Didymo-Gemex Decision Support System

User Manual

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Didymo-Gemex Decision Support System - User Manual

1. Introduction

This Decision Support System (DSS) is designed to assist Regional Partner Groups decide on whether to use Gemex™ (a copper-chelate) in the event that the invasive alga *Didymosphenia geminata* (didymo) is identified in a river. This DSS does not contain background information on the ecology of didymo, or methods used to prevent its spread between New Zealand Rivers. This information is contained within the synthesis of knowledge accompanying this DSS.

The DSS uses a combination of computer algorithms and supporting text to provide you with the information and knowledge to make an informed decision on whether Gemex™ application is appropriate. Computer support is used to assist you identify the infected river reach, abstract site-specific information, on flow characteristics and calculate the likely volumes (and cost) of Gemex™ that will be required to treat it. Fish species known to exist downstream of the infection site are also tabled to assist in determining whether any rare or endangered fish species are likely to be in the path of a Gemex™ treatment. Textual information is provided that will allow you to evaluate the significance of these fish species and their likely response to Gemex™.

Much of the uncertainty surrounding the use of Gemex™ relates to potential environmental effects. These can be categorized into short-term (acute) effects on non-target species, and long-term (chronic) effects due to elevated levels of copper (Cu) in the environment. Short-term effects on a number of non-target species have been evaluated by NIWA and summary of this information is included in the DSS, together with interpretation that will allow extrapolation (where applicable) to other species that have not yet been tested. We also provide a methodology, with worked examples; to assist you evaluate the long-term significance of Gemex™ to the environment downstream of the proposed application site.

As well as decisions on the feasibility of using Gemex™, there are a host of local factors that need to be taken into account. These factors require local information, which is best obtained locally. While it is inappropriate to provide this information within a DSS framework, we do provide a comprehensive list of stakeholders that may need to be consulted, factors that may need to be considered, and guidance on both where to obtain and assess this information. We also provide a comprehensive list of frequently asked questions (FAQs) that different stakeholder groups are likely to ask, together with concise answers and sources of additional information.

If the decision is made to treat the affected river with Gemex™, you will need to follow a particular regulatory pathway. Within the DSS you will find guidance on which pathway is appropriate under particular circumstances. Should a Resource Consent be required, we provide a generic Assessment of Environment Effects (AEE). This will need to be tailored to the region where the infection has occurred, but should markedly reduce the time needed to gain consent.

We emphasize that the DSS does not make the decision on whether Gemex™ treatment is appropriate. It merely provides objective information and guidance. The onus on making the decision is yours. Whatever that decision is, however, will be subject to public scrutiny. We have therefore provided a comprehensive audit trail and reporting facility so that the reasons for using, or not using Gemex™ are clearly documented.

1.1 How this User Manual is organized

The same information contained in this user manual is also embedded in the "help" file within Didymo-Gemex. In the Help file, the user can navigate to a particular topic (e.g. "Accumulation of Gemex™ -copper in sediments") and the most important information on that topic will be displayed. For users that need further information or explanation, a link is provided to a more detailed explanation and case studies. In this paper version, this more detailed information has a grey background.

1.2 Assumptions and limitations

The user needs to be aware that the sole purpose of this Decision Support System is to assist in making a decision whether or not to use Gemex™ for a particular river reach. Whilst computer-assisted support is offered, the user needs to be aware that certain assumptions have been made in calculating variables used in the decision-making process (e.g. length of reach that can be treated with a single Gemex™ injection, volume (and cost of Gemex™) required and that there are limitations to how this information should be used. In addition, there are limitations associated with the advice given on the impacts of Gemex™ to non-target species. The main assumptions and limitations are given in the table below.

Assumptions	**Limitations**
The decision-making framework relates only to a 1-h application of Gemex™ to a river at a maximum (in-river) concentration of 20 mg/L.	The decision criteria will not apply for longer applications (e.g., days to weeks).
Stream velocity is used as a surrogate measure of organic matter (see Section 5.1), which absorbs Gemex™ and therefore reduces the treatment length over which a single injection of Gemex™ will be effective. In general, high velocity waters retain little organic matter whereas at low velocity there is deposition of organic matter.	Whilst this assumption is reasonable for most rivers, there are exceptions and limitations. These are: 1. Under stable flow regimes, periphyton can accumulate at quite high velocities, 2. Using velocity as a surrogate results in a high upper limit for downstream effective distance of Gemex, 3. Some waters may contain atypical amounts of organic matter unrelated to velocity (e.g. streams draining a peat swamp). In such cases, the user should utilize their local knowledge, use the information generated by the DSS on treatment length circumspectly, and seek professional advice if necessary.
The stream velocity –organic matter relationship also assumes that large mats of didymo have not yet established. Didymo is unusual in that large mats (i.e. large quantities of organic matter) form in high velocity flows.	Need to increase the number of injection points; and hence volume and cost of Gemex™ where large mats of didymo have established in high velocity waters.
The volume and cost of Gemex™ is related to flow and number of injection points over the treatment reach.	While this is a valid assumption, the user should be aware of the limitations above and that of the flow estimates. The volumes and costs are approximations, which will be sufficient for the

	purposes of making a decision, but they are not an accurate quotation.
The impact of Gemex™ on non-target species is based on current knowledge.	While this is a valid assumption the user needs to be aware that much of the information of non-target species has been generated from a single field trial (Princhester Creek) and a laboratory ecotoxicology experiments.

2. Summary of decision pathway

A flow chart showing the logic path behind the DSS is shown in Figure 1.

The decision pathway that should be followed once a didymo infection is confirmed is as follows:

1. Location: Determine the location of the new infection on the NZ River Network map. Didymo-Gemex gives guidance on selecting an appropriate treatment reach downstream of the infection point and provides hydrological information on that reach. Guidance is given on how to select appropriate hydrological parameters (flow and velocity) used to later estimate the amount of Gemex™ required to treat the selected reach. Map options also allow you to see sites of known didymo incursion in relation to the new infection.

2. Practicality: Determine whether it is practically feasible to treat the selected reach with Gemex™. Didymo -Gemex assists you decide on risk of reinfection, the likely effectiveness of treatment, access considerations, the volume of Gemex™ required and the cost of treatment. Guidance on deciding whether Gemex™ treatment is feasible is given in Section 5.

3. Environmental effects: If the decision is made that the Gemex™ treatment is practically feasible, the next step is to determine whether the environmental effects of Gemex™ application are acceptable. The elements that need to be considered are similar to those needed for an AEE, but at a coarser level. The idea here is to identify any 'critical' effects at this preliminary stage and assist in making the decision whether any potential environmental effects outweigh the environmental benefits of controlling didymo. Guidance on deciding whether the environmental effects of Gemex™ treatment are likely to be acceptable is given in Section 6.

4. Regulatory options: If from the preceding steps you decide that you wish to continue with Gemex™ treatment, then you will need to have regulatory approval to do so. Normally, this will mean gaining a Resource Consent issued under the Resource Management Act (1991) however there may be alternatives. Guidance on deciding on the regulatory pathway appropriate to the circumstances is given in Section 7.

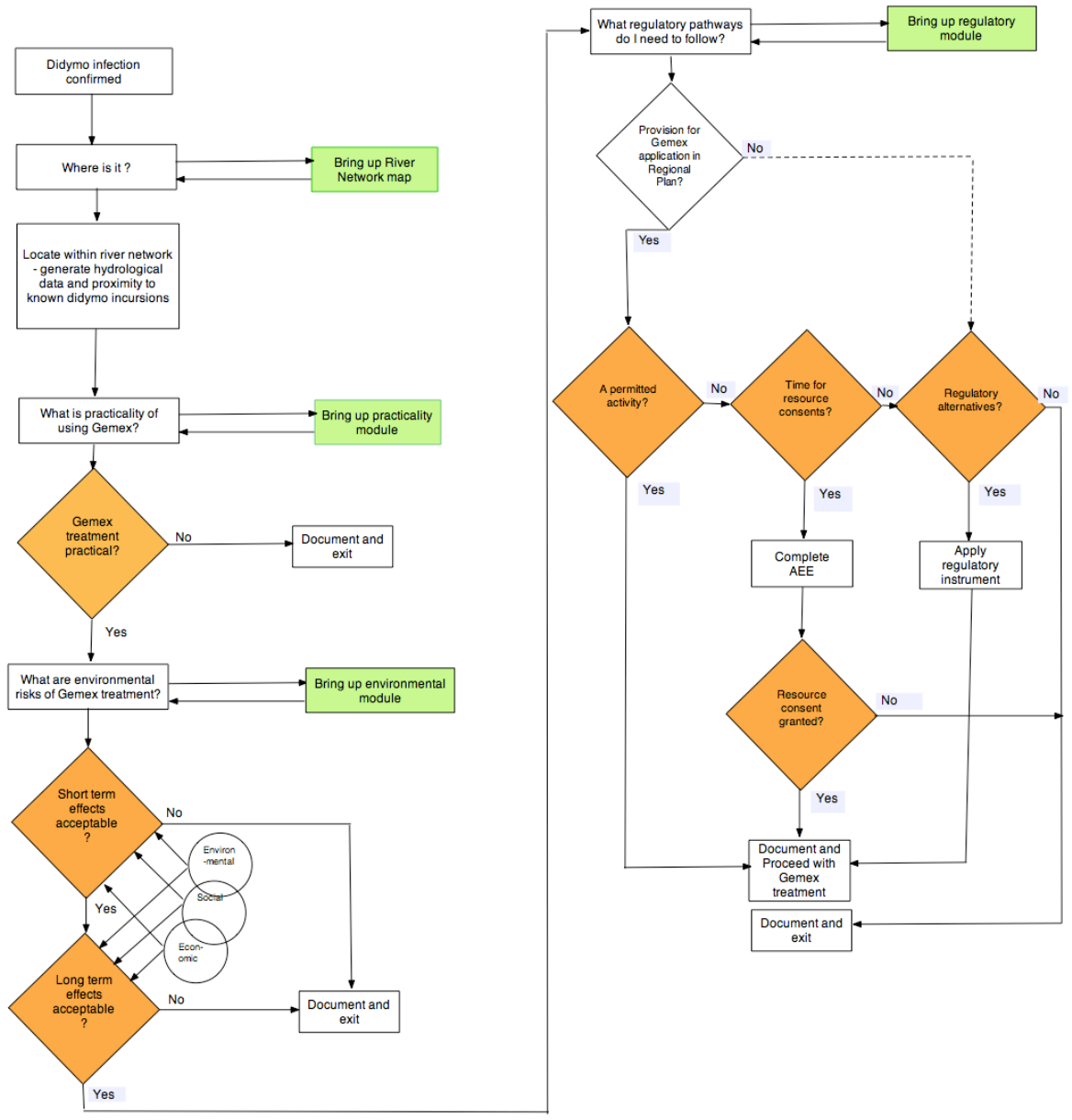


Figure 1. Flow chart showing sequence of decisions in Didymo-Gemex DSS

3. How do I start Didymo-Gemex?

3.1 Installation

System requirements

Before you install Didymo-Gemex, make sure your computer meets the minimum hardware and software requirements.

Any IBM compatible machine with an 80486 processor or higher

A hard disk with a minimum of 50 megabytes available space for installation

Windows 98, Windows 2000, and Windows XP (it may also work with Windows Vista but it is likely that access to help files may be blocked by security measures (see end of 3.4 on how to fix this problem).

Didymo-Gemex will not run properly if your computer does not meet these requirements.

Didymo-Gemex is installed simply by creating a directory such as c:\Program Files\DIDYMO and then copying the files from the Didymo-Gemex CD-ROM provided.

Files created

Didymo-Gemex will create its own ini files (Didymo.ini). This is a simple text file that records default directories and layout. A Microsoft Access database file Didymo.mdb will also be created. This can be stored in the DIDYMO or any other directory.

You can make the program accessible by:

Creating a shortcut

1. Run Windows Explorer (Choose Start Menu | Programs | Windows Explorer).

2. Choose the directory that contains the Didymo program (e.g., C:\Program Files\DIDYMO). Click on Didymo.exe with the right button and select Copy.

3. Move the mouse cursor so that it over the desktop or Quicklaunch bar, click the right button, and select Paste shortcut.

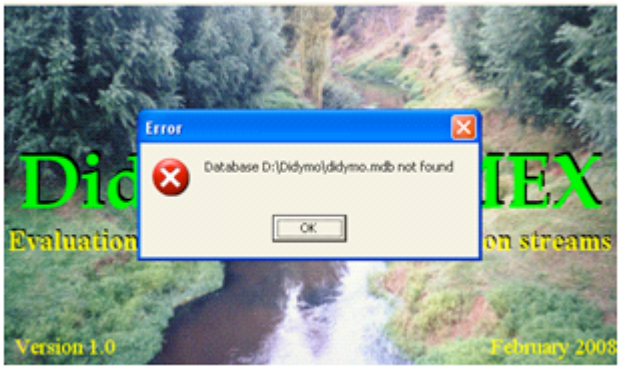
4. Alternatively, click on Didymo.exe and then drag it over to the desktop or Quicklaunch bar.

Uninstalling Didymo-Gemex

To uninstall Didymo-Gemex, simply delete the program directory (normally C:\Program Files\DIDYMO) and any directories and database files (Didymo.mdb) that you have created.

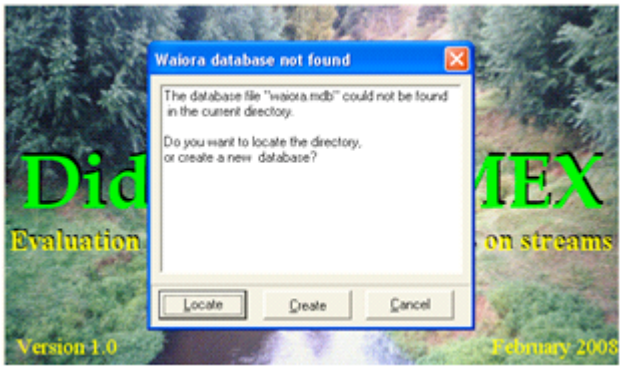
3.2 First Login

The first time that Didymo-Gemex runs, the Didymo Microsoft Access database (Didymo.mdb) will not be found and you will see the following message:



Don't worry!

Press OK and you will be asked whether you want to locate an existing Didymo database or create a new database.



For a new installation press Create and a new database (Didymo.mdb) will be created in the directory that you select. If you subsequently run Didymo-Gemex, and you receive the message "database .. not found" as above, you can locate the appropriate directory. Alternatively, you can create Didymo databases in different directories and select the appropriate directory (Options/Select database) for any stream evaluation.

After the new database is created, you are then given instructions on how to proceed:

1. Login as ANONYMOUS
2. Add yourself as user
3. Login as user
4. Start the evaluation process by selecting the river network

In response you, select ANONYMOUS from the User name drop-down box and then click the OK button.

An anonymous user cannot edit or delete records belonging to other users and database access is restricted. Therefore, you should add yourself as a user (File/Add User) when logged on as ANONYMOUS and then login (File/Login) under that name.

3.3 Normal Login

To start Didymo-Gemex once it has been run for the first time simply double-click the short-cut you have created, or if you haven't created a short cut go directly to the file (e.g. C:\Program Files\DIDYMO), and double-click on Didymo.exe. You will be prompted to enter a user name when the program is started. The last user will be displayed as the default.

If the correct name is not displayed, select your user name from the User name drop-down list box

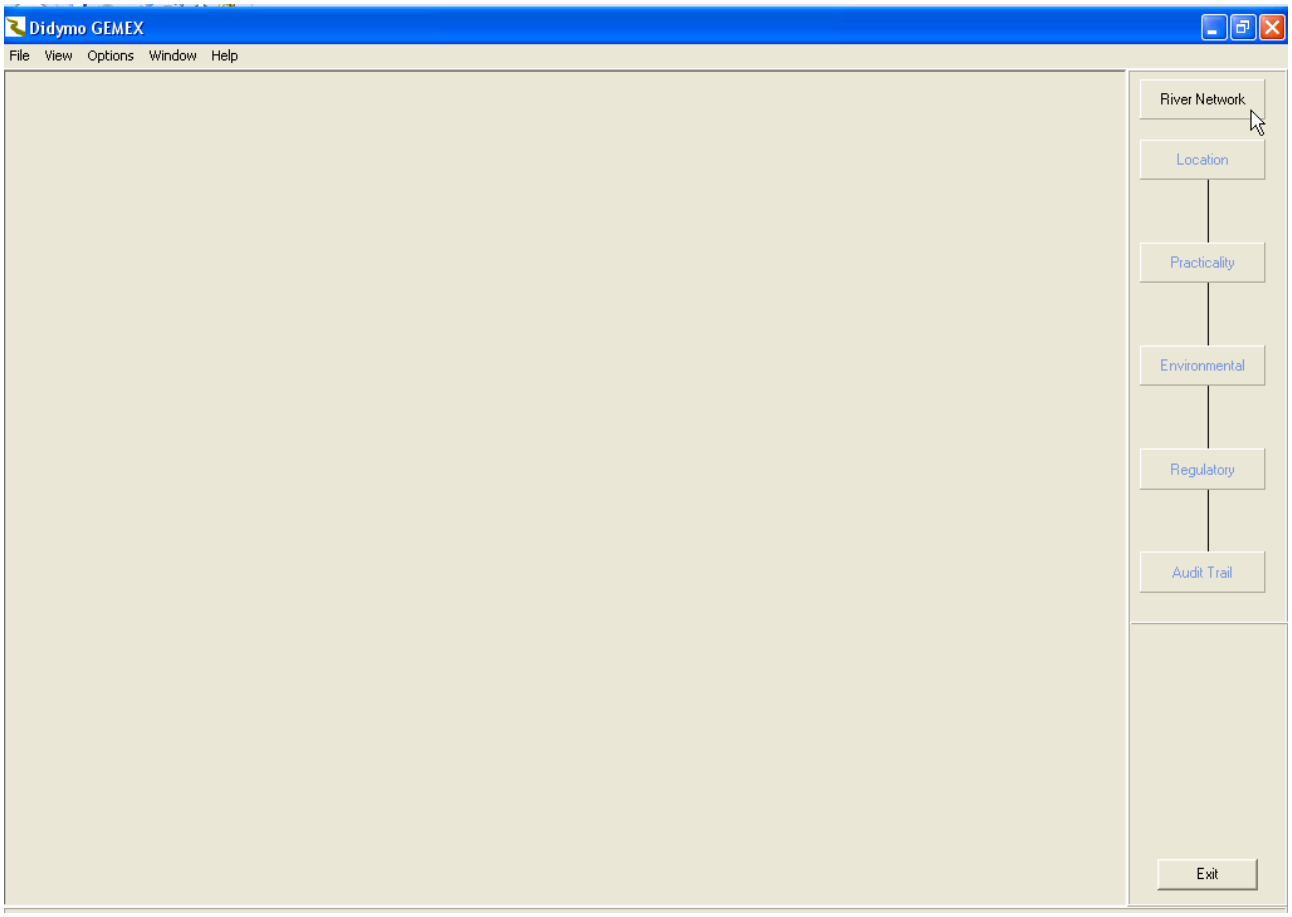
Click the OK button or push ENTER.

If your name is not displayed (as may happen if someone else has done the set-up for you)

1. Select File… Add User
2. Enter the new user name in the User name text box
3. Click the OK button or push ENTER.

3.4 Using Didymo-Gemex

Once you have logged in you will note the sequence to go through the decision-making process is displayed on the right-hand side of the screen (see below). When you click on the first block (River Network) it will be embossed. As you complete each module in Didymo-Gemex the programme will progress to the following one, which will in turn be embossed.



Didymo-Gemex uses data from 3 existing databases to assist you make a decision on whether or not to use Gemex™. These are:

The NIWA River Environment Classification (REC)
The NIWA Freshwater Fisheries database (Fish db)
The MAFBNZ Didymo Samples database managed by ESR.

