges that the detonation of oil wells by Iraqi forces during the final days of their occupation of Kuwait resulted in the release of over 1 billion barrels of crude oil into the environment, much of which was ignited and burned for many months. According to Kuwait, fallout from the burning oil, in the form of soot and oil droplets, contaminated the soil as well as buildings and other structures in Kuwait. In addition, sea water used to fight the oil well fires, together with oil and dissolved hydrocarbons, seeped into the soil and infiltrated the aquifers in Umm-Al Aish and Raudhatain in the north-east of the country.

62. According to Kuwait, the desert soil and vegetation were severely disrupted by the construction of military fortifications, including ditches, berms, bunkers, trenches, and pits; the laying and clearance of mines; and the extensive movement of military vehicles and personnel. These activities are alleged to have resulted in, inter alia, accelerated soil erosion, increased sand movement and increased incidence of dust and sand storms. Kuwait asserts that the construction of military fortifications and movement of military vehicles and personnel also caused significant damage to natural vegetation and wildlife.

B. Claim No. 5000256 – Damage to groundwater resources

63. Kuwait seeks compensation in the amount of USD 185,167,546 for the expense of future measures to remediate two freshwater aquifers that it alleges have been contaminated as a result of Iraq's invasion and occupation of Kuwait. This amount represents an increase in the original amount claimed, reflecting an amendment requested by Kuwait on the basis of new information obtained from its monitoring and assessment projects.[10]

64. Kuwait states that during efforts to extinguish burning oil wells, pits were dug to hold firefighting water from the Persian Gulf. After the fires were extinguished, oil that had spilled from

damaged wells was diverted into some of these pits and stored until the oil was recovered by Kuwait Oil Company. Additional pits dedicated to the recovery of spilled oil were constructed. Kuwait refers to all the pits for the recovery of spilled oil as "oil recovery pits".

65. Kuwait alleges that the Umm Al-Aish aquifer, near the Sabriyah oil field, and the Raudhatain aquifer, located near the Raudhatain oil field, have been contaminated by oil from damaged oil wells and by sea water used to fight the oil fires. According to Kuwait, large quantities of hydrocarbons and sea water from the surface reached the aquifers through infiltration. Kuwait adds that, since 1991, the oil recovery pits, contaminated wadis and oil lakes have continued to act as conduits of pollution of these aquifers.

66. According to Kuwait, Raudhatain and Umm Al-Aish are the only two aquifers in the country that contain freshwater. In both aquifers, freshwater lenses sit on top of brackish water. Kuwait states that water from the freshwater lenses of the two aquifers was potable prior to Iraq's invasion and occupation of Kuwait, but some of it is no longer suitable for drinking due to contamination.

67. Kuwait has submitted results of monitoring and assessment studies which show contamination by total petroleum hydrocarbons ("TPH") and total dissolved solids ("TDS") in the northern part of the Umm Al-Aish aquifer and the southern part of the Raudhatain aquifer.

68. Iraq argues that Kuwait has not provided evidence to support the claim of damage to the freshwater lens of the Raudhatain aquifer. Iraq also contends that the presence of TPH in the aquifers is not sufficient proof of environmental damage or health risks because, according to it, there are no established TPH standards for drinking water.

69. In any case, Iraq contends that TPH and TDS contamination in the aquifers is not the result of Iraq's invasion and occupation of Kuwait. According to Iraq, any groundwater contamination in Kuwait is the result of mismanagement and improper land use. In particular, Iraq asserts that the increased salinity of the water in the aquifers has been caused by over-pumping of water from the aquifers prior to 1990. Iraq also contends that Kuwait was negligent in locating oil recovery pits above the aquifers.

70. In the view of the Panel, some of the data presented by Kuwait to support this claim are difficult to interpret. In particular, the methods used to identify and measure the levels of TPH and TDS raise issues regarding quality assurance, data comparability and data interpretation. Furthermore, the absence of pre-invasion data on TPH levels makes it difficult to assess the full significance of post-invasion data.

71. In spite of these shortcomings, the Panel finds, on the totality of the evidence presented to it, that there is TPH and TDS contamination in the freshwater lenses of the northern Umm Al-Aish and southern Raudhatain aquifers, and that this contamination resulted from the infiltration of large quantities of sea water used to fight the oil well fires and contaminants from the oil recovery pits and the oil lakes. Analysis of TDS in the aquifers suggests that the contamination resulted from

infiltration of sea water used to fight the oil well fires rather than from over-pumping of water from the aquifers.

72. In the view of the Panel, the TPH and TDS contamination makes this water unsuitable for human consumption and it is, therefore, reasonable for Kuwait to take measures to improve the quality of the water. Moreover, considering the urgent need for quick action to extinguish the oil well fires and to control the release of oil from the damaged oil wells, Kuwait was neither unreasonable nor negligent in constructing the oil recovery pits close to where the firefighting and oil recovery activities were being undertaken.

73. With regard to Iraq's assertion that Kuwait had failed to take timely and appropriate steps to remove the oil lakes and oil recovery pits, the Panel notes that removal was initially prevented by mine clearance and further delayed by oil field reconstruction operations. Until recently, there was also a lack of monitoring data identifying the location, nature and extent of surface and groundwater contamination. Although earlier removal of oil lakes and pits might have reduced the degree and volume of contaminated groundwater, the failure to do so was not unreasonable in light of the factors noted above.

74. Accordingly, the Panel finds that contamination of the Raudhatain and Umm Al-Aish aquifers by oil from damaged oil wells and by sea water used to fight the oil well fires constitutes environmental damage directly resulting from Iraq's invasion and occupation of Kuwait, and a programme to remediate the damage would constitute reasonable measures to clean and restore the environment.

75. Kuwait proposes to remediate the two aquifers by pumping contaminated groundwater from the aquifers, treating it in a dedicated facility and re-injecting the treated water into the aquifers. Treatment would include carbon adsorption to remove high molecular weight hydrocarbons; treatment to remove natural organic matter; and a membrane process, utilizing ultrafiltration followed by reverse osmosis, to reduce salinity levels to drinking water standards. Kuwait also proposes to flush residual contamination from the soil and vadose zone above the aquifers.

76. Iraq questions the appropriateness of the model used by Kuwait to determine the location and extent of the contaminated plumes because the model has not been calibrated with site-specific parameters and data. It states that the values used in the model to calculate the rate of natural recharge of freshwater in the aquifers are too low.

77. Iraq also maintains that more complete monitoring and assessment results are needed before any remediation programmes are undertaken. It states that, in any case, other and more appropriate remediation alternatives should be considered.

78. In the view of the Panel, restoration of water quality in the aquifers is an appropriate objective, and the remediation measures proposed by Kuwait are reasonable, subject to some modifications based on alternative approaches. The Panel considers that extraction of contaminated groundwater and its replacement with injected potable water is a reasonable remediation measure. However,

treatment of the contaminated groundwater in a dedicated facility might not be necessary. As an alternative, contaminated groundwater could be pumped into holding ponds and allowed to evaporate. Potable water would be obtained from other sources to recharge the freshwater lenses. Following the development of more specific information on the identity of the contaminants in the groundwater, Kuwait may decide to treat the extracted groundwater for reuse. Furthermore, the available evidence indicates that flushing of the vadose zone is not necessary because there is little risk to the aquifers from any residual contaminants in that zone. Details of these modifications are set out in annex I.

79. The Panel finds that, with the modifications outlined in annex I, the remediation measures proposed by Kuwait constitute measures that are reasonably necessary to clean and restore the environment, within the meaning of paragraph 35(b) of Governing Council decision 7.

80. The expenses of the remediation measures have been adjusted to take account of the modifications in annex I including:

(a) The reduced volume of water that needs to be extracted from the aquifers;

(b) The elimination of a dedicated treatment facility;

(c) The elimination of the flushing of the vadose zone; and

(d) The extra cost of continuous monitoring of the remediation measures.

81. Accordingly, the Panel recommends compensation in the amount of USD 41,531,463 for this claim.

82. For the reasons indicated in paragraph 196, no date of loss for the purposes of interest is indicated for the recommended award.

83. The Panel has not considered the issue of compensation for loss of use of groundwater resources. This issue will be considered in the fifth instalment of "F4" claims as part of claim No. 5000460.

C. Claim No. 5000450 – Damage to terrestrial resources

1. Introduction

84. Kuwait seeks compensation in the amount of USD 5,050,105,158 for expenses of future measures to remediate damage to its terrestrial environment resulting from Iraq's invasion and occupation of Kuwait. This amount represents a decrease in the original amount claimed, reflecting amendments made by Kuwait on the basis of new information obtained from its monitoring and assessment projects.[11]

85. Claim No. 5000450 comprises five claim units for future measures to be undertaken by Kuwait to remediate environmental damage alleged to have resulted from Iraq's invasion and occupation of Kuwait. Kuwait requested the Panel to consider these claim units as separate claims. However, the

Panel decided to treat claim No. 5000450 as a single claim but to review the claim units separately. Accordingly, the Panel's recommendations on the claim units are presented separately in this report.

86. The first claim unit relates to future measures to remediate areas in Kuwait damaged by the construction and backfilling of military fortifications built by Iraqi forces.

87. The second claim unit relates to future measures to remediate areas in and around wellhead pits constructed by Kuwait to fight the oil well fires.

88. The third claim unit relates to future measures to remediate areas damaged by airborne pollutants from the oil well fires that accumulated in desert areas in the form of tarcrete.

89. The fourth claim unit relates to future measures to revegetate desert areas damaged by military fortifications; the laying and clearance of mines; oil releases; tarcrete; movements of military vehicles and personnel; and berms and sand walls.

90. The fifth claim unit is for expenses incurred in cleaning and restoring the facades and air distribution systems of Kuwait government buildings damaged by pollutants from the oil well fires.

91. As stated in paragraph 3, two other units of claim No. 5000450 (relating to measures to remediate raised roads contaminated by the oil well fires and measures to remediate areas contaminated as a result of the disposal of mines and other remnants of war) have been deferred to the fourth "F4" instalment.

