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Traffic and transport: Control and protection

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The most frequently occurring groundwater contaminants from traffic and transport are de-icing agents, particularly salt, fuel, including fuel additives, and some persistent herbicides e.g. atrazine. The issues are, therefore, less related directly to health than to drinking-water acceptability, except in specific local circumstances where a spill due to an accident can lead to a substance draining into an area vulnerable to groundwater contamination.

A number of approaches and control measures can be used to minimize pollution of aquifers with hazardous substances originating from traffic and transport related activities. These include proper planning of new transport links and routes, protective structures and containments, control of construction works, technical improvement of vehicles, impact assessment of substances used in transportation systems (such as de-icing agents or fuel additives), improved management of maintenance activities, regulation of the transport of hazardous goods through drinking-water catchments, rapid response to accidents involving spills of hazardous substances and treatment of traffic surface run-off prior to discharge. Monitoring programmes are important for determining the success of such prevention measures.

The existence of strategies and policies for protecting the environment from traffic and transport-related emissions facilitates the development and implementation of

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specific control measures to protect a drinking-water catchment. While their development and implementation may be initiated by the water supply or the public authority responsible for its safety, establishing effective control measures to protect groundwater usually requires intersectoral collaboration. This includes changes in public awareness and transport policies as well as training of people employed in the traffic sector. Successful implementation of strategies for the protection of groundwater resources may require a combination of education, fiscal, regulatory and supply-orientated measures (see also Chapter 20). Economic incentives can also contribute towards improving traffic behaviour or reducing the use of environmentally harmful types of traffic.

As with other potentially polluting human activities, giving priority to the prevention of groundwater contamination avoids the need for subsequent measures to reduce or remediate groundwater pollution, which is usually much more difficult and expensive. Where necessary precautionary measures are not immediately economically feasible, incremental improvement towards long-term targets should be envisaged, particularly through taking aquifer vulnerability into account when planning new transport systems or expanding existing ones.

As discussed in Chapter 13, situation assessment will collect information on the existing traffic and transport related infrastructure together with data on its proximity to groundwater systems and designated groundwater protection zones in order to assess pollution potential of aquifers. While many protection zone concepts seek to avoid traffic systems in the inner protection zone (i.e. close to abstraction points), they may be tolerated in the outer area of protection zones, though under the prerequisite of locally appropriate, largely constructional measures of protection.

NOTE ▶ *In developing a Water Safety Plan (Chapter 16), system assessment would review the efficacy of control measures and management plans for protecting groundwater in the drinking-water catchment from traffic and transport. Chapter 13 provides the background information about the potential impact of traffic and transport and provides guidance on the information needed to analyse these hazards.*

This chapter introduces options for controlling risks from traffic and transport. As the responsibility for these activities usually falls outside that of drinking-water suppliers, close collaboration of the stakeholders involved, including the authorities responsible traffic and transport, is important to implement, upgrade and monitor these control measures. This may be initiated by the drinking-water sector, e.g. in the context of developing a Water Safety Plan or of designating protection zones (see Chapter 17).

25.1 PLANNING AND REGULATIONS

Planning is particularly important in vulnerable groundwater catchments in order to limit or restrict construction of traffic facilities or to provide robust defences against pollutants entering the groundwater systems. For existing traffic lines, this may result in upgrading protective structures as well as in operational changes such as directing transports of hazardous goods to other routes (e.g. outside of the drinking-water catchment or protection zone). In planning the construction of new or extended traffic routes and facilities, the appropriate traffic system and route should be evaluated with respect to groundwater protection requirements. In some cases the construction of new traffic routes might be dispensed with through the improved utilization of existing routes. Aquifer protection may be an important criterion for decisions on the allocation of investments to railway versus road transport.

Requiring permits for the construction of traffic infrastructure may be an effective planning tool to assess plans for their impact on drinking-water and thus for the protection of human health. In this context, an Environmental Impact Assessment (EIA; see Chapter 20) of the proposed facilities and any alternatives provide a valuable basis for decisions. These include an assessment of the vulnerability of the aquifer to substances potentially emitted from the traffic lines intended and transport-related accumulation of hazardous substances with the potential to contaminate groundwater. Designing traffic infrastructure to include adequate drainage and disposal of drainage as well as less polluting maintenance procedures is easiest and least costly if included already in the planning stage. Management plans which restrict traffic or investment into protective structures may be more easily enforced if the drinking-water catchment or its most vulnerable areas are designated protection zones (see Chapter 17).