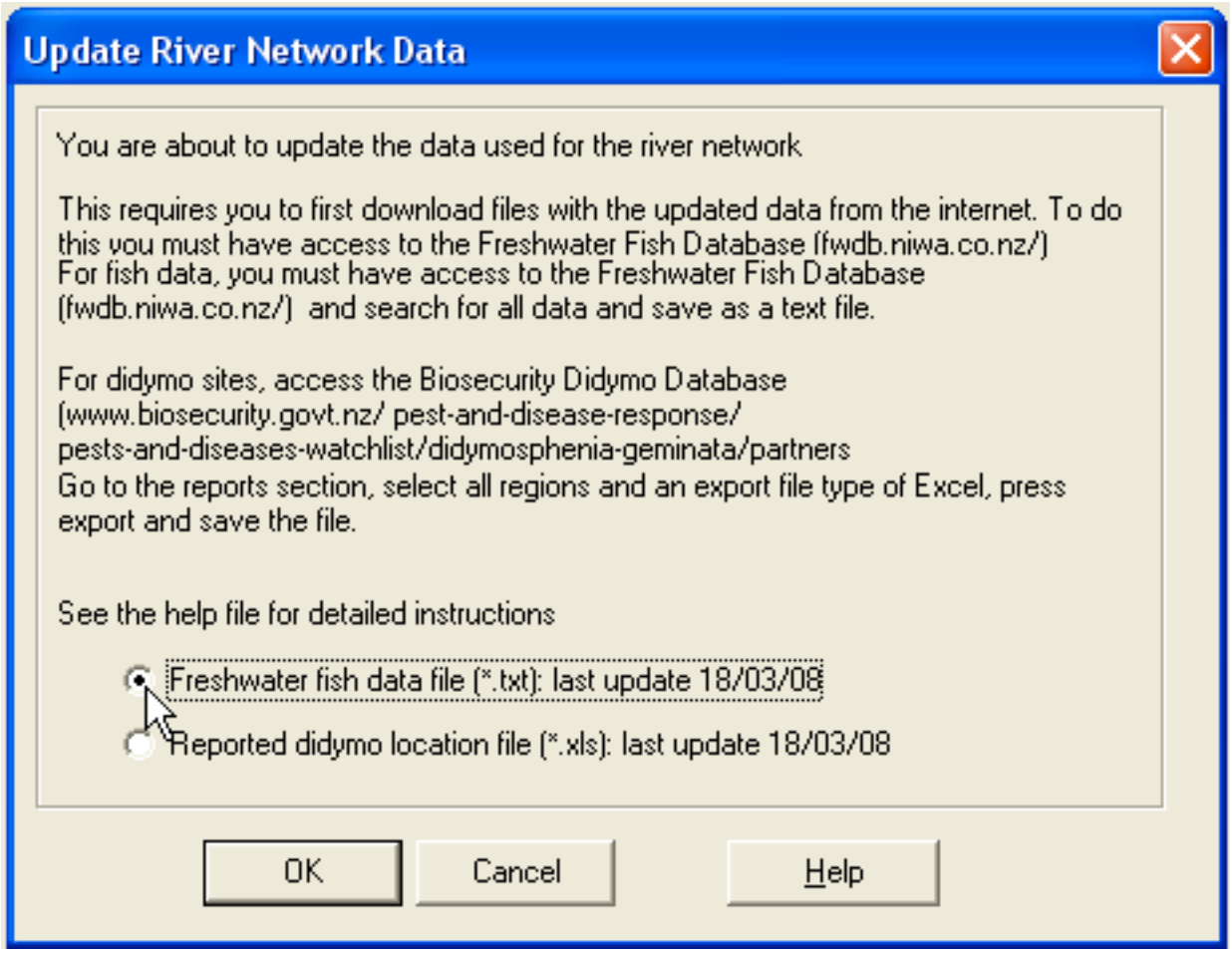
The REC is not expected to change within the next 5 years.

The Freshwater Fisheries Database will change as new records are added to it, however for the purposes of Didymo-Gemex such changes will be very minor.
The Didymo Samples database may change relatively frequently and users (especially in the South Island) who wish to make use of the Reinfection module should update the database monthly.

To check on whether you need to update data go to:

Options … Update River Network Data

The following window will appear:



Note the dates the freshwater fish database and the Didymo Samples file were last updated. If you decide that an update is necessary (probably only necessary for the Didymo Samples file if the site of new infection is the South Island (at this stage) and if the date of last update is > 1 month) then follow the instructions given above

Once you are satisfied that Didymo-Gemex has the most relevant data you are ready to start the evaluation.

The River Network is the focal point of the DSS. Click on this icon and the river network information will load. Once the map is loaded you can progress sequentially through each of the four modules. At the end of each decision module you will be asked to make a decision. The information you enter will be stored and can be exported or printed in the "Audit Trail".

Note: Didymo-Gemex is designed so that there are 'Exit' points at the end of each module (see Figure 1). If you decide to exit, your decisions for so doing can be saved with the record. If you subsequently decide to make further assessment, the site being considered can be retrieved using File…Select Record.

To start the process click on "River Network".

Help

There is a "help" button on each main page. Clicking the help button will take you to the appropriate page of this manual. If you cannot see the help files after clicking the button or you get

a message “The page cannot be displayed”, then it is likely that a Windows security update is blocking your access to the help file (didymo.chm). The solution is to run Windows Explorer, right-click on the CHM file, and select Properties from the popup menu. Click on the Unblock button immediately below the "Advanced" button on the General page. Click Apply to show the content. Once the CHM file has been unblocked, the Unblock button disappears. You will now be able to access the help files.

4. River Network and Location

The River Network is the “engine room” of Didymo-Gemex. It provides the fundamental information on the characteristics of the river/stream under investigation and provides a link to data from the Didymo Incursion database and the Freshwater Fish database.

4.1 Selecting the river reach for potential Gemex™ treatment

In order to progress through the decision-making procedure, you firstly need to locate the upstream and downstream points over which you will apply Gemex™. The upstream point will usually be 1-2 kilometers upstream of the point where didymo infection has been identified. Because didymo cells may be readily washed downstream, the downstream point (which determines the length of the treatment reach) will theoretically be the mouth of the river. However there may be good reasons to treat over a shorter reach. For example:

- The river may flow into a lake
- The substrate of the river changes downstream to one which would not support didymo (upland reach boulders-cobbles -→ lowland reach of silt)
- Reduced water clarity at a point downstream will not support didymo (or other algae)
- Saline intrusion upriver mean will not support didymo.

In practice 2 or 3 of the above conditions may exist in combination, from which you can have some certainty that didymo will not grow, and hence you can reduce the length of the reach over which Gemex™ treatment will be required. If you don’t know whether downstream water quality or substrate will prevent didymo from becoming established seek advice from a qualified freshwater biologist.

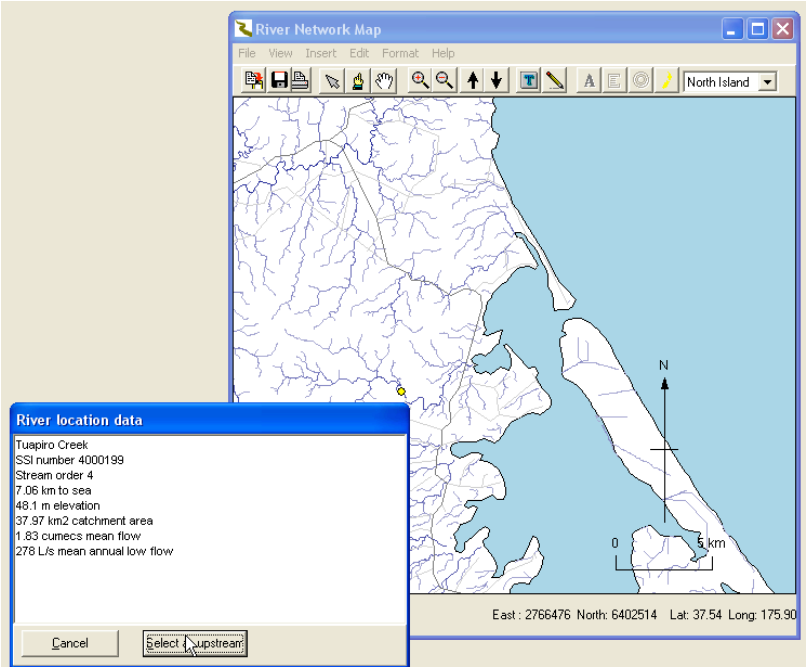
How do I select the treatment reach?

With the river network is displayed, use the hand cursor  to select the reach.

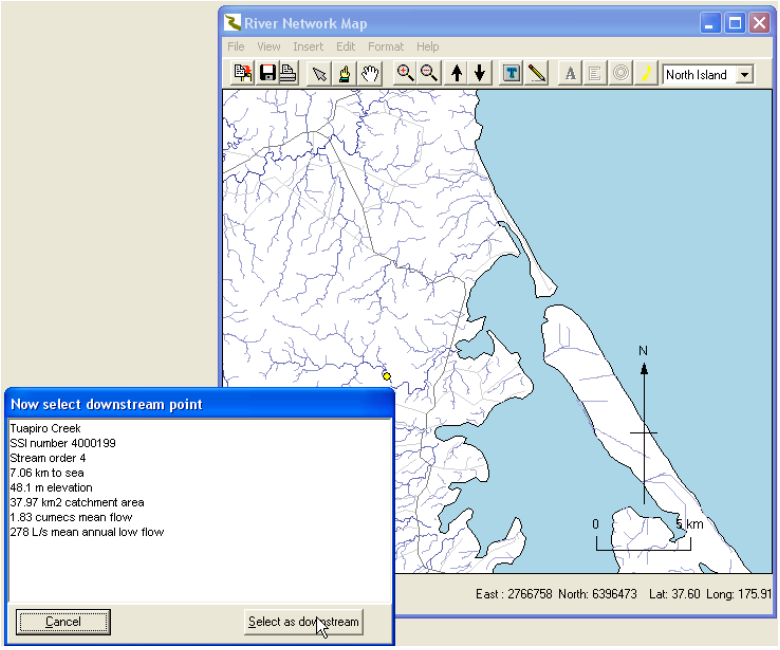
If the cursor is not already a "hand" select the hand cursor from the icon tray at the top of the map window. Then click on the map at the upstream end of the reach that you wish to treat. The map can be moved by using the "grab" cursor  or using the zoom buttons.  (Click on the icon,

and then select a point on the map and, holding down the mouse drag it over the area you wish to zoom in/out on).

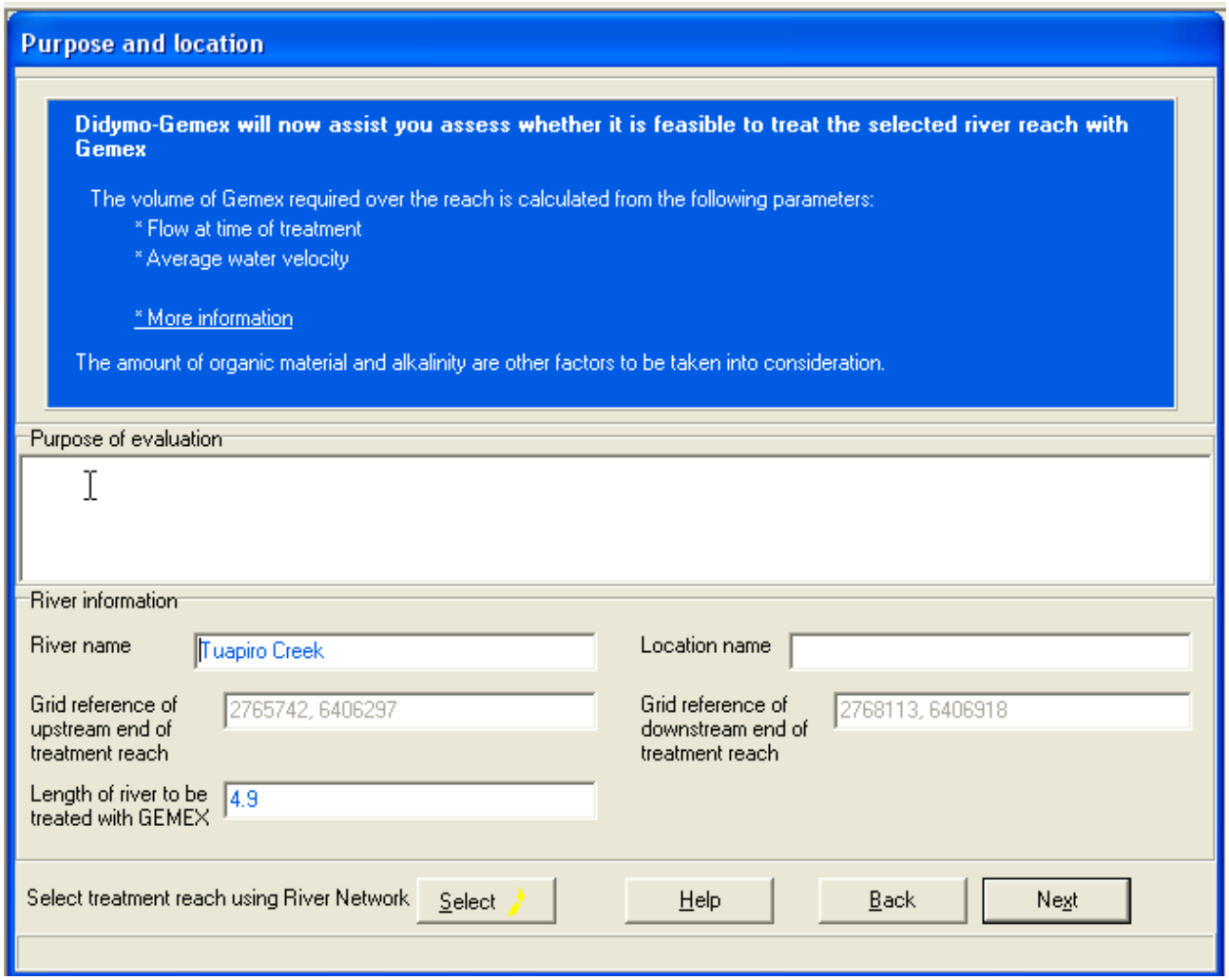
When you click on the map with the hand pointer a yellow dot will mark that location. You are asked to confirm that this is the upstream location.



You are then asked to identify the downstream location and to do this you click downstream with the hand pointer and another yellow dot will be displayed. You are asked to confirm that this is the downstream location.



When you confirm there is a short wait while the program examines the selected reached to calculate hydrological parameters. The following window will appear:



The purpose and location information window contains the following:

Purpose and location - Enter the "Purpose of the evaluation" in the blank window provided. Examples may include Evaluating which rivers in my region are suitable for Gemex™ treatment in the event of didymo being detected", or, "Suppression of didymo in xyz River". The purpose of evaluation will be carried through to the audit trail at the completion of the evaluation.

River name – This should be inserted automatically from the REC database. However the names of some small tributaries will not be in the database. If there is no name in the box, type it in. If you do not know the name type "Unnamed tributary of knownname river"

Grid reference of upstream end of treatment reach – 7 figure NZMS number from program

Grid reference of downstream end of treatment reach – as above

Location name – optional identifier to help you find the reach. E.g. "By Smith's woolshed"

Length of river to be treated with Gemex™ - Calculated distance between upstream and downstream points

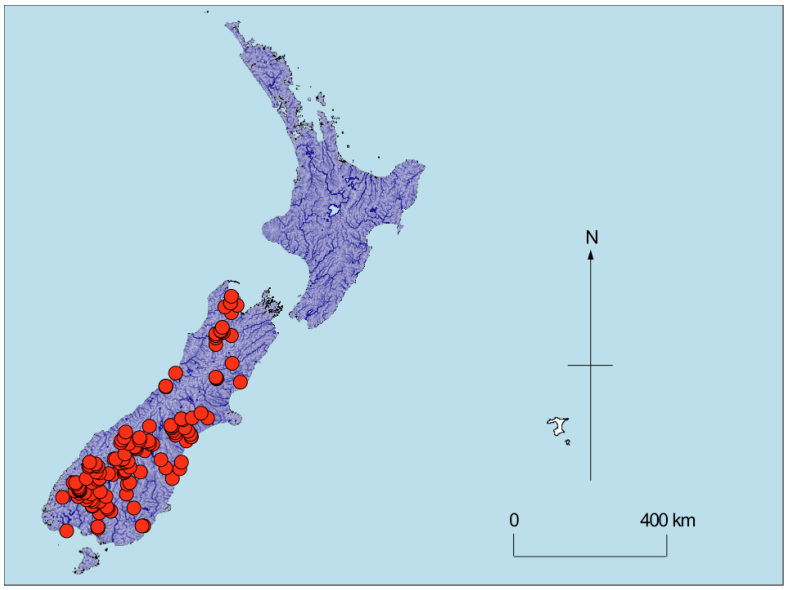
One treatment reach or more?

The hydrological calculations and hence the volume and cost of Gemex™ assume a relatively uniform gradient down the reach. When transitioning from mountainous to lowland regions, hydraulic gradient may change over short distances and care needs to be taken in selecting 'treatment reaches'. Similarly, if the flow changes suddenly within a reach (e.g. a diversion for a power scheme) then the most sensible course of action is to select one treatment reach above the change, and one below it.

4.2 Didymo Incursion Locations

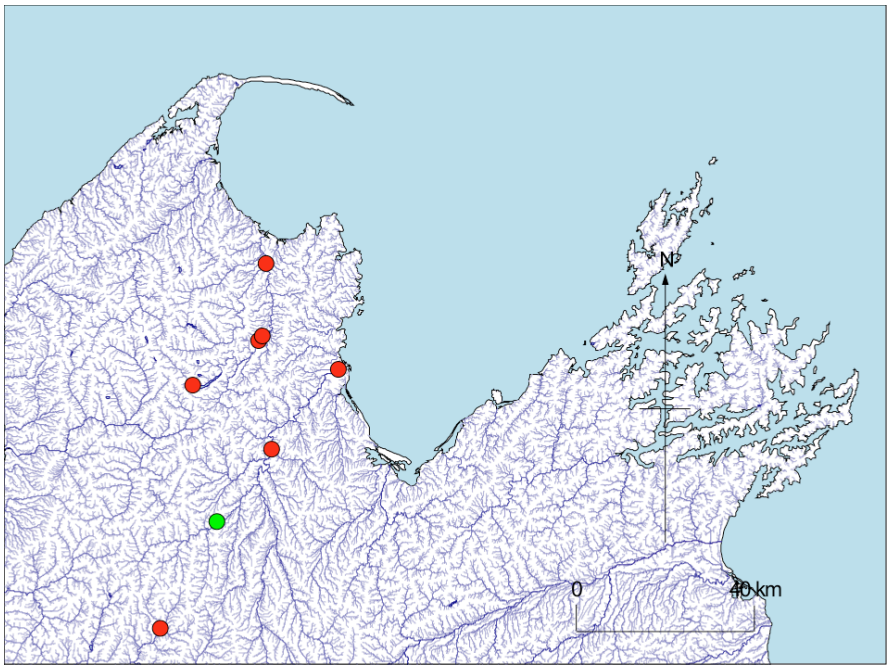
The location where didymo has become established is an important consideration in deciding whether Gemex™ treatment is practically feasible. In most cases you will know whether there is didymo present at other locations within the catchment of the river in which infection has been identified, or in neighbouring catchments. However should you need to confirm sites where didymo is known to occur then Didymo-Gemex provides the location of positive identification from the Didymo samples database.

1. With the River Network map displayed – Click "View - Known Didymo Locations". The locations will be shown as below.



2. If the site of new didymo infection is in the South Island, you may wish to pinpoint the exact location in relation to known didymo incursions.
3. In this case use the click zoom icon or select the Zoom option in the File menu. The cursor changes to a cross. (Unzoom will return you to previous views). Select the required portion by clicking on the top left corner and dragging the selection area to the bottom right corner.
4. You can show the site of new infection in relation to known didymo incursion from the insert menu. *Insert.. Marker*. You will note the cursor changes to a cross. Position the

cursor at the point of the new infection and click.[1] You will note the cursor changes to an arrow again. If you want to change the look of the marker symbol so that it contrasts with the red circles of didymo incursion click on the symbol and go to the *Edit – Text/marker*. Change the fill colour to green and the site of the new infection will display as in the figure below. N.B. You can delete markers from the map using *Edit – Text-marker* and clicking *Symbols – none.* In this case the new point of infection is above a known didymo incursion in the Sherry River (see below).



Clicking the 

button on the "location" screen will move you to the module where you consider the practical feasibility of treating the selected reach.

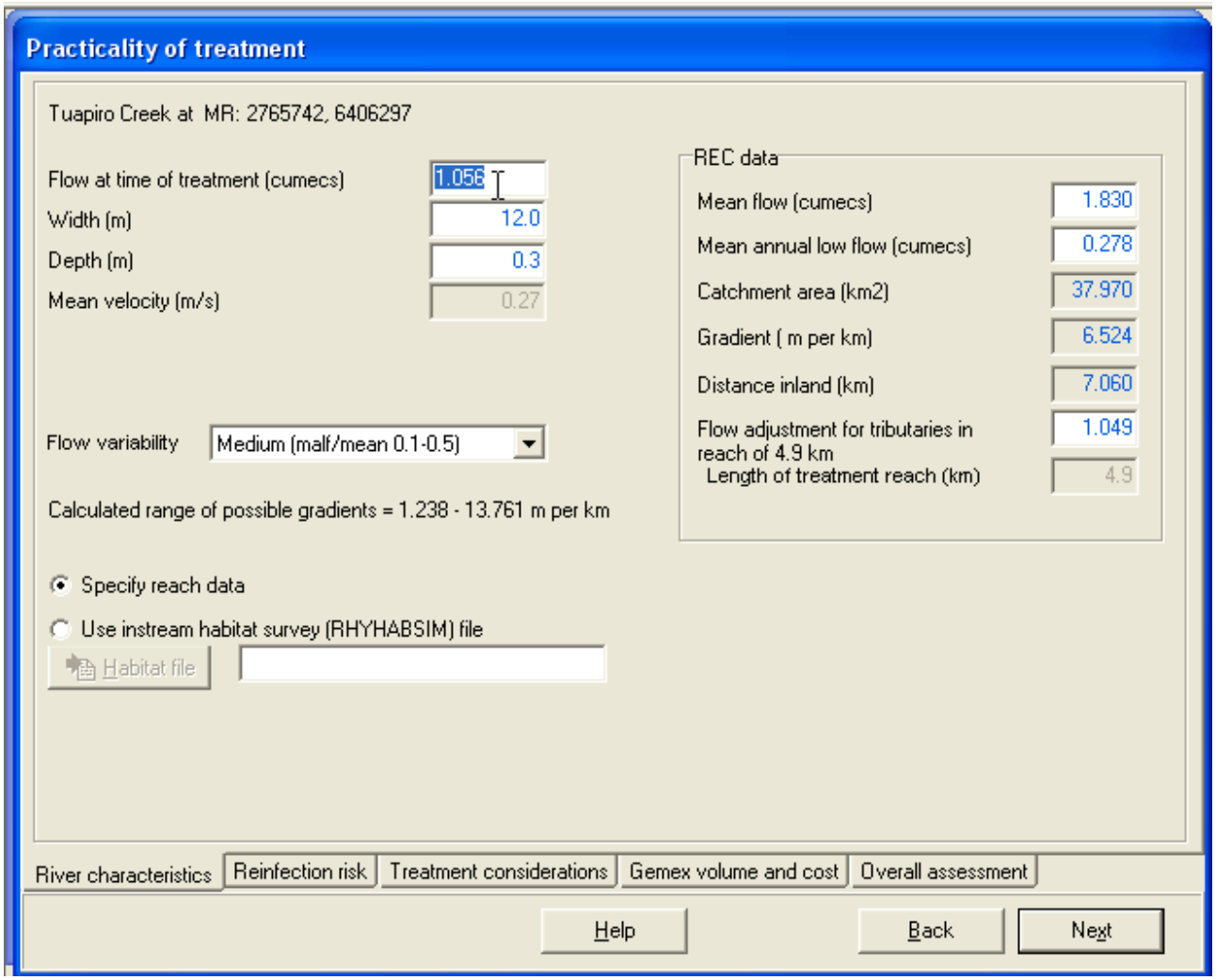
[1] Or you can use the upstream and downstream locator buttons for the selected treatment reach

5. Practical feasibility of using Gemex™ to control didymo

Decisions relating to the practical feasibility of using Gemex™ in a particular river reach relate principally to the proximity of established didymo incursions, flow characteristics, channel characteristics, and access. Each of these aspects affects the effectiveness of Gemex™ at controlling didymo and/or the cost of application. Effectiveness and cost together give a measure of practical feasibility.