2. Remediation of areas damaged by military fortifications

92. Kuwait seeks compensation in the amount of USD 14,170,924 for future measures to remediate areas damaged by the construction and backfilling of military fortifications.

93. According to Kuwait, over 240,000 military fortifications, comprising antitank ditches, berms, bunker trenches and pits, were constructed in Kuwait by the military forces of Iraq during their invasion and occupation of Kuwait. Kuwait submitted data, collected during operations to clear mines and other remnants of war, to support these numbers.

94. Kuwait alleges that the fortifications have caused damage to its desert environment. It states that the construction and subsequent backfilling of these fortifications, representing a total area of approximately 6.25 square kilometres scattered over a large area of its desert, exposed soil and other materials to wind erosion which adversely affected the desert ecosystem, including its biodiversity, soil-water relationships and the long-term productivity of the soil. Kuwait also submitted information to support its contention that the construction and backfilling of military fortifications have contributed to increased sand mobilization in the affected areas.

95. Iraq contends that the location of the military fortifications is unclear and that the estimate of the average size of fortifications lacks "tangible evidence". Iraq also claims that uncontrolled livestock grazing is the "principal issue that affects sand movement, vegetation cover and the ability of the

desert to repair itself". Indeed, Iraq asserts that areas that have been fenced since 1991 "show remarkable levels of vegetation".

96. Iraq also argues that Kuwait "does not provide clear evidence that persistent environmental damage linked to the Conflict and post-Conflict activities is still present". Iraq states that, given the general climatic conditions and dust and sand storm activities in the region, military fortifications in such small areas could have only a negligible impact on sand movements in Kuwait. Iraq also asserts that natural revegetation has occurred in desert areas in Iraq which were similarly damaged.

97. As noted by the Panel in its second "F4" report, there is evidence that Iraqi forces fortified the country against military action by the Allied Coalition Forces. There is also evidence that the construction and backfilling of military fortifications adversely affected plant growth and soil functioning, and increased wind erosion and sand mobilization. The evidence also shows that there has been very little natural recovery at military fortification sites that have been protected from livestock grazing. The Panel, therefore, concludes that construction and backfilling of military fortifications was the major cause of environmental damage at these sites. However, the Panel observes that uncontrolled livestock grazing, both before and after Iraq's invasion and occupation of Kuwait, also caused damage in unfenced areas where military fortifications were located. Accordingly, the Panel finds that the ecological impacts are not attributable solely to Iraq's invasion and occupation of Kuwait.

98. Based on the evidence available, the Panel considers that Kuwait's estimate of the total area affected by military fortifications is reasonable. Moreover, although the small area affected by military fortifications is unlikely to be a major contributor to sand mobilization, the Panel is satisfied that the construction and backfilling of military fortifications have caused environmental damage through destabilization or compaction of different soil types.

99. The Panel, therefore, finds that damage to Kuwait's desert areas from the construction and backfilling of military fortification sites constitutes environmental damage directly resulting from Iraq's invasion and occupation of Kuwait, and a programme to remediate the damage would constitute reasonable measures to clean and restore the environment.

100. Kuwait proposes to stabilize the areas damaged by the construction and backfilling of military fortifications by applying a 2.5-centimetre layer of gravel to control erosion and encourage the re-establishment of indigenous species.

101. Iraq argues that the proposed gravel stabilization "is not technically documented" and "will have significant adverse environmental effects". Iraq suggests that Kuwait should instead address damage to the desert through "a national plan to organize and efficiently manage grazing".

102. The Panel considers that gravel stabilization is an established remediation technique; and it is appropriate for those soil types in Kuwait where there is clear evidence of the presence of a physical soil crust and low concentrations of loose sand upwind of the areas to be remediated. Gravel

application can be accomplished with little negative environmental impact by using lightweight, low-impact equipment.

103. The Panel finds that, with the modifications outlined in annex II, the remediation measures proposed by Kuwait constitute measures that are reasonably necessary to clean and restore the environment, within the meaning of paragraph 35(b) of Governing Council decision 7. The Panel emphasizes that in order to ensure the success of the remediation measures, it will be necessary for Kuwait to adopt appropriate measures to protect vulnerable areas, such as fencing to control grazing and the use of off-road vehicles.

104. The expenses of the proposed remediation measures have been adjusted to take account of the Panel's finding, in paragraph 97, that uncontrolled livestock grazing contributed to the damage. An adjustment has also been made to take account of the decreased area and reduced cost of the remediation measures, as indicated in annex II.

105. Accordingly, the Panel recommends compensation in the amount of USD 9,019,717 for this claim unit.

3. Remediation of areas in and around wellhead pits

106. Kuwait seeks compensation in the amount of USD 34,276,192 for expenses of future measures to remediate areas in and around wellhead pits constructed for the storage of sea water used for fighting the oil well fires. Some of the wellhead pits were subsequently backfilled with material from adjacent areas.

107. Kuwait alleges that releases from the damaged oil wells contaminated the areas in and around the wellhead pits. Kuwait also states that the material used to backfill the wellhead pits was contaminated with petroleum hydrocarbons from these releases.

108. According to data from satellite imagery and field research submitted by Kuwait, a total of 163 wellhead pits are located in oil-contaminated areas. Ninety-eight pits are in the Burgan oil field and 65 pits are in the Raudhatain and Sabriyah oil fields.

109. Iraq argues that Kuwait has not provided sufficient evidence to demonstrate the number, location and size of the wellhead pits. Iraq contends that Kuwait has provided only indirect evidence of oil contamination in the wellhead pits and that no evidence has been provided of damage to the soil surrounding the wellhead pits.

110. In the view of the Panel, data from Kuwait's remote sensing and field verification have provided sufficient evidence to demonstrate the number of wellhead pits and the areas that have been affected by contamination from these pits. The Panel finds that, given the location of the pits and the material used to backfill them, there is a real risk of contamination to the areas in and around the pits from petroleum hydrocarbons in the pits and the backfill material. The pits and backfill material also pose a risk of contamination to groundwater where the pits are located above the aquifers. Consequently, it is reasonable for Kuwait to take measures to remediate the areas in and around the wellhead pits.

111. The Panel, therefore, finds that damage to areas in and around wellhead pits from oil contamination constitutes environmental damage directly resulting from Iraq's invasion and occupation of Kuwait, and a programme to remediate the damage would constitute reasonable measures to clean and restore the environment.

112. Kuwait proposes to excavate contaminated soil and treat it, using high temperature thermal desorption to remove the petroleum contamination. The treated soil would be used to backfill the wellhead pits, and the top of the pits would be stabilized with gravel. Kuwait also proposes to revegetate the remediated areas. The claim unit relating to the revegetation programme of these areas is reviewed in paragraphs 149 to 150 of this report.

113. Iraq contends that using high temperature thermal desorption to treat excavated soil could have serious adverse environmental impacts. Iraq also questions the use of gravel to stabilize the remediated areas.

114. In the view of the Panel, treatment of excavated soil by high temperature thermal desorption is not warranted in the circumstances of this claim. Other remediation alternatives, such as landfilling, have proven to be equally effective, and they involve significantly less expense.

115. As stated in paragraph 102, the Panel considers that the use of gravel stabilization is an appropriate remediation technique.

116. The Panel has indicated modifications to the remediation programme that dispense with high temperature thermal desorption treatment of contaminated soil. Moreover, as stated in paragraph 149, the Panel considers that revegetation is not warranted in these areas. The areas involved are relatively small and can be expected to revegetate naturally, if protected from grazing and off-road vehicles. Details of the modifications are set out in annex III.

117. The Panel finds that, with the modifications outlined in annex III, the remediation measures proposed by Kuwait constitute measures that are reasonably necessary to clean and restore the environment, within the meaning of paragraph 35(b) of Governing Council decision 7.

118. The expenses of the proposed remediation programme have been adjusted to take account of the modifications in annex III, including:

(a) Reduction in the volume of soil to be excavated;

(b) Elimination of high temperature thermal desorption treatment of excavated material; and

(c) Landfilling of excavated material.

119. Accordingly, the Panel recommends compensation in the amount of USD 8,252,657 for this claim unit.

4. Remediation of areas damaged by tarcrete

120. Kuwait seeks compensation in the amount of USD 928,820,719 for expenses of future measures to remediate areas damaged by tarcrete.

121. According to Kuwait, contamination from the oil well fires was deposited over approximately 271 square kilometres of its desert areas, where it formed tarcrete. Kuwait alleges that the tarcrete degraded the desert ecosystem and resulted in plant death and loss of vegetative cover. Kuwait also states that tarcrete interferes with the growth and reproduction of some species, and alters the composition of desert vegetation.

122. Kuwait provided evidence to show that the presence of tarcrete has resulted in chemical contamination of the affected desert areas. Kuwait also provided data from soil sampling to define the chemical composition of tarcrete and tarcrete-affected soils.

123. Iraq argues that the area alleged to be affected by tarcrete is "ill-defined and unclear". Iraq also argues that there is no evidence that tarcrete poses a risk of long-term environmental damage. Indeed, Iraq claims that tarcrete could have a positive effect in promoting soil stabilization, and it alleges that tarcrete has in fact contributed to an increase in the vegetative cover in some parts of Kuwait. Iraq further asserts that, in any case, Kuwait has not undertaken an appropriate risk assessment to demonstrate that there is need for remediation.

124. The Panel finds that monitoring and assessment information submitted by Kuwait has provided a reasonably accurate approximation of the areas damaged by tarcrete. There is clear evidence that tarcrete can impair ecological recovery. While there has been natural recovery in some areas, large areas of tarcrete remain and this has impaired ecological functions such as water infiltration, nutrient cycling and the growth of vegetation.

125. The Panel, therefore, finds that damage to Kuwait's desert areas from tarcrete constitutes environmental damage directly resulting from Iraq's invasion and occupation of Kuwait**,** and a programme to remediate the damage would constitute reasonable measures to clean and restore the environment.