Frequently, not only transport activities themselves, but also the temporary construction areas associated with transport infrastructure pose a significant (though short term) risk themselves (see Chapter 13) and thus should be included in such impact assessments. Where soil and rock are to be removed, care should be taken to ensure this will not remove valuable protective layers to aquifer systems, or that dams created through construction unexpectedly affect flow paths to the groundwater. Management plans for the construction activity may be effective to define sufficiently protective procedures, and surveillance, e.g. through inspection of construction sites, is often critical for their implementation.

Regulatory requirements such as EIAs facilitate the selection of alternative routes and construction methods. Guidelines can be supplied for different construction activities as well as for raising awareness for pollution prevention. In many countries, numerous technical regulations at both a regional and a national level already exist which govern the construction and drainage of traffic routes and also – at least partly – take account of groundwater protection. An example directly addressing groundwater protection are the Guidelines for road construction measures and for existing roads in drinking-water protection areas in Germany (FGSV, 2002). Regulatory approaches have induced behavioural changes in some countries, e.g. safe disposal of motor oil and restriction of car washing to contained sites at service stations.

A further important regulatory and planning approach is the development of accident response plans, particularly for transport of hazardous goods, but also for fuel spills caused by accidents, as rapid clean-up can prevent or substantially reduce groundwater contamination. To be effective, such response plans need to be tailored for the respective setting. Further, it is important to train the response with the parties that need to react quickly in the case of a spill or accident.

A number of international regulations target reducing the environmental impact of transport, and their improved coordination and harmonization facilitates implementation of many measures. For example, the construction and operation of airports is regulated internationally (ICAO, 2000).

25.2 RUNOFF CONTROL

Whether or not collection and treatment of run-off from roads and other surfaces potentially contaminated by transport and traffic is necessary, depends both on the amount of traffic and on aquifer vulnerability and use. In rural areas, scattered run-off from low density traffic routes can percolate over a wide area, and the impact on groundwater quality is frequently regarded as harmless or tolerable if, outside of water protection areas, percolation occurs through a vegetation-covered area with an unsaturated zone at least 1 m thick.

In contrast, roads in built-up areas, as well as aircraft manoeuvring areas and airport aprons, are frequently connected to a drainage system. From less polluted roads this may be directed into a separate storm sewer system, not connected to the foul sewer system, and discharged into a receiving water body. Treatment is often not necessary or may be limited to retention basins (Figure 25.1) which settle some of the particulate load. These are best constructed at least 2 m deep in order to allow evenly distributed through-flow to avoid resuspension through turbulence. Where necessary because of aquifer vulnerability, they need to be impermeable to the underground. Retention basins may also be equipped with a vertical barrier to skim off low-density liquids such as fuels that float as upper layer on the run-off which need to be removed immediately after the pollution event. Removal of solids settled to the bottom, inspection and maintenance should occur at regular intervals and after events such as storms, extended periods of drought or frost and after accidents leading to loading of fuel and oil to the basin. Management plans are useful to define these maintenance activities, including the time intervals and responsibilities for their performance.

For collected run-off from very busy roads (average daily traffic volume >15 000 vehicles) treatment may be a necessary control measure before percolation to groundwater or discharge into surface waters, through mechanical separation as shown in Figure 25.1, through further steps such as percolation through artificial wetlands, or even by retention in larger basins and eventual discharge to a sewage treatment plant. The scale of treatment required for road run-off is determined by the hazard posed. Indeed, as the pollutant load and water volume can vary considerably over time, designing treatment to cope with the variable loading and volumes may be both difficult and expensive.

In some areas, road drainage systems may be connected directly into a sewage system, and the run-off can then be treated together with domestic and industrial waste water. While this is desirable in principle, combined collection of road drainage with sewage also poses problems. Elements of traffic-specific substances – for example, heavy metals – may enrich the sewage sludge and thus compromise sludge reuse and even cause problems for its disposal. Furthermore, during heavy rainfall events, combined sewerage systems can deliver huge volumes of run-off over short periods. Where storage volume is insufficient, this may swamp the treatment process, overflow into recipient water-bodies without treatment, or even place raw sewerage on streets and other areas. Therefore, planning for construction or upgrading of systems directing run-off to sewage treatment plants must include these considerations when calculating the dimensions necessary, particularly for retention basins.