5.1 Practicality of treatment

The next screen you see is labeled 'Practicality of treatment'.



Data on the **RHS** of the window is calculated directly from the REC and the user cannot change shaded items.

The ***Distance Inland*** is the distance from the sea of the upstream end of the treatment reach.

Flow adjustment for tributaries estimates the increase in flow downstream brought about by tributary inflows. Without this calculation the amount of Gemex™ needed to raise the stream to the target concentration would be underestimated. The flow adjustment is worked out for every reach of river between tributaries over the treatment length. The treatment length weighted flow is

Sum(L_i*Qi)/Sum(L_i), where L_i is the length of reach between tributaries and Q_i is the flow in that reach. The flow adjustment is the reach weighted flow divided by the flow in the upstream reach.

Default values

Data on the **LHS** contains some default information on the flow at the time of treatment and the average width and depth of the treatment reach.

The default ***Flow at the time of treatment*** is estimated from the flow statistics as the median flow (1.1597mean annual low flow + 0.4011mean flow). The default ***Width***, Depth***,*** and ***Velocity*** values are calculated from NZ hydraulic geometry relationships Jowett (1998) unless a habitat survey has been used. More information

The stream width and depth are calculated from NZ hydraulic geometry relationships (Jowett 1998) unless a habitat survey is used. The relationships are:

width := 11.755* Flow $^{0.4263}$) ;
area := 3.713* Flow$^{0.6594}$);
Velocity := Flow/Area;
Depth := Flow/Width/Velocity;

Jowett, I.G. (1998). Hydraulic geometry of New Zealand rivers and its use as a preliminary method of habitat assessment. Regulated Rivers 14: 451-466.

Preferred values

The ***flow at the time of treatment*** is a critical parameter for determining how much Gemex™ will be required (by simple dilution to get the required in-stream concentration). Whilst the default (median) value may be adequate as a first estimate, it is much better to enter a more accurate estimate of ***flow at the time of treatment*** by estimating the median flow for the season for which the Gemex™ application is planned.

In Didymo-Gemex, ***mean velocity*** provides an estimate of the length of reach that may be treated by a single injection of Gemex™. NIWA tests in Princhester Creek suggested that the treatment was effective for about 2 km and that reinjection of Gemex™ would be required below this in order to treat further downstream (Clearwater et al. 2007). The principal reason for this is that when Gemex™ is injected into a stream, its concentration gradually declines as organic matter in the stream absorbs it. The amount of organic material in a stream will depend largely on the stream velocity (streams with high velocity usually retain little organic material) and consequently the target concentration of Gemex™ can be maintained over a longer length. In Didymo-Gemex, we have assumed that the length of reach that can be effectively treated by an injection of Gemex™ is proportional to the average velocity, assuming 2 km of effective treatment with an average velocity of 0.2 m/s, as in Princhester Creek[2].

The estimate of the number of treatment reaches required over the treatment length will be more reliable if an accurate measure of ***mean stream velocity*** is used.

[2] This assumes that the didymo infestation is not well established. Didymo is unusual in that large mats (i.e. large quantities of organic matter) form in high velocity flows. See section 1.2.

How do I ensure that the best estimate of average stream velocity is used?

A calibrated RHYHABSIM file will give the most accurate measure of stream velocity and how it changes with flow, but may not be available for many locations. Where such information is available, click the radio button "Use instream habitat (RHYHABSIM) file" and then browse your computer or network to input the appropriate file.[3] It should be noted that the RHYHABSIM data would only improve the accuracy of the mean velocity measurement, which is used to estimate the number of Gemex™ injection points. In most case the estimates based on hydraulic geometry should suffice.

Where habitat survey information is not available, the default values provide a useful estimate for "typical" streams. However because they are "typical streams" the hydraulic geometry equations used may underestimate the width of braided rivers or overestimate the width of spring-fed or confined rivers. Didymo-Gemex provides a check on the accuracy of the geometry by comparing the range of calculated stream gradients with the REC stream gradient.

If the actual reach gradient falls outside the range of possible range of results calculated from the stream geometry, the estimate of stream geometry is probably incorrect and should be modified. The "Calculated range of possible gradients" will be highlighted in red if it is outside this range.

1. To change the gradient to bring the calculated range within the actual REC gradient, simply enter a new estimate of stream width, and revised estimates of ***mean velocity*** and range of gradients will be displayed. Changing stream depth will also change the range of gradients and velocity, but changing stream width is generally preferred. Local knowledge and common sense should prevail to ensure that the mean width and depth entered are consistent with what is observed.

Flow variability

The LHS panel also has an assessment of flow variability categorized as low, medium, or high. This estimate is based on the ratio of the mean to median flow. This information assists in deciding whether Gemex™ treatment is feasible or desirable in the circumstances.

5.2 How do I decide whether use of Gemex™ is practical for the selected length of river?

Up to this point Didymo-Gemex has provided factual information on the river characteristics and calculated estimates of the volume of Gemex™ that will be required together with its cost. It is now up to you to use this information together with supplementary information gathered at a local level to decide whether using Gemex™ is practical in the circumstances. This is a value judgment on your part and will depend (amongst other factors) on the value of the river under consideration, the financial resources you have available (or can get access to) and your assessment of how effective Gemex™ will be in the circumstances. The tabs at the bottom of the "Practicality of

[3] Your local Regional Council should know whether or not habitat survey has been done for a particular river reach. Any habitat surveys carried out under 'public good science funding" are freely available. Others that have been paid for by a particular client require permission of that client to use. Ian Jowett (i.jowett@ihug.co.nz) is a good source of information on the availability of habitat survey data.

treatment" window ask you to make decisions based on information prompted in the following sections.

Risk of reinfection

Use the Didymo incursion map (see section 4) to decide whether there is a high likelihood of reinfection from upstream and neighbouring catchments. For example in the Sherry river example shown previously it would be possible to treat this reach with Gemex™ because there are no points upstream of this site where didymo has been confirmed. However in this hypothetical case, new infection at the Kaihiku Stream has occurred upstream of a known didymo incursion in the Sherry River, and with the presence of didymo in neighbouring catchments, there is clearly some risk of re-infection. You need to evaluate this risk based on local knowledge (e.g., river use by recreational users) and conditions to decide whether it is worthwhile treating the river with Gemex™. Note while there have been reports of didymo moving upstream (e.g. the Kakanui), and conjecture that this has been caused by wading birds, it is much more likely to have been due to fishermen since the sites of new infection coincided with known trout pools or the confluence with tributary inflows.

There may also be good reasons for simply controlling the extent of didymo growth in the reach (e.g. keeping a swimming hole highly valued by the local community clear of undesirable growths during the summer) in which case Gemex™ treatment may still be justifiable.

Flow characteristics

The amount of Gemex™ required to treat the length of river selected is directly related to the flow at time of treatment. Didymo-Gemex has given you an estimate of this amount and its cost. Didymo-Gemex has also given you guidance on flow variability (low-medium-high). High flow variability indicates that there is a high likelihood of a flood event in the near future that could (a) scour the bed and flush didymo growths out of the affected reach, or (b) coincide (or be near) with the time of treatment. Conversely, low flow variability indicates high bed stability and little likelihood of a flood event in the near future that could affect didymo growths or interfere with Gemex™ application.

You should consider the following in deciding whether the flow characteristics favour Gemex™ application.

1. Is my objective to (a) simply control nuisance growths of didymo, or (b) to eliminate (if possible) didymo from this reach of river?

If you simply wish to control nuisance growths, consider the flow variability. If it is high then there is a high likelihood of nature doing the job for you. If it is low, then Gemex™ application is your only realistic option. A low flow variability also indicates that you can plan the Gemex™ treatment with more confidence that flow at the time of treatment will be as predicted. If the river has medium flow variability then more analysis of the flow record may be justified in order to determine, for example, whether there is a strong seasonal bias in flood events that might influence your decision.

If your objective is elimination, then Gemex™ is the only option. However Gemex™ application during a period of low stable flow, immediately followed by a flood event is likely to increase the chances that didymo cells will be both killed, and flushed from system (i.e. minimize the chance of recolonisation in the event of <100% kill).

2. Is it feasible to inject Gemex™ given the predicted river flow at the time of treatment?

The volume of Gemex™ required is directly related to the flow at the time of treatment. Flow strongly influences feasibility and effectiveness as, in general terms, the greater the flow, the more difficult it is to inject Gemex™ at a controlled rate sufficient to reach the target in-stream concentration. To date, Gemex™ has only been applied to a small stream (Princhester Creek, Q =0.243m^3/s) where it was relatively straightforward to apply Gemex™ from a bankside installation where the portable diffuser covered the entire stream width. Larger rivers may require more specialist equipment to apply Gemex™, including the possibility of multiple injection diffusers in order to reach the target concentration across the full width of the river. In addition, it may be difficult to transport large quantities of Gemex™ to the riverside. If you have concerns over whether the flow will cause logistic difficulties you should contact a recommended applicator. The Didymo Long Term Management Coordinator at MAFBNZ will be able to assist finding suitable applicators in your region.
The amount of Gemex™ required is also an important consideration. Currently there is only 2,600L of Gemex™ concentrate stockpiled (1000L in North Island and 1600L in South Island). NIWA (GTPC, 2007 Section 3.3) states that the manufacturer requires 4 weeks notice for quantities in excess of 2000L and that raw materials (if not available in NZ) may take 4-6 weeks to get here (GTCP, 2007). Therefore if the quantity of Gemex™ required exceeds 2,600L because of the river flow, it would not be possible to treat the river for at least one month, unless larger quantities of Gemex™ or raw ingredients have been stockpiled in the interim. Given that Gemex™ is most effective on rivers at an early stage of infection (Clearwater et al 2007) this is a cause for concern.

Stock access and recreational river use will also increase risk of didymo being spread during/before treatment period.

Channel characteristics

For Gemex™ application to be effective, the in-stream concentration needs to be maintained at ~20g/m^3 for 1 hour. Factors that will affect the distance downstream that this concentration will be maintained include the amount of organic matter in the river (adsorbs Gemex™ and therefore reduces the concentration) and the nature of the channel morphology (i.e., as it influences the amount of dispersion).

You should consider the following in deciding whether the channel characteristics favour Gemex™ application.

1. Is the observed organic matter content consistent with the predicted mean velocity?

Didymo-Gemex uses mean stream velocity as a surrogate for the amount of organic matter present, and therefore the length of reach that may be treated effectively. There may, however, be local factors that mean there is more organic matter present than expected (it is unlikely there will be less). For example if the stream drains wetland soils there may be high levels of dissolved organic matter, or point sources may add organic matter to the stream (though this is unlikely in a didymo-infected reach). There may also be large amounts of benthic algae (other than didymo) present at moderate-high velocity rivers (which can occur in regulated rivers) and this may reduce Gemex™ concentrations at a higher rate than expected simply on the basis of velocity.

Didymo mass will have a very strong influence on effective treatment distance. Didymo mats can absorb huge quantities of Gemex™ (Clearwater et al 2007b) –and when present will therefore be the primary determinant of effective treatment distance. If you suspect that organic matter in the treatment reach is anomalously high or didymo mats are present you should seek advice from a

qualified scientist as to what the implications might be in terms of reducing effective treatment length.

2. Will channel morphology reduce the effectiveness of Gemex™ treatment?

The ideal stream for Gemex™ treatment is one in which a single channel is contained between two banks and inflows are defined tributaries. With this configuration we can assume that most didymo cells in the river will come into contact with Gemex™ at the target concentration. However for braided and/or spring fed rivers these conditions may not be met. In a braided river, multiple mobile channels flow across and within a gravel floodplain. The lateral and vertical limits of the river include the entire width of the floodplain and the saturated depths of the alluvial aquifer, within and across which the river moves as a single body of water.[4] In such a braided river system we cannot assume that all didymo cells present will come into contact with Gemex™ at the target concentration, although there is some evidence this may be achievable.
Even single channel can have significant groundwater input, which if not recognized could dilute Gemex™ to below target concentrations. Flow gauging above and below the suspect reach may be necessary to confirm if this is the case and make allowance in terms of initial dose. Monitoring of actual Gemex™ concentrations at multiple locations on the waterway during treatment is essential to detect such influences on efficacy.

The cost of Gemex™

Once you are happy that the hydrologic and hydraulic geometry estimates are the best possible in the circumstances Didymo-Gemex calculates the volume of Gemex™ required and the cost of chemicals.

The information displayed is as follows:

1. The length of river reach over which Gemex™ will be effective (based on mean velocity),
2. The volume of Gemex™ concentrate (30g/L) required for a one hour treatment of this river reach, and its cost,
3. The cost of treating the whole length of river selected, the number of equidistant injection points, and the total cost of chemicals allowing for the downstream flow increases.

Explanation. The cost of Gemex™ concentrate (30g/L) quoted by the manufacturer is $3.50/L. The cost quoted is simply the number of litres x $3.50. It does not include the cost of transport or application of Gemex™. Nor does it include the cost of monitoring for regulatory compliance. These costs are discussed further in the next section.

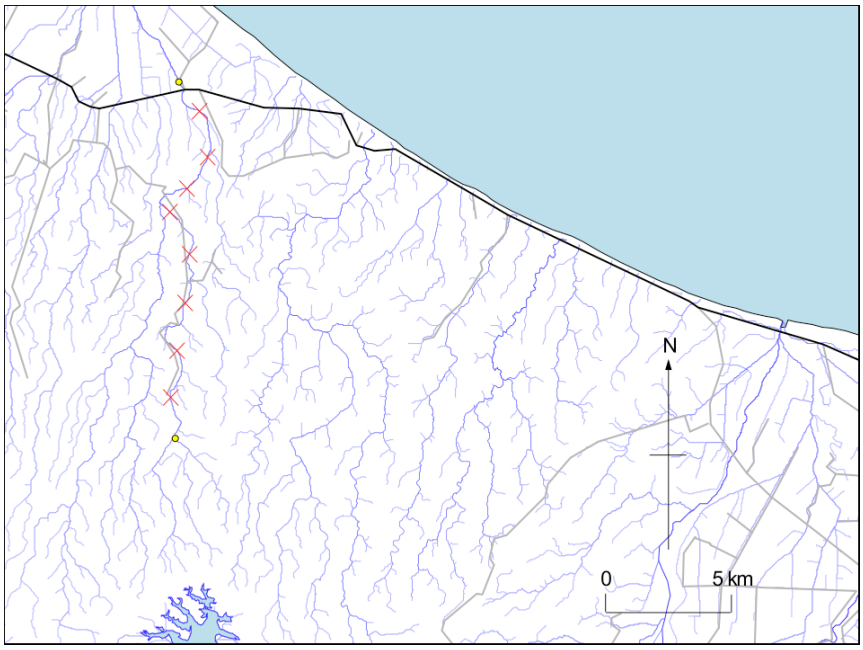
Access

Gemex™ treatment will not be effective unless the target concentration is maintained for ~1hour along the entire length of river selected. Adsorption of Gemex™ on to organic matter reduces this concentration and determines the river reach length over which it can be applied. Didymo-Gemex estimates this length using velocity as a surrogate for organic matter and determines the number of injection points required. Gaining access to the identified injection points (or close by) is therefore critical to the effectiveness of the Gemex™ treatment. Didymo-Gemex can assist you to determine

[4] Gray, D. and Harding, J.S. 2007. "Braided river ecology." Department of Conservation Science for Conservation Series No 279.

road access to the identified injection points, although local knowledge and topographic maps can provide more detailed information.

How do I do this?
On the river network map, go to Format –Roads. A box "Line format" will appear. Pull down the "Show main roads to level" **2**. Click style "solid", ensure colour is "black" and make and pull down the line thickness box to **4**. Your map will look like the one below with main roads in black and secondary roads in grey.
In the example below (Bay of Plenty) Didymo-Gemex has determined that the target river length (between the two yellow dots) requires 9 injection points at ~2km intervals. You can use the scale on the map to position markers (Insert –Marker) on the map. The markers can be changed by clicking on the marker and then going to Edit –Text/marker). In this case the markers have been changed to a red cross. In this case you can see that that there is reasonably good road access to the planned injection points so there should be no problem. In other cases however, there will be no roads, and you will need to ascertain whether helicopter access is feasible and factor that into your costs.



Total cost of Gemex™ treatment

The total cost of Gemex™ treatment is the sum of:

Cost of chemicals
Cost of transport and application
Regulatory costs and monitoring

Didymo-Gemex provides an estimate of the cost of chemicals. NIWA (2007) estimated that the cost of transport (dangerous goods) and application for the Princhester Creek trial was $8-$10K, however this was for a single injection point with good access, and did not include regulatory costs

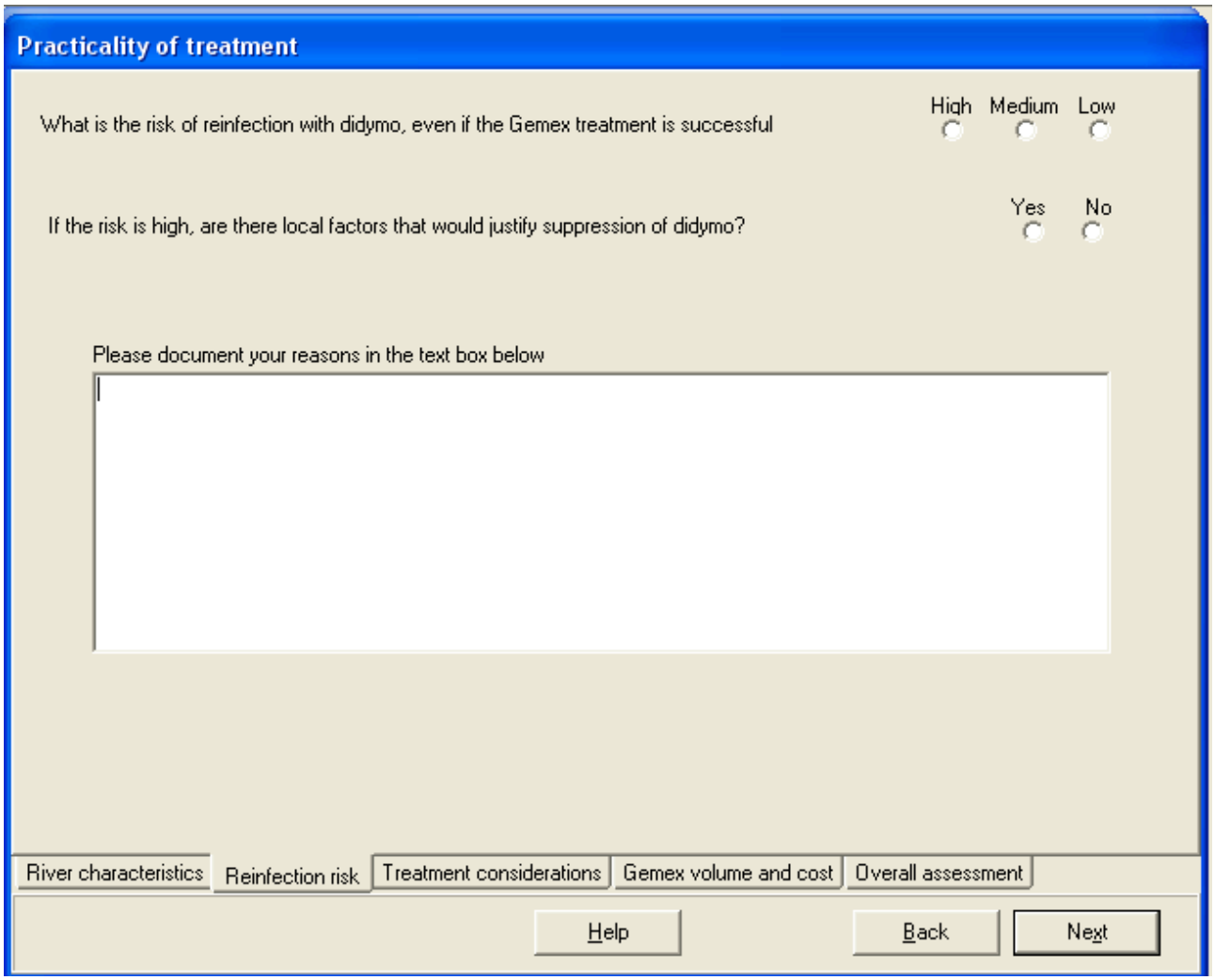
and monitoring. You will need to estimate costs based on local conditions and access. If helicopter transport or special equipment is required, these costs will be higher.

