5. Synthesis of the Methodology

5.1 Anthropo-Environmental Systems and Transdisciplinary Methodology

As has been made explicit in the research objectives, and discussed in previous chapters, this thesis involves, *inter alia*, the articulation of a transdisciplinary methodology for application to environmental problems, particularly in the area of IRM. It has been argued that this methodology should be congruent with the fundamental nature of complex environmental systems in which human impact is significant. To recap, these systems involve non-linear feedback relationships, are likely to exhibit sensitive dependence on initial conditions, generally do not have deterministic algebraic solutions and tend to generate "wicked problems".

The literature on ESD and the related literature on IRM call for an holistic and integrated approach to dealing with complex environmental problems. Within these literatures, it is generally recognised that it is necessary to take a systems approach which embodies community learning as a fundamental management component. The system dynamics and the related learning organisation literatures reviewed in Chapter Three, provide some guidance as to how such an approach can be implemented.

The purpose of this chapter is to describe the transdisciplinary methodology that has been developed by the author as a response to the issues outlined above and in the previous chapters. This methodology is a synthesis across a number of fields, and is designed to:

- embed the principles of transdisciplinarity and systems thinking;
- explicitly incorporate stakeholder participation and learning as an integral part of managing for sustainability;
- capture the systems tools of system dynamics and apply them to the complex problems of environmental management; and
- be a viable option for use by, among others, IRM practitioners and ecological economists.

5.2 A methodology is outlined (Participative Environmental Management)

> *Simplifying reality to simplify the decision process is a dangerously unsustainable way forward.*
>
> *Anthony Judge*

On reading this section, it should be no surprise for the reader to find described a methodology which is based on a participative learning systems approach and that uses the tools of systems dynamics and embeds general systems thinking principles. Following the extensive discussion of transdisciplinarity in the Chapter Two, it should also come as no surprise that the methodology has a transdisciplinary stance. It is transdisciplinary in two ways; it merges insights and knowledge from different disciplines, and it provides a mechanism whereby participants from various disciplinary backgrounds can contribute within a genuine transdisciplinary framework. Moreover, it is a methodology that has been purpose-built to facilitate the generation of synergistically inspired transdisciplinary learning as the foundation of a more insightful framework for IRM praxis.

Fundamental to the methodology that is to be described, is the participation of system stakeholders (widely defined to include expert and non-expert) throughout the entire process. Furthermore, the methodology is specifically focused on issues of environmental management. For the sake of brevity, and in order to avoid the continued use of phrases such as "the proposed methodology" it would be useful to give the methodology a convenient description. From the observations above, the term "Participative Environmental Management" seems to capture the key attributes of what is proposed. The abbreviation PEM will be used from here on when referring to the proposed methodology.

PEM is a process that has five main parts. Figure 5.1 provides an overview of PEM, and continual reference will be made to this diagram during the following discussion.

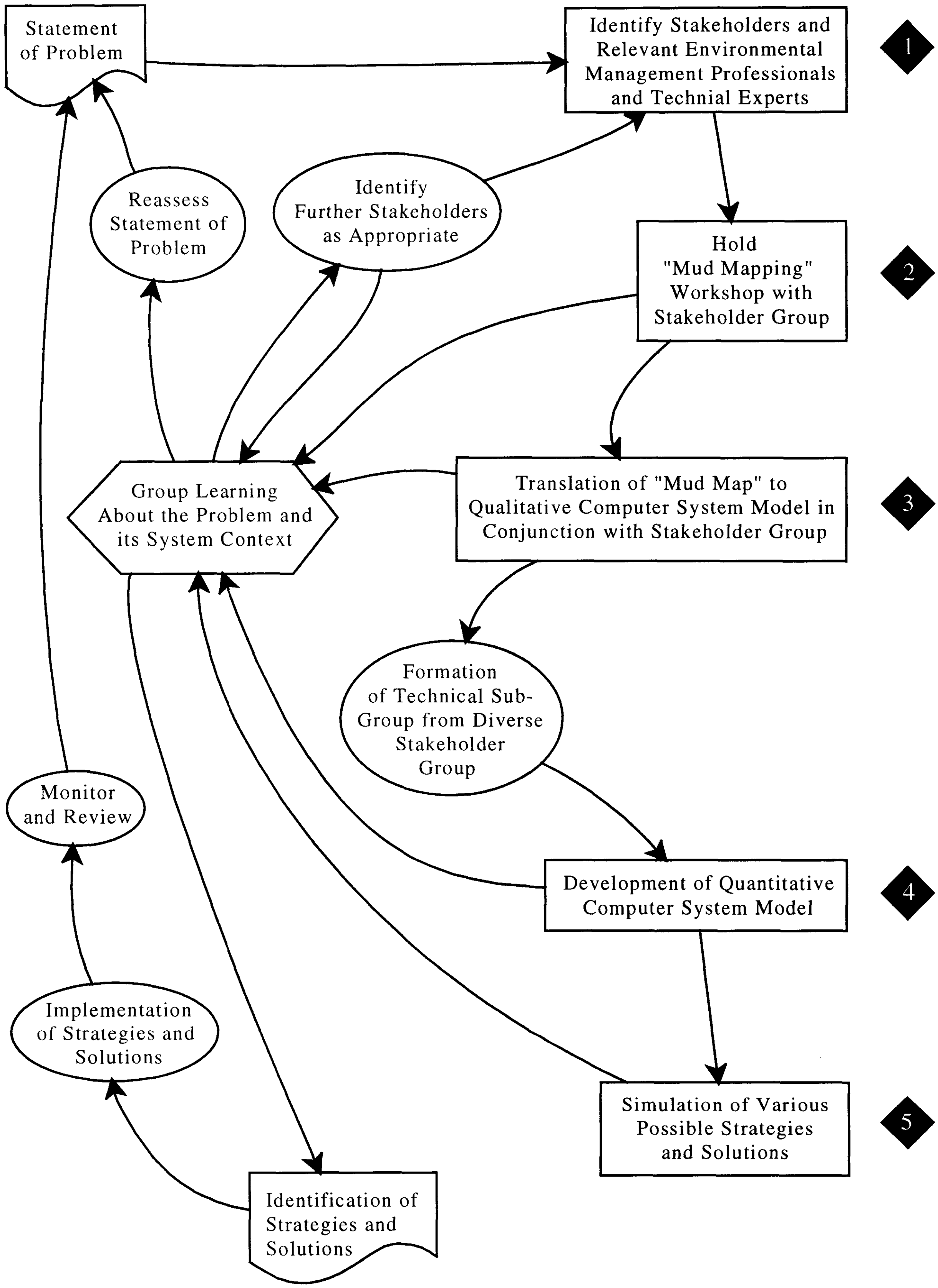

Figure 5.1 Schematic of the Participative Environmental Management process

5.2.1 PEM Stage One

The use of PEM starts with a complex problem that has been identified by some agency or group that has a jurisdiction or interest in fixing the problem (the proponent). There will be a problem statement, either formal or informal, which could be written, pictorial, verbal, or some combination of these. Whether or not such a problem statement is complete and comprehensive is significant from a systems perspective, which is demanding of a good understanding of a problem and its context as a first step in dealing with the problem. Developing such an understanding of the problem is integrated within PEM, and begins at the earliest possible stage. As PEM is applied to the problem, a likely outcome is that the problem definition itself will be modified to some extent as greater understanding of the problem context is developed.

As has been discussed previously, PEM has been developed as an application of systems thinking and learning community approaches. As such, it is a powerful tool for applying to, and systematically exploring the dimensions of, problems of a complex nature. However, if problems are reasonably straight forward then the use of a methodology such as this would be analogous to the use of a sledge hammer to crack a nut. There is thus a need to ascertain that this particular methodology is appropriate for use on the given problem. Indicators for the use of PEM are the existence of some or all of the following:

- many stakeholders;
- a complicated institutional framework;
- feedback relationships;
- evidence of system failure - e.g. non-existent or broken feedback links, one or more system component(s) out of control;
- a complex interrelationship of causes and effects; and
- intractable problems - i.e. those that have refused to succumb to more conventional approaches.

Once an initial problem has been identified and the need to invoke PEM ascertained, the next step is to start the stakeholder identification process. Following is an outline of a structured approach to the management of stakeholder participation.

Just as the problem identification phase is iterative, stakeholder identification also unfolds through time. There are two main approaches to this process; an open invitation to anyone interested with press and word-of-mouth advertising, or a selection of key stakeholders by the proponent. Of course, it would be possible to do both things; invite and encourage the attendance of key people, and also make a general invitation to all interested parties. However the initial stakeholders are identified, PEM makes it possible to adjust representation based on insights about the system that are generated through the process. PEM makes explicit allowance for the interaction of stakeholders for two fundamental reasons: present trends in environmental management are toward more community participation in decision making; and secondly, if learning about a complex system is to be effective, it is necessary to include people with a diversity of perspectives as part of the process. It is these two reasons that must guide the way that stakeholders are included in the process, and the approach adopted an any particular instance will need to be appropriate to that situation.

In the context of IRM, the term *stakeholders* as used in PEM is intended to denote that group of people who have an interest, or stake, in the environmental problem at hand. This would include people living and working in the catchment, state agency and/or administrative staff who have a responsibility to manage various parts of the catchment environment, and 'outsiders', say green groups or other lobby groups, that have an interest in the given problem. Each of these has a legitimate reason to be involved as a stakeholder, and to participate in the collective decision making process. The need also to include empowered decision makers within the process is an important one that will be addressed after a description of the second stage.

5.2.2 PEM Stage Two

Once the initial problem and stakeholder identification stage has been accomplished, tasks that, together, can be thought of as stage one of the process, the next stage is to convene a meeting in which representatives of all stakeholders come together to explore the problem and its system context. The approach used here is a facilitated workshop model in which participants are guided through the process of articulating the problem and its context. This is a facilitation exercise based on the principles of systems thinking, and is carried out differently to the more conventional 'brainstorm and flipchart' approach often encountered.

In the conventional facilitation method, participants are encouraged to generate lists of ideas about a problem. These are recorded on a flipchart and later summarised into categories (see Kaner *et al.* 1996 for a comprehensive workbook on this approach to facilitation). The role of the facilitator in this model is to "... support everyone to do their best thinking" (Kaner *et al.*

1996, p.32) by promoting mutual understanding, cultivating shared responsibility and encouraging full participation. The authors make the point that facilitation is needed when there is a lack of a "... shared framework of understanding ...", (i.e. a lack of shared vision) and that "... a group is likely to make wiser, more lasting decisions if they join forces with someone who knows how to support them to do their best thinking" (Kaner *et al.* 1996, p.32). A similar perspective on facilitation is given as part of the Conflict Resolution Program of Washington State University (1997) wherein facilitation is seen as "... a directive group process in which an informed and objective third party guides the dialogue to ensure that all parties participate, are heard, listen and collaborate on constructing a resolution to a common issue".

PEM is about capturing group knowledge and supporting group decision making processes as the first steps towards the realisation of the synergies available through effective transdisciplinary learning, and it differs in two significant respects from conventional facilitation. First, from a systems thinking position, lists on flipcharts are anathema because they fail to capture relationships between system components, and may well reinforce the non-realisation of a systems perspective. Moreover, the process of reducing lists to a number of categories and then voting on the most important ones (Kaner *et al.* 1996, p.110 and cf. IRM case studies described in Chapter Four), disenfranchises those whose suggestions get lost in the aggregation process. As an alternative to lists, PEM includes system mapping as a way to capture system relationships and the various contributions from participants. Any aggregation that occurs is done interactively with the group and only with consensus about what issues should be collected together. In this way, participants are not disenfranchised. Secondly, group learning is not explicitly embedded in the conventional approach. In both versions of the conventional approach referred to above, the important thing is that all people are given the chance to be heard and are encouraged to participate. PEM goes further than this. It is designed not only to encourage participation and to be inclusive, but also explicitly to enhance group learning.

To start the process, a significant problem or issue is noted and depicted on a whiteboard as a circle with a descriptive label. A related issue is then drawn, with an arrow connecting the two. The direction of the arrow indicates which issue influences the other. If a two way influence is identified, a two headed arrow is drawn between the two. This is the beginning of what is known as an influence diagram (see discussion in Chapter Three) or "mud map". (The term "mud map" derives from an analogous process that is understood to be a cultural tradition in societies in India and South East Asia where abstract concepts need to be explored by non-literate people. The orientation of such approaches to non-exclusionary involvement in planning has sufficient appeal to warrant the use of the term within PEM). Figure 5.2 includes a portion of the mud map developed as part of the Throsby Creek case study which is reported in detail in the next chapter (the actual mud map was drawn freehand on a whiteboard, but to facilitate publication has been redrawn here using a computer drawing package). *Diffuse pollution* was the initial issue recorded, with the other elements emerging from discussion.

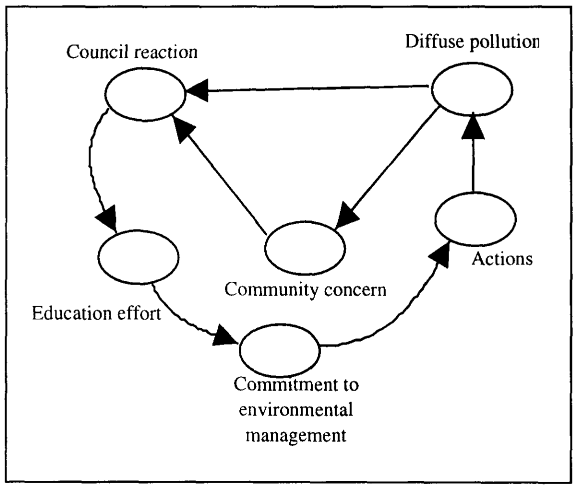

Figure 5.2. A fragment of the mud map developed in the case study.

The construction of the diagram provides a structured process through which the complexities of a problem situation can be explored in some depth. The perspectives of the technical and non-technical are accorded equal billing and are explicitly linked in appropriate causal relationships irrespective of disciplinary domain. It is the role of the group to decide how the various issues interrelate and to assess their relative importance. In order to help understanding, technical perspectives are expressed as simply as possible, so that the non-technical stakeholders are able to grasp the essential concepts. This aids the development of a shared understanding, whereby participants become better equipped to make informed decisions and recommendations.

The mud map is actually a record of group interaction and conversation. Each time an issue is identified, its nature is discussed, with particular emphasis on what other system components it has a relationship with. Except for the most trivial issue, participants invariably have different levels of knowledge and understanding about any given issue. Thus, by going through this process, each person gains knowledge and understanding about key technical, social, environmental and economic issues. As the mud map grows, it becomes a diagramatic record of the many issues that have been discussed and learning that has taken place. The diagram becomes an image representing the developing shared conceptual model of the system, and provides the focus for ensuing discussions. Note that the diagramming process facilitates the development of a *shared* understanding about the system. This is an important aspect of group learning. It is consistent with the "shared framework of understanding" identified above, and more importantly, typically proves to be a consensus position about the main system issues and their relationships. This emergent consensus is a key outcome of PEM, and is a direct result of group learning that has occurred. It should be noted that a similar outcome will usually be achieved through the generic use of influence diagrams as described in Chapter Three. The contribution of the present work is to articulate the use of these techniques within a systematic approach to participative environmental management.

Whereas one obvious output of the mud mapping workshop is a mud map, it is not the main output. Indeed, inspection of Figure 5.1 will show that the key output of the workshop is group learning about the problem and its system context. Based on this group learning, various decisions will need to be made. One thing that will become apparent in the initial workshop is whether or not the problem statement is adequate. As a result of a systematic exploration of the problem and its context by the group, it is possible that the problem will be found to be somewhat different from that which was first identified. There may be complicating factors that had not previously been considered, or simplifications that occur as the system context is articulated. Either way, there is a need to reassess the problem and rethink the strategy for dealing with the problem. If this is a dramatic change, it may be necessary to identify further stakeholders and start the process again. Another finding of the group may be that the stakeholder identification process has been incomplete and that some groups are not represented. If such non-representation is likely to have significant influence on the outcomes, then it may again be necessary to restart the process. However, it may also be possible to take steps to include the missing stakeholders in future activities so that they can become part of the group learning process.

A possible outcome of the group learning that results from stage two may be the identification of strategies and solutions sufficient to fix the problem. If this is the case, there is no need to continue on with steps three to five; the strategies and solutions will be implemented and the problem solved. This is consistent with findings by Wolstenholme (1990) and Coyle (1996) who report the use of such qualitative system dynamics. They have found that "Sometimes a given problem is effectively 'solved' in the sense that the insights from the diagram are so convincing that managers are prepared to act on them without a quantified analysis" (Coyle and Alexander 1997, p.206).

As alluded to before, an important part of the stakeholder identification process is to identify empowered decision makers who have the ability to make significant decisions about the system and the problem under investigation. It is essential that as part of the stakeholder inclusion process, these empowered people are explicitly identified and co-opted. The benefit of including such empowered decision makers in the workshop process, is that they engage in the group learning and develop a stake in the shared mental model that is to be a key outcome of the workshop. With the decision makers as part of the process of developing a consensus view of the problem and its possible solutions, they are able to gain a much more thorough understanding of the issues and possible remedies than they would if external to the process. Failure to include empowered decision makers can lead to significant frustration and disenchantment of group members as they struggle to convince those who can make the decisions of the importance of their findings.

Although it is feasible that the process can stop after Stage Two, it will often be the case that there are dynamics in the system that are extremely difficult to understand and solutions cannot be reliably identified unless their dynamics are better understood. In order to help participants develop a better understanding of how the system is likely to respond over time, the conceptual diagram can be converted into a more structured system map and simulation model. It is at this stage that the techniques applied within PEM depart markedly from influence diagram approaches such as used by Eden (1988).

5.2.3 PEM Stage Three

The third stage of PEM involves migrating the mud map to a computer using software (*ithink*) purpose built for system dynamics (SD) applications. This will generally be carried out with the participation of the stakeholder group, probably in another workshop. This step serves two main purposes; it introduces participants to the visual language of the software, and it enables the generation of a greater degree of understanding about the system. These two aspects of the third step will now be explained.

The conversion to an *ithink* diagram demands a greater level of clarity about the issues than was needed in the mud mapping stage. This is because system elements can only be represented as stocks, physical flows, information linkages (connectors) or auxiliaries. As the group participates in converting the mud map to SD symbols, they learn the language of the modelling environment and develop skill at conceptualising problems in terms of this language. As the mud map is converted element by element, members engage in dialogue about how to represent each concept in the SD symbology. This leads to a greater degree of understanding both about the issues involved and the way they can be represented on the computer.

The output of the third stage of the process is a participatively developed system representation residing on a computer. As noted for the mud map stage, the diagram developed in *ithink* again represents a series of discussions about the nature of the problem. The difference is that in the latter case, concepts, issues and technical problems must be articulated more clearly so that they can be represented appropriately as stocks, flows, auxiliaries and connectors. This imposes a structured approach on the elicitation of stakeholder knowledge and concerns, and leads to the learning experienced by the group being of a greater depth than was achieved previously.

The process to this stage has been about building and understanding a conceptual model of the problem situation. A greater level of detail about the actual numbers involved can be added to the process by moving from a conceptual model to a simulation model. This requires the specification of model parameters, a task that is carried out by the researcher in conjunction with the stakeholder group.

5.2.4 PEM Stage Four

The fourth stage of PEM is to develop the model so that it can be used for the exploration of various decision option scenarios. To achieve this objective, the model is enhanced by the inclusion of a broad range of data. The data can include well specified scientific data, or 'softer' data derived from stakeholders' perception and intuition. It is through the inclusion of this extensive data that the system map is transformed into a simulation model which captures what the stakeholder group believes are the important relationships. Note that even if knowledge is not certain (or what many might call scientific), it can still be included. The important issue is that the model builder carefully includes the data faithful to the knowledge and understanding of the stakeholder group. In this way, the model will enjoy a strong sense of ownership by the group members, who will also have belief in the model's integrity.

