BRGM

L'ENTREPRISE AU SERVICE DE LA TERRE

compte rendu de mission aux Pays-Bas

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INTRODUCTION

Cette mission vient à la suite de deux précédentes effectuées aux Pays Bas, la première (18-19/11/1987) au Service géologique(1), la seconde (15-19/2/1988) auprès d'une dizaine d'autres organismes(2).

La présente mission a comporté :

- une visite au Service central de Planification (R&D) installé à Zwolle (8.10.1990) ;
- une discussion avec E.A.J. de MULDER du Service géologique RGD) sur la cartographie thématique en zone urbaine, précédant la cérémonie officielle d'inauguration des nouveaux locaux du RGD (9.10.1990) ;
- une visite à l'Institut de Recherche pour la Gestion de la nature (RIN) à Leersum (10.10.1990) ;
- une discussion avec le Directeur R&D de la société d'état VAM, gestionnaire de la grande décharge de Wyster, décharge que nous avons visité le 11.10 ;
- une série d'entretiens au RIVM pour actualiser ou compléter les informateurs acquises sur le RIVM en 1988.

Les contacts ont été pris directement avec RIN, RIVM et VAM. Le RGD (C. Van STAALDULNEN) nous a introduit auprès du RPD.

Les conclusions (p. 51 et 52) tiennent lieu de résumé de ce rapport.

(1) DS n° 50 du 8.02.1988.

(2) DS n° 93 du 30.03.1988.

1 - SERVICE CENTRAL DE PLANIFICATION (RPD)(1)

Le RPD (Rijksplanologische Dienst) est rattaché au Ministère de l'habitat, de la Planification et de l'Environnement (VROM). Le ministère regroupe environ 8000 personnes (dont 270 pour le RPD), réparties en directions :

- développement (DSEO),
- planification (DRP),
- politique (DRI).

Nos interlocuteurs du 8 octobre dépendent du Département "Systèmes d'information (SI) du RPD (Figure 1). Il s'agissait des Dr. W.M. de JONG responsable de la recherche et J.H. R Van der SCHUIT chef de la division cartographique. Le responsable du département C.A. Van KAMPEN a été rencontré le 9 octobre lors de la cérémonie d'inauguration des nouveaux locaux du RGD. J. JELLEMA, responsable des développements de système a quitté le RPD pour le RGD où il remplace Van KUILENBERG que j'avais rencontré en 1987(1).

Tout le Département est localisé à Zwolle et comprend environ 25 personnes plus des temporaires. Le coût de fonctionnement de l'équipe est de 3,4-4 M florins par an. L'ensemble des coûts de développement a été estimé à 8 M florins.

1.1 - RÉPARTITION DES TÂCHES DE PLANIFICATION

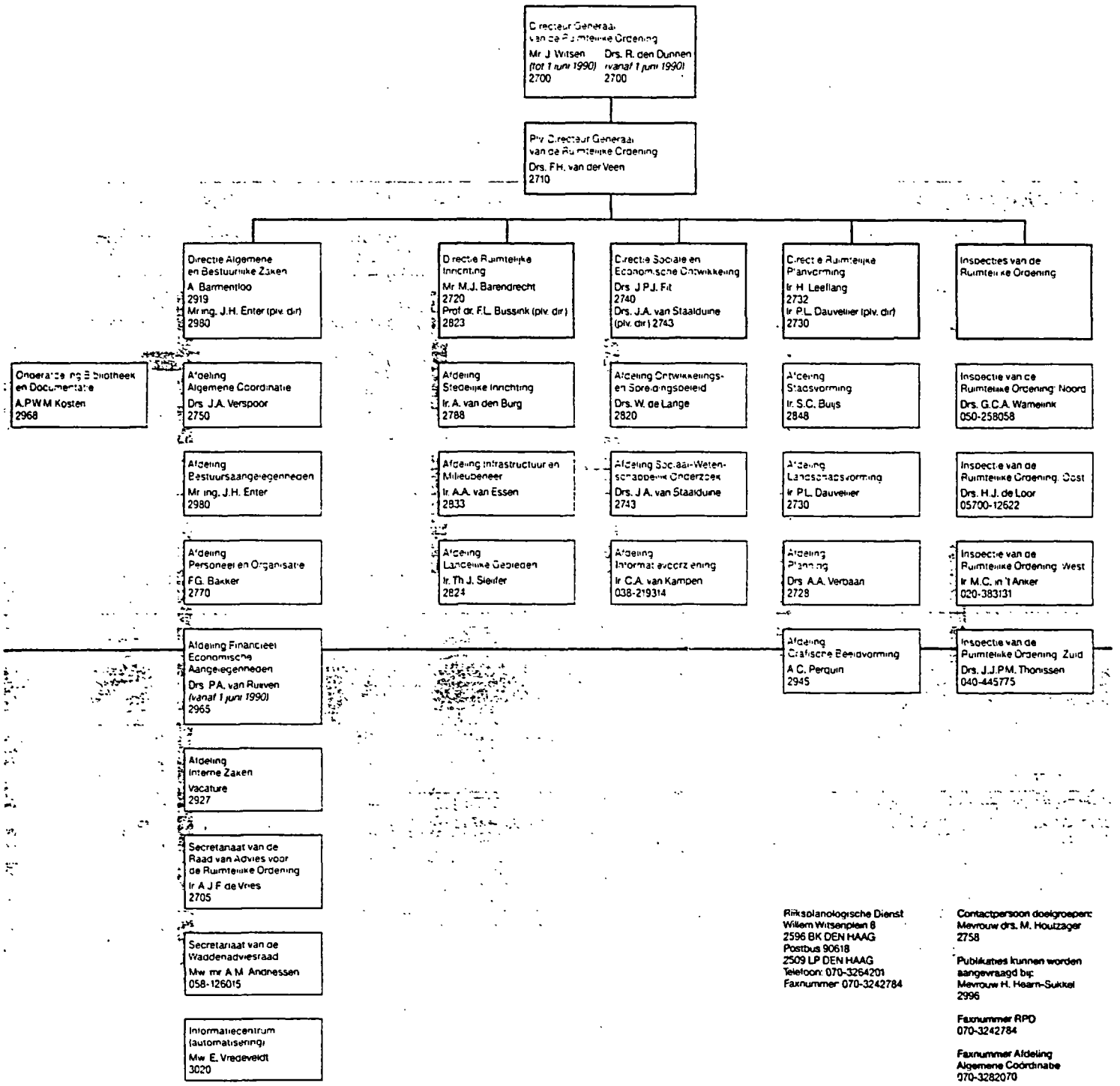
Le RPD est directement responsable de la planification à l'échelle du pays entier. Ceci se traduit par des documents à petite échelle (± 1.000.000). Ce plan national marque des évolutions de stratégie générale au niveau du pays. Il est revu tous les 10 ans environ. Le premier a concerné l'ouest du pays seulement et a été publié après la première guerre mondiale. La deuxième date de 1966, le troisième de 1976 et le dernier de 1988.

Les plans provinciaux sont de la responsabilité des provinces (12). Il en existe une trentaine correspondant à des sous ensembles dont les limites s'inscrivent toujours à l'intérieur de celles des provinces.

(1) DS n° 50 du 8.02.1988.

FIGURE 1

Source : document RPD



Les 714 communes du territoire sont responsables de leur planification. Dans les communes rurales, l'échelle de travail varie entre 1/1000 et 1/5000 ; dans les communes urbaines entre 1/500 et 1/1000.

Dans l'esprit, ces trois échelles de planification sont intégrées, elles ne le sont pas au niveau cartographique. Il n'y a donc pas de système de type GIS permettant de passer d'une échelle à l'autre. En outre, les légendes sont hétérogènes. Le niveau d'informatisation varie également beaucoup. En général, l'information relative aux communes de plus de 100.000 ha est digitalisée(1). Sept provinces disposent d'ARC-INFO.

Le cadastre est sous la tutelle du même ministère que le RPD. Le programme d'informatisation ne porte actuellement que sur 10 à 15 % du territoire. Son achèvement s'étalera sur 15-20 ans.

La couverture topographique est assurée par l'Institut topographique, situé à Emmen. L'échelle de base est le 1/10 000 qui est généralisée au 1/25 000. Il existe également le 1/50 000 et le 1/250 000. Seule le 1/250 000 a été informatisé (demande NATO). Une partie de l'activité topographique est soutenu par le Ministère de la Défense.

1.2 - DÉTAILS SUR LES ACTIVITÉS DU RPD

1.2.1 - Architecture informatique et source des données

Le RPD centralise pour ses besoins des données, dont le rassemblement relève d'organismes extérieurs.

Il y a trois principaux types de données :

- population, habitat, travail ;
- nature, environnement, paysage,
- infrastructure.

Le détail des organismes fournisseurs d'information dans ces trois catégories est donné dans le tableau 1. L'informatisation est présentée globalement à l'échelle du pays, selon des entités administratives (provinces, communes) ou par pixel de 500 x 500 m, 1 x 1 km, 2 x 2 km.

(1) C'est vrai en particulier des grandes agglomérations (Rotterdam, Utrecht, Amsterdam) qui disposent de services techniques structurés. Un contact à Rotterdam : Peter AMERS, Service du Développement urbain, Systèmes d'information (GIS), tél. : (010) 489.5167.

TABLEAU 1

Source d'information du RPD

1 - POPULATION, HABITAT, TRAVAIL

CBS Voorburg/Heerlen	Bureau central de statistiques
PTT	Postes et Télécommunications
Ministerie SZW Den Haag	
Ministerie EZ Den Haag	
Ministerie WVC Den Haag	
Ministerie O en W Zoetermeer	Ministère de l'éducation et des sciences
Provinciale diensten	Bureaux provinciaux
ETI's	
OOM Zwolle	
Topografische Dienst Emmen	Service topographique Emmen
NV Databank Woerden	S.A. DatabankWoerden
VastGoedMarkt Amsterdam	Marché immobilier, Amsterdam
Nationaal Ziekenhuis Instituut Utrecht	Institut national des hôpitaux, Utrecht
Bedrijfsschap Horeca Den Haag	Association hôtelière
DGVH	
EIB	
Gewestelijke Arbeidsbureau's	Agences pour l'emploi
Vereniging Kamers van Koophandel	Association des chambres de commerce
Rijksgebouwendienst	Service de la construction et de l'entretien des bâtiments d'Etat
Nederlandse Bioscoopbond	Association néerlandaise des salles de cinéma
Nederlandse Sportfederatie	Fédération sportive

2 - NATURE, ENVIRONNEMENT, PAYSAGE

CBS Voorburg / Heerlen	Bureau central de statistiques
Ministerie LNV, Den Haag	
Ministerie van Defensie Den Haag	Ministère de la Défense, La Haye
Provinciale diensten	Bureaux provinciaux
Topografische Dienst Emmen	Service topographique d'Emmen
Kampeerraad Amersfoort	Office des campings, Amersfoort
Landinrichtingsdienst	Soutien de l'occupation du sol
Directie Beheer Landbouwgronden	Direction de la gestion des terres agricoles
RIVM Bilthoven	Institut de recherche sur la santé publique et l'hygiène de l'environnement
Stichtingen Landschappen (provincial)	Fondation pour la protection des paysages
Vereniging Natuurmonumenten	Association pour la sauvegarde des monuments naturels
Staatsbosbeheer Utrecht	Service forestier, Utrecht
NMF	
STULM	
Staring Centrum	Institut des sciences du sol, Wageningen
DGM Leidschendam / TNO Apeldoorn	DGM Leidschendam (TNO Apeldoorn)
NRIT Breda	NRIT Breda
KLM-Aerocarto	KLM-Aerocarto
Hansa-Luftbild	Hansa - photographies aériennes
Rijksgeologische Dienst	Service géologique
Landbouw Economisch Instituut	Institut économique pour l'agriculture
Rijksinstituut voor Natuurbeheer (RIN)	Institut de recherche pour la gestion de la nature

TABLEAU 1 (suite)

Rijksdienst voor de Monumentenzorg	Service de gestion et de protection des monuments historiques
Rijksdienst voor Oukeidkundig	
Rijksdienst voor Bordemonderzock	Service de la recherche archéologique

3 - INFRASTRUCTURE

CBS Voorburg / Heerlen	Service central des statistiques
NS Utrecht	Société des chemins de fer, Utrecht
Rijksluchtvaartdienst (RLD)	Service de la navigation aérienne
Ministerie van Defensie	Ministère de la Défense
Topografische Dienst Emmen	Service topographique Emmen
N.V. Nederlandse Gasunie	Gaz des Pays Bas
Rijkswaterstaat / DIV	Travaux publics
Provinciale Waterstaatsdiensten	Bureaux des travaux publics provinciaux
Vereniging van Exploitanten Waterleidingbedrijven (VEWIN)	Union des exploitants de réseaux d'adduction d'eau
Samenwerkende Electriciteis Productie-bedrijven (N.V. SEP)	Electricité
Dienst Verkeerskunde Rijkswaterstaat	Institut des transports routiers
ANWB	Association des automobilistes
KADASTER	Cadastre
NLR	
RIZA	Institut pour les eaux usées (Travaux publics)

Source : document anniversaire pour les 20 ans du SPD

Un des principaux organismes fournisseurs est le Bureau Central des Statistiques qui, tous les deux ans fournit des statistiques d'utilisation de l'espace par pixel et par commune. Les documents cartographiques correspondant sont élaborés par les communes à 1/10 000, à partir de leurs propres documents de planification. En fait, la dernière systématique de ce type disponible date de 1985. Depuis les communes ont demandé à être payées pour ce travail et, faute de pouvoir satisfaire leur demande, une nouvelle approche a été mise en place à partir par traitement de données satellitaires Landsat TM. Cette nouvelle approche associe le Starring Centre de Wageningen (sciences du sol)(1) le RIVM et le bureau d'études DHV à Amersfoot qui a réalisé la classification des données en 16 familles. Ce travail est fait pour les 2/3 des Pays Bas.

Un autre projet en cours avec l'Université d'Utrecht a pour objectif d'intégrer ces données d'occupation de l'espace avec d'autres données physiques ou socio-économiques. L'action est conduite par le Professeur ORMALING de la section cartographique de l'Institut Géographique.

Entre 1970-71 et 1981, le RPD a mis en place un système d'information baptisé KADRO (enregistrement cadastral de la planification de l'espace) organisé selon un système analogue à celui de la Rhénanie Wesphalie. L'échelle de mise en forme de l'information est le 1/25 000. D'abord manuel, ce système de géo-information a été totalement informatisé pour devenir le système BARS dans les années 1980.

BARS est un système vecteur, qui gère environ 46 catégories d'occupation de l'espace. Des entités spécifiques de BARS sont associées à des attributs sur une variété de thèmes : intensité du traffic, propriété d'état de zones particulières, caractéristiques de districts d'activité économique. Le système couvre la totalité des Pays Bas, ce qui correspond à 380 cartes à 1/25 000.

Le système RUDAP est de loin le plus utilisé au RPD. Il contient une banque de données d'environ 3000 variables de démographie, occupation du sol, économie, infrastructure et migrations. L'unité de base est la commune. Le système s'appuie sur des informations collectées depuis 1970 et qui sont fournies par le Bureau Central de Statistiques.

IBV est au premier chef un système de conversion qui inclut toutes les adresses dans les Pays Bas, avec identification d'unités spatiales plus larges comme l'environnement et les municipalités.

LBV est utilisé également pour aggréger des données de différentes banques de données d'adresses diverses au niveau de pixels de 500 x 500 m par exemple. Les banques disponibles concernent les zones de loisirs, les services commerciaux, les installations publiques.

Le système LKN a été mis en place pour les problèmes d'écologie et de paysage, sur la base de pixels de 1 x 1 km. Par pixel, l'information concerne les sols, les caractéristiques de paysage, la flore, la faune, les types d'écotopes, les systèmes aquifères... Les données proviennent de sources très diversifiées. La banque a d'abord été focalisée sur le Randstad (Pays Bas W). On prévoit de l'étendre à tout le pays d'ici 1992.

((1) Voir en particulier MM. BREGT et LENTJES.

(2) DE JONG W.M. (1990) - Geographical information systems database design: experiences of the Dutch national physical planning agency. In: Geographical Information Systems for Urban and Regional Planning, Kluwer, pp. 43-56.

CKN est utilisé pour la cartographie culturelle et historique. Le support est un pixel de 2 x 2 km. Deux dates historiques ont été prises en compte 1840 et 1980 et on a comparé le parcellaire, les schémas de construction, l'infrastructure, la végétation, les phénomènes de retournement de tourbe et la période de première mise en place d'un système de paysage.

Avec le système SvhL, le RPD traite des aspects visibles du paysage en tant que système de rapports de taille verticale et horizontale. Les données sont tirées des cartes topographiques à 1/25 000 et agrégées en pixels de 2 x 2 km.

Le système RPD s'appuie sur la télédétection et correspond à l'action entreprise à partir des données TM évoquée plus haut (Land cover de 16 classes).

Le RPD est engagé dans le montage de ce système de GIS depuis une vingtaine d'années. Le système est maintenant totalement informatisé ou presque dans un environnement ARC-INFO, après l'avoir été sur CAD.

Globalement, le RPD traite donc quatre types de données :

- administratives sous RUDAP ; source unique : Bureau Central de Statistiques ;
- écologiques et d'occupation du sol selon des pixels de 500 x 500 m à 2 x 2 km ; sources très diverses ;
- vecteurs à 1/25 000, 1/250 000 et 1/1 000 000 ; sources très diverses ; orientation zonage de l'occupation de l'espace ;
- adresses, en général traitées par pixels de 500 x 500 m. Le fichier porte sur environ 6 millions d'adresses pour tout le pays. Les données proviennent principalement des PTT.

L'architecture informatique (figure 2) comprend deux ordinateurs PRIME (9955 et 2755) et des terminaux, PC et traceurs variés. Un PRIME 6350 sert pour le projet d'enregistrement des émissions. Deux stations SUN/UNIX et un 386 servent pour le développement des banques de données.

Les systèmes opérationnels sont PRIMOS, UNIX et MS-DOS et la tendance est à une conversion complète sous UNIX. De la même manière, le DBMS INFO doit être remplacé par ORACLE. Pour le GIS, c'est ARC/INFO qui est retenu. Les langages de programmation utilisés sont AML (en liaison avec ARC/INFO), INFO, CWIC (FORTRAN) dBASE III et SQL avec ses extensions. Les langages de programmation de troisième génération sont FORT 77 et C, surtout le dernier en raison de ses facilités d'interfaçage. Les standards graphiques utilisés sont PLOT 10, GKS et CGI.

Le RPD s'est donné de 1989 à 1992 pour mettre en place une organisation géographique centrale, intégrant tous les systèmes développés jusqu'alors, ainsi qu'ORACLE. L'architecture du système est présentée dans la figure 3. La banque centrale est organisée en trois parties : une base thématique qui renferme toute l'information par attributs, une base de situations qui renferme l'information topologique, une base de présentation des produits. L'objet spatial (lignes, points, polygône) constitue la connection centrale entre topologie et attribut.

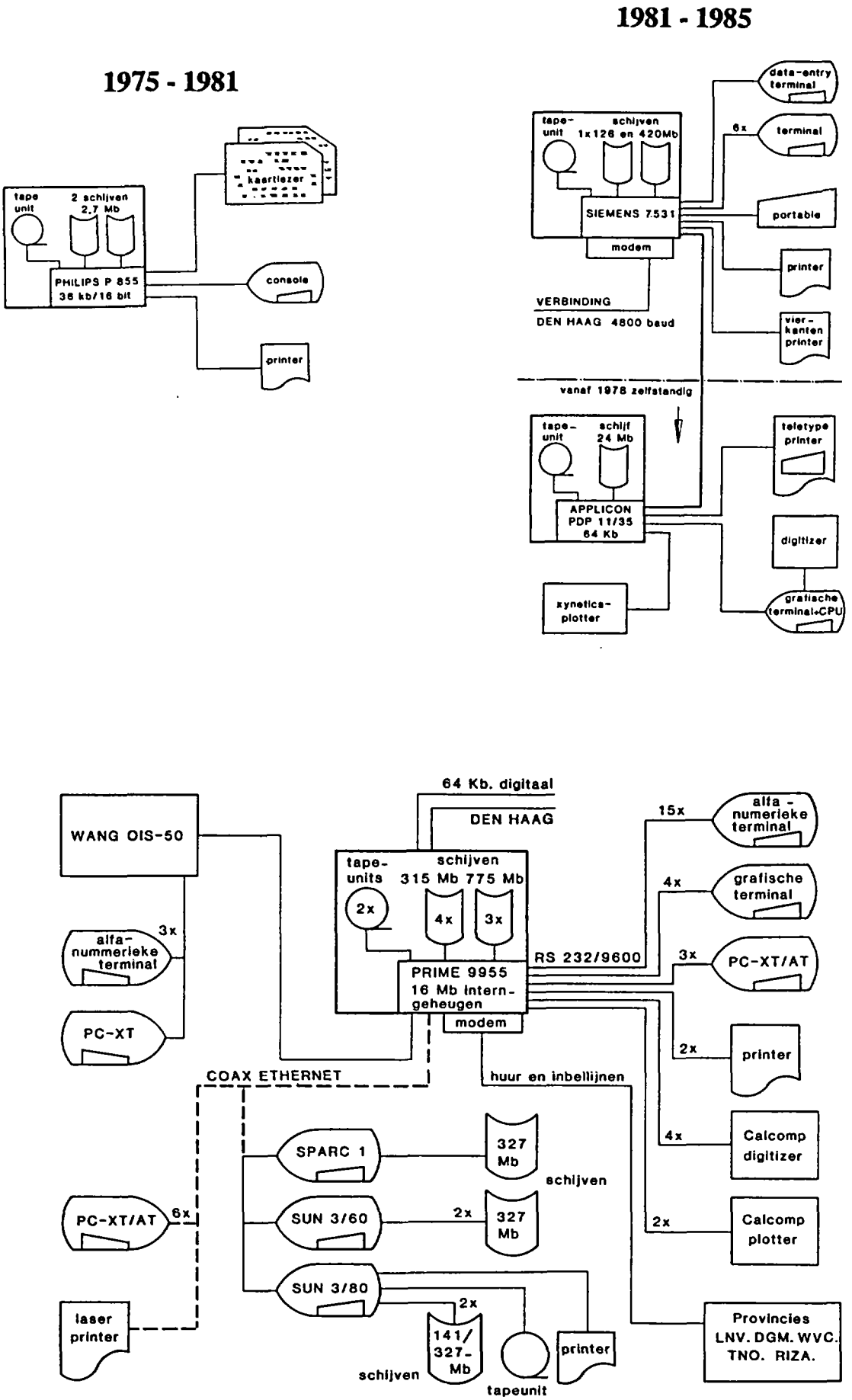


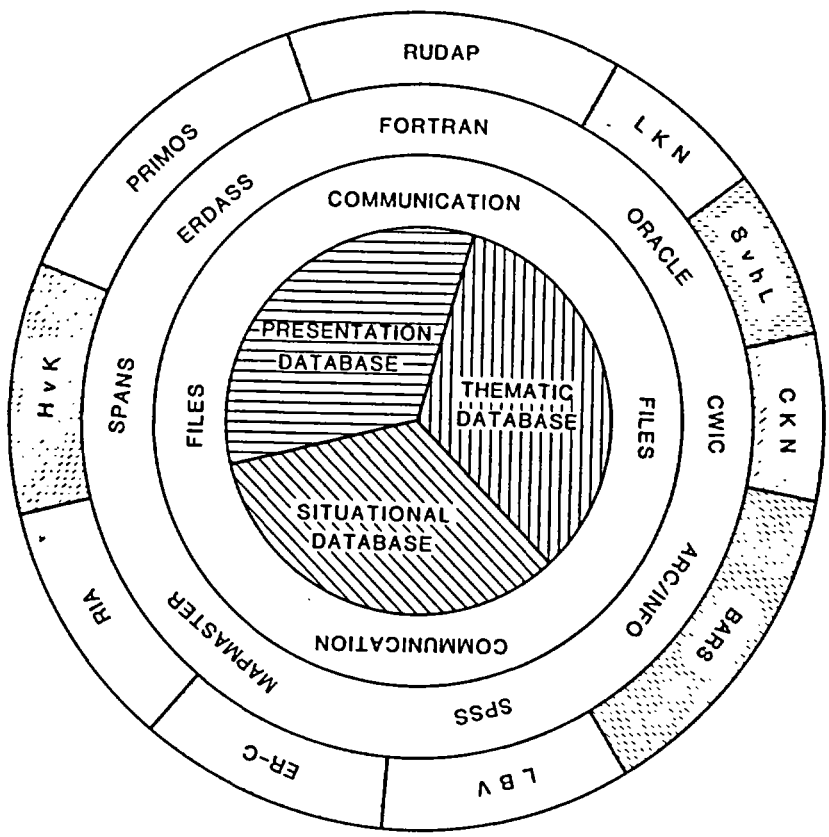
FIGURE 2 - ARCHITECTURE INFORMATIQUE DU RPD

Source : document anniversaire 20 ans du RPD

FIGURE 3

ARCHITECTURE DU GIS DU RPD

Source : réf. 2 p. 10



Les éléments de cette banque peuvent être gérés de façon simple par tous les systèmes existants au RPD, dont ARC-INFO est le principal pour les banques topologique et de présentation et ORACLE pour la banque thématique d'attributs. Le tout est placé dans un environnement UNIX. Dans la banque topologique, on a défini trois familles d'échelle : 1/25 000 à 1/50 000, 1/250 000 à 1/500 000 ; 1/100 000 à 1/5 000 000. Les données pixel stockés sous ARC-INFO le sont par polygônes et points centraux.

1.2.2 - Quatrième Plan National (2015)

Il s'agit d'un plan de politique générale à petite échelle qui insiste sur des changements de qualité, plus que des besoins quantitatifs, la prévention des risques et la coopération entre secteurs public et privé. Cinq principes de base sont pris en compte :

- environnement physique, bien entretenu,
- environnement propre,
- environnement sûr,
- liberté spatiale de choix,
- variété spatiale.

Au niveau de la construction, les besoins sont estimés à 2 M de maisons nouvelles d'ici 2015, l'essentiel avant l'an 2000. La perspective pour le développement urbain est de mettre l'accent sur les besoins d'espace pour la rénovation à l'échelle des régions urbaines et une renovation diversifiée dans les zones d'affaires.

Pour les espaces publics (espaces verts, voies publiques...), l'orientation est l'amélioration des liaisons, la qualité des lieux de rencontre, la cohérence avec l'environnement. Une autre perspective forte est une meilleure accessibilité des centres économiques au transport de marchandises et au trafic passager.

En matière de transport, l'accent est mis sur les transports publics urbains, la liaison entre différents types de transports publics, les sites périphériques pour véhicule privés, l'optimisation du trafic pour différentes finalités.

Pour les déchets, l'optique est : un maximum de recyclage, les économies de matières premières, la protection de l'environnement, la limitation du nombre de sites de traitement. Les autorités provinciales sont en première ligne pour la gestion des déchets.

En matière de développement rural l'accent est mis sur les besoins de conversion et de changements d'usage notamment en liaison avec les règlementations CCE, les fonctions non agricoles de ces régions, la qualité et la variété de l'environnement.

Au delà de ces considérations générales, les propositions les plus concrètes du plan se situent en matière de grandes orientations de développement spatial :

- intersections urbaines : localisation des activités de production et des services associés,
- spécificités régionales : agriculture du Nord, développement international de l'Est et du Sud-Est,
- chaîne urbaine du centre,
- équilibre du Randstad qui regroupe le système des grandes métropoles : Amsterdam, La Haye, Rotterdam. Développement d'une liaison internationale traversant toute la zone,
- amélioration de la qualité de l'eau pour la consommation domestique et industrielle. 10 % du territoire est représenté par des surfaces d'eau. Développement des zones de protection écologique,
- entretien et rénovation des zones rurales : spécificité des zones de production ; développement de la zone des rivières dans la région centrale ; accroissement des secteurs d'activité de loisirs.

En matière de besoins de R&D, les thèmes fléchés sont :

- les changements spatiaux et sociaux dans le contexte européen,
- les développements économiques régionaux,
- la rénovation urbaine,
- les changements d'occupation du sol dans les zones rurales,
- la qualité de l'eau.

1.2.3 - Eventail d'activités thématiques spécifiques du RPD(1)

Ces activités correspondent à des applications spécifiques à partir des trois groupes principaux de données venant de tiers et centralisées au RPD (cf. 1.2.2). Le système permet une variété d'exploitation à la demande à l'échelle du pays est un découpage par provinces ou communes et pour une diversité de thèmes. Le tableau 2 donne un éventail d'applications déjà réalisées.

(1) Cf. Document "Twintig jaur Ruintelijke Informatic-Voorziening in beil gebracht" : 20 ans de mise à disposition de données spatiales, expliqués par l'image. Document élaboré pour les 20 ans du RPD. Archivage SGN/SP.

TABLEAU 2

EVENTAIL D'APPLICATIONS THÉMATIQUES A PARTIR DU SYSTÈME D'INFORMATION DU RPD

- Cartes thématiques de type infrastructure à l'échelle du pays : réseau routier, réseau routier, réseau ferroviaire, lignes haute tension, réseau naviguable, décharges.

- Données diverses réparties par communes.

- Système RUDAP de gestion des données physiques spatiales : pôles de développement de la construction, habitants par km^2, par commune.

- Système MODEST (ARC INFO) pour montrer des flux entre entités administratives (RUDAP-est statique).

- Activités sociales par commune à partir de 10 000 ha.

- Système d'information pour l'Europe du NW : densité de population par région administrative. Basé sur le système CLENUTS.

- Zonage écologie, nature, utilisation des sols, infrastructure routière et ferroviaire, réseaux d'assainissement, hors découpage administratif.

- Choix fondamentaux de planification : agriculture, zones agricoles protégées (nature), nature, zones rares concentrations urbaines, régions sous influence urbaine.

- Régions naturelles : paysages protégés, évolution par années.

- Paysages agricoles protégés.

- Zones inondables : effets d'une élévation du niveau de mer. Collaboration avec Delft Hydraulics.

- Zonage des émissions avec sources, rapporté à l'utilisation de l'espace.

- Zonages en mode raster (pixels de 500 x 500 m, 1 x 1 km, 2 x 2 km) :

  . superficies d'eaux de surface,
  . écologie du paysage,
  . relations sol eaux souterraines : infiltrations, émergence.
  . répartition de la forêt,
  . évolution du parcellaire entre 1840 et 1980,
  . piste aérienne de Rotterdam : répartition de l'habitat proche avec pour objectif le coût de protection contre le bruit,
  . couverture du sol par traitement d'imagerie TM,
  . occupation humaine du sol,
  . répartition des concentrations de camping,
  . capacité hôtelière.

1.3 - CONCLUSIONS

De la visite au RPD, il convient de retenir :

- la faible prise en compte des données de Sciences de la terre dans la planification. L'accent a été mis sur les données socio-économiques et l'occupation de l'espace. Néanmoins, les données du sol sont partiellement prises en compte (elles le sont beaucoup plus au RIVM pour la gestion nationale) de la pollution et, d'après Van KAMPEN, il est prévu d'en tenir beaucoup plus compte à l'avenir ;

- la conception d'une grande diversité de cartes thématiques avec référence aux communes ou à des pixels standards de 500 x 500 m, 1 x 1 km, 2 x 2 km ;

- une grande similitude de préoccupations avec le BRGM pour la mise en place d'un GIS s'appuyant sur ORACLE et ARC INFO. Un échange RPD-BRGM sur ce point me paraît utile, d'autant qu'ils sont dans leur phase de conception et de mise en place du dispositif.

Actuellement leurs relations avec l'étranger sur ce thème se font surtout dans le cadre des conférences organisées par ESRI (ARC-INFO). Le responsable de ce développement informatique est W. SCHAKEWBUS.

A noter que l'ensemble du Département "Systèmes d'Information" du RPD doit être déplacé de Zwolle à La Haye en 1992.

2 - CARTOGRAPHIE GÉOLOGIQUE GÉOTECHNIQUE URBAINE (CGGU) CONDUITE PAR LE SERVICE GÉOLOGIQUE (RGD)

Les informations sur ce chapitre ont été obtenues le 5.10.1990 de E.F.J. de MULDER qui, dans l'organigramme du RGD, est maintenant rattaché à une équipe de chefs de projets (5 personnes dont 1 secrétaire), sous la responsabilité de T.E. SHÜTTENHELM, ancien chef de la géologie marine au RGD et remplacé aujourd'hui par C. LABAN. Les opérations de CGGU ont porté sur deux villes pilotes Amsterdam et Leiden.

2.1 - EXPÉRIENCE D'AMSTERDAM

A **Amsterdam,** les travaux ont concerné deux secteurs pilotes, l'un au centre ville (5 km^2, plus de 400 sondages et essais pénétrométriques par km^2), l'autre en banlieue (5 km^2, environ 40 sondages/km^2).

Ces travaux ont été faits en association avec l'Unité de Recherche pour l'Environnement et la Mécanique des sols (OMEGAM) qui fait partie des Services techniques de la Municipalité(1), Delft Geotechnics l'Université Technique de Delft (Département de Géologie de l'Ingénieur), le Centre de Télédétection d'Entschede, l'Université libre d'Amsterdam. L'idée de l'opération a émergé en 1986, les études ont été faites en 1987 et le rapport publié par OMEGAM, est sorti en 1990. La partie RGD a été financé sur le budget propre du RGD. Les financements n'ont pu être débloqués pour généraliser l'opération.

Les études ont été conduites sur données existantes (sondages, essais pénétrométriques, occupation de l'espace, profondeur des fondations...) avec pour objectif essentiel d'établir un zonage de vulnérabilité à l'aménagement, qui correspond en gros à un risque de compaction de terrains.

L'idée est de convaincre les municipalités de l'intérêt économique de procéder à ce zonage préventivement pour les installations futures.

(1) Contact : Margot PHILLIPART ; Tél. : (020) 59.61.653.

2.2 - ESSAI PILOTE DE LEIDEN

Un deuxième essai a été conduit pour la municipalité de Leiden sur une zone de 9 km^2 comportant 2700 sondages (dont 2200 essais pénétrométriques). L'étude a été conduite dans le même esprit qu'à Amsterdam. Son impact a été beaucoup plus net pour des raisons politiques et financières.

En effet, depuis 25 ans environ, le gouvernement néerlandais subventionne les municipalités urbaines dont plus de 50 % du territoire correspond à des terrains difficiles sur le plan de la constructibalité. C'est aussi qu'Amsterdam reçoit environ 33 M Fl/an à ce titre (> 100 MF) et Rotterdam 18,6 M Fl. A Leiden, avec le redécoupage municipal, le pourcentage de terrains difficiles étant devenu voisin de 50 % ce qui risquait de ramener à zéro les subventions. Le RGD est ainsi arrivé à point nommé pour proposer une approche plus adéquate d'une classification des terrains difficiles.

Dans le système de référence pour les subventions, on regroupe dans une même catégorie les terrains argileux et les terrains tourbeux, ce qui est abusif, les derniers soulevant beaucoup plus de difficultés. Par ailleurs, la puissance minimale de couche difficile est de 5 m.

Le RGD a proposé des critères moins schématiques en mettant l'accent sur la notion de lotissement - aménagement potentiel (potential settlement) pour introduire un zonage d'une région urbaine et cela par combinaison de données lithologiques, géotechniques et géohydrauliques ainsi que l'occupation de l'espace. Cette notion est associée à un coût d'aménagement, qui conduit à privilégier certaines zones pour les développements futurs urbains.

2.3 - EVALUATION ECONOMIQUE

Une analyse coût-bénéfice est proposée pour évaluer l'impact d'une cartographie géotechnique ou thématique au sens large. Cette analyse est proposée en 8 étapes dont les 4 premières correspondent à l'analyses des bénéfices et les 4 suivantes à celle des coûts :

1 - Inventaire des activités concernées : extensions urbaines, sélection de sites constructibles ou de décharge, préparation de sites de construction par drainage ou rehaussement de la topographie, recherche de sites de matériaux ou d'eau douce, recherche de fractures... Dans ce contexte, il convient de distinguer entre les thèmes (fondations, subsidence, sites de contruction, extraction de matériaux...) et les tâches qui peuvent permettre des économies (réduction des coûts de recherche de site) ;

2 - Calcul des coûts. Cette rubrique implique une collaboration étroite avec les autorités qui disposent des données ;

3 - Calcul des économies possibles, par exemple sur les phases de conception et faisabilité des constructions s'il existe une cartographie des profondeurs de fondation. Le tableau 3 donne une idée des économies potentielles ;

4 - Uniformisation et synthèse des économies ;

5 - Inventaire des activités impliquées dans le conseil géologique : études de bureau, acquisition et interprétation des données, mise en forme, divers (coordination et gestion des projets...) ;

6 - Calcul du coût des activités : coût du conseil géologique ;

7 - Uniformisation et synthèse des coûts ;

8 - Comparaison coût-bénéfice : point d'équilibre, retour financier.

La procédure présentée ci-dessus a été utilisée pour l'étude d'Amsterdam. Les résultats sont présentés dans le tableau 4. Ces coûts normaux, de même que les économies sur ces coûts ont été calculés selon le tableau 1 et les résultats exprimés en florins par an et km^2. Ces sources obtenues ont ensuite été données par le coût de préparation des cartes thématiques soit 6000 florins/km^2, ce qui permet d'obtenir la durée d'amortissement de l'investissement et le point d'équilibre coût-bénéfice. Les chiffres présentés dans le tableau 4 ne peuvent être appliqués qu'à Amsterdam. Ils sont basés sur des valeurs fournies par les autorités municipales.

2.4 - CONCLUSIONS

La mise en place de ces expériences pilotes de cartographie urbaine traduit le souci de rapprocher le plus possible des applications la connaissance du RGD en matière de géologie proche de la surface aux Pays-Bas (1). L'association avec Delft Geotechnics, l'Université technique de Delft et les services techniques des villes était d'ailleurs une garantie d'une approche conçue vers les besoins de l'ingénierie.