Regulatory and monitoring costs are highly variable and depend upon the conditions placed upon the Consent for Gemex™ application (or other requirements if a different regulatory pathway is used see Section 7). You should discuss likely regulatory and monitoring requirements with the consents manager of your Regional Council at an early stage in order to estimate these costs.

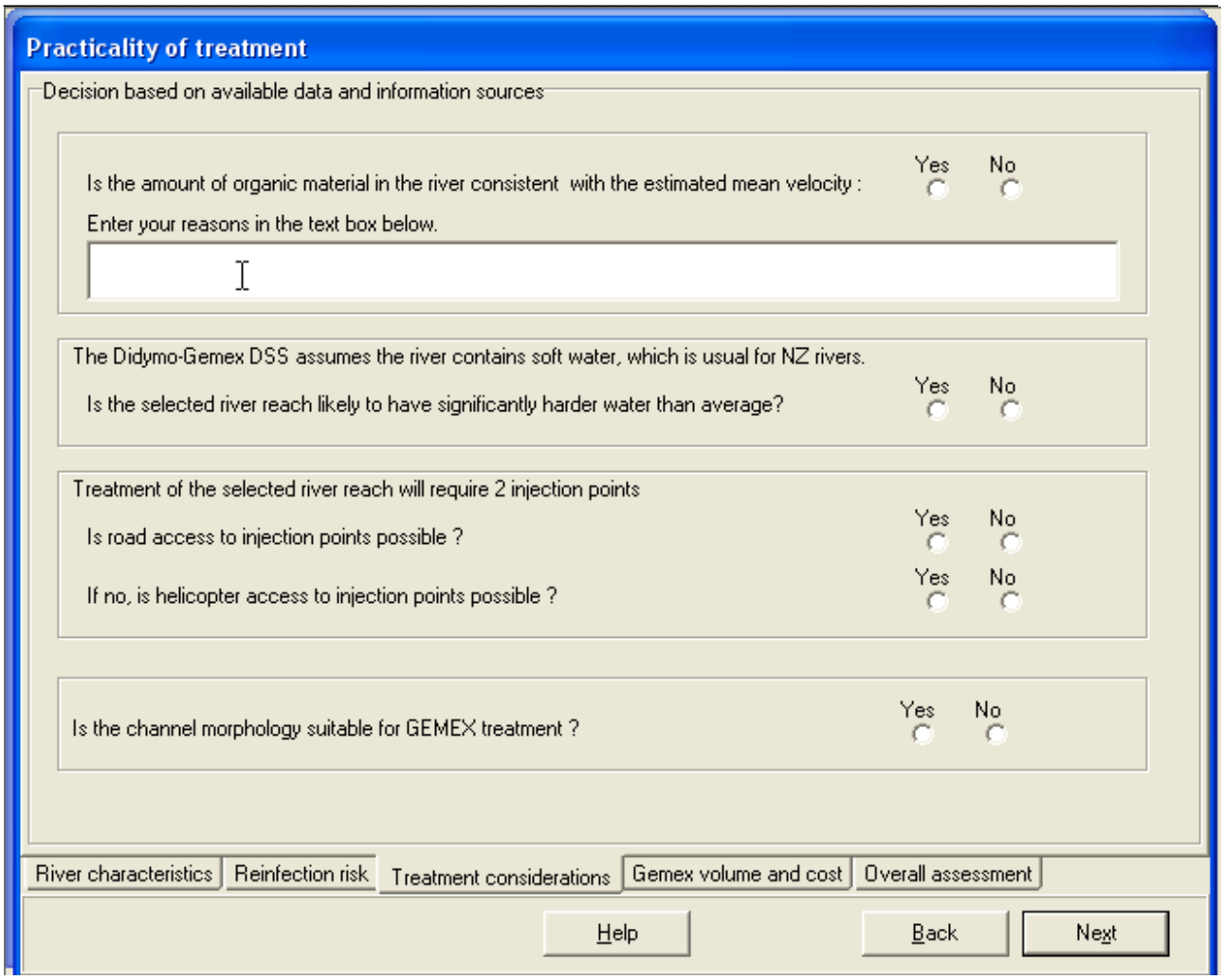
The assessment as to whether the cost of Gemex™ treatment is justifiable is entirely a value judgment. It will depend upon the value of the river (and surrounding rivers) in question. A didymo infection of the Tongariro River for example, could cost many millions of dollars in lost revenue to the tourism and trout fishing industries, and the cost of Gemex™ treatment has to be measured in that context. It should also not be assumed that Gemex™ treatment is not feasible if the estimated costs are high. If, for example, the infection being considered is the first in the North Island, it is in everyone's interest (in the North Island anyway) that every possible step is taken to eliminate it. In such a case you may need to consider alternative regulatory pathways (see section 6), which may lead to alternative funding sources.

5.3 Decision on feasibility of treating the selected length of river with Gemex™

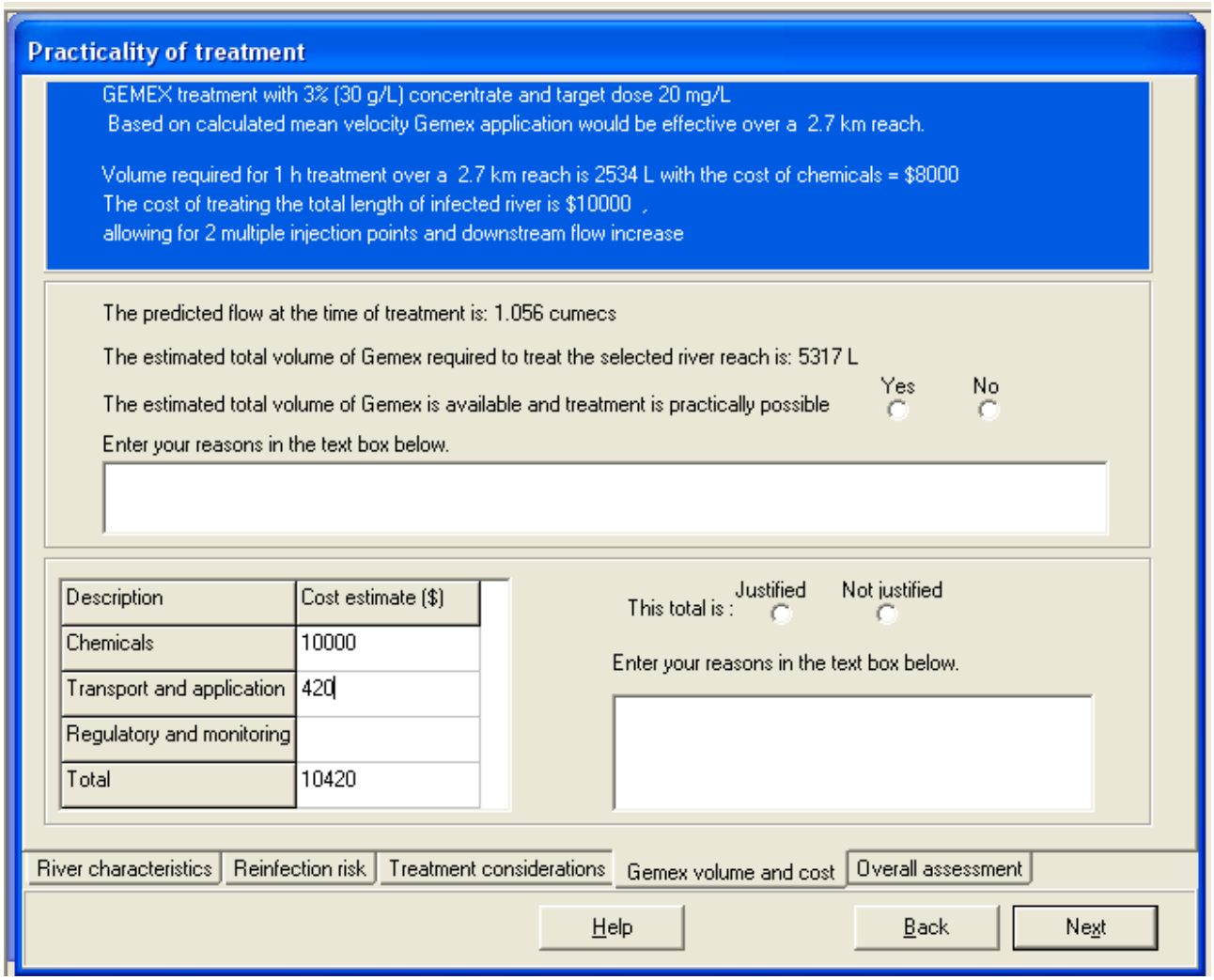
Based on the guidance given above, you will be asked to record your decision relating to the practical feasibility of Gemex™ treatment in the four tabs. Screen shots of these tabs are given below.



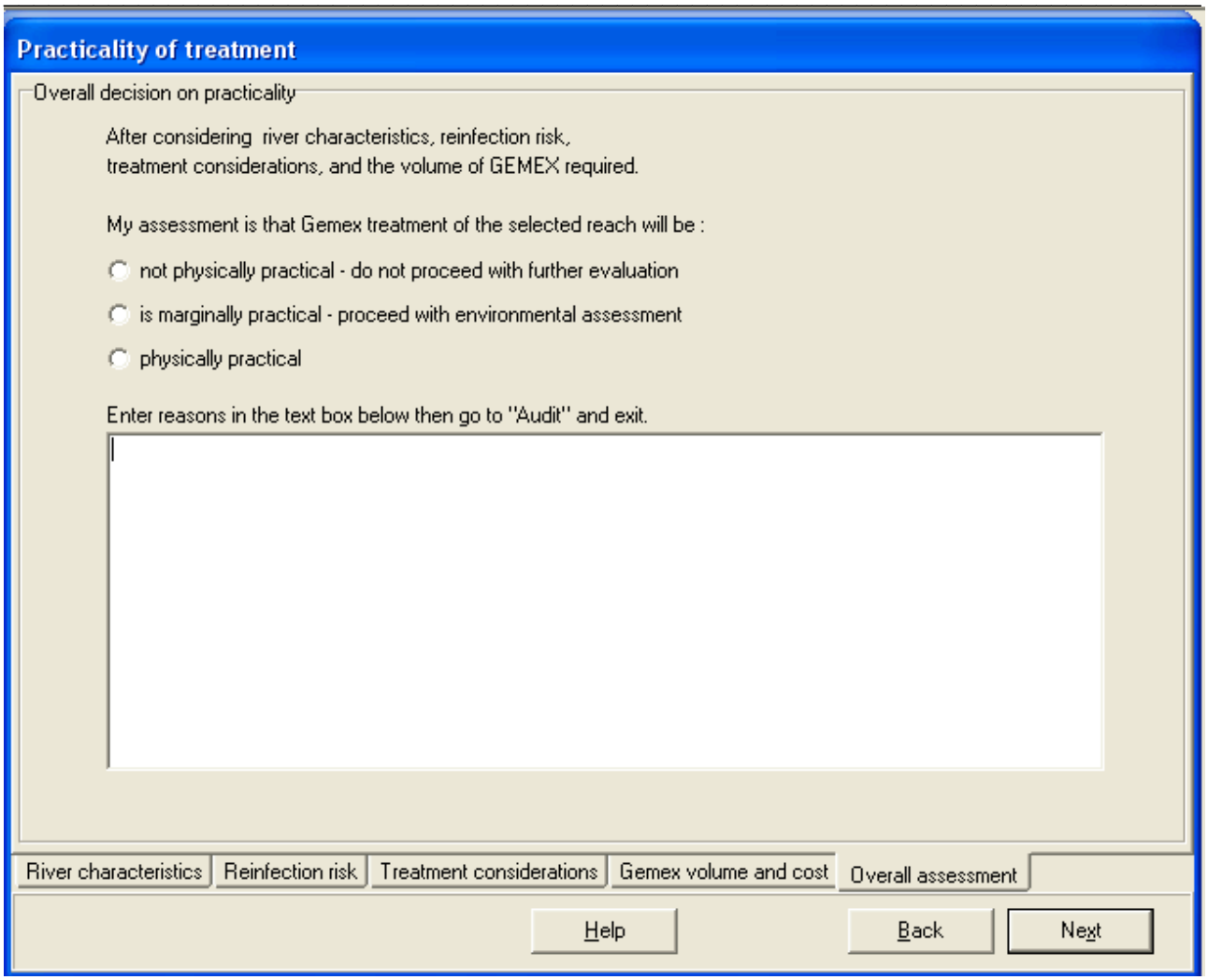
Decision on risk of reinfection



Decision on treatment feasibility. Note that Didymo-Gemex calculates the number of injection points for the selected river reach based on the distance, mean velocity and increases in flow from the upstream point due to tributaries. In most cases there will be more than one injection point over a reach (see next screen). In some cases many injection points may be required to treat the whole reach. Assessing whether this number of treatment points is practically feasible in terms of access and cost is one of the decisions you will need to make. Clearly injecting Gemex™ at all point simultaneously is not practical and the most sensible application scheme is to start at the upstream site and work downstream.



Decision on cost of Gemex™ treatment. Note the cost of chemicals is calculated by Didymo-Gemex but the user has to enter cost estimates for transport and application, and regulatory and monitoring requirements.



Overall decision on practical feasibility. Note – if you click the 'Not physically practical' box when you click the 'Next' button you will go directly to the audit trail without completing the environmental or regulatory modules.

6. Environmental Assessment

6.1 Introduction

Adding any chemical to a natural waterbody will have an environmental effect. It is, however, the significance of the environmental effects on non-target instream species as well as users of the resource, which regulatory authorities must take into account when deciding whether to allow the application of the chemical to go ahead. In the case of Gemex™, the maximum in-river target concentration is 20 g/m3 for a period of one hour. This provides a useful boundary condition upon which to assess the significance of environmental effects.

Didymo-Gemex provides information on the fish species downstream of the identified treatment reach (from the NIWA Freshwater fisheries database). However this is only one of a large number of factors that must be taken into account when deciding whether Gemex™ treatment will be environmentally acceptable. While the object at this stage is to identify any major problems, a similar range of issues to that for a full Assessment of Environmental Effects (see Section 7 and Appendix 1) needs to be canvassed, only in less detail. It is important that all affected stakeholders are comfortable with the proposed treatment and therefore the assessment of effects needs to go beyond simply the biophysical effects, and include social, cultural, and economic considerations.

Matters likely to be considered by regional councils

The following matters, while not exhaustive, are likely to be considered by regional councils when assessing the effects of a discharge to water.

• Water quality	• Comparison of discharge with defined water quality guidelines
• Rare and endangered species or species of national importance.	• Areas of significant natural value
• Areas being managed in their natural state	• Non-target species
• Trout and salmon	• Human health
• Cultural values	• Groundwater implications
• Water takes	• Relationship to wetlands
• Accumulation of copper	• Treatment methodology
• Management of spills	• Discharges to air (spray, odour)
• Impacts on other users	• Measures to mitigate effects
• Term of consent	• Consultation undertaken
• Implications of other discharges	• Timing of discharge
• Use of tracer dye	• Property ownership
• Mixing zones (relevance)	• Aquatic ecosystems
• Any exceptional circumstances that may justify effects	• Current ERMA approvals
• Other resource consents already held relevant to the use of Gemex™.	• Potentially affected people or groups
• Impacts of didymo on the environment versus impacts of Gemex™.	

The following sections sets out our understanding of the environmental effects of Gemex™ at the target concentration. It is set out as frequently asked questions (FAQs). For each section a brief answer to the FAQ is presented in this Help file. Links are provided to more in depth explanations and additional references should you require them. It is important that you read and understand all the relevant issues covered in Sections 6.2-6.13. Section 6.14 guides you through the decision making process for whether treating the Didymo-infected reach with Gemex™ will be environmentally acceptable.

6.2 What is Gemex™?

Gemex™ is a copper-based biocide, specifically designed to treat didymo, while minimizing impacts on non-target species.

It is a mixture of copper sulphate (which is also a common garden fungicide) with relatively simple organic molecules, which act as chelating agents (Clearwater et al. 2007b, ERMA 2007).

Copper and copper chelates have been commonly applied to treat waterways for aquatic weeds, especially in Florida. They are also commonly used as a treatment for fish diseases and to remove algae in aquaria.

The chelating agents themselves are not toxic. They are commonly found in living organisms, are metabolic by-products and are also found in foodstuffs.

6.3 What are the short-term non-target impacts?

Algae

There is short-term inhibition of some non-target algae. However, rapid recovery is expected by the existing algae in the treated reach and through recolonisation from upstream.

Benthic invertebrates

Short-term negative effects may include a minimal to moderate decrease in the numbers of some sensitive species (e.g. amphipods) and life stages, However the Princhester Creek trial showed minimal impact on the majority of the benthic invertebrate community three weeks post-treatment. Such an impact can be regarded as acceptable because invertebrate populations in rivers normally undergo wide fluctuations in population, e.g., from flow perturbations. NIWA expects rapid recolonisation from resistant life stages and from drift from upstream. Laboratory trials also show minimal sensitivity of larval mayflies, snails and juvenile koura to short-term (1-8 hour) exposures to Gemex™ (Clearwater et al., 2008). Note that longer exposures (e.g., days to weeks) even of very low Gemex™ concentrations (<0.5 g/m^3) would probably have a significant impact on invertebrates.

Trout

Gemex™ can be toxic to trout in some cases. Predicting impacts on trout is complex and depend on the rate of loss of Gemex™ downstream and the water pH and hardness.

Most NZ freshwaters are soft and the following will apply to most NZ Rivers. Gemex™ is quite acidic, so it lowers the pH at the application site. This low pH results in high trout survival, and because exposure times are short, the low pH is not toxic itself. However, as pH increases downstream and the Gemex™ dose is spread out, significant impacts to trout may occur. The zone of impact is from ~1 km to ~4 km for reaches with a high algal biomass and may be longer for rivers with a low algal biomass, and hence less adsorption and removal of Gemex™ although this is difficult to predict.

In hard waters, the effects of Gemex™ are yet untested. The high alkalinity will buffer the water, so pH is higher (and this enhances Cu toxicity) but this will probably be offset by the inhibition of Cu toxicity by high concentrations of hardness ions Ca^{2+} and Mg^{2+}.

Native Fish

In general Gemex™ appears to be less toxic to native fish species, than juvenile rainbow trout. Both migratory and non-migratory galaxiid species appear to be relatively resilient to Gemex™ exposures. Upland bullies (a non-migratory species) were intermediate in sensitivity to Gemex™ compared to juvenile rainbow trout and galaxiids (Clearwater et al. 2008). Gemex™ treatment effects are therefore expected to be insignificant on common galaxiid populations. On the basis of the known toxicity of copper to adult eels, Gemex™ is expected to pose minimal risk for eel populations. Gemex™ will probably be more toxic to juvenile life stages of all species (e.g., migrating whitebait), so an increased impact of a Gemex™ treatment during spawning or larval recruitment seasons should be accounted for in the assessment of potential environmental effects (Clearwater et al. 2008).

Although Gemex™ has been tested on 4 native fish species which increases our confidence in the prediction of impacts on other species, we cannot predict effects on all species, particularly those with physiological adaptations to unusual environments – this would potentially include rare and endangered species. In conclusion, caution should be exercised when rare or endangered species, or large numbers of juveniles are present. If significant mortality occurred, some rare galaxiid populations with limited distribution (i.e., especially non-migratory species) might not recover at all because of recruitment limitation. Some pre-testing of Gemex™ tolerance is recommended (this can be conducted very quickly) and management (e.g., temporary removal of founder populations) should be considered to reduce risks (Clearwater et al. 2008).

Mussels and koura

In laboratory trials, both juvenile and adult koura survived a range of Gemex™ exposures expected to occur during a 1-hour river dosing. There was no significant Cu bioaccumulation in adult koura. The uptake of Cu from the diet, via Gemex™ contaminated periphyton, was not examined but dietary Cu bioavailability is low and so the risk is thought to be much lower than uptake from water. These data indicate that a Gemex™ treatment will have minimal effects on koura populations or will present minimal risk to human consumers of adult koura (Clearwater et al. 2008).

There was 100% survival of freshwater snails exposed to a range of Gemex™ concentrations for 1 to 8 hours. The snails avoided exposure by retreating into their shells; a similar response is expected of freshwater mussels (Clearwater et al. 2008). It should be noted that in general, shellfish (bivalves and snails) are relatively sensitive to copper (96 h LC_{50} <20 ppb), so if a different

Gemex™ dosing regime were used resulting in exposures lasting longer than 8 hours, much greater toxicity would be expected.

Birds

Birds are not sensitive to copper and no effects are expected. There may be some issues associated with effects of low pH on wading or swimming birds but there have been no studies to quantify these effects. In cases where birds are rare or endangered, a precautionary approach should be taken, such as keeping them out of the water during the 1 h that the main pulse passes.