Reference is made in the above to the inclusion of soft data, or data derived from perceptions and intuitions. The ability to include such soft data in a model is an important feature of the approach, and is to a large extent, made possible by the unique features of *ithink* and other SD software. In most approaches to system modelling, data that cannot readily be quantified are simply excluded from the model, leading to model results that can miss out important aspects of system behaviour. However, the approach to modelling employed here is predicated on a learning stance in which the objective is to improve understanding of how various parts of the system interrelate and behave. Due to the fact that these anthropo-environmental systems invariably include human activity, it is appropriate to include such activity in the model. Rather than assume idealised behaviour of humans (as is implicit in economic models), various aspects of relevant human behaviour are included directly within the model. For example, the perceptions that people have about the quality of the environment can affect the way they respond to different system conditions. Thus, perceptions are included in the model and allowed to vary under changing system conditions, and in their turn cause actors within the system to have differing responses to various system conditions. The actual modelling technique that is employed to include soft data is detailed in the discussion of the case study in the next chapter.

5.2.5 PEM Stage Five

Once the simulation model has the data included, it can be used for scenario testing and analysis which is the fifth stage of PEM. The knowledge that has been generated by the group about relationships between system elements is maintained in the simulation model, with the added feature of participants being able to explore the dynamics of those relationships (i.e. how they change through time). Through the exercise of running the model under various scenario settings, participants are able to test their understanding of the system's dynamics as well as ensure that the model is behaving in accordance with their general expectations about the system being modelled. If the model generates results that are counterintuitive or counterfactual, there can be only two reasons for this: either the intuitions or 'facts' are wrong, or the model is incorrectly specified. As participants explore these possibilities, they will either modify the model and/or modify their intuitions and understanding of facts until congruence is achieved.

The simulation model serves to facilitate further learning about the system, and can be used to focus discussion about controversial policy options. It provides a mechanism to explore the various implications of alternative policy/management options so that participants are able to develop an understanding of which alternatives lead to the more desirable outcomes. In this way, a ranking of alternatives can be undertaken, with the rank order reflecting not only economic criteria, but also ecological and social criteria. Moreover, the basis of the ranking is a model that performs an holistic analysis of the interaction between these various criteria as well as indications as to the likely trends in selected model variables. The overall operation of the model and the interaction of the stakeholders with the modelling process provide a basis for the integrated analysis and prioritisation of options. An example of how this works in practice is given in the Throsby Creek case study reported in the next chapter.

Stages three through five all lead to increases in group learning about the problem and its system context. At each stage, the process can be terminated if it is decided by the group that sufficient information has been gleaned to deal with the problem situation. Indeed, there can be considerable enlightenment generated from mud mapping and/or qualitative system dynamics modelling. However, it does not necessarily follow that just because the group believes they have the answer, that they do in fact have it. The dynamics of systems can be quite complex, and the human brain is not particularly good at analysing complex dynamics (Richmond 1994). This can lead to the situation where some "... people attain enough revealing insights from systems thinking that they feel the need for nothing else, (but they are in danger of taking) ill-advised actions that make matters worse" (Forrester 1994, p.252). Thus, although moving through to steps four and five will involve a commitment of additional time and money, it may be that failing to do so could lead to false assurances and incorrect solutions.

The above discussion has described an approach to solving complex anthropo-environmental problems that is predicated upon the power of group learning, system thinking and a transdisciplinary methodology. In some ways, the actual techniques employed are very similar to those that many system dynamics practitioners use. However, there are some important differences, and these are discussed in the next section.

5.3 Participative Environmental Management and System Dynamics

Generally, the application of system dynamics has been in expert mode, that is, where the consultant finds out what the client's problem is, and then creates a model which can be used to allow the client to explore alternative management options. A researcher might take a similar approach in exploring the dynamics of, and potential management options for, a system he or she is interested in.

Sometimes, the models are developed in a more participative way, with clients (and/or stakeholders) involved interactively in the model building. This is becoming a more common occurrence among system dynamics practitioners (e.g. Coyle 1998), and was no doubt at least partly responsible for the focus on group model building found in a recent edition of the *System Dynamics Review* (Vol. 13 No. 2, 1997).

Usually, part of the process of systems dynamics research (or a consultancy) is that the researcher (or consultant) attempts to ascertain key system attributes from the client. There are two main ways that this is done; one involves the use of causal loop diagrams, while the other involves the direct application of the stocks and flows symbology of the computer modelling software. Whereas conceptually similar to causal loop diagrams, the use of mud maps as the initial phase of the present methodology has been adopted in preference to causal loop diagrams. There are definite reasons for this, and these will now be addressed.

PEM has been developed as a way of working with diverse stakeholder groups that may include people from government agencies, advocacy groups and the general public. Many of these people will be volunteers who have limited time available to contribute. Moreover, when working with groups such as these, there is usually no compulsion for group members to keep working with the group if they do not want to. Therefore, an important aspect of any group interaction is to move quickly to an exploration of the main issues without too much preamble, otherwise group interest can be lost. Also, in order to make the process of system exploration as straightforward as possible, a direct approach that requires little explanation is appropriate. Each of these factors points to the need for an approach where the facilitator can move straight to a white board and start working, drawing out knowledge about the system from those present. The mud mapping approach seems an ideal method to adopt in order to satisfy these requirements. Participants learn as they go about how the mapping works, and seem to adapt readily to the approach.

At the initial mud mapping workshop, it is likely that the particular group of people involved will not have worked together before as a group. This means that the group dynamics will be unformed and people within the group will be unsure of their ground. There is thus an important role for the facilitator in dealing with the group dynamics, and it is therefore important that the facilitator has maximum opportunity to do this. Mud mapping has been selected in preference to the use of causal loop diagrams for facilitation because it is more straightforward. A concept is suggested and included in the diagram. Links are made based on input from the group, and the direction of the links is ascertained at the same time. Causal loop diagrams are more demanding than simple mud maps, because they impose the need to identify feedback loops as the fundamental unit of the system. This requires an extra degree of critical review by the facilitator, and thus detracts from his or her ability to work effectively with people in the group.

Besides this issue of tractability, there is another important reason that causal loops *per se* are not employed in PEM; despite the additional effort required to identify feedback loops, they can nevertheless result in incorrect understanding about the way that feedback mechanisms work. This results from the fact that no attention is given to whether any particular item in a causal loop diagram is a stock or a flow, nor whether one thing leads to another directly or causes it to happen via some intervening mechanism (Richardson 1997). This leads to the possibility of significant misunderstanding about the real dynamics of the system. Elsewhere, Richardson (1996) points to the difficulty that people have in conceptualising the dynamics in systems, and emphasises the need to use simulation modelling that incorporates "... accurate circular causal structure and information feedback ..." (Richardson 1996, p.xiv) as a necessary part of developing sound understanding about the dynamics of a system. The use of a mud mapping approach implicitly defers the substantive analysis of feedback to the computer modelling phase, which, according to many system dynamicists, is the appropriate place to undertake it.

Finally, the mud map approach is employed because it simplifies the translation of the system map into an *ithink* system diagram. The mud map uses circles, word and arrows in order to describe a system. With the addition of only two symbols (those for stock and flow), along with a more precise definition and/or formulation of some of the system components, it is possible to describe the system directly in the computer modelling language. In this approach, the concept of feedback is still addressed, but not as the starting point of the work. Rather, an exploration of the mud map can reveal feedback paths through the simple technique of tracing around the map following connections and arrow direction. Feedback is also explicitly addressed as part of the computer model building exercise. When converting the mud map to the formal modelling symbols (stocks, flows, auxiliaries and connectors), feedback loops can be identified as they become apparent. The direction and impact of these feedback loops can be identified while data are being entered into the model and relationships are being quantified.

It is not proposed that the above is a definitive argument for the selection of the particular approach employed in PEM over some other. However, it does reflect some of the issues that have been considered as important, and why the present approach has been developed by the author in the way that it has. The articulation of this approach is consistent with the ideas of Vennix (1996), who argues for an adaptation of approach to suit the specific circumstances, in which the selected method is "... more tailor made than ready made" (cited in Vennix *et al*, 1997 p.104).

PEM has been developed as an implementation of system dynamics methodology for use in the applied context of ecological economics. It has been devised to have a specific focus on IRM, and to suit the particular demands of environmental management within a participative framework. Notwithstanding variations from the more usual system dynamics approaches, it can still readily be identified as an application of system dynamics methodology, and is consistent with the general group model building approaches that are to be found in the system dynamics literature. A number of goals of group model building have been identified in recent literature and these include (after Andersen *et al.* 1997): alignment of mental models; creating agreement (consensus) about a policy or decision; and generating commitment for a decision. PEM has been developed with view to incorporating each of these goals as a fundamental part of its application. Moreover, an emphasis on group learning in which participants can question assumptions and test strategies is an integral part of PEM, and this is also consistent with contemporary system dynamics practice (Vennix *et al.* 1997). The most readily identifiable distinction to be drawn between PEM and general system dynamics praxis is that the former is intended for use in a virtual organisation (one that is created from system stakeholders for the purpose of managing a particular environment system problem) rather than a real corporation that provides the usual context for the majority of system dynamics investigations.

A notable exception to the above generalisation about system dynamics is van den Bergh (1995) which involves a study of the many facets of tourism and development in the Greek Sporades Islands. In this work, the author explores a complex anthropo-environmental system and reports on a range of ecological, economic and social indicators. Van den Bergh's work is conceptually similar to the present research as it draws from the tools of system dynamics within the context of ecological economics. However, there is a marked difference in that the present research is about a methodology to include stakeholders within an intentional participative learning framework as a strategy to address complex anthropo-environmental problems. This is in contrast to van den Bergh's work where the emphasis is on systems analysis rather than a participative learning approach leading to the identification and implementation of integrated options within a stakeholder-driven management context.

5.4 Rationale for a case study - testing PEM

The foregoing presentation has described an approach to dealing with environmental problems in the context of IRM that has been developed from the system dynamics literature along with inputs from assorted other literatures. It is an approach that incorporates the participation of the wider stakeholder community in decision making, while adopting a learning stance within a systems framework of exploration. Above all, it is presented as an articulation of the concerns of the general ecological economics agenda and of the more specific problem focus of IRM as articulated in the research problem identification in Chapter One.

In the next chapter, a detailed report of the application of PEM within the context of IRM is provided. Two examples of the application of PEM are given (together with some reflections from a less extensive overseas application), and each of these provides the basis for critical review. The case study examples are not meant to provide fully worked solutions to problems, but rather to demonstrate the use of PEM. As such, the examples should be taken as indicative only, and not as final results of in-depth study. The intention throughout this thesis has been to articulate an holistic methodology that could be adopted by ecological economics practitioners as part of their transdisciplinary analytical toolboxes. The purpose of the case studies is therefore to demonstrate the application and possible implications of PEM, and to provide a basis for describing PEM as it is actually applied, rather than just as a conceptual framework.

6. Case Study Applications of Participative Environmental Management (PEM)

As indicated at the close of the previous chapter, the case studies reported in this chapter are intended only as examples of the way that PEM can be used to facilitate a more integrated approach to the management of complex environmental problems. Whereas some tentative conclusions about the efficacy of the approach are tendered, no attempt is made to test PEM in a scientifically rigorous way. Therefore, the case studies should not be interpreted as data collection exercises as such, but rather as part of the early development of, and experimentation with, PEM. A more robust testing of the methodology may well be carried out in the future, and this possibility is discussed at Section 8.5 where the issue of future research needs is addressed.

Two comprehensive demonstrations of PEM are reported in this chapter. The first of these is the Throsby Creek case study, undertaken in the Newcastle Area in a subcatchment of the Hunter River, northern New South Wales, Australia. This served as the first demonstration of, and test-bed for, PEM, and was also responsible for modifications to PEM in order to fine tune some of the techniques. The second involves an ongoing IRM project related to catchment management in general, and to urban water supply management in particular, undertaken for the catchment of the Malpas Dam near Armidale, New South Wales, Australia. A third, less detailed application undertaken in the northern area of London, England is reported to reflect on the potential of the methodology for international application.

6.1 Throsby Creek[4]

6.1.1 Background

Throsby Creek is an urbanised catchment in the inner residential areas of the New South Wales coastal city of Newcastle, Australia. The land area is highly developed, with the built environment heavily dominant. Table 6.1 gives a breakdown of the main land uses. Note that

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4 The report of this case study has been written based on unpublished material including minutes of meetings, proceedings of workshops, and the researcher's notes.

there is no vacant land suitable for development. The only 'development' possible is to redevelop existing sites. This means that catchment management engineering works are constrained to bushland and/or built open spaces, or 23 per cent of the catchment. Moreover, technical strategic planning tends to be limited to consideration of these areas, although there has been some discussion of gradually allowing a few built areas to revert to open space/bushland as buildings age and are demolished. Another perspective on the catchment is that of population density. The population of 67,512 is equivalent to 21.4 people per hectare. This is quite high by Australian standards, only being exceeded by some densely settled inner suburbs of the main cities.

Table 6.1 Land Use in the Throsby Creek catchment

Land Use	Area (hectares)	Percent of Catchment
Bushland, mostly regrowth	280	9
Parks and recreational areas	420	14
Built environment (dwellings, commercial and light industrial)	2,450	77
Total	3,150	100

When taken together, high population densities and a significant proportion of built environment suggest that this catchment is likely to have problems very different from the predominantly rural or urban/rural catchments that, typically, are managed under the rubric of Integrated Catchment Management. Nevertheless, Throsby Creek Catchment Management Committee is constituted under the New South Wales Catchment Management Act (1989) and is therefore a legitimate example of ICM implementation in New South Wales. Whether or not the use of PEM within this catchment is indicative of its applicability in other catchments could be debated, however there is no known reason why PEM could not be applied elsewhere. Furthermore, subsequent use of PEM in a rural context (see case study three) is suggestive of its general applicability.

While many catchment management committees are formed as community groupings that have no direct financial empowerment, the situation for the Throsby Creek Total Catchment Management Committee (TCMC) is different. This committee is set up as a sub-committee of the Hunter Catchment Management Trust, an organisation which is able to raise funds via a system of property levies. Moreover, the Trust provides a coordinating role in a management environment replete with local and state government agencies, farming interest groups and volunteer environmental organisations.

The Hunter Catchment Management Trust (formerly the Hunter Valley Conservation Trust) is responsible for the implementation of Total Catchment Management within the Hunter Valley. It has the corporate vision of "A clean, healthy and productive catchment through ecologically sustainable use and management of our natural resources, for the benefit of future communities of the Hunter, and Australia" (HCMT undated, p.4). A part of the Trust's mission is to facilitate "... development and implementation of a comprehensive Catchment Master Plan and subsidiary subcatchment strategy plans, in partnership with the community, industry and government" (HCMT undated, p.4). Throsby Creek is a subcatchment of the Hunter, and thus integrated within the above vision and mission. The work done by the present researcher was carried out in cognisance of the overall objectives of the Trust as well as the Throsby Creek TCMC (a subcommittee of the Trust).

In 1989, the Throsby Creek TCMC produced a report titled *Throsby Creek Total Catchment Strategy* (Throsby Creek TCM Committee, 1989). This report was the culmination of some eighteen months work by staff from ten New South Wales local and state government agencies. The agencies were: Department of Water Resources, Hunter Valley Conservation Trust, Hunter Water Board, Lake Macquarie City Council, Maritime Services Board, Newcastle City Council, New South Wales Agriculture and Fisheries, Public Works Department, Soil Conservation Service, and State Pollution Control Commission.

As part of the preparation of this report, a number of task groups were formed to address particular aspects of the Throsby Creek catchment. These groups were: Boating Facilities, Catchment Erosion, Foreshore, Hydrology, Pollution/Ecosystem, Sedimentation, Tidal Inundation. These groups proposed a number of actions and strategies, and in the ensuing years many of these have been implemented.

In 1996, the Hunter Catchment Management Trust reconvened the Catchment Committee to revisit the 1989 strategy plan, review its success and recommend future directions and actions. A workshop attended by 18 individually invited people was held on 20 June 1996. Of the participants, five were from the Hunter Catchment Management Trust, three from Newcastle City Council, two from the Department of Land and Water Conservation, one from Hunter

Water Corporation, the remaining seven from the community. In addition to the above, a facilitator was engaged to assist at the workshop.

This group was asked to address two main tasks:

- To construct a framework to be able to attack the issues. This included the formation of task groups.
- To form a small group to construct a vision statement for the Throsby catchment using input from the overall committee.

The outcomes of these tasks were intended to serve as input to a public meeting to be held the following month.

Task one involved facilitated discussion and the making of lists. Following from this, four task groups were formed: Wildlife, Recreation, Vegetation and Erosion; Community Involvement and Education; Flood and Pollution Control; and Policy, Planning and Process. The names of these task groups reflect an attempt to capture and group the 56 separate tasks identified during the discussion and list making activity.

Task two was not fully completed at that time. Rather, the three people who considered this presented 15 key points that they felt could be the basis of a vision statement. It was to be left to the following public meeting to refine the vision statement.

A public meeting was held on 4 July 1996. This meeting was attended by nine of the participants from the previous meeting and eleven others. Participants came from Hunter Catchment Management Trust (5), Newcastle City Council (2), Hunter Water Corporation (1), and the community (12). A facilitator was also engaged for this meeting.

The meeting was briefed on the outcomes of the workshop of 20 June, and participants were invited to contribute to the overall process. It was explained that the TCM Committee would value public input. The background of TCM for Throsby Creek was outlined, with the original strategy plan noted as a landmark for such work in future. It was observed that a difference between the 1989 efforts and the 1996 review was that the latter comprised more community input.

Following these general introductory comments, the meeting was presented with an outline of work so far carried out by the task groups. The facilitator then invited the participants to focus on task group issues, and to record their reactions and additional comments. This activity generated 28 points in addition to the original 56, bringing the total so far identified to 84.

Finally, the meeting considered the elements of a vision statement contained in the 15 key points brought from the 20 June meeting. Following much discussion, the following statement was suggested:

> A clean, safe, attractive environment where the community of Newcastle care for and enjoy Throsby Creek and its catchment as a place of living[5], learning, recreation and natural habitat.

The various task groups and the plenary TCM Committee continued to meet during the latter part of 1996 and 1997. The purpose of these meetings was to develop the revised strategic framework for ongoing catchment planning in Throsby Creek. The four task groups each addressed their relevant points from the list of 84, with a view to identifying priorities for action and funding. The recommendations of each task group were brought to the TCM committee for discussion and the allocation of overall priorities.

It is useful to note at this point that three of the task groups (Wildlife, Recreation, Vegetation and Erosion; Community Involvement and Education; and Flood and Pollution Control) were responsible for project-type activity. That is, their brief was to consider actual projects that could be funded and to attempt to prioritise these based on the overall vision for the catchment.

The other task group, Policy, Planning and Process (PPP), was focused somewhat differently. Following recognition by some committee members of the need for strategic coordination and integration, the PPP task group was formed to address a variety of non-project-type activities. Of the 84 separate items mentioned above, this group was responsible for 17, or 20 per cent, of the total. Issues such as funding, integration and coordination, evaluation of policies and programs, learning by doing, integration of public awareness into policy and planning processes and the need for decisions based on good knowledge were included on the agenda of the PPP group.

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[5] The word 'living' was included in the statement following discussion at a subsequent meeting.