L'opération n'a pas pour l'instant fait tâche d'huile, mais l'exemple de Leiden montre que les municipalités peuvent trouver leur compte et économiser de l'argent dans une telle approche. Un budget de 25 M florins serait fléché au niveau du Parlement pour les travaux d'aménagement de 350 villes des Pays Bas et ceci pourrait avoir des incidences fortes sur la généralisation de la méthode.

La transposition de l'exercice en France n'est pas évidente vu les différences de contextes géologique et politique. On peut toutefois en retenir le principe, avec une approche souple de la gestion de l'information dans le sens d'un GIS.

(1) Voir notamment le document "Subsoil Uncovered" élaboré conjointement par RGD, STIBOKA (staring Centre aujourd'hui) et TNO-DGV et présenté dans le rapport DS n° 50 du 8.02.1988, p. 21.

TABLEAU 3

ECONOMIES PONCTUELLES POUR UNE MUNICIPALITÉ PAR L'UTILISATION DE CARTES GÉOLOGIQUES

	Financial savings (direct/indirect)								
	Site investigation		Site selection						
Themes	Feasibility	Design	Construction	Maintenance	Claims	Hazard prediction	Counter-measures	Planning	Licensing
Foundation depth	75–100	5–15	10–50			+	+ +	+ + +	
Vulnerability to settlement	70–80	10–20	10–50	50–100	+ + +	+	+ +	+ + +	+
Preparation of building sites	100		10–50	25–100	+ +	+	+ +	+ + +	+
Construction materials	100	15–50	20–50		+ + +		+	+ + +	+
Underground construction	85–95	25–40	15–35	5–15	+ +	+ +	+	+ + +	+
Exploitation of groundwater	75–95	25–50	50–70		+ + +	+ +	+ +	+ + +	+ +
Exploitation of geothermal energy	100	25–60	40–75		+ +	+	+	+ +	+ +
Environmental protection (including waste-disposal sites)	60–90	10–25	40–75		+ + +	+ + +	+ +	+ + +	+

*Where possible, savings are expressed as percentage of total costs influenced by subsoil conditions; percentages refer to average cities in the Holocene area of the western part of The Netherlands and to thematic maps on a scale of 1:5,000.

Symbols: + + + = very large savings, + + = substantial savings, + = slight savings.

Source : E.F.J. de MULDER, Envir. Geol. Water Sci.
Vol. 16 n° 1 p. 24 - Springer Verlag, 1990

TABLEAU 4

RÉSULTATS DE L'ANALYSE DE COÛT-BÉNÉFICE D'UNE SÉRIE DE CARTES GÉOTECHNIQUES POUR LA VILLE D'AMSTERDAM

	Amount			Amount	
	Step 2	Step 3a	Assumptions[b]	Step 3B	Step 4
Activities (1)					
Site investigation					
Feasibility phase	225,000	80	1	180,000	900.00
Design phase	1,275,000	10		127,500	637.50
Archive searches	140,000	50		70,000	350.00
Foundations for housing	36,000,000	10	2,3,4	360,000	1,800.00*
Foundations for infrastructural works	300,000,000	10	4,5	3,000,000	15,000.00*
Drainage of building sites	75,000	25	6,10,11	18,750	93.75*
Sandfills for infrastructure and housing	20,000,000	10	9,12,13	200,000	1,000.00*
Maintenance of sewerage systems	38,000,000	25	6,7	14,615	**73.07*
Maintenance of roads	82,000,000	25	6,8	31,540	**157.70*
Total per year and per km² (4)					20,011.52
Cost of map preparation in Dfl/km² (7)					6000.00
Earn-back time/breakeven point (8)					
Based on site selection and archive work only					3.2 years
Based on all items except foundation costs for infrastructural works					1.2 years

*The heading numbers refer to the steps in the cost–benefit procedure. Amounts are given in Dutch guilders (Dfl) per year.

[b]Assumptions

1. Number of data points per km² for (pre)feasibility phase: 50 (= number for thematic maps on a scale of 1:5,000); cost of site investigation per house in Amsterdam are of the same order as those for the city of Leiden (personal communication, L. Barendregt).
2. Number of houses to be built: 5000 annually; savings hold for at least 500 houses (= 10%).
3. Average pile length: 12 m (= 7,200 Dfl/house).
4. Potential reduction of cost of average pile length/foundation achieved by optimal site selection: 10% (see column 3a).
5. Potential saving of at least 10% of cost of newly built infrastructures or sandfills.
6. Reduction of maintenance or construction costs by better site selection: 25% (=25% less settlement; see column 3a).
7. Present maintenance costs applicable to 325,000 existing houses (= Dfl. 29.23); potential savings in maintenance costs only applicable to 10% of newly built sewerage systems, corresponding with 500 newly built houses (= 29.23 × 500 = 14,615) (see assumption 2).
8. Present maintenance costs applicable to 325,000 existing houses (= Dfl 63.08 per house); potential savings in maintenance costs only applicable to 10% of newly built roads, corresponding with 500 newly built houses (see assumption 2).
9. Estimated use of 2 million m³ sand for filling in Amsterdam yearly; price of 1 m³ sand for filling: Dfl. 10.
10. Area to be drained annually: 0.05 km².
11. Costs of drainage systems: Dfl 15,000 per 0.01 km².
12. Potential reduction of amount of sand for filling gained by optimal site selection: 10%.
13. Potential savings in sand-fill costs applicable in at least 10% of new sand fills.

Source : ibid tableau 3

Une vue plus large des actions conduites au RGD sur la géologie de "faible profondeur" est donnée dans les publications référencées ci-dessous(1). A noter la poursuite de la publication de la carte géomorphologique des Pays en collaboration avec le Staring Centre, publication dont l'arrêt avait été fortement envisagé en 1989. C'est surtout son faible coût de conception qui a été décisif. La carte géologique à 1/50 000 serait, par ailleurs, extrèmement peu utilisée pour les besoins appliqués. Chaque feuille s'appuie néanmoins sur la collecte de 2000 à 5000 informations ponctuelles.

Au niveau de la fourniture des données, des discussions sont en cours entre le RGD, le Staring Centre, TNO et le RIVM sur les procédures d'acquisition, la mise en forme et la distribution à l'extérieur des données de sciences de la Terre.

Un cahier des charges devrait être établi pour fin avril 1991. Le RGD dispose de deux banques de données, l'une pour les sondages de moins de 10 m et l'autre pour ceux qui font plus de 10 m. Il y a environ 300 000 sondages dans la première dont 200 000 informatisés et 67 000 dans l'autre (dont 2000 > 150 m).

L'accès à un dossier de sondage > 10 m (non confidentiel) coûte 40 florins. Le prix d'accès pour les sondages courts n'est pas établi. Les données de diagraphies de sondage et d'essais hydrauliques peuvent être fournis par le TNO. Le RIVM a mis l'accent sur la qualité.

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(1) - de MULDER E.F.J. (1986) - Applied and engineering geological mapping in the Netherlands. 5ème Congrès international de l'AIGI, 1986, GIS pp. 1755-1759.

- de MULDER E.F.J. (1990) - Géologie de l'ingénieur aux Pays Bas. A paraître Proceedings symposium AIGI. Amsterdam.

Archivage 4S.

3 - INSTITUT DE RECHERCHE POUR LA GESTION DE LA NATURE (RIN)(1)

Le RIN a été créé en 1969 par fusion d'instituts mis en place en 1939 et 1947. Son but est de fournir les bases scientifiques pour la mise en place de la politique et des actions gouvernementales en matière de protection et de gestion de la nature et des ressources naturelles. C'est l'un des nombreux instituts du Ministère de l'Agriculture de la Gestion de la Nature et des Pêches (équivalence globale avec l'INRA) dont le détail est donné dans l'annexe 1. En 1988(2), nous avions visité les instituts de sciences du sol de Wageningen qui font également partie des instituts de recherche de l'agriculture. Il en est de même de l'Institut de recherche forestière De DORSCHKAMP, que nous évoquerons brièvement en 4.

Le 9 octobre, nous avons discuté avec le Professeur W.J. WOLFF, directeur de la recherche et le Dr. G. GONGGRYP, responsable pour la conservation des sites en sciences de la Terre.

3.1 - PRÉSENTATION GÉNÉRALE

Le RIN est actuellement éclaté en quatre sites (figure 4) :

- Direction et administration générale à Arnhem, ainsi que certains laboratoires de recherche ;
- Centre de Leersum : écologie botanique et du paysage, hydrobiologie ;
- Centre de l'île de Texel : écologie estuarienne ;
- Station de terrain de l'île de Terschelling.

Ce découpage est lié à des raisons historiques. Il est question d'effectuer un regroupement à Wagenningen d'ici quelques années, peut être avec l'Institut de Dorschkamp. La répartition des activités entre les différents centres est donnée dans le tableau 5.

Le personnel de RIN représente 125-130 permanents (dont 60 chercheurs) et de l'ordre de 70 temporaires pour des contrats à durée déterminée (pas des étudiants de PhD). Ce sont à 80 % des biologistes, plus quelques chimistes, spécialistes de sciences du sol et géographes.

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(1) Rijks Instituut voor Naturbeher.
PO BOX 46
3956 ZR Leersum
Kasteel Broekhuizen. Brockhuizerlaan 2
Tél.: (0) 34.34.52.941.

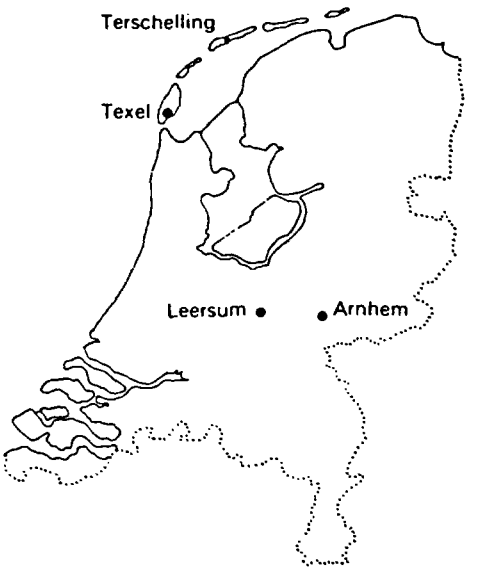
Rapport annuel 1988, en néerlandais sauf pour la partie Coopération internationale, archivé à 4S/EAU.

(2) DS n° 93 du 30 mars 1988.

FIGURE 4

LOCALISATION ET ADRESSES DES CENTRES DE RECHERCHE DU RIN

Source : document RIN



Directorate
Dr. A.B.J. Sepers, Director General (Arnhem)
Prof. W.J. Wolff, Director of Research (Leersum)

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- Kemperbergerweg 67, Arnhem
- Kasteel Broekhuizen, Broekhuizerlaan 2, Leersum
- Zuiderhaaks 17, 't Horntje (Texel)

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- P.O.Box 9201 NL-6800 HB Arnhem
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- Arnhem: + 31 85 452991
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TABLEAU 5

RÉPARTITION DES ACTIVITÉS ENTRE LES DIFFÉRENTS CENTRES DE RIN

Botanical Ecology / Leersum and Arnhem
- Ecological landscaping and habitat construction
- Air pollution in relation to vegetation and species extinction
- Climatic change
- Ecohydrology
- Forest, grassland, and wetland management
- Development of simulation models
- Application of remote sensing for nature conservation

Animal Ecology / Arnhem
- Distribution and ecology of mammals, reptiles, and amphibians
- Large herbivores in forest and nature management
- Natural regulation of bird numbers
- Management of bird populations and habitats
- Effects of wind-turbine parks on birds
- Insects in grassland ecosystems

Hydrobiology / Leersum
- Effects of eutrophication and acidification on aquatic ecosystems
- Nutrient budgets in shallow waters such as drainage ditches and moorland pools
- Typology of surface waters
- Experimental ecological research on invertebrates
- Ecotoxicological research in micro- and mesocosms

Estuarine Ecology / Texel
- Management problems associated with coastal ecosystems
- Salt-marsh and tidal-flat ecology
- Ecology and management of coastal birds and mammals
- Experimentation done in large-scale model ecosystems
- Effects of pollutants on fish and marine mammals
- Effects of shellfish culture on marine ecosystems
- Mathematical modelling of ecosystems

Landscape Ecology / Leersum
- Landscape fragmentation and plant and animal populations; effect of corridors; dispersal movements in fragmented landscapes
- Model simulation of the dynamics of fragmented populations
- Spatial dynamics in distribution patterns, effects of climatic change
- Earth-science conservation: inventories, impact assessment, and preservation of valuable sites in the landscape

Ecotoxicology / Arnhem
- Background studies on soil organisms in relation to pollution levels
- Relationship between abiotic factors, bio-availability, and effects of soil pollutants, particularly heavy metals
- Transfer of pollutants via terrestrial food chains
- Effects of interaction between heavy metals and organic compounds on the decomposition of organic matter
- Effects of heavy metals and organic compounds on small mammals
- Typology of soils

Toute la recherche du RIN est orientée vers les problèmes de conservation et la biologie des écosystèmes. Le RIN a deux fonctions principales et uniquement sous l'angle de la recherche :

- le conseil pour la gestion des parcs nationaux. 50 % des parcs sont nationaux, gérés par le Service forestier d'Etat, 50 % sont privés. Le RIN a une activité de conseil pour les deux catégories qui représentent au total 5 à 10 % du territoire ;
- la conservation de la nature en dehors des parcs : surveillance de la pollution et de ses effets par exemple.

Le Service d'Etat pour les Forêts est responsable de la réalisation de beaucoup des actions proposées (1).

L'activité de surveillance du RIN a beaucoup décru : 5 % de l'activité contre 50 % il y a 20 ans. Les inventaires concernent les comptages d'oiseaux, champignons, lichens... Le relais a été pris par les associations écologiques.

L'essentiel de l'action porte sur les actions méthodologiques et scientifiques. Ainsi à titre d'exemple :

- une étude sur la réintroduction des castors dans la région au SE de Rotterdam, région abandonnée par eux il y a deux siècles ;
- l'examen de l'effet de l'épandage des boues de rivières sur les écosystèmes.

Il y a toujours environ 8 à 10 projets en cours.

En matière d'eaux côtières, les travaux sont multifonctionnalités : pêche, aquaculture, loisirs, extraction de sable, exploitation de gaz, zones de protection. Le RIN procède à l'avance à des études d'écosystèmes en prévision du développement de telle ou telle activité. Autres domaines d'études côtières : les effets de la pollution sur la faune, l'impact des pollutions par hydrocarbures, du largage en mer des boues draguées... C'est un domaine pour lequel le RIN collabore avec le Rijkswaterstaat.

En matière d'écotoxicologie, les travaux aboutissent en général à définir des normes de tolérance de produits chimiques dans les réserves, des niveaux maximaux de pollution des sols... Sur ces thèmes, le RIN travaille avec le Staring Centre (Wageningen) et le RIVM.

En hydrobiologie, le RIN étudie les caractéristiques des différentes communautés vivantes dans les eaux douces, l'effet des produits phytosanitaires sur leur développement(2), des problèmes spécifiques comme le développement contrôlé des moustiques dans une réserve.

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(1) Cf. Mrs de HULLU - Staatsbosbeheer (State Forest Service)
Princenhof park 1
3972 NG Driebergen
Tél. : 03404 - 26111
Fax : 03404 - 14404.

(2) Sur ces problèmes de pesticides, cf. Dr. LEEUWANCH (pesticides et environnement aquatiques) et Dr. LEISTRA (application des pesticides au milieu terrestre) au Staring Centre (Wageningen).

5 à 10 % de l'activité se fait à l'étranger toujours sur des problèmes de protection de la nature. Les terrains de jeu sont divers : Afrique de l'Ouest, Inde, Sri Lanka, Indonésie, Caraïbes (1).

Tous les travaux du RIN ont contribué à l'élaboration du Plan National pour la Gestion de la Nature publié en 1989 par le Ministère de l'Agriculture et dans lequel on trouve d'ailleurs une référence à l'inventaire de sites géoscientifiques à protéger, thème que nous allons aborder maintenant. Un résumé du Plan National est donné en annexe 2 et le texte complet (ou néerlandais) est archivé à DS.

3.2 - CONSERVATION DES SITES GÉOSCIENTIFIQUES

Au RIN, cette activité relève d'une seule personne, G.P. GONGGRIJP, géographe de formation(2). Le bilan qu'il propose résulte de 20 ans de travaux, pour recueillir l'information, l'évaluer et convaincre les autorités du bien fondé de cette action de conservation. Le démarrage remonte à 1908 avec l'appel de Van BAREN pour la conservation des sites géologiques les plus importants aux Pays Bas. Cet appel suit de 2 ans la création de la première réserve au Pays Bas sur le Naardermeer.

En 1908, c'est le lac Mery sur l'île de Texel qui est devenu une réserve. La même année, la zone dunaire de Kootwijkerzand a également mise sous protection. C'est le premier site géoscientifique retenu. La première société provinciale pour la conservation de la nature a été fondée en 1927.

La mise en place du groupe de travail GEA remonte à 1969, année de la réorganisation du RIN, un an après la parution du Nature Conservation Act. GEA, outre une représentation du RIN, inclut des représentants de la Société Géologique, du Service géologique, du Staring Centre de Wageningen du Laboratoire de Géographie Physique et Science du sol de l'Université d'Amsterdam, auxquels se sont joints plus tard le Musée national de Géologie et Minéralogie et le State Forest Service (cf. 3.2).

Le GEA a d'abord travaillé sur le matériel recueilli par les prédécesseurs et en particulier l'inventaire de Van RIJSINGE présenté après guerre. A la fin des années 1960, seuls une douzaine de sites géologiques étaient protégés. Après la création du RIN, le directeur de l'époque F. de SOET considéra que la conservation de tels sites constituait un enjeu et, au début des années 1970, c'est à G.P. GONGGRIJP qu'on a confié le travail d'inventaire et de contrôle.

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(1) Cf. à titre d'exemple, une étude S. de BIE (1990). Wetlands of West Africa. Recommendations for a coordinated conservation policy - RIN 1990-3. Archivage 4S/EAU.

(2) Voir en particulier :

- GONGGRIJP G.P., BOEKSCHOTEN G.J. (1981) - Earth Science conservation: no science without conservation. In: A.J. Van LOON (ed) - Quaternary geology: a farewell to A.J. WIGGERS. Geol. en Mijnbouw, 60, pp. 433-445.

- GONGGRIJP G.P. (1987) - Earth-science conservation: the GEA project. Annual rep. 1987. RIN, pp. 93-101.

Celui-ci a d'abord travaillé sur l'information déjà collectée. Ensuite, devant la difficulté d'évaluer correctement les sites correspondant aux anciens inventaires, un nouvel inventaire a été lancé par province. Cet inventaire vient de se terminer avec un rapport par province et environ 800 sites identifiés, dont une centaine environ déjà protégés. Les sites ont été retenus pour leur valeur géologique, géomorphologique ou pédologique. L'étape suivante consiste à élaborer un rapport pour le gouvernement présentant les 150 meilleurs sites à protéger, principalement géomorphologiques et qui ont une importance provinciale, nationale voir internationale.

La reconnaissance de l'intérêt de ce travail s'est manifestée pour la première fois en 1982 dans le Structural Scheme for Nature and Landscape Conservation, dans lequel ces sites sont considérés comme des objets à protéger. Par ailleurs, les sites eux-mêmes ont été fréquemment pris en compte à divers niveaux de planification ou d'exploitation des ressources naturelles. Certaines municipalités les ont retenus pour des motifs éducatifs.

Dans le dernier Nature Protection Policy Scheme publié en juin 1990, de nombreux projets relatifs à la conservation des sites ont été évoqués, dont deux pour les sciences de la Terre :

1 - révision et choix de sites prioritaires dans l'inventaire des 800 sites. Révision également des critères de classification ;
2 - étude de la vulnérabilité des sites et de l'impact des activités humaines - Prévention.

Le travail initié il y a une vingtaine d'années commence à prendre sa pleine dimension. En dehors du travail technique, G.P. GONGGRIJP a passé beaucoup de temps à convaincre les autorités de l'intérêt de ces sites. Il reste toutefois seul aux Pays Bas pour animer globalement le thème. L'objectif final visé est l'introduction systématique des sites dans les plans et leur maintenance. A noter les services rendus par la carte géomorphologique (RGD - Staring Centre) pour la recherche et la qualification des sites.

G.P. GONGGRIJP a contribué à lancer une dynamique internationale sur ces problèmes, ce qui s'est traduit par la mise en place d'un groupe de travail européen et trois rencontres internationales :

- Leersum 1988, qui a abouti à la mise en place du groupe européen,
- Bregentz (Autriche), 1989,
- Fossheim (Norvège), 1990.

La première rencontre a donné lieu à une Newsletter. Les proceedings de la seconde doivent être publiés à l'automne 1990 par le Service géologique d'Autriche (Dr. H. SCHÖNLAUB). Le principe d'une publication à la suite de la rencontre de Fossheim est retenu mais sa forme est encore en discussion.

On trouvera en annexe 3, une liste des correspondants de G.P. GONGGRIJP dans différents pays.

La prochaine réunion est prévue en juin 1991 en France. Elle doit être coordonnée par G. MARTINI, Conservateur de la Réserve Géologique de Haute Provence(1), réserve qui comporte 18 sites protégés.

G.P. GONGGRIJP espère qu'un comité consultatif sur la conservation des sites géoscientifiques pourra se mettre en place au niveau du Conseil de l'Europe. Actuellement, il n'existe un tel comité que pour la biologie.

Comparativement, la structure équivalente en Grande Bretagne a une assiette plus forte. Il s'agit du Nature Conservancy Council créé en 1949 (2). 2200 sites ont obtenu un certain niveau de protection, sur un total inventorié de 25 000. Les sites sont protégés dans le cadre du National Parks and Access to the Countryside Act de 1949 et le Wildlife and Countryside Act de 1981. Un document très détaillé nous a été envoyé par K.L. DUFF assistant chief scientest qui fait état de la stratégie qu'entend suivre ce conseil(3). Celle-ci est résumée en annexe 4, avec la bibliographie sur le sujet.

3.3 - CONCLUSIONS

Il est bien clair que les activités du RIN sont actuellement assez éloignées de celles du BRGM. On retiendra tout de même trois points :

1 - pour toutes les actions européennes dans lesquelles une composante sur l'écologie des milieux est demandée, le RIN est certainement un excellent partenaire ;

2 - Les réserves naturelles, la protection de sites de référence et tout simplement de notre environnement quotidien deviendront des enjeux de plus en plus forts au fur et à mesure que la pression du développement se fait sentir. Dans cet esprit, la maîtrise d'outils pour apprécier les risques, les impacts et développer la prévention sera importante ;

3 - Les travaux conduits en Grande Bretagne et aux Pays-Bas aboutissent à une liste impressionnante de sites à protéger et à la mise en place d'une stratégie technique et politique. Il n'y a pas de raisons pour que la France, moins impliquée jusqu'ici dans ces problèmes, ne le soit pas plus à l'avenir. Dans cet esprit, la protection des sites non seulement géologiques (reconnus pour les stratotypes et quelques sites régionaux typiques) mais également géomorphologiques et pédologiques peut constituer un élément de la stratégie d'avenir du BRGM, dans le cadre de son activité de service public et de recherche.

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Tél. (92) 31.51.31.

(2) Northminister House, Peterborough PEI IUA
Tél. (0733) 40345
Fax : (0733) 68834.

4 - INSTITUT DE DORSCHKAMP (1)

Il s'agit de l'Institut de recherche sur la Forêt. Comme nous l'avons vu précédemment (cf. 3 et annexe 1), il fait partie des instituts de recherche qui sont sous l'égide du Ministère de l'Agriculture. Nous n'avons pas visité cet institut mais, lors de la visite à Wageningen, avons pris le rapport annuel 1989 que nous a remis le bibliothécaire J.H. VEENHUIS. Le personnel de l'institut comprend 90 personnes + 40 collaborateurs extérieurs.

Cet institut est très éloigné des préoccupations du BRGM car il ne s'intéresse guère qu'à la biologie de la forêt. Une série de thèmes émergent du rapport annuel (2) et sont regroupés dans le tableau 6. On retiendra essentiellement les essais d'application des boues de dragage des rivières et des ports (Rotterdam) comme sous-couche de plantation forestière ou en couverture et composante neutralisante pour les décharges. Sur ces thèmes, l'interlocuteur est J.P. PEETERS.

Curieusement, il n'y a semble-t-il aucun thème de recherche sur les pluies acides.

En 1989, la partie de l'institut qui se consacre aux problèmes de sols a été rattachée au staring Centre (Wageningen) et l'équipe correspondante a déménagé.

(1) Bosrandweg 20
Postbox 23
6700 AA Wageningen
Tél. 08370-9511
Fax : 083 70 . 24988

(2) Rapport en néerlandais, parcouru avec M. KLUYVER

TABLEAU 6

PRINCIPAUX THÈMES DE RECHERCHE DE L'INSTITUT DE DORSCHKAMP (1)

- GESTION PASSIVE DES FORÊTS

- Fertilisation des forêts
- Rajeunissement naturel des plantations de chênes, hêtres et pins Douglas
- Relations sols-types de végétation dans les stades jeunes
- Santé des chênes
- Identification des champignons parasites
- Champignons pathogènes de l'arbre
- Causes des épidémies des champignons Sphaeropsis
- Populations animales des forêts
- Dommages par les insectes

- GESTION ACTIVE DES FORÊTS

- Utilisation des bois
- Réaforestation de terrains agricoles
- Système HOPSY de récolte des bois
- Planification intégrée de gestion forestière

- ÉCOLOGIE

- Classification des écosystèmes
- Réserves de bois
- Impact de la baisse du niveau piézométrique sur la croissance forestière

- GESTION DES ARBRES

- Vitalité des arbres en contexte urbain (2)
- Utilisation des boues de dragage du port de Rotherdam (10 M m^3/an) en sous couche de plantation forestière et couverture de décharge (+ fonction de neutralisation)
- Sélection des arbres pour plantations urbaines
- Sélection du Prunus Avinum
- Problèmes racinaires des ormes
- Maladie des hêtres

- PHYSIOLOGIE DES ARBRES

- PLANTATIONS EN ZONES DE LOISIRS

- GIS : possèdent ARC-INFO depuis 1987

- COOPÉRATION : INDONÉSIE, BURKINA FASO

- TRANSFERT DES CONNAISSANCES.

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(1) Source : Rapport annuel 1989. Archivage 4S.
(2) Voir le rapport de A. KOSTER : Stedelijk groen naturlijker 1990. Archivage 4S.

5 - INSTITUT DE RECHERCHE SUR LA SANTÉ PUBLIQUE ET L'ENVIRONNEMENT (RIVM)

Cette visite, coordonnée par W. Van DUIJVENBOODEN, hydrogéologue senior, complète celle que nous avons faite en 1988 (1). Elle a été l'occasion d'aborder d'autres thèmes et d'actualiser les connaissances sur les thèmes déjà abordés en 1988.

Outre W. Van DUIJENBOODEN, nous avons rencontré :

- J.C. Van ANDEL, responsable du laboratoire déchets et émissions ;
- F.J.J. BRINKMAN, responsable de la section "accidents à l'environnement",
- D. BEKER, responsable des problèmes de traitement, valorisation des déchets et sitologie des déchets. Il nous a accompégné pour la visite à VAM le 11 octobre après-midi.

5.1 - ENTRETIEN AVEC W. VAN DUIJVENBOODEN

Cette entretien a porté sur la nouvelle organisation du RIVM, le document "Concern for to-morrow", la situation des réseaux de contrôle, l'organisation GIS du RIVM.

5.1.1 - Nouvelle organisation du RIVM

Dans la nouvelle organisation du RIVM, N.D. Van EGMOND, ancien responsable de la section "Sol et eau souterraine" est devenu une des trois personnes principales du RIVM. La nouvelle structure, en cours de mise en place, comporte 7 directions :

1 - Production de vaccins,

2 - Santé publique : virologie, bactériologie,

3 - Santé publique : pathologie,

4 - Groupe intégré : état de l'environnement. Orientation économique. Chargé en particulier de l'actualisation de "Concern for to-morrow". Modèles globaux.
Responsable : P. F. LANGEWEG.

5 - Laboratoires d'analyses :
- inorganiques : responsable H.J. Van der WIEL
- organiques : responsable H.A. Van KLOOSTER

6 - Toxicologie,

(1) DS n° 93 du 30 mars 1988.

7 - Environnement. Responsable C. Van de AKKER
- Sol et eau souterraine. Responsable pas désigné, pour remplacer : N.D. Van EGMOND
- Air : responsable : R. M. Van AALST
- Recherche dans le domaine de l'eau (surface et de boisson). Responsable ?
- Radiations : Responsable : Dr. J.E.T. MOEN
- Déchets et émission : Responsable Dr. A.H.M. BRESSER.

5.1.2 - "Concern for to-morrow"

En 1989, le RIVM a élaboré un document sur les problèmes posés par l'environnement à l'horizon 2010. Ce document a donné lieu à deux versions, néerlandaise et anglaise, sous la forme d'un texte complet et d'une version abrégée. Il fait suite aux précédents travaux globaux : Rapport du Club de Rome (1971), rapport OCDE "Facing the Future" (1979), rapport BRUNDLAND "Our Common Future" (1987). Le texte prend appui sur le Plan National de Politique de l'Environnement (NMP) publié en 1989 et qui porte sur une durée de 8 à 10 ans.

Les problèmes sont abordés à des échelles successives, soit de la plus petite à la plus grande :

- échelle globale : effet de serre.Remèdes pour la réduction des émissions de CO_2 et de CFC ;

- échelle continentale : pluies acides, concentration d'ozone, pollution particulaire, radio-nucléides. Orientations proposées : réduction de 90 % des émissions de SO_2 et de 70 % de NO_x ;

- échelle environnement fluvial. Orientations proposées :
  - réduction de 75 % de P et N pour lutter contre l'eutrophisation ;
  - plan pour le Rhin ;
  - solution à quelques problèmes de pollution portuaire pour les métaux lourds ;
  - récupération des matières premières et de l'énergie dans les stations d'épuration ;

- échelle régionale : problèmes liés aux intrants agricoles (N, P, K), aux métaux, aux produits phytosanitaires, à la sécheresse, au stockage des déchets. Orientations proposées :
  - gestion globale de N agricole. Le stock P restera limité aves les mesures déjà prises ;
  - réduire au delà de 35 % la pollution des sols par Cu et de 50 % par Cd ;
  - protection spécifique des zones sableuses contre les pesticides peu dégradables ;
  - réduire les volumes de déchets et accroître la récupération des matières et de l'énergie. Perspectives 2020 : 65 % des déchets réutilisés, 20 % incinérés, 25 % stockés (40 % aujourd'hui).

- échelle locale : réduction du bruit, des odeurs, de la surface urbaine pour la circulation, des émissions de NO_2, radon et particules transportées.

Devront également être développées les études de santé publique, ainsi que certains travaux spécifiques régionaux (vulnérabilité des zones de haute altitude).

Le coût global de la protection de l'environnement est estimé à 2 % du PNB actuellement et devrait passer à 3-3,5 % en 2010.

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(1) Archivage DS.

5.1.3 - Situation des réseaux de contrôle

Le RIVM gère plusieurs réseaux de contrôle : qualité des eaux souterraines, qualité de l'air, qualité des sols, radioactivité.

a) Qualité des eaux souterraines

La conception du réseau de contrôle de la qualité des eaux souterraines, largement mis en place dès 1984, a été présentée dans le document DS n° 93 du 30 mars 1988. Ce réseau comprend actuellement 380 points et ne doit guère être enrichi que d'une dizaine de points supplémentaires pour les aquifères profonds. Ce chiffre doit être complété par les réseaux provinciaux. On arrive à un total de 1 000-1 200 points. Les points sont choisis en fonction du système aquifère (plusieurs points par système), la profondeur du niveau hydrostatique, le type de sol, l'occupation du sol et la charge en intrants ainsi que les émissions à partir des intrants. La gestion de ces différents paramètres permet des sorties de combinaisons variées au sein d'un G.I.S. La responsabilité de l'élaboration des statistiques incombe à L.J.M. BOUMANS et J.W. de KWAADSTENLET, ainsi qu'à G. Van DRECHT pour le G.I.S.

La vitesse de déplacement des nappes étant très faible (30m/an), il suffit d'une mesure annuelle. O_2, pH et redox sont mesurés in situ. Les échantillons d'eau sont prélevés dans les crépines 1 et 3 (cf. DS n° 93) correspondant respectivement à l'aquifère supérieur et à l'aquifère inférieur. Lors de l'installation de l'équipement, on prélève aussi dans la crépine 2. Afin de juger de façon plus directe de l'effet des mesures gouvernementales, on procède à des actions de surveillance temporaire avec 30 à 40 points.

Un objectif de teneur < 500 mg NO_3/l pour l'aquifère supérieur à l'horizon 2000 a été décidé au niveau gouvernemental. L'automatisation des systèmes d'acquisition-transmission ne joue que pour les eaux de surface (Rijkswaterstaat) pas pour les eaux souterraines.

b) Qualité de l'air

Dès 1966, il a été demandé à l'ancêtre du RIVM (créé en 1984 par regroupement de trois instituts) de concevoir un système automatisé de surveillance de l'air à l'échelle nationale. En 1968 un premier module non automatisé a été mis en place sur le comté de Twente et uniquement pour la mesure de SO_2. En 1975, la première phase de mise en place était terminée et comportait 220 stations pour la mesure de SO_2 et 40 pour la direction et la vitesse du vent. L'extension à NO_x, ozone et CO_2 a été faite en 1978.

En 1986, le réseau a été complètement modernisé pour être en accord avec les règlements nationaux et internationaux. Il a ainsi été organisé autour de 17 macrostations chargées de mesurer un large éventail d'aérosols et polluants et sur lesquelles le Réseau de Institute for Plant Protection effectue des contrôle biologiques. Par ailleurs, 13 stations étaient installées dans des villes sur des zones de fort trafic et 5 dans des zones de référence urbaines.

Dans l'ancien système, la transmission des données se faisait au moyen de lignes téléphoniques fixes, louées ; le nouveau système est branché sur le réseau téléphonique public. L'ordinateur des stations collecte et stocke les données. Sa mémoire est lue sur demande directe du système central de Bilthoven.

Le réseau mis en place a cinq objectifs :

- surveillance réglementaire,
- alerte,
- détermination des tendances à long terme,
- sources de pollution,
- dépôts de pollution au sol.

Il est organisé selon cinq types de stations :

1 - des stations spatialement représentatives : à usage multiple, macrostations, pluviométriques, pour la mesure du vent ;

2 - stations urbaines,

3 - stations de rues,

4 - stations de recherche,

5 - stations pour la mesure du vent au sommet des tours radio.

Un descriptif plus détaillé du système est donné en annexe 5, ainsi qu'une information sur les systèmes d'acquisition et de traitement utilisés. Les ordinateurs sont du type SIEMENS SMP. Les mesures de SO_2 et CO sont faites sur instruments Thermo Environmental Instruments Inc. Pour les mesures d'ozone et de NO_x, on emploie des instruments Philips. Le détail des paramètres mesurés et des spécifications d'instruments est également donné en annexe 5.

c) Qualité des sols

Le réseau a été mis en place en 1988-89 et comporte 40 champs surveillés. Il y en aura 200 à l'avenir, de façon à assurer un échantillonnage de 40 champs par an sur un cycle de 5 ans.

Dans chaque champ on prélève 320 échantillons, dont 160 entre 0 et 20 cm de profondeur et 160 entre 20 et 40 cm ou 40 et 50 cm. Les échantillons sont mélangés pour aboutir à 8 échantillons par champ. Il s'agit d'un programme mixte RIVM, Staring Centre (Wageningen) et Institute for Soil Fertility (Haren).

d) Qualité de l'eau de pluie

14 stations du réseau de contrôle de qualité de l'air possèdent un équipement de collecte des eaux de pluie pour la mesure de la qualité. Le chiffre comprend 9 des macrostations et 5 stations séparées. La météo nationale, chargée des mesures de quantité de pluie, dispose de son propre réseau.

Dans chaque station il y a deux collecteurs pour l'air, l'un pour les composants principaux des précipitations, l'autre pour les composés organiques. Dans 3 stations, il y a en outre des collecteurs en vrac pour la surveillance des micropolluants organiques.

Dans le détail, voici la liste des composants analysés :

- 14 stations : pH, conductivité, acide libre, NH_4, Na, K, Ca, Mg, Zn, F, Cl, Ni, SO_4, Co_3H, P, Cd, Cu, Fe, Pb, Mn, Ni, V.
- 3 stations : As, Cr, Co, α et γ hexachrorohexane, hexachlorobenzène, 20 biphénols polychlorés, 13 hydrocarbures aromatiques polycycliques.

e) Qualité des eaux de boisson

Depuis les années 1950, tous les pompages d'AEP sont contrôlés, deux fois par an selon les instructions gouvernementales, beaucoup plus fréquemment par les organismes responsables. Les résultats sont stockés dans une banque développée depuis une vingtaine d'années.

f) Radioactivité

Il s'agit d'un réseau de 28 stations mis en place en 1989 selon un espacement d'environ 25 km. Le réseau fonctionne de façon automatique et permanente (cf. annexe 6). 14 d'entre elles sont équipées pour suivre la radioactivité de l'air.

g) Contrôles biologiques

Nous les avons évoqués en liaison avec la surveillance de l'air. Des recherches ont débuté en liaison avec le réseau "Qualité de l'eau" mais il ne s'agit pas d'une activité de surveillance. Des études sont également en cours pour la biologie des sols en liaison avec les Universités d'Amsterdam (Institute of Environmental Problems, RVM) et de Leiden (qui effectue des recherches en surveillance biologique).