126. Kuwait proposes to remove tarcrete by hand and treat it by high temperature thermal desorption. It proposes to dispose of the treated material in existing quarries and pits near the oil fields. The areas from which tarcrete is removed would be stabilized with gravel and revegetated. The revegetation component of the remediation programme is discussed in paragraphs 151 to 152.

127. Iraq claims that the proposed remediation will cause "additional damage". It states that "tarcrete is stable and does not present a risk whereas the excavation of tarcrete for treatment will be destructive to vegetation and soils". Instead, it suggests that consideration should be given to alternative remediation approaches that would accelerate the recovery process.

128. In the view of the Panel, the physical removal of tarcrete could damage the affected soil, impair natural recovery and reduce the chances of successful revegetation. Furthermore, treatment of excavated soil by high temperature thermal desorption is not warranted in the circumstances.

129. The Panel has outlined a modified remediation programme that involves fragmentation of the tarcrete, instead of removal and treatment by high temperature thermal desorption. Furthermore, as indicated in paragraph 151, the Panel does not consider that any revegetation measures are warranted in the areas damaged by tarcrete. After fragmentation of the tarcrete, natural recovery can be accelerated by the application of organic amendments to provide additional nutrients. Details of the modified remediation programme are set out in annex IV.

130. The Panel finds that, with the modifications outlined in annex IV, the remediation measures proposed by Kuwait constitute measures that are reasonably necessary to clean and restore the environment, within the meaning of paragraph 35(b) of Governing Council decision 7.

131. The expenses of the proposed remediation programme have been adjusted to take account of the modifications in annex IV, including:

(a) On-site manual fragmentation of tarcrete for part of the affected areas;

(b) Elimination of high temperature thermal desorption treatment; and

(c) Addition of organic soil amendments to all affected areas.

132. Accordingly, the Panel recommends compensation in the amount of USD 166,513,110 for this claim unit.

5. Revegetation of damaged terrestrial ecosystems

133. Kuwait seeks a total compensation in the amount of USD 4,039,217,642 for expenses of future measures to revegetate areas of its desert that it alleges have been damaged as a result of Iraq's invasion and occupation of Kuwait.

134. This compensation is sought for a comprehensive and integrated programme to revegetate the areas alleged to have been affected by military activities; the areas in and around the wellhead pits; and the areas alleged to have been damaged by tarcrete. Kuwait states that such a programme is necessary because vegetative cover provides an essential mechanism for desert surface stabilization. It also helps to regulate the distribution of rainfall and provides sustenance for wildlife.

(a) Areas affected by military activities

135. Kuwait alleges that the construction and backfilling of military fortifications, mine laying and mine clearance, movement of vehicles and personnel and construction of berms and sand walls (collectively referred to as "military activities"), caused soil compaction which "disrupts the soil's natural permeability and infiltration properties, resulting in reduced water storage capacity". Kuwait

further alleges that military activities increased wind erosion of the soil, which "inhibits the regeneration of stabilizing vegetation". Kuwait also states that these activities led to a "sudden and dramatic increase in sand mobilization".

136. Iraq argues that "the degree to which military activity during the Conflict has contributed to an increase in dust storms is not documented". Iraq also contends that there are other sources of sand mobilization, such as overgrazing, which Kuwait has failed to take into account.

137. Although overgrazing is a well-documented problem in Kuwait, the Panel considers that the military activities were the primary cause of the increase in sand mobilization during the years immediately following the end of Iraq's occupation of Kuwait.

138. The Panel, therefore, finds that damage to Kuwait's desert areas from these military activities constitutes environmental damage directly resulting from Iraq's invasion and occupation of Kuwait, and a programme to remediate the damage would constitute reasonable measures to clean and restore the environment.

139. Kuwait proposes to revegetate areas affected by military activities. Kuwait states that vegetation in these areas has not recovered from the effects of Iraq's invasion and occupation of Kuwait and a revegetation programme is necessary to restore biological productivity and to "address the large-scale mobilization of sand".

140. The revegetation programme proposed by Kuwait involves the establishment of 70 revegetation islands, covering 420 square kilometres. Each revegetation island would cover an area of 6 square kilometres. Half of each island would be designated for active revegetation by the "planting of shrubs, grasses, and forbs tailored to the specific revegetation island location and ecosystem type". The remaining half of each revegetation island would be left to revegetate naturally. To minimize damage by livestock grazing, Kuwait proposes to fence each of the revegetation islands.

141. In order to stabilize and control sand movement and encroachment, Kuwait also proposes to construct 70 shelter belts, covering an area of 385 square kilometres. Each shelter belt would be 5 kilometres long. The shelter belts would be located upwind of the revegetation islands to control sand movement in the disturbed areas where increased sand movement has been observed.

142. Iraq states that the revegetation methods proposed for areas affected by military activities "are over-elaborate [and] may well have negative effects on the biodiversity of Kuwait". Iraq argues that no active revegetation is necessary and that fencing and security maintenance would be sufficient.

143. The Panel finds that revegetation of the areas damaged by military activities is appropriate. In the view of the Panel, fencing alone would not ensure timely restoration of areas experiencing serious sand mobilization.

144. The Panel considers that Kuwait's proposal for establishing shelter belts and revegetation islands is a reasonable approach for restoration of the affected areas. However, this programme should rely more on natural revegetation processes and avoid the introduction of non-native species

which could have negative environmental impacts. A modified revegetation programme based on these considerations is outlined in annex V.

145. The Panel finds that, with the modifications outlined in annex V, the remediation measures proposed by Kuwait constitute measures that are reasonably necessary to clean and restore the environment, within the meaning of paragraph 35(b) of Governing Council decision 7.

146. The expenses of the proposed revegetation programme for areas affected by military activities have been adjusted to take account of the modifications indicated in annex V.

147. The Panel has made a further adjustment to the costs of the revegetation programme to take account of the contribution of other factors unrelated to Iraq's invasion and occupation of Kuwait including, in particular, uncontrolled livestock grazing and the use of off-road vehicles in sensitive desert areas. In the view of the Panel, the need for revegetation is due, in part, to these other factors.

148. Accordingly, the Panel recommends compensation in the amount of USD 460,028,550 for this unit of the claim.

(b) Areas damaged in and around wellhead pits

149. Kuwait proposes a revegetation programme for the areas in and around wellhead pits. In its review of the remediation programme for these areas, the Panel has recommended an award that includes remediation measures that rely on natural revegetation (see paragraph 116). Accordingly, the Panel does not consider that a revegetation programme is necessary for these areas.

150. Consequently, the Panel recommends no compensation for this segment of the claim.

(c) Areas damaged by tarcrete

151. Kuwait proposes a revegetation programme for the areas affected by tarcrete. In its review of the remediation programme for the areas affected by tarcrete, the Panel has recommended an award that includes remediation measures that rely on natural vegetation (see paragraph 129). Accordingly, the Panel finds no need for a revegetation programme for these areas.

152. Consequently, the Panel recommends no compensation for this segment of the claim.

6. Cleaning of government buildings

153. Kuwait seeks compensation in the amount of USD 33,619,681 for expenses to clean and repair 2,066 government buildings alleged to have been damaged as a result of Iraq's invasion and occupation of Kuwait.

154. Kuwait alleges that the buildings require repairs "as a result of damages associated with oil fires and smoke". According to Kuwait, the facades of the buildings were contaminated by air pollution. Kuwait also alleges that some of the contaminants entered the air conditioning systems and that this could have long-term adverse health consequences for the occupants of the buildings.

155. The Panel finds that damage to government building facades and air conditioning systems by releases from the oil well fires would constitute environmental damage directly resulting from Iraq's invasion and occupation of Kuwait. However, Kuwait has not presented evidence sufficient to demonstrate the circumstances and amount of the claimed loss. Consequently, the Panel finds that Kuwait has failed to meet the evidentiary requirements for compensation specified in article 35(3) of the Rules.

156. Accordingly, the Panel recommends no compensation for this claim unit.

7. Recommended award for claim No. 5000450

157. The Panel's recommendation for compensation for claim No. 5000450 is summarized in table 2.

Table 2. Recommended award for claim No. 5000450

Claim No.	Claim unit	Amount claimed (USD)	Amount recommended (USD)
5000450	Remediation of areas damaged by military fortifications	14,170,924	9,019,717
	Remediation of areas in and around wellhead pits	34,276,192	8,252,657
	Remediation of areas damaged by tarcrete	928,820,719	166,513,110
	Revegetation of damaged terrestrial ecosystems	4,039,217,642	460,028,550
	Cleaning of government buildings	33,619,681	nil
Total		5,050,105,158	643,814,034

158. The Panel has not considered the issue of compensation for loss of use of terrestrial resources. This issue will be considered in the fifth instalment of "F4" claims as part of claim No. 5000460.

159. For the reasons indicated in paragraph 196, no date of loss for the purposes of interest is indicated for this recommended award.

D. Claim No. 5000452 – Damage to the Central Bank of Kuwait building

160. The Central Bank of Kuwait (the "Central Bank") seeks compensation in the amount of USD 52,471, for expenses incurred to clean and restore the exterior of its building in Kuwait City. The amount claimed includes interest in the amount of USD 7,185.

161. The Central Bank alleges that the building was damaged by airborne pollutants from the oil well fires resulting from Iraq's invasion and occupation of Kuwait. The oil well fires released oil, smoke and other pollutants in an airborne plume that settled over Kuwait City between 15 February and 30

May 1991. The Central Bank submitted contracts and invoices for cleaning and restoration work performed in 1993 on the exterior of the building and the wood carvings around the windows.

162. Iraq contends that the Central Bank has not provided evidence that environmental damage occurred. Iraq further states that "it is unclear whether the repairs have been performed" and that "at least part of the work could have been regular maintenance works not related to the Conflict".

163. As noted in paragraph 23 of its second "F4" report, the Panel considers that expenses of measures undertaken to prevent or abate harmful impacts of airborne contaminants on property could qualify as environmental damage within the meaning of paragraph 16 of Security Council resolution 687 (1991) and paragraph 35 of Governing Council decision 7, provided that the expenses are a direct result of Iraq's invasion and occupation of Kuwait.