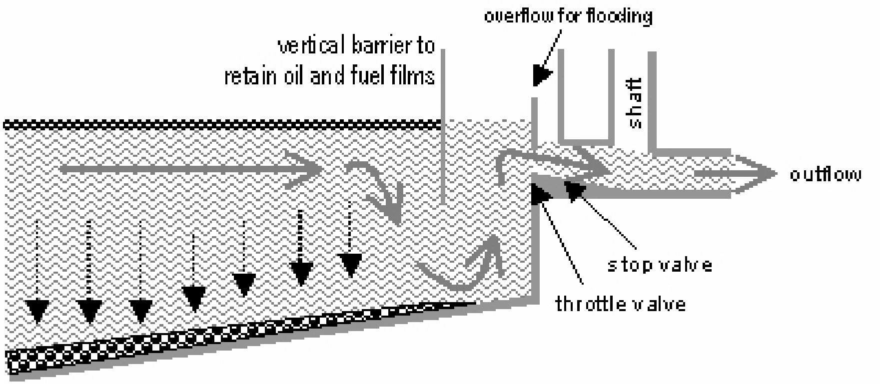

Figure 25.1. Basic scheme of a retention basin for particle sedimentation with vertical barrier to retain oil and fuel films

25.3 DESIGN AND MAINTENANCE OF PROTECTIVE STRUCTURES

The appropriate design for pollution prevention structures is best selected following a pollution risk assessment that considers both the type of traffic and the vulnerability of any aquifers in the vicinity. Legislation requiring protective structures in specified settings exists in many countries, often in combination with good practice codes or engineering guidelines (see e.g. DEFRA (2002) for the United Kingdom or FGSV (2002) for Germany). Typical pollution prevention designs incorporate the use of double-skinned tanks for fuel storage, bunding (i.e. containing) of above-ground storage facilities, adequate monitoring facilities in above and below-ground storage facilities (e.g. observation boreholes in tankpits, leak detection mechanisms in double-skinned tanks, pressure sensors in delivery infrastructure), overfill prevention systems, tanker stand areas with drainage capturing spills during delivery.

These engineered pollution prevention systems are effective only in combination with procedures for site operations, preferably described in a management plan and subjected to regular surveillance or audit. Regardless of the presence of pollution prevention structures, early detection of contaminant release is critical in protecting groundwater. This requires adequate training of operational staff to ensure that monitoring procedures are followed correctly, including regular (at least weekly) monitoring of volumes of stored fuels and other wetstock (at the most simple level, regularly conducting an audit of fuel delivered versus fuel supplied). It also requires developing staff awareness of, and interest in, the nature of plumbing and tank corrosion.

Where drainage and pollution preventing structures exist, it is essential that they be maintained in an optimum condition. For example, oil traps must be kept free of grit and other particles, otherwise they will overflow and fail in their protective capacity. Containments to prevent groundwater contamination (e.g. for fuel tanks) need to be inspected regularly to ensure integrity. Management plans would include regular maintenance programmes and operational monitoring to ensure such structures and treatment facilities are kept functional. Inspections of conditions downstream of outfalls are also recommended as part of a maintenance programme to ensure any adverse impacts are noted and dealt with on a timely basis. Improving the maintenance of roads, rail-track systems and airport operational areas forms part of effective control measures. The positive effects of road cleaning and major factors influencing cleaning efficiency were demonstrated by early investigation (Sartor and Boyd, 1972; Shaheen, 1975).

25.4 MINIMIZING USAGE OF HARMFUL CHEMICALS

Minimizing the amounts of chemicals used in maintenance of transport routes is an obvious method of reducing pollution potential. Management plans should be developed and applied to address applications of such chemicals. Subjecting the plans to regular audit helps ensure that they are implemented correctly. Restrictions on the use of particular chemicals in catchment areas will also aid in reducing pollution. For example, in the United Kingdom, following serious pollution of run-off from some stretches of railway lines with atrazine, the use of a different weed control method was adopted for designated sections of track in drinking-water catchment areas, resulting in a decrease in the levels of pesticide detected. The use of leaf and soil herbicides with quickly-degradable active substances, potentially within the framework of integrated vegetation control, represents an improvement in protective measures as compared with the current, largely preventative application of herbicides. A further example is the replacement of nitrogenous by non-nitrogenous de-icing agents on airfields.