5.1.4 - Systèmes d'information géographique

Jusqu'ici, le RIVM a fonctionné avec son propre système raster dans lequel l'information était rapportée à des pixels de 500 × 500 m. Depuis 1989, un équipement ARC-INFO a été installé. Au niveau de l'équipe sols et eaux, le responsable est J.J. Van der VELDE. La conception du GIS pour tout le RIVM relève de H.J. SCHOLTEN. Au cours d'une récente visite au RIVM, Y. GOUISSET a rencontré L. HORDIJK qui travaille sur le système DATAFLOW de modélisation graphique d'analyse structurée des systèmes (1).

(1) Cf. le rapport de visite de Y. GOUISSET (4S/ENV) du 21.9.1990.

W. Van DUIJVENBOODEN nous a remis un document sur la politique du RIVM en matière de G.I.S. (1). Selon ce document, l'articulation proposée comporte :

1 - Un niveau général de structuration des données pour la rendre accessible à tous les utilisateurs (MILGIS) ;
2 - Un niveau de G.I.S. pour laboratoire (MILGIS). Le concept de MILGIS évite les duplications de stockage pour un même laboratoire ;
3 - Un niveau de G.I.S. analytique ;

4 - Un niveau de présentation des données.

Les trois premiers niveaux sont interfacés entre eux et sont connectés individuellement au niveau de présentation.

Cette organisation a été introduite dans le RIVM en 1989, elle relève des compétences de H.J. SCHOLTEN. Les données de Laboratoire des Sols et de l'Eau Souterraine sont déjà traitées dans le système qui doit être opérationnel pour l'ensemble du RIVM d'ici 5 ans.

Au niveau des logiciels, le système MILGIS s'appuie sur ARC-INFO, mis en place en 1989, et SPANS (Tydac, Canada) pour la partie analytique, qui est organisée selon une structure en quadtree permettant de subdiviser une région en quarts successifs jusqu'à ce qu'une valeur homogène soit atteinte. SPANS tourne sur PC. Pour la présentation des données ATLAS GRAPHICS a été retenu. Des applications du système ont déjà été faites notamment pour une étude sur la qualité des eaux aux Pays-Bas (1989) et une autre sur la modélisation de l'acidification. Un descriptif plus détaillé de l'organisation de MILGIS est données en annexe 7.

5.1.5 - Pesticides

Le remplaçant de J.P. LOCH rencontré en 1988 (cf. DS n° 93, 1988) est R.V. de BERG. Je ne l'ai pas rencontré.

5.1.6 - Diffusion des données à l'extérieur (SAG)

W. Van DUIJVENBOODEN participe aux discussions avec le RGD, TNO et le Staring Centre (Wageningen) sur les conditions de diffusion des données à l'extérieur. Ces discussions devraient aboutir début 1991 à un projet concernant les formes d'accès aux données de tous les organismes, quel que soit l'organisme par lequel on rentre dans le système.

Chaque organisme resterait toutefois propriétaire de ses données et maître de son organisation. L'accès aux données du Staring Centre (Wageningen) pose un problème de mise en ligne qui n'est pas réglé. Le RIVM dispose de leur banque à titre officieux. Les problèmes à régler dans le cadre du SAG sont donc de nature technique et juridique.

(1) KUSSE B., PADDING P. (1990). The environmental geographical information system of the Netherlands. RIVM. Archivage SGN/CSG/SIG.

5.2 - ENTRETIEN AVEC J.C. VAN ANDEL

J.G. Van ANDEL est responsable du laboratoire "déchets et émission". La discussion a porté sur la pollution des sols et les techniques de dépollution.

Les sociétés qui traitent des sols pollués après extraction utilisent principalement deux techniques :

- l'incinération (30-40 %) qui permet d'éliminer les organiques, également Hg, Cd. On l'emploie surtout pour des sols sableux. Son application aux sols argileux et tourbeux entraîne une déstabilisation de la structure minérale qui pose ensuite problème pour la remise en culture ;

- l'extraction par solvants chimiques (acides ou alcalins) qui marche bien pour les composés métalliques, pas pour les organiques.

Le RIVM a fait le point des techniques de traitement (après extraction) des sols pollués en vigueur aux Pays-Bas. Le texte complet de cette mise au point est donné en annexe 8.

En 1989, il y avait 6 installations de traitement thermique en fonctionnement, avec une capacité unitaire de 4 000 à 80 000 t/an. Les résultats obtenus sur sables (y compris argileux ou silteux) sont très probants pour les hydrocarbures aliphatiques et aromatiques, les PCA et composés CN. Le coût du traitement varie entre 80 et 200 florins par tonne en fonction de la teneur en eau du sol et des types de contaminants. Les premiers essais de traitement d'hydrocarbures chlorés ont été ou doivent être réalisés fin 1990. Parmi les polluants métalliques, seul Hg peut relever d'un traitement thermique.

En 1989, il y avait 7 installations de traitement par solvants aux Pays-Bas avec une fourchette de capacité unitaire située entre 8 000 et 80 000 t/an. Les résultats montrent une capacité extractive de 95-99% des polluants pour l'huile, les cyanures, les PCA. Pour les métaux lourds, le pourcentage tombe à 80-95 %. Le coût du traitement à la tonne varie de 50 à 200 florins. Dans le texte de l'annexe 5, on trouvera également des indications sur le traitement biologique par épandage (3 sociétés) et bioréacteur (stade expérimental dans divers organismes de recherche).

L'annexe 9 donne les références des principales sociétés des Pays-Bas impliquées dans la décontamination des sols.

Depuis 2 ans, le RIVM travaille sur la possibilité de traiter les rejets organiques d'un traitement par solvants, au moyen d'un traitement biologique. Les travaux sont au stade du laboratoire. Le principal problème est la disponibilité biologique. La tendance serait à faire agir successivement deux populations bactériennes, la première pour une action rapide de dégrossissage et la deuxième pour finaliser. On envisage ainsi un traitement de la partie fortement polluée extraite d'une part et d'autre part un traitement in situ du solde.

En matière d'incinération, le RIVM ne travaille pas sur les procédés, mais sur les émissions de dioxine et leurs conséquences en matière de toxicité ainsi que le lessivage des métaux lourds à partir des scories et cendres volantes (cf. rapport MAMOUTH non remis). A noter l'existence de VEABRIN, syndicat des industriels exploitants d'installations d'incinération. Leur activité en matière de R & D serait faible (ce n'est pas l'avis de VAM, cf. 6).

J.G. Van ANDEL soulève aussi le problème des normes A, B, C vis à vis de la pollution (annexe 10) qui, selon lui, sont souvent inadaptées et trop strictes et correspondent à une surestimation du risque.

En ce qui concerne la dépollution in situ, le RIVM a établi un bilan des expériences conduites dans divers pays (1). Ce rapport a été élaboré par J.J. M. STAPS avec le soutien du NATO/CCMS (Comittee on the Challenge of Modern Society) dans le cadre de son étude pilote "Demonstration of Remedial Action Technologies for Contaminated Land and Groundwater", coordonnée par D. SANNING (EPA Cincinnati).

Ce sont principalement trois pays qui ont conduit des essais pilotes dans ce domaine : Pays-Bas, RFA et USA. Un total de 23 projets sont recensés dans le rapport dont 5 aux Pays-Bas, 9 en RFA et 9 aux USA. L'intérêt de la biorestauration est que dans beaucoup de cas il s'avère impossible ou trop coûteux d'extraire le sol pollué. L'étude de STAPS a débuté en 1987. A l'époque, il a été considéré qu'il n'y avait aucune expérience acquise en France, au Japon, en Norvège et en Italie et une expérience limitée et sans mise en pratique au Royaume Uni, au Danemark et au Canada.

La figure 5 donne le schéma général d'une installation de biotraitement. Les facteurs suivants jouent sur l'optimisation du processus : redox, niveau de saturation, éléments nutritifs et en traces, pH, température.

La liste des projets étudiés, leurs caractéristiques et les principaux résultats sont donnés dans le tableau 6. Le principal procédé utilisé est la recirculation. L'aérage est utilisé seul ou couplé à recirculation ou inoculation dans trois cas, l'inoculation seule ou combinée dans quatre cas et le chauffage combiné dans deux cas.

La surface contaminée varie de 20 m^2 à 75 000 m^2. Dans le cas de pollution à partir de dépôts d'hydrocarbures, la zone polluée s'étend sur 400 à 1 000 m^2. Avec les grands complexes chimiques on atteint 20 000 à 75 000 m^2. La profondeur contaminée se situe en général entre 3 et 10 m sous la surface du sol. Le sous-sol dans ces opérations pilotes est principalement constitué de sable avec des perméabilités variant de 10^{-2} à 10^{-5} m/s.

Dans les projets des Pays-Bas, les concentrations résiduelles après traitement se placent au-dessous du niveau de teneurs B. 5 projets sur 9 atteignent le niveau A. Un des projets qui utilisait l'aérage à donné de bons résultats pour les composants volatils, pas pour les PAH (polynuclear aromatic hydrocarbons).

La durée de l'opération est très variable (3 mois à 4 ans), de même que son coût selon la méthode employée : 40 à 250 US$ pour les contaminations à partir de stations, 7 à 150 pour les décontaminations sur sites industriels.

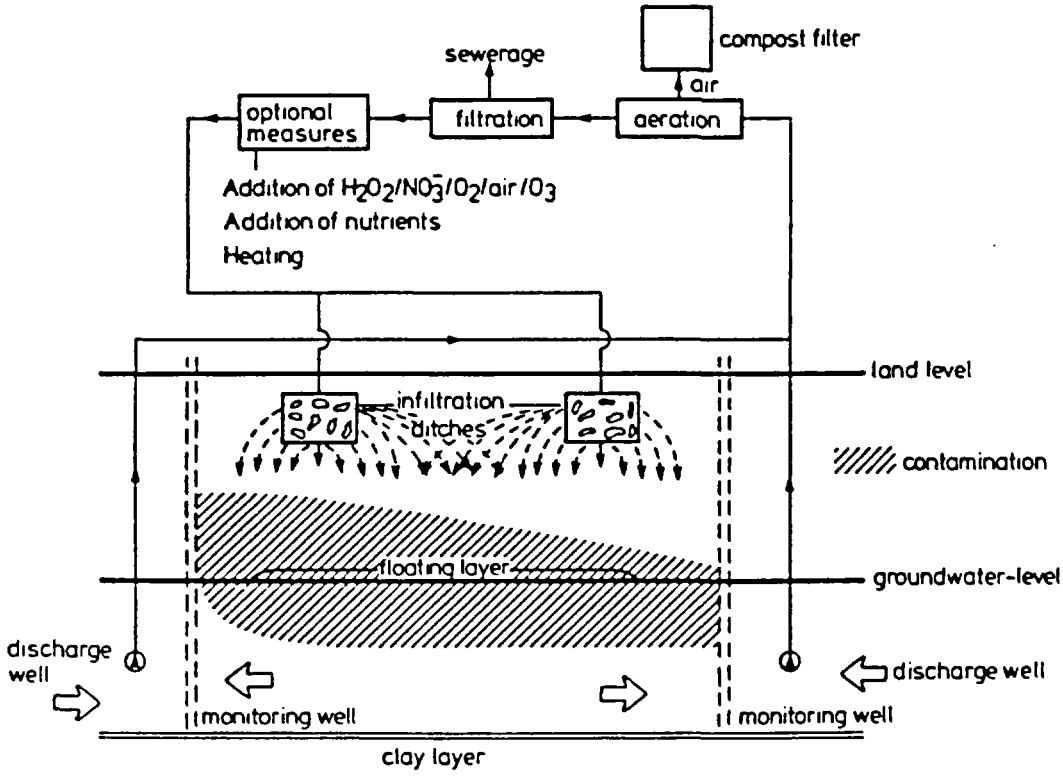
On trouvera en annexe 11 les conclusions du rapport STAPS, les recommandations, la bibliographie, les références des sociétés gérant les projets.

(1) STAPS J.J.M. (1990). International evaluation of in situ biorestoration of contaminated soil and groudwater. Rep. n° 738708006. Archivage 4S/ENV.

FIGURE 5

PRÉSENTATION GÉNÉRALE D'UN SYSTÈME DE DÉCONTAMINATION IN SITU DES SOLS ET EAUX

Source : rapport J.J.M. STAPS, p. 6.



Code	Organization	Location	Soil structure	Contamination	Oxygen source	System	Nutrients	Costs	Results	Remediation time	Problems
N1	RIVM / TNO	Filling station	sand	petrol	hydrogen peroxide	recirculation	NH4NO3 * KH2PO4/Na2HPO4	$ 325,000 $ 125/ton		Exp: 6-12 months	
N2	HTTS	Filling station	sandy	petrol / diesel	air	recirculation	COD:N:P=100:5:2		46-99.6% removed in 6 months		-infiltration -control system
N3	DRM	Contaminated soil beneath building	sand and loamy sand layers 10e-5 / 6x10e-4	domestic fuel oil	air	recirculation	KNO3 C:N:P=100:10:1		B-value for aliphatics and mineral oil	half year	infiltration in loamy layers
N4	NAM	Gas exploration site	sandy with clayy layers	condensate; volatile arom.	air nitrate	recirculation	NO3 K2O	$ 350,000			pumped up conc.>than expected
N5	Delft Geotechnics	Field test	sand 4x10e-4<K<10e-4	petrol and diesel	air	venting inoculation	C:N:P=100:10:2		p:96% removed d:33% removed	12 months	
D1	Messer-Griesheim	Chemical industry site	gravel / sand	hydrocarbons	Pure oxygen	Recirculation	Na3PO4	< 41 $/m3	COD 175->30 in 1 year		hydrologic. isolation
D2	Institut fuer Mikrobiologie	Solution industry site	sandy with clay	chlorinated hydrocarbons	nitrate	unsaturated	nitrate fertilizer	330,000 $; 6-8 $/m3	120->60 mg/l in 14 months		
D3	AnaKat	Bus station		hydrocarbons	hydrogen peroxide	inoculation					
D4	Argus	Filling station	coarse sand	diesel oil	air	unsaturated / inoculation	phosphate ammonium manganese	62 $/m3	<4600 mg/kg	12 months	
D5	TGU	Refinery	sand / gravel	PAH's	nitrate	recirculation / heating	(NH4)3PO4			Exp: 5 years	
D6	Baugrund Institut	Former refinery	clay layers and gravel sands	chlorinated hydrocarbons / mineral oil PAH's	nitrate	will result from research	id				

TABLEAU 6

LISTE DES PROJETS DE DÉCONTAMINATION IN SITU PRIS EN COMPTE DANS LE RAPPORT STAPS

TABLEAU 6
LISTE DES PROJETS DE DÉCONTAMINATION IN SITU PRIS EN COMPTE DANS LE RAPPORT STAPS (suite)

D7	IMA GmbH	Industry site	sandy 10e-2 / 10e-3.5	fuel oil	hydrogen peroxide	unsaturated / inoculation	(NH4)3PO4 + trace elements	41-80 $/m3	6000-><100 mg/kg	9 months	
D8	Kloeckner Oecotec	Refinery		diesel petrol aromatics		saturated / recirculation	not specified		175->25 mg/kg	15 weeks	
D9	Engler-Bunte Institut	Marshalling yard	coarse sand and gravel 2.1x10e-3	oil aromatics	nitrate / ozone	saturated / recirculation / heating			undetectable levels	300 days	
U1	DuPont Biosystems	Filling station		gasoline	hydrogen peroxide	saturated / recirculation	C:N:P=6:1:1	$ 750,000 $9/kg hc	<10 mg/kg	4 years	
U2	ECOVA	Pesticide production	sandy till	4-chloro-2-methylphenol	air	saturated / recirculation	no addition	$300,000		5 years (planned)	
U3	RS Kerr Env. Lab US Coast Guard Rice University	Air station, leaking storage tank	sand and gravel highly permeable	BTEX	hydrogen peroxide	no recirculation	NH4Cl KH2PO4 Na2HPO4		7.2x10e-4 mg/l in 250 days	> 6 months	
U4	John Mathes & Ass., Inc.	Leaking pipeline assembling plant	overburden clay 10e-5 m/s	gasoline	hydrogen peroxide	recirculation and venting	Restore 375R		undetectable (80% of area)	2 years	NO3 formation
U5	Stanford University	Research project	sand / gravel 10e-3 m/s	DCE, TCE	methane / oxygen	recirculation		--	50% TCE, 90% t-1,2-DCE and VC removed	8 days	
U6	USAF Eng. and Serv. Center	Airforce Base Leaking pipeline	coastal sand 7x10e-4 m/s	JP 4	hydrogen peroxide	infiltr. gallery injection wells spray irrigation	Restore 375R	> $ 1.4 mln	550 kg hc removed	12 months	peroxide destabili-zation
U7	Groundwater Technology	Industrial facility	glacial till	BTEX C4-C12	hydrogen peroxide	recirculation	Restore		undetectable levels (80%)	72 days	
U8	ENSR	Hazardous waste lagoon	lagoon	BTE, naphtalene chloroform a.o.	air sparging	aerating / mixing	no addition	Exp:$90 mln	90% in 112 days		
U9	LSU	Abandoned refi-nery (research)	river silt / sandy clay	(polycyclic) aromatics, oil		landfarming		$ 6 mln	80-83% degrad. in 25 days		

5.3 - ENTRETIEN AVEC F.J.J. BRINKMAN

F.J.J. BRINKMAN (FB) est responsable de la section "accidents à l'environnement". C'est une petite section de RIVM (3 personnes + 1 secrétaire), qui a une activité de conseil et d'assistance pour les autorités de santé et de surveillance de l'environnement, notamment l'Inspectorat de l'Environnement de La Haye. L'équipe de FB intervient donc au cas par cas, notamment à la demande des responsables de la Santé Publique à différents niveaux administratifs, évalue les problèmes et fédère l'action des différents spécialistes du RIVM. L'équipe dispose de quelques équipements portables (spectro IR, GC) et intervient souvent sur des questions d'écotoxicologie.

5.4 - ENTRETIEN AVEC D. BEKER (1)

D. BEKER est responsable des études concernant les déchets. L'après-midi du 11 octobre, il nous a accompagnés pour la visite du site de décharge de VAM à Wyster (cf. 6).

Aux Pays-Bas, on recense actuellement :

- 80 sites de décharge mis en place selon l'Act on Waste Material (1977), autorisés au niveau provincial ;
- 200-300 sites de décharge spécialisés pour un ou deux déchets et mis en place selon l'Anti-Nuisance Act (1953), avec une autorisation donnée au niveau communal ;
- 2 000 à 3 000 points noirs correspondant souvent à des sites agréés selon l'Anti-Nuisance Act.

Depuis quelques années, le nombre de décharges autorisées a beaucoup diminué (pour être ramené à 80 sites). Il reste beaucoup de problèmes à résoudre en ce qui concerne les 200-300 sites relevant de l'Anti-Nuisance Act et qui correspondent pour une large part à des déchets de l'industrie agroalimentaire, ainsi qu'au niveau des points noirs.

Conformément à la législation, les 80 décharges restant doivent avoir les spécifications suivantes :

- déchets situés au minimum à 50 cm au-dessus du niveau hydrostatique (législation de 1980, issue de l'Act on Waste Materials) ;
- isolation du fond nécessaire sauf s'il est prouvé que les contaminants sont dispersés (législation de 1985, issue de l'Act on Waste Materials).

(1) Voir aussi : BECKER D. (1990). Sanitary Landfilling in the Netherlands. *In* : International Perspectives in Municipal Solid Wastes and Sanitary Landfilling. Acad. Press., pp. 119-155.

La réglementation sur les sites et décharges correspond aux trois critères I.B.C. I correspond à l'isolation du site ainsi qu'il a été mentionné ci-dessus. Le critère B relève de la gestion du site, impose le traitement des lixiviats et leur recyclage, recommande la fabrication de composts. Le critère C correspond au contrôle général du site et la surveillance des eaux et du sol.

Le tonnage de déchets mis en décharge représente 13-14 Mt/an dont 3,5 Mt de déchets domestiques mis en décharge (pour un total de 5 Mt produits). Le tableau 7 donne une ventilation par type de déchets et type d'élimination.

Le RIVM n'a pas d'autorité administrative en matière de déchets et se contente de développer des actions de R & D et de conseiller les autorités. C'est dire que le RIVM n'a aucune intervention systématique pour les ouvertures de décharge.

Le contrôle des décharges et points noirs se réfère aux normes A, B et C pour les eaux et sols, dont nous avons parlé en 5.2 et dont le détail est donné en annexe 7.

Dans le but de disposer d'éléments de référence et de comparaison pour l'évaluation des émissions à partir des décharges, une étude de caractérisation des 80 sites en fonctionnement a été entreprise. Le rapport sur les 30 premiers sites étudiés sera disponible en 1991. Cette étude devrait également permettre d'évaluer l'efficacité des dispositifs de confinement et en particulier de la tenue à terme de l'isolation du fond de la décharge (stabilité à terme sur formations meubles) ou de l'engorgement des systèmes de drainage. Sur ce point, les législations entre pays diffèrent. Aux Pays-Bas c'est l'isolation du fond, en Allemagne la solution multibarrières de protection préconisée par l'UBA (Berlin) ainsi que l'isolation du fond et du toit, au Royaume-Uni la gestion mixte de déchets divers (codisposal).

A l'avenir aux Pays-Bas, la tendance d'évolution repose sur les orientations suivantes :

- minimisation de la quantité de déchets,
- tri et maximum de recyclage,
- incinération et compostage de déchets organiques non recyclés,
- mise en décharge des produits finaux avec protection du fond et du toit,
- gestion séparée des déchets dangereux.

Sur ce dernier point il existe actuellement dans la zone de Rotterdam une usine d'incinération pour déchets spéciaux (AVR) et une décharge entièrement confinée pour déchets dangereux non incinérés.

En ce qui concerne les points noirs ou à problèmes, diverses approches sont proposées : extraction et nettoyage du produit extrait, décontamination in situ, isolation in situ (exemple d'un site pollué par la dioxine près d'Amsterdam). La plus grande partie des points noirs sont de petite taille. A noter les problèmes non résolus de dioxine résultant de l'emploi de l'incinération. Ce problème conduit à se limiter à des installations modernes. La capacité de décharge relais s'avère insuffisante ou en voie d'engorgement (c'est le cas aux Pays-Bas et en Allemagne).

Une fois la décharge remplie, le coût des travaux de clôture et de mise en place de surveillance est estimée à 10-20 florins par tonne de déchet.

TABLEAU 7

RÉPARTITION DU TONNAGE ANNUEL DE DÉCHETS AUX PAYS-BAS (1986)

Source : D. BEKER (1990) cf. (1), p. 46

Waste type	Quantity (1000 t/year)	Recycling (%)	Incineration (%)	Landfilling (%)	Miscellaneous[1] (%)
Household waste	4700	15	34	51	
Bulk household waste	600	8	33	59	
Road sweeping/market/park waste, flotsam, dredged slurry, pit mud	1400	14	7	79	
Office/shop/service waste	1800	17	22	61	
Building and demolition waste	7750	41	1	58	
Sewage sludge	4710	59	1	10	30
Industrial waste[2]	15100	78	1	21	
Hospital waste	115		52	48	
Car tyres	65	23	54	23	
Shredder waste (mainly car wrecks)	510	78		22	
Phosphoric acid gypsum	2000				100
Fly ash from coal-fired power plants	530	94		6	
Hazardous waste and waste oil	1100		21	9	70[3]
Dredged spoil	60000				100
Surplus manure	14000	100			
Contaminated soil	500	55		45	

[1] Mainly discharged into surface water.
[2] Excluding sewage sludge and hazardous waste.
[3] Including recycling.

Le RIVM est le seul organisme néerlandais à réaliser des travaux de R & D sur les décharges. Une importante capacité d'expertise existe dans les bureaux d'étude. La société VAM qui a mis en place un système de compostage et différents tris de déchets constitue un cas un peu unique aux Pays-Bas.

D. BEKER participe à de nombreux meetings européens sur le thème des déchets et consacre beaucoup de temps à cette activité.

6 - CONTACTS AVEC L'EXPLOITANT DE DÉCHARGE VAM

Le contact a été pris conjointement directement avec le bureau d'Amsterdam (1) et via le RIVM. Une discussion a eu lieu avec J. Van TUBERGEN, responsable R & D, le 10 octobre, dans le bureau VAM de Wageningen (2). Le 11 octobre, en compagnie de D. BEKER du RIVM, nous avons visité le site VAM de Wyster (3) où nous avons été reçus par F. MOORMAN.

VAM a été fondée en 1929 et tout le capital est détenu par l'État (99 % Ministère de l'Agriculture, 1 % Province de Drenthe). Elle reçoit environ 1 Mt de déchets domestiques par an à Wyster, soit 20 % des déchets domestiques des Pays-Bas, dont 35 % (du total) sont incinérés. Il existe par ailleurs une organisation municipale à Rotterdam qui gère une mise en décharge d'1 Mt/an. A Rotterdam, l'organisme municipal ROTIB gère une installation d'incinération. La Haye et Amsterdam ont un système d'incinération municipal. Arnhem a un système d'incinération en régie. En raison de problèmes de dioxine, beaucoup de petites incinérateurs anciens ont été fermés (Alkmar, Leiden, Leerwarden, Zaamstad,...). Les tonnages correspondants sont envoyés en décharge notamment à Wyster. Les gros sites de décharge (en dehors de Wyster et de Rotterdam) sont situés près d'Eindhoven (RAIOB), à Boeldershoch dans la région de Twente et dans un site dans la région de Breda.

L'incinération (35 % des déchets ménagers) donne 35 % de résidus qui sont mis en décharge ou réutilisés dans de grands aménagements (routes, digues...). Pour lutter contre la dioxine, un nouveau règlement a été promulgué en 1989, qui impose un maximum de 0,1 mg d'équivalent toxique par m3. Ce règlement contraint les gros incinérateurs à s'équiper et les petits à fermer (4).

Les chiffres clefs concernant VAM Wyster sont les suivants :

- 70 ha couverts par la décharge sur un périmètre de 100 ha ;
- 90 communes désservies (envoi des déchets par train ou camion) ;
- 160 employés et un chiffre d'affaires de 50 M florins par an ;
- 1-1,5 Mt de déchets/an. On est passé à 1,5 Mt suite à la fermeture des petits incinérateurs ;
- sur ce total, 0,7-1,2 Mt sont mis en décharge, 0,2 Mt séparés à la source et compostés (50 000 t de compost) ;
- 80 000 t/an triés mécaniquement dans un pilote industriel de 40 t/h pour séparer les emballages de conserve (Fe + Sn). Papier et plastique (RDF) sont remis en décharge. Une petite installation complémentaire de traitement thermique permet de nettoyer les déchets d'emballage de conserve.

---

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Fax : (020) 79 11 12

(2) Staring Centre
Marigkeweg 11, 6709 PE Wageningen
5ème étage
Tel. : 083 70 74 698.

(3) VAMweg 7, 9418 TM Wyster
Tel. : 05936 939

(4) Sur ces problèmes, voir l'association des sociétés exploitantes VEABRIN à Rotterdam. M. LEENDERS est le coordinateur du thème "utilisations des scories". Tél. : 010 489 42 72.

VAM modifie sa stratégie et met en place un gros investissement d'incinération et de tri. Les travaux doivent commencer début 1991 et durer 30 mois. Le tonnage annuel (1-1,5 mt) se ventilerait aussi comme suit :

- 28 % de déchets organiques séparés à la source et compostés ;
- 72 % passant dans l'usine de séparation :
  - 20 % triés et recyclés (verre, papier...),
  - 52 % :
    - 17 % mis en décharge (faible valeur calorifique) ;
    - 34 % incinérés (forte valeur calorifique = RDF) ;
    - 1 % déchets métalliques récupérés (Fe, Sn, Al, Cu).

F. MOORMAN fait actuellement des essais de valorisation sur cette fraction métallique. Aux Pays-Bas, il y a déjà beaucoup de verre (> 70 %) et de papier (60 %) recyclés. Il n'y a pas de séparation à la source des plastiques.

Le système de gestion multisystèmes des déchets est assez unique aux Pays-Bas et spécifique de VAM. L'équipement actuel de la décharge comporte en outre :

- un système d'extraction du biogaz (tranchées de collecte remplies de palettes de bois et extraction du gaz par tuyaux verticaux) qui permet de récupérer 2 300 m^3/j, soit 30 % du gaz émis, le solde partant dans l'atmosphère. Ce gaz, après traitement pour séparer en particulier CH4 et CO_2 alimente pro parte (800 m^3/j) une centrale électrique qui couvre les besoins du centre de Wyster et pro parte le réseau national (1 500 m^3/j). L'installation a été montée par la société LAYBOLD (Allemagne) ;

- un système de récupération des lixiviates de décharge (280 000 m^3/an ; 30 m^3/h) qui permet, par un traitement par osmose inverse (9 sections successives), de rejeter 75 % d'eau propre dans un canal d'évacuation et de recycler 25 % sur la décharge. Pluie efficace : 300 mm/an. L'usine a été montée par la société STORKWAFILIN (Pays-Bas). Le coût du traitement est estimé à 6-7 florins/m^3, y compris les amortissements pour retraiter les 25 % repompés, le coût est estimé à 20-25 florins/m^3.

La décharge ne comporte pas de dispositif d'isolation du fond, seulement une étanchéité du toit sur une partie de sa surface. Le contrôle des émissions périphériques est assuré par des piézomètres suivis par VAM et par la Province. En dehors des déchets ménagers, la décharge reçoit des sols pollués extraits (30-40 000 t/an) et divers déchets.

La politique de VAM n'est pas totalement en accord avec la position gouvernementale de ramener à < 5 % la part de déchets organiques mis en décharge. Le prix actuel de mise en décharge de déchets ménagers à Wyster est de l'ordre de 30 florins/t. On atteint > 100 florins pour les déchets spéciaux. La moyenne aux Pays-Bas serait de 40 florins/t. Ce chiffre pourrait être multiplié par 2 à 4 avec l'application intégrale du plan de gestion des déchets : recyclage maximum, incinération moderne, limitation maximale de la mise en décharge des organiques. A Amsterdam, on parle d'un coût de 170 florins à la tonne pour la seule incinération.

7 - CONCLUSION

La présente mission a permis de compléter le panorama dressé en 1988 par une visite d'autres instituts et l'actualisation de données recueillies alors. Les conclusions qui suivent sont présentées par organisme (1).

Service national de Planification (RPD)

- Prise en compte faible de données de géosciences mais développement prévu à l'avenir ; il pourra être intéressant de suivre cette prise en compte en liaison avec RGD et TNO.

- Architecture d'acquisition, traitement et valorisation des données présentant de fortes similarités avec celle du BRGM et s'appuyant sur ORACLE et ARC-INFO. Un échange d'expériences entre les deux organismes peut s'avérer profitable d'autant que RPD traite des informations en mode raster et vecteur et qu'il prévoit que son système sera complètement opérationnel en 1992 (interface ORACLE en particulier).

Service géologique (RGD)

- Intéressantes expériences de cartographie géotechnique urbaine conduites à Amsterdam et à Leiden ; suivre la prise en compte de cette approche par les autorités urbaines.

Institut de recherche pour la gestion de na ture (RIN)

- Partenaire de qualité pour des actions européennes dans lesquelles une composante sur l'écologie des milieux est demandée.

- Bonne expérience sur la protection des sites naturels y compris en sciences de la Terre (géologie, géomorphologie, pédologie), transposable en France si la sensibilisation sur ce thème se développe.

Institut de Dorschkamp

- Orientation vers la biologie des forêts. La composante sols a été regroupée avec le Staring Centre.

- Intéressants essais d'application de boues de curage de rivières et de ports comme sous-couches de plantations forestières ou couverture de décharges.

Institut de Recherche sur la Santé Publique et l'Environnement

- Partenaire compétent sur un large éventail de problèmes touchant à l'étude de l'environnement et à sa surveillance ;

(1) Pour tous les noms de correspondants, nous renvoyons aux textes de chaque chapitre.

- Expérience en automatisation de l'acquisition, du traitement, de la valorisation des données intéressantes dans le domaine de la surveillance de l'air, pas des eaux (dispositifs manuels).

- Travaux méthodologiques en cours en laboratoire sur le traitement biologique des déchets. Peuvent déboucher sur des nouvelles idées en matière de dépollution in situ. Rapport de synthèse de STAPS sur les expériences de dépollution in situ (pays-Bas, Allemagne, USA) transmis à 4S/ENV.

- Mise en place d'une architecture SIG s'appuyant sur ARC-INFO, SPANS et ATLAS GRAPHICS ; éléments de comparaison BRGM-RIVM sur ce thème. Proposition d'une séance de travail sur ce thème par M. van DUIJVENBOODEN (lettre du 27.11.1990). Cette séance pourrait avoir lieu au premier semestre 1991.

- Implication forte dans les travaux méthodologiques sur décharges.

VAM

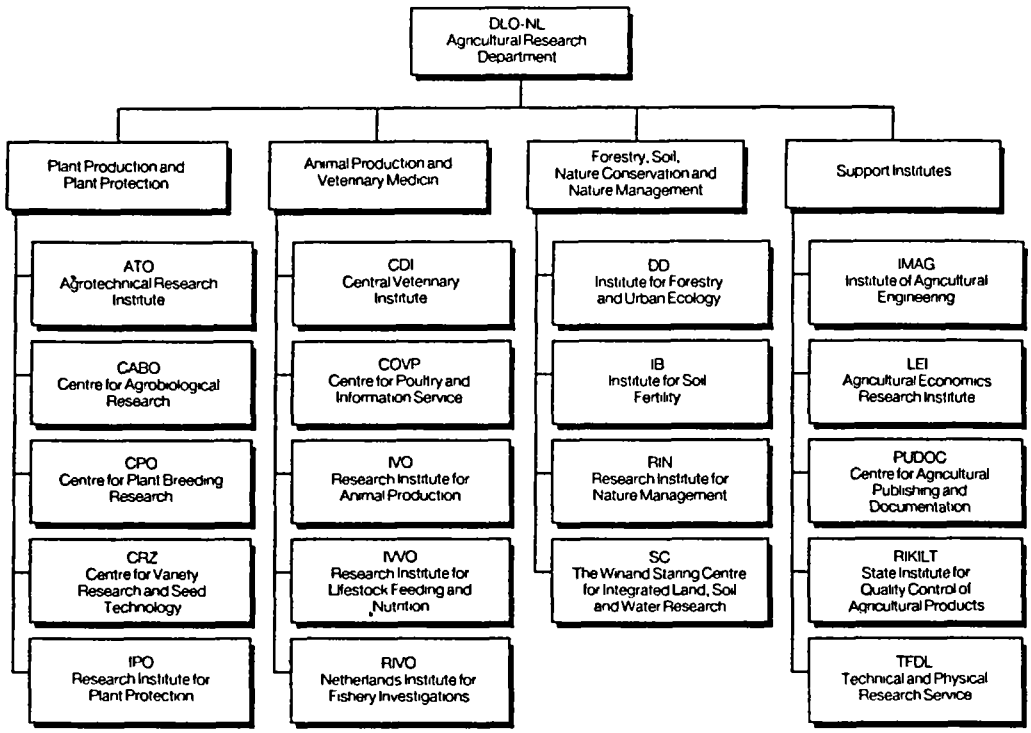
- Expérience unique de valorisation intégrée des déchets.

- Information sur l'expérience de DAM/MIN transmise à VAM qui a des travaux en cours sur la séparation des non ferreux des déchets (lettre E. de BACKER du 15 novembre 1990).

ANNEXE 1

INSTITUTS DE RECHERCHE DÉPENDANT DU MINISTÈRE DE L'AGRICULTURE AUX PAYS-BAS

Source : Document DLO - Research Institutes for Advanced Agriculture. Archivage DS.


DLO-NL
Agricultural Research
Department
Plant Production and
Plant Protection
Animal Production and
Veterinary Medicin
Forestry, Soil,
Nature Conservation and
Nature Management
Support Institutes
ATO
Agrotechnical Research
Institute
CABO
Centre for Agrobiological
Research
CPO
Centre for Plant Breeding
Research
CRZ
Centre for Variety
Research and Seed
Technology
IPO
Research Institute for
Plant Protection
CDI
Central Veterinary
Institute
COVP
Centre for Poultry and
Information Service
IVO
Research Institute for
Animal Production
IVVO
Research Institute for
Lifestock Feeding and
Nutrition
RIVO
Netherlands Institute for
Fishery Investigations
DD
Institute for Forestry
and Urban Ecology
IB
Institute for Soil
Fertility
RIN
Research Institute for
Nature Management
SC
The Winand Staring Centre
for Integrated Land, Soil
and Water Research
IMAG
Institute of Agricultural
Engineering
LEI
Agricultural Economics
Research Institute
PUDOC
Centre for Agricultural
Publishing and
Documentation
RIKILT
State Institute for
Quality Control of
Agricultural Products
TFDL
Technical and Physical
Research Service

DLO and its institutes

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The Department represents the Ministry of Agriculture, Nature Management and Fisheries in matters of agricultural research policy. Its activities include the responsibility of the multi-annual research plan, overall management of research programmes, budgets and staff of research institutes, promoting national and international cooperation and coordination.

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Research is focussed on development and application of knowledge in the fields of storage, transport, biotechnology, processing, handling, product development and process optimization, logistics and expert systems, including agrification, of food and non-food products of a great variety of agricultural and horticultural crops.

CABO Centrum voor Agrobiologisch Onderzoek
Centre for Agrobiological Research

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Research is focussed on basic processes of plants and eco-systems related to problems of crop husbandry, plant breeding, plant protection and agrotechnology.
Specialisms: plant physiology, crop science, weed science, ecology and management of productive and non-productive vegetation, system analyses.

CDI Centraal Diergeneeskundig Instituut
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Telefax: (+31 3200) 7 34 73/Telex: 40227 edi nl

Research is focussed on infectious diseases and toxicological problems in animals with an emphasis on livestock. In addition to diagnostical and epidemiological research the institute develops and produces diagnostica, sera, vaccins and synthetic vaccins.
Specialisms: veterinary sciences, pathology, parasitology, bacteriology, immunology, analytical chemistry, toxicology, virology.