6.1.2 Involvement of the Researcher

The present researcher was invited to become involved with the TCM committee following a meeting of that committee on 15 October 1996. The researcher's work had been focusing on the need for better processes in environmental policy and planning, and the Chair of the PPP group recognised the potential of this work to assist the functions of the PPP while providing an opportunity to test-bed and develop PEM.

The nature of the research was such that the alternative processes for policy and planning of PEM were tested in parallel to the strategic planning processes that were already in train. This approach was good because it allowed for the assessment of the practical applicability of the alternative processes, while not being overly demanding of the techniques for real-time outcomes. The parallel main processes would generate outcomes acceptable to the TCM group, whether or not the alternative processes succeeded. Moreover, this research approach allowed the PPP group to review critically the application of PEM, with the more conventional processes providing a basis for comparison.

6.1.3 First Workshop Presentation

The first significant input by the researcher occurred at a meeting of the PPP task group on 4 December 1996. The purpose of this meeting was to explore ways in which the new methodology could be applied to the particular problems faced by the Throsby Creek TCM committee.

This meeting began with a presentation of the background of the management of Throsby Creek, and the role of the PPP group in this. The PPP group was responsible for the preparation of the strategic review report, and to coordinate activities among the various stakeholder agencies who would be called upon for significant financial and in-kind commitment to identified projects and action plans. The group recognised the importance of institutional questions such as:

- who is the best manager for TCM?
- who "owns" the stormwater? and
- how to ensure that rates collected for drainage work be appropriately allocated?

The task group recognised the need to address such issues, and noted that perhaps it could take a lead role in pursing such matters.

A crucial aspect of the overall process was identified as the need for all stakeholders to agree on the 'big picture' (or the overall transdisciplinary context). Importantly, this particular insight received strong consensus among group members. At the same time, there was a recognition that although such holistic perspectives are to be desired, they are very difficult to achieve in practice. The researcher's methodology, incorporating stakeholder participation with system modelling was anticipated to be of benefit because it could:

- help stakeholders understand the dynamics of the decision-making process; and
- build a conceptual model for the catchment with which to test policy implications.

The next activity involved an indepth presentation of the researcher's methodology. The task group was invited to give feedback, and to help to refine the mechanics of applying PEM in the Throsby Creek catchment management process. PEM, as has been described in Chapter Four, is the result of a number of iterations. In particular, first attempts at explaining PEM involved a focus on the computer modelling aspects, with little attention given to the stakeholder identification and mud-mapping phases. The presentation that was given to the PPP group was the first attempt at explaining PEM[6]. It started with a discussion of the modelling tools, giving examples of what a model of the particular catchment problems might look like. Subsequent uses of the approach have resulted in the refined methodology as outlined in Figure 3.1. Following is a synopsis of the presentation that was made at the first workshop with the PPP group. Although present applications of PEM start with stakeholder identification and initial problem mud mapping rather than explanation of the modelling tools, the following reflects early attempts at describing the process and is included to record these early attempts.

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[6] There have been a number of attempts to label the methodology that is presented herein. At various stages in its development, it has been called 'Integrative Learning Approach' (ILA) and 'Integrative Decision Making Process' (IDMP). The participants in the various case studies reported in this chapter are not familiar with the acronym PEM, since this has only been applied recently. However, it could be confusing to use different names in this thesis, so in the interests of clarity the term PEM will be applied throughout.

PEM involves the use of a software program called *ithink*, a commercial software package developed by High Performance Systems in the United States. The software provides a tool to assist the decision-making process by:

- building a conceptual model of the catchment, with the underlying assumptions determined by agreement between the stakeholders in the decision-making process;
- keeping track of complex interrelationships and feedback loops among variables; and
- allowing decision makers to test implications of policy changes.

It was noted to the group that software of this type was originally developed at the Massachusetts Institute of Technology, and has been involved in decision-making processes since the early 1960s. Australian examples include management of the maintenance of the Royal Australian Air Force's F111 fleet, and the development of policy for beekeepers in Tasmania and New South Wales. (These particular observations were included in the presentation because of a perceived need to assure the stakeholders that what they were being asked to be involved in was reputable and had been done before. While they seemed willing to explore innovative approaches to dealing with their particular problems, they were wary when it came to committing time and effort to a new approach).

As part of explaining how the software could be used for facilitation, a demonstration model was presented to the group. This model had been built to capture many of the issues brought out in the earlier workshops. However, because it had been constructed by the researcher in isolation from the stakeholders, the model was at this stage an artefact of the researcher's own interpretation of the issues. Its purpose was to introduce the overall concepts to the PPP task group.

Initially, it was explained that an hypothetical conceptual model of catchment issues had been constructed, and that this model could be used to investigate how various policy interventions might affect selected variables. The following model outputs were presented to the group.

Figure 6.1 presents the outline of the hypothetical conceptual model as depicted in the upper mapping layer of *ithink*. For descriptive purposes, this iteration of the modelling process will be referred to as Alpha. In the Alpha model, three sector groupings were identified: socioeconomic, ecology and infrastructure. The purpose of this layer of the model is to make explicit the multifaceted nature of the problem under review.

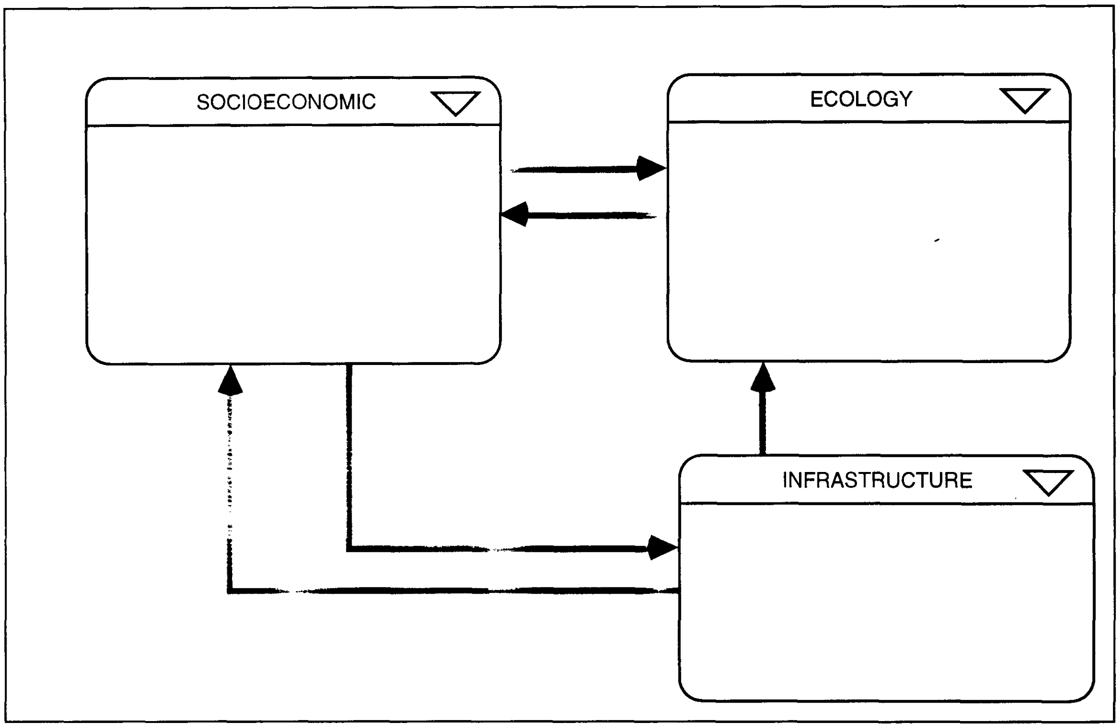

Figure 6.1 The conceptual map layer of the hypothetical model of Throsby Creek

Once this upper layer had been presented, the participants were introduced to the idea that the model could be used to explore how particular policy decisions might impact on key variables. The graphical output shown in Figure 6.2 was used to show how the time paths of *Citizen Environmental Awareness*[7] and *Diffuse Pollution* might unfold when there was a policy that no expenditure on environmental education occurred. Next, the policy setting was changed so that maximum feasible expenditure occurred. Figure 6.3 displays the outcome of this simulation. It was noted to the participants that the results of the Alpha model simulation should not be taken seriously, because of the hypothetical nature of the embedded relationships.

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7 Model variables are given in italics to distinguish them from the underlying real behaviour that might also be described by the same words.

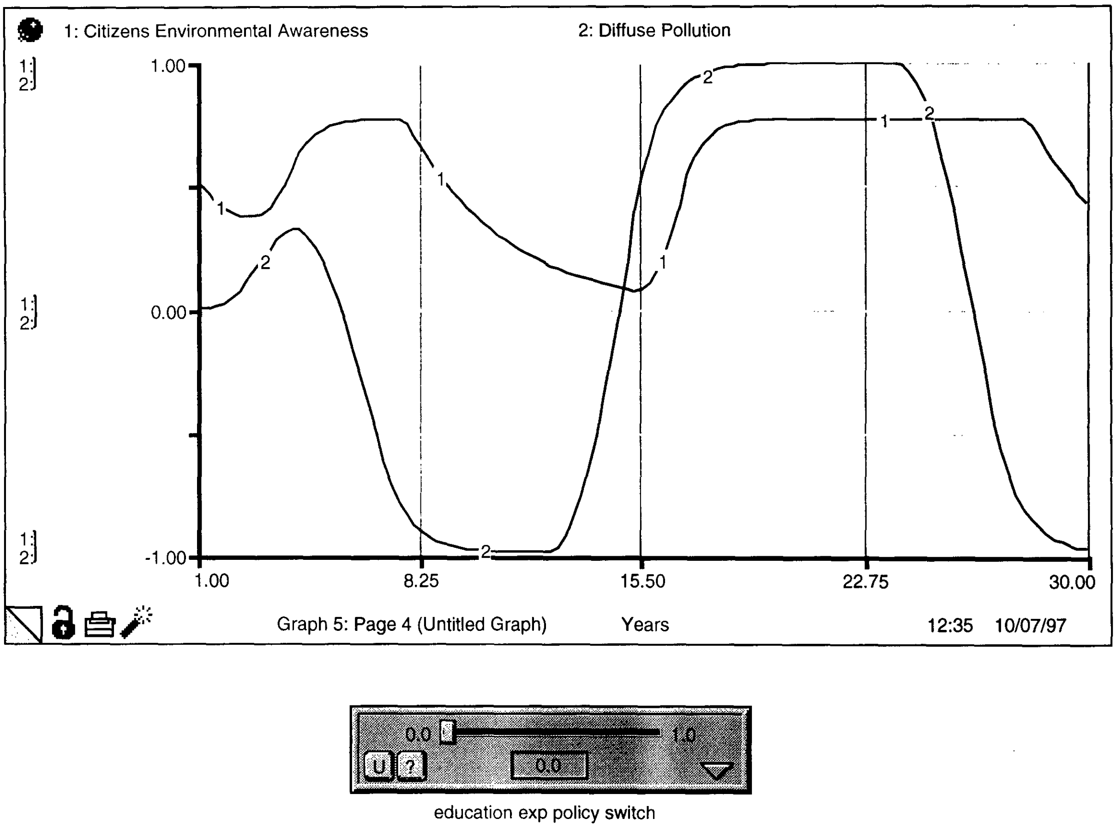

Figure 6.2 The Alpha model simulation of *Citizen Environmental Awareness* and *Diffuse Pollution* with no expenditure on environmental education.

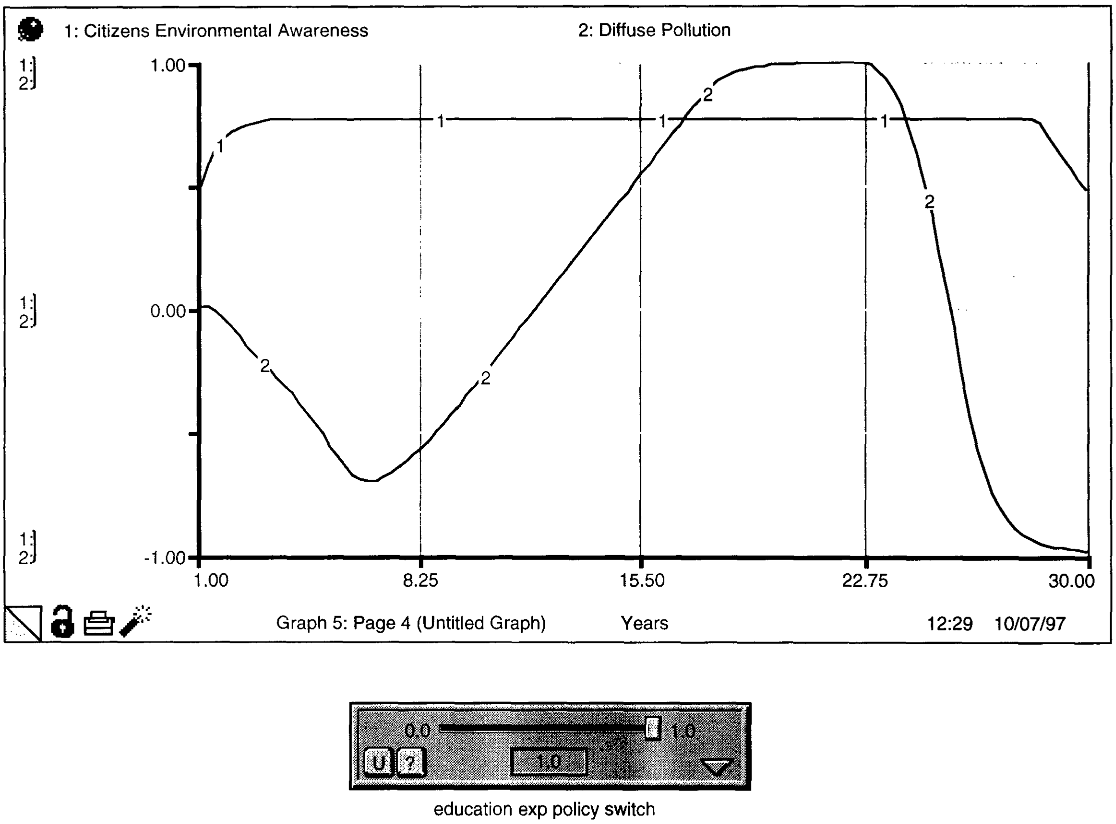

Figure 6.3 **The Alpha model simulation of *Citizen Environmental Awareness* and *Diffuse Pollution* with maximum feasible expenditure on environmental education.**

The next step for participants was to explore the inner workings of the model. Essentially, this involved explaining that a model completed interactively with system stakeholders would contain generally agreed assumptions about what affects what, and the size and direction of the effect. The *ithink* software uses a number of modelling elements to capture this information. The stakeholders were presented with an introduction to these modelling elements, and a description of some basic system relationships using these elements (cf. the descriptions given in Chapter Three).

Once the basic concepts of the modelling language were explained, the detail of the actual model was revealed. As a starting point, the portion of the Alpha model reproduced as Figure 6.4 was used as the basis for discussion about how the problems in the catchment could be represented using *ithink* symbology. In this diagram, diffuse pollution is seen to have an impact on the visual appeal of residential properties. *Visual Appeal* is modelled as a stock. This can be interpreted to mean that visual appeal is something that exists through time and can increase or decrease according to a rate of change specified by the flow *change in visual appeal. Diffuse Pollution* is also modelled as a stock. However, in the part of the model shown in Figure 6.4 there are no flows connected to it. This is because the stock *Diffuse Pollution* is included at this point in the model as a 'ghost'. The purpose of using a ghosted symbol is "to help to keep the diagram tidy" (High Performance Systems 1994, p. 5-18). The ghost is a read-only variable that allows the value of its underlying variable to be available at other points in the model without the need for many connectors that cross each other and confuse the diagram. The non-ghosted version of *Diffuse Pollution* was modelled in the Ecological sector of the model.

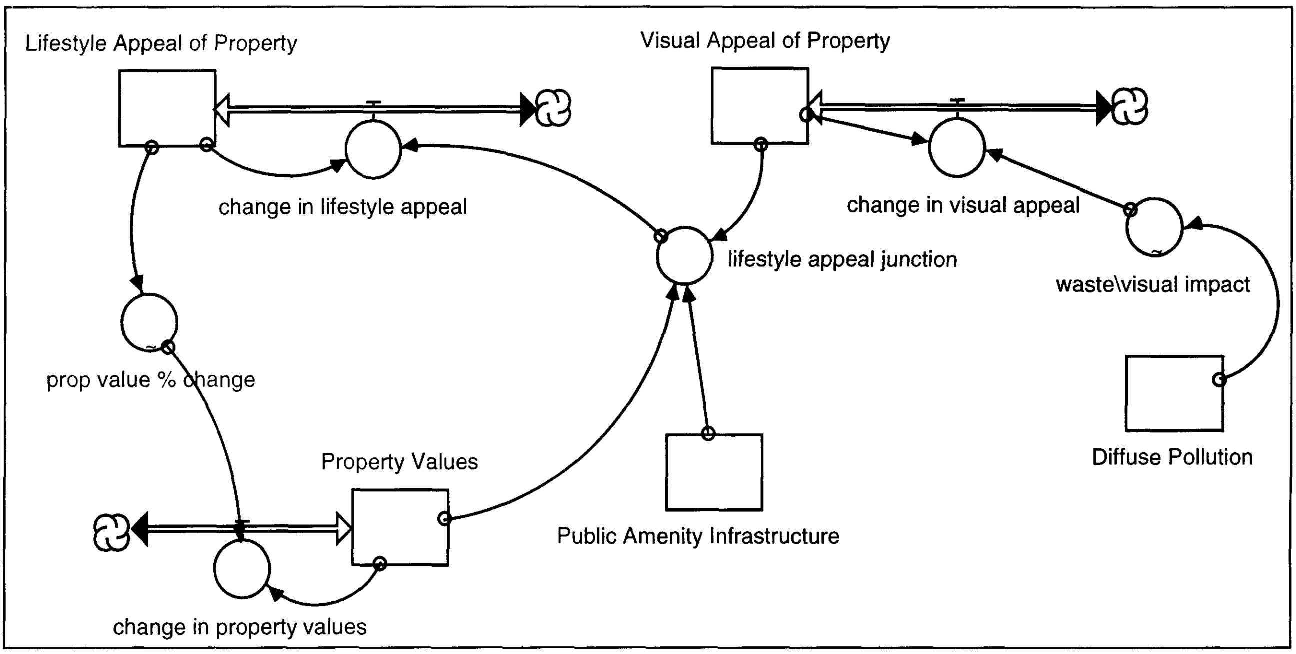

Figure 6.4 A portion of the Alpha model taken from the Socioeconomic subsector.

In this diagram, the pollution is seen to have an indirect effect on property values. The diagram is used to capture the nature of this effect, and the mechanisms through which it works. By following the direction of the arrows around the diagram, it is clear that in this representation of the system, the variable *Lifestyle Appeal of Property* is impacted on by *Visual Appeal of Property, Public Amenity Infrastructure* and *Property Values.* The auxiliary *lifestyle appeal junction* is merely a modelling device that allows the values of the three stocks to be algebraically combined and the resulting value fed into the flow *change in lifestyle appeal.*

The concept of feedback can be explored in the diagram. As the overall lifestyle appeal of the property increases, this will tend to increase demand for such property, thus driving property values up. The level of property values has an impact on the overall appeal of the property. In this simple model, an increase in property values has a negative affect on the overall lifestyle appeal of the property. This is an example of the negative feedback that was discussed in Chapter Three. The way this feedback loop is configured means there is a degree of self-regulation, or negative feedback, built in. The self-referencing nature of this feedback loop can be seen in Figure 6.5 where the impacts of *Visual Appeal of Property* and *Public Amenity Infrastructure* have been removed. In this example, increasing *Property Values* cause a reduction in *Lifestyle Appeal of Property.* Falling lifestyle appeal will cause a percentage change in the property values at the rate defined in *prop value % change.* As *Property Values* fall the lifestyle appeal will increase and so on.