Further explanation and notes on short-term non-target impacts

Algae

NIWA found significant growth inhibition (but <46%) of a sensitive green alga (*Pseudokirchneriella subcapitata*) at a Cu dose of 20 mg/L as Gemex™ for one hour (Jellyman et al. 2006, p13). Trials at Princhester Creek found negligible long-term effects on non-target algae (Clearwater et al. 2007d, p44) such as the green alga *Ulothrix* sp. and *Phormidium* sp. and the diatoms *Eunotia* sp. and *Gomphoneis* sp. Rapid recovery is expected. A similar response is expected from periphyton, biofilms and macrophytes in the treatment area. Rooted macrophytes would be expected to recover rapidly as a portion of the plant below the sediment substrate would remain as root stock (Jellyman et al. 2006a, p13).

Macro-invertebrates

NIWA found 60-70% survival of mayflies and stoneflies from single and multiple doses of Gemex™ @ 20 mg/L. One species of mayfly (*Coloburiscus*) was more sensitive than another (*Deleatidium* spp.), while stonesflies were much less sensitive (Clearwater et al. 2007). . On the basis of other NZ and overseas studies on copper toxicity, NIWA expects macro-invertebrates with a larger body size are less sensitive.

Daphnia magna, a common toxicity test organism, was sensitive to Gemex™, but this organism is not expected to be exposed to toxic doses in the real environment, being a pond dweller (Clearwater et al. 2007c). The Princhester Trials indicated that the Gemex™ treatment had a minimal effect on the macroinvertebrate community in Princhester Creek three weeks post-treatment (Clearwater et al. 2007d, p76). Recent laboratory trials have confirmed that *Deleatidium* spp. are relatively resilient to a 1 to 8-hour Gemex™ exposure (Clearwater et al. 2008).

Trout

In field laboratory trials, trout survived 4 mg/L Gemex™. The LC50 for juvenile trout is about 50 mg/L, with 100% surviving a dose of 20 mg/L for 1 hour.

In Princhester Creek field trials (Clearwater et al. 2007d) 70% of caged juvenile trout survived an application dose of 16 mg/L for 1 hour, but significant mortality occurred downstream where the copper dose was dispersed and diluted, but pH had recovered to circum-neutral values. So although Gemex™ concentrations were lower, the caged animals were exposed for a slightly longer time at a higher pH (6 – 6.5), which enhances Cu toxicity to fish. No trout survived at a site 1.9 km downstream. Numerous dead resident (wild) trout were found in this length of stream where pH had recovered, smaller numbers of dead fish were found upstream. Survival was higher at sites further downstream (100% at 4.2 km). Data from electric fishing surveys supported the caged fish data, but

nonetheless indicated minimal overall effect on the fish population 11 weeks post-treatment; although trout populations were not at pre-treatment levels in localized reaches where the greatest toxicity had occurred (Clearwater et al. 2007).

Subsequent laboratory trials in slightly harder water than Princhester Creek have shown 100% survival of juvenile rainbow trout after 1 h doses up to 36 mg Cu/L (i.e., 1 h LC_{50} >36 mg Cu/L). For longer exposures there was a dose-dependent response and a 4 h LC_{50} of 13 mg Cu/L and an 8 h LC_{50} of 9 mg Cu/L (Clearwater et al. 2008). Together the field and laboratory data suggest that in locations that receive intermediate Gemex™ doses (3-10 mg Cu/L) there may be some localized mortality of juvenile rainbow trout and other salmonids, particularly in soft waters (hardness <25 mg/L as $CaCO_3$) (Clearwater et al. 2008).

Native Fish

NIWA artificial stream trials showed 100% survival of native galaxiids (adult) after a 1-hour exposure to 20 mg/l Cu as Gemex™ (Clearwater et al. 2007). There was a small mortality over two weeks (5%), which could have been related to repeat applications of Gemex™. Caged common galaxiids in the Princhester Creek field trials (Clearwater et al. 2007d) were not affected by the Gemex™ treatment although a few dead resident (wild) galaxiids were found in the treated reach. Population data from electric fishing surveys showed minimal effect on the native galaxiid population. The common bully was tested in artificial streams only at 4 mg/L Cu as Gemex™ for 1 hour and showed no sensitivity at this concentration (Jellyman et al. 2006).

In subsequent laboratory trials the dwarf galaxias showed similar resilience to Gemex™ exposures, as the galaxiid species in Princhester Creek. Upland bullies were intermediate in sensitivity to juvenile trout and the galaxiids (Clearwater et al. 2008).

Both longfin and shortfin eels are not expected to be affected, based on the relative sensitivity of juveniles to copper sulphate (Jellyman et al. 2006a, p 16).

Other Aquatic Vertebrates

NIWA regard molluscs as potentially vulnerable (Clearwater 2007d, p89). Lamprey juveniles, which spend 4-5 years in silty burrows on stream margins and backwaters, may be sensitive if present in the application area (Jellyman et al. 2006a, p 17). Dosing may need to avoid spring periods when adult lampreys migrate.

Birds

The ERMA application (2007) describes birds as relatively insensitive to Gemex™. The lowest lethal dose for copper sulphate in ducks is 600 mg/kg (Jellyman et al. 2006a, p17).
Similar copper chelates had lethal oral doses (LD50) to several California birds (bobwhite quail, mallard duck) of >2236 to >5620 mg/kg and was classified as relatively non-toxic (CaDPR 2007).

6.4 Is Gemex™ Toxic to Humans?

Based on the concentration of the chelated copper present within Gemex™ and the pH of the formulated product, ERMA considers that the stock solution is harmful if ingested, and is corrosive to skin and eyes.

NIWA has identified that adverse effects to human health and welfare may arise from the concentrated product, or briefly when initially diluted in river water. Consequently, they recommend that risks to public and non-treatment personnel could be reduced to a minimal level by restricting access of public and all non-essential personnel to the treatment site and waterway on the day of Gemex™ application.

The Ministry of Health (MoH) Maximum Acceptable Value (MAV) for copper is 2 mg/L for long-term ingestion in drinking water.

Overseas pesticide data sheets state that there is no restriction on the use of similar type of herbicides (i.e., other or similar copper chelates) in respect to potable water or swimming (e.g., CADPR 2007)), which suggests a conservative approach has been taken by ERMA and NIWA. However, previously copper chelates have been used at maximum concentrations of ~5 mg/L generally for application to lakes or ponds.

Further explanations and notes for effects on humans

The stock solution is harmful if ingested (ERMA 2007, clause 4.10).

NIWA estimated the hazard classification of Gemex™, based on data on copper sulphate anhydrous. This reference substance is regarded to be more toxic than Gemex™. ERMA has not undertaken a full hazard classification of the substance, but based on the concentration of the chelated copper present within Gemex™ concentrate and the pH of the formulated product, considers the concentrated substance to trigger the following classifications (ERMA 2007 clause 4.24):

- 8.3A Eye Corrosiveness
- 8.2C Skin Corrosiveness
- 9.1A Aquatic Ecotoxicity

The Agency considers that adverse health effects may occur as a result of the corrosive properties of Gemex™ concentrate. NIWA has identified that adverse effects to the human health and welfare may arise from the concentrated product, or while diluted in river water.

Overseas pesticide data sheets state that there is no restriction on the use of similar type of herbicides (i.e., other or similar copper chelates) in respect to potable water or swimming (e.g., CADPR 2007).

The Ministry of Health (MoH) commented on the Maximum Acceptable Value (MAV) of compounds present in the water downstream of the treatment site. MoH suggests that no applications be made upstream of water supply intakes unless:

1. owners of water supply intakes are advised when (and for how long) copper exceeding 2 mg/L will pass their intake, and

2. the water supplier can arrange to close the intake while the water with more than 2 mg/L of copper content passes, or flow from a tributary, or uptake, or deposition has reduced the copper content to less than 2 mg/L.

Suspending water abstraction for the entire day of treatment is a conservative approach since copper concentrations are unlikely to be greater than 2 mg/L at any location in the waterway for more than 2 hours.

The Gemex™ Treatment Contingency Plan (Clearwater et al. 2007) states that water supplies (for irrigation, drinking and stock watering) within the treatment area will be identified and arrangements made with the landowners/occupiers to cease water abstraction on the day of treatment (ERMA 2007 Clause 3.7 – 3.10).

6.5 Is Gemex™ toxic to stock?

The Ministry of Health (MoH) Maximum Acceptable Value (MAV) for Cu in stock drinking water is 2 mg/L.

The Gemex™ Treatment Contingency Plan (Clearwater et al. 2007a) states that water supplies (for irrigation, drinking and stock watering) within the treatment area will be identified and arrangements made with the landowners/occupiers to cease water abstraction on the day of treatment. This is consistent with recommendations from the Agricultural Compounds and Veterinary Medicines Group (ACVM) of the New Zealand Food Safety Authority (NZFSA).

Californian pesticide data sheets state that there is no restriction on the use of these types of herbicides (i.e., copper chelates) in respect to irrigation and stock watering, (e.g., CaDPR 2007).

Further explanation and notes for toxicity to stock

The Agricultural Compounds and Veterinary Medicines Group (ACVM) of the New Zealand Food Safety Authority (NZFSA) noted that sheep, and some particular breeds, are considered more sensitive to copper. A recommendation was made that the applicant should ensure there are no stock water supplies being taken off for reticulated water systems (e.g. being piped to troughs, water tanks etc or supplying stock water races). The Gemex™ Treatment Contingency Plan (Clearwater et al. 2007a) requires cessation of water abstraction on the day of the treatment.

USA pesticide data sheets state that there is no restriction on the use of these types of herbicides (i.e., copper chelates) in respect to irrigation, stock watering, (e.g., Californian Department of Pesticide Registration 2007).

Sheep

As described above, sheep are relatively susceptible to copper toxicity, not having the ability to regulate uptake in all circumstances. Under current EU Legislation, complete sheep feeds must contain no more than 15 mg Cu/kg in total feed (17 mg Cu/kg total feed DM). Assuming a maximum DM intake of 2 kg/ewe/d, the EU permits a maximum oral intake of about 34 mg Cu/ewe/d (less, pro-rata, for lighter sheep).

In NIWA trials at Princhester Creek, didymo in the application area had Cu concentrations of 31-69 mg/kg DW before the trials, which is greater than the EU limit. After application concentrations increased to 133-997 mg/kg, and after 42 days they were still high 109-367 mg/kg (Clearwater et al. 2007, p37). However, dead didymo is fixed to streambed by stalks until eroded by floods. Therefore, it is unlikely that sheep will be exposed to either live or dead didymo, except where

floods deposit dead didymo on flood plains. Even if dead didymo were to be eaten by sheep, it would be inadvertently while grazing pasture, so it is likely that total Cu ingested would be less than the EU limit.

6.6 What is the toxic action of Gemex™? Why is it more toxic to didymo than fish?

Reactive free copper is mostly the 'free' uncomplexed ion Cu^{2+}, or its weakly hydrated forms. This is the form that is widely toxic to a range of aquatic organisms, especially salmonid fish.

Chelation makes the copper relatively non-toxic to many aquatic organisms, while still maintaining its toxicity to didymo. The toxic action of Gemex™ to didymo appears to be due to the adsorption of the chelated copper compound directly into the algae.

Further explanation and notes for Gemex™ toxic action

The following was adapted from the USEPA Aquatic Life Ambient Freshwater Quality Criteria – Copper, 2007 Revision (USEPA 2007). "Copper is an abundant trace element found in the earth's crust and is a naturally occurring element that is generally present in surface waters. Copper is a micronutrient for both plants and animals at low concentrations and is recognized as essential to virtually all plants and animals. However, it may become toxic to some forms of aquatic life at elevated concentrations. Thus, copper concentrations in natural environments, and its biological availability, are important.

The toxicity of a chemical to an aquatic organism requires the transfer of the chemical from the external environment to biochemical receptors on or in the organism at which the toxic effects are elicited. Often, this transfer is not simply proportional to the total chemical concentration in the environment, but varies according to attributes of the organism, chemical, and exposure environment so that the chemical is more or less "bioavailable". Definitions of bioavailability vary markedly and are often specific to certain situations, but a useful generic definition is the relative facility with which a chemical is transferred from the environment to a specified location in an organism of interest.

Of particular importance to bioavailability is that many chemicals exist in a variety of forms (chemical species). Such chemical speciation affects bioavailability because relative uptake rates can differ among chemical species and the relative concentrations of chemical species can differ among exposure conditions. (In the absence of chelating agents such as those used in Gemex™) the cupric ion - Cu(II) weakly associated with water molecules ($Cu.nH_2O^{+2}$), is the primary toxic form. This 'free' copper is usually a small percentage of the total copper. Most dissolved copper is part of stronger complexes with various ligands (complexing chemicals that interact with metals), including dissolved organic compounds, hydroxides, carbonates, and other inorganic ligands. Substantial amounts of the total copper can also be adsorbed to or incorporated into suspended particles."

The concentration of Cu^{2+} is therefore determined by the total concentration of copper and the chemistry of the water. This chemistry determines how much copper is complexed by other ions and molecules in the water and hence the concentration of free reactive copper. The most relevant components of the water chemistry are hardness, alkalinity (and pH) and dissolved organic matter. The alkalinity ions, such as bicarbonate, form non-reactive complexes with copper, as does natural dissolved organic matter. However, as described above, the chelating agents tend to dominate the water chemistry for copper when applied as Gemex™.

The toxic effect of Cu^{2+} is also modified by other ions, which compete with it for biologically active sites, thus reducing its toxicity. The most important of these are H^+ and Ca^{2+}. As hardness increases (and hence the concentration of Ca^{2+} and Mg^{2+}), Cu^{2+} toxicity decreases. Therefore the hardness of the river water is important in determining the off-target dose effects of Gemex™. Cu^{2+} is also most toxic at circum-neutral pH (6 – 7). As the pH drops below pH 6, H^+ competition becomes increasingly important; while at pH above 7, complexing with HCO_3^- increases, thus reducing Cu^{2+}.

When Gemex™ is dosed into water, the chelating agents dominate the chemistry, and free copper is mainly determined by the chemical equilibrium with the chelated copper, which in turn is determined mainly by the concentration of Gemex™ in the water, and only a limited extent by the chemistry of the water.
NIWA measured the fate and toxicity of Gemex™ in laboratory trials, flume trials and in Princhester Creek, Southland, and subsequently summarized the likely toxicity and fate if Gemex™ was applied to the Kakanui River (Clearwater et al. 2007b). The following is summarized from that report.

The active ingredients in Gemex™ are chelated copper compounds. The chelates form a shell around the copper ion, forming a stable compound and altering the properties of the copper ion, rendering it chemically and biologically different from inorganic copper – the usual form of the copper that contaminates the environment. It reduces the concentration of the most toxic forms of copper – chiefly the free metal ion Cu^{2+}. This free copper is toxic to fish through absorption by the fish gills.

Gemex™ is thought to be toxic to algae because it is transported by cell membranes into the cell, and copper is incidentally transported in the cell itself where it exerts toxicity intracellularly, or during the transport process.

The copper chelates are thought to be less toxic to fish because:
- chelate reduces the concentration of bioreactive Cu in the water
- the chelate compounds are less readily transported by the fish gill membranes

More detailed explanation of copper toxicity can be found in the NIWA reports (e.g., Clearwater et al. 2007b) and many other sources (e.g., USEPA 2007, Meyer et al. 2007).

6.7 Copper concentrations exceed Water Quality Guidelines. Is that a problem?

Gemex™ is unquestionably toxic to the target organisms and some non-target organisms in a finite zone of effect in the application area and further downstream. Concentrations of copper greatly exceed water quality guidelines. In addition, Gemex™ may exceed guidelines for pH in the application zone, however this is all part of what is only a short - term perturbation.

The Gemex™ concentrations recommended for effective treatment far exceed the water quality guidelines for some distance beyond that zone. However, there are some mitigating circumstances, as described in the following

Firstly, water quality guidelines for copper are very low (see Explanation) and not much greater than background concentrations. ANZECC (2000) guidelines are for copper and not Gemex™ itself. The guidelines are for long term or continuous exposure and not short-term, high

concentration doses, so they are not appropriate to apply in this situation. The guidelines are effectively 'trigger levels', where exceedance only denotes potential effects and 'triggers' further investigations. These investigations follow a decision tree, which takes into account the management aims of the activity and bioavailability of copper. In the case of Gemex™, following this decision tree would establish that Gemex™ is toxic to didymo and some non-target species in the application zone. Further downstream, total copper may still exceed trigger levels, but will be less toxic because of complexation by the chelating agents in Gemex™.

USEPA Guidelines have often been used in NZ for water quality management. They include long term (typically average concentrations over 4 days) and short - term guidelines (average concentrations over 1 hour); the latter appear more relevant to short-term dosing.

The USEPA guidelines have evolved over many years; starting with total recoverable copper, then moving to dissolved copper, then incorporating hardness effects, then effects of other water chemistry (Water Effects Ratio), and the latest development being the use of the Biotic Ligand Model to estimate guidelines (EPA 2007). The latest guidelines are not really appropriate for use with Gemex™, because they do not take into account toxicity through uptake of copper chelates into living cells of some species and not by others. However, if the Water Effects Ratio approach is considered, it should reflect that copper toxicity is attenuated by the water chemistry (i.e., the chelating agents.

Further explanation and notes for Water Quality Guidelines

ANZECC Guidelines

The ANZECC (2000) guidelines refer to "total" metals' concentrations in the first instance. If total concentrations exceed these guidelines, then the ANZECC guidelines suggest a more detailed investigation including, as a first step, comparing dissolved levels with guidelines, because these more closely approximate the bioavailable fraction. The ANZECC (2000) guideline is unusually low for Cu and close to background levels, but this may be an artifact of the way guidelines values are calculated rather than reflecting a real threat to aquatic life. The guidelines are:

	Trigger values for freshwaters			
	Level of protection (% species)			
	99%	95%	90%	80%
Copper (µg/L)	1.0	1.4	1.8	2.5

Briefly, the trigger values derived using the statistical distribution method were calculated at four different protection levels, 99%, 95%, 90% and 80%. Here, protection level signifies the percentage of species expected to be protected. The decision to apply a certain protection level to a specific ecosystem is the prerogative of each regional council, in consultation with the community and stakeholders.

The 95% protection level trigger value is recommended for apply to ecosystems that could be classified as slightly–moderately disturbed. The highest protection level (99%) has been chosen as the default value for ecosystems with high conservation value, pending collection of local chemical and biological monitoring data. For ecosystems that can be classified as highly disturbed, the 95% protection trigger values can still apply. But it may be appropriate to apply a less stringent guideline trigger value, say protection of 90% of species, or perhaps even 80%.

NIWA followed the ANZECC Guideline (2000) decision tree (Jellyman et al. 2006a) and concluded that "although a Gemex™ treatment of didymo will exceed the trigger value for Cu, a biological effects assessment of chelated Cu shows that the management aim of long-term didymo control with minimal long-term effects on non-target species (especially fish) can be achieved in keeping with the principles of the ANZECC WQG".

EPA aquatic life criteria

EPA aquatic life criteria for copper have evolved over the last 30 years or so. The first criteria were total copper, but the USEPA moved to address bioavailability about 20 year ago. The next set of aquatic life criteria documents for copper (e.g., U.S. EPA, 1980, 1985, 1996) expressed the copper toxicity as a function of water hardness. They incorporated the effects of hardness on metal toxicity using empirical regressions of toxic concentrations versus hardness for available toxicity data across a wide range of hardness. Such regressions provided the relative amount by which the criteria change with hardness, but have certain limitations. The regressions incorporated any other factor that was correlated with hardness in the toxicity data set used for the regressions, particularly pH and alkalinity.

Existing EPA metals criteria also address bioavailability by using dissolved metal as a better approximation for metal bioavailability than total metal (U.S. EPA, 1993). This approach accounts for the low bioavailability of metal on suspended matter.

To address more completely the modifying effects of water quality than the hardness regressions achieve, EPA issued guidance in the early 1980s on the water-effect ratio (WER) method. The WER is "a biological method to compare bioavailability and toxicity in receiving waters versus laboratory test waters". A WER is calculated by dividing the acute LC50 of the metal, determined in water collected from the receiving water of interest, by the LC50 of the metal determined in a standard laboratory water sample, after adjusting both test waters to the same hardness. However, a WER accounts only for interactions of water quality parameters and their effects on metal toxicity to the species tested and in the water sample collected at a specific location and at a specific time. There is also significant cost to generate a single WER.

A new approach by USEPA (2007) uses a bioavailability modeling approach commonly termed the "Biotic Ligand Models" to acknowledge that the biochemical receptor is a metal-binding ligand that is treated similarly to ligands in the exposure water, except that it is on the organism and is the keystone for metal accumulation and toxicity. The BLM accounts for all important inorganic and organic ligand interactions of copper while also considering competitive interactions that influence binding of copper at the site of toxicity, or the "biotic ligand." The BLM's ability to incorporate metal speciation reactions and organism interactions allows prediction of metal effect levels to a variety of organisms over a wide range of water quality conditions. These guidelines are not appropriate for use with Gemex™, because they do not take into account the direct toxicity of copper chelates through uptake into or onto living cells by some species, and not by others.