COVP Centrum voor Onderzoek en Voorlichting voor de Pluimveehouderij 'Het Spelderholt'
Spelderholt, Centre for Poultry Research and Information Services

Dr.ir. W. de Wit, director
Ir. G.W.H. Heusinkveld, deputy-director

Address: Spelderholt 9, Beekbergen
Mailing address: Spelderholt 9, 7361 DA Beekbergen, The Netherlands
Telephone: (+31 5766) 61 11/Telefax: (+31 5766) 32 50

The research topics are: reproduction, industrial poultry and furred animals farming, poultry and furred animals feed, processing, product and consumer matters.
The National Extension Service for Poultry Farming also belongs to the Centre. This Service takes care of the national information.
Specialisms: quality of produce, technology, farm management, reproduction, breeding, nutrition, animal welfare.

CPO Centrum voor Plantenveredelingsonderzoek
Centre for Plant Breeding Research

Dr.ir. N.G. Hogenboom, director
Dr. L. van Vloten-Doting, deputy-director

Address: Droevendaalsesteeg 1, Wageningen
Mailing address: P.O. Box 16, 6700 AA Wageningen, The Netherlands
Telephone: (+31 8370) 1 91 12
from September 17th 1990: (+31 8370) 7 70 00
Telefax: (+31 8370) 1 65 13

Research is focussed on the development of breeding methods and half bred material for the production of improved varieties of arable, horticultural and ornamental crops and trees for urban amenities. The research programme concentrates on the development of the scientific base of plant breeding in general and on the specific contribution that plant breeding may offer to the resolvement of problems in the industry and environmental problems.
Especially plant molecular and cell biology, developmental biology, selection methodology, disease and pest resistance, quality improvement, stress tolerance and the development of new crops are being studied.

CRZ Centrum voor Rassenonderzoek en Zaadtechnologie
Centre for Variety Research and Seed Technology

Dr.ir. N.G. Hogenboom, director
Ir. C.A.A.A. Maenhout, deputy-director

Address: Willem Dreeslaan 1, Bennekom
Mailing address: P.O. Box 32, 6700 AA Wageningen, The Netherlands
Telephone: (+31 8370) 7 91 11
Telefax: (+31 8370) 7 92 28

Research is carried out on plant variety characteristics and plant propagation materials. Besides seeds, also other plant propagation materials like bulbs, tubers, planttissues and single cells are research objects of the institute.
Within the research on plant varieties the registration and breeders rights research is carried out.

DD De Dorschkamp, Instituut voor Bosbouw en Groenbeheer
De Dorschkamp, Institute for Forestry and Urban Ecology

Ir. J. van den Bos, director
Ir. J.C.A.M. Bervaes, deputy-director

Address: Bosrandweg 20, Wageningen
Mailing address: P.O. Box 23, 6700 AA Wageningen, The Netherlands
Telephone: (+31 8370) 9 51 11
Telefax: (+31 8370) 2 49 88/Telex: 45055 dorsk nl

Research is carried out on forestry and urban forestry.
Specialisms: forest ecology, silviculture, forest soils, tree physiology, genetics, pests and diseases, forest techniques, forest economics and policy; landscape science, planning and design methods, landscape use and perception, applied informatics and computer aided design; aboriculture.

IB Instituut voor Bodemvruchtbaarheid
Institute for Soil Fertility Research

Dr.ir. K. Harmsen, director
Dr. P.J. Lont, deputy-director

Address: Oosterweg 92, Haren (Gr.)
Mailing address: P.O. Box 30003, 9750 RA Haren (Gr.), The Netherlands
Telephone: (+31 50) 33 77 77
Telefax: (+31 50) 33 72 91/Telex: 53990 ibhrn nl

Research is focussed on soil fertility in all its physical, chemical and biological aspects to optimize yield and quality of agricultural and horticultural plant production. Considerable attention is given to environmental aspects, particularly to the use of chemicals and wastes from livestock and other sources. The study of contamination of soil, water and food crops by chemicals is part of the research programme.
Specialisms: soil physics, soil tillage, soil chemistry, soil biology, soil fertility and plant nutrition.

IMAG Instituut voor Mechanisatie, Arbeid en Gebouwen
Institute of Agricultural Engineering

Ir. A.A. Jongebreur, director
Drs. G.J.H. Rijkenbarg, deputy-director

Address: Mansholtlaan 10-12, Wageningen
Mailing address: P.O. Box 43, 6700 AA Wageningen, The Netherlands
Telephone: (+31 8370) 9 49 11
Telefax: (+31 8370) 9 46 66 / Telex: 45330 ctwag nl

Research is focussed on mechanization, automatization, labour and work organization in agriculture and horticulture. Research on agricultural buildings and glasshouses, includes also climate control and energy consumption.
Specialisms: mechanical, electrical, electronical and architectural engineering, labour and work management, process technology, environmental technology.

IPO Instituut voor Planteziektenkundig Onderzoek
Research Institute for Plan Protection

Dr.ir. O.M.B. de Ponti, director
Ir. J. Leeuwangh, deputy-director

Address: Binnenhaven 12, Wageningen
Mailing address: P.O. Box 9060, 6700 GW Wageningen, The Netherlands
Telephone: (+31 8370) 1 91 51
from November 26th 1990: (+31 8370) 7 60 00
Telefax: (+31 8370) 1 01 13

The research programme deals with plant protection against fungi, bacteria, viruses, viroids, insects, mites and nematodes. The effect of air pollution on plants is also investigated.
Specialisms: entomology, mycolocy, bacteriology, virology, nematology, phytotoxicology of air pollution.

IVO Instituut voor Veeteeltkundig Onderzoek 'Schoonoord'
Research Institute for Animal Production 'Schoonoord'

Dr.ir. A.J. van der Zijpp, director
Ir. D. Minkema, deputy-director

Address: Driebergseweg 10D, Zeist
Mailing address: P.O. Box 501, 3700 AM Zeist, The Netherlands
Telephone: (+31 3404) 2 96 11 / Telefax: (+31 3404) 1 51 44

The research aims to promote animal production of cattle, sheep, goats and pigs with emphasis on management and housing, reproduction, breeding, selection and slaughter quality.
Specialisms: efficiency of production, housing and management aspects, reproduction, selection, biotechnology, animal welfare, slaughter quality.

IVVO Instituut voor Veevoedingsonderzoek
Research Institute for Livestock Feeding and Nutrition

Dr. ir. Y. van der Honing, director

Adress: Runderweg 2, Lelystad
Mailing address: P.O. Box 160, 8200 AD Lelystad, The Netherlands
Telephone: (+31 3200) 9 32 11/Telefax: (+31 3200) 4 15 84

Research is focussed on feeding and nutrition relevant to animal production and animal husbandry.
Specialisms: blochemistry, physiology, ruminant feeding, pig feeding.

LEI Landbouw Economisch Instituut
Agricultural Economics Research Institute

Prof.drs. J. de Veer, director
Prof.dr.ir. L.C. Zachariasse, deputy-director

Address: Conradkade 175, 's Gravenhage
Mailing address: P.O. Box 29703, 2502 LS 's Gravenhage, The Netherlands
Telephone: (+31 70) 61 41 61
Telefax: (+31 70) 61 56 24

The institute studies the management and general economics of Dutch agriculture and fisheries, including descriptive and prognostic research for the government and for farmers. Results of farm-oriented and policy-oriented research have a wide range of application.
Specialisms: statistics, economics, social sciences, information systems.

PUDOC Centrum voor Landbouwpublikaties en Landbouwdocumentatie
Centre for Agricultural Publishing and Documentation

Drs. J.M. Schippers, director
Dr. A.J. Lever, deputy-director

Address: Gen. Foulkesweg 19, Wageningen
Mailing address: P.O. Box 4, 6700 AA Wageningen, The Netherlands
Telephone: (+31 8370) 8 44 40
Telefax: (+31 8370) 8 47 61/Telex: 45015 bluwg nl

Pudoc assists agricultural research institutions in editing, publishing and printing of publications and it acts as a focal point for literature information and documentation in a nationwide network.
Specialisms: editing, publishing, literature information and documentation systems, literature searches.

RIKILT Rijks-Kwaliteitsinstituut voor land- en tuinbouwprodukten
State Institute for Quality Control of Agricultural Products

Ir. G.S. Roosje, director

Address: Bornsesteeg 45, Wageningen
Mailing address: P.O. Box 230, 6700 AE Wageningen, The Netherlands
Telephone: (+31 8370) 1 91 10
from June 25th 1990: (+31 8370) 7 54 00
Telefax: (+31 8370) 1 77 17/Telex: 75180 rikil nl

Research is focussed on development, improvement, standardization and application of methods in relation to the quality of agricultural products and raw materials for agricultural production. The Institute carries out official quality control analyses and supervises semi-official laboratories in this regard.
Specialisms: analytic chemistry, microscopy, microbiology, toxicology, sensoric evaluation, food irradiation.

RIN Rijksinstituut voor Natuurbeheer
Research Institute for Nature Management

Dr. A.B.J. Sepers, director
Prof.dr. W.J. Wolff, director of research

Address: Kemperbergerweg 67, Arnhem
Mailing address: P.O. Box 9201, 6800 HB Arnhem, The Netherlands
Telephone: (+31 85) 45 29 91
Telefax: (+31 85) 42 21 75

Research is dedicated to conservation and mangement of nature and natural resources. Studies are made on the structure and function of (semi)natural terrestrial, freshwater and coastal ecosystems, including ecology of individual plant and animal species.
Specialisms: botany, zoology, ornithology, hydrobiology, estuarine ecology, landscape ecology, environmental pollution.

RIVO Rijksinstituut voor Visserijonderzoek
Netherlands Institute for Fishery Investigations

Mr. B.B. van der Meer, director
Dr. P. Hagel, deputy-director

Address: Haringkade 1, IJmuiden
Mailing address: P.O. Box 68, 1970 AB IJmuiden, The Netherlands
Telephone: (+31 2550) 6 46 46
Telefax: (+31 2550) 6 46 44 / Telex: 71044 rivo nl

Research is focussed on biological, chemical and technical aspects of the fishing industries. Studies are made on the interrelations of fish stocks in the North Sea and in fresh water as well on the influence of water pollution.
Specialisms: sea fisheries incl. shellfish, fresh water fisheries, fish culture, micro-biology, biochemistry, engineering, environmental ecology.

SC Staring Centrum, Instituut voor onderzoek van het Landelijk Gebied
The Winand Staring Centre for integrated Land, Soil and Water Research

Ir. G.A. Oosterbaan, director
Drs. F. van de Weg, deputy-director

Address: Marijkeweg 11, Wageningen
Mailing address: P.O. Box 125, 6700 AC Wageningen, The Netherlands
Telephone: (+31 8370) 1 91 00
from October 1st 1990: (+31 8370) 7 42 00
Telefax: (+31 8370) 2 48 12 / Telex: 75230 visi nl

The Winand Staring Centre carries out integrated research on the relationships between the various functions and potential uses of rural areas.
The task fields have been spread over six divisions: land inventory and land evulation, soil physics and soil management, water management, environmental protection, landscape development, rural land use planning and outdoor recreation.

TFDL Technische en Fysische Dienst voor de Landbouw
Technical and Physical Engineering Research Service

Drs. A.M.K. van Beek, director
H.G. ten Brinke, ir. R. Koppe, deputy-directors

Address: Mansholtlaan 12, Wageningen
Mailing address: P.O. Box 356, 6700 AJ Wageningen, The Netherlands
Telephone: (+31 8370) 1 91 43
from October 8th 1990: (31 8370) 7 66 00
Telefax: (+31 8370) 1 13 12 / Telex: 45330 ctwag nl

The institute renders consulting, development and construction services for advanced instruments, tools, installations and systems (including computer hard- and software) to be used in agricultural research institutions. Calibration, maintenance, instrument lending and electron microscopy facilities are available.
Specialisms: mechanical, electric and electronic engineering, automation, electronic microscopy, computer systems, design and maintenance of buildings, installations and equipment.

ANNEXE 2

RÉSUMÉ DU PLAN NATIONAL POUR LA NATURE DES PAYS-BAS (1989)

essentials

landbouw en visserij

NATURE POLICY PLAN

Policy intention

The Nature Policy Plan - published in May 1989 - sets out the objectives and outlines of the national government's nature and landscape policy in a coherent manner, for a period of thirty years. It indicates in particular which elements of this policy the government intends to realize in the coming eight years. The Nature Policy Plan and simultaneously presented Agricultural Structure Memorandum will form important pillars of a coherent policy of the Ministry of Agriculture and Fisheries. On the basis of these memorandums an integrated policy can be formulated for the whole of the rural area.
The Nature Policy Plan and the Agricultural Structure Memorandum also interface with other government plans in the domain of land-use planning, development and management of the rural area, inter alia with the National Environmental Policy Plan, the Fourth Report on Physical Planning and the Third Memorandum on Water Management which was published in August 1989. Of especial importance are the three 'Green Structure Plans'. These plans for land development, outdoor recreation and nature and landscape conservation will shortly be revised and combined in one Structure Plan for Agriculture, Nature and Outdoor Recreation. It will set out among other things what the Nature Policy Plan means to the physical planning policy.

Plans not yet definite

The Nature Policy Plan and the Agricultural Structure Memorandum are not yet definite. During three months after their publication consultations will be conducted with other authorities. At the same time the Nature Conservation Council, the Industrial Board for Agriculture, the Central Council on Environmental Protection, the Town and Country Planning Advisory Council and the Council of the Public Works Department will be consulted. The results of the consultations and the recommendations will be incorporated in a government decision, which will be submitted to the Second Chamber of Parliament for its approval.

Existing policy not sufficient

Nature and the environment are under great pressure in and outside our country. The government policy places great emphasis on the improvement of the quality of our environment. Clean water, clean air and clean soil are not, however, enough in themselves to create an environment fit for people to live in. Ecological and landscape values, wild plant and animal species are also needed.

The decline in the populations of plants and animals in our country is still continuing, in spite of the policy efforts of the past years. This applies not only to rare species. There is an overall decline. The deterioration of nature is especially serious since the rate of deterioration has not slowed down.
In spite of efforts to the contrary, the area of habitats for wild plant and animal species continues to decline. The acreage of areas of high ecological value and natural elements is declining. Besides, new barriers bring about the fragmentation of the habitats of populations of plants and animals. This endangers their continued existence. The diversity of nature is affected adversely in different ways. The increasing impact of pollutants on areas of high ecological value via soil, water and air is a matter for concern. Besides local disturbance of species and ecological communities there is also a more widespread influence. This is especially at the expense of the more vulnerable species. These influences pose a threat to areas of high ecological value and surface waters which have so far been little influenced. The steady and insidious increase of poisonous substances in the natural environment pose a special threat.
The landscape, too, is subject to deterioration. It is becoming more uniform. Its individuality and distinctiveness are fading in consequence. The main cause is the reat change in land use and the effects of this on the landscape.
Especially the development of post-war agriculture has had a major influence on the landscape. The result of these developments is that the effect of current policy

efforts in the field of nature and the landscape is uncertain. In short, the sustainability of ecological and landscape values is not ensured. This is why the Nature Policy Plan has been developed. The main objective of the nature policy is the sustainable development and restoration of ecological and landscape values. This applies in the first place to the Netherlands, but in general is also true of the international nature policy. At national level the aim is conservation and development of *general* ecological and landscape values and the creation of certain *special* ecological and landscape values.

General ecological and landscape values

The national government shares responsibility with other authorities for the more general ecological and landscape values. Government policy is aimed at creating suitable conditions for the conservation of general ecological and landscape values by means of adequate environment and water policy measures and by means of supporting measures in the field of nature and landscape policy. The government sets out the perspectives for this task and takes measures in respect of information, research and stimulation.

Special ecological and landscape values

The national government is responsible in the first place for areas with special ecological and landscape values. Particularly the special ecological and landscape values are under strong pressure. Intensification of the policy is therefore necessary. The limited financial resources require the setting of clear priorities. The *ecological values* are foremost.
The emphasis is on activities regarding:
- brooks, poor grassland, scrub, semi-natural woodland on chalk soil and spring forests in the South Limburg hills;
- shifting sands, heath and fens, bogs, poor grassland, brooks, marshes and older forests on the higher-lying sandy soils;
- cut-off meanders, scourholes, marshes, (poor) grassland and forests in the fluvial region and especially in the winter bed of the Maas and the forelands of the great rivers;
- (poor) grassland (including ditches), marshes and pools and canals in the low-lying peatland area;
- wet grasslands (including ditches), marshes and forests in the marine clay area;
- young dunes, as well as poor grassland, scrub and forests in the inland dune area;
- cut-off sea inlets and river mouths;
- tidal waters;
- offshore sea.

National ecological network

The Nature Policy Plan's primary objective is to realize a national ecological network. The national ecological network is a coherent network of areas which will form a durable basis for the ecosystems and species considered important in an (inter)national context. The ecological network consists of *core areas, nature development areas* and *ecological corridors*. Their sustainable development is supported by a buffer policy aimed at removing or minimizing negative external influences on the core areas.

Core areas are areas with existing ecological values of international or national importance, with a minimum size of about 500 ha. Forests, large waters and the North Sea have also been included as core areas. In some cases the biotopes of animal species which are characteristic of the Netherlands and are of great international importance, have been included as core areas. The policy concerning core areas is aimed at safeguarding and increasing the existing ecological values. To that end negative developments will be countered and the desired management will be made possible. Measures will be taken to counteract deterioration of the quality of ground and surface water and to prevent changes in water management with adverse effects on nature.

The *nature development areas* are areas offering special perspectives for the development of ecological values of (inter)national importance or for the substantial increase of the existing ecological values. The development of these areas brings, inter alia, a network of wetlands of high ecological value within reach. This is in line with the position of our country as a link in an international chain of wetlands. It is also in line with the emphasis placed in the Fourth Report on Physical Planning on areas in the 'wet axis' across the Netherlands and with developments in the context of the EEC.

For a limited number of species important to and characteristic of core areas it is possible to indicate *ecological corridors*, in order to restore migration facilities between and within core areas. This concerns species whose requirements regarding

corridors are known (otter, badger, red deer, and some fish species). Facilities for these species will also prove significant for a number of other species in the core areas.

Landscape

A number of areas have been selected with special geological, cultural-historical and perception values, which are of particular importance to the conservation of the great diversity of landscapes in our country. These areas partly coincide with the ecological network. The policy on these areas with specific landscape values will be aimed at conservation, restoration and development of the characteristic features and structures in these areas.

Species policy

The national ecological network policy affords plant and animal species within these areas better chances. Specific measures are also being taken for a number of species.
The animal species covered by this species policy are:
- Mammals: bats, badger, otter, seal, common porpoise, Tundra vole;
- Birds: spoonbill, darkbreasted barn owl, geese, kingfisher, common partridge, common crane, blackgrouse;
- Fish: pond loach, sea trout, brown trout, bitterling, pike, salmon;
- Amphibians and reptiles: Bombina variegata, midwife toad, tree toad, great crested newt, wall lizard, ringed snake;
- Invertebrate animals: butterflies, dragonflies and damselflies, crayfish;
- Plants: weeds of arable land, marsh marigold, chantarelle, water soldier, Bardfield oxlip, yew tree, lime tree, orchids, snake's head fritillary.

Species protection plans are being drawn up for a limited number of species. Measures in this connection consist of subsidizing specific (technical) facilities and information activities.

Policy instruments

The realization of the national ecological network must be supported by a number of instruments.
The following choices are made:
- *Systematic application of the Nature Protection Act* in existing areas of high ecological value in the national ecological network;
- Completion of the ecological network by means of the acquisition of areas of high ecological value, forests and landed estates;
- Acquisition of land for *nature development;*
- Expansion of the environmentally sensitive areas by another 100,000 ha (present area is 100,000 ha);
- Expansion of the area covered by the *Regulation on farmers in hilly and mountainous areas*;
- Further realization of a system of *National Parks* in the large areas of high ecological value in the national ecological network.

Supporting policy

The realization of the policy goals requires supporting policy measures.
It will be necessary to implement a number of pilot and demonstration projects. The policy-supporting research effort also needs to be improved. Private initiative is indispensable to the realization of the plan. The private nature protection organizations are assured of the continued support of the Ministry of Agriculture and Fisheries.

International

To define the relation between nature in the Netherlands with areas of high ecological value outside it, and our international responsibility in the field of nature conservation, the Nature Policy Plan provides for activities in the domain of international nature policy.

This policy centres on those ecosystems and species which:
- greatly contribute to the natural diversity on earth and are seriously threatened;
- have a direct relationship with the Dutch nature policy;
- can be influenced through Dutch activities.

Priorities are wetlands, tropical forests, offshore seas and coastal areas, migratory birds and large animal species such as whales. More attention will also be paid to the monitoring of the relationship between ecology and development co-operation.

Finances

To finance the Agricultural Structure Memorandum and the Nature Policy Plan extra resources will be added to the budget of the Ministry of Agriculture and Fisheries, rising to £ 91 million in 1994.
Within the budget of the Ministry of Agriculture and Fisheries funds will be made available by means of internal shifts of budget.
The policy laid down in the Nature Policy Plan requires additional financial efforts

with regard to the acquisition of land, management, development work and subsidization of research, projects and (international) organizations. For the Ministry of Agriculture and Fisheries the intensification of policy efforts as from 1990 means the allocation of extra resources up to a total of £ 21.5 million in 1994. A quarter of this will be raised by a tax on water sports. The current financial efforts of the nature policy are already aimed to a considerable extent at the areas forming part of the ecological network. This policy will be continued. Besides, the intensification of policy - where area conservation is concerned - will be aimed mainly at the national ecological network.
Additional funds will be earmarked for the species policy, the general nature policy and the international nature policy, as well as for the support of the policy by inventories, monitoring, research and subsidization of relevant projects and experiments.

Further information

For additional information please contact the Ministry of Agriculture and Fisheries,
P.O. Box 20401
2500 EK The Hague
Telephone 70 - 79 20 57 or 79 20 62

The Hague, November 1989
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Information and External Relations Department

ANNEXE 3

LISTE DES PARTICIPANTS/ CORRESPONDANTS EUROPÉENS DANS LE CADRE DU "EUROPEAN WORKING GROUP ON EARTH SCIENCE CONSERVATION"

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ANNEXE 4

STRATÉGIE DU NATURE CONSERVANCY COUNCIL ET RÉFÉRENCES

Source : Document envoyé par K.L. DUFF, Assistant Chief Scientist.

NATURE
CONSERVANCY
COUNCIL

EARTH SCIENCE CONSERVATION

A DRAFT STRATEGY

SUMMARY OF PROPOSED STRATEGY

Initiating Individuals/ Organisations	Proposed Role
Individual geologists, local geological and specialist societies, museums and NSGSD members, earth science teachers, and local nature conservation organisations.	a. Set up or join a county based RIGS group with the following objectives: * Carry out and/or coordinate selection and conservation of a network of sites within the county or region. Conservation could include seeking recognition in Structure Plans, clearance, interpretation and stabilisation of sites, promoting better management of sites, deflecting or opposing damaging developments, encouraging wider use of sites and monitoring (Chapters 6 and 13). * Promote local involvement in conservation of earth science sites, particularly of nature and wildlife conservation organisations, planners, local industry, schools and amongst site owners (Chapter 7-9). * Investigate more general conservation problems and, taking account of the research and solutions available, develop new solutions and techniques where need arises (Chapter 10) b. Undertake individual initiatives on sites to conserve them (Chapter 6). c. Seek wherever possible to increase local understanding and involvement in conservation of sites particularly the groups identified above (Chapter 7). d. Take advantage of international contacts to seek and disseminate information on conservation internationally (Chapter 11).

	e. Provide specialist advice to NCC on the science of sites to assist in their conservation (Chapter 14).
	f. Participate in updating NSGSD records. (Chapter 12).
National geological/geomorphological societies and associations, and national conservation bodies.	a. Formal recognition and strengthening of the role of earth science conservation within the organisation (Chapter 6).
	b. Participation in regular theme meetings, conferences and input to publications on all aspects of earth science conservation (Chapter 6).
	c. Add to the focus for international consultations (Chapters 6 and 11).
	d. Liaison with other national and local earth science conservation bodies to promote greater links and cooperation with mineral extraction, coastal engineering and waste disposal industries (Chapters 7-9).
	e. Promotion and support of RIGS groups. (Chapter 13).
	f. Continuing local and national sponsorship of practical site conservation and conservation research. (Chapter 6 and 10).
Nature Conservancy Council	a. Continuing statutory role of conservation of SSSI network including enhancement and documentation of science of sites (Chapter 14).
	b. Continue to commission research into conservation techniques and solutions to problems (Chapter 10).
	c. Develop existing role in advocacy of earth science conservation particularly with the geological community, industry, educationalists, other conservation bodies, the general public and the Government (Chapter 7-9).

	d. Promote RIGS schemes (Chapter 13).
	e. Support as far as possible other national and local conservation bodies in earth science. (Chapter 6).
British Geological Survey	a. Complete computerisation of NSGSD (Chapter 12).
	b. Coordinate maintenance of the national records, leading to an integrated scheme for documentation of sites in Britain. (Chapter 12).

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ANNEXE 5

ORGANISATION ET SPÉCIFICATIONS TECHNIQUES DU RÉSEAU DE CONTRÔLE DE LA QUALITÉ DE L'AIR GÉRÉ PAR LE RIVM

Source : Rapport RIVM "Natural Air Quality Monitoring System".
Déc. 1989

National Air Quality Monitoring Network

1. Introduction

In 1966 the former National Institute of Public Health was requested to design an automated monitoring system for the nation-wide monitoring of air pollution. In 1968 a non-automatic monitoring network for sulphur dioxide was installed in the county of Twente for feasibility purposes.
Based on the results of this study and in co-operation with the regional authorities the 'First draft of the National Monitoring Network for Air Pollution' was accepted in 1970.
In 1975 the first phase of the installation was terminated. By that time 220 stations for measuring sulphur dioxide and 40 for wind direction and wind velocity were in full operation. The extension to the monitoring of nitrogen oxides, ozone and carbon monoxide was completed in the spring of 1978.
The network was completely modernized in 1986, using the experiences of the old one. Such in order to meet the requirements of national and international air quality regulations.
The new network was put in operation on April 1st 1986. It was extended with 17 so called macro-stations; platforms on which a wide variety of aerosols and gaseous air pollutants as well as wet deposition can be measured.
On the premises of some of these macro-stations biological effect measurements are conducted by 'IPO' (Research Institute for Plant Protection), by exposing indicator plants to ambient air pollution concentrations.
Furthermore 13 stations were installed in city streets with heavy traffic to measure traffic related pollutants and 5 additional stations in city background environments.

Data transmission in the old network was effected by fixed and leased telephone lines. In the new one communication is established through the public telephone network. The use of automatic calling units results in very short connection times and low costs.
The stations data processor collects and stores the data. Its memory is read out on the call of the central acquisition system (CAS) in Bilthoven. Fig. 1.

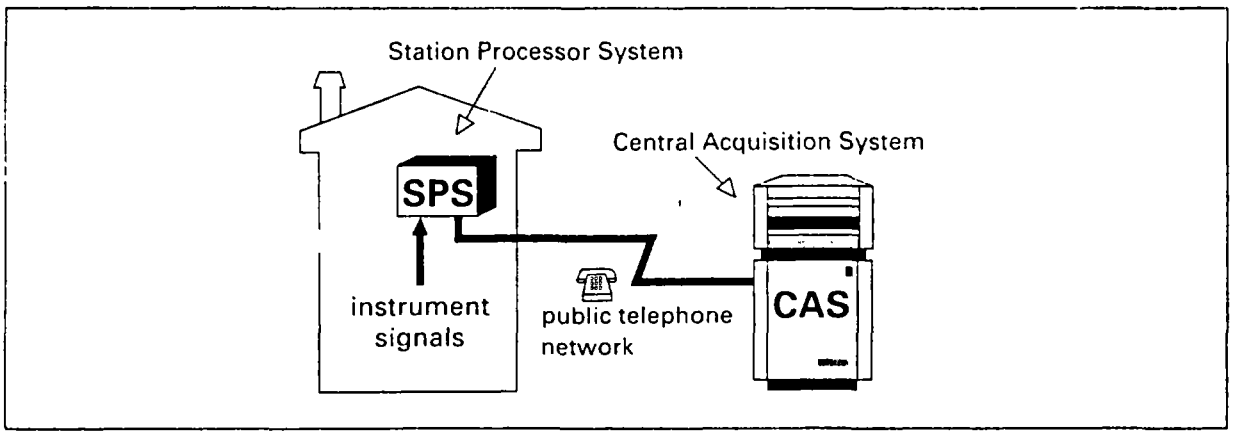


Fig. 1. Data Acquisition System

This report describes the Network as it existed in midyear 1989.

2. Objectives (A), monitoring strategy (B), data handling (C), general description (D) and summary of numbers (E).

A. There are five objectives of the network:

1. Regulatory control.
The network furnishes information relevant to air quality standards as set by national or international legal regulations. Its design and station criteria are specified in the national legislation.

2. Alert system.
The alarm function of the network enables action to be taken during pollution episodes. Episodes are periods lasting up to several days with pollution levels significantly above normal which pose a potential hazard to health.
Meteorological information is used to produce a forecast.

3. Determination of long term spatial distribution and trend. These quantities yield information on the need for regulatory action as well on the effects of earlier actions.

4. Attribution of sources.
The development of dispersion models to describe the measurements of the network strongly increases the understanding of the effects and sitings of the sources and sinks of the pollutants in the Netherlands and abroad. The models form an indispensable tool for a successful abatement strategy.

5. Determination of deposition.
The combined application of model calculations and the measurement of pollutant concentrations in air as well as in rain-water enables the determination of the downward flux of material to the soil. In the case of acid deposition control the assessment of the exceeding of threshold values on a nation wide scale is required.

B. Monitoring strategy.

In order to meet the requirements of national and international air quality regulations the Dutch network was redesigned in 1986. The new network is set up in such a way that the 50-, and 98-percentiles of daily average SO_2-concentrations can be derived from the measurements for every 1 x 1 km^2 in areas where exceedings of limit values may be expected. The required accuracy of the estimation is set at 15%. The necessary statistical spatial properties of the percentiles are derived from the former more dense network.
SO_2-stations are arranged in a grid with an interstation distance of 40 km. In the southern part of the country additional stations are installed leading to an interstation distance of at least 28 km. Stations are added to cover hot spots in the southern part of the county of Zeeland and the northern part of the county of Limburg, resulting in an interstation distance of 16 km. In the Rotterdam-Rijnmond area the interstation distance is as low as 4 km.
Isolated sources can not always be detected by the network stations. The contribution of these sources is calculated with the aid of a dispersion model. A set of the SO_2-network is equipped with monitors for NO, NO_2, CO and O_3, to provide information on the nation wide background levels. The pertinent interstation distance is about 70 km in the northern part of the country and about 50 km in the south.
Additional stations are operated in the densely populated areas of the cities of Rotterdam, The Hague, Amsterdam and Utrecht.
To estimate the concentrations originating from traffic emissions a combination of modelling and measuring is applied.
The concentration at the kerb of a street is composed of

1. regional background
2. city background
3. emissions in the street itself

The regional background follows from the network stations. The city background and the street traffic contributions are computed by a relatively simple similarity model (CAR).

Streets are classified in 6 categories depending on a.o. width, height of buildings and presence of trees. Measurements are performed on the kerb in a limited number of streets and in situations with no traffic in the nearby vicinity (city background). The CAR-model is 'fitted' to these validation measurements. Subsequently it is used to calculate the concentration from the traffic load in all streets.
The density of the so called macro-stations have been considered along the same lines as the SO_2-stations.

C. Data handling.

All stations are equipped with a small computer the so called station processor system.
This computer controls the automatic operating monitors and reads the minute-values of the continuously measured air pollution as well as the implemented technical parameters of the monitors. Each hour the minute-values are averaged to hour-values. When the technical parameters are outside the ranges of acceptance a message is sent to the central acquisition system in Bilthoven.
The storage capacity of a stations computer is 120 minute- and 120 hour-values which are communicated to the central computer by public telephone on request.
The central computer contains a data base for the hour-values of all components measured at all stations.
Data are furnished directly and automatically to the regional authorities by means of the 'Viditel'-system of the Telecommunications B.V.
At the same time a map with the air pollution pattern over the Netherlands in gray scales is constructed by interpolation in the network results and presented to the Netherlands Broadcasting Corporation for relaying on the air via 'Teletext' and so to the general public.
This on-line part of the data acquisition of air pollution concentrations functions in the alert system of the network.
In addition the hour-values of air pollution concentrations are used to calculate percentile values over different periods of time and reported yearly to the central government, the county- and European authorities.
Exceedings of threshold values are reported separately. Moreover the data are applied to test dispersion models by comparing the calculated contributions of sources to the observed pollution levels, so presenting an estimation of the consequences of abatement strategies.

D. General description.

In the network five kinds of monitoring stations are discernable:

1. Spatially representative stations comprising of:
   1.1 Multi component stations
   1.2 Macrostations
   1.3 Rain-water stations
   1.4 Wind stations measuring WD/WV only
2. City stations
3. Street stations
4. Research stations
5. Wind stations on top of radio-towers

1. Spatially representative stations.

The results of these measurements are used to construct the general concentration fields over the country. They are combined in different configurations to meet the need for detailed information on the various subjects in air pollution problems.
A multi component station contains several automatic monitoring facilities. In chapter 5 the full complement of monitors in each station is specified.
A macro station is a special kind of spatially representative station. In addition to the normal full multicomponent configuration a larger variety of air pollutants can be monitored. These results are to be combined with measurements of the other environmental compartments 'water' and 'soil'.
On 9 of the total of 17 macrostations rain-water measurements are conducted.
For reasons of representativeness 5 rain-water sampling stations are sited in different locations from their macro stations i.e. Lelystad for Biddinghuizen, Gilze Rijen for Houtakker, Beek for

Wijnandsrade, De Bilt for Bilthoven and Rotterdam Airport for Vlaardingen. These stations carry the number of the corresponding macro stations raised by one.
4 Spatially representative stations monitor wind direction and velocity only. As all other WD/WV-stations they are free of obstacles within 200 m. and their sitings are accorded by 'KNMI' (the Royal Netherlands Meteorological Institute).
Standard measuring height is 10 m above ground level except for the stations 108, 123 and 124 in the county of Limburg which measure at 20 m.

2. City stations.

City stations are sited in streets with less than 2750 motor vehicles passing in 24 hours in a circle of 35 m around the station. They are located in the built up area of the town. The results of these observations are representative for the city background concentrations in traffic models.

3. Street stations.

Street stations are located in heavy traffic loaded streets of different types, carrying at least 10.000 motor vehicles per 24-hours inside a circle of 35 m around the siting. Their results are used to establish the relation between the traffic load and air pollution in those streets with the aid of the above mentioned traffic models.

4. Research stations.

These stations are set up for the study of air pollution gradients in the vertical.

5. Wind stations on top of radio-towers.

On the very top of 5 of the main transmitter masts of the Telecommunications B.V. wind direction and velocity are continuously monitored. Measurement results are used in short and long range air pollution transport models.

E. Summary of numbers. (for glossary see chapter 5)

The network consists of the following number of stations irrespective of their combinations.

Sulphur dioxide	85
Nitrogen oxide	45
Carbon monoxide	26
Ozone	38
Wind direction and velocity	34
Black smoke	23
B-scat	6
MVS	4
HVS	2
Nd	14
E	6
T	17
R	17
ANS	6
Macro stations	17
Rain-water stations	14
City stations	5
Street stations	13

3. Specifications of monitor housings, station processor system and monitors.

B12-standard-monitor housing.

Outside dimensions (LxWxH)	1.87 x 1.09 x 2.39 m
Sampling height above ground level if not stated otherwise	3.5 m
Residence time in sampling system	< 6 seconds
Heating	Ventilator-heater 2000 W Thermostat on at <15°C
Ventilation	Slow speed axial ventilator Ventilation factor 200 times/hr Thermostat on at >25°C

Macro monitor housing.

Outside dimensions (LxWxH)	6.73 x 2.87 x 2.64 m
Sampling height above ground level if not stated otherwise	3.6 m
Residence time in sampling system	<6 seconds
Heating	Ventilator-heater 2000 W Thermostat on at <15°C
Ventilation	Slow speed axial ventilator Ventilation factor 16 times/hr Thermostat on at >20°C

Station Processor System.

Hardware:	Siemens SMP-system CMOS-memory 64 kb I/O 2x 16 channel ADC, 12 bits 1 x digital out 16 channel Clock battery back up Automatic calling unit 1200-baud modem
Software: Siemens designed:	Operating system: Nucleus communication HDLC-protocol
RIVM-made:	Application software (Pascal) Component modules Data storage

Central Acquisition System.

Hardware:	Siemens SMP-system Internal memory 1 mb External memory 60 mb 5 Automatic calling units 5 1200-baud Modems
Software:	Operating system: concurrent CPM communication HDLC-protocol Data base Application software (Pascal)

Sulphur dioxide monitor Thermo Environmental Instruments Inc. Model 43 W. Version 2.