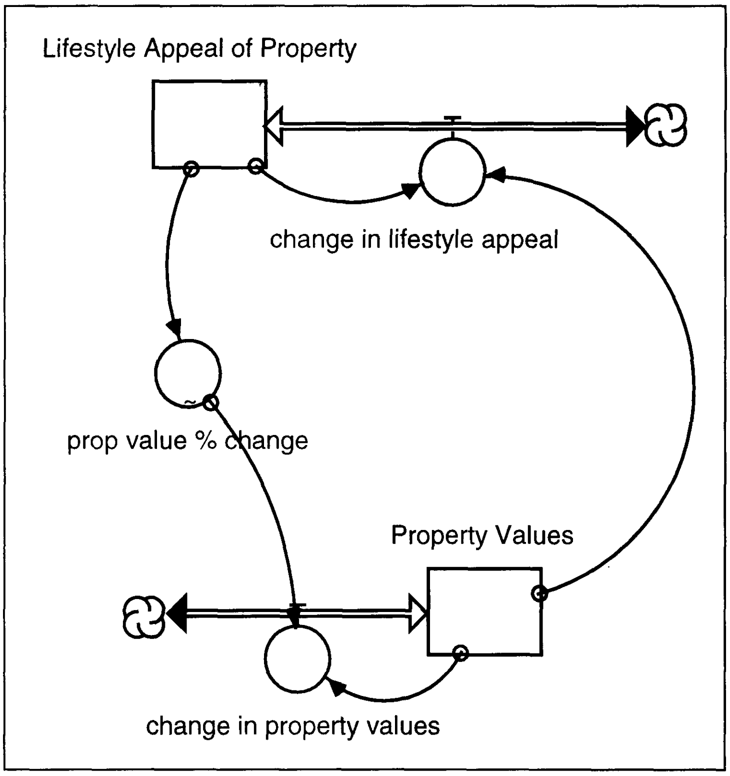

Figure 6.5 A model fragment showing a feedback loop

In the Alpha model, this simple relationship is complicated by the fact that increasing levels in either of *Visual Appeal of Property* or *Public Amenity Infrastructure* will push *Lifestyle appeal of Property* upwards, possibly even overriding the effect of increasing property values (see Figure 6.4). In this example, it is not clear intuitively how the overall appeal of property, and thus its value, would change as a result of the aggregated dynamic effects of visual appeal, public amenities and property values. However, the model enables these dynamic effects to be tracked and thus provides valuable insights for system managers as they attempt to understand the complicated relationships of the system.

Once the system dynamics approach outlined above had been presented to the workshop members, general discussion of the approach and its potential applicability to the Throsby Creek strategic management task occurred. The model was likened to a "sandbox" in which interested people could test out various ideas to see what their impacts might be on the real system. Some participants were keen to "play" in this particular sandbox, even though the model had only been constructed by the researcher as a demonstration of what could be achieved using real data, and was based on the researcher's limited knowledge and biases. A key outcome of the initial workshop was the decision to develop a model that better embedded the real data available from the stakeholders, including any expert knowledge that was available.

6.1.4 Subsequent Workshops and Development of the Stakeholder Defined Model

The first step in developing the stakeholder defined model was to build a mud map of the significant issues in the catchment. As discussed in Chapter Four, this is a participative process in which stakeholder involvement is fundamental. The mud map of the Throsby Creek issues was developed at a workshop to which members of the TCMC were invited. This workshop resulted in a diagram drawn on a white board, but for improved clarity, the diagram has been redrawn and is presented as Figure 6.6.

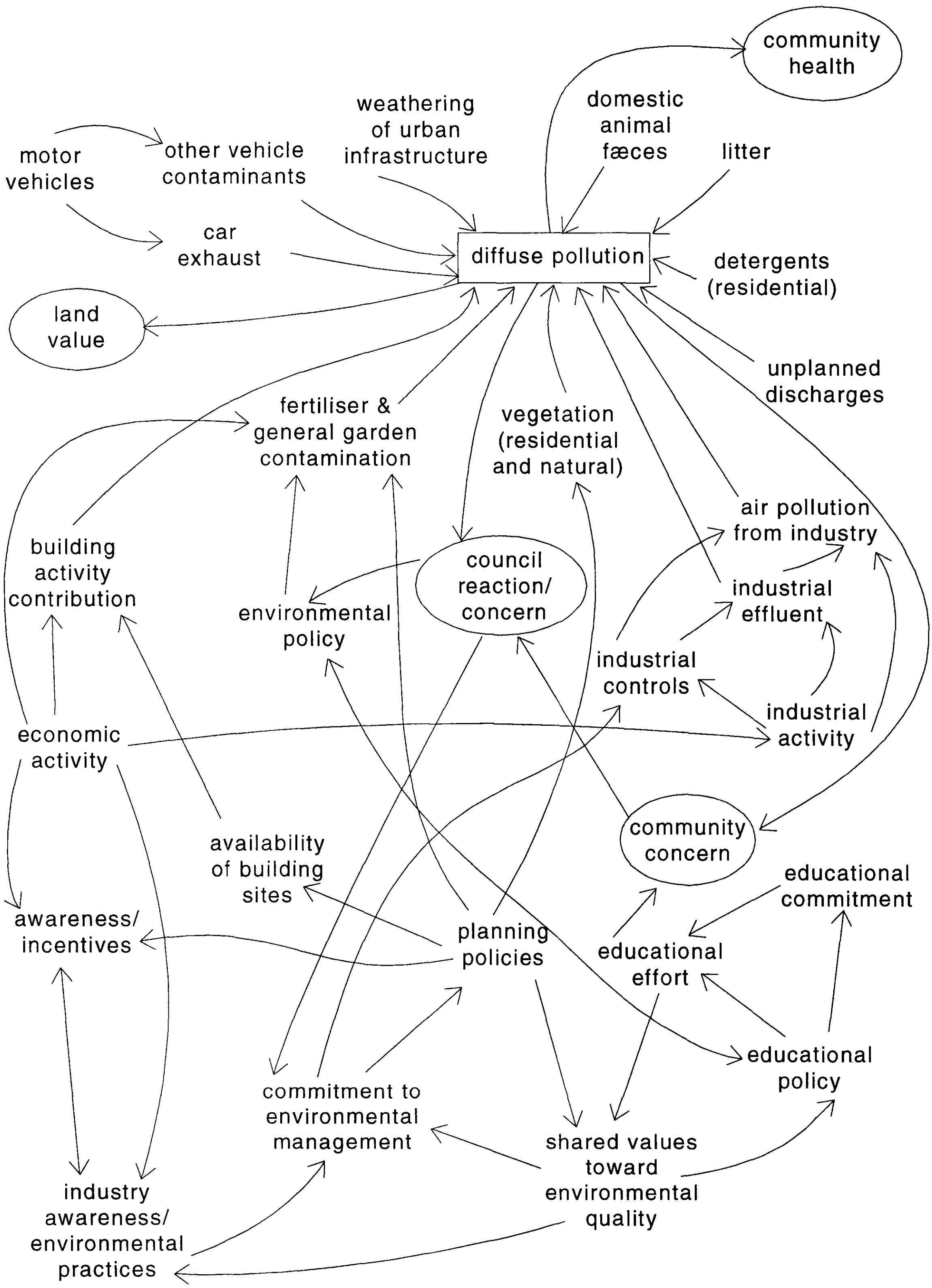

Figure 6.6 The mud map constructed with the Throsby Creek stakeholder group.

As a starting point for the mud map, the group was asked to consider how diffuse pollution might fit into the overall management scenario. In this case, the term *diffuse pollution* was intended to mean pollution that is spread around in the general environment, and that has not been captured in some pollution management infrastructure. Diffuse pollution generally would be from diffuse (nonpoint) sources.[8] An inspection of Figure 6.6 reveals the many components of diffuse pollution that the group identified. The group thought that diffuse pollution was likely to have an impact on a number of community issues. These included; community health, land value, community concern and council reaction and concern. Note that of these impacts, it was "council reaction/concern" that was identified as being central in modifying various aspects of the management environment.

The mud map that is described above could reasonably be criticised for being incomplete. For example, the role of the Environment Protection Authority (EPA) has been ommitted altogether. In New South Wales, as in many states and countries, the EPA (or equivalent agency) has the lead role in controlling pollution from industry, as well as other sources of pollution generated by society. To exclude their actions from this diagram is technically naïve. This is an example of the need for an iterative approach to model creation. As the mud map is taken to the next stage of development (a qualitative system dynamics computer model), the role of the EPA can be identified and included. In this way, PEM incorporates an evolutionary approach to system articulation.

Following the development of the mud map, the next step was to convert this diagram into the more precise language of the *ithink* program. The mud map described above, and other knowledge available from the task group, were used to identify the key sectors of interest. This led to the articulation of sectors for consideration; economic, environment, government, industry, community and flood management. These are shown as recorded in the *ithink* model as Figure 6.7. Note that this conceptual map is itself a type of mud map at a broad level. The thin arrows represent direction of influence or action from one sector to another. The thick black arrow from Industry to Environment represents an actual physical flow. In the Throsby

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8 A definition of a diffuse or nonpoint source is: "A source of pollution that is not a unique point such as a chimney or pipe, but is emitted from multiple small sources spread over a considerable area - for example urban runoff..." (Morrison and Izmir 1994).

Creek model, there is a physical flow of effluent from the Industry sector to the Environment sector (see Figure 6.8).

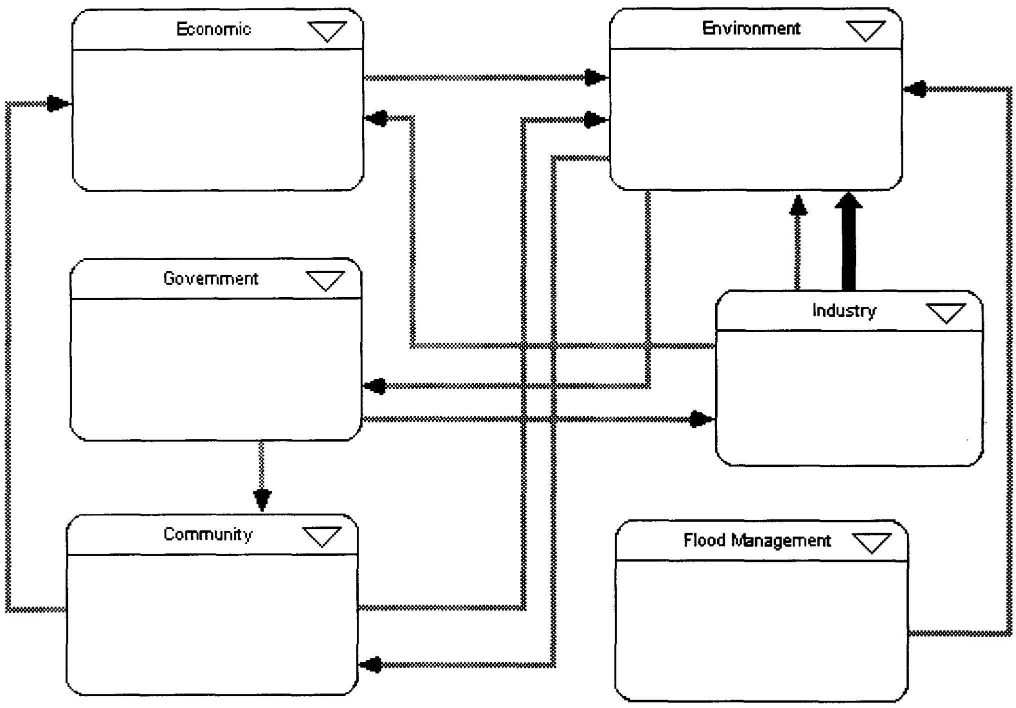

Figure 6.7 The conceptual map layer of the stakeholder developed model

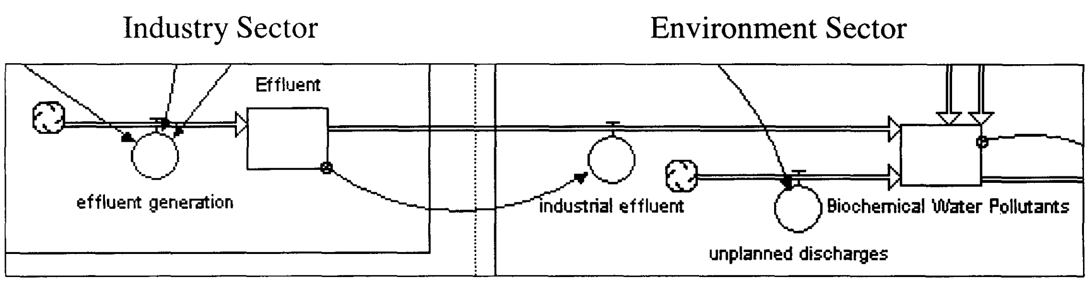

Figure 6.8 A fragment of the model showing the physical flow of effluent from the Industry Sector (on he left) to the Environment Sector. Effluent combines with other pollutants to make up total *Biochemical Water Pollutants.*

Once the key sectors had been identified by the group, the system components identified in the mud map were categorised as belonging to one of the various sectors. This process led to the observation that some components could not easily be categorised as belonging to just one sector. For example, industrial effluent could be included in either the industrial or environmental sectors. This finding provided further evidence to the group of the complexity and interrelatedness of the many issues involved, and led to discussion about system relationships and behaviour.

The tasks of identifying key system sectors and categorising system components also served as a reminder of issues that had been overlooked in the mud map. For instance, flood management is a crucial aspect of catchment planning in the entire lower Hunter catchment (of which Throsby Creek is a sub-catchment), and yet in the mud map it had been left out. To remedy this fact, details of key issues in flood management were captured at a later time by consultation with flood management engineers and other relevant experts.

With the main system components identified, the author was able to construct the preliminary system model using the *ithink* software. The purpose of the preliminary model was twofold; to record as accurately as possible the system knowledge that had been surfaced during the preceding steps, and to provide a focusing mechanism (i.e. the model) to facilitate further discussion and learning by the task group.

A preliminary model consists of a system map in which stocks, flows, auxiliaries and connectors are used to articulate the issues that have been deemed to be important by the focus group. Such a model can be quite complex, and can lead quickly to confusion of the stakeholder group if care is not taken in presenting the model in an appropriate way. One of the main reasons for the selection of the commercial *ithink* software package is its provision of a mechanism that enables a gradual presentation of the model to be undertaken. This *tracing* feature is used:

> ...to sequentially unfold the logic of a particular model, working back through the inputs to a given model variable. By displaying the model structure in mind-sized bites, tracing makes it far easier to understand how the model is put together. Tracing can also be used to step through the feedback loops associated with a given model variable.
>
> (High Performance Systems 1997a, p. 6-15)

In the case study, the place chosen to start the tracing process was the stock *Gross Water Pollutants* (see Figure 6.10), a term that is analogous with the term *Diffuse Pollution* that was used in the mud map. The change in name reflects the need to be more precise in terminology when building the model. This is because stocks and flows have units of measurement associated with them, and for these to be meaningful they need to refer to some readily identifiable concept.

In order to use the trace feature, the computer is connected to a data projector, and the image generated on the computer screen is projected so that all in the focus group can easily see it. A single element from the model, such as that shown in Figure 6.9, is the starting point of the tracing procedure. The dot in the middle of the stock *Gross Water Pollutants* indicates that there are connections to that model element that have yet to be revealed. By repeatedly clicking with the mouse on the dot in the middle of *Gross Water Pollutants*, an increasingly complex picture of activity around the variable is exposed. The model fragment shown in Figure 6.10 is the picture that is revealed when there is no longer a dot to click in the centre of the model element. The model elements that relate directly to *Gross Water Pollutants* have now been fully identified.

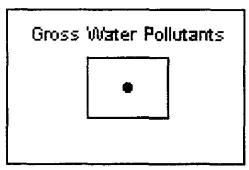

Figure 6.9 The start of the trace process. The dot in the middle of the stock means that there are connections to it that have not yet been revealed.

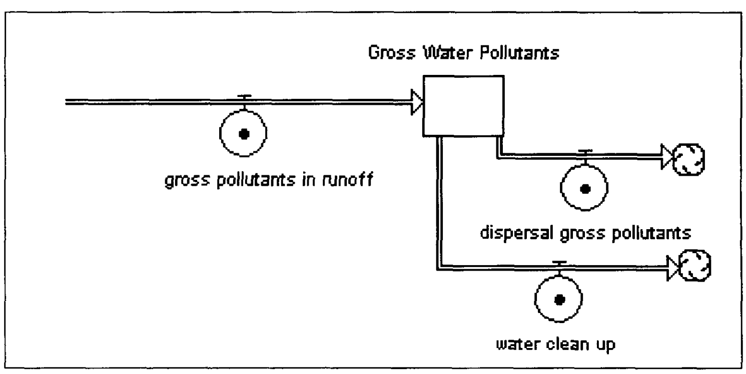

Figure 6.10 Flows in and out of *Gross Water Pollutants* have been revealed.

The flow control valves still have dots in them because factors influencing flow rates have not yet been revealed. Before factors influencing flow rates are explored further, it is appropriate to reveal the overall path of the physical flow so that the picture is complete in terms of where the flows come from and where they go to. The issue of what factors cause the flows to move faster or slower can be dealt with subsequently.

The diagram in Figure 6.11 shows that all gross water pollution starts out as gross land pollution. This makes explicit the fact that pollutants deposited directly into the waterways by boat users and other people with direct access to the water was not thought to be significant by the stakeholder group. Furthermore, runoff is identified as the sole contributing factor in the transport of land pollution to the water. This is obviously a simplification as wind blown litter and dumping could well find its way into the waterways. Nevertheless, for purposes of modelling and as a means of focussing group discussion on the key issues, this representation was thought to be appropriate.

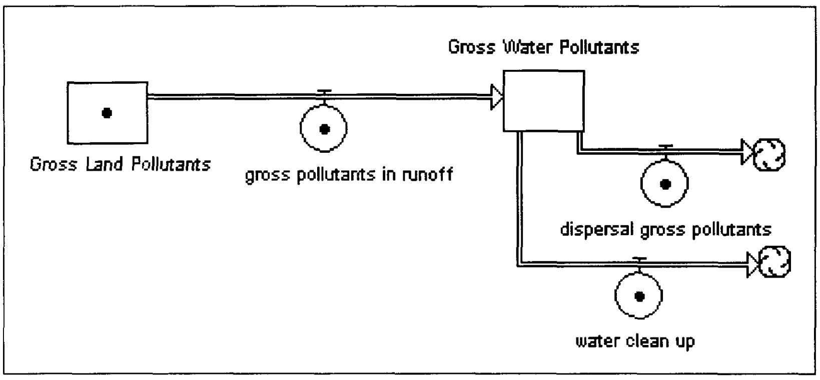

Figure 6.11 The source of the *gross pollutants in runoff* flow has now been revealed.

So far, the model diagram has not clarified what it is that makes up *Gross Land Pollutants*. The next step is to reveal the physical flows that lead to an increase (and/or) decrease in land pollution. The diagram at Figure 6.12 reveals the entire interconnected system with the components of *Gross Land Pollutants* explicitly identified. Furthermore, the possibility of cleaning up litter from the land or water is also accounted for.