6.8 What is the Long Term Fate of added Gemex™?

Gemex™ is rapidly adsorbed by organic material including didymo, other periphyton, macrophytes, and decaying vegetation. didymo and other algae killed by Gemex™ will slough off, especially during high flows, and be washed downstream. These dead algae or algal mats will undergo biodegradation through bacterial breakdown and consumption by detritus feeders. The copper associated with the Gemex™ dose will go through biotic cycles of breakdown, uptake, utilisation, and excretion during its transition downstream to its ultimate receiving water. In time, the Gemex™ copper will be indistinguishable from "natural" copper, occurring in similar forms and going through similar processes.

Dissolved copper is strongly adsorbed onto particulate matter, especially organic matter, so concentrations of dissolved copper in water will be very low.

In terms of water quality management, the probable ultimate fate of most Gemex™-sourced copper is incorporation into fine sediments. This occurs through settling and flocculation of particulate matter carrying copper and through adsorption of dissolved copper onto sediment particles. However low levels of Cu will remain in the receiving water through physical and chemical equilibrium processes. While these concentrations are expected to be very low, the mass of Cu transported in the dissolved phase can be relatively high (a function of flow rate) and so can be a significant factor in the fate of Gemex™-sourced copper.

Where fine sediments are discharged into energetic receiving waters, they are widely dispersed by currents and waves and 'Gemex™ signal' will be rapidly diluted and indistinguishable from natural levels of copper in sediments. However, in quiescent waters such as sheltered estuaries or lakes, fine sediments can accumulate along with any incorporated copper. Slow moving, lowland rivers will also accumulate sediment-bound copper, although on a less permanent basis than sheltered estuaries or lakes.

NIWA have identified the accumulation of copper in sediments of quiescent water bodies (lakes and sheltered estuaries) as the result of repeated Gemex™ applications, as being of potential concern. One-off applications are unlikely to have any significant effect.

6.9 What is the Intermediate Fate of added Gemex™?

The immediate (< 1 day) fate of the Gemex™ is adsorption and absorption onto/into biota (didymo, other algae, leaves, bacteria, macrophytes). Dead or living algae with elevated levels of Cu or Gemex™ may cause toxic responses in invertebrate grazers. Any toxic response under this circumstance could be viewed as part of the effects of the original perturbation brought about by the application.

After the applied Gemex™ is adsorbed or flushed downstream, the intermediate fate of Gemex™-Cu (CuG) depends mainly on the fate of the plant biomass. Initially, CuG is transferred downstream in or on dead or sloughed biomass during high flows. This organic detritus will undergo complex grazing/metabolism/excretion/decomposition processes, as it passes downstream. So there will be more Cu in the biotic component of the stream ecosystem.

This CuG is not readily bioavailable, being bound to organic matter. Its release from this form depends mainly on bacterial decomposition and grazing by detritus feeders, which is a relatively slow process. Cu is an essential element and many organisms can regulate its uptake through excretion and storage. Cu does not biomagnify (i.e., Cu concentration are not magnified as it passes to higher trophic levels, as e.g., mercury does). There is also unlikely to be biomagnification of Gemex™ chelates, because Cu is delivered to the cell in chelated form and there will be many strongly binding ligands and sites to dissociate copper from the Gemex™ chelates. So once in the cell, our current understanding is that CuG will behave like other Cu.

The above processes may increase copper concentrations in the water slightly because of some 'leakage' into the water column, but this would probably not be measurable because:
large volumes of water will pass over sites where the relatively slow decomposition and transfer processes occur.

Eventually Cu will be transferred to the sediments and buried or transported in that form.

6.10 Accumulation of Gemex™-copper in sediments

If treated rivers flow into quiescent receiving waters such as sheltered, muddy estuaries, or small lakes, then copper applied in multiple treatments can accumulate in the sediment. Threats to sediment dwelling organisms are indicated if concentrations exceed sediment quality guidelines.

Desktop modeling (see case studies below) suggests a low risk of concentrations exceeding sediment quality guidelines and only in very unfavourable circumstances.

Further explanation and notes on long-term effects of Gemex™ on the aquatic ecosystem

Assessing Cu build up in sediments

As described above, in the long term, Gemex™-sourced copper will be indistinguishable from copper from other sources in terms of its forms, effects and fate. As far as we know, the only long-term effect of Gemex™ would be due to the accumulation of copper in sediments.

Most copper added to the environment either naturally or through anthropogenic inputs will end up in fine sediments. The accumulation of copper in sediments is a cause of concern in other situations. In the past, industrial and mining discharges high in copper have greatly contaminated receiving water sediments. These are now largely under control or diverted to treatment facilities. In recent times, there have been concerns for copper accumulation in the sediments of waters receiving copper from more diffuse sources such as urban stormwater and boats.

The potential for impact by Gemex™-sourced copper depends primarily on the concentration of copper in sediments. As with water quality guidelines, ANZECC (2000) had trigger levels for sediment concentrations – viz. 65 mg Cu /kg of sediment. ANZECC guidelines for Cu in estuary sediments were recently reviewed by the Auckland Regional Council, which derived two trigger levels (called environmental targets) for urban stormwater, which is repeatedly discharged to receiving waters: 19 mg/kg Cu as a “early warning” and 34 mg/kg as target not to be exceeded if possible; the latter being a level where there is some evidence that effects on aquatic organisms will begin to occur.

Sediment quality guidelines are complex and controversial, and there is little consensus on how to employ them or use them. ANZECC (2000) guidelines are being revised and currently favour a weight of evidence approach using chemistry, toxicity and other biotic evaluations, but this is not much use for predicting effects. Consequently, we have used Sediment Quality Guidelines themselves as a conservative approach to evaluate under what circumstances Gemex™ addition would cause potential long-term contamination in a series of case studies below.

Factors controlling Cu build up in sediments

Where there is the potential for fine sediments to accumulate, the concentration of Cu in sediments will depend on:

- The dose of Gemex™
- The natural concentrations of copper (background concentrations)
- Other copper inputs
- The proportion of Gemex™-sourced copper (CuG) that settles in the receiving water sediments
- The combined contributory catchments sediment load
- The degree of mixing of freshly-deposited sediment with underlying sediments in the receiving waters

The dose of Gemex™ depends on the river flow, amount of algal cover, and the number of application sites and the frequency of repeat applications.

Natural concentrations of copper in soils in New Zealand range from about 2 mg/kg to 30 mg/kg. An average undeveloped soil contains 11.4 mg/kg (Longhurst et al. 2004). Concentrations in uncontaminated rivers are typically lower (e.g., 5 mg/kg).

For the sake of this assessment, other copper inputs are assumed to be zero.

The proportion of copper that is incorporated into receiving water sediments in sheltered (muddy) estuaries is assumed to be 75% - the rest being more widely distributed and dispersed in the environment (Williamson et al 1999). The methodology for calculating contaminant build up in estuarine sediments was developed for stormwater discharge into urban estuaries (Williamson & Morrisey 2000, Morrisey et al., 2000).

While the settling behaviour in muddy, largely intertidal estuaries is reasonably well characterized, and can be calculated, settling in lakes will exhibit different behaviour. This is likely to be no settling near shore (because of wave action) and progressively less settling from source. A simple way to take this into account is to use measured sediment deposition rates. Thus, the proportion of copper that is incorporated into receiving water sediments in lakes is calculated on the basis of sediment settling rate in lake.

The total catchment fine sediment load depends on the size of the catchment, the erodibility of source materials (soils and rocks) and the rainfall. For long-term impacts, such as the build up of copper in sediments, long-term average loads are of greatest interest. These are estimated in NIWA's Webmodel (http://wrenz.niwa.co.nz/webmodel/).

Sediments contaminated with Gemex™-sourced copper will settle in quiescent environments onto other sediments uncontaminated by Gemex™. A feature of most quiescent environments is sediment mixing by bioturbation. The degree of mixing can be a discontinuous and diminishes with depth, but can often be represented by a mixing depth similar to visible bioturbation structures in the sediment. For example, in sheltered muddy estuaries in Auckland an effective mixing depth of ~15 cm is observed (Williamson et al 1999). The deeper the mixing, the greater the dilution by underlying sediments. If there is no mixing, then the Gemex™-sourced copper is only diluted by the sediment that settles over the same time that sediment containing CuG settles. Estuary mixing is understood relatively well in New Zealand; lake sediment mixing is less well understood.

Case Study 1: Princhester Creek plus Hypothetical Lake or Estuary

To scope the magnitude of sediment contamination, two hypothetical cases are considered: (1) a hypothetical lake and (2) a hypothetical estuary was placed at the bottom of Princhester Creek. The reason for using this hypothetical case rather than a real case (which are considered below) is that conditions can be easily manipulated to give a worse case. These hypothetical examples can also be linked to a real dosing trial carried out by NIWA. NIWA dosed a reach of the Princhester Creek in Southland, which was flowing at about 0.25 m^3/s. The Princhester Creek flows for a further 8 km before discharging into the Mararoa River (25 m^3/s).

The Mararoa River is relatively large (mean annual flow ~25 m^3/s) and offers approximately 100-fold dilution of any Gemex™ remaining in the in water column. The estimated sediment yield (158 kt/yr) is about 22 times greater than in Princhester Creek. The Mararoa is a tributary of the Waiau River, which provides massive dilution of any CuG in dissolved, suspended sediment or bed loads.

In these hypothetical examples, we replace the Mararoa River with a hypothetical lake or estuary. The resulting concentrations in the hypothetical lake and estuary sediments from a variant of the NIWA trials are shown in the following Table 6.1.

Table 6.1. Estimation of Cu build up in a hypothetical estuary and hypothetical lake at the outlet of Princhester Creek.

Princhester Creek	Value	Units	Source
Treatment Dose			
Treatment Target	20	g/m^3	NIWA
Dosing time	3600	sec	NIWA
Number of treatments (space, time)	1		Scenario
Flow at time of treatment	0.25	m^3/s	NIWA
Mass of Cu in all doses	18	kg	calculated
Natural sediment and Cu loads			
Total area of stream catchment	38.6	km^2	webmodel
Total stream sediment load	6.9	kt/yr	webmodel
Background Cu in stream sediments	12	mg/kg	Longhurst et al 2004
Natural Cu load	82.8	kg/yr	calculated
CuG diluted into annual load	14.61	kg/kt	calculated
'Princhester Estuary'			
Settling Zone Area	4%		Williamson et al 2000
Estuary sediment mixing depth	0.15	m	Auckland
Proportion SS settling in estuary	75%		Williamson et al 2000
Resulting [Cu] in estuary sediments	12.04	mg/kg	calculated
Increase in [Cu]	0.04	mg/kg	calculated
'Princhester Lake'			
Lake sediment mixing depth	0.05	m	guess
Sediment deposition rate in lake	0.0014	m/yr	L Taupo
Dilution factor from mixing	37		calculated
Resulting [Cu] in lake sediments	12.07	mg/kg	calculated
Increase in [Cu]	0.07	mg/kg	calculated
Sediment Quality Guidelines			
ANZECC	65	mg/kg	ANZECC 2000
Environmental Response Criteria Red	34	mg/kg	ARC (2004)
Environmental Response Criteria Amber	19	mg/kg	ARC (2004)

The calculated concentrations are much lower than SQG (Table 6.1), and more importantly, the increase in Cu is relatively small. However, NIWA considered that potential threats would be only be achieved through repeated dosing, so this case is considered next.

The following example uses 20 times the dose trailed by NIWA at Princhester Creek. This might be equivalent to dosing at 2 km intervals on two occasions. The cost of Gemex™ through repeated use would probably limit the total number of doses, so this example represents a reasonable worse case scenario (Table 6.2).

Table 6.2. Estimation of Cu build up in a hypothetical estuary and hypothetical lake at the outlet of Princhester Creek. Scenario= 20 Gemex™ doses. Values changed from Table 6.1 are highlighted.

Princhester Creek	Value	Units	Source
Treatment Dose			
Treatment Target	20	g/m^3	NIWA
Dosing time	3600	sec	NIWA
Number of treatments (space, time)	20		Scenario
Flow at time of treatment	0.25	m^3/s	NIWA
Mass of Cu in all doses	360	kg	calculated
Natural sediment and Cu loads			
Total area of stream catchment	38.6	km^2	webmodel
Total stream sediment load	6.9	kt/yr	webmodel
Background Cu in stream sediments	12	mg/kg	Longhurst et al 2004
Natural Cu load	82.8	kg	calculated
CuG diluted into annual load	64.17	kg/kt	calculated
'Princhester Estuary'			
Settling Zone Area	4%		Williamson et al 2000
Estuary sediment mixing depth	0.15	m	Auckland
Proportion SS settling in estuary	75%		Williamson et al 2000
Resulting [Cu] in estuary sediments	12.77	mg/kg	calculated
Increase in [Cu]	0.77	mg/kg	calculated
'Princhester Lake'			
Lake sediment mixing depth	0.05	m	guess
Sediment deposition rate in lake	0.0014	m/yr	L Taupo
Dilution factor from mixing	37		calculated
Resulting [Cu] in lake sediments	13.42	mg/kg	calculated
Increase in [Cu]	1.42	mg/kg	calculated
Sediment Quality Guidelines			
ANZECC	65	mg/kg	ANZECC 2000
Environmental Response Criteria Red	34	mg/kg	ARC (2004)
Environmental Response Criteria Amber	19	mg/kg	ARC (2004)

http://wrenz.niwa.co.nz/webmodel/

The calculated concentrations are again much lower than SQG, and more importantly, the increase in Cu is relatively small. This is only a hypothetical example of one case, but it is very useful in determining under what circumstances that Gemex™ would represent a long-term threat.

Case Study 2: Waiotaka River, Taupo

The Waiotaka River drains to southern Lake Taupo. While it drains to the lake, there are a great many other streams and rivers in the vicinity which also discharge sediment, including the much larger Tongariro River (802 km^2, 137 kt/yr). The scenario requires 6 injection points along the treatment reach. Table 6.3 estimates the copper concentration in lake sediments after treatment, assuming sediment inputs from Waiotaka and the adjacent Waimarino River only. Natural sediment loads are probably much greater because of inputs from the nearby Tongariro River, so there is very low risk of excessive copper build-up in sediments.

Table 6.3. Estimation of Cu build up in southern Lake Taupo at the outlet of Waiotaka River.

Waiotaka River (and River)	Value	Units	Source
Treatment Dose			
Treatment Target	20	g/m^3	NIWA
Dosing time	3600	sec	NIWA
Number of treatments (space, time)	6		DSS
Flow at time of treatment	1.061	m^3/s	DSS
Mass of Cu in all doses	1244	kg	DSS
Natural sediment and Cu loads			
Total area of stream catchment	73	km^2	DSS
Total stream sediment load	23.3	kt/yr	webmodel
Background Cu in stream sediments	12	mg/kg	Assumed
Natural Cu load	279.6	kg	calculated
CuG diluted into annual load	65.40	kg/kt	calculated
Southern Lake Taupo			
Lake sediment mixing depth	0.05	m	guess
Sediment deposition rate in lake	0.0014	m/yr	L Taupo
Dilution factor from mixing	37		calculated
Resulting [Cu] in lake sediments	13.45	mg/kg	calculated
Increase in [Cu]	1.45	mg/kg	calculated
Sediment Quality Guidelines			
ANZECC	65	mg/kg	ANZECC 2000
Environmental Response Criteria Red	34	mg/kg	ARC (2004)
Environmental Response Criteria Amber	19	mg/kg	ARC (2004)

Case Study 3: Opotiki Estuary

The Waioeka River drains through the Opotiki (W) estuary. The estuary will trap some of the river suspended material, but is probably a very inefficient trap because the relative large size of the river compared with the estuary.

In this case, we consider the situation where 10% of the river-borne sediment settles in the estuary. This is likely to be a worse case; the estuary should be at least 8-20 km^2 for effective settling, whereas we estimate the settling zone is only about 0.75 km^2. Table 6.4 estimates Cu concentration build up in estuary sediments. This scenario requires 6 injections points along the treatment reach. In this example, there is a contribution from Opotiki urban and highway stormwater of about 27 kg/yr of copper. This is dwarfed by the natural Cu load and is massively diluted by the river sediment load.

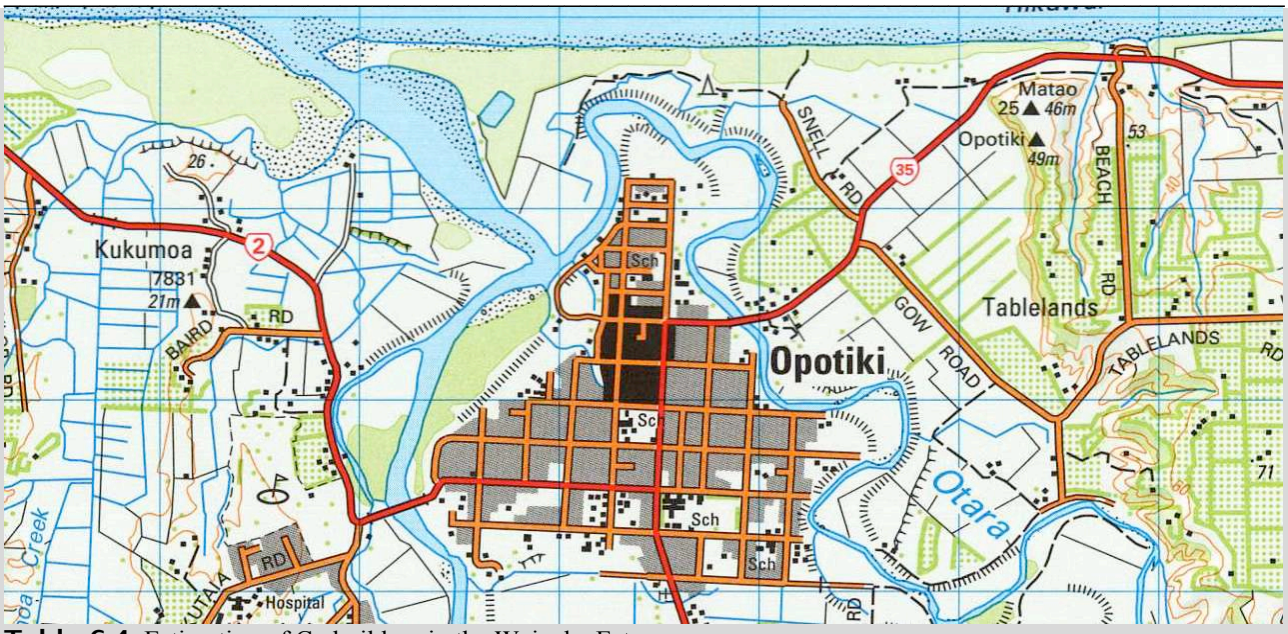


Table 6.4. Estimation of Cu build up in the Waioeka Estuary.

Waioeka River Estuary	Value	Units	Source
Treatment Dose			
Treatment Target	20	g/m^3	NIWA
Dosing time	3600	sec	NIWA
Number of treatments (space, time)	6		DSS
Flow at time of treatment	15.82	m^3/s	DSS
Mass of Cu in all doses	1350	kg	DSS
Natural sediment and Cu loads			
Total area of stream catchment	807	km^2	DSS
Total stream sediment load	684.3	kt/yr	webmodel
Background Cu in stream sediments	12	mg/kg	Given
Natural Cu load	8211.6	kg/yr	calculated
CuG diluted into annual load	14	kg/kt	calculated
Waioeka Estuary			
Settling Zone Area	0.09%		calculated
Estuary sediment mixing depth	0.15	m	Auckland
Proportion SS settling in estuary	10%		Worse case
Estuary area	0.75	km^2	estimated
Resulting [Cu] in estuary sediments	12.57	mg/kg	calculated
Increase in [Cu]	0.57	mg/kg	calculated
Sediment Quality Guidelines			
ANZECC	65	mg/kg	ANZECC 2000
Environmental Response Criteria Red	34	mg/kg	ARC (2004)
Environmental Response Criteria Amber	19	mg/kg	ARC (2004)

Assuming that 10% of the applied CuG deposits in the estuary, there is a significant increase in copper concentrations compared with the other case studies, but still less than sediment quality guidelines. In this case, however, any deposited CuG is highly likely to be diluted and flushed out in subsequent years because of the sediment dynamics in this small estuary.

Conclusions on assessing Cu build up in sediments

The above case studies indicate that it will be difficult to Gemex™-treated rivers to cause exceedance of sediment quality guidelines downstream. This is because of sediment loads carried

by streams, and the mixing of Gemex™ contaminated sediments with uncontaminated sediments in the quiescent receiving water downstream. Large lakes like Taupo are highly unlikely to be susceptible to copper build up. Many estuaries also have unfavourable settling conditions that result in Gemex-contaminated sediments being widely dispersed. However, it is possible that small lakes and small sheltered estuaries could be susceptible to Cu build up, from repeated Gemex™ treatments in tributary streams and rivers, where these treated waterways constitute the majority of the inputs to the receiving water. If this is suspected, expert advice should be sought.

6.11 Are copper or copper products used elsewhere to treat algal infestations?

Copper is commonly used as a treatment for fish diseases, and algae in aquaria, and many proprietary products utilize copper chelates. Copper is also used as a herbicide in lakes and irrigation channels, either as inorganic copper (usually copper sulphate) or as copper chelates (e.g., K-TEA™, a common algacide used in the USA, also trailed by NIWA for didymo). This is a widespread practice in some states in North America. For example, over 32 tonne of copper as active component were applied in Florida from 1987-89 for control of nuisance planktonic and filamentous algal and vascular macrophyte growths, but mostly in one major river and one major reservoir.

Note that Copper herbicides are banned from Washington State, possibly because of extensive salmonid fisheries.