Principle of operation	Gasphase-fluorescence
Measuring range	0-750 ppb (0-2000 ug/m^3)
Lower detection limit	1 ppb
Precision (80% full scale)	1%
Selectivity:	
- moisture	Less than a 3% change in the SO_2-signal following a change in the relative humidity from 0% to 80% at 20°C
- aromatic hydrocarbons	Total contribution of aromatic hydrocarbons from motorized traffic to the SO_2-signal is less than 5 ppb at a CO-level of 15 ppm
- nitric oxide	Contribution of NO to the SO_2-signal is less than 0.5% of the ambient NO-concentration
- carbon disulphide	Contribution of CS_2 to the SO_2-signal is less than 5% of the CS_2-concentration
Temp. influence on zero	<0.05 ppb/°C
Temp. influence on sensitivity	<0.1%/°C
Zero drift	<1 ppb/day and <+15 ppb/year
Sensitivity drift	<2%/week or <5%/year
Nonlinearity	<0.5% of measured value or less than 0.5 ppb
Response time (99%)	6 min. or less
Sampling flow	<0.5 l/min
Calibration	- Zero once a day by removing the pollutant from the sampling flow by means of impregnated and activated carbon, type Norit RB. Pellet size 1 mm. - Span once in 7 days by means of a pressure bottle containing the pollutant in a concentration certified by the 'Nederlands Meetinstituut' (Netherlands Measurings Institute)

Monitor and calibration unit are in procedural accordance with the requirements of the 'Besluit luchtkwaliteit zwaveldioxide en zwevende deeltjes', Staatsblad (1986) nr. 78 and the additional 'Meetbesluit zwaveldioxide en zwevende deeltjes (zwarte rook)' of 13 February 1986

Carbon monoxide monitor Thermo Environmental Instruments Inc. Model 48.

Principle of operation	Gas filter correlation spectrometry
Measuring range	0-50 ppm (0-58000 ug/m^3)
Lower detection limit	<0.1 ppm
Precision (80% full scale)	<1%
Selectivity	Total interference due to change in humidity from 0% to 80% R.H. at 20°C and change in CO_2-concentration from 0 to 330 ppm is less than 0.2 ppm
Temp. influence on zero	<0.02 ppm/°C (5-40°C)
Temp. influence on sensitivity	<0.15%/°C (5-40°C)
Zero drift	<0.05 ppm/day; <2 ppm/year
Sensitivity drift	<3%/week; <10%/year
Non-linearity	<0.2 ppm or <1% of the concentration

Response time	<5 min (99% full scale)
Sampling flow	<0.5 l/min
Calibration	- Zero once a day by removing the pollutant from the sampling flow (Vide SO_2) - Span once in 7 days by means of a pressure bottle containing the pollutant in a concentration certified by the 'Nederlands Meetinstituut' (Netherlands Measurings Institute)

Monitor and calibration unit are in procedural accordance with the requirements of the 'Besluit luchtkwaliteit koolstofmonoxide en lood' Staatsblad (1987) nr. 34 and the additional 'Technische aspecten van het besluit luchtkwaliteit koolstofmonoxide en lood', Publicatiereeks Lucht nr. 52. (Measuring range excepted which should be 60 mg/m^3)

Ozone monitor Philips PW 9771/00.

Principle of operation	Chemiluminescent reaction of ozone and rhodamine B
Measuring range	0-500 ug/m^3 (250 ppb)
Lower detection limit	<0.6 ug/m^3
Precision (80% full scale)	0.7%
Selectivity	Change of sensitivity by water vapour <0.3%/°C-dew point below dew point 0°C and <0.1%/°C-dew point above it
Temp. influence on zero	<0.1 ug/m^3/°C
Temp. influence on sensitivity	<0.3%/°C
Zero drift	<0.4 ug/m^3/24-hr
Sensitivity drift	<+/-2% full scale/24-hr
Non-linearity	<+/-4% full scale
Response time	80 sec (100% full scale)
Sampling flow	0.6 l/min

Nitrogen oxides monitor Philips PW 9762/00.

Principle of operation	Chemiluminescent reaction between NO + O_3; NO_2 is measured after reduction to NO. (conversion efficiency better than 99%) Cyclic operation of NO and NO_2 by the same detector with automatic zero correction. NO_2 is calculated from the difference of total NO and NO.
Measuring range	NO: 0-4 ppm (0-5000 ug/m^3) NOx: 0-5 ppm
Lower detection limit	NO- en NOx-channel: <1 ppb
Precision (80% full scale)	<1% of the measured value with a min. of 1 ppb for NO and NOx
Selectivity	Impact of ozone concentration depends on the gas reaction between both gases during the retention time in the sampling system. Change of sensitivity by water vapour is 5% for a dew point range from -15°C to +15°C 85% of a PAN-concentration and <0.5% of a NH_3-concentration is measured by the monitor as NOx
Temp. influence on zero	see zero drift
Temp. influence on sensitivity	<0.2%/°C
Zero drift	<0.2%/24-hr of the selected analoguous range (temp. dependence inclusive)
Sensitivity drift	<2%/24-hr and <10%/3-months

Non-linearity	<+/-1% of the indicated value with a minimum of 0.001 ppm
Response time	3 min (99% full scale)
Sampling flow	0.9 l/min
Calibration	- Zero once/24-hours by removing the pollutant from the sampling flow (Vide SO_2) - Span once/24-hours by means of a pressure bottle containing the pollutant in a known concentration followed by a partial gasphase titration

Monitor and calibration unit are in procedural accordance with the requirements of the 'Besluit luchtkwaliteit stikstofdioxide' Staatsblad (1987) nr. 33 and the additional 'Technische aspecten van het besluit luchtkwaliteit stikstofdioxide', Publicatiereeks Lucht nr. 64.

Nephelometer Meteorology Research Inc. model 1550B.

Principle of operation	Light scattering by gases and suspended particles
Measuring range	(0.23 - 100) x 10^{-4} m^{-1}
Precision	+/- 10% of the indicated value
Selectivity	100% at relative humidity values below 65%
Sampling flow	141.5 l/min

Wet deposition meter, make Van Essen, wet-only type ECN.

Principle of operation	Wet only. Light protected
Hysteresis of lid closing mechanism	2.5 min
Sampling height above ground level	1.5 m
Sampling cycle	Fortnightly
Sampling orifice	400 cm^2

Specifications are in accordance with the 'Ontwerp Norm NEN 6585 Regenwatermonsterneming van de natte depositie'

Black smoke OECD method.

Principle of operation	Decrease in light reflectance of filter paper stained by suspended particles during an aspiration period of 24-hr
Measuring range	6-563 ug/m^3
Lower detection limit	6 ug/m^3
Precision	1 unit reflection corresponds with 1.3 ug/m^3 at the beginning of the scale and with 8.1 ug/m^3 at the end
Stain diameter	1 inch
Filter paper	Whatman nr. 1
Funnel diameter	5 cm
Sampling flow	1.4 l/min.
Sampling height above ground level	3.6 m

Black smoke measurements are in accordance with the instructions of the OECD as laid down in their publication: 'Methods of Measuring Air Pollution' from 1964.

Wind velocity meter Thies 4.3300.

Principle of operation	Contactless counting of pulses originating from a revolving disc with slits.
Max. measuring range	35 m/sec
Sensitivity of action	0.2 m/sec
Non-linearity	none
Measuring height above ground level if not stated otherwise	10 m

Wind direction meter KNMI-Tdm 3a TBv 4603/2070a.

Principle of operation	Gonio meter angle detection
Measuring range	0-360 degrees
Sensitivity of action	0.28 m/sec
Measuring height above ground level if not stated otherwise	10 m

Temperature meter Vaisala HMP121Y.

Principle of operation	Pt-100-measuring resistance
Measuring range	-40 - +55°C
Precision at 20°C	+/- 0.3°C
Response time (63% at 20°C and air velocity of 0.5 m/sec)	1 min
Measuring height above ground level	1.5 m

Relative humidity meter Vaisala HMP112Y.

Principle of operation	Change of capacitance due to water vapour
Measuring range	0-100%
Precision at 20°C	+/-2% in the range of 0-80% +/-3% in the range of 80-100%
Response time (90% at 20°C and air velocity of 0.5 m/sec)	5 sec
Measuring height above ground level	1.5 m

Global radiation meter Kipp & Zn CM 11.

Principle of operation	Heat absorption by a black surface attached to a thermo element
Measuring range	0-2000 W/m²
Sensitivity	4-6 $_{m}$V/W/m²
Temp. influence on sensitivity	max. 1% in the range of -10 to +40°C
Non-linearity	+0.7% at 1000 W/m²
Sensitivity drift	+/- 0.5%/year
Measuring height above ground level	4 m

High Volume Sampler (HVS) Electronica.

Principle of operation	Air filtration by a Whatman EPM 2000-filter followed by weighing the retained particles
Sampling flow	2100-2800 l/min
Sampling height above ground level	1.8 m

Medium Volume Sampler (MVS) RIVM method.

Principle of operation	Air filtration by a Whatman nr. 42-filter. Element-analysis by atom absorption spectrometry and X-ray fluorescence
Sampling flow	6.9 l/min
Sampling height above ground level	3.6 m

Total-ANS-Filterpack ECE-EMEP method.

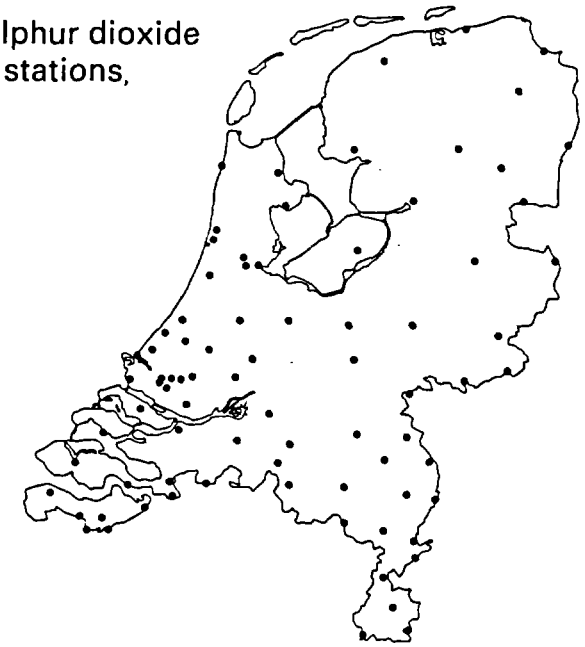
Principle of operation	Collection and absorption of total ammonium, nitrate and sulphate (gas and particles) on (impregnated) filter paper. Analysis by ion-chromatography (nitrate and sulphate) and fotochemical reaction (ammonium)
Sampling height above ground level	2 m

Measurements are in accordance with the instructions of ECE-EMEP as laid down in the publication: A filter-pack method for determination of total ammonia, total nitrate, sulphur dioxide and sulphate in the atmosphere.

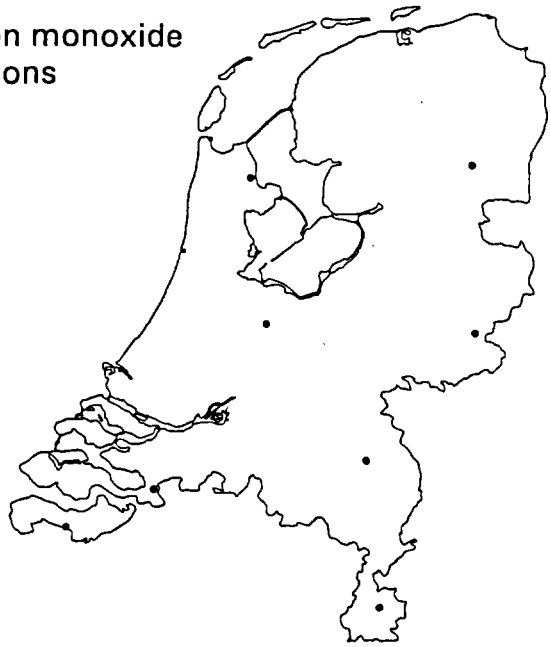
Karsten Fuglsang, MST LUFT-A103 (1986),
National Agency of Environmental Protection, Roshilde, Denmark.

4. Spatial distribution of the monitoring sites.

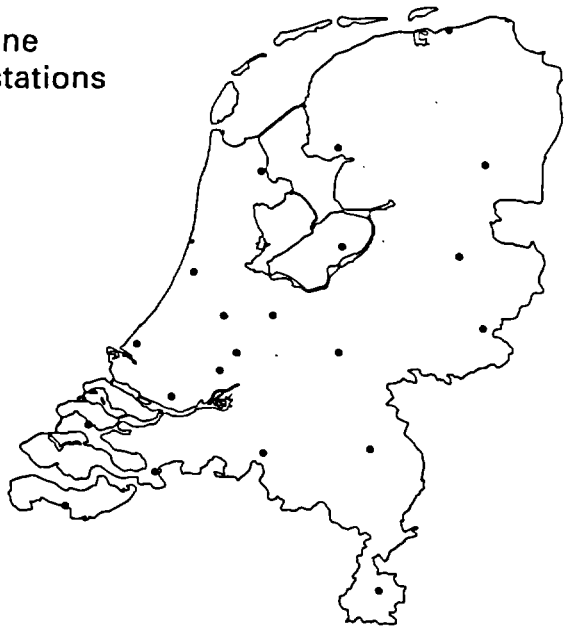
Sulphur dioxide
83 stations,



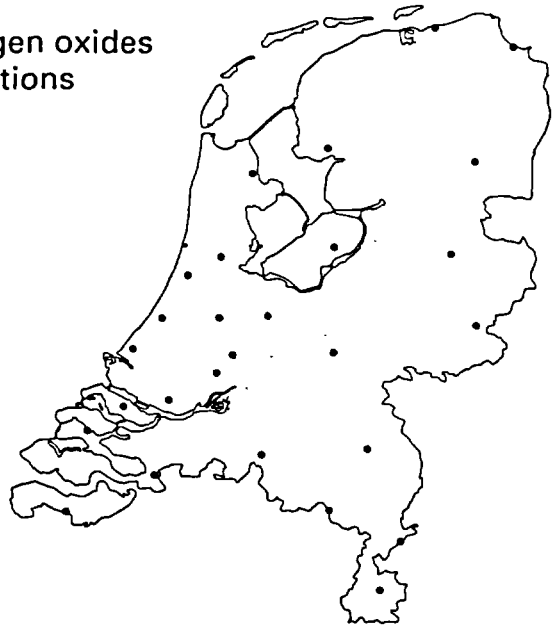
Carbon monoxide
8 stations



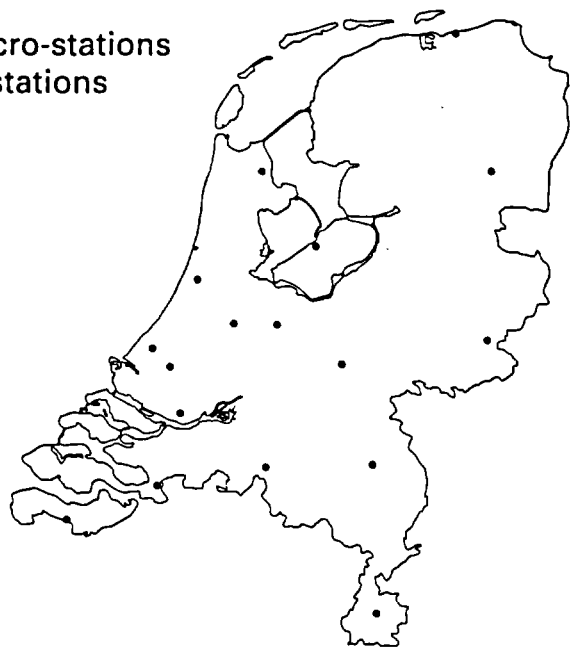
Ozone
21 stations



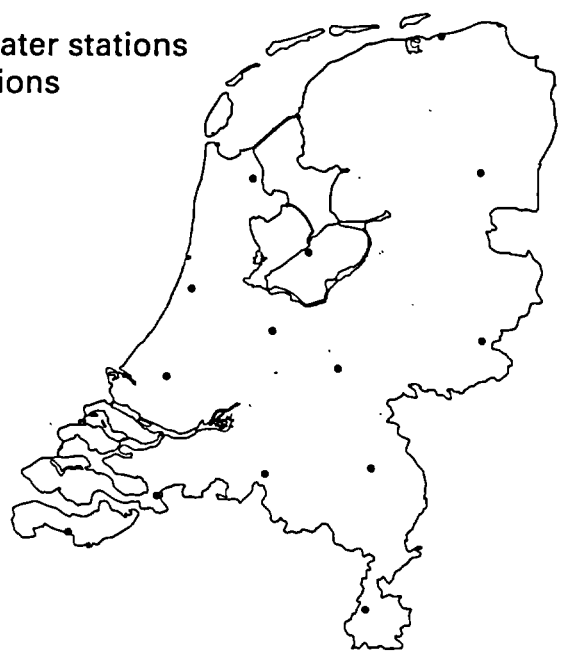
Nitrogen oxides
25 stations



Macro-stations
17 stations



Rain-water stations
14 stations



Meteorological stations
33 stations

5. Characteristics of the monitoring sites. Measured components.

Glossary:
Prefix of the stations number:

R Station in spatial representative surroundings
RW Rain-water station idem
S City station. Less than 2750 motor vehicles per 24-hrs inside a circle of 35 m located in the built up area of the town.
St Street station. At least 10.000 motor vehicles per 24-hrs inside a circle of 35 m.
B Special station for research activities
M Macro-station
T Wind-station on radio-tower
W Wind-station, WD/WV only

Coordinates:
State Survey Coordinates X and Y (in tenths) of the 'Rijksdriehoeksmeetnet' (Netherlands Triangulation Network)
The monitoring site is thus indicated within an area of X=100 m and Y=100 m

Geographical coordinates in degrees, minutes and seconds latitude and longitude. The monitoring site is indicated within an area of 31 m (north/south) and 19 m (east/west)

Surroundings:
Surroundings of the sites:
characteristics of the landscape; bearings and distances (km) of villages and towns in degrees relative to the true north in an area of 16 km^2 around the station. (64 km^2 for rain-water stations)
(D) Town or village in West Germany
(B) Town or village in Belgium

Stations monitoring WD/WV are free of obstacles within at least 200 meter

Traffic:
Dual highways and main roads in the area are indicated by: (from left to right)
- the bearing relative to the true north along the shortest distance to the monitoring site
- the registered name of the road
- the distance in km to the site
- traffic density in motor vehicles/24-hrs (weekday averages)

CAR-parameters for street stations:
N number of vehicles/day
S distance to the axis of the road in m
Vx mean velocity of traffic in km/hr
Fb parameter describing influence of trees on the dispersion in a street
Fp percentage of passenger cars
Fa mean distance to the border of the built-up area
L/H distance to road axis relative to building height
loc percentage CO due to local traffic in total CO

Emissions:
Surface emissions of SO_2, NO_2 (and NH_3 in case of rain-water stations) in kg/hr SO_2, NO_2 and NH_3 respectively, within the indicated area around the station followed by point sources within the indicated distance from the same

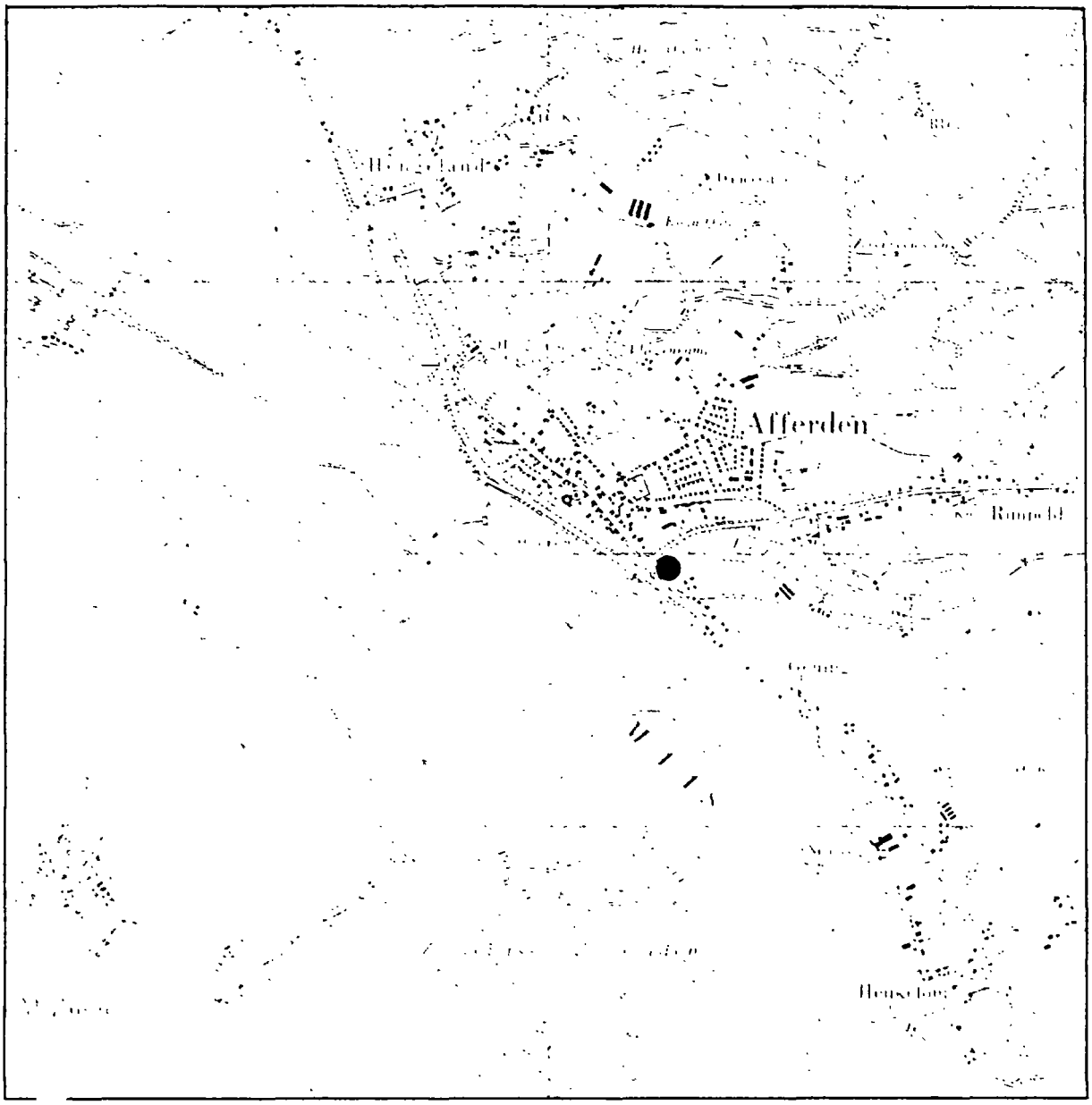
Source SOx and NOx: Emission Inventory TNO 1980
Source NH_3: Publicatiereeks Lucht nr. 41 and 76

Components and units:
Monitored pollutants and other entities:

SO_2	sulphur dioxide in ug/m^3
CO	carbon monoxide in ug/m^3
O_3	ozone in ug/m^3
NOx	nitrogen monoxide and nitrogen dioxide in ug/m^3
WD	hourly averaged wind direction in degrees relative to the true North
	derivates of WD:
	sdWD standarddeviation of the hourly average
	sdWD10 standarddeviation of last 10 min average
WV	hourly averaged wind velocity in m/sec
	derivates of WV:
	sdWV10 standarddeviation of last 10 min average.

Zwr	black smoke in ug/m^3
bscat	coefficient of light diffusion in 10^{-4} m^{-1}
Nd	wet deposition in which a.o.
	-Vc acidifying components
	-Zm heavy metals
	-Oc organic components
E	global radiation in W/m^2
T	temperature of ambient air in deg Celcius
R	relative humidity of ambient air in %
HVS	total suspended particulates in ug/m^3
MVS	heavy metals such as Pb, Hg etc.
ANS	total ammonia, nitrate and sulphate

101



R 101 Afferden 1 : 25.000
Address: Dorpsstraat
State survey coordinates: 1984 4049
Geographical coordinates: 51°37' 57"N 06°00' 52"E

Components: SO_2

Surroundings:	330°-150°	woods and heath			
	150°-330°	Maas valley (arable land and meadows)			
	360°	Afferden 0 km			
Traffic:	240°	RW 771	0.04 km	12300	

Emissions:	surface sources		point sources		
	5x5 km²	15x15 km²	<1 km	1-3.5 km	3.5-10 km
SOx	13	103	0	0	210
NOx	33	174	0	0	188

ANNEXE 6

RÉSEAU DE CONTRÔLE DE LA RADIOACTIVITÉ AU RIVM

Source : document RIVM

ENVIRONMENTAL MONITORING AND THE APPLICATION OF PREDICTIVE MODELS FOR NUCLEAR EMERGENCIES IN THE NETHERLANDS

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Summary

In this paper the organization within the Netherlands of the technical information in case of a nuclear emergency is shortly described. Part of this structure is the fully automatic radioactivity measurement network and the Information and Documentation Centre. Considerations on the interface between real-time monitoring and predictive modelling are given and some practical applications are presented.

1. THE ORGANIZATION OF THE TECHNICAL INFORMATION IN THE NETHERLANDS

In February 1989, three years after the Chernobyl accident, the "Policy Document for Nuclear Emergency Planning and Response" [1] and the "National Plan for Nuclear Emergency Planning and Response" [2] were presented to the Dutch Parliament. In these documents a new framework is presented for the planning of nuclear emergencies, considering all administrative levels, taking into account the various radiological accidents and dealing with both the technical information and the information to the public and the media.

In this paper, dealing with monitoring and predictive models, our main interest is in the organization of the technical information on the national level. This organization contains all services and institutes which are active in the field of radiological monitoring and evaluation on a regular basis in non-accident situations. In accident situations the data produced by these monitoring networks, monitoring teams and other facilities are collected by the so called Support Centres, each of them dealing with their specific area of responsibility, such as public health, agriculture or environment. These Support Centres in turn will report in a systematical way the results obtained in their specific discipline to their respresentative in the Technical Information Group (TIG). The TIG collects and interprets the data in order to formulate an advice to the Management Team, which is responsible for the over-all coordination of the emergency handling, including the counter-measures and their (political) consequences. The structure of this organization of the technical information is shown schematically in Figure 1. For a review of the national plan and the technical information aspects the reader is referred to references [3] and [4] respectively.

As can be seen from the figure the National Institute of Public Health and Environmental Protection (RIVM) is one of the Support Centres. In addition an automated Information and Documentation Centre, which will collect, store and interpret the data from all

Support Centres will be installed at the same institute. Both functions of RIVM within the technical information organization will be discussed below.

2. RIVM AS SUPPORT CENTRE

As a Support Centre RIVM has the following facilities related to both environmental monitoring and to public health [5]:

- Nation-wide radioactivity monitoring network
- Two fully equipped mobile monitoring teams
- A fully equipped monitoring plane
- A variety of laboratory facilities, including a whole body counter
- Extensive facilities for the treatment of persons exposed to radiation
- Contracts with specialized institutes within the country which on demand will carry out specific measurements making use of the standardized methods of measurements as developed in the Normstar project [6].

In addition messages from the Global Telecommunication System (GTS), used by the IAEA for radiological emergency situations, will arrive at and be decoded by RIVM.

3. THE NATION-WIDE RADIOACTIVITY MONITORING NETWORK

Underlying philosophy and technical realization

The pathways through which the population is exposed to environmental radioactivity following a radiological accident can be divided in three main categories: (1) external irradiation, (2) inhalation and (3) ingestion. The first two can be regarded as direct and the latter as indirect. In case of a radiological accident, the direct pathways ask for direct counter measures. For this reason the primary function of the Dutch radioactivity monitoring network is early warning of increases in (man-made) radiation levels by sampling the direct pathways. Its secondary function is to provide qualitative information on the geographical distribution of the radioactivity or radiation. In order to quantify the network data for radioprotection purposes two nuclide specific measurements are also carried out on an on-line basis which are an integral part of the network. One apparatus measures the gaseous radioactive iodine concentration in air (Herfurth H1399), and the other the nuclide-specific gamma activity of airborne particles (FAG FHT59N).

The entire Dutch network consists of 58 locations which corresponds to a mutual distance of typically 25 km. The network is more dense in the southwestern area of the country taking into account the average wind direction in The Netherlands, the presence of a domestic power plant and nearby foreign nuclear installations. All locations contain a proportional gamma radiation counter (Bitt RS02 tube with RM10E electronics) to detect an increase of external gamma radiation levels. To cover the inhalation pathway 14 locations are equipped with an airborne activity monitor (FAG FHT59S) which yields the aerosol bound man-made gross beta activity concentration in air.

In Figure 2 the geographical distribution of the network is shown. The network is integrated in the infrastructure of the Dutch National Air Quality Monitoring Network which is also operated by RIVM. Thus the radioactivity measurements can be easily supplemented with other relevant data such as total dust concentration, wind velocity and direction, temperature and solar radiation. These data can be useful to interpret the radioactivity measurements, both in normal and in accident situations.

Further technical specifications

The Bitt RS02/RM10E proportional gamma counter equipment, which was purchased as an exposure rate meter, was investigated at the primary X-ray standard laboratory at RIVM. The response was established for four different Röntgen qualities and gamma radiation from a cesium-137 and a cobalt-60 source. The averaged results of 6 tubes are shown in Figure 3 (solid triangles). The data, which cover the energy range between 65 and 1100 keV and are normalized to the response of cesium-137, clearly show that this equipment should not be regarded as an exposure rate meter. In fact, the energy dependent response follows, as a first order approximation, the ambient dose equivalent function (see solid line in Figure 3). Based on these results it was decided to interpret the measurement results directly in terms of the dose equivalent rate by applying an energy independent conversion factor.

The FAG FHT59S aerosol monitor samples airborne dust on a circular spot (5 cm in diameter) on a 42 meter long glass fiber filter. Every 10 minutes a 2.5 mm filter step is made. The collected activity is measured by a ZnS/plastic scintillator combination on the front of a photomultiplier tube. By using pulse discrimination, the alpha and beta activities are measured almost independently. In order to make a proper calculation from filter activity to activity concentration in air, the air flow is continuously measured by a differential pressure meter. The FHT59S corrects for the naturally occurring radon-222 series. The monitor measures the ratio between the alpha and beta activity concentrations in air two days after installation. After this period, this semi-experimentally found ratio is set as a constant for the ratio between the natural alpha and beta radioactivity concentration. The output of the monitor consists of the gross alpha activity concentration and the "man-made" gross beta activity concentration. The latter is calculated by subtracting the calculated natural beta activity concentration (assuming equilibrium) from the measured gross beta activity concentration. During the first year of the operation of these monitors, several modifications in both hardware and software have been implemented. As a result of this, the response time of the FAG FHT59S was reduced from 80 to 10 minutes, while the detection level has decreased to well below 1 Bq/m3. As an example, the alpha and beta activity concentrations in air as collected on 10 February 1990 are shown in Figure 4.

Preliminary data analysis under normal conditions

Since February 1989 14 stations have been in operation. During this period natural background levels have been recorded both of external radiation and of airborne beta-activity.

As for the external dose equivalent rate, usually levels in the range between 45 and 90 nSv/h were recorded, depending mainly on the geographical position of the station. However, under certain weather conditions increments with values up to 60 nSv/h were noted. This especially occurred during heavy rainfall after a long dry period and is tentatively assigned to the removal of radon-222 daughters from the air.

In contrast with the rather stable external gamma radiation levels, the natural gross alpha activity frequently showed fluctuations in the range between 0 and 20 Bq/m3. In figure 5 a typical pattern of gross alpha activity is shown for week 34 in 1989. During this week meteorological conditions resulted in a "smog" episode, and the observed alpha activity follows the same day and night pattern as the polluting agents. This can be interpreted in terms of daily fluctuations of radon-222 emanation (related to the temperature of the earth's surface), the mixture height and the wind direction and velocity.

Nuclear emergencies

All data from the field locations are actually 10 minute average values. Under normal circumstances, these data are collected every hour. However, when a significant increase in a measured level is detected, a warning or alarm signal is given immediately, and the read-out time can be diminished to 10 minutes.

The alarm levels are defined in such a way that validated data in excess of one of these levels cause an immediate national state of alarm. Presently, the alarm levels still need to be established in The Netherlands. The warning levels are by definition the lowest levels which, when passed, make it highly probable that the noted increase of radioactivity is due to an artificial cause. By this definition, a warning level can be decreased when a more sophisticated monitor or measuring method is used, or when more experience is gained on the behavior of the natural background radiation process. It is planned to supplement the on-line measurements with model calculations, taking into account the parameters which influence the levels of natural radioactivity and radiation. In this way it should be feasible to decide on a much more solid basis whether or not an observed increase is due to natural or to other processes.

When at a certain location a predetermined level is reached, automatically a message is sent to the main computer system. Then it will generate a warning call containing all relevant information on a digital semaphone which is received by an officer on duty. After office hours, this officer has a portable personal computer with a built in modem at his disposal. After connection with the main computer has been made, a data file containing all information from the last 24 hours is transmitted. The connection with the main computer system can then be interrupted for further evaluation of these data. Special mouse-managed software was developed for this controlling PC which makes it possible to generate a quick overview of the status of the network. Necessary action can be taken when the data are sufficiently validated by the officer on duty.

4. TASKS OF THE INFORMATION AND DOCUMENTATION CENTRE

The Information and Documentation Centre (IDC) at RIVM has the task to provide the Technical Information Group with the information which is needed to advise the Management Team on counter measures. The primary tasks of the IDC are therefore twofold:

- to provide a real-time diagnosis of the radiological situation primarily based on measurements
- to provide prognoses of the radiological situation making use of models, based on meteorological forecasts and other relevant parameters.

Secondary tasks of the IDC are:

- support of monitoring strategies and response planning
- data storage for evaluation of accidents and the emergency planning

As can be seen from the tasks of the IDC this system is actually the interface between monitoring data and results of model calculations.

5. THE INTERFACE BETWEEN MONITORING DATA AND MODELLING

When discussing the interface between monitoring data and model calculations, it is important to realize that both have their sources of error. When the interface is restricted to comparison of results, there will be no interaction between the errors. However when output of measurements is used as input for calculations or vice versa, the influence of the uncertainties on the final result can be of importance. Monitoring data are restricted in space and time, contain intrinsic and statistical variations and yield only part of the information that is necessary to evaluate effective doses. Model calculations make use of assumptions, approximations and default values which are possible sources of error. When in accident situations the interface between monitoring data and model calculations is used by the emergency management the influence of uncertainties on the final results has to be taken into account.

General considerations

In case of a nuclear accident both monitoring data and model calculations will be applied. In this section some general considerations on the interface between the two are given.

Monitoring data yield only part of the information that is necessary to evaluate effective doses to the population. As an example the dose rate monitors and the beta-monitors of the Dutch radioactivity network are illustrative. The data produced by this equipment do not yield much information on the effective dose, when no nuclide specific data are available. However, when the nuclide specific composition of the contamination is known, this result can be applied to all other measurement data and these then give very relevant information on effective doses. This extrapolation can be made very accurate by the use of model calculations.

When monitoring data are available which yield information on the quantity or the composition of a release, these data can be used as input for dispersion models. Usually an estimate of the source term is reported from the plant where the accident has taken place, but more accurate information can be obtained by mobile monitoring teams or a monitoring plane. These data should then be

used for the dispersion models, rather than the estimations given by the plant itself.

When both monitoring data and model calculations are available, the results from both can be compared and validated. When important differences are observed, possibly the reason for these differences can be found, resulting in more accurate information. When good agreement is obtained, information can be obtained for places or times for which no monitoring data are available.

If a release has not yet taken place but is likely to occur, or if no data can be obtained because of high levels of radiation, model calculations can be a powerful tool for the emergency planning. Counter measures can be considered and prepared without actual measurement data. Also models can be used to obtain prognoses for the dispersion and the dose for the longer term, provided meteorological data are available.

A practical application

In this last section an application of model calculations is presented which gives important information on the monitoring strategy [6,7]. We were interested in the efficiency and accuracy of automatic monitoring networks with respect to the detection of accidents. We have used a Puff Model, EUPUFF [8], to determine the probability of detection of air contamination by means of using monitoring systems around a nuclear power plant. The monitoring networks consisted of a series of measurement posts located on a circle around the plant. Weather conditions were randomly selected from a distribution based upon the long term observations at Schiphol International Airport in The Netherlands. Thus wind velocities, wind directions and heights of the mixing layer were obtained for 600 situations. For each of these situations a series of half hour accidental releases was simulated and the probability of detection of the "accident" using each of the local monitoring networks was calculated. As soon as one of the posts reported that the response level was reached, the particular accident was "detected". In Figure 6 the probability of detection for three monitoring networks at a location of 5 km from the plant (using 5, 10 and 20 posts respectively), is plotted versus the source/detection limit. The source detection limit is defined as the total amount of emission (in arbitrary emission units) divided by the lowest concentration at which detection would take place. In fact, the source detection limit represents the maximum air volume in which the detection limit could be reached. From the results, it can be seen that 5 measurement posts have substantially lower detection probabilities than 10. The difference between 10 and 20 posts is much smaller. In Figure 7 we have indicated the probability of detection versus the radius of the circle on which the posts are placed. If emissions take place at higher altitudes measurement stations close to the plant are found to be very ineffective. Thus the optimal distance between the posts and the plant is dependent upon the altitude of the emission (and the effective plume rise).

It can be concluded from our results that a radius of 5 km and approximately 10 posts provides good detection capabilities for a wide variety of emissions.

6. CONCLUSIONS

Both automatic monitoring systems and advanced predictive modelling are relatively new developments within the nuclear emergency planning. It is therefore to be expected that the interface between the two is only starting to appear and will be an intensive area of research in the following years. Sofar we make therefore only the following concluding remarks:

- Both automatic monitoring networks and predictive models are a prerequisite for efficient emergency management.
- The uncertainties and limitations of both have to be recognized or investigated.
- Measurement data can be used to validate model calculations and vice versa. In some cases the possibility of minimizing the difference between the two in order to obtain more accurate information should be considered.
- Output of monitoring networks can yield essential input for the model calculations, especially with respect to the source term and processes like deposition.
- Model calculations can be successfully applied to determine measurements strategies, both for planning ahead and for actual emergency situations.

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[6] Dal A.H., Van Hienen J.F.A. and Van Lith D., "Monitoring strategies in the Netherlands" (submitted for publication).

[7] Slaper H., de Haan B.J. and Veling E.J.M, "The probability of detection of nuclear accidents by radioactivity monitoring networks (in Dutch with a summary in English). RIVM report nr 248903001, 1989.

