Summary Statement

The hazards to human health represented by zoonotic pathogens in animal excreta remain poorly understood and inadequately addressed in the literature. These hazards present special challenges for authorities charged with maintaining the quality of surface waters used for recreation and as sources of drinking-water. Current water quality standards in most countries focus on control of human faecal contamination and do not reflect risk posed by faecal contamination from animal sources. Few studies have attempted to examine the relationship between swimming-associated health impacts and the quality of water contaminated by animals or birds, and that the evidence base is lacking to determine whether or not this type of exposure may result in excess illness. Furthermore, we do not know if the current regulatory response, with its focus on contamination by human excreta, is appropriate for animal or bird-contaminated waters. Human faeces are frequently treated and may be disinfected before they are discharged into surface waters, whereas non-human faecal contamination is commonly neither treated nor disinfected. Moreover, the human derived pathogens are frequently viruses, whereas zoonotic pathogens are primarily bacteria and protozoans. A limited number of studies in a range of contexts have shown that their relative relationship to faecal indicator organisms varies widely. These key differences complicate the application of standards derived from studies on the health impacts of human faeces to waters contaminated by animals or birds.

1 This summary was prepared by Al Dufour, Jamie Bartram and Robert Bos. The summary reflects significant highlights from the chapters in this book and ideas that were discussed at the workshop on Animal; Waste, Water Quality and Human Health conducted at the University of North Carolina, Chapel Hill in October 2009.
The variability in the occurrence of zoonotic pathogens in waters used for recreation or as a source of drinking-water adds to the complexities of developing water quality standards for surface waters. Unlike pathogenic viruses, which typically occur in human populations with a consistent frequency, the zoonotic pathogens found in animal and bird populations tend to occur sporadically and/or seasonally. This characteristic of zoonotic pathogens in animal and bird faeces makes the establishment of the relationship between water quality and health difficult.

These issues limit our ability to develop guidelines and also monitoring requirements for determining and maintaining the safety of waters contaminated by domestic animals and birds. At the same time, pressures including increasing numbers of humans and livestock and changes in their spatial distribution and related interface create an imperative to act to assess and manage risks in order to protect health. These limitations will, however, not be remedied in the near future. Therefore, innovation is required on various fronts in order to protect the public from potential exposures to zoonotic pathogens that may occur in waters contaminated with livestock faecal waste and to reduce the associated health risks.

Two protozoan parasites (of the genera *Cryptosporidium* and *Giardia*) and three bacteria (EHEC with *E. coli* O157 as the most important representative, and of the genera *Salmonella* and *Campylobacter*), all cosmopolitan in their distribution, meet the criteria to warrant further attention: they are important pathogens in humans, they are known to be carried by animals and discharged in their faeces, and they have been isolated from surface waters. The parasites and bacteria differ in that the former do not replicate outside of their hosts.

This book collects relevant information, in connection with these five pathogens, on the scope of domestic animal and bird faeces discharged into the environment, the fate and transport of the faecal wastes (and the pathogens they may contain) that have been discharged into the environment, human exposure to the faecal wastes, potential health effects associated with those exposures and interventions that will limit human exposures to livestock waste. It also addresses the monitoring, detection and management related to these phenomena.

Participants in the expert meeting that contributed to the development of this volume agreed on twelve key conclusions from their deliberations:

- Although there are a large number of zoonotic pathogens that affect humans, five are known to cause illness around the world with high-frequency: *Cryptosporidium*, *Giardia*, *Campylobacter*, *Salmonella* and *E. coli* O157. Efforts to control these pathogens are likely to be effective in controlling other related zoonotic pathogens whether known, as-yet-unrecognized or emergent.
- Domestic animals such as, poultry, cattle, sheep and pigs generate 85% of the world’s animal faecal waste, proportionally a far greater amount than
the contribution by the human population. The faecal production rate and contribution to the environment of these animals can be as high as $2.62 \times 10^{13}$ Kg/Year.

- Limiting zoonotic pathogen-shedding in farm or production facilities for domestic animals should be accomplished by preventing illness in livestock, through minimizing exposure to pathogens, by increasing immunity, by manipulation of the animal gastrointestinal tract microbial ecology and by managing (including treating) animal waste to reduce the release of zoonotic pathogens into the environment.

- The carrier status of animals, particular for the protozoan parasites, appears to peak in very young animals, while in the entire animal population the phenomenon of “super-shedders” provides a possible handle on reducing overall pathogen loads in the environment, provided reliable and cost-effective techniques are developed for timely detection of super-shedders.

- Rivers and streams deliver faecal wastes (and the zoonotic pathogens they may contain) to surface water bodies used for recreation, commercial shellfish harvesting and as sources of drinking-water. The transport of faecal material and the fate of zoonotic pathogens in a catchment is not understood with a great degree of certainty. Modeling is the greatest source of the information in this area and has the potential to be further developed.

- In the context of animal husbandry four control points exist: minimizing exposure of livestock to pathogens, increasing reservoir host immunity and resistance, manipulation of the microbial ecology of the host’s gastro-intestinal tract and treatment of animal wastes to reduce zoonotic pathogens. Raising pathogen-free animal herds or flocks as well as treatment of animal waste through composting and anaerobic digestion at high temperatures have proved feasible and effective but, at a considerable cost. Animal vaccination and manipulating the host animal’s intestinal flora have met with mixed success.

- The most effective management practices in catchments are at the farm or production facility. Their overall purpose is to reduce pathogen transfer from their sources to a watercourse and they should be evaluated and optimized to that end. Manures can be intercepted and stored in ponds, contaminated water can undergo on-farm treatment and constructed farm wetlands can be used to reduce pathogen load. Bridging and fencing can be used to control livestock near streams. Managing the spatial distribution of animals can avoid the build-up of high concentrations of contamination in sensitive areas.

* http://faostat.fao.org
Direct human exposure to zoonotic pathogens can be limited by restricting use of affected beaches or other resources through regulation or through public health education regarding exposure to nonhuman sources of faecal contamination. Effective regulation and monitoring may be hindered by sectoral, jurisdictional and geographical boundaries.

Sanitary surveys and modeling for source attribution have important contributions to make towards the evaluation and categorization of principal sources of faecal pollution.

Faecal source identification methods should be used to measure potential risk associated with exposure to human and animal pathogens and to target interventions effectively. They merit further research and development.

Comparative risk assessment can be used to compare risk from various sources in order to make informed decisions about what health or economic benefits might be realized by taking appropriate actions to protect water resources.

Economic evaluations are more frequently being required so that the greatest benefit might be realized from actions taken to improve the safety of recreational and other waters.

The paucity of information in the literature on human health effects associated with exposure to recreational waters contaminated with animal and bird faeces, combined with the limitations outlined above, leads to the conclusion that current standards and control measures may not be appropriate for maintaining the safety of recreational water contaminated with non-human faeces. The implication is that other means of protecting the health of swimmers and other water users must be considered. The approach suggested in this book is to better define the risk posed by animal and bird faecal contamination and provide effective means to manage them.

Information that defines the scope of faecal discharge by domestic animals and the estimated carriage of zoonotic pathogens in their faeces, their transport in the environment and the potential exposure of humans to animal wastes is available in some detail. Intervention and prevention approaches for reducing exposures to animal excreta include prevention of animal infections, intervention at the source, and control measures at exposure locations such as bathing beaches. Of the methods for identifying sources of animal faecal contamination, currently comparative risk assessment provides the most reliable tool for ranking risk and making judgments about where significant economic benefits might be realized. Methods and procedures for benefit: cost and health effectiveness: cost analysis exist to support decision making taking economic benefits into account.