Despite its widespread use, documented major copper-induced non-target kills of fishes and other fauna are rare in Florida. This is in part due to movement of motile organisms from treated areas, the general practice of not treating entire water bodies, and poor monitoring (Leslie 1990).

Rules of application seem very vague apart from reaching target concentrations in the water column, and have not been useful for assessing Gemex™ application in New Zealand. In terms of toxicity and effectiveness, the importance of alkalinity is, however, often emphasized. It is not generally recommended to treat water with copper at low hardness or alkalinity, because of the risk to fish. Also, high alkalinity can reduce the copper toxicity to the target organisms (plants) as well. Copper sulfate in waters with high total alkalinity levels will precipitate the copper as copper hydroxides which settles before algae is completely controlled. Algae control in waters with high alkalinity levels (greater than 250-300 ppm) can be improved by use of chelated copper compounds as well.

Further notes on uses of copper products to treat algal infestations

The USEPA lists a number of uses for copper pesticides in waters (USEPA 2006). The following was adapted from this USEPA report and lists some of the uses reported to the USEPA.

Aquatic Weeds and Algae

Copper is extensively used in direct aquatic applications including the management of algae, aquatic weeds, and molluscs that may host harmful parasites.

Aquaculture ponds containing certain cyanobacteria species can cause off-flavors in farm-raised catfish. As a preventative measure, full-pond treatments are sometimes used for cyanobacteria control to minimize potential algal blooms that may cause off-flavors. Copper is the only registered chemical for treatment of these off-flavor causing algae.

Drinking Water

Algae can clog water filters, reducing filter run times and requiring frequent backwashing, which all lead to greater coagulant demand and other treatments that impose greater costs to treatment facilities. Some species of algae can cause various off-flavors in drinking water, such as cyanobacteria, which can produce chemicals called cyanotoxins that lead to earthy or musty flavors. Only rarely are taste and odor problems the result of algal toxins in drinking water. Thus, this requires early detection and treatment of algae to ensure effective treatment with the minimum amount of pesticide needed. These cyanotoxins and other chemicals are often difficult and more expensive to remove during water treatment. The use of copper for this application can be costly, but often times necessary for drinking water quality. Current labels for copper compounds allow for up to 1 ppm of copper in drinking water, which is in accordance with the Agency's 1.3 ppm MCLG for residues of copper in drinking water.

Irrigation/Conveyance Systems

In the western part of the US, 68% of the crops produced rely on irrigated water. Thus, regular maintenance of distribution canals in important for optimal water flow to receiving fields. Dense mats of vegetation can be a mechanical hindrance to valves and gates, which divert and control the flow of water. Cyanobacteria and filamentous algae can lead to clogging of water intake screens in lakes and aqueducts. This reduction in water flow can result in millions of dollars lost due to failed crops as well as up-system flooding of areas surrounding the canal. Aquatic weed control in irrigation systems is essential, since debris from weeds can decrease water flow. In addition, physical clogging by weeds can cause obstructions to valves and gates needed to control or divert water flow to receiving fields.

Quiescent Water Bodies (Recreational, Ornamental)

Control of aquatic weeds in quiescent water bodies, such as ponds and lakes, is needed to maintain the safety of recreants and recreational activity operations that include fishing, water sports or swimming. In addition, many of these water bodies are also used as drinking water supplies. On rare occasion, cyanobacteria are known to produce hepatotoxins that may be harmful to humans and other mammals. Excess algae and other vegetation in quiescent or near-quiescent water bodies can impact overall water quality that may lead to decreased food availability and even fish kills. Dense algal or weed mats can block sunlight from reaching submerged biota, potentially affecting the entire ecological cycle, and even pose physical barriers for mobile animals. As the plant debris die back, increased microbial decay would lead to the decrease of dissolved oxygen available to fish and other organisms living in the same water body.

6.12 Is Gemex™ a problem for water abstractors?

The maximum treatment dose is 20 mg/L, while the MOH MAV for drinking water is 2 mg/L. Abstraction of large proportions of Gemex-treated water is operationally difficult, because it involves the uptake of a high proportion of the treated water. Abstraction is restricted on the day(s) of treatment. It is highly unlikely that abstraction will occur when river concentrations are above 2 mg/L, because this will involve abstraction within 1 few km of the application point – which should be easy to prevent by the Gemex™ Treatment Management Plan (GTCP). Further downstream and within a few hours, Gemex™ Cu is expected to drop to below 2 mg/L. Therefore, in the unlikely event of inadvertent abstraction occurring on the day of application, and it is highly improbable to envisage that there are many situations where Cu is not diluted or removed to concentrations < 2 mg/L. Levels <2 mg/L are not expected to be toxic to humans, stock animals or

taint food products processed with this waters because the MOH MAV has been set to prevent these problems.

The Ministry of Health (MoH) commented on the Maximum Acceptable Value (MAV) of compounds present in the water downstream of the treatment site and suggests that no applications be made upstream of water supply intakes unless:

- owners of water supply intakes are advised when (and for how long) copper exceeding 2 mg/L will pass their intake, and,
- the water supplier can arrange to close the intake while the water with more than 2 mg/L of copper content passes, or
- flow from a tributary, or uptake, or deposition has reduced the copper content to less than 2 mg/L.

6.13 How and how often will Gemex™ be applied?

Before treatment commences, the personnel, equipment, and Gemex™ will be transported to the treatment site using trucks, boats or helicopters. There may be a requirement to redistribute some substance to larger tanks for distribution by the pumping equipment. A sub-surface diffuser would be placed across the width of the waterway at the treatment location. The maximum target application rate would be 20 mg Cu/L in receiving water.

Some follow-up hand spraying may be undertaken of isolated, interconnected backwaters and moist fragments. Gemex™ used for hand spraying would be diluted to a maximum of 20 mg Cu/L before spraying.

Multiple strategic follow up treatments by application to flowing water and hand spraying may be required. Between 3 and 10 follow up treatments spaced 24 hours apart may be more effective than a single treatment.

Prior to commencing the application of Gemex™ to the waterway, the flow in the river is estimated with dye tracing, using the non-toxic dye rhodamine.

Depending on the length of waterway to be treated, Gemex™ will have to be applied at multiple locations down a waterway over several days. These treatment points will be spaced anywhere from 1.5-6 km apart, depending on the conditions in the waterway and the goals of the treatment (i.e., didymo elimination versus suppression). More intensive treatment will be required for elimination attempts.

These downstream applications would occur at least 24 hours apart, after initial assessment of the preceding treatment. Each pulse dose of Gemex™ must move downstream and dissipate before the next application is started to avoid excessive non-target toxicity.

It is likely that to achieve long-term elimination, the process will have to be repeated 3 weeks to several months after the first set of Gemex™ applications. As only one field trial of one application of this product has been completed on a well-established infestation, it is difficult to predict its long-term efficacy if applied in more favourable circumstances (i.e., on an early stage infestation).

6.14. Frequently asked questions on environmental effects of Gemex™

An assessment of the environmental effects of applying Gemex™ to a river is not simply a top-down process. Stakeholders who fish, gather food, or who have a spiritual connection with the river reach in question will have concerns and need to understand the effects in order to feel assured that their interests will not be compromised.

Similarly abstractors of water will need to be assured that their usage of the water will not be affected by the Gemex™ treatment, or can be managed. In this section, we set the concerns of different stakeholder groups and provide a list of frequently asked questions (FAQs) , concise answers, and references to further information.

Maori

Issues of concern to Maori

1. Kaitikitangi – governorship and management responsibilities
2. Spiritual values associated with water
3. Mahinga kai – gathering food and the relationship of food species with the rest of the environment.
4. How are cultural concerns weighed against environmental/economic concerns in making a decision?

Customary practices to consider

1. Food gathering
2. Transport
3. Drinking and bathing
4. Healing
5. Special ceremonial practices

Questions and answers to assist in understanding Gemex™ effects

Question	Short Answer	Further Information
What is it?	Copper-based biocide for didymo	Section 6.2
What is it made from?	Copper sulphate (a common garden fungicide) and chelating agents	Section 6.2
What is the difference between chelated copper and normal copper?	Chelating agents bind the copper making it more soluble but less available to other aquatic organisms	Section 6.6
Does it break down naturally? What happens to it?	Plants and other organic matter adsorb the copper chelates. When plants breakdown the copper becomes part of the "copper cycle". The chelating agents are commonly found are commonly found in living organisms, are metabolic by-products and are found in foodstuffs	Sections 6.6, 6.8, 6.9
Will there be accumulation of toxins in Mahinga Kai?	It will accumulate in algae and other plants. It is not expected to accumulate in aquatic animals	Section 6.6

Is it poisonous to humans?	The stock solution is harmful if ingested and corrosive and to skin and eyes. The GTCP prevents all non-official access to rivers being treated. The Ministry of Health Maximum Acceptable Value (MAV) for copper is 2 mg/L, c.f dose of 20 mg/L.	Section 6.4
Can it change in the environment to become poisonous to humans?	No, after plants and sediments adsorb it, it is expected to become indistinguishable from natural copper.	Sections 6.6, 6.8, 6.9
Is it poisonous to animals that drink it?	The MOH guidelines for Cu are 2 mg/L for long-term consumption. The GTCP requires stock access to the stream and water take for stock watering is prevented during day(s) of application.	Section 6.5
Is it poisonous to birds?	Copper sulphate is not very poisonous to birds. A similar product to Gemex™ was tested in California and found not to have low toxicity to 2 species of birds.	Section 6.3
Is it poisonous to native fish?	It is not poisonous to common galaxiids. Bullies are slightly more susceptible, but survival rates should be high. Larval fish (e.g., whitebait) are likely to be vulnerable, so treatment should be avoided when large numbers are present.	Section 6.3
Is it poisonous to eel?	It is not expected to be poisonous to eels because eels are relatively insensitive to normal copper	Section 6.3
Is it poisonous to shellfish (mussels) and koura?	When applied for one hour Gemex™ is not toxic to snails and koura. Snails and mussels are expected to avoid Gemex™ by closing their shells as the dose passes by.	Section 6.3
Is it poisonous to introduced fish such as salmon and trout?	It can be poisonous to trout and salmon depending on water chemistry.	Section 6.3
Does it affect the bugs that fish feed on?	Some invertebrates will be killed. However, the effect is expected to be similar to the effect of storm flows; and natural recovery will occur.	Section 6.3
Does it have a colour?	It is blue in the stock solution, colourless in application reaches	Section 6.2
Does it change the colour of the water?	No	Section 6.2

How long will it stay in the water?	Gemex™ is quickly adsorbed by living and dead plant material, and by sediments, and diluted downstream. It is not expected to stay in the water longer than a day.	Section 6.6, 6.9
How far downstream will it travel?	Uptake rates depend on the amount of organic material. It becomes progressively diluted and dispersed as it travels downstream. In trials, concentrations reduced to below drinking water guidelines within 3 km. . Very low concentrations will travel some distance downstream (< 10 km or so).	Sections 6.6, 6.8, 6.9
Will the flavour of fish, etc be tainted?	Gemex™ is not expected to accumulate in fish and so is not expected to taint flesh. Overseas similar Cu products are used to prevent taints associated with cyanobacteria blooms in fish ponds	
Where does it come from?	It is made by mixing copper sulphate with the chelating agents	
Will fish passage be affected?	This is unlikely to be a major effect because concentrations are high only for a short period (hours - day)	
Will fish spawning be affected?	It would be inappropriate to apply it at spawning times. However, it could be applied before spawning times to remove didymo from redds	
Will it kill other plants that grow in the water?	It is probably toxic to some other algae and plants. However, many common algae survive Gemex™ treatment. Macrophytes are expected to grow back quickly from rootstock.	Section 6.3
What happens to our health if we eat water-grown plants?	There is the possibility that water plants may adsorb enough Gemex™ in the treatment reaches to make consumers sick. Don't eat dead plants! The plants will recover as copper is washed out of the system and will probably be suitable to eat 6 months after the last treatment, however no research has been done on this in New Zealand.	

How quickly will didymo return after it has been treated?	This depends on many factors. Eradication can be achieved in favourable circumstances (low infestations) although the research has not been done to demonstrate this is achievable. Suppression maybe achieved in situations where there is heavy infestations of didymo.	Section 6.13
What will happen in the event of unanticipated effects occurring?	The GTCP includes monitoring, and stakeholders will be kept informed. Any information will be fed back into didymo control knowledge database.	GTCP
Where else has it been used?	Similar compounds are commonly used in some states in the USA to control waterweeds, algae and some other pests. Similar compounds are also used in aquaria	Section 6.11
Does is cause any smells?	Gemex™ itself does not smell. Decaying didymo may cause odour when it is removed from the river.	
Who will be responsible for the discharge?	Depends on regulatory pathway used. There is an expert on-site coordinator responsible for the application.	ERMA 2007, GTCP (Clearwater et al. 2007a)
What happens if the chemical is spilled accidentally?	The GTCP has instructions to deal with spills. It will be diluted rapidly by water, soil or sawdust.	ERMA 2007, GTCP (Clearwater et al. 2007a)
How does the chemical work on didymo?	Didymo adsorbs or absorbs Gemex™, after which Cu interferes with cell or cell membrane processes	Section 6.6
How often would the chemical be applied?	Depends on extent of didymo infestation, size of river, flow, amount of inorganic matter in river and management objective	Section 6.13, GTCP
How would the chemical be applied?	From a storage tank (e.g., 5000 l) through an underwater diffuser	FAQ 11, GTCP
Where would the chemical be applied?	Based on expert appraisal of infestation, river size and locations,	FAQ 11, GTCP
When would the chemical be applied?	As soon as possible after the didymo is discovered to increase chance of success. Best applied in summer. Based on expert appraisal	See DSS, GTCP
What does it do to water quality in the short term?	It increases chelated copper concentrations and decreases pH	Section 6.6
What does it do to water quality in the long term?	It is not expected to affect WQ in the long term (apart from effects on didymo)	Section 6.8,6.9, 6.10

Do people need to stay out of the river? For how long?	On the day(s) of treatment	GTCP
Does it affect land plants that are irrigated with water from the river?	No risk if GTCP followed. Still highly unlikely in the event of inadvertent abstraction occurring on the day of application unless abstraction occurs within 1 km of injection point at the time of injection.	Section 6.12
Will Gemex™ affect fish and shellfish in estuaries and intertidal areas at river mouths?	Very unlikely. Gemex™ would be largely adsorbed by the time flows reach estuaries.	Section 6.10

Anglers and Food Gatherers

Anglers and food gatherers include trout and salmon, eel and whitebait fishers as well as people collecting edible plants. Gathering of other species such as freshwater mussels and crayfish is also included. Aquaculture activities fall within this sections, for example salmon, prawn and freshwater crayfish farms.

Issues of Concern to Anglers and Food Gatherers

1. Effects of human contact with Gemex.
2. Human consumption of food
3. Access to waterways.
4. Usability of waterways.
5. Availability of fish/food species

Anglers and Food Gatherers Practices to Consider

1. Times of activity (seasonal and daily).
2. Access points to waterways.
3. Movement between catchments and waterways.
4. Consumption of food.

Questions and Answers to assist Anglers and Food Gatherers to Understand Gemex™ Effects

Question	Short Answer	Further Information
Will fishing and food gathering have to stop while Gemex™ is in the water?	Yes	GTCP
How long will fishing and food gathering have to stop for?	On the day(s) of treatment (fish) and up to six months (plants).	GTCP

Will Gemex™ harm people if they come into contact with treated water?	The GTCP excludes public from waterway on application day.	GTCP
Will Gemex™ corrode fittings and components?	The public are excluded at the time water could be slightly corrosive. Gemex™ treated water is only corrosive for < a few km and < a few hours.	Section 6.6
Will Gemex™ harm people if they eat food sourced from a treated waterway?	No (as long as don't eat dead fish)	
Will Gemex™ cause the flavour of food to be tainted?	Gemex™ is not expected to accumulate in fish and so is not expected to taint flesh. Overseas similar Cu products are used to prevent taints associated with cyanobacteria blooms in fish ponds	Section 6.6 , 6.11
Will trout be harmed or killed by Gemex?	It can be poisonous to trout depending on water chemistry. Some trout may die in localised areas on the treatment day(s).	Section 6.3, 6.6
Will salmon be harmed or killed by Gemex?	It is probably be poisonous to salmon depending on water chemistry.	Section 6.3, 6.6
Will aquatic or water edge plants be harmed by Gemex™ (e.g. water cress)?	It is probably toxic to some other algae and plants. However, many common algae survive Gemex™ treatment. Macrophytes are expected to grow back quickly from rootstock.	Section 6.3, 6.6
Will freshwater mussels and crayfish be harmed by Gemex?	No. Latest laboratory trials show a wide safety margin for koura and shellfish for a 1-hour application to a river, and for the longer exposures downstream.	Section 6.3 Clearwater et al. 2008
Will Gemex™ affect fish spawning?	It would be inappropriate to apply it at spawning times. However, it could be applied before spawning times to remove didymo from redds	
Will Gemex™ affect whitebait?	Gemex™ is not very toxic to adult galaxiids, and there is a wide margin of safety for one-hour applications, and for the longer exposures downstream. Juvenile fish (whitebait) will be more susceptible, and application during whitebait runs should be avoided at this stage.	Section 6.3, Clearwater et al. 2008
Will Gemex™ affect eel?	It is not expected to be poisonous to eels because eels are relatively insensitive to normal copper	Section 6.3
Will Gemex™ affect ducks and other hunted waterfowl?	Copper and copper chelates are relatively non-toxic to birds. There is a very low risk that blue duck might be affected by the low pH for one hour immediately downstream of the treatment point, but the treatment management plan could include efforts to keep birds out of the water for one hour Gemex™ is being applied. This would reduce the risk to negligible.	Section 6.3
Will Gemex™ affect species down up the food chain, which may in turn affect species gathered for food/sport?	Copper does not bioaccumulate in the food chain. Only very small amounts are taken up from food.	Section 6.6

Recreational users

Recreational users include organisations such as rowing, jetboating, kayaking and rafting clubs, as well as individuals using the waterway for bathing or water-based activities. This group includes people or organisations that have physical contact with the water in the waterway.

Issues of Concern to Recreational Users

1. Effects of human contact with Gemex.
2. Access to waterways.
3. Usability of waterways.

Recreational Users Practices to Consider

1. Times of activity (seasonal and daily).
2. Access points to waterways.
3. Movement between catchments and waterways.

Questions and Answers to assist Recreational Users to Understand Gemex™ Effects

Question	Short Answer	Further Information
Will Gemex™ corrode fittings and components?	The concentrated stock will corrode metal fittings, but once the Gemex™ is diluted in the river it will only be slightly corrosive for the hour that it is present at high concentrations. The public are excluded from the river on the day water could be slightly corrosive.	Section 6.6
Will recreational use have to stop while Gemex™ is in the water?	Yes	GTCP
How long will water uses have to stop for?	On the day(s) of treatment.	GTCP
Will the dead didymo cause a drowning hazard?	Dead didymo is still attached after treatment, and is only removed during subsequent storm flows so risks are probably similar to live didymo	
Is Gemex™ toxic to humans if they drink water that has been treated with it?	Toxicity via drinking is very unlikely because an adult would have to drink 31 L of the treated water while river concentrations remained at their highest (i.e., within an hour). The GTCP prevents all non-official access to rivers being treated. The Ministry of Health Maximum Acceptable Value (MAV) for copper is 2 mg/L, c.f a one hour dose of 20 mg/L.	GTCP, Section 6.4
Will Gemex™ harm people if they come into contact with treated water?	See above	
Will Gemex™ cause harm to eyes?	The stock solution is corrosive. The public is excluded from treated reaches during the treatment day(s). The day after the treatment the water will not cause harm to eyes.	GTCP, Section 6.4
Will Gemex™ harm dogs swimming in the waterway or drinking the water?	There may be some harm to dogs drinking the water on the treatment day, or swimming near the application point. Restricting public access during application will minimize this risk.	GTCP, Section 6.5, 6.6

Drinking water abstractors

Drinking water abstractors are individuals and organisations that take water for the purposes of human drinking water. This includes municipal water supplies, small community water supplies and individual private supplies. This category also includes individuals or businesses taking water to use in food processing industries where products are for human consumption (e.g. freezing works, breweries, fruit/vegetable packing houses, etc).

Issues of Concern to Drinking Water Abstractors

1. Contaminants that cause people to become ill or die.
2. Contaminants that may cause products to be rejected or downgraded due to the presence of a contaminant.
3. Availability of water.
4. Reactions of contaminants with other additives or product ingredients.

Drinking Water Abstraction Practices to Consider

1. Timing of water takes (seasonal and daily).
2. Locations of water takes (from backwaters or unconfined aquifers where flushing of contaminants may be slower than the main waterway channel).
3. Storage of water.
4. Discharges of unused or wastewater.