[8] van Rheineck-Leyssius H.S., van Jaarsveld J.A. and de Leeuw F.A.A.M., "A lagrangian model for the real time simulation of atmospheric transport and dispersion of accidently released materials". Paper presented at the 17th NatoCems ITM, Cambridge, september 1988.

FIGURE LEGENDS

Figure 1
Schematic drawing of the organization of the technical information as described in reference [1] and [2]. For explanation of the abbreviations see text.

Figure 2
Geographical distribution of the monitoring stations of the Dutch nation-wide radioactivity monitoring network.
- ● - station where only the gamma dose rate is measured.
- ★ - station where gamma dose rate and beta activity concentration in air are measured
- ✪ - station where gamma dose rate, beta activity concentration in air, nuclide specific composition of airborne radioactivity and gaseous iodide are measured

Figure 3
Energy dependence of the response of the gamma dose rate meters of the network (triangles), compared with the ambient dose equivalent curve (solid line).

Figure 4
Illustration of the data performance of the beta activity monitor. The square points represent the gross alpha activity, attributed to radon daughters, the bars represent the "man-made" beta activity as calculated from measured the gross beta and gross alpha activity.

Figure 5
The gross alpha activity as measured during a week at one of the stations, illustrating the periodicity which appears under stable meteorological circomstances.

Figure 6
The probability of detection for three circular monitoring networks around a nuclear plant as a function of the source strength. Results are shown for 5, 10 and 20 stations at a distance of 5 km.

Figure 7
The probability of detection for three circular monitoring networks as a function of the distance from the power plant for a single source strength (for a source/detection limit of 10^{11} m^3).

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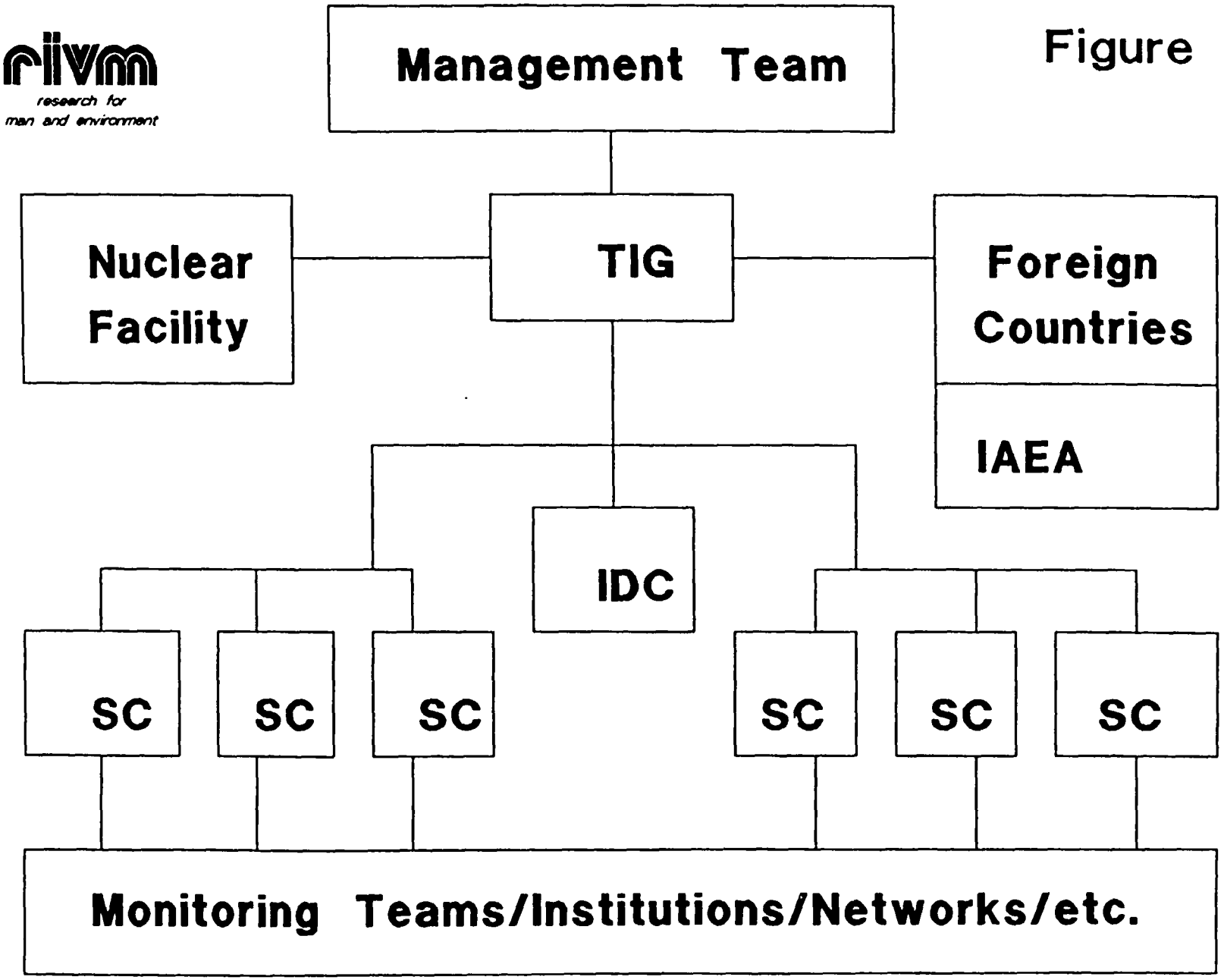
Figure 1



Nation-wide radioactivity monitoring network

Figure 2

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Bitt RS02/RM10E ENERGY RESPONSE

and the ambient dose equivalent curve

▲ RESPONSE H*(10)/X

Figure 3

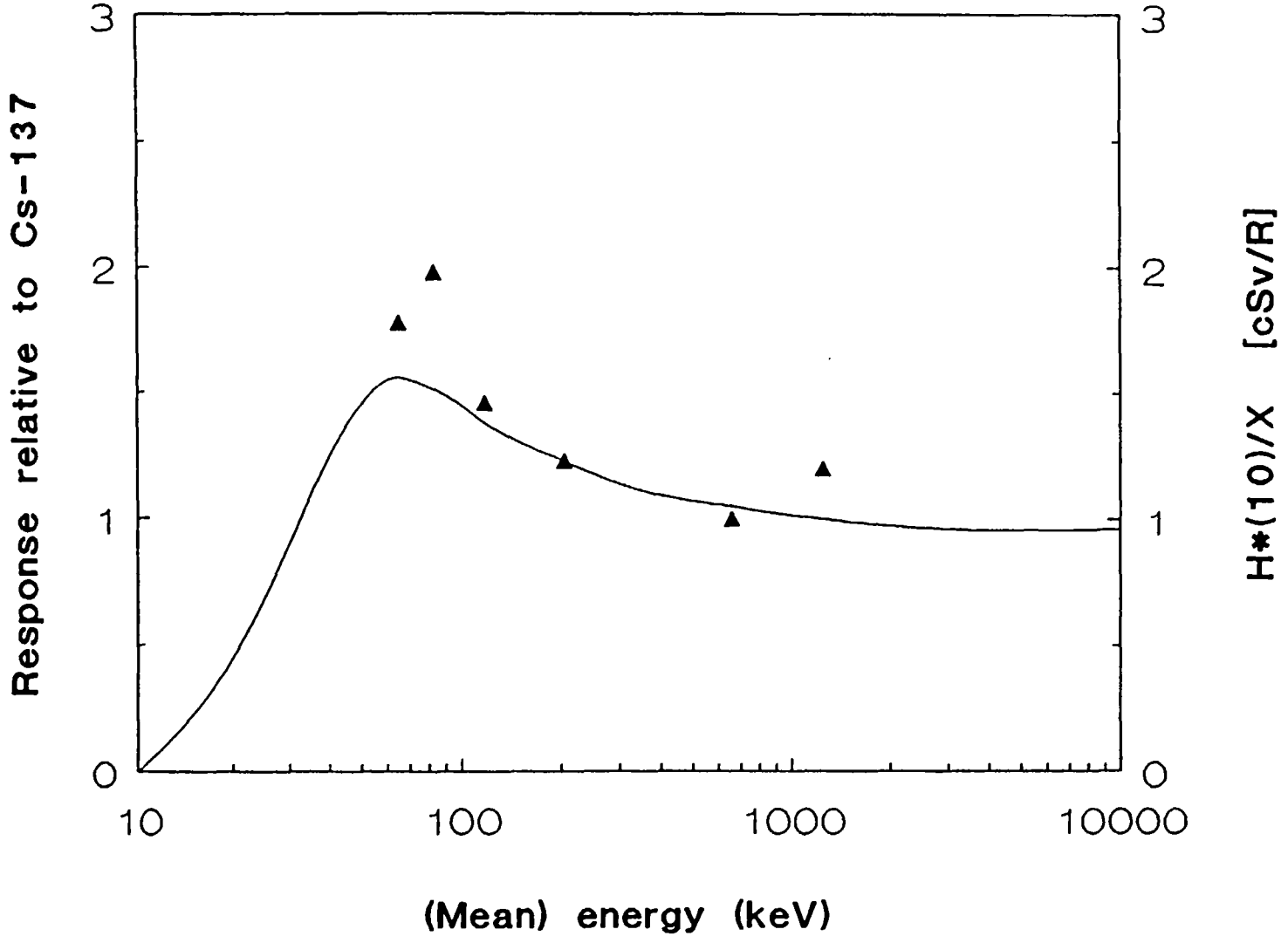


Figure 4
10 february 1990 HUIBERGEN

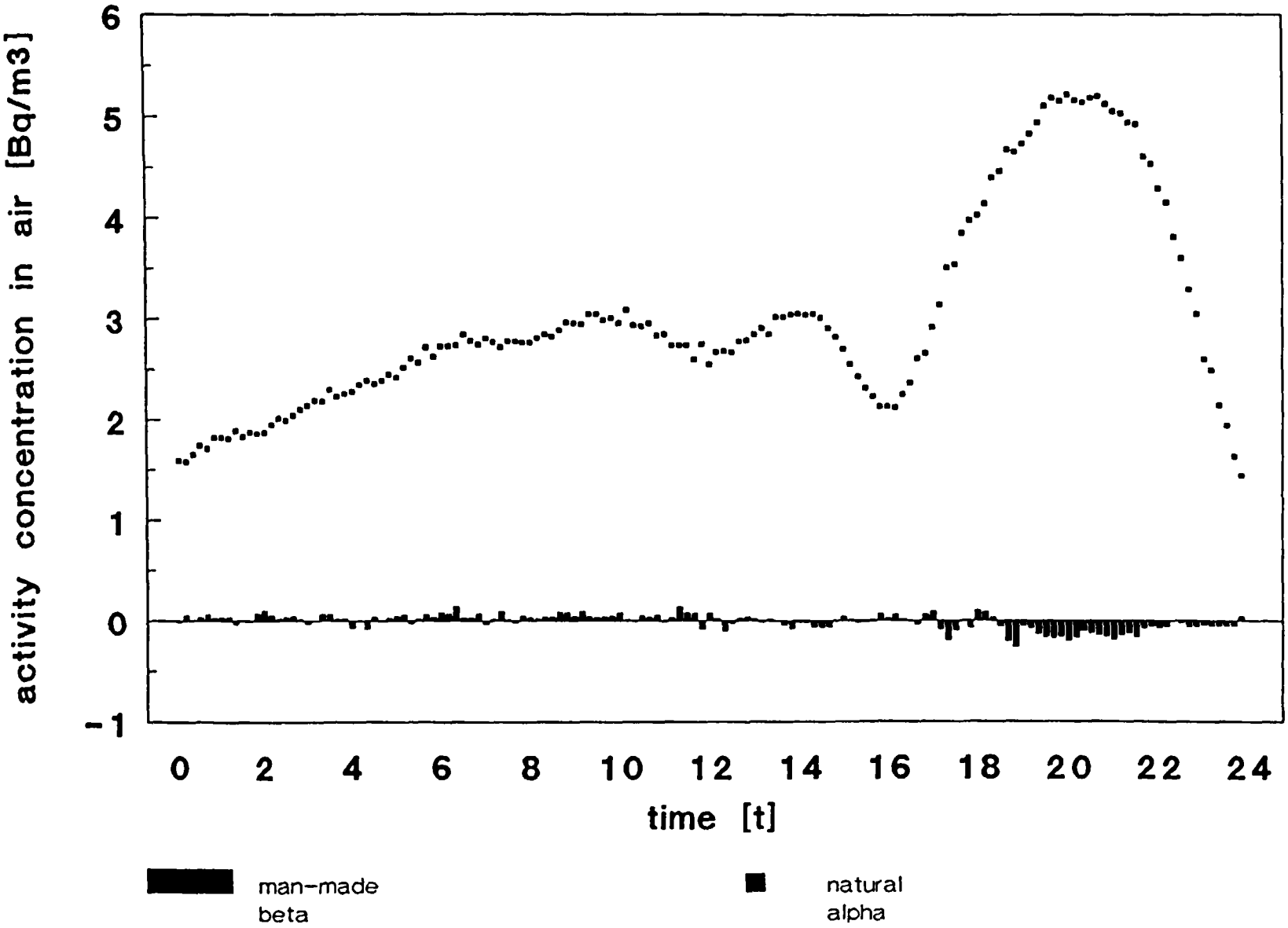
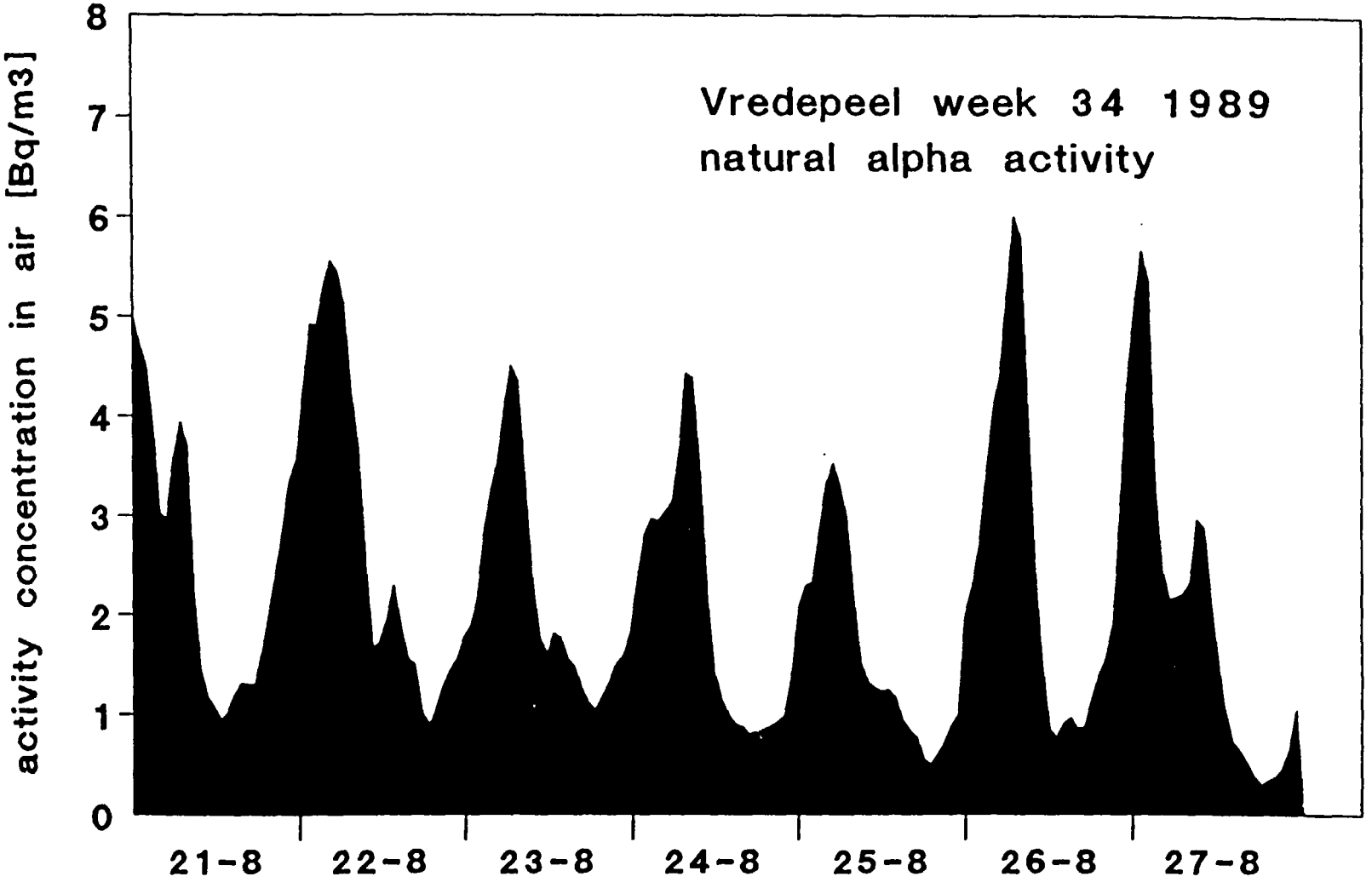


Figure 5

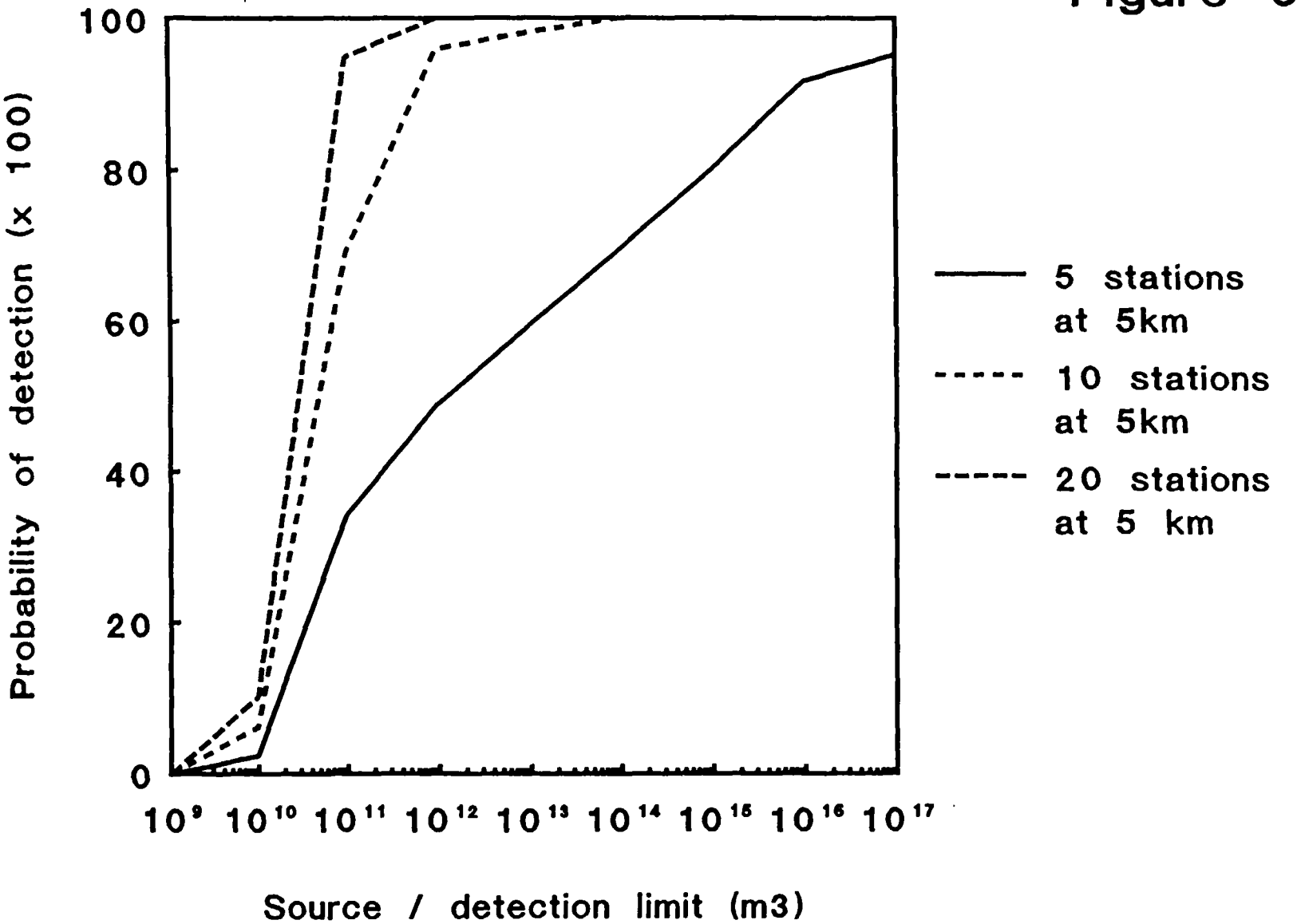

Vredepeel week 34 1989
natural alpha activity
activity concentration in air [Bq/m3]
0
1
2
3
4
5
6
7
8
21-8
22-8
23-8
24-8
25-8
26-8
27-8

rivm
research for
man and environment

PROBABILITY OF DETECTION WITHIN 4 HOURS

height of emission = 200 m

Figure 6



rivm
research for
man and environment

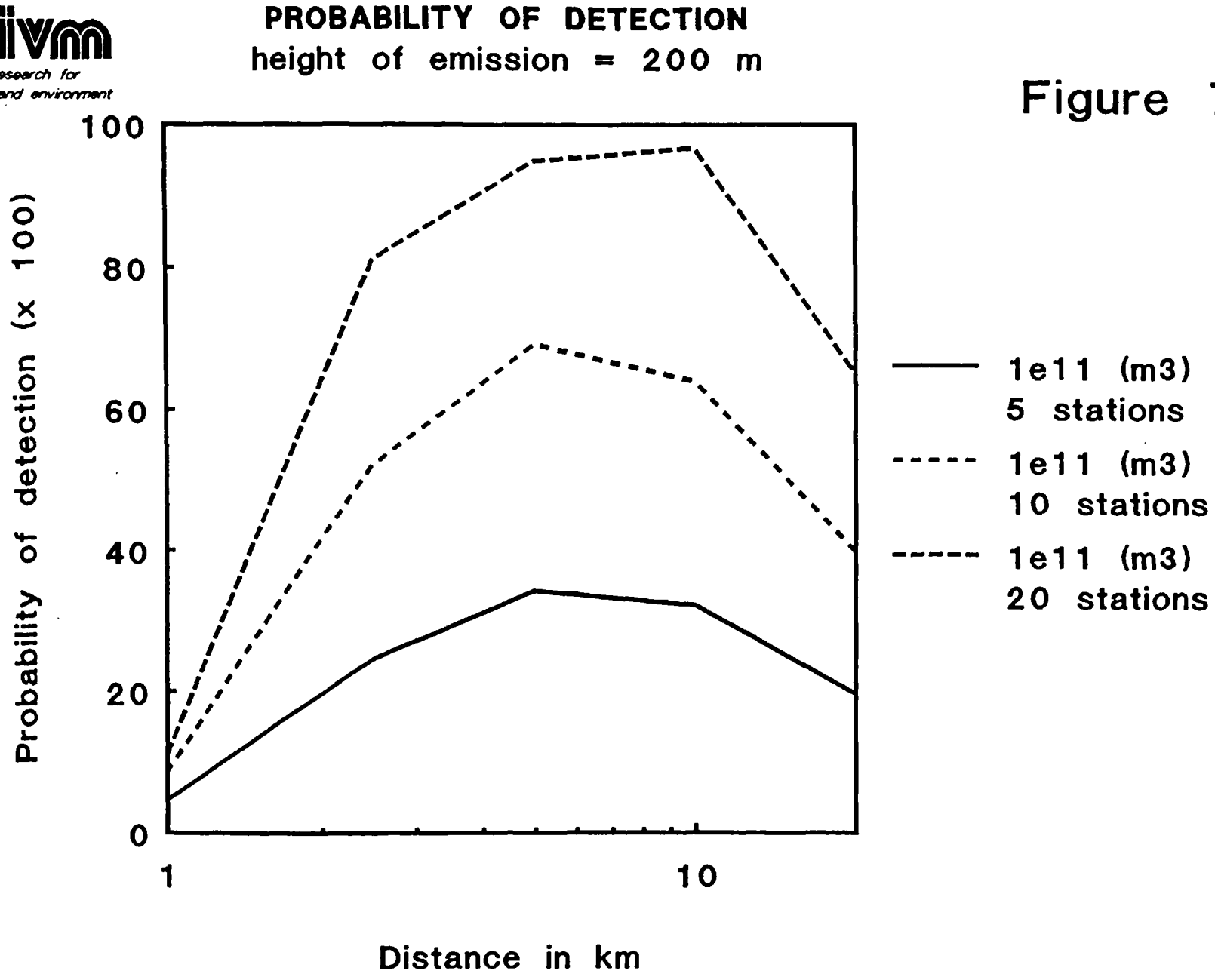


Figure 7

Dutch Environmental Monitoring for Nuclear Emergencies

*By D. van Lith**

The Netherlands has two nuclear power plants, producing nearly 6 % of its electricity, and no immediate decision expected on nuclear expansion. However, within a radius of 1000 km from the Netherlands, 120 nuclear power units are operational and 40 under construction. In view of this reality, and based on the lessons learned from the Chernobyl accident, the Dutch Government decided to review thoroughly the emergency response organization and the monitoring capacity.

The newly developed emergency organization is only briefly summarized here by assuming that a serious nuclear accident, necessitating coordination on a national level, has occurred. After notification, verification and a first assessment of the accident, the national emergency organization will be activated. The heart of the organization is a policy team with representatives from the following ministries: Home Affairs; Foreign Affairs; Agriculture & Fisheries; Housing, Physical Planning & the Environment; Transport & Public Works; Welfare, Health & Cultural Affairs; and Social Affairs & Employment. This policy team takes the relevant decisions and coordinates execution of the countermeasures and is supported in this by a team responsible for information to the media and the public, and a team of (radiological) experts, the Technical Information Group (TIG). This TIG is responsible for collection, processing and interpretation of all the (radiological and meteorological) data within the country. The Group's members are in contact with the institutes and organizations which produce the data (see Table).

The support centers collect and reduce the data they receive from the laboratories and monitoring teams of the organization they represent. In spite of the data reduction, the support centers will transmit a very large amount of data in an emergency. Therefore, they will send the data not only to the TIG but also to the National Institute of Public Health and Environmental Hygiene (RIVM) where a computer system will store, analyze and interpret it. This dynamic information, together with static radiological, geographic and demographic information, will then be converted into easily interpretable overviews such as external dose contours, radiation load as a function of time for different pathways, etc. Models will enable prediction of the trajectory of the plume, the radioactivity levels in milk and food, the effect of countermeasures, and so on. All this information will be directly available on-line from RIVM to the TIG.

RIVM, being where all data are collected and processed, has a central and coordinating task within the technical organization. Too, RIVM is one of the support centers (see Table) where data are produced. RIVM data originate from:

Mobile monitoring teams of radiation experts from RIVM's Laboratory of Radiation Research. These teams can be directed to anywhere in the Netherlands within a few hours, having at their disposal two fully equipped mobile monitoring stations for routine measurements, such as exposure and surface contamination. In addition, airborne iodine and radioactive dust can be analyzed by high resolution gammaspectrometry.

Dutch Radiation Monitoring Network

Support Center	Data Concerning
National Institute of Public Health and Environmental Hygiene (RIVM)	Environmental samples
Royal Meteorological Institute	Meteorological situation and forecasts
State Institute for Quality Control of Agricultural Products	Agricultural products and raw materials
Ministry of Welfare, Health, Cultural Affairs	Contaminated persons
Commodity Inspectorate	Consumer goods
Ministry of Home Affairs	Air and deposition (mobile teams)
Ministry of Housing, Physical Planning & the Environment	Drinking water
Institute for Inland Water Management & Waste Water Treatment	Surface water, water beds and sewage sludge

Lab analysis by the Laboratory of Radiation Research, which is fully equipped to investigate alpha, beta or gamma activity in environmental samples of different origin. Also, externally and internally contaminated persons can be examined.

A model which can calculate plume trajectory and deposition, based on on-line meteorological data or forecasts, has been developed by RIVM in cooperation with the Royal Meteorological Institute.

A nationwide fully automated radioactivity monitoring network is being installed (see the accompanying map). The network continuously monitors:

- gamma exposure rate at background level (at 58 points);
- gross beta activity concentration in air particles with correction for the naturally occurring radionuclides (14 points);
- gaseous radioactive iodine concentration (at RIVM);
- nuclide specific gamma activity of airborne particles using high resolution gammaspectrometry (at RIVM).

Presently, the 14 points where beta activity concentration and gamma radiation levels are simultaneously measured, are operational, reporting the data automatically every two hours. By end 1989, the entire network is to be operational, including the possibility to report any unexpected increase in environmental radiation level within 10 minutes. As a support center for environmental measurements, RIVM has two other sources of data. For the early phase of an accident, a fully equipped airplane is on standby to localize and analyze airborne radioactivity. In later stages of the emergency management, the airplane can possibly be used to do large-scale measurements of the gamma activity deposited on the ground. Finally, RIVM will conclude "standby" agreements with several institutes in the Netherlands which have the equipment and expertise to do specific measurements needed, depending on the circumstances (alphaspectrometry, measurement of strontium, etc.).

Within the Netherlands, as probably in most countries, highest priority is given to the national aspects of the emergency planning organization. However, the next step will be to improve international cooperation and exchange. ■

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ANNEXE 7

SYSTÈME DE GIS MIS EN PLACE AU RIVM

THE
ENVIRONMENTAL
GEOGRAPHICAL INFORMATION SYSTEM
OF THE NETHERLANDS

Editors: Bart Kusse and Paul Padding

Bilthoven, August 1990

Contributors:

Henk Scholten
Arthur van Beurden
Wim Evers
Fokke de Boer
Paul Padding
Bart Kusse

5 A Hybrid GIS, a Communication and Integration Challenge.

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Henk Scholten, Informatics Service Centre (ISC)/Free University of Amsterdam (VU)

Abstract

Currently, the GIS community appears to be maturing; attention is shifting from justification to application of the technology. GIS applications are increasing in number and are responding to a wide variety of public and private sector needs. However, the overall problem of data duplication, incompatibility and communication is compounded. When there are also different GIS-packages in use, the need for cooperative management structure is paramount. Until a common set of standards or guidelines are available, GIS technology can not develop to it's full potential.
This paper provides a brief commentary, highlighting current GIS developments which are used to start the installation of MILGIS (Environmental Geographical Information System) within the RIVM.

5.1 Introduction

Geoprocessing has finally become a reality with the advent of database-oriented GIS's in the early 1980's. These solutions have gradually become accepted in the marketplace as a useful technology.
The trend today, not only in GIS's but in computing generally, is towards distributed computing environments allowing networks of servers, workstations, diskfarms, and peripheral devices to be linked together and shared by users on the network.

5.2 Towards an adaptable spatial processing architecture

A modern GIS is expected to be able to integrate a variety of data sources. These data sources will be used in many ways to support decision making. The nature of separate user views of the same data base accompany a series of (sometimes conflicting) demands to the GIS designer that must somehow be met to guarantee the usefulness and longevity of the system. In synthesis, a GIS is a multidisciplinary tool that facilitates interdisciplinary support. Specialized spatial information systems are not multidisciplinary tools, thus are very restrictive in regards to what can be done with them.
The objective of the MILGIS concept is to integrate several geographical information systems by standardizing the data transfer between them. The joint will not support direct access but data exchange between GIS's. Neither further processing of the exchange data is supported but processing will be made in the user's own system. In the first phase the user is provided with simple tools to order the data he/she needs. The data is converted into the standard formats automatically.
For this reason MILGIS was designed using a hybrid model. The ARC/INFO environment primarily for managing and integrating locational data, a (not yet selected) relational Database Management System (Ingres, Oracle etc.) for tabular data, SPANS

software as an analytical tool and the MacIntosh environment for high quality graphics and intermediate to the printers' office.

5.3 MILGIS architecture

The MILGIS architecture is based on the idea that different applications are needed for different purposes, but that the pieces must be brought together. Developments in technology make this also possible.
For instance, consider the raster - vector debate. GIS systems have developed along two main line: the *vector* model, whereby the geographical entities are represented as points, lines and areas, and the *raster* model which consists of a regular array of cells. Fortunately this discussion is beginning to be somewhat irrelevant through technological change. While raster and vector systems should no longer be thought of as irreconcilable alternatives it is a hard fact that certain tasks can better be done in the one mode than in the other, either because the current state of the development of algorithms, because of hardware capabilities, or because of storage requirements. The two modes should now be seen as complementary in any GIS, but the accent on a dominantly vector-based or a dominantly raster-based approach should depend on the type of GIS application under consideration. The MILGIS approach is to acquire a number of specialized modules that do a certain number of tasks very well: eg. vector mapping (ARC/INFO), raster overlays, interpolation (SPANS) and link them together so that they can make use of common data sources.

5.3.1 High-end GIS: ARC/INFO

This application has, as part of its datamodel and functionality, the capability to manage large collections of geographic data either at small or large scales. The management tools allow different pieces of the geographic database to be accessed by multiple users across a distributed network even if they are on different types of hardware.
Another aspect of ARC/INFO is its ability to integrate data from a number of sources, such as map layers, satellite images, scanned aerial photographs, CAD files, video photo logs, and relational database managements systems.
The X-Windows environment provides multiple windows at any workstation or X-terminal on the network. X-Windows also allows customization of colours, text and cursor symbols used in ARC/INFO and facilitates fast data and graphics communications across the network. It is also possible to enable users to add Ethernet cards and X-driver software to their PC or MacIntosh, allowing the device to behave like an X-terminal. The Illustrator software on MacIntosh hardware and the X11 interchange format make it possible to 'grab' a picture for further use. Data exchange between the first two platforms and the MacIntosh environment can also be based on postscript (Encapsulated Postscript) format. For exchanging data from ARC/INFO to Atlas*Graphics a conversion program has been made.
ARC/INFO is also used for digitizing and updating maplayers, for manipulating geo-referenced data and for graphic output. Furthermore it is used for analytical purposes.
ARC/INFO consists of a series of interconnected modules:

ARC	the main module;
INFO	the relational database system of ARC/INFO for managing thematic data;
ARCPLOT	for graphic output (maps) and composition;
ARCEDIT	for editing and updating maplayers (points, lines, polygons);

TIN the Triangular Irregular Network module to assemble a triangular network from sample or monitoring points which can be used for contouring, slope or aspect analysis or just presentation;
NETWORK for routing analysis (shortest path).

Standards for the high-end GIS (platform 1):
- Hardware:
  Hewlett Packard, HP 9000/370 servers and HP 9000/340 workstations.
- Operating system:
  HP-UX version 7.0
- Network:
  Ethernet; ARPA/BERKELEY (TCP/IP) with NFS.
  X-11 Window environment
- Programming Languages:
  F77, ANSI C, C++, GKS.
- Relational Database Managements System:
  INFO (+ Oracle or Ingres)

5.3.2 Analytical GIS: SPANS

The analytical GIS is basically a standalone powerful PC linked to the high end GIS platform through ethernet. Data is down-loaded from the main databases (both attributes and topology) and transformed to the SPANS dataformat. A dedicated procedure to facilitate this is made. It is also possible to export information back to the host system. Within SPANS locational data can be produced in polygons, vectors, points as well as in its own quadtree structure.

A problem that had to be solved was the importation of large rasterbased files (sometimes containing over 100.000 cells). Storing this information in a vector based package like ARC/INFO, this means very large datafiles (due to the number of polygons), almost impossibly transferrable to SPANS. To solve this problem, an application was made that intermediate between ARC/INFO and SPANS.

SPANS consists of seven modules. The basic CORE-module contains operations like data-import and export, transformation, display functions, and analytical functionality like matrix overlay, Thiessen polygons, point- and line-buffering. CONTOUR gives you the opportunity to interpolate point data into a thematic map. POTMAP does almost the same, but for discontinuous variables. The interface modules (VECMENU, RASTMENU) handle the importing of vector- and rasterfiles. Also there is a digitizing module, TYDIG. Furthermore, a DBSPANS module is added for database functions.

Standards for the analytical platform (platform 2):
- Hardware:
  COMPAQ-386 computers
  Inkjet printers
- Operating systems:
  DOS 4.1, OS/2
- Network:
  Ethernet; ARPA/BERKELEY (TCP/IP) with NFS.
- Programming Languages:
  SPANS modelling language, C, C++, F77.

5.3.3 Low-end GIS: MacIntosh software, Atlas*Graphics

There is no discussion that the MacIntosh environment offers the best opportunities for user-friendly high quality graphical output nowadays. The integration of maps, scanned pictures and photographs, graphics and text is well developed in this environment. Unfortunately, from a technical point of view a lot has to be done to fix the connection between this environment and platforms 1 and 2. Up to now there is no elegant solution for this integration. On the other hand, those technical problems probably will be solved in the near future, both with the emphasis of the industry and cooperating institutions. For instance, Birkbeck College has already a MacIntosh interface around ARC/INFO and in the Netherlands the MacKarto foundation has started to work on the integration of cartography and desktop publishing.
The Illustrator software on MacIntosh hardware and the X11 interchange format make it possible to 'grab' a picture for further use. Data exchange between the first two platforms and the MacIntosh environment can also be based on postscript (Encapsulated Postscript) format.
Cart/o/Graphix is a typical MacIntosh based GIS-package that combines some database functions with cartographic elegancy. It allows the user to classify data for thematical mapping, offers a wide range of graphics which can be used on the map, and provides colour-divided output.

Next to the high-quality graphics of the MacIntosh runs Atlas*Graphics on almost any 'ordinary' PC with at least an EGA-monitor to provide the remaining users with a means to present their data. The great advantage is that you can use the ARC/INFO boundary files, such as: municipalities, counties or even postal code areas; and use these boundary files to present your results. Furthermore you don't have to be an expert on it because it is all menu-based. This type of approach can be extremely useful to the management where they don't want to be into GIS to get their results, but just need a tool with which they can compare the results of several calculations of predictions and base their policy upon.