Developments to reduce the health hazards from transport-related substances in groundwater include use of alternative chemicals less likely to pollute groundwater, environmentally more compatible fuels, mechanical (instead of chemical) snow, ice and weed clearance; these may all contribute to a coordinated pollution minimization policy. Groundwater pollution from air fields can be reduced by safer refuelling of aircrafts as well as switching fertilization of air-field lawns with highly soluble nitrogen compounds to controlled-release fertilizers, or by using more readily biodegradable pest control agents used against e.g. field voles (a burrowing rodent which needs to be controlled to reduce damage to air strips).

Regulating the nature, type and availability of maintenance materials can also aid in reducing pollution. Checklists of suitable alternatives can be provided to operators and local authorities to inform them of the benefits of their use over traditional substances known to cause pollution. Legislation banning the production, import or use of heavily polluting materials can be effective in avoiding the pollution they would otherwise cause.

25.5 ACCIDENTAL SPILLAGE AND DISPOSAL

A major pollution risk associated with traffic is spillage caused by accidents. Particularly in drinking-water catchments, the risk of accidents on roads can be lowered through technical measures (such as crash barriers, concrete skidding-walls, ramparts) and traffic-regulation measures (speed limits, overtaking bans, prohibition or restriction of vehicles with loads hazardous to water) (FGSV, 2002). National legislation banning the use and transport of specific hazardous substances or banning their transport on roads, particularly near vulnerable aquifers or in protection zones, can be an effective measure to prevent accidental pollution. Where this is not possible, issuing permits is an important control measure. They should take full account of the nature of the potential pollutant and detail emergency procedures. Where permits for the transport of hazardous goods are granted, emergency response plans to deal with accidents are important. These need to take into account that for some spills, the clean up chemicals used and subsequent washing of surfaces can introduce additional pollutants and aid in the spread of these.

Leaks from fuel storage tanks and pipelines are frequent sources of pollution. Such infrastructure should be subject to regular inspections and testing programmes. Even simple physical structures such as bunded fuel tanks (i.e. placing them inside a structure that can contain the tank's volume should it leak) can provide a significant reduction in pollution risk.

Groundwater pollution with hazardous substances from filling stations, fuel or waste transfer depots can be controlled by adequate design minimizing the risk of spillage and, if spillage should occur, accident response plans should be in place to allow rapid recovery of the spilt materials. If the facility is in the catchment of a public supply source, the responsible water authority should be informed and immediate remediation and control measures carried out, taking account of local conditions and the characteristics of the hazardous substance. These may include temporary closure of drinking-water abstraction to minimize drawing the pollutant into the aquifer, the construction of scavenger wells to remove the pollutant, or the diversion of the pollution through infiltration measures, thus producing a hydraulic barrier.

25.6 MONITORING AND VERIFICATION OF MEASURES CONTROLLING TRAFFIC AND TRANSPORT

The approaches to controlling traffic and transport in drinking-water catchments proposed above range from planning tools in the context of broader environmental traffic policy to specific technical measures such as structures, containments or the restriction of chemicals used in maintenance of traffic facilities. They also include process controls to check if transport facilities are operated properly in order to avoid contamination of drinking-water catchments. The most important measures are summarized in Table 25.1. In some settings, some of these measures may be suitable for integration into the WSP (see Chapter 16) of a drinking-water supply and become subject to operational monitoring in the context of such a plan.

NOTE ▶ *The implementation of control measures such as those suggested in Table 25.1 is effectively supported if the stakeholders involved collaboratively develop management plans that define the control measures and how their performance is monitored, which corrective action should be taken both during normal operations and during incident conditions, responsibilities, lines of communication as well as documentation procedures.*

The implementation of control measures protecting drinking-water aquifers from traffic and transport is substantially facilitated by an environmental policy framework (see Chapter 20).

In all settings, monitoring of the measures implemented is crucial to ensure that they are in place and effective. Table 25.1 includes options for surveillance and monitoring of the protection and control measure examples given. Most of these focus on checking whether the controls are operating as intended, rather than on contaminant concentrations in groundwater. For planning, surveillance will address whether plans exist, are appropriate and are being implemented, particularly in the context of issuing permits for traffic and transport infrastructure. Auditing of plans is an effective tool for such surveillance. Similarly, for measures addressing design and construction, the first verification step is to assess whether or not they are adequate for achieving the protection target, and whether or not they are in place as indicated in the construction plan. For the routine operation of controls, monitoring focuses on assessing whether they are functioning correctly, e.g. whether containments are leaking or whether restrictions on transport of hazardous goods through a catchment are being enforced (see Table 25.1).