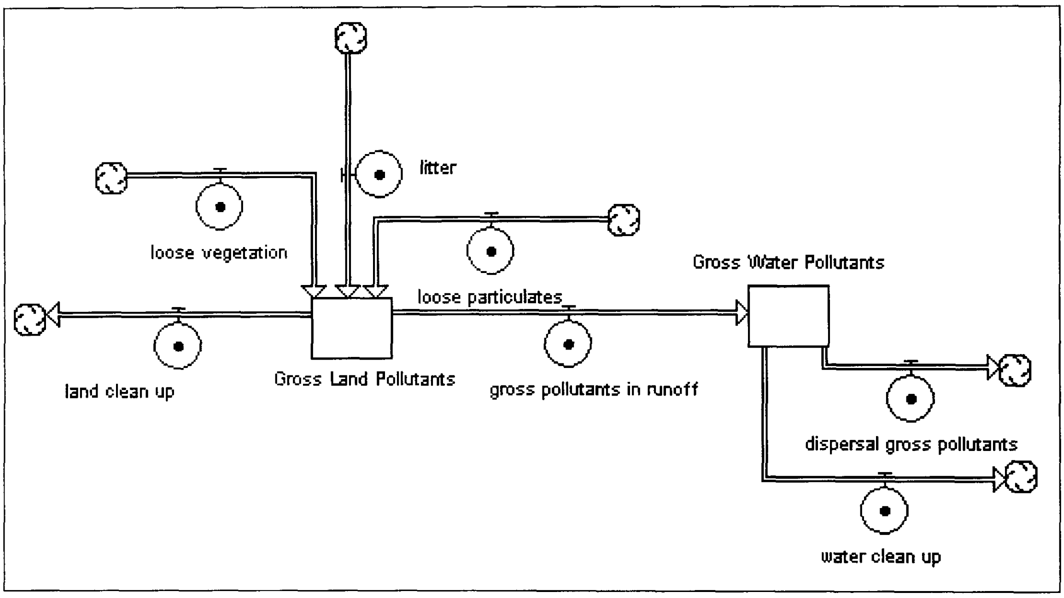

Figure 6.12 The complete interconnecting series of flows that make up *Gross Water Pollutants* has now been revealed.

Figure 6.13 reveals more detail, with the factors influencing the flow rates of the components of *Gross Land Pollutants* now included. Note that two new stocks have been introduced; *Catchment Population* and *Commitment to Environmental Management.* Each of these is a ghost as defined previously, and each comes from the Economic and Community sectors, respectively.

Catchment Population is conceptually very straightforward - it is merely a stock that tracks the changing levels of catchment population through time. Its starting value is set at 65,840 persons, which is the figure for 1997 derived from the census data. The change in population reflects underlying data from the catchment, and is set to fall by 0.5 per cent per annum.

Commitment to Environmental Management, on the other hand, is a less concrete label. It refers to the fact that the stock is used to capture the community's commitment to allocate effort and resources to improving the environment. This is an abstract concept because it is not possible to single out one tangible measure that captures changes in this stock. No attempt has been made to define the stock any more precisely than by its name, and this leads further to its abstract nature. This, however, does not mean that, as defined, the stock is a useless concept. On the contrary, the focus group was able to recognise that the meaning conveyed by *Commitment to Environmental Management* was a convenient way to lump together the various unspecified factors that might cause more or less enthusiasm for funding environmental projects and for people to engage in environmentally friendly behaviour.

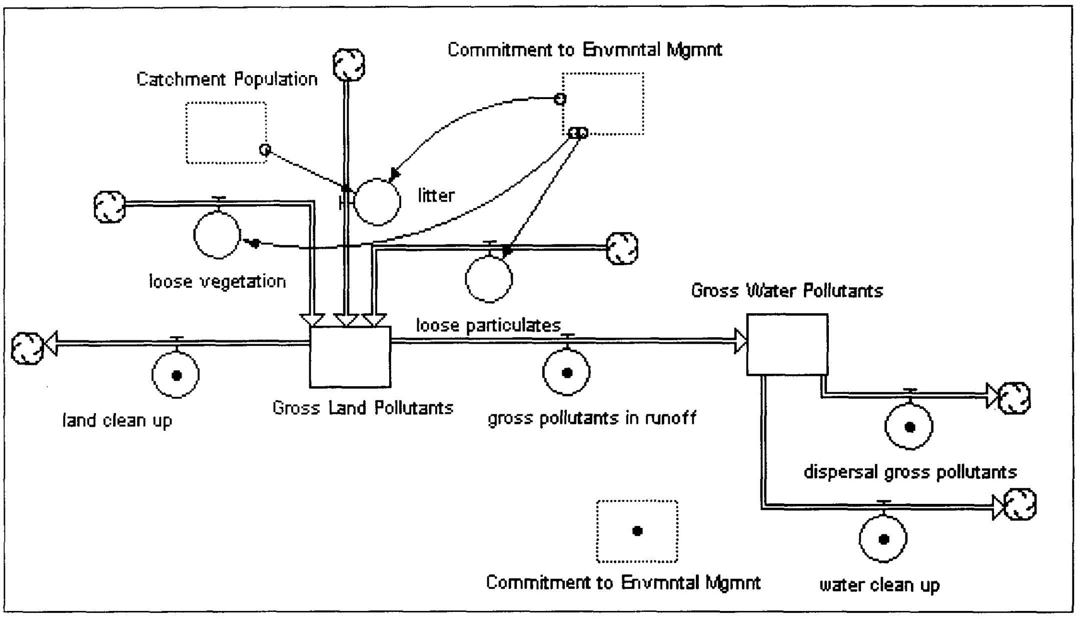

Figure 6.13 Factors influencing the flow rates of gross pollution sources are identified.

Whereas in Figure 6.13, *Commitment to Environmental Management* impacts on factors that lead to an accumulation of land pollution, the subsequent diagram in the series (Figure 6.15) depicts *Commitment to Environmental Management* influencing the clean up of land pollution. One would expect a strong positive relationship in this instance, and this is embedded in the model where higher levels of commitment lead to greater effort being applied to clean up activities.

This is perhaps an appropriate place to comment on how the abstract concept of *Commitment to Environmental Management*, for which no convenient measures exist, can be included in a numerical model. This variable can be thought of as an index that varies between zero and two. Under this convention, a value of zero would imply that there is no effective commitment, a value of one would mean that the level of commitment is such that it has moderate impact on the intensity of environmental remeditation, and a value higher than one would imply an increase in activities such as the clean up of polluted land and water, and a reduction in activities such as littering and careless disposal of green waste. Essentially, the index is used to scale the impacts of variables.

For example, litter generation is thought to decrease as the general level of commitment to the environment increases, and this is captured in the model by dividing *litter* by *Commitment to*

Environmental Management. The mechanics of this are as follows. When the value of the index *Commitment to Environmental Management* is at its neutral value of 1.0, the result of (*litter generation*)/1.0 is identical to the initial value of *litter generation*. However, as real world commitment is thought to rise, this is reflected in an increase in the index to a value higher than 1.0 (say 1.25). The result of (*litter generation*)/1.25 is a value that is 75 per cent of the initial value of *litter generation*, reflecting the fact that overall litter generation has fallen because of increased commitment to environmental management in the community.

It is important to note that the scaling of this relationship in the model is based on a simplistic relationship between commitment to environmental management and the level of littering. It is a reflection of the belief of the group that more of the former will result in less of the latter (or vice versa). Unarguably, such a method for quantifying abstract relationships is imprecise; imprecise in that a dimensionless value is involved, and imprecise because the relationship is based on the best guess of participants and not on hard data. However, it is still a useful approach because it allows for the inclusion of difficult-to-quantify variables in the model. This in turn means that the model can be responsive to issues that the stakeholder group thinks are important, irrespective of whether comprehensive data is available.

It is noted that such an approach to modelling is fundamentally different to the better known approach of predictive modelling, where historical data sets are of prime importance, and model variables are constrained to quantifiable and measurable concepts. This lack of emphasis on predictive modelling is an intentional and purposeful part of system dynamics modelling which is:

> ... not aimed at accurate prediction or solutions. It is more concerned with the shape of change over time. Accurate prediction on the basis of past performance, assumes that the structure and strategies of the future will not be too dissimilar from the past.
>
> (Wolstenholme 1990, p.5).

Indeed, the present methodology has been developed to deal with complex environmental systems, and it is implicit within such systems that structures and strategies will change through time. This has led to the selection of an approach based on system dynamics principles rather than the more conventional predictive modelling approaches. This is also in accord with Gill (1993), who argues for an index valuation approach to dealing with unquantifiable system relationships. His thesis is that this is warranted and justifiable as an adjunct to group learning within an environmental management context.

Returning now to the discussion of the model, the stock *Commitment to Environmental Management* changes during simulation due to factors in the Community sector of the model which impact on it. The part of the Community sector that applies is reproduced as Figure 6.14. Note that when this diagram is taken in conjunction with Figure 6.13, a feedback loop can be identified. *Gross Land Pollutants* and *Gross Water Pollutants* are seen to affect *aesthetic appeal*, which in turn has an effect on the rate at which *Commitment to Environmental Management* increases. Since the latter has direct impact on causes of water pollution, namely loose vegetation, litter and loose particulate matter, the stocks *Gross Land Pollutants* and *Gross Water Pollutants* will in their turn be affected. A feedback loop is thus identified. Note that, as more of this part of the model is revealed in subsequent diagrams, *Commitment to Environmental Management* will be seen to have even more influence on the stocks of land and water pollution, thus strengthening the feedback loop.

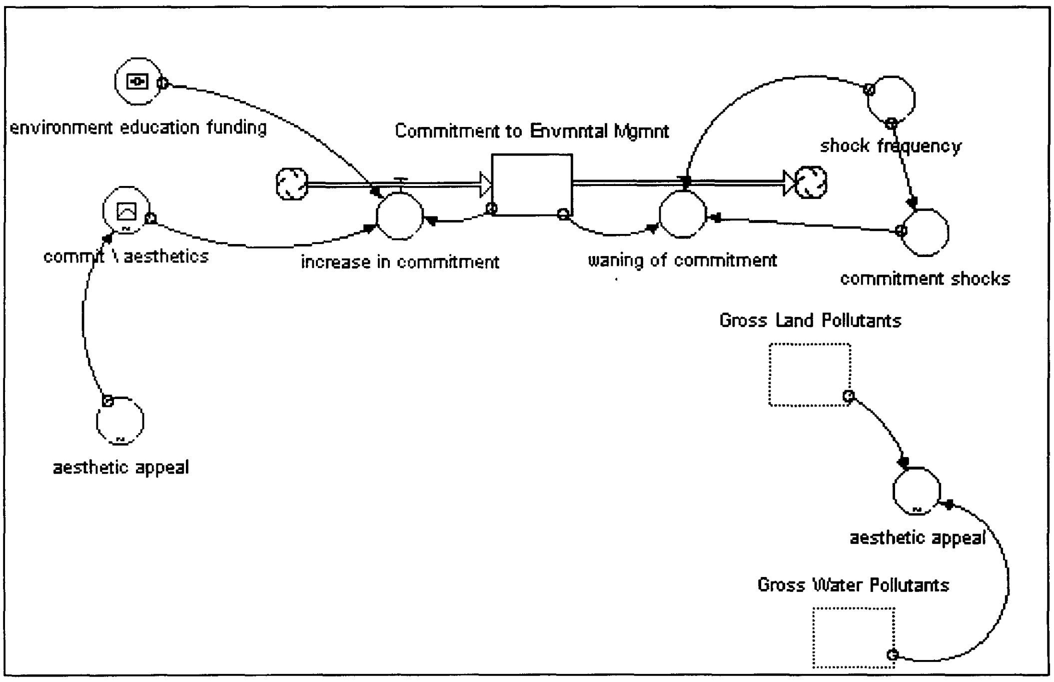

Figure 6.14 Factors influencing levels of *Commitment to Environmental Management.*

In the next step of model exploration (revealed in Figure 6.15), the index *Commitment to Environmental Management* is shown to be influential in the rate at which the clean up of land pollutants occurs. This is an intuitively plausible relationship since a higher level of commitment is likely to lead to a greater allocation of resources to the task.

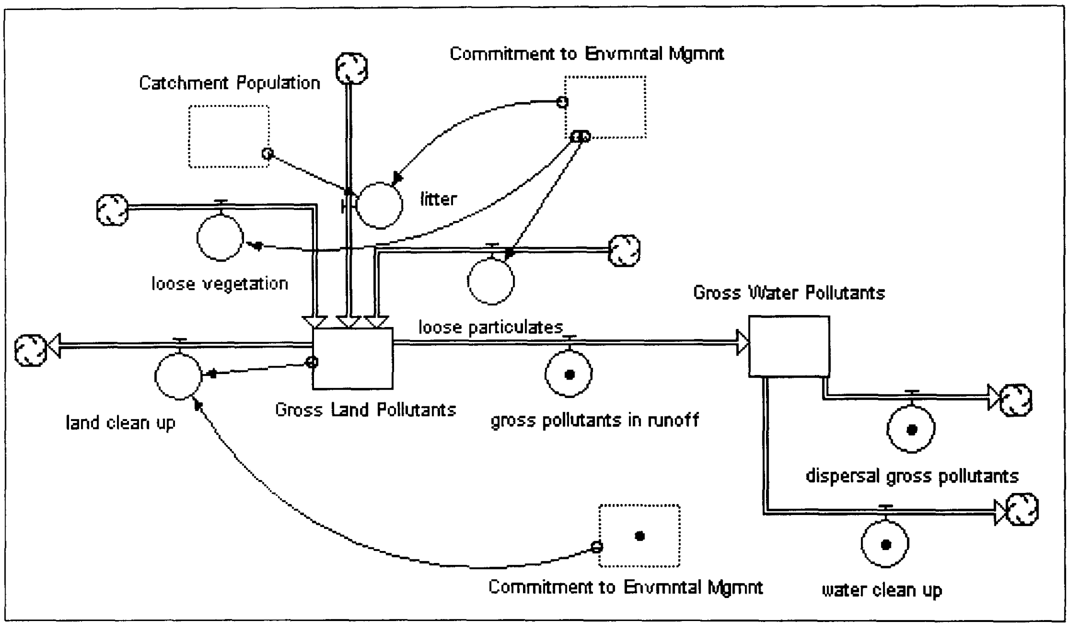

Figure 6.15 The variable *land clean up* is shown to be a function of the stock of *Gross Land Pollutants* and the community's commitment for environmental management.

The rate at which land pollutants are transported to the waterway is modelled as the flow *gross pollutants in runoff*. This variable is controlled by the auxiliary *gross pollutant movement* (see Figure 6.16). The latter is included in the model at this point as a ghost, with its conceptual construction being included in the Flood sub-sector of the model. Figure 6.17 shows the factors that are used to determine the rate at which the pollution is transported from land to water. Essentially, the movement of pollution is modelled as a direct response to stormwater (*flood flow)* resulting from significant rainfall events. This is based on the fact that stormwater runoff is seen to be the major source of pollutants entering urban waterways, and has serious implications for the quality of water in rivers and estuaries (Commonwealth Environment Protection Agency 1993). The variable *flood flow* is itself a function of the severity of the storm and the level of flood control and stormwater management infrastructure.

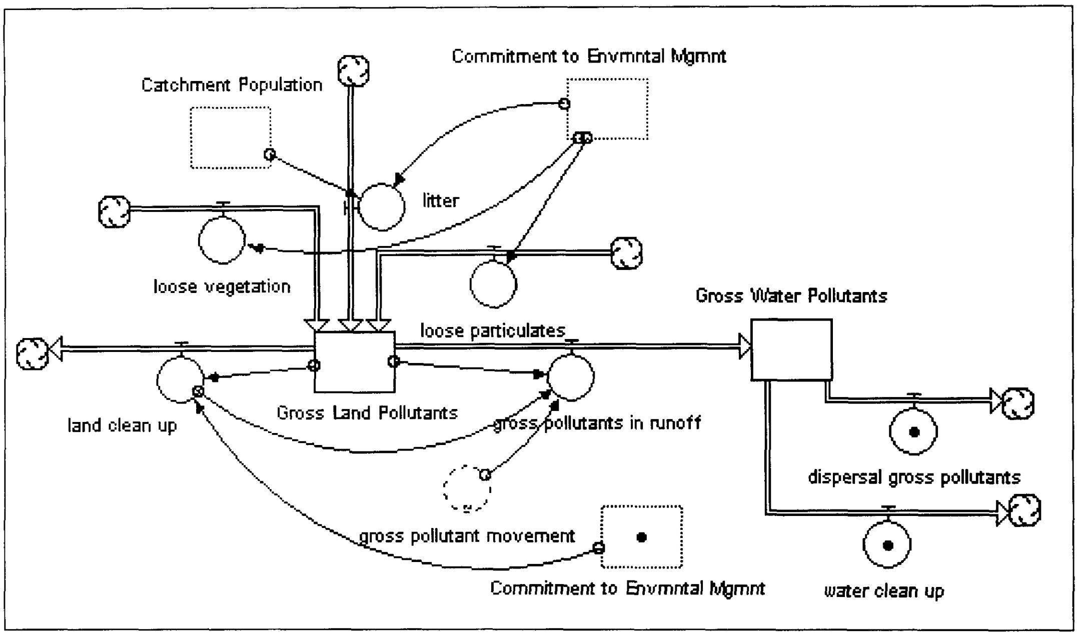

Figure 6.16 The movement of gross pollutants from land to water is modelled as depending on how much land pollution there is, and an impact factor *gross pollutant movement*, which is elsewhere calculated as related to storm flows.

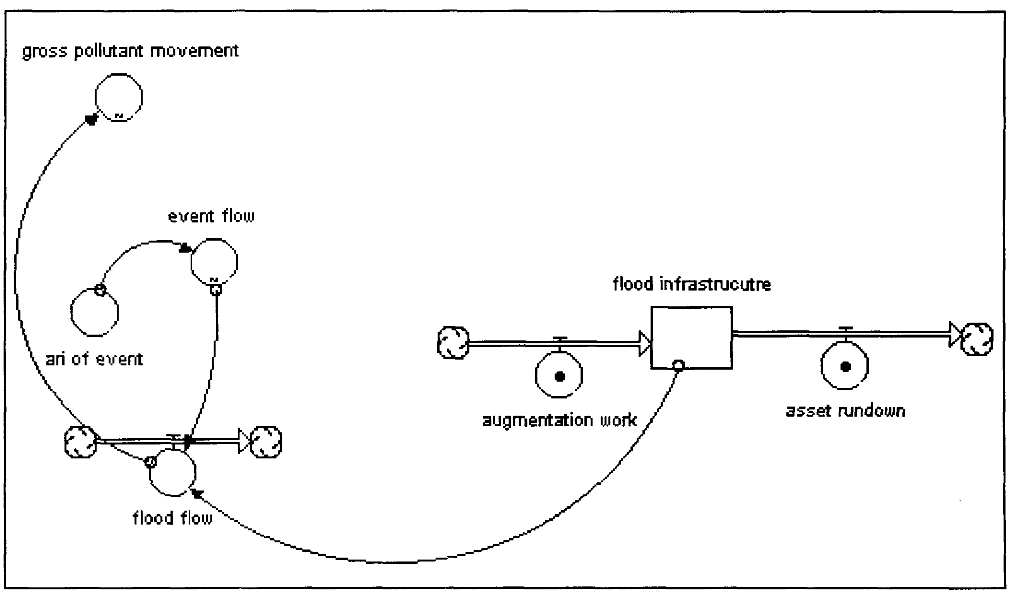

Figure 6.17 The variable *gross pollutant movement* is a function of *flood flow*. The latter is modelled as depending on stochastic flood events, and the standard of flood control infrastructure.

The final stage of model exploration for the stock *Gross Water Pollutants*, reveals the factors that influence the dispersal and clean up of water borne pollution (see Figure 6.18).