164. The Panel finds that the remediation activities undertaken by the Central Bank constituted reasonable measures to clean and restore environment that was damaged as a direct result of Iraq's invasion and occupation of Kuwait. Consequently, the expenses of those activities qualify for compensation in accordance with paragraph 35(b) of Governing Council decision 7.

165. However, the evidence presented does not enable the Panel to substantiate the full amount of the expenses claimed because the Central Bank has not provided evidence that shows the exact nature and scope of the work undertaken. Accordingly, the Panel has made an adjustment to account for the risk of overstatement in the claimed amount.

166. For the reasons stated in paragraph 195 the Panel makes no recommendation regarding the interest claimed in the amount of USD 7,185.

167. Accordingly, the Panel recommends compensation in the amount of USD 36,230 for this claim.

168. In accordance with the approach set out in paragraph 196, the Panel finds that the date of loss for this claim is 31 August 1993.

Table 3. Summary of recommended awards for the claims of Kuwait

Claim No.	Subject matter	Amount claimed (USD)	Amount recommended (USD)
5000256	Damage to groundwater resources	185,167,546	41,531,463
5000450	Damage to terrestrial resources	5,050,105,158	643,814,034
5000452	Damage to the Central Bank of Kuwait building	52,471	36,230
Total		5,235,325,175	685,381,727

VI. CLAIMS OF THE KINGDOM OF SAUDI ARABIA

A. Claim No. 5000451 – Damage to coastal resources

169. Saudi Arabia seeks compensation in the amount of USD 4,748,292,230 for expenses of future measures to remediate damage to its coastal environment resulting from Iraq's invasion and occupation of Kuwait.[12] This amount represents a decrease of the original amount claimed, reflecting amendments made by Saudi Arabia on the basis of new information obtained from its monitoring and assessment projects.[13]

170. Saudi Arabia states that its coastal environment was damaged by (a) more than 10 million barrels of oil deliberately released into the Persian Gulf by Iraqi forces; (b) contaminants released from oil wells in Kuwait that were set on fire by Iraqi forces; and (c) other releases of oil into the Persian Gulf as a result of Iraq's invasion and occupation of Kuwait.

171. Saudi Arabia asserts that the oil released as a result of Iraq's invasion and occupation of Kuwait dwarfed all previous inputs of oil into the Persian Gulf from spills, refinery operations, natural seeps, exploration and production activities, operational discharges from vessels, urban run-offs and similar sources.

172. According to Saudi Arabia, the 1991 oil spills caused extensive oil contamination to a total of more than 600 kilometres of shoreline, from the border with Kuwait to Abu Ali. Saudi Arabia states that chemical analysis ("biomarker fingerprinting") of over 3,000 sediment samples, collected in the areas it proposes to remediate, indicates that the oil currently found in that area is predominantly of Kuwaiti origin. The chemical analysis and collection of underlying data were carried out as part of a survey of the entire affected shoreline that was funded by an award in the first instalment of "F4" claims.[14]

173. Saudi Arabia explains that the damage to its shoreline results from the toxicological effects of chemical constituents of oil as well as the physical effects resulting from smothering of sediment layers by oil. According to Saudi Arabia, the continued presence of layers of oil-contaminated sediments and tar mat at many sites on the shoreline is preventing natural recolonization and ecological recovery in sections of the supra-littoral and inter-tidal regions. As a result, many areas of the shoreline are almost devoid of plant and animal life or show significant reduction in biological diversity.

174. Iraq states that "there is no dispute that the oil spill occurred or that it had immediately caused environmental damage to wildlife and the beaches and habitats of the coast of Saudi Arabia". However, Iraq contends that the damage to Saudi Arabia's shoreline cannot be attributed solely to the events in 1991. It points out that the region "is constantly exposed both to accidental spills and routine ongoing pollution". It refers in particular to the large spill "associated with a well at Nowruz, Iran that resulted in 1.9 million barrels of oil being dumped in the northern section of the Gulf" in 1983. Iraq also contends that it is not liable for damage caused by oil releases that resulted from bombing of Iraqi

tankers by the Allied Coalition Forces or for damage from oil that was released from oil wells in Kuwait "long after [Iraqi forces] had withdrawn from Kuwait".

175. Iraq refers to a study funded by the European Union, which it contends found "significant recovery of all habitat types in the Jubail area after five years (end of 1995). The only exceptions were some areas of salt marshes." Iraq claims that this is "the only long-term research ever undertaken on the impacted coastline". It also states that a "survey team in 1991 made much more modest assessments of the extent of the damage than currently claimed" by Saudi Arabia. Iraq further asserts that biological assessment studies submitted by Saudi Arabia are incomplete, rely on a "coarse" methodology, and have been misinterpreted by Saudi Arabia.

176. As noted in paragraph 23, Governing Council decision 7 states that "direct loss, damage, or injury" includes any loss suffered as a result of military operations by either side during the period 2 August 1990 to 2 March 1991.[15] Accordingly, damage caused by oil releases are compensable whether they resulted from military operations by Iraq or the Allied Coalition Forces. In the view of the Panel, evidence available from a variety of sources supports the conclusion that the overwhelming majority of the oil currently present in the areas which Saudi Arabia proposes to remediate resulted from Iraq's invasion and occupation of Kuwait.[16]

177. The Panel observes that, while there has been some attenuation of oil contamination since Iraq's invasion and occupation of Kuwait, recent studies indicate that there are still areas with high levels of oil contamination. Saudi Arabia submitted shoreline survey data on the presence of oil and on the biological conditions along its shoreline. The data, which were collected at more than 19,500 sampling sites in the area proposed for remediation, indicate that there are large areas where oil contamination continues to impair coastal resources and where there has been little or no biological recovery.

178. The Panel, therefore, finds that damage from oil contamination to the shoreline between the Kuwait border and Abu Ali constitutes environmental damage directly resulting from Iraq's invasion and occupation of Kuwait, and a programme to remediate the damage would constitute reasonable measures to clean and restore the environment.

179. Saudi Arabia proposes to remediate 20 areas, totalling approximately 73 square kilometres, along the coastline between the Kuwait border and Abu Ali. In these areas it proposes to excavate and remove visibly contaminated material. During the excavation, salt marsh and tidal flat areas would be isolated from the sea by the construction of sea walls and dikes; these would be progressively removed as work is completed in each area. Following sediment excavation, residual contamination in remaining sediments would be treated with bio-remediation techniques. The excavated material would be treated using high temperature thermal desorption at a number of facilities to be constructed for that purpose. Treated sediments would be blended with dredged subtidal sediments and replaced in excavated areas. The salt marshes would be revegetated after bio-remediation treatment. Saudi Arabia states that it will review and modify the remediation programme as additional information from its monitoring and assessment studies becomes available.

180. Iraq states that the proposed remediation would have "large scale and deleterious environmental impacts", and argues that Saudi Arabia has failed to assess these impacts. It also asserts that high temperature thermal desorption is not a suitable method for remediation of the oil-contaminated coastal sediments.

181. The Panel has some concerns with the remediation programme proposed by Saudi Arabia. The extensive excavation proposed by Saudi Arabia poses a risk of causing substantial environmental harm to areas that are already experiencing natural recovery, as well as to other sensitive areas where excavation may cause more harm than good. Furthermore, the extensive infrastructural work related to this excavation, such as construction and deconstruction of numerous seawalls, dikes and access roads for the transport of excavated material could have considerable adverse impacts on the coastal and marine environment. The Panel also considers that the problems relating to the disposal of excavated material and the backfilling of excavated sites have not been adequately addressed.

182. The Panel does not consider that treatment of oil-contaminated material by high temperature thermal desorption is warranted in the circumstances of this claim. The evidence presented does not justify the use of high temperature thermal desorption rather than other disposal options, such as landfilling, which is an accepted waste management practice throughout the world and is routinely utilized for the disposal of oil-contaminated material.

183. The Panel has evaluated a modified remediation programme that will target the impediments to ecological recovery and accelerate natural recovery without posing unacceptable risks of adverse environmental impacts. Details of the modified programme are set out in annex VI.

184. The Panel finds that, with the modifications outlined in annex VI, the remediation measures proposed by Saudi Arabia constitute measures that are reasonably necessary to clean and restore the environment, within the meaning of paragraph 35(b) of Governing Council decision 7.

185. The expenses of the proposed remediation programme have been adjusted to take account of the modifications in annex VI, including:

(a) Reduction in the total area and volume of materials to be remediated;

(b) Emphasis on in situ treatment methods;

(c) Elimination of high temperature thermal desorption treatment of excavated material; and

(d) Landfilling of excavated material.

186. The recommended award includes provision for long-term monitoring of the remediation activities. The Panel considers it appropriate to integrate continuous monitoring into the design and implementation of the remediation programme. This will make the programme flexible and more able to respond to new information.

187. The Panel, therefore, recommends compensation in the amount of USD 463,319,284 for this claim.

188. For the reasons indicated in paragraph 196, no date of loss for the purposes of interest is indicated for this recommended award.

189. The Panel has not considered the issue of compensation for loss of use of coastal resources. This issue will be considered, as necessary, in the fifth instalment of "F4" claims as part of claim No. 5000463.

B. Claim No. 5000360 – Monitoring of coastal remediation activities

190. Saudi Arabia seeks compensation in the amount of USD 20,602,177 for a project to assess the effectiveness of clean-up and remediation measures in coastal areas affected by oil pollution resulting from Iraq's invasion and occupation of Kuwait, and to determine whether additional remediation is required. This amount represents an increase in the original amount claimed, reflecting an amendment requested by Saudi Arabia on the basis of new information obtained from its monitoring and assessment projects.[17]

191. As indicated in paragraph 186, the Panel has included appropriate provision for the costs of long-term monitoring of the remediation activities in the award recommended for claim No. 5000451.