Standards for the low-end GIS (platform 3):
- Hardware:
  Apple-MacIntosh IIx or PC-AT
- Software:
  MS-DOS (> v3.3) or OS/2,
  Cart/o/Graphix, Atlas*Graphics.

5.4 Spatial Data Transfer Specifications

Many attempts have been made to develop a uniform data exchange standard. Existing formats have been unsuccessful for a variety of reasons.
For instance IGES (Initial Graphics Exchange Standard) was designed for the CAD industry and has no attribute capabilities, CAMRAS (Computer Assisted Mapping and Record Activity System) failed from lack of user support, SIF (Standard Interchange Format) also 'standard', but vendor/system specific.
Although DLG (Digital Line Graph) is *de facto* data format standard from the USGS (U.S. Geological Survey), it was not intended to be a general standard. While useful, it is primarily used to exchange topological data.

For these reasons data exchange between the different platforms within MILGIS is mostly done using vendor supported data transfer standards (eg. ARCEXPORT). When necessary special data transfer programs are developed.

Data exchange standards supported by ARC/INFO and SPANS:

Vector data (ASCII-files), containing topological information based on segment coding, transfers point, line and polygon data.
- DLG-3 Optional format file
- DIME-40 (Dual Independent Map Encoding)
- DIME-120
- ARC/INFO-export format file

Raster data (binary files)
- USGS DEM (Digital Elevation Model) files, the 7.5 minute and the 1 degree
- ERDAS (Earth Resources Data Analysis System) file (8 bit data and 16 bit data grid file)

Special data exchange programs:

- ARC*ATLAS (ASCII-file) converts (ARC/INFO) point, line and polygon data to Atlas*Graphics
- "PICTure This" converts SUN raster files and X11 bitmaps (ARC/INFO screen-dumps) to MacIntosh .PICT files

Data Transfer Flow

5.5 Conclusion

The way in which the environmental GIS is established at the RIVM, is a way in which all users can find their piece of mind. Whether it be 'The Mac', workstation or PC, whether it be multiple analysis using a number of datasets, fine-tuning the results of your analysis for presentation, modelling within a GIS or presenting the results of some calculation you have made on a county level to base some prediction or policy upon, it all fits into this 'Hybrid GIS' due to the flexibility in data exchange between the different packages.

ANNEXE 8

PRÉSENTATION DES TECHNIQUES DE DÉCONTAMINATION DES SOLS AUX PAYS-BAS. DOCUMENT RIVM.

REVIEW OF SOIL TREATMENT TECHNIQUES IN THE NETHERLANDS

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1. INTRODUCTION

In the last ten years, many countries have been faced with the necessity for remedial actions on an increasing number of contaminated sites. A survey, carried out in 1986 in five European countries (The Netherlands, West Germany, Denmark, The UK and France) indicated that about 8,900 industrial sites require immediate remedial action [1]. However, since that time it became clear that this number of sites will be exceeded many times. At the moment, it is estimated that the number of suspect contaminated sites could be 120,000 - 160,000 in the EC. The policies of European countries on groundwater and soil contamination show different attitudes. In the following we will focus on the situation in the Netherlands.

In The Netherlands, the Interim Soil Clean-up Act was put into force in January 1983. The examination framework for clean up of contaminated sites is indicated in the Soil Clean-up Guideline [2]. Under the Interim Soil Clean-up Act, up to now, about 1700 contaminated sites have been investigated and about 750 sites have been cleaned up. The total expenditure for the investigation and the clean up was subsidized by the government at a cost of approximately 1.5 billion guilders.

For the enforcement of the above mentioned act the development of adequate investigation and clean up methods were very important. The development of these methods has been stimulated by various (research) programmes of the Dutch government, such as the Stimulation Programme for Environmental Technology, the Netherlands Integrated Soil Research Programme and the Innovation-Oriented Research Programme Biotechnology. Due to the policy of the government, and also to the effort of research institutes and

companies, a number of thermal, physical-chemical and biological methods are operational or in the developmental stage at present. In this paper a short summary is given dealing with the applications and results of operational techniques including the latest developments.
More information about the Dutch soil treatment techniques is given in the "Handbook for Remedial Action Techniques"[3] and other included references.

2. EX-SITU TREATMENT METHODS

2.1 Thermal treatment

The principal thermal processes for the treatment of contaminated soil are evaporation and combustion.
The *evaporation* of the contaminants usually takes place in a rotary kiln at a temperature between 200-700 °C by means of direct or indirect supply of heat. The vapors of the contaminants are combusted in an afterburner at a temperature between 750-1300 °C. The flue-gas purification system consists of a filter system and a wet scrubber. The discharged water from the scrubber is neutralized and partly recycled, or used to moisten the treated soil. Figure 1 shows a scheme of one of the thermal soil treatment plants.

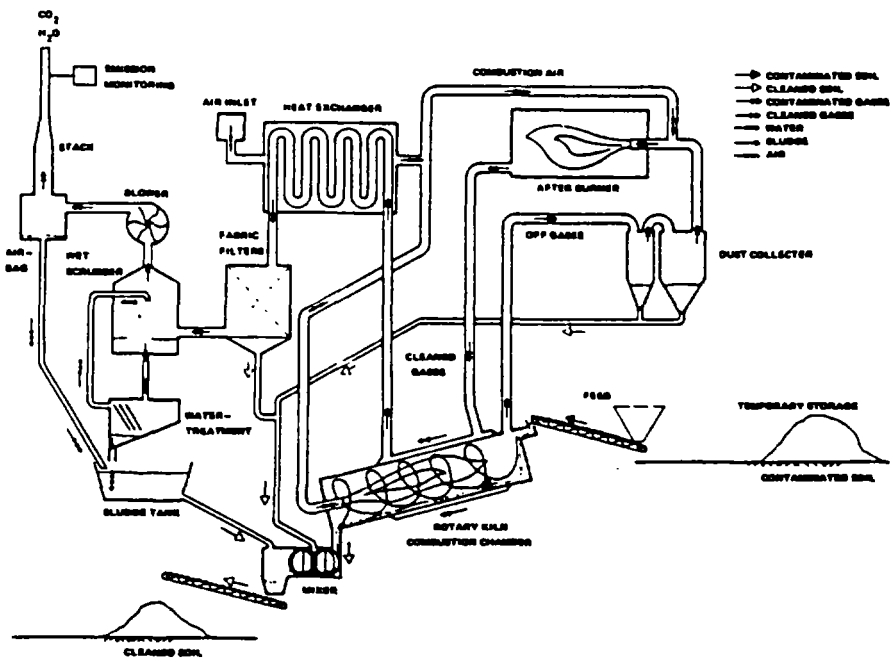

Fig. 1. Process scheme of the thermal treatment plant of Ecotechniek [4]

The *combustion* of the contaminants takes place in a fluid bed incinerator. In this case, the soil is mixed with fuel and this mixture is combusted at the temperature ranging from 800-1000 °C. The afterburning of the gases takes place in the free-board above the fluid bed.

Thermal plants have been operating in the Netherlands for several years. As indicated in table 1, at this moment five full-scale plants operational are available. The fluid bed incinerator of Boskalis Esdex is a pilot-plant [3].

Table 1: Operational thermal soil treatment plants in The Netherlands (1989)

Name of company	Location	Process temp	Capacity (tons/year)*
Broerius	Barneveld	< 400 °C	25.000
ATM	Moerdijk	< 800 °C	60.000
Ecotechniek I	Utrecht	< 800 °C	55.000
Ecotechniek II	Rotterdam	< 800 °C	80.000
NBM	Schiedam	< 800 °C	60.000
Boskalis Esdex**	IJmuiden	> 800 °C	4.000

* based upon 8 h/day
** pilot plant

Some treatment results of the above mentioned plants are summarized in table 2. On the basis of these treatment results it can be concluded that thermal treatment is suitable for the removal and destruction of contaminants such as oil compounds (alifatics and aromatics), PCA's and cyanides. The cleaning efficiency is high, in most cases being 98-99.5%. On the basis of laboratory results it is expected that some of the existing plants should be able to clean soil contaminated with chlorinated hydrocarbons, i.e. pesticides effectively. (The first demonstration projects will be carried out at the end of 1990). In principle, heavy

metals can not be removed by thermal techniques, except for the more volatile mercury, for which, however, special measures will have to be taken in the afterburner. As a side effect of thermal treatment other metals can be made more mobile in the soil or contrarily in other cases immobilised. Usually additional cleaning methods will be neccesary or otherwise the presence of an excess of heavy metals will inhibit thermal treatment. Thermal plants can be used for the treatment of a variety of types of soils including soils with high contents of humus, peat, loam or clay. The costs of thermal treatment will vary between Dfl 80-200 per ton of soil depending mainly on both the moisture content of the soil and the types of contaminants [3,4,5].

Table 2: Some treatment results of Dutch thermal plants

Type of soil	Contaminants	Initial conc mg/kg d.m.*	Final conc mg/kg d.m.
sand	alifatics	4,500-30,000	< 20
clayey sand	alifatics	450- 2,600	< 100
loamy sand	aromatics	880- 8,900	< 1
sand	PCA's**	700- 4,000	< 0.1
clayey sand	PCA's	100- 8,000	< 0.01
sand	CN-compl	200- 500	< 5
loamy sand	CN-compl	110- 500	< 5

* mg/kg dry matter

** Measurements are based on the sum of several PCA'S: the 6 PCA's of Borneff respectively the 16 PCA's of the EPA (USA)

2.2 Extractive treatment

Extractive treatment bases on a soil washing process combined with separation of fine particles by classification or a flotation process [6]. This means that the pollutants are not destroyed but concentrated into a residue. In the case of classification, the separation is mainly based on particle sizes. In the case of flotation the separation is based on adjustment of the flotation properties of the contaminated particles, resulting in a selective separation. A general scheme of the soil washing process is shown in Figure 2.

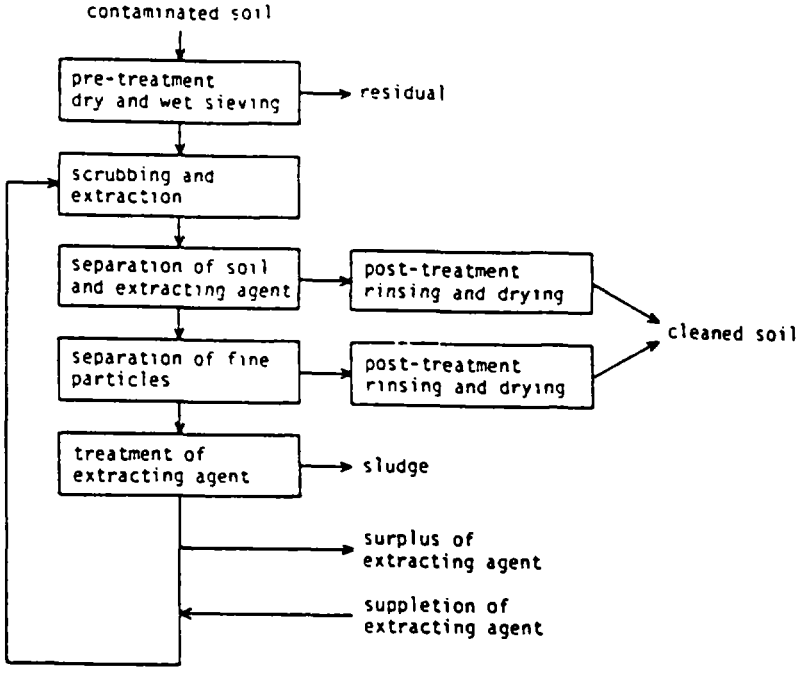

Fig. 2. General scheme of soil washing treatment process [4].

The contaminants are made to dissolve and/or disperse into the extraction fluid by means of a scrubber. The extraction agent usually is water with some pH regulators added. Heavy metals contamination is usually treated with acidified water (sometimes in combination with complexing agents), cyanides have to be extracted by an alkaline solution to prevent emission of HCN. The treated soil is usually separated from the extracting agent by

means of hydro-cyclons. The contaminants are partly removed in the water treatment system and partly with the remaining sludge. Several methods are available for the treatment of the aqueous extracting agent.

In the case of high pressure soil washing, the pollutants are mobilized by a high-pressure water jet in a jet pipe specially designed for this purpose, in which nozzle pressures of 200-350 bar can be applied. Due to the partial vacuum arising in the closed jet pipe, an additional stripping effect can be obtained which is useful in the presence of volatile contaminants. After the water jet, the pollutants are transferred (dissolved or undissolved) from the soil into the aqueous and gas phases and are subsequently removed by further treatment systems.

In the case of the flotation process (more specific froth-flotation) the contaminants are removed with the froth. The layer of froth is produced by forced aeration after the addition of relatively small amounts of chemical agents that are specific for the combination of types of soil and contamination and that regulate the distribution of contaminated particles over the liquid phase and the froth.

The sludge, produced in an extraction process has to be considered as hazardous waste. In most cases, the sludge is transported to a controlled waste disposal site. The operational full-scale extraction plants in The Netherlands are shown in table 3 [3].

Table 3: Operational extraction soil treatment plants in The Netherlands (1989)

Name of company	Location	Process	Capacity (tons/year)*
BSN	Weert	high pressure	24,000
Heidemij	Den Bosch	flotation	34,000
Heijmans	Rosmalen	extraction	20,000
	Moerdijk	extraction	45,000
HWZ	Amsterdam	extraction	27,000
Mosmans	mobile	flotation	8,000
Jaartsveld	Moerdijk	flotation	80,000

* based upon 8 h/day

Some treatment results of the above mentioned plants are summarized in table 4.

Table 4: Some treatment results of Dutch extraction plants

Type of soil	Contaminants	Initial conc mg/kg d.m.	Final conc mg/kg d.m.
sand	alifatics	1,500-12,000	< 100
clayey sand	alifatics	9,000-25,000	< 150
sand	PCA's	200- 300	< 5
loamy sand	CN-compl	400- 1,000	< 20
sand	Cd	1,750	< 2.5
sand	Pb	2,000	< 75
clayey sand	Zn	500- 1,400	< 200

On the basis of treatment results it can be stated that by means of extraction techniques about 95-99% of contaminants such as oil, cyanides, PCA's can be removed from the soil. The cleaning efficiency for heavy metals vary between 80-95%. At present, the extraction techniques are the most suitable for the removal of heavy metals. However, they are unfit for the treatment of clay or soil with high loam or peat content. The costs of the treatment by means of extraction vary between Dfl 50-200/ton of soil depending mainly on the quantity of small particles in the soil [3,5].

2.3 Biological treatment

At present two kinds of ex-situ biological treatment can be distinguished: landfarming and bioreactors. The landfarming method is operational; bioreactors are still in the stage of development.

The aim of biological soil treatment is to create favourite environmental conditions in the soil for the improvement of micro-biological activity and consequently the enhancement of the biodegradation of the contaminants. The favourite conditions for microbes roughly include : sufficient oxygen, nutrients supply, pH around 7 and temperature between 25-30 ^{o}C. The moisture content and a good soil structure are also very important for the biological activity [7].

Landfarming

Landfarming is applied on a practical scale by several companies in The Netherlands. (See table 5) [3]. In the case of the most simple landfarming method (used by De Ruiter), the contaminated soil is spread out over a sand layer with a drainage system to a depth of about 40 cm. Prior to this the soil is protected by means of a plastic layer (foil of about 0,5 mm PVC). Landfarming is also carried out under conditioned circumstances. This means that during the clean-up process a better control of parameters such as oxygen and water contents and temperature control is achieved. In the case of the system of Mourik, forced aeration is used for the enhancement of the oxygen supply. By aeration with hot air, the soil temperature can be increased. In the case of the so-called "Cum Bac" system of Heidemij, the temperature of the soil is raised by the actual greenhouse effect. Forced aeration and heating make it possible to increase the depth of the layer of the soil to be cleaned to about 1 to 1.5 m, in the same time increasing the rate of breakdown of the contaminating substances.

Table 5: A few treatment results of landfarming in The Netherlands

Company	Type of soil	Type of contamination	Initial conc mg/kg d.m.	Final conc mg/kg d.m.
De Ruiter	clayey sand	heavy oil	3,000- 8,000	1,000
	loamy sand	heavy oil	5,000-20,000	1,000
Maurik	clayey sand	kerosine	1,000-10,000	500
	clayey sand	aromatics	100	3
Heidemij	clayey sand	mineral oil	12,000	500

Some treatment results are summarised in table 5. It can be concluded that good results have been achieved with the treatment of contaminated sand and clayey or loamy sands. Experience has shown that this technique is in general suitable for the removal of different types of oil and aromatic hydrocarbons. The final oil concentrations are in most cases between 400 and 1000 mg/kg dry matter. The clean-up costs of landfarming are in the range of Dfl. 50,- to Dfl. 80,- per ton of soil [4,8].

Bioreactors

In general, the development of bioreactors is considered to be important for the biological treatment of soil contaminated with substances which are resistent to breakdown, for example, chlorinated hydrocarbons and soil types, such as clay, which are difficult to treat. A few advantages of bioreactors over other techniques are:

- greater possibilities for process management and control
- increased availability of the contaminants to the micro-organisms as a result of better homogenization of the soil
- the possibility of using specially cultivated micro-organisms.

It is expected that by the use of bioreactors a faster decontamination and a more effective biodegradation can be achieved.

Several research institutes and companies are engaged in the development of bioreactors [8].

Delft University of Technology is conducting research into the possibilities of microbiological degradation of various contaminants in a 3-phase (air, liquid, solid) slurry reactor, the so-called Pachuca reactor. The design procedure of this slurry reactor includes three steps: the study of the kinetics of the decontamination process, the technological studies regarding construction and scale-up aspects and the integral process design. Last year, experiments were carried out with a 400 liter reactor. Research was focused on the "suspension behaviour" of the solid phase with a "one phase" (air) injection and with a "dual phase" (air liquid) (See figure 3). These experiments indicated that dual injection for keeping the soil in suspension is succesful. Preliminary kinetical studies showed a fast degradation rate for oil compounds. Based on these results a 4 m^3 pilot-plant reactor was constructed at the beginning of 1990 [9].

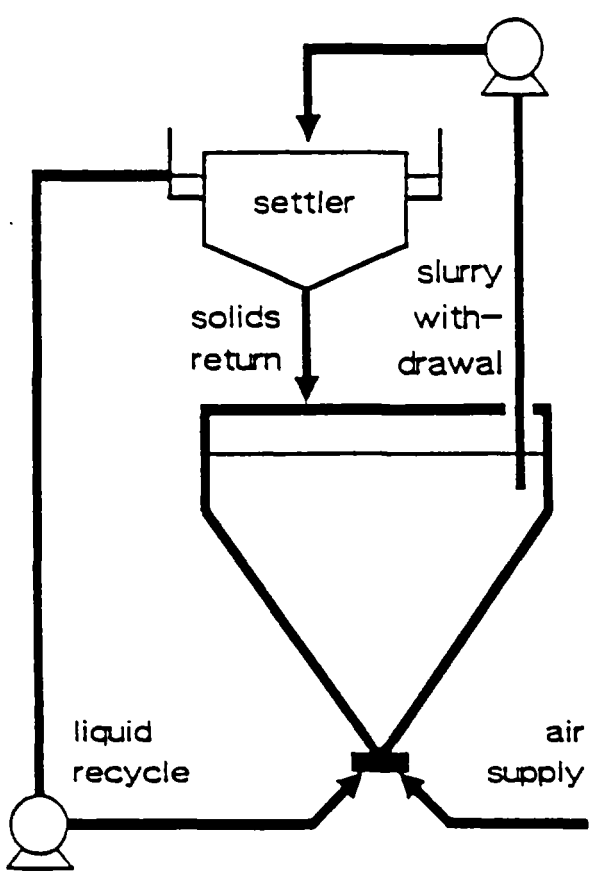

Figure 3: Schematic representation of the slurry reactor with dual injection (Kleijntjens, 1988).

TNO has conducted laboratory research, in co-operation with the University of Groningen, regarding the development of different types of bioreactors for a period of three years. The conclusions of the reported investigations can be summarized as follows:

- high biodegradation rates can be achieved in bioreactors, in the case of oil compounds and low molecular PCA's. The treatment time is about one hundredth of the time to reach a similar result with landfarming;
- the final decontamination rate is limited by the rate of mass transfer from the soil particles to the degrading micro-organisms.

In the future research will be directed towards the improvement of the bioavailability of contaminants and the possibilities of inoculation with selected micro-organisms [10].

The Agricultural University of Wageningen (LUW) completed laboratory research in 1987 into the degradation of hexachlorocyclohexane (α- en β-HCH) under different redox conditions. It can be concluded from the results obtained, that α-HCH is degraded most rapidly under aerobic conditions (see Fig. 4). There are hardly any intermediate products accumulating. No breakdown of β-HCH was observed under any of the conditions.

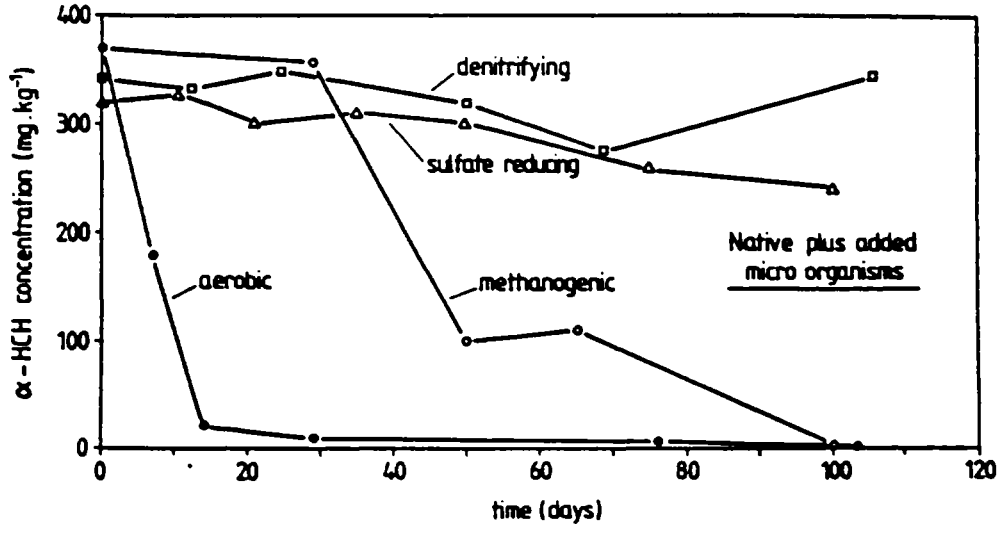

Fig. 4. Biodegradation of α-HCH under different redox conditions (Bachman and Zehnder, 1988)

On the basis of this conclusion, the Research Institute for Nature Management (RIN) carried out several field experiments with "wet" and "slurry" soils. As with the laboratory experiments, the best results were obtained with a continuously aerated slurry system. The α-HCH content of the soil decreased by about 80 % within four months (from 300 mg/kg d.m. to 40-60 mg/kg d.m.). It can be concluded that redox condition, soil homogenity, and temperature proved to be key factors in the bioconversion of α-HCH in the soil. Internal mass transfer limitations from the absorbing surface to the bulk liquid limited overall mineralization rates of this compound. The biological clean-up of α-HCH can be optimized in a reactor [11]. The construction of a reactorsystem has already been patented by LUW. Based on this reactor concept, a demonstration project will be carried out by Witteveen and Bos (Consulting Engineers) in collaboration with LUW, in 1989.

3. IN SITU TREATMENT TECHNIQUES

Some operational in situ techniques are indicated in Table 6. It has to be mentioned that, compared with techniques applied after excavation, there are only a few practical experiences with in situ techniques.

Table 6: Review of in situ treatment techniques (1988)

Technique	Company	Type of contaminants
Biorestoration	De Ruiter Ecolyse/HTTS	alifatics, aromatics
Chemical extraction	Heidemij Mourik Mourik/TAUW*	alifatic aromatics Cd
Streamstripping	Heidemij	volatile hydrocarbons
Electro-reclamation	Geokinetics	heavy metals

*Consulting Engineers

In the case of the in situ technique, the treatment of the contaminated soil takes place without excavation of the soil. Usually it is applied to locations with contaminants deep in the subsoil or underneath buildings (i.e. petrolstations), where cleaning up by means of removal and treatment of the soil, is too expensive or less possible.

The method of biorestoration in situ is based on the stimulation of the natural degradation processes in the soil itself. The groundwater is used as a medium for addition of oxygen, nutrients and eventually detergents and organisms to stimulate biodegradation of the contaminants. The water is infiltrated via drains, trenches or wells. The pumped-up water containing the dissolved degradation products and a part of the contaminants is treated above the ground and usually recycled. Before starting the biorestoration, the floating layer must be removed. To prevent the contaminations from spreading, isolation of the contaminated soil by means of hydrological or civil-engineering barriers is required.

This method can be used for sandy soils contaminated by oil compounds and aromatics. In the last three years, a few clean up project projects were completed succesfully. In 1990, a demonstration project will be carried out at a site (petrolstation) is Asten. In this case, hydroperoxide will be used as oxygen source [12].

The method, chemical extraction in situ was developed by the engineers of TAUW Infraconsult together with RIVM. For the first time it has been succesfully applied by the company Mourik in the case of a contaminated industrial site. This contamination no less than 700 kg cadmium was located in a dune landscape in Soest near Utrecht. The average concentration was in the range of 5-20 mg Cd/kg dry material [13].

The principle of this method is based on the extraction of heavy metals by means of the acidification of the water. The acidified water is pumped into an artifical infiltration pond. During the penetration, the cadmium is dissolves in the water. The water containing the cadmium is pumped up and treated in a mobile unit by means of a selective ion exchange resin.

The clean up of the contaminated site was carried out over a period of ten months. The final concentration, achieved in the soil was 1 mg Cd/kg dry material [13]. By means of this method cadmium and other heavy metals lead, copper can be extracted effectively without excavation the soil. It is a cost effective method only in the case of soils with high permeability and protection of groundwater by effective drainage is necessary.

In the case of streamstripping, the steam is injected into the soil by means of pipes. The temperature of the soil is increased to 150-200 ^{o}C in order to evaporate the contaminants. The steam containing the contaminants is then collected by means of vacuum drains and conducted to the condensor. The condensed water is purified in a water treatment system. This method is applicable for the volatile hydrocarbons and phenols. It can be applied in the case of different types of soils and also in the case of waste disposal sites. Steamstripping can be used only at levels above groundwater making drainage beforehand usually necessary.

The methode electro-reclamation is based on electrokinetic effects such as electro-osmose, electro-forese and electrolyse. The system consists of electrodes placed in the soil and a watercirculation system connecting electrodes with the water treatment unit. By means of the electrodes, electricity is conducted through the soil resulting in a transport movement of groundwater and contaminants towards the electrodes (i.e. in case of heavy metals to the cathodes). The contaminants are collected in the watercirculation system, which is also used for the maintenance of the desired moisture content in the soil. The water is treated by coagulation and filtration [14].

Electro-reclamation can be applied for the treatment of clay or clayey soils which are contaminated with heavy metals. The clean up process will take several weeks extending to several months, dependent on the concentration of the contaminants and the soil structure. Based on the first experiences, the cost is estimated to be approximately Fl. 150-200/ton of soil.

4. RESEARCH PROGRAMMES

As mentioned in the introduction, research in the field of the development of soil treatment techniques is stimulated by several programmes of the Dutch government. The Netherlands Integrated Soil Research programme is one of the most important programmes in this field. It started about two years ago and is financially supported by four state departments. An amount of 56 million guilders has been allocated for fundamental and applied research. Research is done into soil quality, natural processes in the soil and parameters for description of the ecological and structural state of the soil and into the development of methods for soil remediation and soil protection.
The development and the demonstration of remedial action technologies is financially supported by the stimulation Programme for Environmental Technology and by the Interim Soil Clean Up Act.

In the framework of the different progammes, research projects are usually carried out in collaboration with various institutes and universities. Engineering consultants and firms participate mainly in the projects aiming at the development of techniques.

The laboratory for Waste Materials and Emissions of the RIVM is responsible for the supervision and coordination of research and demonstration projects. During the implementation of the research programmes, an intensive exchange of knowledge and a collaboration, on both a national and an international level is wellcomed. The Netherlands is participating, for example, as a co-pilot country in the NATO/CCMS study "Demonstration of Remedial Action Technologies for Contaminated Land and Groundwater". This project was started at the beginning of 1987 and will be completed in 1991.

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ANNEXE 9

SOCIÉTÉS INTERVENANT DANS LA DÉCONTAMINATION DES SOLS AUX PAYS-BAS

Source : Document NVPC. 1988 (transmis par RIVM)

Foreword

The Dutch Association of Process-Based Soil Treatment Companies (NVPG) is a trade organization representing companies engaged in various forms of process-based soil treatment.
Soil purification presents a widespread and costly issue which has led to the enforced development of soil treatment techniques. In a relatively short period the members of the NVPG have succeeded in developing a wide variety of practical methods of treatment.
As a result, much of the market demand for soil treatment can be met. Other techniques are still being developed. This justifies the expectation that, within foreseeable time, is will be possible to treat almost every form of pollution.
This brochure presents an up-to-date overview of the treatment facilities offered by NVPG members. It forms a handy reference work for all those who are professionally engaged in the problems of soil pollution and soil treatment, or who are otherwise interested in these subjects.

After a short introduction concerning the tasks, the position and the activities of the NVPG, it provides concise information on each of the members. This gives an insight into the activities carried out and the techniques available.
In conclusion, addresses are given of the Dutch authorities most concerned with soil treatment.

We hope that the information given is useful and this brochure will serve as a guide to the companies in the Netherlands engaged in soil treatment.

Voorburg
March 1988

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Mr J.H.M. Struijk

NVPG
nederlandse vereniging van procesmatige grondreinigingsbedrijven

Introduction

Tasks and position of the NVPG
The Dutch Association of Process-Based Soil Treatment Companies was set up on 18 September 1984 with the objectives of:
1. Treating polluted soil in a process-based and environmentally-responsible manner.
2. Creating a climate in which the investments of the member companies in treatment techniques and equipment will result in economically acceptalbe returns.

In support of these aims the Association carries out the following activities:
- promoting the interests of its members (e.g. towards the government, towards bussines and towards industry);
- supplying information;
- carrying out studies; and
- providing advice.

One of the reasons for the formation of the Association is to act as the branch-of-trade organization of soil-treatment companies, particularly in relationships with the authorities concerned. This has resulted in the establishment in the Netherlands of a formal consultative structure, mainly within the framework of a consultative body on soil treatment (Overleg Overheid-Bedrijfsleven-Bodemsanering-,OBB). Regular consultations also take place with other specialist and coordinating organizations.

Trends
The necessity to make optimal use of available dumping capacity has led to an increasing demand for treatment capacity (less dumping, more treatment).
At the same time, sighs are received that the export of polluted soil for treatment in other countries will become increasingly costly as well as administratively and legally more difficult.

Introduction

The treatment capacity provided by the members of the NVPG can currently deal with about 600.000 tons of polluted soil annually (approximately 50% of the amount required). Taking technological developments into accout, this percentage can be increased to about 80% in the not-too-distant future.
The research being carried out by NVPG members together with research agencies and universities is directed towards finding solutions to the problem presented by that part of the polluted soil which is currently untreatable.

Interest from abroad

Increasing interest in the Dutch approach and facilities is being shown by foreigh authorities and organizations. In other countries too soil pollution occurs (in some cases to a very serious degree). As a result the transfer of large quantities of polluted soil to be disposed off from other countries becomes unacceptable, and to an increasingly degree the necessity is felt to make use of domestic treatment facilities. Until very recently the activities of the NVPG were directed mainly towards developments at home. Systematic work is now being done on the export of soil-treatment techniques and processes to other countries. Without any argument, Dutch know-how in this field can be described as unique. Wherever possible, contacts with foreign authorities, companies and commercial organizations will be strengthened and extended. In addition, various forms of cooperation are among the possibilities.

Address NVPG-members

Membershiplist

Afvalstoffen Terminal Moerdijk BV
Vlasweg 12
P.O. Box 30
4780 AA MOERDIJK
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BodemSanering Nederland BV

Your partner in environmental protection

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BSN
BODEMSANERING
NEDERLAND BV

The provision of overall solutions is central to BSN's services. An environmental problem can not be met by a standardized approach but requires a specific solution. Definition of the problem and sample tests in the laboratory determine which are the correct measures to be taken. Know-how gathered in the specialized fields of process technology, civil engineering and water treatment is combined to form a spectrum of unique, interconnected and complementary services.

BSN is a cooperative company comprising the following companies:

- Kroon Milieutechniek BV
- Bruil Arnhem Groep BV
- Bruil Apeldoorn BV
- Aannemingsbedrijf J.G. Nelis BV
- Ooms Beheer Avenhorn BV
- Wegenbouw Schagen-Zwolle BV
- Wegenbouw Van de Kreeke NV

The services offered by BSN include a large number of activities in the fields of soil purification and cleaning, treatment of polluted surface and groud waters, refuse treatment, sludge, submerged soils and air.

In calamitous situations a quick solution can be provided thanks to the availability of equipment, techniques and storage capacity.

Techniques used

Soil treatment

- High-pressure extraction treatment combined with air treatment. This method is very suitable for treating soil polluted with volatile toxic components. Components which can be removed are: mineral oils, PAKs, aromatics, cyanides, heavy metals, chlorinated hydrocarbons, insecticides and herbicides.
- Biological purification of soil polluted with hydrocarbons such as mineral oils and polycyclic aromatics.

Treatment of ground and surface waters

- BSN has developed its own processes on the basis of the high-pressure technique and cooperates in this field with an internationally-recognized company engaged in water-treatment systems.
- Separation, detoxification of emulsions and sludges.
- Supply of water-treatment equipment.

Waste products

Treatment of wet or slurried waste products includes DCR technology, aimed at recycling or incineration. BSN provides directly or indirectly for the responsible removal of waste products.

Sludge treatment/Submerged soils

Dewatering of both biological and mineral sludges is carried out with mobile continuous pressure filters. By the use of carefully-selected flocculants a weight reduction of up to about 20% can be achieved without additives.

Liquid-tight foundations

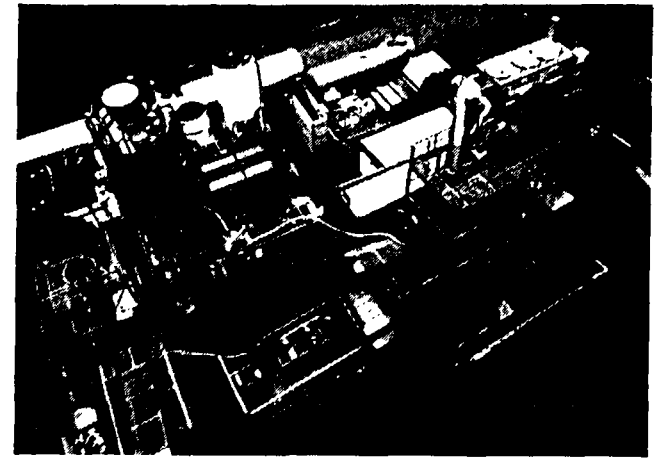
BSN has developed a foundation material for the use in tank farms and loading stations for petrochemical products.

The characteristics of this material include:

- good compactibility;
- absorbs mineral-oil products and repels water;
- insensitive to frost.

This foundation can be used beneath normal paving materials and can be removed and used again so that repair and maintenance of underlying piping remains possible.

Location treatmentplant:
Boshoverheide 2
6002 SM WEERT
Telephone: (0)4950 - 4 30 35



BSN high-pressure soil treatment installation in Berlin.
(Supplied under licence)

Heidemij Uitvoering Milieutechniek

The certainty of economically-tailored work

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afd. Milieutechniek
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Heidemij aims at the improvement of the physical living climate using a wide range of service, both in the Netherlands and elsewhere. As a division of Heidemij Uitvoering BV it is engaged with problems concerning the pollution of soil and water. To solve such problems, both conventional and self-developed techniques are used, depending on the nature and the extent of the pollution.
Expertise and special equipment guarantee optimal support of a project, from planning and investigation phases right up to press information and final evaluation.
All financial consequences are made clear in advance. Organizational and administrative support offer total control of the progress of the activities, the findings and the transport. A mobile laboratory carries out continuous measurements.

Techniques used
Water treatment
Oil separation, boundary-film evaporation, physical-chemical treatment, adsorption on activated carbon, membrane filtration and chemical precipitation are some of the techniques used, either singly or in combination. Oils, phenols, aromatic hydrocarbons, PCBs, PAKs, pesticides, cyanides and heavy metals can be extracted from the water.

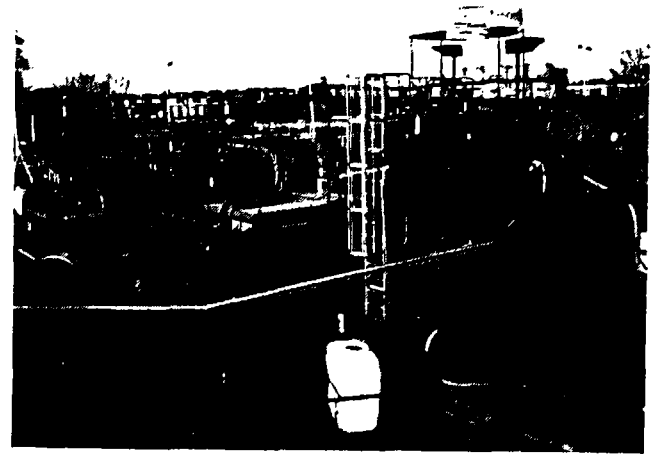
Soil treatment
Sampling drills, sampling tubes, oil pans and cyanide measurements allow quick detection. So far as possible and necessary, excavation can be used, allowing a large number of techniques to be used for treatment.