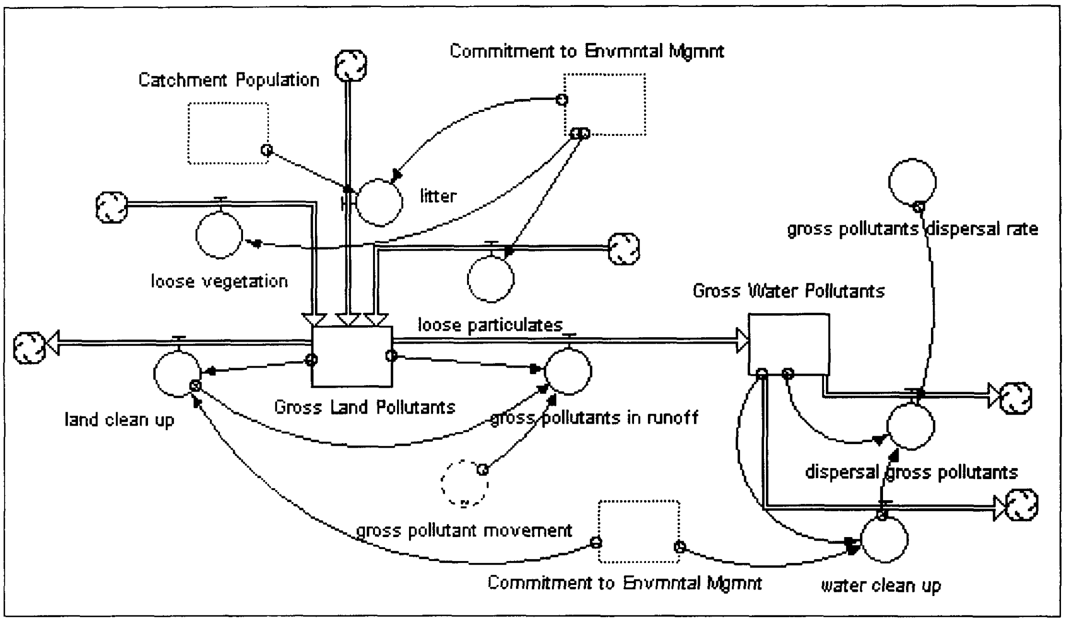

Figure 6.18 With the addition of factors influencing the dispersal and clean up of pollution, the picture is now complete.

The depiction of this part of the model is now complete. When used with the focus group, this diagram was the basis for discussion about various aspects of management of the gross pollution that enters Throsby Creek. It serves to clarify issues, and to give a clear picture of the key issues and how they interact.

There are, however, many other issues in the management of Throsby Creek besides gross pollutants. What has been reported so far are those parts of the demonstration model that were developed in conjunction with the larger stakeholder focus group. In conjunction with various individuals drawn from the PPP subcommittee, and under the general guidance of that group, a more comprehensive model has been developed. This model includes the diversity of issues that has been identified through the overall Throsby Creek TCM process, and has been developed to the stage where it can provide information about the likely behaviour of some key variables. The complete model can be found in the appendices: the system map from the model appears as Appendix A, while the equations underlying the model have been included as Appendix B.

One decision that the TCM committee had to deal with, was to determine what amount of money to allocate to community education as part of its overall strategy. The model enabled stakeholders to explore the likely impact of various levels of education expenditure on total diffuse pollution in the waterway. The model includes a number of relationships that link expenditure on environmental education, through commitment to environmental management, with behavioural changes such as reduced littering and polluting as well as an increased likelihood of clean up activity being undertaken. There are also some relationships in the model that allow for unexpected drops in community interest in the environment, and these work against the build up of community awareness and activity that the environmental education might generate. The interaction of these and other factors results in the variable *total diffuse pollution* changing through time, with some component of that change attributable to the variable *environment education funding*. This dynamic relationship is traced out in Figure 6.19.

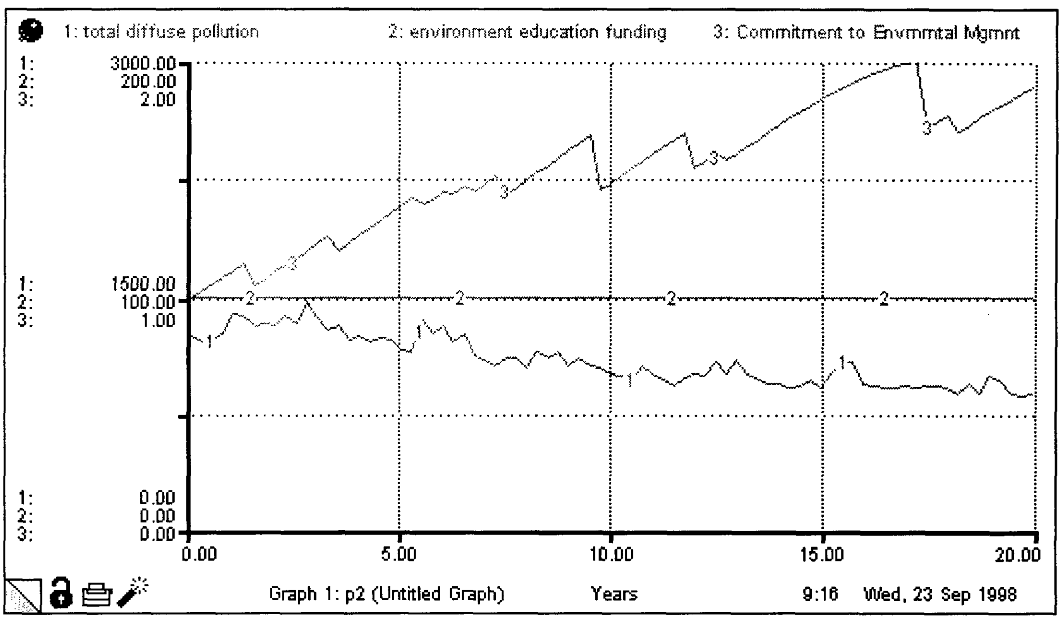

Figure 6.19 One possible future path for the variables *total diffuse pollution* and *Commitment to Environmental Management* for the given and continuing level of *environment education funding*.

Due to constraints imposed by the TCM committee and the demonstrative nature of the model, it was neither possible nor appropriate to calibrate the model properly. This means that the output of the model can be taken as indicative only, and not as a definitive statement of real future events. However, this was not considered to be a limitation given the context of the exercise as a facilitated learning experience for the participants. Nevertheless, the model does generate some interesting insights. Whereas the model is not calibrated is such a way that a level of expenditure of 100 equates to, say, $100,000, it nevertheless generates outputs that reflect *relative* movements of key indicators. Thus, a moderate level of expenditure on environmental education can be equated to the amount 100, an infinitesimally small level to 1, and a high level to 200. In this way, the impact of relatively higher and higher expenditures can be seen. Figure 6.19 was generated for a moderate level of expenditure of 100 units. In this scenario, commitment to environmental management is seen to follow an upward trend, while the pollution level follows a downward trend. The results for a very low (negligible) level of funding can be seen in Figure 6.20. In this example, the model shows increasing pollution levels, contributed to by the fall in the community's commitment to environmental management.

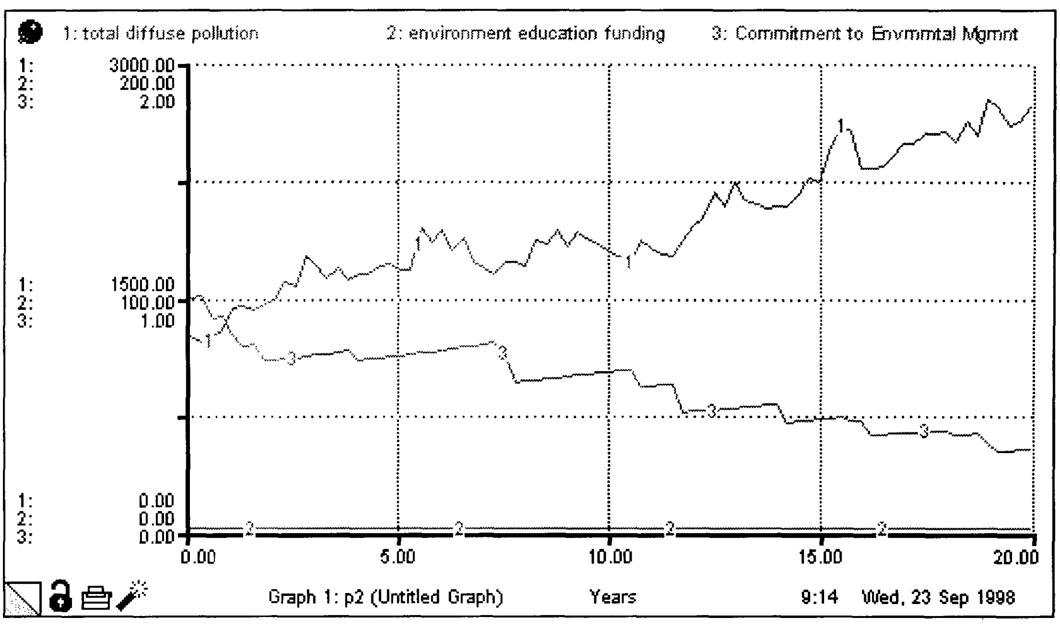

Figure 6.20 Indicative trends for total pollution and environmental commitment for negligible levels of funding for environmental education.

The last scenario tested is for a doubling of the expenditure from 100 to 200 monetary units. Possible dynamics under this scenario are given in Figure 6.21, where it can be seen that with this level of funding, commitment rises to a maximum sooner than under the 100 unit scenario, and this is accompanied by a falling trend in pollution. However, note that even with a level of funding that is higher than that underlying Figure 6.19, commitment levels start to fall around year nine, and never recover to their maximum. This is accompanied by pollution levels starting to rise again. This particular result occurs because the model includes many factors other than environmental education funding that affect commitment to environmental management. The aesthetic appeal of the neighbourhood is thought to have an influence in encouraging increasing commitment, while the level of commitment can fall due to unpredictable events such as influential community leaders leaving, or disputes within community based management groups.

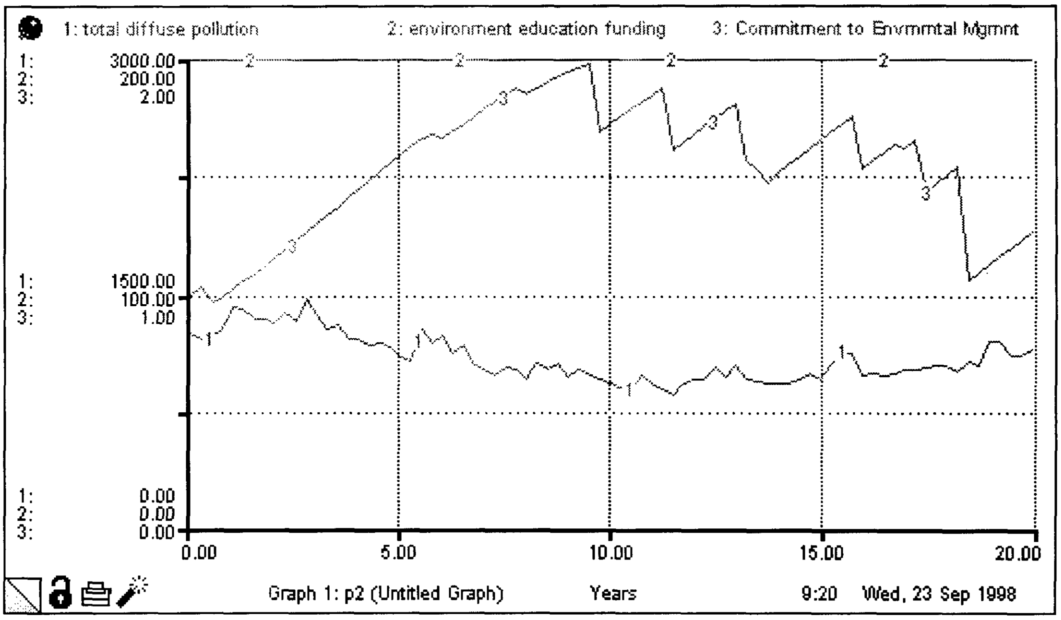

Figure 6.21 Model output under relatively high levels of expenditure on environmental education

At first sight, it probably seems strange that a higher level of funding has not resulted in more sustained levels of commitment and lower levels of pollution than for other, lower funding scenarios. This is an example of what could be identified as a 'counter-intuitive' result from the model. It can be caused by errors in model structure, or mistaken understanding about the system and the way that interactions lead to certain outcomes.

This counter-intuitive result is an important adjunct to the group learning process. It provides a reason for the group to explore in more detail the way that the model is operating in an attempt to understand the reason for the behaviour. The first step in this process is to investigate the portion of the system map that describes the behaviour of the variable C*ommitment to Environmental Management*. This part of the model is reproduced in Figure 6.22.

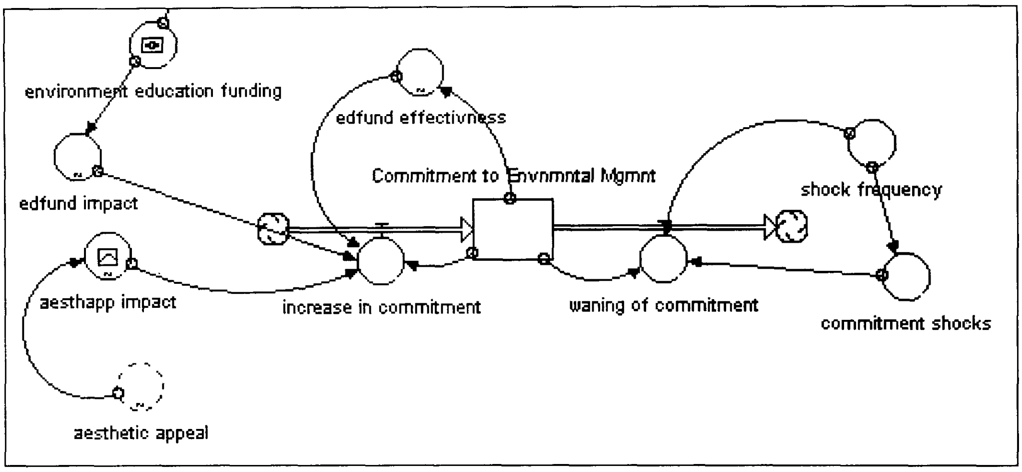

Figure 6.22 Model fragment depicting the factors that influence the variable *Commitment to Environmental Management*

In this part of the model, *Commitment to Environmental Management* is seen to be a stock which increases via the flow *increase in commitment* and decreases through the flow *waning of commitment.* Increases are characterised as being attributable to two factors; the aesthetic appeal of the neighbourhood, and the level of expenditure on environmental education. Each of these factors impacts on *increase in commitment* through what is called a table function. The table function is a feature of the software that allows underlying relationships to be made explicit, and allows for the interactive adjustment of these. The table function that is used to relate the aesthetic appeal index to its impact on environmental commitment is reproduced below (Figure 6.23). In this example, the relationship is one in which poor aesthetic appeal leads to low levels of commitment by the community, rising levels of aesthetic appeal lead to increasing levels of commitment by the community, and once the appeal reaches a certain level, the impact on commitment tends to taper off.

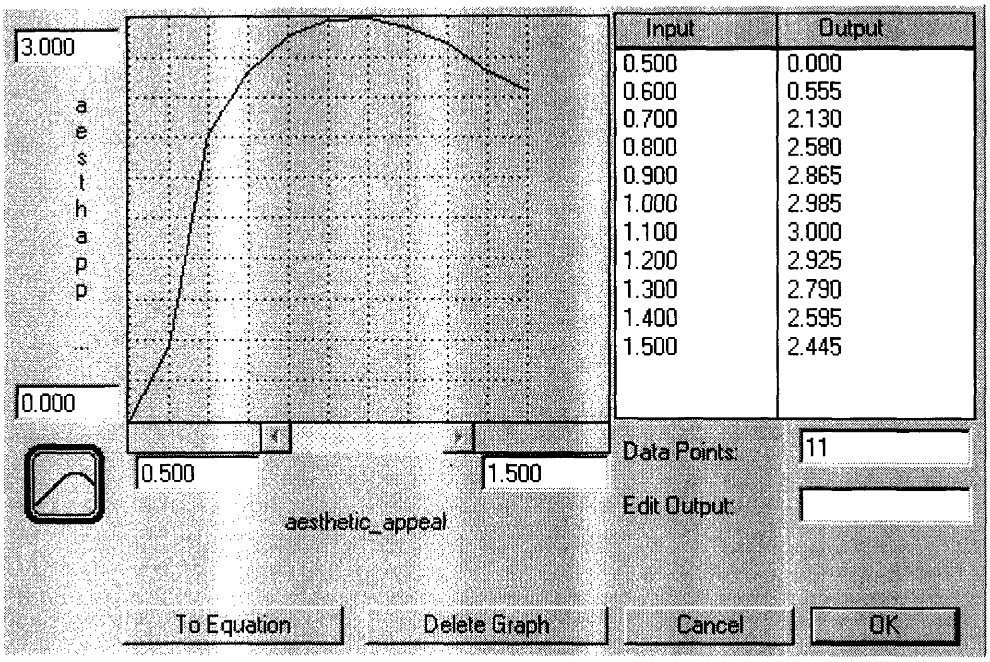

Figure 6.23 The table function that relates aesthetic appeal to its impact on community commitment to environmental management.

Although a particular relationship has been included in the model, the form of this relationship is by no means unambiguous. Indeed, some might argue that a better form for the relationship would be as shown in the following diagram (Figure 6.24). The useful thing about a table function is that it makes the relationships explicit, and allows for the relationship to be adjusted either as a shape, by directly clicking the mouse pointer over the graph, or as numbers, by entering appropriate data in the window under the input and output columns. This feature means that stakeholders can have their say about how key relationships are embedded in the model, and this in turn can lead to a greater belief by the stakeholders in the internal integrity of the model.

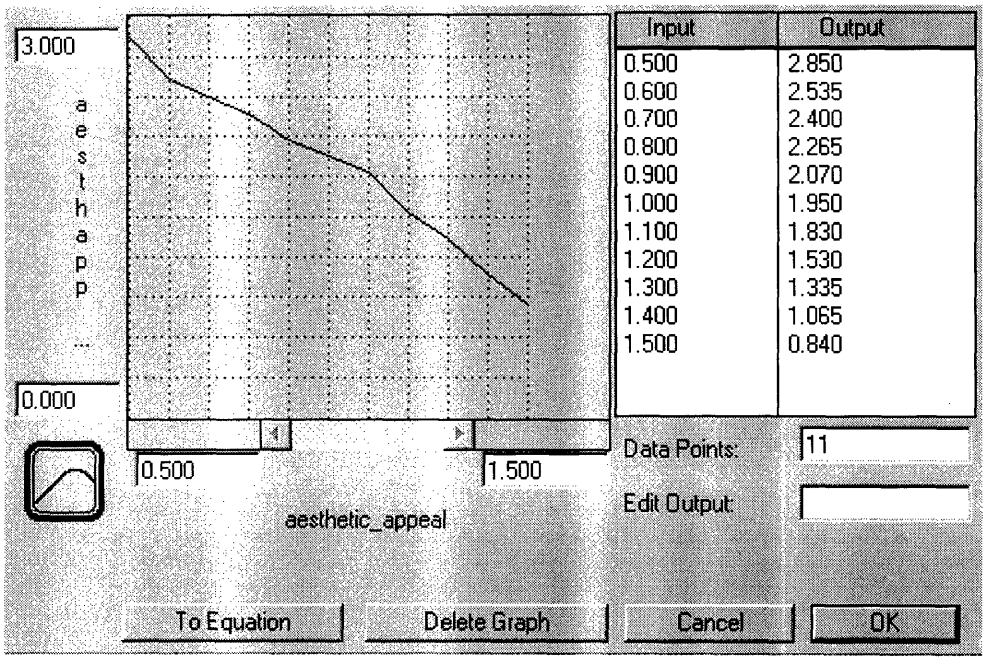

Figure 6.24 An alternative form for the relationship depicted in Figure 6.23.