192. Accordingly, the Panel recommends no compensation for this claim.

Table 4. Summary of recommended awards for the claims of Saudi Arabia

Claim No.	Subject matter	Amount claimed (USD)	Amount recommended (USD)
5000451	Damage to coastal resources	4,748,292,230	463,319,284
5000360	Monitoring of coastal remediation activities	20,602,177	nil
Total		4,768,894,407	463,319,284

VII. RELATED ISSUES

A. Currency exchange rate

193. The Commission issues awards in United States dollars. Some losses were claimed in United States dollars after conversion from other currencies. In keeping with the practice of other panels of Commissioners, the Panel has used currency exchange rates reported in the United Nations Monthly Bulletin of Statistics.

194. For claim No. 5000452, the Panel has used the monthly currency exchange rates reported in the United Nations Monthly Bulletin of Statistics for the months in which losses were incurred.

B. Interest

195. Governing Council decision 16 (S/AC.26/1992/16) provides that "[i]nterest will be awarded from the date the loss occurred until the date of payment, at a rate sufficient to compensate successful Claimants for the loss of use of the principal amount of the award". It also provides that the Governing Council will consider the methods of calculation and payment of interest at the appropriate time, and that interest will be paid after the principal amount of awards. Accordingly, the Panel must determine the date from which interest will run, where relevant.

196. The majority of the third instalment remediation claims are for financial expenditures that have not yet been incurred. In such cases, no interest is due and, accordingly, no date of loss has been indicated. With respect to completed remediation activities, the Panel has selected the approximate mid-point of the period during which expenses were incurred as the date of loss.

VIII. SUMMARY OF RECOMMENDATIONS

197. Based on the foregoing, the Panel recommends that the amounts set out in table 5 be awarded in respect of the claims included in the third "F4" instalment.

Table 5. Summary of recommended awards for the third "F4" instalment

Country	Claim No.	Amount claimed (USD)	Amount recommended (USD)
Kuwait	5000256	185,167,546	41,531,463
	5000450	5,050,105,158	643,814,034
	5000452	52,471	36,230
Kuwait subtotal		5,235,325,175	685,381,727
Saudi Arabia	5000451	4,748,292,230	463,319,284
	5000360	20,602,177	nil
Saudi Arabia subtotal		4,768,894,407	463,319,284
Total		10,004,219,582	1,148,701,011

Geneva, 11 July 2003

(Signed) Thomas A. Mensah
Chairman

(Signed) José R. Allen
Commissioner

(Signed) Peter H. Sand
Commissioner

Notes

[1] See paragraph 29 of the "Report and recommendations made by the Panel of Commissioners concerning the first instalment of 'F4' claims", S/AC.26/2001/16 ("first 'F4' report"). In the first "F4" report, the Panel recommended awards for monitoring and assessment projects to identify and evaluate damage or loss suffered as a result of Iraq's invasion and occupation of Kuwait. Some of these projects were intended to provide information to assist with the review of substantive claims by producing scientific and technical information about the nature and extent of environmental damage and potential remediation measures. Data produced by the following monitoring and assessment projects were transmitted to Iraq: claim Nos. 5000374, 5000375, 5000376, 5000433, 5000434, 5000435, 5000409, 5000359, 5000363, 5000411.

[2] "Report of Secretary-General pursuant to paragraph 19 of Security Council resolution 687 (1991)", S/22559, paragraph 20.

[3] "Report and recommendations made by the Panel of Commissioners concerning the second instalment of 'F4' claims", S/AC.26/2002/26 ("second 'F4' report"), paragraph 22.

[4] Paragraph 39.

[5] Ibid.

[6] Second "F4" report, paragraph 25.

[7] First "F4" report, paragraphs 33-34; second "F4" report, paragraph 40.

[8] Paragraphs 100-101.

[9] Second "F4" report, paragraph 94.

[10] The increase in claimed costs is based on information produced by monitoring and assessment projects that were funded by awards in the first instalment of "F4" claims for claim Nos. 5000374, 5000375 and 5000376 (see table 7 of first "F4" report).

[11] The decrease in claimed costs is primarily due to Kuwait's decision to use less costly remediation techniques for tarcrete-affected areas and areas that need to be revegetated. This decision was based on information produced by monitoring and assessment projects that were funded by awards in the first instalment of "F4" claims for claim Nos. 5000433 and 5000434 (see table 7 of first "F4" report).

[12] As stated in paragraph 3, a portion of claim No. 5000451, relating to measures to remove sunken oil from the marine environment, has been deferred to the fourth "F4" instalment.

[13] The decrease in claimed costs is primarily due to a reduction in Saudi Arabia's estimated volume of contaminated sediment to be excavated and treated by the high temperature thermal desorption process. The reduction in estimated sediment volume was primarily based on data collected as part of the monitoring and assessment programme which was funded by the award for claim No. 5000409 (the "shoreline survey": see table 9 of first "F4" report), as well as modifications to the proposed remediation programme. Relevant information was produced by monitoring and assessment projects that were funded by awards in the first instalment of "F4" claims for claim Nos. 5000359, 5000363, 5000409 and 5000411 (see table 9 of first "F4" report).

[14] The shoreline survey, funded by the award for claim No. 5000409.

[15] See also paragraph 98 of second "F4" report.

[16] See paragraph 548 of first "F4" report. As noted by the Panel, there is strong evidence in the scientific literature that unusually large quantities of oil entered Saudi Arabia's marine and coastal environment as a result of Iraq's invasion and occupation of Kuwait.

[17] The increase in claimed costs is due to changes to the proposed remediation monitoring methodology, based on information from the monitoring and assessment programme which was funded by the award for claim No. 5000409 (see Table 9 of first "F4" report).

TECHNICAL ANNEXES TO THE REPORT ON THE THIRD "F4" INSTALMENT

Introduction

1. In reviewing the remediation measures proposed by the Claimants, the Panel found that modifications in the design, methodologies and the nature and extent of work to be undertaken would improve the net environmental benefit and reduce the cost of some of the measures. The general outlines and objectives of the modifications have been indicated in the parts of the report dealing with the relevant claims. In some cases the Panel considers it useful to set out technical details of the modifications. As stated in paragraph 57 of the report, these details are indicated in the respective annexes.

2. The Panel recognizes that, in implementing the remediation activities, claimants may find it necessary to make further modifications, to take account of new information or changing environmental conditions. In this regard, the Panel stresses that its findings regarding the proposed remediation measures, and its suggestions of possible modifications, have been based on information available to it on the environmental conditions in Kuwait and Saudi Arabia prior to March 2003.

3. As noted in paragraph 50 of the report, remediation programmes must be implemented with utmost caution, taking due account of the need to avoid potential adverse environmental impacts of remediation activities. This requires the use of flexible and site-specific approaches, incorporating a broad set of remediation techniques that are capable of addressing the wide range of habitats, the varying levels of contamination and the different ecological conditions present.

4. The Panel has been guided by the following principles in considering modifications to the remediation programmes proposed by the Claimants:

(a) Remediation approaches or techniques that pose unacceptable risks of ecological harm should be avoided.

(b) Remediation activities should be undertaken only if they are likely to result in more positive than negative effects.

(c) Remediation techniques that facilitate natural recovery processes should be preferred, and active remediation should build on and enhance natural recovery that has already occurred.

(d) Remediation should rely on proven and well-established technologies and techniques in preference to experimental or untested approaches.

(e) The effectiveness of remediation activities should be monitored to ensure that remediation targets are met. Remediation programmes should be designed to be sufficiently flexible and responsive to new information obtained from such monitoring.

(f) Where more than one remediation approach or technique is appropriate to achieve the desired remediation goal, the most cost-effective option should be selected.

(g) Remediation decisions should consider both the short-term and long-term effects of remediation activities on neighbouring ecosystems, including transboundary effects.

Annex I

MODIFICATIONS TO REMEDIATION PROGRAMME – CLAIM NO. 5000256

KUWAIT – DAMAGE TO GROUNDWATER RESOURCES (PARAGRAPHS 63 TO 83)

1. Kuwait proposes to extract a total of 255.5 million cubic metres of contaminated groundwater over 40 years, and to treat the water using: flow collection; coagulation/flocculation; gravity clarification; granular activated carbon; ozonation; ultrafiltration; and reverse osmosis. Treated water would be reinjected into the aquifers through wells, and the vadose zone would be flushed to remove any remaining contaminants. The modifications indicated in this annex focus the remediation programme on freshwater areas at southern Raudhatain and northern Umm Al-Aish and involve the extraction of a smaller volume of groundwater that is considered as likely to be contaminated. With these modifications, remediation would be completed over a shorter period, using more flexible and less expensive methods of groundwater treatment.

2. Groundwater remediation is to be considered for plumes of contaminated water within the boundaries of the freshwater deposits at Umm Al-Aish and Raudhatain, i.e., the areas with total dissolved solids ("TDS") lower than 2,000 parts per million. Within these areas, contaminated freshwater lenses with a thickness of more than 10 to 15 metres are to be remediated by extraction of the contaminated water. Thinner lenses are to be left to natural recovery to avoid the risk of brackish water intrusion if contaminated groundwater is extracted.

3. To avoid intrusion of brackish water, a total of 5.5 million cubic metres at Umm Al-Aish and 9.5 million cubic metres at Raudhatain could be gradually extracted over a period of 12 to 15 years, using approximately 38 extraction wells at Umm Al-Aish and 38 extraction wells at Raudhatain. Extraction of plumes that are known to be contaminated is to begin immediately, with extraction of additional plumes to begin as soon as they are discovered.

4. Each extraction well (or group of wells located close to each other) is to be supplied with a diesel generator to provide power to run the well's pump. Using generators is less expensive than running electrical power lines to each extraction well and will provide flexibility since generators can be moved easily from area to area as new wells are put into service.

5. Evaporation ponds are to be used as the initial method for the disposal of contaminated groundwater. Several extraction wells and one or more evaporation ponds can be constructed quickly to begin remediation. The effectiveness of evaporation ponds for disposal of contaminated groundwater does not depend on the specific contaminants found in the groundwater. As plumes are detected and extraction begins, evaporation ponds can be built as needed to accommodate the volumes of groundwater being pumped.