Steam stripping
Steam stripping is a new, environmentally friendly and economical system of high efficiency for treating soil polluted with volatile compounds. The method can be applied to all types of soil, both excavated and in its original location, and irrespective of the degree of pollution.

heidemij
Uitvoering Milieutechniek

Froth flotation-seperation
This quick, controllable and financially-attractive process is carried out in a mobile installation of our own design. Water and special soaps clear the excavated soil from chemical pollutants. The residues needing treatment elsewhere are kept to the minimum.

Cum-Bac (R)
With this perfected form of land-farming the conditions for biological treatment are optimized in a controlled manner. An integrated combination of several techniques ensures fast results.



Heidemij's froth flotation-separation installation in use for treating soil polluted with cyanide in The Hague.

Serasea
Serasea is a collaborative undertaking of Heidemij Uitvoering Milieutechniek and Wijsmuller Salvage. With its two sludge-treatment vessels Serasea can provide succesful solutions for soil treatment. The Fair acts as a vacuum cleaner and extracts the top layer of the bed for fractionating on board. The Square treats the still-polluted sludge after fractionation by means of foam separation.

Heijmans Milieutechniek

Prevention is better than cure

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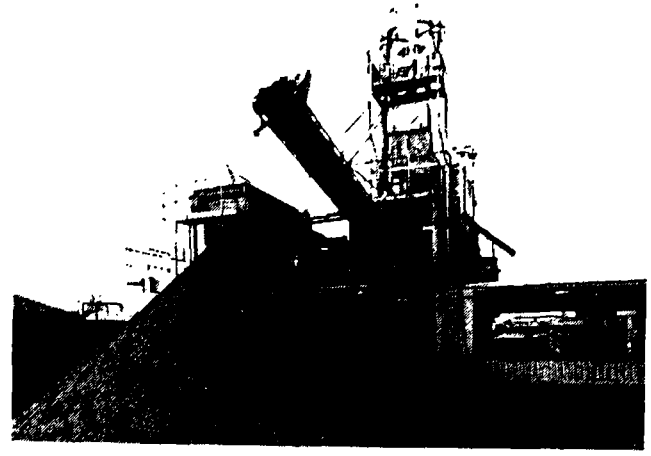
Heijmans Milieutechniek BV is part of the Road and Hydraulic Engineering Division of the Verenigde Heijmans Bedrijven BV. It is active in the prevention and treatment of soil, water and air pollution.
Pollution prevention includes the modification of existing systems and the installation of new systems for the protection of the soil, water and air. Noteworthy in this respect are construction of water storage basins, in the Biesbosch, construction of dumps for polluted soil, such as the recently opened interprovencial dump at Moerdijk, installation of exhaust-gas purification systems for process plants, e.g. exhaust-gas treatment of asphalt producers, together with biological purification of gasses resulting from soil treatment projects.
Treatment of environmental pollutants starts with the excavation and transport of soil: work which has been carried out by Heijmans for many years.
Such activities take into account all applicable safety and health regulations using procedures designed to allow later treatment of the polluted soil.
Among other aspects, this last factor includes selective excavation, resulting in reduction of the total treatment costs.

Techniques used
Polluted soil is treated by means of a physical-chemical extraction process developed by us.
The first treatment installation at Rosmalen has been operational for 3 years and has successfuly treated thousands of tons of soil polluted with mineral oil, heavy metals, cyanides, PAKs and others.
The process results in high-quality, classified sand, ready for reuse. Due to the possiblities for its use as a raw material for, e.g. asphalt or concrete, disposal of the treated soil presents no problem.
A second treatment plant was taken into operation early in 1988 on the Moerdijk industrial estate.

HEIJMANS

Treatment of groundwater
The services offered also include treatment of polluted groundwater using, for example, stripping, activated-carbon adsorption, sand filtering, gravity separation etc.
This is usually carried out in situ and in combination with other measures.

Refuse treatment
Heijmans Milieutechniek is equally active in the field of refuse treatment. In particular, processes for domestic refuse are used, based on optimal recovery of energy.



Soil-washing installation of Heijmans Milieutechniek BV

HWZ-Bodemsanering

Versatile and thorough

Hollandse Wegenbouw
Zanen BV
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HWZ-Bodemsanering in Amersfoort is an autonomous unit within the HWZ organization and has the availability over all the resources of that organization. HWZ has 18 regional offices in the Netherlands, from which it can fast and savely carry out soil treatment projects.
HWZ-Bodemsanering employs many methods for thorough treatment of soil pollution. Most of them are used on their own. Moreover, in combination with one of its sister companies, HWZ-Bodemsanering has at its disposal the know-how and facilities of the Hollandsche Beton Groep (HBG) and can thus make use of related techniques for the purpose of soil treatment. There is no soil pollution so large that HWZ-Bodemsanering can not find a solution. The service package includes the following treatment techniques, aimed at the environment of the future.

Removal by
- Excavation and dumping
- Extraction treatment
- Water purification

Isolation by
- Bentonite-cement walls
- Bentonite-film screens
- Diaphragmwalls
- Sheet piling
- Chemical injection

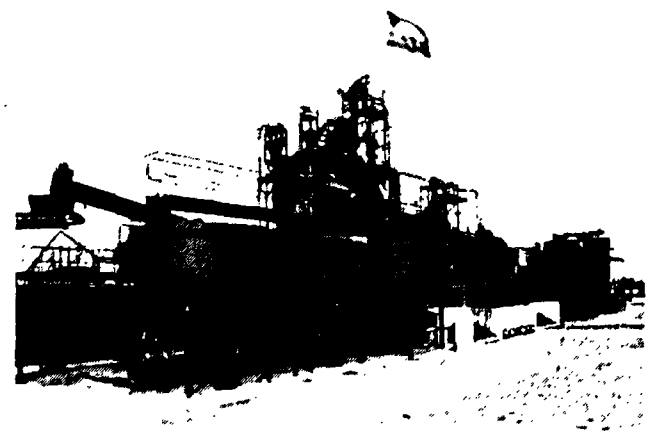
In situ treatment by
- Land farming
- Bacteriological cleaning
- Vacuum stripping

Groundwater treatment
- Using installations build up of various components selected to suit the nature of the pollution

General
- Storing of polluted sludge and submerged soils in specially-equipped depots such as foil lined pits.
- Setting up temporary dumps for polluted soil.
- Increasing stability and processability of polluted sludges and submerged soils using the vacuum consolidation method.

Techniques used
In recent years HWZ-Bodemsanering has acquired a great deal of experience in the treatment of polluted soils with the physical-chemical extraction method. The soil-treatment installation is a cooperative venture of HWZ, HBG, TNO and two Dutch Ministries. (Ministeries of Economic Affairs and Environment)
The process consists of three main phases.
1) Blending the polluted soil with the extraction medium.
2) Physical separation of soil from the polluted extraction medium.
3) Purification of the extraction medium.

Using this extraction method, e.g. cyanides, heavy metals, hydrocarbons and pesticides can be safely and economically removed.
HWZ-Bodemsanering has the know-how and experience required for handling toxic and dangerous substances. Qualified chemists and laboratory workers provide the guarantee.



Physical-chemical soil treatment installation at Amsterdam

Important adresses in the Netherlands

Ministery of Housing, Physical Planning and Environment
DGM / Hoofdafdeling Bodem
Dr. van der Stamstraat 2
P.O. Box 450
2260 MB Leidschendam
Tel.: (0)70 - 20 93 67

Ministery of Transport and Public Works
Plesmanweg 1-6
P.O. Box 20 901
2500 EX 's-Gravenhage
Tel.: (0)70 - 51 61 71

Ministery of Economic Affairs
Bezuidenhoutseweg 30
P.O. Box 20 101
2500 EC 's-Gravenhage
Tel.: (0)70 - 79 89 11

Ministery of Agriculture and Fisherries
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Province Groningen
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Provinciale Waterstaat
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Province Friesland
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Province Drenthe
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Province Utrecht
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Province Noord-Holland
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Province Zuid-Holland
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Province Zeeland
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Provinciale Waterstaat
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Province Noord-Brabant
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Province Limburg
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ANNEXE 10

NORMALISATION DES TENEURS EN POLLUANTS POUR LES SOLS ET LES EAUX AUX PAYS-BAS

Source : Rapport J.J. M. STAPS (RIVM, 1990).

NATIONAL INSTITUTE OF PUBLIC HEALTH AND ENVIRONMENTAL PROTECTION
BILTHOVEN
THE NETHERLANDS

Report no. 738708006

International evaluation of in-situ biorestoration of contaminated soil and groundwater

J.J.M. Staps[1]

January 1990

This report was made in connection with the project "Remedial action techniques for contaminated soil" on behalf of the Department of Drinking Water, Soil and Water of the Dutch Ministry of Housing, Physical Planning and the Environment. As a Fellowship report, it is also published in relation with the NATO/CCMS pilot project on Demonstration of Remedial Action Technologies for Contaminated Land and Groundwater.

1 At present employed with Grontmij nv, P.O.Box 203, 3730 AE De Bilt, the Netherlands.

APPENDIX 5.

A: Examination framework for soil pollutants: indicative values for concentration levels.

Indicative values: A- reference value
B- indicative value for further investigation
C- indicative value for cleaning-up

Presence in:	soil(mg/kg dry weight)			groundwater (µg/l)		
	A	B	C	A	B	C
I. metals						
Cr	*	250	800	*	50	200
Co	20	50	300	20	50	200
Ni	*	100	500	*	50	200
Cu	*	100	500	*	50	200
Zn	*	500	3000	*	200	800
As	*	30	50	*	30	100
Mo	10	40	200	5	20	100
Cd	*	5	20	*	2.5	10
Sn	20	50	300	10	30	150
Ba	200	400	2000	50	100	500
Hg	*	2	10	*	0.5	2
Pb	*	150	600	*	50	200
II. inorganic compounds						
NH_4 (as N)	-	-	-	*	1000	3000
F (total)	*	400	2000	*	1200	4000
CN (total free)	1	10	100	5	30	100
CN (total Complex)	5	50	500	10	50	200
S (total)	2	20	200	10	100	300
Br (total)	20	50	300	*	500	2000
PO_4 (as P)	-	-	-	*	200	700

III. aromatic compounds						
benzene	0.05(d)	0.5	5	0.2(d)	1	5
ethylbenzene	0.05(d)	5	50	0.2(d)	20	60
toluene	0.05(d)	3	30	0.2(d)	15	50
xylene	0.05(d)	1	10	0.2(d)	15	50
phenols	0.05(d)	1	10	0.2(d)	15	50
aromatics (total)						
IV. polycyclic aromatic compounds (PAHs)						
naphtalene	*	5	50	0.2(d)	7	30
phenantrhrene	*	10	100	0.005(d)	2	10
anthracene	*	10	100	0.005(d)	2	10
fluoranthene	*	10	100	0.005(d)	1	5
chrysene	*	5	50	0.005(d)	0.5	2
benzo(a)anthracene	*	5	50	0.005(d)	0.5	2
benzo(a)pyrene	*	1	10	0.005(d)	0.2	1
benzo(k)fluoranthene	*	5	50	0.005(d)	0.5	2
indeno(1,2,3cd)pyrene	*	5	50	0.005(d)	0.5	2
benzo(ghi)perylene	*	10	100	0.005(d)	1	5
total PAHs	*	10	100	0.005(d)	1	5
V. chlorinated organic compunds						
aliphatic chlor. comp. (indiv.)	*	5	50	0.01(d)	10	50
aliphatic chlor. comp. (total)	-	7	70	-	15	70
chlorobenzenes (indiv.)	*	1	10	0.01(d)	0.5	2
chlorobenzenes (total)	-	2	20	-	1	5
chlorophenols (indiv.)	*	0.5	5	0.001(d)	0.3	1.5
chlorophenols (total)	-	1	10	-	0.5	2
chlorinated PAH (total)	*	1	10	-	0.2	1
PCB (total)	*	1	10	0.001(d)	0.2	1
EOCl (total)	0.1	8	80	1	15	70
VI. pesticides						
org.chlorinated (indiv.)	*	0.5	5	1/0.001(d)	0.2	1
org.chlorinated (total)	-	1	10	-	0.5	2
non-chlorinated	*	1	10	1/0.001(d)	0.5	2

(indiv.)						
non-chlorinated (total)	-	2	20	-	1	5
VII. other pollutants						
tetrahydrofuran	0.1	4	40	0.5	20	60
pyridine	0.1	2	20	0.5	10	30
tetrahydrothiophene	0.1	5	50	0.5	20	60
cyclohexanone	0.1	6	60	0.5	15	50
styrene	0.1	5	50	0.5	20	60
phtalates	0.1	50	500	0.5	10	50
oxidated PAHs (total)	1	200	2000	0.2	100	400
mineral oil	*	1000	5000	50(d)	200	600

* = reference value soil quality (see appendix 2)

d = detection limit

B: List of soil quality reference values (Moen, 1988).

The list consists of two tables: 1. inorganic compounds, and 2. organic compounds. They should be used only with reference to the following commentary.

1. Inorganic compounds

Reference values for heavy metals, arsenic and fluorine can be calculated for all soil types with the formula presented for each substance. In these formulas, the reference value is a function of the clay fraction and/or organic matter content. The clay fraction is defined as the percentage of mineral elements smaller than 2 μm in the total dry weight of the soil. As an example, the reference values have been presented for a standard soil with 25 percent clay (1) and 10 percent organic matter. Except for phosphate and ammonium compounds, the reference values for groundwater in the saturated zone are independent of the soil type.

2. Organic compounds

The values presented in the table for organic compounds belonging to the black list as published in the Environmental Programme of the Netherlands 1986-1990 apply to a standard soil with anorganic matter of 10% (H= 10).
In evaluating the quality of a soil, the values presented should be divided by 10 and multiplied by the organic matter content (H) of the soil samples that have been taken from this soil. For soils containing more than 30 percent or less than 2 percent organic matter, H values of respectively 30 and 2 are used.
It is expected that the detection limits for many black list substances in soil are not exceeded when groundwater concentrations equal the norms in the 1984 Decree on Water Supply, the surface water quality objectives for preparing drinking water, or values based on effect and risk considerations (WHO drinking water quidelines, EPA water quality criteria). Therefore separate values for these substances have not been included in the table. When the prevailing detection limit for organic compounds is exceeded, it may be seen as a signal for the groundwater (saturated zone). Of course, this is also true with respect to organic black list compounds which have not been presented for the solid phase for the reasons mentioned above.

Use of the tables.

In general, when concentrations are less than or equal to the values presented in the tables, the soil can be considered multifunctional according to current insights, which means that the substance involved is not expected to cause effects which can be considered detrimental. A technical manual is in preparation which should be used in evaluations of soil quality. Concentration in excess of the reference values do not necessarily mean that the soil is no longer multifunctional. Locally higher contents may be of natural origin. If there is reason to evaluate the soil's multifunctionality further, more information is needed about these local circumstances and about the prevailing environmental factors which may influence possible human, animal or plant exposure routes.

Where reference values are exceeded as a consequence of human soil use, it is also important to evaluate the extent to which the situation must be considered irreversible or irreparable. Temporarily higher concentrations resulting from allowed soil use, for example after application of permitted pesticides, must be taken into account in this evaluation.

Table 1. Reference values for inorganic compounds (see commentary for use of the table)

	Soil		Groundwater	
Name	Formula	Standard soil reference value (H=10/L=25) in mg/kg on a dry matter basis		
Chromium	(Cr)=50+2L	100	1	µg/l
Nickel	(Ni)=10+L	35	15	µg/l
Copper	(Cu)=15+0,6(L+H)	36	15	µg/l
Zink	(Zn)=50+1,5(2L+H)	140	150	µg/l
Cadmium	(Cd)=0,4+0,007(L+3)	0,8	1,5	µg/l
Mercury	(Hg)=0,2+0,0017(2L+H)	0,3	0,05	µg/l
Lead	(Pb)=50+L+H	85	15	µg/l
Arsenic	(As)=15+0,4(L+H)	29	10	µg/l
Fluorine	(F) =175+13L	500	-	
Nitrate *		-	5,6	mgN/l
Sulfate**		-	150	mg/l
Bromides		-	300	µg/l
Chlorides**		-	100	mg/l
Fluorides**		-	0,5	mg/l
Ammonium compounds**		-	2/10	mgN/l***
Phosphate (total phosphate)*		-	0,4/3,0	mgP/l***

() Concentrations in mg/kg on a dry matter basis

H = weight percentage of organic matter basis in the soil

L = weight percentage of the clay fraction in the soil

* lower values can be required for protection of nutrient poor regions

** higher values appear naturally in regions with a strong marine influence (salty groundwater)

*** the lower values apply to groundwater in sandy regions; the higher values apply to groundwater in regions with clay and peat soils.

Table 2. Reference values for organic compounds (see commentary for use of the table)

Name	Reference value at 10% organic matter (H=10) on a dry matter basis (for individual substances)*
a) Halogenated hydrocarbons and choline-esterase inhibitors	
hexachlorocyclohexane; endrin tetrachloroethane; tetrachloromethane; trichloroethane; trichloroethene trihcloromethane PCB IUPAC numbers 28 and 52	less than 1 µg/kg
chloropropene; tetrachloroethene; hexachloroethane; hexachlorbutadiene; heptachlorepoxide; dichlorobenzene, trichlorobenzene; tetrachlorobenzene; hexachlorobenzene; monochloronitrobenzene; dichlororonitrobenzene; aldrin, dieldrin; chlordane; endosulfan; trifluralin; azinphos-methyl; azinphos-ethyl; disulfoton; fenitrothion; parathion (and -methyl); triazophes PCB IUPAC numbers 101, 118, 138, 153 and 180	less than 10 µg/kg dry weight per substance
DDD; DDE; pentachloropheno	less than 100 µg/kg dry weight per substance
b. Polycyclic aromatic hydrocarbons	
naphthalene; chrysene	less than 10 µg/kg
fenantrene; antracene; fluorantene benzo(a)pyrene	less than 100 µg/kg
benz(a)antracene	less than 1 mg/kg
benzo(k)fluorantene; indeno (1,2,3cd)pyrene; benzo(ghi)perylene	less than 10 mg/kg

c. Mineral oil

total	less than 50 mg/kg
octane; heptane	less than 1 mg/kg

* or detection limit if this is higher than the value indicated

ANNEXE 11

DÉCONTAMINATION IN SITU CONCLUSIONS, RECOMMANDATIONS, BIBLIOGRAPHIE, LISTE DES PROJETS.

Source : Rapport J.J.M. STAPS (RIVM, 1990).

NATIONAL INSTITUTE OF PUBLIC HEALTH AND ENVIRONMENTAL PROTECTION
BILTHOVEN
THE NETHERLANDS

Report no. 738708006

International evaluation of in-situ biorestoration of contaminated soil and groundwater

J.J.M. Staps[1]

January 1990

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1 At present employed with Grontmij nv, P.O.Box 203, 3730 AE De Bilt, the Netherlands.

6. CONCLUSIONS

Application

- The locations at which in-situ biorestoration has been used can be divided into two main groups:
  * filling stations (service stations, airforce bases, marshalling yards, bus stations) with leaking pipelines or storage tanks (400 - 1,000 m^2),
  * chemical industry sites, mainly (former) refineries (20,000-75,000 m^2).

- The depth up to which the contamination was dispersed was generally between 3 and 10 meters below surface level.

- With respect to soil structure and geology, nearly all locations can be defined as sandy. Clay layers are present in several areas. Only in an exceptional case in-situ biorestoration is used at a site with overburden clay and fractured bedrock.

- Regarding hydrology, permeability is a very important parameter for in- situ biorestoration. In the projects reviewed, the K_f-value varied between 10^{-2} and 10^{-5}m/s, but was mostly of the order of 10^{-3}-10^{-5} m/s. In general, a K_f-value of 10^{-5} m/s is regarded as being the minimum permeability required for successful application of in-situ biorestoration.

- All locations were contaminated with hydrocarbons. Most contaminations are defined as petrol and/or diesel. A few locations were contaminated with PAHs or a mixture of chlorinated hydrocarbons, mineral oil and PAHs. The frequent discovery of secondary sources of contamination points out that the characterization is not always sufficiently carried out.

Design

- The approach of in-situ biorestoration at the visited projects could be characterized by either a hydrological or a microbiological background. Only rarely, a good integration of both disciplines could be seen.

- The decision for application of in-situ biorestoration can only be taken after a comprehensive site-characterization. The specific characterization of the contaminated site and preliminary biotreatment laboratory studies (if possible followed by field studies) should be performed to determine optimal stimulation actions and thus the different forms in which the technology can be applied.

- As regards hydrological measures, generally a system is designed, in which the groundwater is centrally withdrawn and, after aboveground treatment, is reinfiltrated at several spots at the outer border of the location. In order to support the degradation in the subsurface, an aboveground treatment system is used to degrade the contaminants in the groundwater which is pumped-up, and to condition the water before reinfiltration.

- Recirculation of the pumped-up groundwater has positive effects on the biodegradation in the soil. This may be due to the infiltration of degradation products, which are relatively easy to break down and which stimulate the activity of the microorganisms in the subsoil.

- As regards the aboveground treatment, the first part is generally a sandbox. Undissolved contaminants are removed in an oil/water separator. An air stripper is applied for removal of volatile contaminants. At a few projects, biological systems, such as a trickling filter, were used for degradation of dissolved compounds.

- The contaminating vapours in the air from the air stripper can be oxidated by means of a biological compost filter or a catalytic oxidizing system in order to acquire degradation of the contamination instead of moving the contaminants from one compartment (groundwater) to another (air). In practice, this application is dependent on the requirements, set by the legislator.

- On demonstration scale, most of the time the limiting factor is lack of oxygen or necessary redox conditions. Hydrogen peroxide is most popular as oxygen source. However, for certain applications it can be relatively expensive. Other sources are air, pure oxygen and nitrate (as electron acceptor). The choice for a system is based on cost-efficiency, contaminant load and the ease of transport and utilization.

- Necessary nutrient addition is fully dependent on the original available nutrients in the soil and the uptake by the microorganisms. Usually, addition of nitrogen and phosphorus is necessary. In a few cases, also trace elements have been supplied. Other projects could be biorestorated without any artificial supply of nutrients.

- The effect of the adding detergents is still questionable. Fundamental research and most practical experience indicate that the effect on degradation is negative. Clogging of the soil can occur when detergents are supplied, probably due to an interaction between the oil, water, detergent and solid phase.

- Addition of microorganisms to the subsoil, with the aim of enhancing the biodegradation, is being used by a few companies. Although such supply will always have some beneficial effect, until now, this has not been proved. Cost-benefit calculations are also lacking. A major objection here is, that soil micro organisms tend to adsorp onto (soil) particles, and consequently cannot be transported over long distances in the subsoil. This implies that the effect of the inoculation is very limited.

Sampling and analysis

- Very few work is done as concerns strategies for soil sampling in relation with in-situ biorestoration.

- Although important, it turned out to be impossible in the framework of this study to get a comprehensive overview of the methods of analysis used.

White spots

- Bottle-necks in relation with in-situ biorestoration can be:
  * insufficient infiltration rates, mostly caused by clogging,
  * insufficient hydrological isolation,
  * relatively long remediation period, needed for reaching low concentrations of contaminants.

- When using in-situ biorestoration, the precise fate of degraded hydrocarbons, such as gasoline, is not yet known. A proportion is transformed to leachable DOC, another part to DIC, but a large part is still unaccounted for.

- With the exception of project N1, research on in-situ biorestoration has not provided knowledge about mass balances. When degradation occurred in project N1, the percentages of leached and degraded aromatics were about the same. The aliphatics were removed by degradation only, and then almost completely.

Results and significance

- As regards feasibility, in-situ biorestoration can technologically compete with other technologies when it is applied at a suitable location, and the process is well run. As regards the Netherlands examination framework for soil pollutants, residual concentrations below B-level, or even undetectable levels of contaminants have been reached in most of the finished projects. Contaminants are mainly hydrocarbons (gasoline, diesel, mineral oil).
  The remediation time varies roughly between 3 months and 4 years, largely depending on the initial concentrations, the kind of contaminants, the soil structure and the requirements which are set. Concerning practical projects without research aspects, costs can vary between approximately 40-80 $/m^3$. This means that in many cases in-situ biorestoration will also be more cost-effective than other techniques (approximately 70-170 $/m^3$ excluding excavation and transport costs (Staps, 1989[b])).

7. RECOMMENDATIONS

General policy

- This evaluation included the visit of 17 contaminated sites, and concludes that in-situ biorestoration is a promising technology for a selection of contaminated sites. However, it is important to notice that most spills, and thus damage to the environment and the spending of large amounts of money for remediation, could have been prevented by good house-keeping. Therefore, at locations where spills might occur, prevention is recommended in the first place.

- The most fundamental recommendation that can be made from this study, is to stimulate the development of in-situ biorestoration. This study shows that the technology has a large potential. At present, it is important to collect reliable (demonstration) data, which can be used in the following areas:
  * optimization of the technology, mainly regarding oxygen transport and utilization, peroxide transport and stability and removal of contaminant residuals from soils (bio-availability).
  * extending the technology's range of applications, especially to more recalcitrant contaminants.
  * development of models of (in-situ) biorestoration, which are helpful for both prediction and development of the process.

- In-situ biorestoration is expected to be a promising technology, especially for application at contaminated industrial sites. This is mainly because of the minimal physical impact on the environment, caused by the process; industrial activities can be continued during the clean- up.

- When demanding certain residual concentration levels, regulators should not only consider concentrations in the groundwater, but also in the soil. It should be prevented that an in-situ biorestoration project is finished because the contamination levels in the groundwater are sufficiently low, while significant concentrations are still present in the unsaturated zone of the soil. Percolating water from precipitation will transport (a part of) residual contaminants and contaminate the clean groundwater again, making a second clean-up operation necessary.

- The approach taken by the experts involved in several of the projects visited can be characterized by either a hydrological or a microbiological background. However, in-situ biorestoration is not only pure biotechnology, but is indeed an integration of biotechnology and hydrology. Integration of a number of disciplines is indispensable. A prerequisite for a successful clean-up by in-situ biorestoration is intensive cooperation between microbiologists, hydrologists and civil engineers.

- Because of the general complexity of soils, the course of the degradation process can never be predicted completely. Therefore, preliminary research, both in the laboratory and in field tests will always be necessary. The field tests should include oxygen utilization rates, possible in-situ peroxide stability and potential clogging problems.
  Laboratory methods for predicting the course of the in-situ biodegradation, peroxide stability and geochemical site reactions should all be improved.

- There is a need for more sharing of meaningful site data by those experiencing in the application of this technology. This is especially needed as regards data on peroxide stability and transport, oxygen utilization and the removal of fuel residuals from soils. Therefore, projects like N1, U3 and U6 are very useful. An open policy of

organizations with experience of the technology can expose bottlenecks concerning both practice and demonstration, thereby directing the research of universities and governmental institutes and making this research more valuable.

- Knowledge about modelling of transport behavior in the soil seems to be sufficient. Modelling of biodegradation processes in the soil however, is still a difficult problem and requires further attention. A precondition for further development however is the availability of representative data, which should be published by the experts involved in in-situ biorestoration projects.

System design

- Venting of volatile contaminating compounds in the unsaturated zone and treatment of these components above ground (possibly combined with recirculation and biorestoration in the saturated zone) seems to be a promising and cost-effective method calling for further attention.

- A combination of chemical treatment above ground and biological treatment in the subsoil can possibly expand the application of in-situ biorestoration, especially to compounds which are more difficult to break down biologically (such as PAHs) and more readily biodegraded once a first oxidation step has taken place. Further research in this field can be recommended.

- Stimulation of the biological activity by heating the infiltrating groundwater has been used at one project only (D5). Here, it was not conclusively shown that this was a cost-effective method. Measurements in test plots should be conducted to demonstrate whether and when the heating effect is economical.

- There is much uncertainty about the efficacy of the supply and distribution of oxygen (-sources) in the subsoil. Research on alternative oxygen sources (O_2, H_2O_2) and electron acceptors (NO_3^-) is useful. Hydrogen peroxide is a relatively expensive oxygen source, the more so because only a very limited part of it can actively be used for the biodegradation of the contaminants; this is estimated to be approximately 15% (Brown, 1989).

- In-situ peroxide stability must be greatly improved to provide adequate oxygen downgradient of injection points. At the present cost of S 0.8- 1.10 per liter of 35% hydrogen peroxide, the available oxygen is costing S 3.30-5.30 per kg. In comparison, the cost of industrial grade liquid oxygen is only S 0.40 per kg. Therefore, if the effective oxygen concentration achieved with peroxide addition is not substantially greater than the 40 mg/l of oxygen saturation possible with liquid oxygen, then the use of peroxide is not cost effective.

- As regards inoculation, the selection by enrichment culturing is especially performed by compounds of the contamination. A very interesting possibility would be to expand this technique to a selection for the tendency of microorganisms to adsorp onto soil particles. The small percentage of the population that does not tend to sorb, could thus be selected, possibly resulting in improved biodegradation in situ because these organisms can be carried a longer distance in the subsoil. This aspect needs further attention.

- Co-metabolism, such as the biodegradation by methanotrophes, deserves more attention because it may broaden the applicability of biorestoration.

- Detergents could be useful with respect to the following aspects:

  * limitations caused by the low availability of contaminants to the microorganisms,
  * extension of the applicability of in-situ biorestoration for compounds with a low solubility.
- In order to open up possibilities for these aspects, fundamental research into the use of detergents in this field is necessary. Not only artificial supply of detergents in the in-situ biorestoration system should be considered, but also the possible use of surfactants produced by microorganisms in the soil. The use of these naturally produced detergents, directly at the spot where they are needed, might open new possibilities. Research in this field has been started at the Department of Environmental Science and Engineering of Rice University in Houston (TX).

Mass balances

- There is a strong need for mass balances on both laboratory and pilot plant scale. Mass balances will improve the insight in the contribution of different processes in the total biodegradation process.

- The limited possibilities to monitor biological activities in the soil is partly responsible for the lack of knowledge about the process of in-situ biorestoration. ATP and ADP measurements have been used for pure cultures. It is still questionable whether these measurements are also reliable for mixed cultures. The development of methods, which can be used for monitoring the biological processes in the soil, would greatly contribute to a better understanding of the processes, and thereby, to a more selective and economical supply of for example oxygen and nutrients.

- In order to gain a better insight into the contribution of biodegradation to the total degradation process in the laboratory, a satisfactory method for sterile experiments should be developed. The methods currently available, specific radiation and the use of $HgCl_2$, are insufficient; the first method because there is still uncertainty about how deep radiation can penetrate into the soil, the second because the treatment does not stop all biological activity.

- The precise fate of degradation products is not yet known. A proportion is converted to leachable DOC, another part to DIC, but a large part is still unaccounted for. Insight into the quantity, quality and significance of degraded hydrocarbons, such as gasoline, is needed, especially as regards the question of "how clean is clean?".

Specific problems

- More attention should be paid to the problem of clogging in the subsoil, resulting in disappointing infiltration rates. This problem can be related to different factors, such as geology (permeability), excessive growth of microorganisms, or high concentrations of iron or manganese.

- Once relatively low residual (threshold) concentrations with in-situ biorestoration have been reached, the limiting factor usually becomes the availability of contaminants to the microorganisms. This is in the region of, for example, less than 250 mg/kg of dry soil in the case of mineral oil. When cleaning up soil contaminated by mineral oil in the Netherlands, residual concentrations must always be less than 100 mg/kg (Appendix 5). This makes the limiting factor in this case, principally availability, even more important. Further fundamental research in this area is recommended.

Overview

A general overview of the recommendations is given in table 10.

Table 10. General overview of recommendations.

Policy	System design	Research
* stimulation of experience and sharing of information * integration of microbiology, hydrology and (soil-) chemistry * preliminary research including heating and mass balances * consideration of both soil and groundwater	* combination of bioresto-ration and venting * problem of clogging	* oxygen: - supply and distribution - alternative oxygen sources - peroxide stability * monitoring possibilities * extension to broader application * threshold concentrations * co-metabolism * addition of micro-organisms * addition of detergents * sterile experiments * modelling of biorestoration * combination of chemical and biological treatment

8. LITERATURE [1]

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Brenoel, M. and Brown, R.A. Remediation of a leaking underground storage tank with enhanced bioreclamation. Paper presented at the NWWA fifth national symposium & exposition; aquifer restoration and groundwater monitoring. Columbus, OH, May 21-24, 1985.

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1 Literature, directly related to a project is mentioned under "Literature" in de descriptions of appendix 4.

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Riss, Gerber and Schweisfurth. Mikrobiologische Untersuchungen über wesentliche Faktoren bei der unterirdischen Beseitigung organischer Altlasten unter anaeroben Bedingungen mit Nitratdosierung. Universität des Saarlandes, Homburg/Saar. 1987.

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Staps, J.J.M. Biorestoration of contaminated soil and groundwater. Chemistry & Industry, p. 581-584, 18 September 1989[a].

Staps, J.J.M. European experience in hydrocarbon contaminated groundwater and soil remediation. RIVM-report no. 738708002. 1989[b].

Verheul, J.H.A.M., van den Berg, R. and Eikelboom, D.H. In situ biorestoration of a subsoil, contaminated with gasoline. In: Wolf, K., van den Brink, W.J. and Colon, F.J. (Eds.), Contaminated Soil '88, p. 705-716. Kluwer Academic Publishers, 1988.

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Yaniga, P.M. Alternatives in decontamination for hydrocarbon-contaminated aquifers. In: groundwater Monitoring Review, 1982.

APPENDIX 1.

REFERENCES / SITES VISITED [1].

	Project code
The Netherlands	
M. de Muinck Keizer Ecolyse Nederland BV Groningen	N2
J. van Eyk Grondmechanica - Delft Delft	N5
E. v. Keulen HTTS Groningen	N2
P.A. de Boks IWACO B.V. Rotterdam	N4
NAM T. Veltkamp Assen	N4
R. v.d. Berg RIVM/LBG Bilthoven	N1
C.A. Zewald De Ruiter Milieutechnologie B.V. Halfweg	N3
L.G.C.M. Urlings TAUW-Infraconsult Deventer	N3

1 "no project" means no demonstration project in relation with in-situ biorestoration.

D.H. Eikelboom — N1
TNO/MT
Delft

WestGermany.

Experts visited

U. Bernhardt — D3
AnaKat
Institut fuer Biotechnologie GmbH
Berlin

H. Niebelschütz — D4
Argus Umweltbiotechnologie GmbH
Berlin

P. Ripper — D6
Baugrundinstitut Dr. Trischler und Partner
Darmstadt

J. Rohloff — D7
IMA GmbH
Institut fuer Molekularbiologie und Analytik
Zeppelinheim

Z. Filip — D6
Institut für Wasser-, Boden- u. Lufthygiene des BGA
Außenstelle Langen
Langen

J. Hilker — D8
Kloeckner Oecotec GmbH
Duisburg

H.J. Gährs, A. Knapp — D1
Messer-Griesheim
Düsseldorf

H.-J. Schwefer — no project
Probiotec
Düren

G. Battermann — D5
Technologieberatung Grundwasser und Umwelt GmbH
Koblenz

H.H. Hanert — D2
TU Braunschweig
Institut fuer Mikrobiologie
Braunschweig

Other experts contacted

P. Werner — D9
Engler-Bunte-Institut
Universitaet Karlsruhe
Karlsruhe 1

R. Schweisfurth — no project
Universität des Saarlandes
Angew. Mikrobiologie und Hygiene
Homburg / Saar

USA

Experts visited

DuPont Biosystems — U1
Michael D. Lee,
Aston, Pennsylvania 19014

ECOVA — U2
Al W. Bourquin,
Redmond, WA 98052

ENSR — U8
Dick Woodward,
Houston, TX 77098

Groundwater Technology, Inc. — U7
Louis B. Fournier
Chadds Ford, PA 19317

Illinois Natural History Survey — no project
Allan Felsot
Natural Resources Studies Annex
Champaign, Illinois

John Mathes & Associates, Inc. — U4
Richard A. Bell,

Columbia, IL 62236-0330

Louisiana State Univ. U9
Institute for Environmental Studies
Mr. Ralph J. Portier,
Baton Rouge, LA 70803

Rice Univ. U3
Department of Environ. Science and Engineering
C.H. Ward, Philip Bedient,
Houston, TX 77251

Robert S. Kerr Environmental Research Laboratory U3
Ada, OK
John T. Wilson

Stanford University U5
Perry L. McCarty, Paul Roberts, Lewis Semprini,
Stanford, California 94305-4020

The Traverse Group, Inc. U3
William M. Korreck
Traverse City, Michigan

University of Illinois at Urbana-Champaign no project
Bruce E. Rittmann, Albert J. Valocchi
Department of Civil Engineering
Urbana, Illinois 61801 - 2397

USAF Engineering & Services Center U6
HQ AFESC/RDV
Douglas C. Downey,
Tyndall AFB, FL 32404

Other experts contacted

Hazardous Waste Research and Information Center no project
David Thomson
State Water Survey Division
Savoy, Illinois 61874

US EPA no project
Donald E. Sanning
Cincinnatti, OH 45268

APPENDIX 2.

PROGRAM OF VISITS (chronologically)

	Project code
ITINERARY WEST GERMANY, SEPTEMBER 14-23, 1988.	
140988	
Gaehrs	
Messer Griesheim	
Krefeld	
Discussion and visit of project (near Düsseldorf)	D1
150988	
H.H. Hanert	
Institut für Mikrobiologie	
Braunschweig	
Discussion of project	D2
160988	
H. Niebelschütz	
Argus	
Berlin	
Discussion of project	D4
170988	
Bernhardt	
AnaKat	
Berlin	
Discussion of project	D3
200988	
G. Battermann	
TGU	
Koblenz	
Discussion of projectn	D5
210988	
P. Ripper, A. Riss	
Baugrundinstitut	
Darmstadt	
Visit of project at Hanau	D6