The other table function that impacts on *increase in commitment* is that which shows the expected relationship between levels of education funding and its impact on the increase. In this function (Figure 6.25), a relationship that reflects diminishing returns is used. Under diminishing returns, each additional dollar of expenditure results in a little less output than did the previous dollar of expenditure. The input scale used is from 0 to 200, the range of expenditure units used in the model, while the output is a number in the range 0 to 10. The output value is a number describing the percentage increase in commitment to environmental management that results from the given level of expenditure.

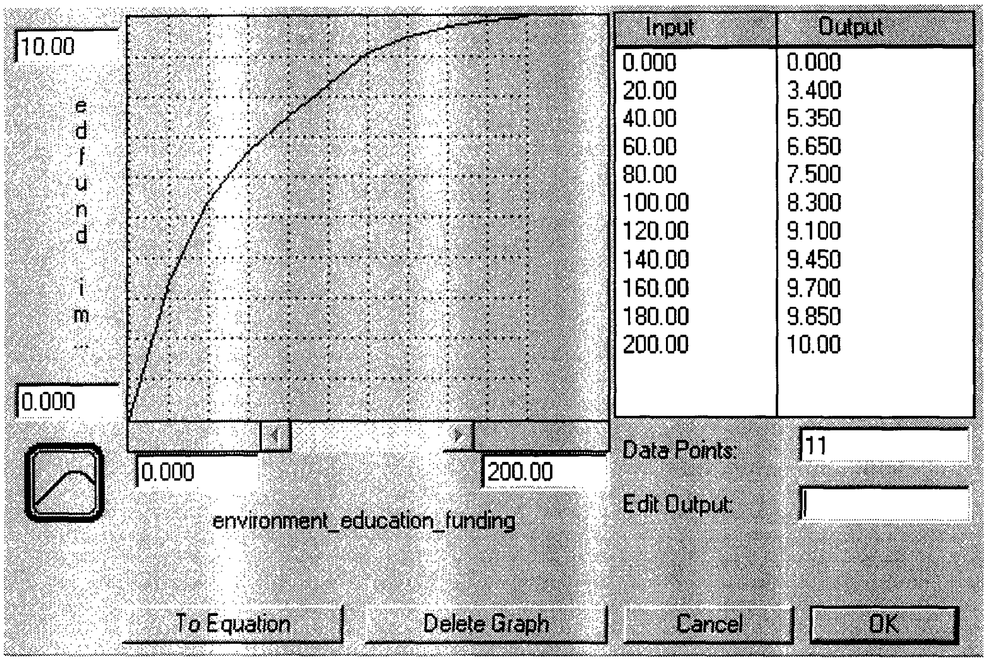

Figure 6.25 The table function that relates expenditure on environmental education expenditure, and the expected percentage increase on environmental commitment that would result.

From inspection of the diagram at Figure 6.23, a third factor is shown to impact on *increase in commitment*, the variable *edfund effectiveness*. This variable is used to capture the idea that the effectiveness of environmental expenditure varies, not only in terms of diminishing returns per dollar invested, but also as a function of the existing level of commitment. At low levels of commitment, education is expected to have maximum impact on increases in commitment, whereas at higher levels of commitment, the effectiveness of education falls off. This relationship is depicted in Figure 6.26.

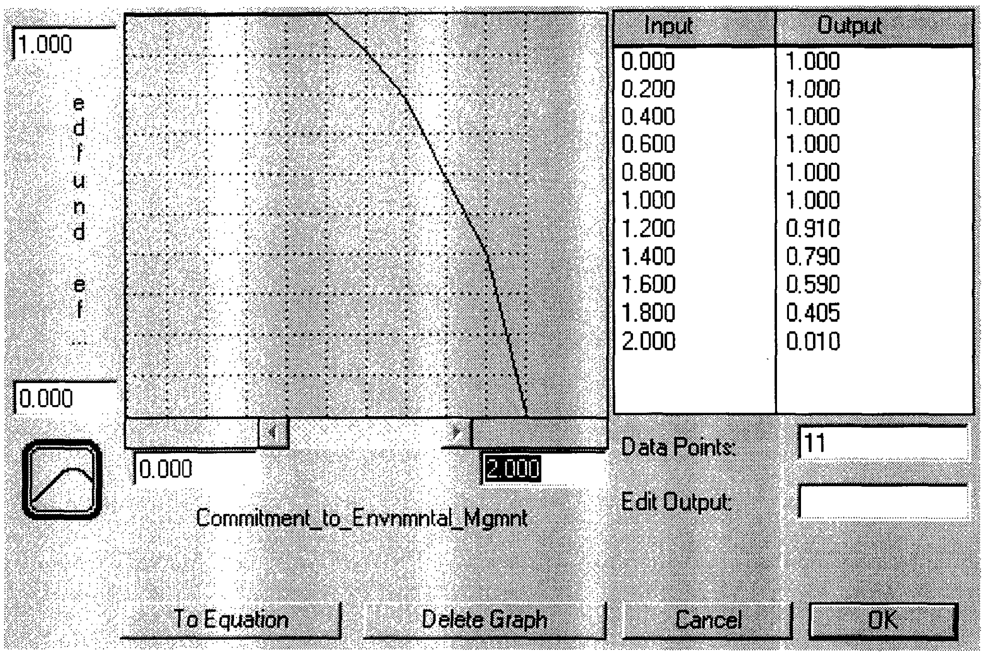

Figure 6.26 The table function that shows the relationship between the level of commitment to environmental management and the effectiveness of environmental education.

To calculate the overall effect of educational funding, the output of the table function *edfund impact* (a number between 0 and 10) is multiplied by the output of *edfund effectiveness* (a number between 0 and 1). Thus, when overall commitment to environmental management is low to medium (represented when the variable is between 0 and 1), educational funding has its maximum possible impact of a 10 per cent increase in *Commitment to environmental management*, and when commitment levels rise above an index value of 1.0, the effectiveness falls in the manner indicated in Figure 6.26.

The above factors are those that affect the increase in commitment, but there are also factors that influence its decrease, and it is both sets of factors taken together that result in the level of commitment at any point in time. From inspection of Figure 6.23, the factors affecting the variable *waning of commitment* which causes the stock to decrease, are *shock frequency* and *commitment shocks*. These variables contain random number generators that simulate the reductions in commitment that could occur as a result of social or other factors which might influence commitment from time to time. The action of these variables is to generate a shock of random size between 0.0 and 0.7, with the probability of occurrence in any three month period of 0.125. The resultant effect is that the stock *Commitment to environmental* *management* has downward pressure exerted on it from time to time, and this pressure results in the sharp falls in that stock which can be seen in Figure 6.19 through Figure 6.21.

The net effect of the flows into and out of the stock *Commitment to environmental management* is the trend line that is traced out when the model is simulated (Figure 6.19 through Figure 6.21). The gradual upward movement in the line represents the way that commitment is understood to increase through time as a result of education and other factors, while the downward falls reflect the understanding that there are factors that could cause such adjustments in the real world, and that these factors would tend to operate over a relatively short period of time causing a sudden fall in commitment.

Whether or not commitment actually behaves in this way is moot; the point of the model is that it is an attempt to represent the best understanding and information that is available to the stakeholder group. As such, the relationships described above result in a trend for *Commitment to environmental management* that is credible to the group, and which they believe is an approximation of real system behaviour appropriate to support their learning about the system.

The foregoing detailed discussion of the variables that influence the stock *Commitment to environmental management* was presented in the context of exploring the reasons for the counter-intuitive response of the stock represented in Figure 6.21. The response in question was that commitment fell, even under higher funding levels than shown in Figure 6.20 where commitment continued to trend upwards. From the above description of the relevant part of the model, the reasons for this counter-intuitive behaviour can be inferred.

A stock will fall in value if outflows exceed inflows. In the particular simulation run reported above, the downward pressure on commitment during the latter part of the run was such as to exceed the upward pressure exerted by the education funding. This reflects a possible real world situation where social and other factors could combine to defeat attempts to increase commitment through use of the policy variable of environmental education funding.

This particular finding was of interest to the group, because it pointed to the fact that although increased levels of education funding would generally be expected to cause an increase in commitment, that are some conceivable situations where this result would not be forthcoming because of other unpredictable factors. This provided the basis for a better understanding of the uncertainty of the real system, and enhanced knowledge about the possible effectiveness of a given policy decision.

The preceding discussion has outlined the application of PEM within a stakeholder driven process as part of the Throsby Creek TCMC. The various aspects of the model and its application that have been discussed, reflect the way in which these issues were presented to the PPP group and the TCMC.

6.2 Malpas Dam

The second application of PEM to be reported in this thesis is a case study in the management of an urban water supply. Malpas Dam, built on the Gara River, is the main water supply for the rural city of Armidale, on the Northern Tablelands of New South Wales, Australia. The catchment for Malpas Dam includes the northernmost part of the Macleay catchment discussed in Chapter Four. The Armidale community has experienced extremely poor water quality on a number of occasions, and this has been attributable to outbreaks of cyano-bacteria (blue-green algae) in Malpas Dam. Such outbreaks are understood to be influenced by, among other things, nutrient levels in the dam, and the temperature, oxygen content and stillness of the water. The main source of nutrients in the dam is from the Gara River after storm events. During a storm, surface flows collect phosphorous and other nutrients from farm lands and deposit them into the Gara River and its tributaries. A part of the Guyra township is also in the Malpas catchment, and polluted stormwater from south Guyra is thought to have contributed significant nutrient loads to the waterways over the years.

Present approaches to the problem involve water treatment by Armidale City Council, although this is not always effective. The water treatment employed includes the application of copper sulphate to kill the cyano-bacteria within the impounded waters, and filtration using activated carbon filters at the Armidale water treatment plant. Although these measures are generally effective, there remain episodic outbreaks of cyano-bacteria resulting in poor water quality. Moreover, the use of copper sulphate is now severely restricted by the EPA. Council is exploring ways of improving the reliability of supply of high quality potable water, and at the time of writing, is arranging to trial water treatment by ozonation as an alternative approach.

The engineering solutions employed by the Armidale council are not the only attempts being made to deal with the problem. Under the auspices of TCM in New South Wales, a catchment committee has been formed which has as its primary objective the management of the water quality in the Gara River upstream of the Malpas Dam. Stakeholders within the Malpas catchment, are endeavouring to attack the cause of poor water quality by identifying those land

and water management practices that are exacerbating the problem (Malpas Catchment News, September 1997).

As an aid to the community participation process, the PEM methodology has been employed in conjunction with the Malpas catchment coordinator. A grant has been received from the Natural Heritage Trust of Australia to enable the researcher, and his colleague and supervisor Dr Roderic Gill, to apply PEM as part of the integrated management of the Malpas catchment. To date, this work has involved an extensive stakeholder identification process, a workshop with the stakeholders (facilitated by the researcher and Gill), and the production of a report of the workshop (Gill 1998). A subsequent meeting has led to the identification of a number of integrated strategic and tactical responses based on the system understanding developed in the workshop.

This case study is important because it is the first time that PEM has been employed from very early on in the strategic planning process. In fact, the proposal for funding was written in conjunction with the Malpas catchment coordinator, with this methodology in mind. The crucial factor here is that because PEM has been involved right from the start, the stakeholder identification process has been addressed intentionally. This contrasts to the other two case studies reported in this chapter where the stakeholder groups were already in existence prior to implementation of PEM. In each case, this led to less than ideal representation at the stakeholder workshops. In fact, the initial 12 months of this project were devoted (among other things) to identifying stakeholder groups and ensuring that they would be interested in being involved in the process. This might be construed as an excessive period of time, however it should be noted that the catchment coordinator has only a part time appointment, and therefore can devote only limited hours to the job.

Following the stakeholder identification phase, interested stakeholders were brought together for an initial system mapping and problem exploration workshop. During this workshop, the construction of a mud map was used to focus discussion and to ensure that system relationships were captured. The mud map generated at the workshop is reproduced as Figure 6.27. This is a complex diagram which is, at first sight, difficult to comprehend. However, since the real outcome of the workshop is really the learning about the system, the problem, and its possible solutions, it is not of particular relevance that the diagram is hard for an outsider to understand. It is intended as a record of conversation for the involved stakeholders, and provides a context for the articulation of strategies and solutions by that group.

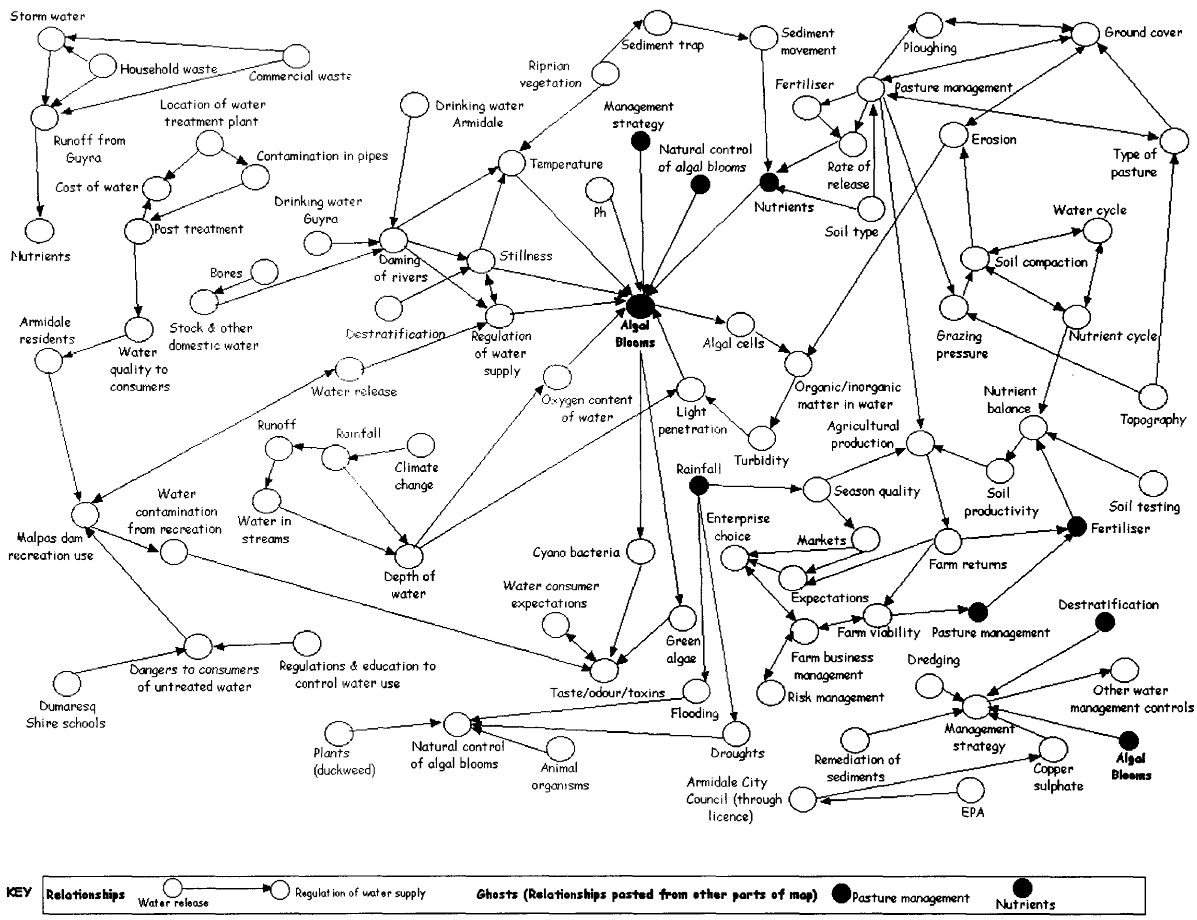

Figure 6.27 Mud map developed at the Malpas community stakeholder workshop (source: Gill 1998)

As an outcome of the workshop, a number of draft actions and recommendations were developed, under the general headings of farm business management, land management, water user issues, biological issues and urban issues (Gill 1998). These have been promulgated for general discussion, and were addressed at the subsequent meeting of the stakeholder group.

An analysis of the effects of the application of the PEM methodology has been carried out through an interview with the Malpas catchment coordinator (Henderson 1998, pers. comm.). In his view, the systems based approach being used is supporting a developing stakeholder-driven community management culture that is distinct from other approaches. He sees evidence of genuine interest and involvement by a variety of people from the community. Moreover, he reports favourable comments on the process by group members. These comments generally note the distinctive process and particularly the way it is focused on their *genuine* involvement, as contrasted with other approaches where this has not been the case. The author has also discussed the process informally with other members of the stakeholder group. The consensus seems to be that group members are pleased with the way things are going, and are interested to maintain their involvement with the group.

It is recognised that the informal survey of participants reported above is highly subjective and certainly does not 'prove' the PEM methodology. However, there is at least strong support for the process, and a preparedness by the stakeholders (including the people with technical expertise) to continue with the process. The work with the Malpas catchment community is continuing under the existing National Heritage Trust grant. It is expected that the final outcome will be a stakeholder developed strategic management plan, and that some innovative approaches dependent upon cooperation among stakeholders will be included. In support of the management plan, it has been recommended (by Gill 1998) that the Malpas group consider applying steps three through five of PEM (i.e. the modelling and scenario testing stage). This would involve gathering of appropriate data and building this into a model that is developed, as much as possible, as a transparent implementation of the knowledge base of the stakeholder group. The resulting model would then be able to be used by the group in order to choose between alternative courses of action so that the best integrated set of outcomes might be achieved.

As a general comment on the Malpas case study, and in the context of the discussion in Chapter Four, there already appears to be evidence of genuine cooperation occurring among the various stakeholders. As a direct result of the initial workshop and subsequent discussions, two projects for addressing different aspects of the catchment management problem have been identified. Each of these projects has strong evidence of integrating across a wide range of issues.

One of these involved cooperation between Guyra and Armidale Councils, the Centre for Water Policy Research at the University of New England and the Atlantis Corporation, to develop an application for funding to address the south Guyra stormwater flow problem. This application has been successful, and Guyra Council will undertake installation of infrastructure that ought to mitigate the pollutant load resulting from urban stormwater originating in south Guyra.

The stormwater infrastructure to be installed utilises the principle of on-site detention and infiltration into the soil and water table. This technology has been invented by Atlantis Corporation and is still experimental in many respects. This has led to the involvement of faculty members from Resource Engineering at the University of New England who will oversight the installation and carry out research to determine its economic and technical effectiveness.

The other project is still at the proposal stage awaiting funding. It involves the cooperation of researchers, local farmers and Guyra and Armidale Councils to explore the environmental impacts of various grazing management strategies upon the transport of nutrients from grazing lands during storm events. The project will also address the economic and social implications of graziers changing their traditional practices. This project has been developed as a direct outcome of the activities of the Malpas TCM Committee and has the support of many key stakeholders.