6. Square cells, 200 metres on each side and 2 metres deep, are to be built. Using a series of adjacent cells, it will be possible to construct the ponds incrementally to keep pace with installation of extraction wells. This approach will allow draining of individual cells in the event that a leak is

suspected. The ponds are to be lined with a 1.5-millimetre high density polyethylene (HDPE) liner. A geotextile fabric cushion is to be placed under the liner to prevent abrasion or puncture by the soils below. It is advisable to consider building two or more ponds at each freshwater field in order to minimize the piping needed to reach the ponds from extraction wells.

7. Sludge caused by TDS and by windborne particles deposited in the ponds will need to be removed from the evaporation ponds on a regular basis during operations. Once dried, the sludge is to be disposed in a landfill. When no longer needed, ponds are to be closed in place by removing the liner and geotextile on the berms and then back-filling the ponds with clean soil. The liners at the bottom of the ponds could be left in place. No hazardous materials or TDS are to remain once the ponds are closed.

8. When the specific contaminants in the groundwater have been identified and studies on the feasibility of alternative treatment methods are completed, it might be preferable to treat contaminated groundwater for reuse rather than disposing of it in evaporation ponds. Alternative disposal methods such as deep well injection of contaminated groundwater with oil production brines might also be considered. Any change of remediation measures is to be based on a consideration of the full range of benefits and costs of treating contaminated groundwater for reuse as compared to disposal.

9. Extraction of a total of 15 million cubic metres of contaminated groundwater over a period of 12 to 15 years will reduce the volume of freshwater at Umm Al-Aish and Raudhatain. While natural recharge from rainfall will replace the extracted water over time, this process could last many years. Thus, to restore the freshwater deposits, potable water will need to be recharged in the general areas where extraction takes place. The volume of water recharged over time will have to be equal to the volume of contaminated groundwater extracted.

10. Construction of the recharge well system is to be delayed for several years after groundwater extraction begins. This will allow time for the initial plume extraction areas to be ready for recharge; and will also give enough time for a determination to be made whether it is advisable to treat the extracted water to potable standards and recharge it to the aquifers.

11. For recharging the aquifers with potable water, approximately eight recharge wells at Raudhatain and four recharge wells at Umm Al-Aish will be sufficient. Each well is to have a 20-centimetre diameter bore and be cased with stainless steel. Well depths are to range between approximately 70 metres at Raudhatain and approximately 61 metres at Umm Al-Aish. These depths would allow recharge to all three aquifer layers that contain freshwater. Wells at each area would be piped to a 200-cubic-metre tank, and recharge wells would be fed by gravity flow from the tank. Provision is to be made for annual maintenance on each well and for power to run the pumps that distribute the potable water to the storage tanks.

12. Potable water for recharge could be produced by treatment of contaminated groundwater, as discussed in paragraph 8 of this annex. Alternatively, potable water for recharge could be purchased from existing desalination plants, or could be produced near Umm Al-Aish and Raudhatain using reverse osmosis technology to desalinate brackish groundwater. A reverse osmosis plant with capacity

of approximately 3,800 cubic metres per day could be constructed near Umm Al-Aish and Raudhatain. Potable water from this reverse osmosis plant could be piped to the 200-cubic-metre tanks serving the recharge wells. Two supply wells could be used to produce brackish groundwater for treatment, at distances of up to 1.5 kilometres from the reverse osmosis plant. In addition to potable water, the reverse osmosis plant would produce a concentrated brine waste stream that could be disposed into a deep injection well drilled into the saline groundwater below and away from the freshwater aquifers.

13. Continuous monitoring will be required to evaluate the progress of the remediation actions outlined in paragraphs 2 and 3 of this annex, and to monitor the status of the groundwater contamination plumes to be remediated using natural recovery. This monitoring will be additional to the monitoring and assessment projects funded by awards in the first instalment of "F4" claims (claim Nos. 5000374, 5000375, 5000376).

Annex II

MODIFICATIONS TO REMEDIATION PROGRAMME – CLAIM NO. 5000450

KUWAIT – REMEDIATION OF AREAS DAMAGED BY MILITARY FORTIFICATIONS (PARAGRAPHS 92 TO 105)

1. Kuwait proposes to apply a 2.5-centimetre layer of gravel to the disturbed soil surface in order to stabilize the 6.25 square kilometres of desert damaged by construction and backfilling of fortifications. Gravel stabilization is an established remediation technique and is appropriate for soils with a physical crust and low concentrations of loose sand upwind of the areas to be remediated.

2. In this case, gravel stabilization is suitable for sites located in areas where soil conditions suggest that the greatest benefits will be derived. These are the desert pavement and compacted sites that exhibit a much lower natural recovery response, generally in areas with five of Kuwait's soil types, namely, calcigypsids, haplocalcids, petrogypsids, torripsamments and petrocalcids.

3. A reduced gravel stabilization programme can be implemented faster, i.e. in 635 crew-weeks, instead of 1,040 crew-weeks as proposed by Kuwait.

4. Although gravel stabilization can promote revegetation in these areas, full restoration of ecological functions will not occur without restrictions on uncontrolled land use. In particular, it will be necessary for measures to be taken to protect the sites from overgrazing by livestock and the use of off-road vehicles.

Annex III

MODIFICATIONS TO REMEDIATION PROGRAMME – CLAIM NO. 5000450

KUWAIT – REMEDIATION OF AREAS IN AND AROUND WELLHEAD PITS (PARAGRAPHS 106 TO 119)

1. Kuwait proposes to remediate hydrocarbon contamination at 163 wellhead pits by excavating contaminated soil and treating it with high thermal temperature desorption, backfilling the excavated pits with the treated soil, and stabilizing the surface of the backfilled pits with a 2.5-centimetre layer of gravel.

2. A remediation programme combining excavation and off-site landfilling for some wellhead pits and a closure-in-place option for others would be a less costly approach. Moreover, it is more likely to protect human health and restore ecological functions in the wellhead pit areas.

3. For purposes of remediation, wellhead pits are to be divided into two categories. The first category includes 19 wellhead pits that are directly above the freshwater aquifers in Kuwait's northern oil fields. The second category includes all the remaining wellhead pits identified in the claim. For both categories, further testing needs to be conducted and remediation implemented, as necessary, to eliminate any risks to the aquifers or other parts of the environment.

4. For the 19 wellhead pits that pose direct risks to freshwater aquifers, the appropriate remediation is excavation and landfilling. To prevent leakage of contaminants from the wellhead pits to groundwater, the landfill approach needs to include a clean closure of the pits. This involves the removal of all petroleum-contaminated soil located within the pits or surrounding berms. The excavations are then backfilled with clean soil and provided with a 2.5-centimetre stabilizing layer of gravel to prevent wind erosion and promote revegetation. The clean fill for the pits can be taken from the landfill excavation or from local sources of fill material.

5. The same 19 wellhead pits are appropriate for clean closure (i.e. they need to be excavated until there is no visible oil contamination and then backfilled with clean soil). The total excavated material from the 19 pits would be approximately 70,000 cubic metres. This would require a single, square landfill facility of about 100 metres on each side, with a depth of approximately 10 metres. The landfill could be constructed such that, once closed, it would be completely below grade, with no visible presence.

6. Once a landfill is suitably closed, there is an extremely low risk of infiltration of hydrocarbons into the underlying groundwater. Hence, the construction of the landfill with an appropriate liner system and cap will prevent any potential contaminants from migrating into the underlying groundwater, especially given the low rainfall in the area. As an additional precaution it may be advisable to locate the landfill inside the fenced oil field areas in order to bring it under the institutional control applicable in those areas. Furthermore, any landfill facilities constructed within

the northern oil fields should be located outside the infiltration catchment areas for the underlying freshwater aquifers.

7. For all remaining wellhead pits in Kuwait, closure-in-place provides an appropriate means to minimize human health and ecological risks and restore ecological functions. Closure in place involves the levelling of contaminated pits, which are then covered, using an engineered low-permeability cover. This will minimize infiltration of rainwater and thereby significantly reduce the risk of movement of any remaining contaminants in the pits. The cover is to consist of low-permeability soil materials and might include a geomembrane layer. The affected area needs to be graded to prevent ponding of rainwater on the cover and run-on from adjacent areas. Finally, the cover is to be stabilized with a 2.5-centimetre layer of gravel to minimize wind erosion and promote revegetation. The resulting closed pit will isolate any contaminants present in the backfill by eliminating exposure pathways.

Annex IV

MODIFICATIONS TO REMEDIATION PROGRAMME – CLAIM NO. 5000450

KUWAIT – REMEDIATION OF AREAS DAMAGED BY TARCRETE
(PARAGRAPHS 120 TO 132)

1. Kuwait proposes to remediate tarcrete contamination in an area of 271.5 square kilometres by manually excavating the tarcrete layer and stabilizing excavated areas with a 2.5-centimetre layer of gravel; treating the contaminated soil using high thermal temperature desorption; and disposing of the treated material in existing quarries and gatch pits. The modifications indicated in this annex are intended to build on the natural recovery that has already taken place, and they rely on in situ fragmentation of tarcrete followed by the application of organic amendments to the areas of fragmented tarcrete.

2. A remediation programme that leaves the tarcrete in place but manipulates it to enhance natural recovery processes is more likely to result in successful recovery than a programme that involves physical excavation. Indeed, excavation of tarcrete could reduce the success of any revegetation efforts. Manual fragmentation of the tarcrete in situ will accelerate ongoing natural fragmentation while minimizing damage to existing vegetation and soil resources.

3. Manual fragmentation of tarcrete should not require any specialized equipment or procedures. Labourers would break the tarcrete into pieces using shovels and picks. However, instead of excavating it, they would further fragment the tarcrete and leave it in place.