NOTE ▶ *Options for monitoring suggested in Table 25.1 rarely include regular groundwater quality monitoring. Where containments and protective structures are poorly accessible for inspection of their integrity, however, monitoring of selected indicator parameters in groundwater may be needed to detect leakage.*

Comprehensive groundwater quality monitoring programmes are a supplementary aspect of monitoring with the purpose of providing verification of the efficacy of the overall drinking-water catchment management.

Some protection measures are difficult to monitor directly, e.g. integrity of a subterranean fuel road drainage pipes, and may most effectively be monitored by some parameter analysed in groundwater that would most sensitively indicate leakage (e.g. chloride, conductivity or in some settings, simply changes in water-table). Intensified monitoring of specific contaminants in groundwater may serve as a control measure after transport accidents involving hazardous goods or fuel spillage. Also, in drinking-water catchments with a potential for pollution by traffic and transport, overall verification of the catchment management concept would include monitoring of specific transport-related contaminants anticipated or known to occur.

Table 25.1. Examples of control measures for traffic and transport and options for their monitoring and verification

Process step	Examples of control measures for traffic and transport	Options for their monitoring and verification
PLANNING	Planning of new or expansion of existing traffic lines and facilities in relation to vulnerability of drinking-water catchments including e.g. siting, choice of materials and mode of construction, run-off collection, restriction of substances used in maintenance	Review plans with respect to the vulnerability and protection of drinking-water catchments
	Accident response plans in drinking-water catchments for releases of fuel and/or hazardous substances including lines of communication, immediate and subsequent measures	Approval, possibly audit, of accident response plans by public authority responsible
DESIGN AND CONSTRUCTION	Collect and adequately dispose wastes and wastewater during construction	Review adequacy of design and compliance with plans and regulations
	Install protective structures that minimize groundwater pollution through routine traffic and accidents, e.g. run-off collection, impermeable surface barriers, bunding of fuel tanks, crash barriers, retention and settling ponds, oil separators treatment facilities for run-off	Inspect sites regularly (including construction sites) and test functioning of facilities Assess integrity of containments, tanks, pipelines and tankers through visual inspection and leak monitoring systems
	Install specific protective structures of refuelling and vehicle maintenance stations (e.g. containment, drainage, oil separators)	
	Install terminal reception facilities for sewerage collection (e.g. from trains, busses, ships, planes)	
	Document construction details relevant for targeted response to spills, e.g. location of drainage pipes, sites for infiltration, location and construction of pipe joints	Check record drawings and documentation of construction details

Process step	Examples of control measures for traffic and transport	Options for their monitoring and verification
OPERATION AND MAINTENANCE	Maintain protective structures that minimize groundwater pollution from traffic, e.g. keep run-off drainage clear of obstacles, remove sludge from retention/settling ponds; repair sealed surfaces when damaged	Inspect integrity of structures and test functioning at regular intervals Where critical, monitor downstream groundwater for parameters indicating leakage
	Collect and adequately dispose wastewater from vehicles, terminal reception facilities, toilets; maintain sanitary facilities Maintain tanks and pipelines for fuel (e.g. kerosene, diesel, gasoline)	Inspection of records for maintenance activities Regular inspection of integrity of containments (leak monitoring systems) Regular monitoring of fuel amounts delivered, stored and supplied; action plan to follow up discrepancies indicating losses
	Control amounts and types of chemicals used for maintenance of traffic lines (e.g. de-icing agents, herbicides)	Inspect records of chemical consumption, devices for use, storage of chemicals
	Devise and conduct regular staff training programmes in auditing and monitoring procedures such as to ensure early detection of leaks	Audit the number of staff trained and the frequency of that training Conduct regular checks of the efficacy of the training by testing staff response to a range of simulated scenarios Review staff performance during both simulated and real situations and modify the training if necessary
	Develop response plan for anomalies found during routine audits and monitoring	Conduct regular reviews of the plan with staff Evaluate staff response to real and simulated situations and revise the response plan if necessary
	Control traffic through protected drinking-water catchments to implement restrictions on the transport of hazardous goods as well as speed limits and bans on overtaking	Inspect records for traffic controls

25.7 REFERENCES

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