Whereas it is reasonable at this stage to note that the Guyra TCM process is showing signs of effective integration across issues and stakeholders, it would be gratuitous to assert that this is completely or even significantly due to the application of PEM. Indeed, it is entirely possible that the initiatives identified above would have unfolded anyway. However, it *is* worth noting that PEM involves an intentional focus on the possibility of developing and harnessing strategic links among stakeholders. Moreover, PEM makes explicit the way that various catchment system components (environmental, economic and social) interact, and provides an opportunity for stakeholders to explore the implication of these linkages. Clearly, the two outcomes identified above each contain elements consistent with these aspects of PEM. The fact that such outcomes have occurred, is at least indicative that so far PEM has not failed. Furthermore, there is significant commitment to persisting with the systems-based PEM approach from the empowered stakeholders in the catchment. In his report of the initial workshop, Gill (1998, p.24) concludes that "Progress will proceed through short term achievements through to measurable improvements in the direction of the very long term processes in accordance with the goals of the project". Subsequent achievements, two of which are described above, suggest that things are on course, at least in the short term. Whether PEM will prove successful in the longer term can only be assessed through time.

6.3 Pymmes Brook

As part of the further testing and refinement of the integrated decision making methodology, and as a demonstration of its potential, an application of the approach was undertaken in conjunction with the Environment Agency of England and Wales. This was a much smaller case study in terms of research effort than those described above. It involved a facilitated systems mapping workshop in which people from both the Environment Agency and

Middlesex University were involved. Due to time and other constraints, only a partial application of PEM was possible, although even this resulted in some significant outcomes. Following is a description of this work.

6.3.1 Background

Pymmes Brook is a permanent stream that rises in farmland and woodland to the north of greater London, England. It is a part of the Lower Lee River catchment, and as such is included in the Lower Lee Catchment Management Plan (CMP). The River Lee is a northern tributary of the Thames River, joining the latter in the centre of London. The CMP process for the Lower Lee has been underway since 1995, when a consultation report was released for public comment (National Rivers Authority 1995a). In this document, the National Rivers Authority (NRA) presented a survey of the major issues and suggested a number of practical solutions to the problems encountered. The purpose of the document was to invite public comment and to provide the context for ongoing catchment management planning work.

Following from the consultation report and input from a wide range of stakeholders, the *Lower Lee Catchment Management Plan Action Plan* (NRA 1995b) was produced. As the name implies, this document includes, *inter alia*, specific actions that are to be undertaken with the objective of improving the water quality and amenity value of the Lower Lee catchment. As part of this catchment, Pymmes Brook receives specific mention for actions including:

- Reduction in sewage contamination by reducing the number of combined sewer overflows;
- Completion of the Pymmes Brook Walk by upgrading paths, clearing undergrowth, signing and the production of an information leaflet; and
- Wetland habitat creation, landscaping and access improvement at Tottenham Marshes.

Elsewhere in the document, it is noted that:

> The Pymmes Brook suffers from poor water quality as a combined result of polluting discharges to the river and removal of natural river corridor. This is worsened by similar degradation of the tributaries of Pymmes Brook for example Bounds Green Brook and Moselle Brook. A sustainable future for these rivers and brooks can only be achieved by respecting their value to the environment.
>
> (NRA 1995b, p.9)

It is suggested in this document that actions to improve the state of the river corridor could include: de-culverting; replacing engineered river sections with natural materials; and installing local reed beds. This leads to the land use policy that "All development alongside the Pymmes Brook or any of its tributaries, or which discharges surface water to any of these watercourses must make a positive step to improving their physical environment and reducing its pollution burden" (NRA 1995b, p.9). Whether or not such a policy will be effective is not clear, since the policies that are articulated as part of the Lower Lee CMP are not legal requirements to be met prior to planning consent. Rather, they "... seek to influence local authorities in making decisions on planning applications" (NRA 1995b, p.8).

All actions to be taken within the Pymmes Brook catchment, are to occur within the context of the overall strategy and vision for the Lower Lee. Within the vision for the catchment, it is recognised that three particular themes are central to its management. These are: improved communications and coordination; raised aspirations for the catchment to break the cycle of decline; and improvements to the physical and aesthetic quality of the catchment. In embracing these themes as part of achieving the vision, the stakeholders

> ... want to build on a growing optimism that waterside areas in the catchment can be places that people want to use and want to live and work by. However, the problems of poor water quality, degraded and unnatural physical environment and difficult access to riverine areas for informal recreation are long established.
>
> (NRA 1995b, p.3)

The sustainable use of the Lower Lee catchment is also a theme of the CMP. This is based on principles derived from Agenda 21, and published in *Thames 21* (NRA 1995c). *Thames 21* is a "... planning perspective and sustainable strategy for the Thames region" (NRA 1995b, p.8), and is based on principles drawn mainly from Agenda 21. It sets out the following key principles.

- Levels and locations of future major development can only satisfactorily be identified after the environment has been assessed at a strategic level;
- The polluter should pay for the cost of pollution;
- The precautionary principle should be applied in decision making;
- Thresholds of environmental capacities must be identified and respected; and
- Partnership working and community involvement are essential for practical implementation of these principles.

(NRA 1995b, p.8)

In early 1998, the second annual review of the Lower Lee CMP was undertaken, and the report of this published by the Environment Agency (1998). The report includes a review of action taken under the CMP, provides documentation about some new initiatives, and presents information about the role of the Environment Agency which superseded the NRA from April 1996. Generally, the change in name and expanded scope of the new agency has not impacted greatly on the underlying focus of the CMP. Like the NRA before it, the Environment Agency is the government agency with the primary responsibility for water quality. Another role inherited from the NRA is that of protection from the risk of flooding for people and property in the catchment.

Whereas the underlying themes of the CMP have largely been unaffected by the change in institutional structure, the CMP process itself is to be abolished and will be replaced by the creation of Local Environment Agency Plans (LEAPs). The Lower Lee CMP will become part of the North London LEAP, a strategy and action plan that will incorporate the Lower Lee Catchment with the Rivers Brent and Crane.

The CMP and now LEAP processes involve the integrated management of catchments, with a major emphasis on stakeholder involvement. Even though these catchment planning processes are driven by just one agency, first NRA and now the Environment Agency, they nevertheless involve integration across a large number of agencies and community groups. Not only are groups other than the Environment Agency involved, but the Environment Agency itself (and before it the NRA) is the result of the amalgamation of around 80 individual departments and agencies over the last decade (Gardiner 1998, pers. comm.), and many of these different functional areas of the Environment Agency have an interest in the CMP/LEAP process. As a result of such a diverse stakeholder and interest base, the task of coordination and integration is a significant one.

6.3.2 Workshop with Environment Agency and Others

In the context of the above, and in conjunction with the Flood Hazard Research Centre at Middlesex University, the researcher approached the Environment Agency with view to trialling PEM as an adjunct to the existing CMP/LEAP process. A workshop was arranged, to which people from the Environment Agency as well as Middlesex University were invited. The purpose of the workshop was to identify strategies for the restoration of Pymmes Brook, and to demonstrate the new methodology. The workshop involved about 20 people drawn from various functional areas of the Environment Agency and four people from the Flood

Hazard Research Centre. Clearly, this group was not representative of the diverse stakeholder interests that prevail in the catchment. This limitation of representation was acknowledged by those present, and part of the workshop involved a comprehensive stakeholder identification task.

Whereas the diversity of stakeholder interests represented at the meeting was poor, there *were* many empowered decision makers involved. This has the implication that learning generated at the workshop can be implemented directly by many of the participants. One outcome of this could be a commitment to an inclusive stakeholder involvement process, which, given the emphasis placed upon this within PEM, would be a highly significant outcome.

As an introduction to the workshop, it was explained to the participants that PEM is a systems approach to environmental management problems which involves (amongst other things) the development of rich system maps. As these maps are constructed by the facilitator with input from workshop participants, all concerned should find that their understanding of the system is deepened. This systems approach is concerned with exploring relationships among system components (including the human dimension), and using this understanding to identify key leverage points. The leverage points then become the focus of strategic system intervention.

Once this introduction of the process had been given, the participants were led through the exercise of developing a mud map of the catchment issues. Starting with the issue of water quality, participants were invited to contribute their knowledge on factors that influence water quality, and the way that water quality in its turn affects other parts of the overall system. The resulting mud map is reproduced as Figure 6.28.

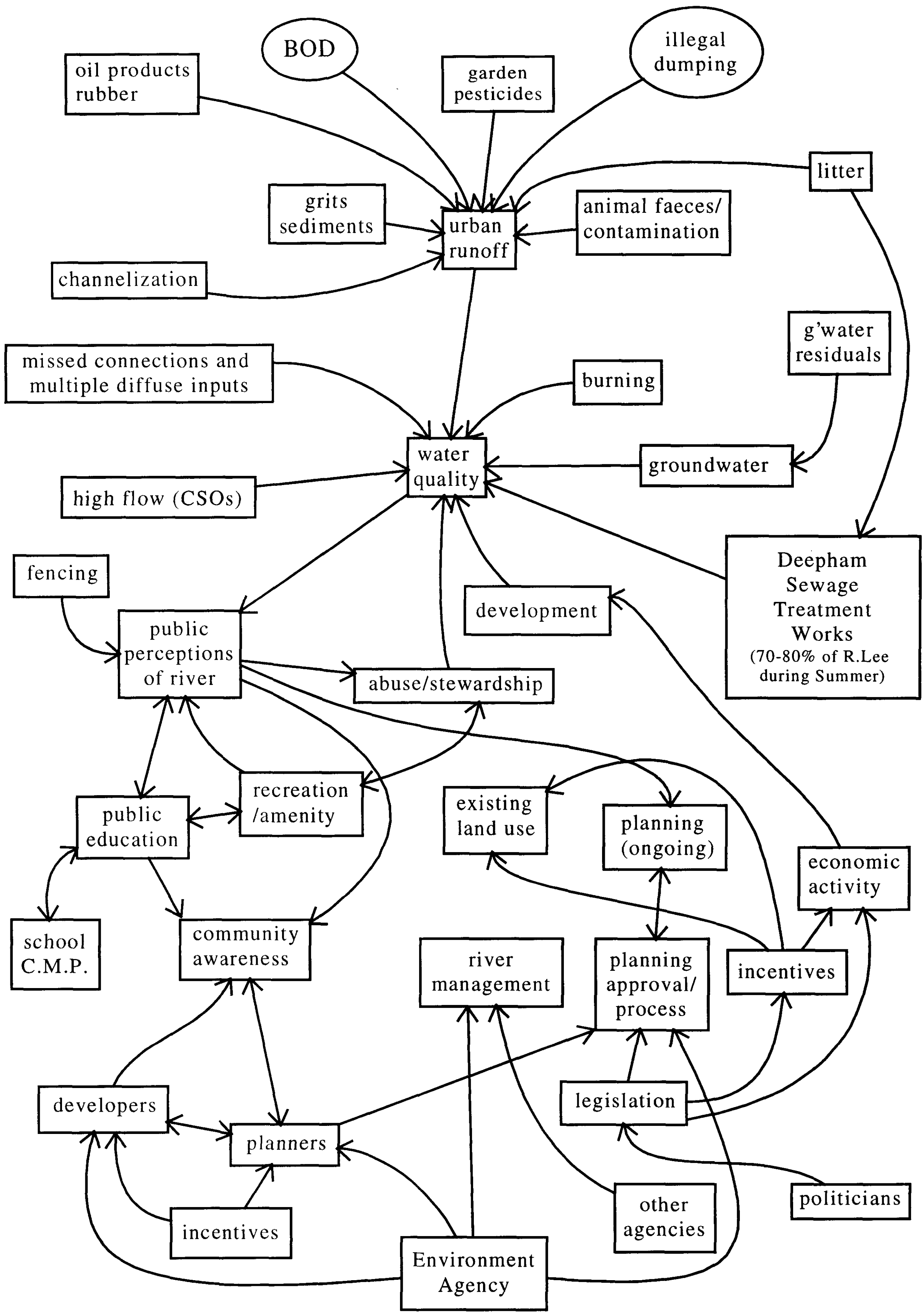

Figure 6.28 The Pymmes Brook catchment mud map

As has been previously noted, a mud map is a record of the interactions and discussions that occur within a group. As can be seen from an inspection of Figure 6.28, the discussions at this workshop were focussed on the issues surrounding the physical causes of poor water quality, and the ways that different groups and organisations in the community have closely interrelated roles in the management task of improving the water quality. Emergent from the discussions, was the developing understanding that public perceptions of the stream and its surrounds as a recreational facility are a key component in the overall management framework. Based on this insight, the group was taken through a more indepth exploration of the role of public perceptions. In order to achieve this, the qualitative modelling features of *ithink* were employed. The system diagram that was developed with the group is reproduced as Figure 6.29.

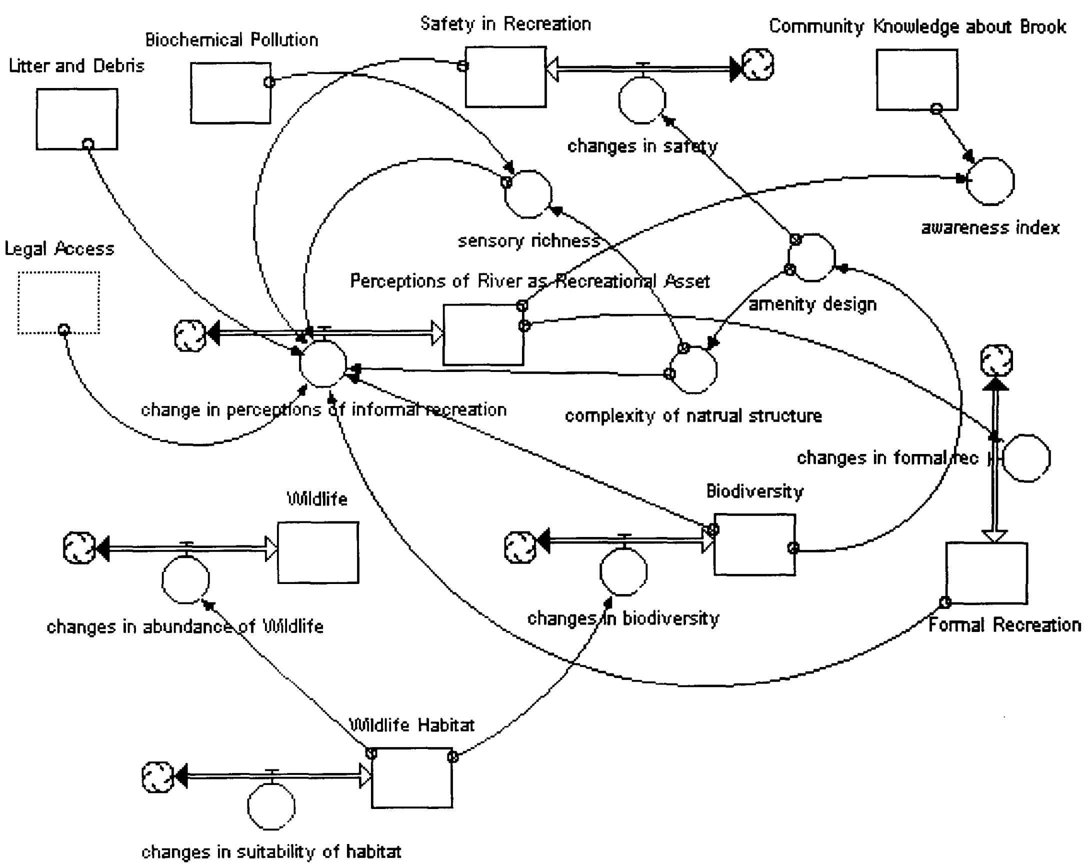

Figure 6.29 A detailed subsystem map exploring the factors surrounding the community's perceptions of the Pymmes Brook as a recreational asset.

The *ithink* diagram incorporates the factors related to community perceptions of the stream corridor. Various recreational activities were discussed, and it was noted that whereas some require open spaces (organised activities such as team sports), others require a high degree of biodiversity (the recreational enjoyment of a natural environment). The overall design of the river corridor as a recreational amenity would impact on the complexity of the natural environment, impacting on sensory richness which in turn would affect perceptions. Biochemical pollution would adversely affect sensory richness, whereas expectations of a safe environment for recreation would tend to enhance positive perceptions.

Some debate ensued about the issues involved in access to the stream corridor. In order to articulate these, the diagram at Figure 6.30 was developed. The development of the diagram served to focus discussion on the issues, and to allow participants to express their views about the important factors.

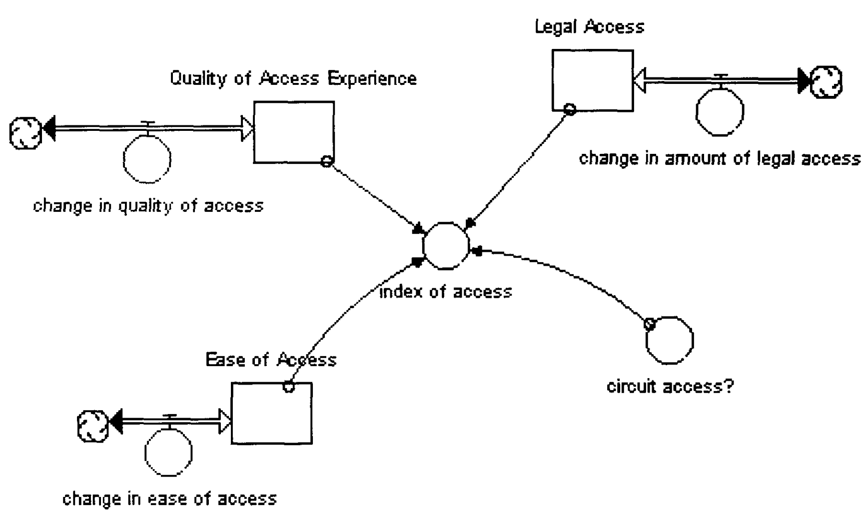

Figure 6.30 Some of the factors affecting access to the stream corridor

As noted in the introduction to this section, because of time limitations and also because this application of the methodology was to serve as a demonstration only, PEM was only partially implemented in this case study. As a result of this, the construction of system diagrams was not completed, nor was a quantitative model of the situation developed. Furthermore, the stakeholders involved in the workshop were hardly representative of the broad community, since participants were either from the Environment Agency or Middlesex University. Nevertheless, the workshop did produce some practical outcomes, and these are outlined below.

Although the systems maps were incomplete, they did serve to focus discussion on, and facilitate learning about, a number of key aspects of the system. The workshop provided the opportunity for participants to explore issues jointly, and to develop a shared understanding of how they interrelate. Although just one organisation, the Environment Agency comprises many different functional groups, and a number of these were represented at the workshop. Each of these participants brought a different perspective on the catchment to the meeting. Moreover, there were clearly divergent views and understandings about the nature of the catchment, and what the key management issues were. As the workshop progressed, the general discussion led to the development of a common picture of, and understanding about, the catchment. This led to the possibility of a more coordinated approach to its management being implemented.

As previously observed, the workshop was not representative of the broad community. However, stakeholder identification is included in PEM as an iterative process that should be undertaken as understanding about the system unfolds (refer to Figure 4.1 and the associated discussion). Based on the system maps, workshop participants were asked to identify the stakeholder community that ought to be involved in the development of a properly integrated approach to the management of the catchment. The following groups were identified: planners, riparian owners, statutory agencies, local authorities, non government organisations, central government, water utilities, roads agencies, residents associations, conservation groups, developers, flora/fauna scientists and activists, recreational users, local residents, children, social interest groups, urban vandals, financial institutions, politicians and local business. So, although the workshop did not have a representative stakeholder group in attendance, participants were nevertheless able to articulate a comprehensive list based on the systems exploration of the catchment. This can now form the basis of future community based planning and implementation.

One objective of the researcher in demonstrating PEM was as an educational service to the Environmental Agency. It was thought that PEM could be useful to the agency as it seeks to implement *Thames 21,* a strategy plan that explicitly requires the active involvement of the community. It seems that this expectation might come to fruition, as the agency coordinator for the North London LEAP has expressed an interest in utilising PEM as part of the LEAP process (Beck 1998, pers. comm.).