4. Once the tarcrete is fragmented, application of appropriate organic amendments to the fragmented tarcrete will provide additional nutrients and accelerate the recovery process. Appropriate organic matter should be low in available nutrients and slow to decompose. Sources of such organic matter include wheat or barley straw, bark or wood chips, fully composted biosolids, olive cake residue or other readily available organic material. This type of organic matter is more appropriate for improving the physical characteristics of the soil because matter with a higher concentration of nutrient sources would encourage the growth of undesirable invasive weed species.

5. Adding slowly decomposing materials of these types can accelerate development of more complete soil processes by improving soil physical conditions, stimulating microbial activity and regulating levels of available nitrogen. However, further field testing of different amendments will be necessary to identify the most effective organic matter for tarcrete areas, the appropriate application rate and the timing of the application.

6. Organic soil amendments will also help to provide shelters and construction materials for soil invertebrates such as termites, which produce surface structures in these environments that result in the progressive burial of stones, gravel and solid deposits including tarcrete fragments. The organic matter will also be used by a number of other invertebrate decomposers and thus indirectly stimulate

their predators, especially ants, whose activities are also beneficial to the soil. These organisms are able to use low quality organic residues that they fragment and partly digest.

7. Fragmentation of tarcrete and addition of soil amendments will be beneficial throughout the area affected by tarcrete. Even where the tarcrete is already fragmenting, further break-up of the surface can be expected to accelerate the ecosystem recovery process. The only exception would be the area just outside the Burgan oil field fence (approximately 71 square kilometres) where the tarcrete has already been completely broken up by livestock grazing. This area would benefit from the addition of soil amendments only if it is adequately fenced to prevent further grazing by domestic livestock during the recovery period.

8. From a physical and biological perspective, fragmentation of the tarcrete has a variety of benefits that enhance the ecological recovery process. At all sites, fragmented tarcrete will promote recovery of vegetation by serving as a medium for trapping seeds and organic matter and storing moisture.

9. Enhancing natural recovery through manual fragmentation of tarcrete will require two important support activities. First, the site will need to be monitored for unexploded ordnance during the tarcrete fragmentation process in order to minimize risks to workers at the sites. Second, additional security measures will be needed in the areas controlled by the Kuwait Oil Company because of the increased number of workers who will be engaged in tarcrete fragmentation in those areas.

10. A long-term remediation monitoring plan that collects relevant data before, during and after implementation of remediation should be carefully integrated into the remediation programme. During the course of the project, remediation activities are to be adapted in response to data and analysis developed through the monitoring programme. This provides opportunities to identify and address negative impacts of remediation activities, if any arise. It will also assist in identifying successful remediation approaches.

Annex V

MODIFICATIONS TO REMEDIATION PROGRAMME – CLAIM NO. 5000450

KUWAIT – REVEGETATION OF DAMAGED TERRESTRIAL ECOSYSTEMS
(PARAGRAPHS 133 TO 152)

1. Kuwait proposes to revegetate areas within approximately 3,500 square kilometres of its territory damaged by military fortifications, mine fields, vehicle tracks, and berms and sand walls using shelter belts and revegetation islands established for that purpose. The areas involved are suitable for revegetation, subject to certain refinements that would help to improve the success of the revegetation programme and reduce the cost of the shelter belts and revegetation islands.

2. Natural revegetation should be relied upon as much as possible in the revegetation islands. Transplanting of seedlings and seed planting, in conjunction with irrigation and the application of soil amendments, will be necessary in only 15 or 30 per cent of each 6-square-kilometre revegetation island area. Thirty per cent revegetation is appropriate in areas of active sand dunes and exposed gatch where the natural recovery processes are considerably slower than on the remaining lands. Approximately one-quarter of the revegetation islands appear to be located in such areas. Fifteen per cent revegetation will be adequate for the remaining islands. The inclusion of some planted areas in the revegetation islands is needed to increase biodiversity beyond what would result if only natural reseeding processes were used.

3. For revegetation to be effective it is necessary to protect the areas concerned from overgrazing and off-road vehicle use. This will enable the biota of the areas to develop and grow in the existing soil and climatic conditions. Protection can be achieved by fencing the revegetation islands.

4. Although active replanting is only necessary on a relatively small portion of the revegetation island area, organic soil amendments would be beneficial across the entire 6-square-kilometre protected area. The organic matter suitable for this purpose should be low in available nutrients and slow to decompose. This type of organic matter is essential for improving the physical characteristics of the soils because organic matter with higher concentration of nutrient sources would encourage the growth of undesirable invasive weed species.

5. Sources of such organic matter include wheat or barley straw, bark or wood chips, fully composted biosolids, olive cake residue or other readily available organic materials. Adding slowly decomposing materials of these types (i.e. materials with high carbon to nitrogen ratios) can accelerate development of more complete soil processes by improving soil physical conditions, stimulating microbial activity, and regulating levels of available nitrogen.

6. Organic soil amendments will also help to provide shelters and construction materials for soil invertebrates such as termites, which produce surface structures in these environments that result in the progressive burial of stones, gravel and solid deposits including tarcrete fragments. The organic

matter will also be used by a number of other invertebrate decomposers and thus indirectly stimulate their predators, especially ants, whose activities are beneficial to the soil.

7. It will be necessary to develop a local facility with the capability to produce the large numbers of seeds and plants required by the programme. Since the focus of the revegetation effort will be on a wide variety of native species which are not necessarily amenable to greenhouse-scale production, it would be useful to establish a germination laboratory to provide ongoing seed testing and evaluation during the life of the project.

8. Drought can drastically affect vegetation, especially in stressed, degraded or recovering systems. It is, therefore, necessary to provide for an irrigation system for the revegetation areas, in the event that rainfall is inadequate to support recovery and establishment of newly planted vegetation. However, instead of supplying water to the irrigation system by trucks, it would be more cost-effective to have an on-site water supply and drip irrigation system for each revegetation island. Such a system would consist of a well and, where necessary, a reverse osmosis system for purifying brackish water prior to use. Grass for these areas will most probably be established from seed, and a combination of precipitation and residual moisture from the drip irrigation system can provide adequate moisture for its healthy growth.

9. A number of maintenance and monitoring efforts will be needed to ensure the success of the revegetation program. Careful monitoring will need to be conducted to assess the effectiveness of the production and planting methods, species selection, amendments and irrigation programme. The results of the monitoring will make it possible for the programme to be modified as necessary to maximize its success. Two-person monitoring teams, consisting of an ecologist and a technician will need to spend approximately half a week per month at each revegetation island. In addition, maintenance replanting will be required in order to achieve the desired species variety and density. This will involve three years of maintenance replanting at 30 per cent of the initial planting level each year, for a total replanting effort equal to 90 per cent of the initial effort.

10. It will not be necessary to undertake inoculation of plants and application of fertilizer. Existing communities of the appropriate organisms in the areas to be remediated will be adequate to support the revegetation effort. If the soil used to grow seedlings is taken from local sources, it will already contain appropriate organisms. Additional fertilizer beyond the organic amendments would encourage excessive growth of undesirable invasive weed species.

11. Shelter belts, designed to trap mobile sand upwind of the revegetation islands, are an integral component of the revegetation programme. The proposal to use a biological wind-break of trees and fences is appropriate, but with some modifications:

(a) First, three rows of trees in each shelter belt will be sufficient.

(b) Second, impounding fencing is only needed before the trees are fully established. Thereafter, experience suggests that the trees will successfully impound mobile sand. If sand

overwhelms a fence before the trees are fully established, it will be more cost-effective to construct a replacement fence.

(c) Finally, monitoring of the shelter belts could be combined with monitoring of the revegetation islands. The monitoring teams for the revegetation islands, as described in paragraph 9 of this annex, should be able to effectively monitor the success of the shelter belt programme as part of their work at each revegetation island.

Annex VI

MODIFICATIONS TO REMEDIATON PROGRAMME – CLAIM NO. 5000451

SAUDI ARABIA – DAMAGE TO COASTAL RESOURCES (PARAGRAPHS 169 TO 189)

1. Saudi Arabia proposes to remediate 20 areas along its coastline between the Kuwait border and Abu Ali. In these areas, it proposes to excavate and remove material that is visibly contaminated. During the excavation, salt marsh and tidal flat areas would be isolated from the sea by the construction of seawalls and dikes; these would be progressively removed as the work is completed in each area. Following sediment excavation, residual contamination in remaining sediments would be treated with bio-remediation techniques. The excavated material would be treated using high temperature thermal desorption at a number of facilities to be constructed for that purpose. Treated sediments would be blended with dredged subtidal sediments and replaced in excavated areas. The salt marshes would be revegetated after bio-remediation treatment. Saudi Arabia states that it will review and modify the remediation programme as additional information from its monitoring and assessment studies becomes available.

2. It is preferable to rely on natural recovery in areas where the presence of oil is not impeding ecological recovery or where active remediation could result in adverse impacts approaching or exceeding expected environmental benefits. This appears to be the case especially in the following areas:

(a) Areas of sabkha, marsh, tidal flat and rocky shoreline habitat where there is only light oil contamination;

(b) Areas where residual oil has not formed a barrier to recolonization and is unlikely to do so in the future, usually because it is present in relatively low concentrations or below the working depths of the crabs, snails and other fauna and flora; and

(c) Salt marshes where natural recolonization by salt marsh plants has occurred or is in progress.

3. Remediation in these areas would be counterproductive because it is likely to reverse some of the recovery that has already occurred. Furthermore, the physical alteration of the shoreline could result in slower subsequent recovery.

4. In areas where active remediation is found to be appropriate, more reliance is to be placed on in situ techniques that are commonly used by oil spill remediation experts to deal with shoreline pollution from oil spills. These techniques include tilling, mixing, sediment relocation and channelling, as described below:

(a) Tilling/mixing – Surface oil and algal mat is broken up and subsurface oil is exposed to accelerate the natural removal and weathering of oil by the atmosphere, waves and tidal processes. Tilling and raking are used to break up the oil-contaminated sediment layer. Digging and ploughing

turn over or displace the sediments or algal mat. These techniques may be most appropriate for breaking up surface and near-surface layers of oil and algal mat.

(b) Sediment relocation – Oil-contaminated material is moved from the upper to the lower shore to accelerate the natural weathering and removal of oil. The physical action of the waves in the lower shore zone is greater and is sustained for longer periods compared to the upper shore. Tidal action returns the cleaned sediments to the natural topographic contour over time. This technique would be applicable at open beaches where there is sufficient wave action to physically rework the oil-contaminated sediments.

(c) Manual channelling – Salt marsh sediment is scored with a hoe to increase the amount of time that tidal water is present in the vicinity of the sediment ("micro-canalization") and to encourage tidal water to penetrate further into the sediments.

(d) Mechanical channelling – Sediment is removed to clear channels blocked by oil or filled with sediment (due to the cessation of tidal flow), altering the local hydrology. The objective is to allow return of the tidal flow to restore the hydrological character of the affected area.

5. Channelling should be considered for use in supratidal areas without halophytes where improving water circulation may be a necessary precursor to tilling or break-up of algal mats or oil-contaminated sediment. In some cases, the supratidal zone is not heavily contaminated with oil, but is dominated by thick algal mats that are a barrier to recolonization. In other cases, the supratidal zone has developed into a hyper-saline lagoon. Careful channelling (whether manual or mechanical) will help to improve water circulation to accelerate weathering of the oil-contaminated sediments and to provide a route for recolonization by crabs and other fauna. Careful, detailed surveys will be needed to design the channelling work.

6. Oil containment booms and other equipment, such as sorbent materials and oil skimmers, are to be used to collect and remove oil that might be released on the water surface by the treatment activities to reduce the risk of adverse impacts on sensitive biota.

7. Ex situ techniques, especially sediment removal, are to be utilized only as a minor component of the overall remedial approach and generally limited to very specific areas where a discrete layer of asphalt pavement or heavily oil-contaminated sediment is present at or near the surface. Excavated areas need to be filled to restore the surface of the site to pre-excavation conditions. To achieve this it is advisable to use material with similar physical and chemical characteristics as the original soil in the area.

8. It is advisable to consider beneficial reuse of excavated material in order to reduce the volume of material that will need to be disposed of.

9. Marsh areas are to be considered for revegetation after the sediment has been sufficiently remediated with one or more of the treatment technologies described above to make it suitable for halophyte growth. Planting is an appropriate means to enhance the natural recolonization of the

habitat and thereby accelerate recovery. Halophytes are extremely sensitive to small changes in environmental conditions, such as tidal elevations; hence prior remediation activities need to be carefully chosen and implemented. Halophytes do not necessarily require the sediment to be completely free of visible oil before they begin to recolonize and slowly break up the remaining oil, making the sediment more acceptable for recolonization by crabs and other fauna. Revegetation is likely to be time-consuming and labour-intensive; however, it is unlikely to have adverse environmental effects and has the potential to significantly accelerate the restoration of a natural, healthy biotic community in these areas.

10. Planning needs to focus on developing detailed, site-specific guidance for clean-up teams, and is to be based on existing rapid assessment data and additional field visits by multidisciplinary remediation planning teams.

11. Multiple rounds of treatment will be required in some areas. In many areas, it is unlikely that a single round of treatment will be sufficient to meet restoration goals. At some sites it may be clear from the outset that multiple treatments will need to be applied over time (for example, micro-canalization of marsh sediments, followed by tilling or targeted breaking up of algal mat to allow other biota to recolonize). Also, initial remediation efforts may be less successful than expected in some areas, and these areas will require additional attention.

12. A long-term monitoring plan that collects relevant data before, during and after remediation activities needs to be carefully integrated into the remediation programme. During the course of remediation, it is essential for remediation activities to be adapted in response to data and analysis developed through such a monitoring programme. This will provide opportunities to identify and address negative impacts of remediation activities, if any arise. It will also assist in identifying successful remediation approaches.

13. Criteria for the evaluation of the remediation programme need to be specified before the monitoring programme is implemented. The planning team needs to consider carefully how data collected by the monitoring programme will be used to evaluate and potentially alter remediation decisions. Where quantitative indicators of ecological conditions are utilized, it is essential to determine in advance the number of samples that need to be collected in order to make meaningful statistical comparisons. It is also advisable to increase the number of monitoring transects devoted to reference sites, based on the observed variability in habitats, the shoreward extent of oil contamination, shoreline slope, sediment type, exposure to winds, tides and waves and the presence of embayments.

GLOSSARY

aquifer:	Natural water-bearing geological formation found below the surface of the earth.
berm:	Mound or wall of earth.
biomarker fingerprinting:	Method for determining the source of oil contaminants based on analysis of petroleum components that remain detectable and relatively unchanged in oil residues even after natural environmental weathering and biodegradation.
boom:	Floating barricade used to contain oil spills.
calcigypsids:	Sandy or loamy soils forming a great group of the gypsid suborder of the aridisol soil order.
clean closure:	Removal or decontamination of all waste residues, contaminated system components and subsoils, including the removal of all wastes, liners, leachate and other contaminated materials that pose a substantial present or potential threat to human health or the environment.
closure in place:	Placement of a cover system over a waste disposal area designed to minimize infiltration and erosion of contaminants into soil or groundwater.
coagulation/flocculation:	Collection of water flows from various sources in a tank or chamber prior to further processing or treatment. In the coagulation/flocculation phase of water treatment, a chemical (e.g. alum, iron salts or lime) is added to the water to be treated. With stirring, the chemical additive causes small particles of silt and other impurities to form clumps which can be removed by subsequent processes.
flow collection:	Collection of water flows from various sources in a tank or chamber prior to further processing or treatment.
freshwater lens:	Body of freshwater floating on top of brackish water in an unconfined aquifer.
gatch:	Gypsiferous soils containing a hardened layer that limits or prevents root growth.

geomembrane:	Impermeable thin sheet of rubber or plastic material used primarily as a liquid or vapour barrier.
granular activated carbon:	Substance produced from a variety of carbonaceous materials. It is used to remove dissolved organic material from water.
gravity clarification:	Water treatment process in which particles suspended in water sink to the bottom of a container. This process may be used after coagulation/flocculation.
halophytes:	Plants which are able to tolerate high salinity in their growth media.
haplocalcids:	Sandy or loamy soils forming a great group of the calcid suborder of the aridisol soil order.
high temperature thermal desorption (HTTD):	Process using heat to separate contaminants from contaminated material. In the process, water and organic contaminants are volatilized from the material. The volatilized contaminants usually require further treatment.
impounding fencing:	Chain link fencing with slats, approximately 2 metres high, placed perpendicular to the prevailing wind direction, for the purpose of preventing the accumulation of mobile sand on revegetated areas.
landfill:	Waste disposal facility on land. State-of-the-art landfills have liners and leachate collection and treatment systems to prevent contamination of surface and groundwater.
leachate:	Water that has percolated through waste material and leached out some of the constituents of the material.
liner:	Relatively impermeable barrier usually made from plastic or dense clay designed to keep contaminants inside a landfill.
oil lakes:	Pools of oil from damaged oil wells and oil spills.
oil production brine:	Liquid that is separated from oil following pumping of oil wells, drilling or during the normal extraction of oil. Most of this material is usually returned underground through injection wells following separation from the oil. Brines are very salty because they are composed largely of sodium-laden waters that are mixed with the oil underground.

organic amendment:	Material containing organic matter such as plant residues, manure, sewage sludge, composts or peat, added to soil to improve its physical, chemical and biotic properties.
ozonation:	Treatment process using ozone to disinfect water and eliminate colour, odour and taste problems.
petrocalcids:	Sandy or loamy soils containing a strongly cemented layer of carbonate accumulation, which form a great group of the calcid suborder of the aridisol soil order.
petrogypsids:	Sandy or loamy soils containing a gatch layer, which form a great group of the gypsid suborder of the aridisol soil order.
reverse osmosis (RO):	Water treatment process that removes contaminants from water using pressure, forcing water molecules through a semi-permeable membrane. Reverse osmosis removes ionized salts, colloids, and organic molecules down to a molecular weight of 100. The process is also called hyperfiltration.
sabkha:	Arabic term for salt flat, usually located in areas of groundwater discharge exposed only rarely to free-standing sea water. Sabkha soils may have strength in the surface hypersaline crust when dry, but once wetted or disturbed exhibit very low strength and bearing capacity.
shelter belt:	Trees, shrubs, or other vegetation, usually planted perpendicular to the principal wind direction, to protect soil and crops against the effects of wind, such as wind erosion and the drifting of soil.
supra-littoral:	Spray zone of the shore, located above the highest astronomical tide; seawater penetrates these elevated areas rarely (e.g., during storm surges coincident with the highest tides).
tar mat:	Crust of spilled oil and soil which forms a pavement-like surface.
tarcrete:	Oil contamination consisting of dry tar and soil forming a thin oil crust with no visible contamination of the underlying soil, resulting from deposition of oil droplets.
torripsamments:	Sandy soils forming a great group of the psamment suborder of the entisol soil order.

total dissolved solids (TDS):	Measure of salinity. The total weight of solids dissolved in water is determined by filtering a given volume of water, evaporating it at a defined temperature and then weighing the residue.
total petroleum hydrocarbons (TPH):	Term used to describe a class of several hundred chemical compounds, comprising mainly hydrogen and carbon, often present in oil.
ultrafiltration:	Filter technology that removes some suspended or dissolved solids from water or other liquids. It is especially useful for removing suspended oil, grease, and fine solids from water and is used in a variety of water treatment processes.
vadose zone (also called zone of aeration or unsaturated zone):	Area between the land surface and the water table, including the root zone, the intermediate zone and capillary fringe where pore spaces contain water, as well as air and other gases, at less than atmospheric pressure. It may include water-saturated portions.
wadi:	Arabic term for streambed or other natural depression that is dry except during the rainy season.
wellhead pit:	Excavation in the ground for the purpose of storing sea water used in fighting oil well fires.