Questions and Answers to Assist Drinking Water Abstractors to Understand Gemex™ Effects

Question	Short Answer	Further Information
Will water takes have to stop while Gemex™ is in the water?	Yes	GTCP
How long will water takes have to stop for?	On the day(s) of treatment.	GTCP
Does Gemex™ harm humans?	The stock solution is harmful if ingested and corrosive and to skin and eyes. The GTCP requires that all non-official access to rivers being treated is prevented. The Ministry of Health Maximum Acceptable Value (MAV) for copper is 2 mg/L, c.f one-hour dose of 20 mg/L.	GTCP, Section 6.4
What are the risks of Gemex™ contaminating drinking water supplies?	The max. treatment dose is 20 mg/L, while the MOH MAV is 2 mg/L. Abstraction of large proportions of Gemex-treated water is operationally difficult. Abstraction is restricted on the day(s) of treatment. In the unlikely event of inadvertent abstraction occurring on the day of application, it is highly improbable that there are many situations where Cu is not diluted or removed to concentrations < 2 mg/L.	Section 6.12

Will there be an accumulation of copper in food products or in stored water?	No, the MOH MAV of 2 mg/L and abstraction restrictions on day of treatment are designed to prevent any possibility of this happening. Copper will not biomagnify in the aquatic food web.	Section 6.12
Will Gemex™ react with other chemicals added to drinking water (e.g. chlorine, fluoride, flocculants, etc)?	Yes – the chelating agents may react with chlorine. However abstraction is restricted on treatment day(s) so this should not be an issue.	
Will Gemex™ taint the taste of water?	Yes, near the application point, but not after dilution to below MoH MAV level of 2 mg/L). Abstraction is restricted.	
Will Gemex™ taint the taste of food made using treated water?	Tainting is unlikely if water is inadvertently abstracted on a treatment day. Abstraction is restricted on treatment days.	
Will Gemex™ corrode pipework and fittings	The stock solution is acidic and dosed water may have low pH (3-5) for short periods (1-2 hours) near the point of application. pH rises to natural levels after a few km on the day of treatment , and immediately after the treatment. Remember, abstraction is restricted on treatment days	
Will the dead didymo cause filters to clog more often than if the didymo dies off naturally?	Possibly. Dead didymo is still attached after Gemex™ treatment and is only removed by stormflows – which also occurs with live didymo.	
What happens to Gemex™ if it is stored for a period of time (e.g. in a reservoir or tank)?	In this unlikely event, Gemex™ is taken up by live or dead organic matter and sediments However, abstraction is restricted, see above.	Section 6.6, 6.12
What happens if stock eat didymo that has been killed by Gemex?	Sheep are susceptible to copper poisoning and must be kept out of riverbanks if didymo is deposited there by stormflows. Other stock should also be kept away from riverbanks.	Section 6.5
Will Gemex™ affect fresh products that are washed in treated water (e.g. fruit and vegetables)?	Abstraction is restricted on treatment days. Inadvertent traces of Gemex™ will not taint food as long as the MoH MAV of 2 mg/L is not exceeded.	

Stock water abstractors

Stock water abstractors are individuals and organisations that take water for the purposes of animal drinking water. This includes pastoral farmers and businesses holding or rearing stock in enclosures or buildings (e.g. horse stables, poultry farms, etc).

Issues of Concern to Stock Water Abstractors

1. Contaminants that cause animals to become ill or die.

2. Contaminants that may cause animals to be rejected or downgraded due to the presence of a contaminant.
3. Availability of water.

Stock Water Abstraction Practices to Consider

1. Timing of water takes (seasonal and daily).
2. Locations of water takes (from backwaters or unconfined aquifers where flushing of contaminants may be slower than the main waterway channel).
3. Storage of water.

Questions and Answers to Assist Stock Water Abstractors to Understand Gemex™ Effects

Question	Short Answer	Further Information
Will water takes have to stop while Gemex™ is in the water?	Yes	
How long will water takes have to stop for? **Does Gemex™ harm animals?**	On the day(s) of treatment Abstraction not allowed. (See above). Sheep are susceptible to copper poisoning if they drink a lot of water. The GTCP requires animals to be excluded from river on day(s) of treatment.	Section 6.5
Will there be an accumulation of copper in animal tissue?	This is highly unlikely. Firstly, abstraction is not allowed (See above). Secondly, Cu is sometimes added as a stock nutrient to stock feed.	
Will Gemex™ affect the growth of animals?	This is highly unlikely because the GTCP restricts exposure to stock - Abstraction not allowed (and it is very unlikely that stock water will exceed MOH MAV of 2 mg/L - see above)	GTCP, Section 6.5, 6.12
Will Gemex™ react with animal remedies and animal health products added to drinking water?	This is highly unlikely because the GTCP restricts exposure to stock - Abstraction not allowed (and it is very unlikely that stock water will exceed MOH MAV of 2 mg/L - see above)	GTCP, Section 6.12
Will Gemex™ taint the water so that animals don't drink it?	This is highly unlikely because the GTCP restricts exposure to stock - Abstraction not allowed (and it is very unlikely that stock water will exceed MOH MAV of 2 mg/L - see above)	GMTP, FAQ 12
Will Gemex™ corrode pipework and fittings?	Abstraction is prevented at the time water could be slightly corrosive. Gemex™ treated water is only corrosive for < a few km and < a few hours.	GTCP

Will the dead didymo cause filters to clog more often than if the didymo dies off naturally?	Possibly. Dead didymo is still attached after Gemex™ treatment and is only removed by stormflows – which also occurs with live didymo.	
What happens to Gemex™ if it is stored for a period of time (e.g. in a reservoir or tank)?	In this unlikely event, Gemex™ is taken up by live or dead organic matter and sediments However, abstraction is restricted, see above.	Section 6.6,6.12
What happens if stock eat didymo that has been killed by Gemex?	Sheep are susceptible to copper poisoning and must be kept out of riverbanks if didymo is deposited there by stormflows	Section 6.5

Irrigators

Irrigators include individuals and organisations that take water directly from waterways or from hydraulically connected aquifers to use for non-drinking purposes. This includes irrigation of pasture and crops.

Issues of Concern to Irrigators

1. Contaminants that cause crops to die or be damaged.
2. Contaminants that may cause a product to be rejected or downgraded due to the presence of a contaminant.
3. Availability of water.

Irrigation Practices to Consider

1. Timing of irrigation and therefore water takes (seasonal and daily).
2. Locations of water takes (from backwaters or unconfined aquifers where flushing of contaminants may be slower than the main waterway channel).
3. Transfer of water between catchments.
4. Storage of water.

Questions and Answers to Assist Irrigators to Understand Gemex™ Effects

Question	Short Answer	Further Information
Will irrigation have to stop while Gemex™ is in the water?	Yes,	GTCP
How long will irrigation have to stop for?	On the day(s) of treatment	GTCP
What are the risks of Gemex™ contaminating irrigation water supplies?	The max. treatment dose is 20 mg/L, while the MOH MAV is 2 mg/L. Abstraction of large proportions of Gemex-treated water is operationally difficult. Abstraction is restricted on the day(s) of treatment. In the unlikely event of inadvertent abstraction occurring on the day of application, it is highly improbable that there are many situations where Cu is not diluted or removed to concentrations < 2 mg/L.	Section 6.12

Does Gemex™ harm crop species?	Abstraction stops at the time of treatment. (See above) Anyway, it is highly unlikely because copper is used as a fungicide for some crops	Sections 6.11, 6.12
Will there be an accumulation of copper in plants?	As above	Section 6.12
Will Gemex™ affect the growth of plants?	As above	
Will the be an accumulation of Gemex™ in the soil?	No, under the GTCP there will be little Cu in the irrigation water. Anyway, Cu is added as an essential nutrient. (Also see above)	GTCP
Will Gemex™ react with fertilisers?	No see above	
Will Gemex™ react with pesticide sprays?	No see above	
Will Gemex™ corrode pipework and fittings?	Water take is prevented at the time water could be slightly corrosive.	GTCP, Section 6.5,
Will the dead didymo cause filters to clog more often than if the didymo dies off naturally?	Possibly. Dead didymo is still attached after Gemex™ treatment and is only removed by stormflows – which also occurs with live didymo.	
What happens to Gemex™ if it is stored for a period of time (e.g. in a reservoir)?	In this unlikely event, Gemex™ is taken up by live or dead organic matter and sediments However, abstraction is restricted, see above.	Section 6.6, 6.12

Hydro electricity generators

Hydro electricity generators include major generators that either have dams and generators within the river and those that abstract water from a waterway to use for generation in a different location. Also included in this category are small local generation systems.

Issues of Concern to Hydro Electricity Generators

1. Constraints on water use.

Hydro Electricity Generators Practices to Consider

1. Times of activity (seasonal and daily).
2. Movement between catchments and waterways.

Questions and Answers to assist Hydro Electricity Generators to Understand Gemex™ Effects

Question	Short Answer	Further Information
Will Gemex™ corrode fittings and components?	The public are excluded at the time water could be slightly corrosive. Gemex™ treated water is only corrosive for < a few km and < a few hours.	Section 6.6

Will the amounts of dead didymo increase after a Gemex™ treatment?	Yes	
Will water takes have to cease or be restricted while Gemex™ is applied?	Yes, on the day(s) of treatment	GTCP
Will the transfer of water between catchments need to cease?	Yes, during application (1 day)	
Will Gemex™ harm people if they come into contact with treated water?	The GTCP excludes public from waterway on application day.	GTCP

6.15 How do I decide whether treating the didymo-infected reach will be environmentally acceptable?

1. Use Didymo-Gemex to obtain a list of fish species found downstream of the infection point. Didymo-Gemex will display a list of species found downstream of the upstream end of the treatment reach together with the distance downstream of this point. You should edit the list (double-clicking on each species will give you options) to ensure that the list is relevant. For example, if you are assessing a river flowing into Lake Taupo, Didymo-Gemex will give you a list of all species found downstream, including the Waikato River as far as Port Waikato! As Gemex™ will not cause any effects below the confluence with Lake Taupo, you should delete those species recorded only in the Waikato River.

   Conversely some small coastal rivers may have no species at all recorded in the Freshwater Fish database. In this case you may wish to add species likely to be present by looking at species present in adjacent stream and rivers. Use the **View** .. **Fish location** option to see all sites where there are fish records, and click on those sites closest to your treatment reach to get the species present. You can add those species to your list using the edit option mentioned in the paragraph above. Note, care should be taken with this option, as just because species are present in neighbouring streams does not necessarily mean they will be present in your treatment stream. If in doubt, consult a fisheries biologist.
2. Compare your final list of fish species with those species known to be susceptible to Gemex™ at the target concentration (currently only trout are known to be susceptible but further work currently being carried out by NIWA may find other vulnerable species).
3. Identify whether any of these fish species are rare and endangered through web resources (e.g. http://www.seafriends.org.nz/enviro/reddata.htm) or consulting with Department of Conservation and/or Regional Council biologists.
4. If trout or salmon are present, identify the significance of the didymo-infected reach as a fishery. Consult with Fish and Game (and Ngati Tuwharetoa if in Taupo Region) whether some localised impact to fish stocks is acceptable compared to prevention of didymo incursion.
5. Identify any other species known to inhabit the river downstream of the infection point and that may be susceptible to Gemex™. Decide on their regional significance by using Didymo-Gemex to display sites in the region (but not downstream) where these species have also been found (see Section 8.3 for how to do this).
6. If there is a lake or estuary (as opposed to open coast) downstream of the treatment reach, carry out the calculations (see 6.10) to decide whether there is a risk of Cu accumulating in sediments of those ecosystems that may breach sediment quality guidelines.
7. Use Regional Council databases and local knowledge to identify all consented abstractions and diversions along the selected treatment reach. These may include drinking water takes, irrigation takes, hydroelectric generation, and industrial takes. Check whether stock water and/or domestic drinking water is a permitted activity under the Regional Plan (and will therefore not need a consent).
8. Identify from local knowledge (including Regional Council/District Council resources) all significant social/cultural uses of the selected treatment reach.
9. Consult with potentially affected parties. Guidance is given in Section 7.12 on who and how to consult for the regulatory process. The same list of parties should be involved at this preliminary stage, but clearly the amount of consultation required will be less. Consulting with stakeholder representatives is probably all that is required at this stage though you may wish to hold a public meeting close to the proposed treatment point to ensure stakeholders in the

immediate locality have an opportunity to be informed and understand the situation. The idea is to decide whether there are any other social/cultural, or economic or human health 'show stoppers' can be identified at this stage that mean obtaining regulatory approval for Gemex™ treatment is unlikely. You should make use of the FAQs for stakeholder groups (6.14. Frequently asked questions on environmental effects of Gemex™) to assist stakeholders understand the effects of Gemex™ on their river and water uses and to identify effects that can and cannot be managed.

10. Considering the outcomes from 1-10 above complete the preliminary Assessment of Environmental Effects on the effects of Gemex™ treatment in the following matrix. An example of a completed assessment for the Tiraumea River is given below complete with the reasoning and reference to sources of information.

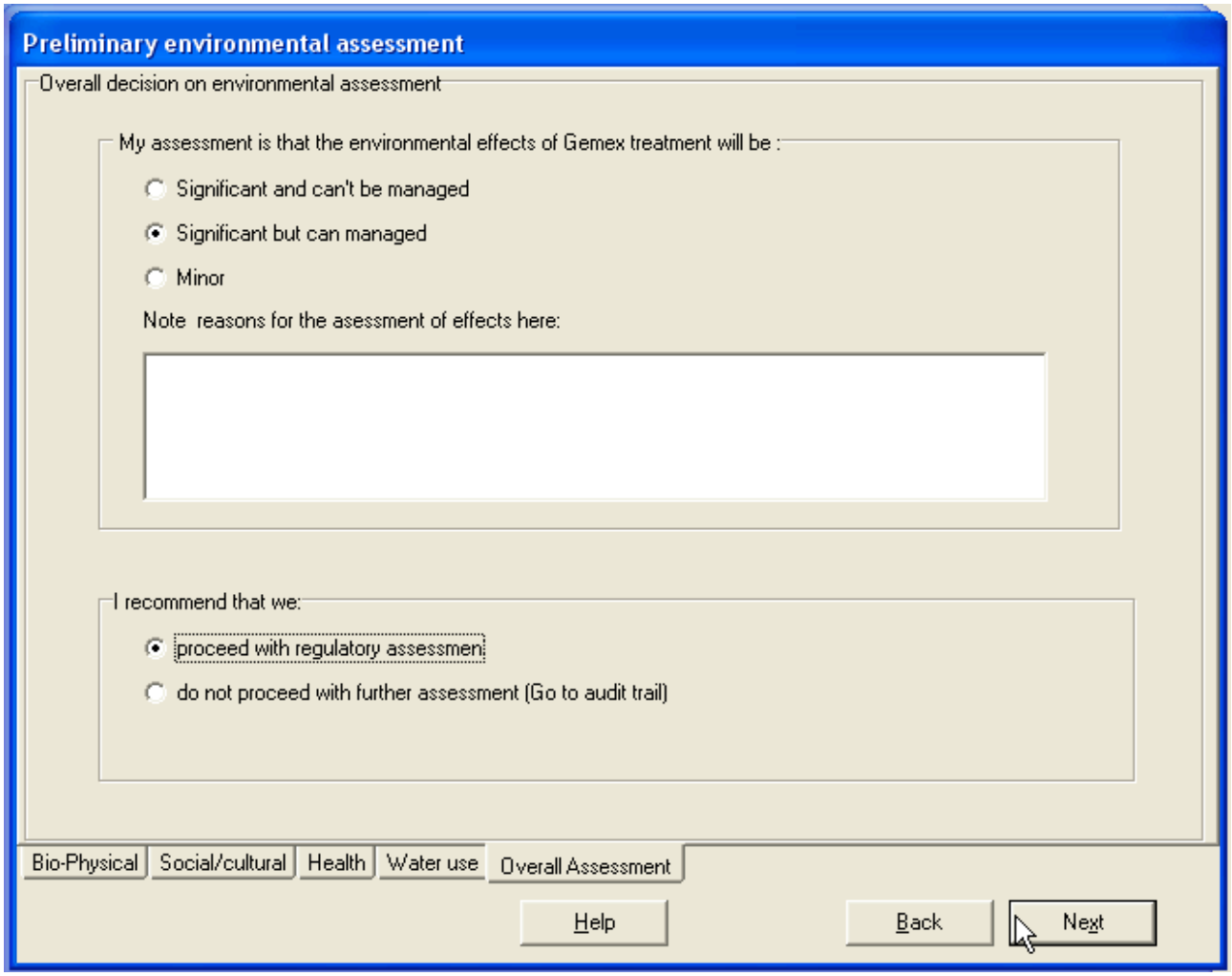
Example preliminary Assessment of Environmental Effects for the Tiraumea River.

Type of Effect	Parameter	Relevant to assessment	Significant effects that can't be managed	Significant effects that can be managed	Minor effects	Comment
Biophysical	Rare and endangered species	No				No rare or endangered species recorded in reach (from fish db)
	Trout and/or salmon	Yes		X		Trout present in reach. Mortality likely however repopulation from upstream and downstream likely to occur. Very limited fishing occurs along reach as mainly private land so access is restricted. Difficult fly fishing river due to steep vegetated banks.
	Other fish species	Yes			X	Eel present but Gemex™ unlikely to have significant impact. Some other species present (effects unknown) but repopulation from upstream and tributaries likely to occur reasonably rapidly.
	Other aquatic biota	Yes			x	Some crayfish, mussels and snails present. Unknown effects of Gemex™ but any mortality will be remedied through natural repopulation. Green algae does occur during prolonged low-flows but loss of this as a result of Gemex™ will have minimal impact.
	Cu accumulation in sediment (long-term)	No				No lakes/estuaries below discharge area.

Social/Cultural	Waterbody significance to Maori	Yes			X	Water quality in general has significance to Maori however this area had minimal historical use and no special significance. (Regional council records)
Health	Drinking water supplies	No				No drinking water supplies. Water quality in river is not suitable for drinking water. (Regional Council and local knowledge)
	Stock water supplies	Yes			X	4 stock water takes present (unconsented). Majority are for cattle water and takes can be easily restricted during treatment period. (Regional council records)
	Contact recreation	Yes			X	Some swimming by local children, but only occurs during summer months. Can be restricted during treatment period.
	Food gathering	Yes			X	Very limited and occasional gathering of watercress from tributaries. Some recreational eeling with occasional commercial activity. All food gathering activities can easily be restricted. (local knowledge)
Economic	Irrigation takes	Yes			X	Only one consented take for irrigation below the treatment reach. Take can be avoided during treatment period. (Regional council records)
	Hydro electricity generation	No				The river is not used for hydro-electric generation.
	Product quality standards/organic production	No				No significant organic crops are grown in this area. Only water takes are for conventional farming activities. No sensitive production activities.
	Industry takes	No				No industry takes present d/s

11. Consider the effects of a full didymo incursion (i.e. no Gemex™) treatment on each of the appropriate parameters given above. A formal assessment procedure to undertake this is not given here because our objective is to identify impediments to the use of Gemex™ rather than the effects of didymo. Nevertheless, it is useful to be aware of these possible effects in making a judgment on whether the 'effects' of Gemex™ treatment outweigh the 'benefits'
12. Make your assessment on the overall environmental effects of Gemex™ below. You should note that any adverse effects that can't be managed probably mean that Gemex™ is not

appropriate to use or that there is a high chance that resource consent will not be granted for the discharge. This does not necessarily mean that it can't be done, but it does flag a serious impediment to getting regulatory approval. Users are encouraged to consult with MAFBNZ, Diffuse Sources and NIWA if they encounter significant barriers to a Gemex™ treatment. Knowledge around didymo and Gemex™ is progressing rapidly and solutions may soon be available to some of the environmental concerns listed above. In addition, other information may be available about didymo, its impacts or lack of impact, in different environments and about how to manage it.



Overall decision on environmental assessment. Note – if you click the 'Do not proceed' box when you click the 'Next' button you will go directly to the audit trail without completing the regulatory module.

7. Regulatory Assessment

7.1 Introduction

If your decision has been that it is both practical and environmentally acceptable to apply Gemex™ to treat didymo, then you will need regulatory approval to do so. This section sets out a logical pathway for you to obtain the necessary approvals. The normal route for applying a chemical to a river is through the resource consent process (under the Resource Management Act, 1991) but this consent process is designed for activities that can be planned a significant time in advance. Unless applying Gemex™ to rivers for the purposes of treating didymo is specified in a regional plan as a permitted activity, or a resource consent has been granted in advance of didymo being detected, it is unlikely there will be sufficient time to go through the consent process. Because of the invasive nature of didymo, however, there may be alternative regulatory pathways that avoid the need for resource consent, particularly through the emergency provisions of various acts. A flowchart demonstrating the regulatory pathways to be considered is shown in Figure 2 below. This is an expansion of the regulatory module shown in Figure 1.

If you are familiar with the regulatory processes, then reading the summary below in conjunction with Figure 2 may be sufficient. Otherwise, you should read and understand the remainder of this section (7.2-7.12) before making your decision of the regulatory pathway to be followed (Section 7.13).

If your assessment suggests that a Gemex™ treatment would be appropriate, you are encouraged to obtain regulatory approval ahead of time, as the chances of successfully treating didymo will be much improved if it is treated quickly.

Summary of regulatory process

This section summarises the regulatory process shown in Figure 2. The following sections expand on each of the steps in the assessment process and should be referred to as part of the decision-making process.

Begin by determining whether the Gemex™ application site is within a conservation area administered by the Department of Conservation (DOC). If it is, consult with DOC to determine permissions and other requirements before proceeding. If it isn't within a conservation area, proceed to considering whether the existing Environmental Risk Management Authority (ERMA) approvals for Gemex™ are in place. Proceed to an assessment of the provisions of the relevant regional and district plans. Where the use of Gemex™ isn't specifically provided for by a rule in a regional plan, resource consent for a discretionary activity will be required. Where the activity is controlled by a rule in a plan, resource consent will be required. Determine the activity status for the activity. If it is permitted, you may apply Gemex™ without resource consent. Where the activity is a controlled, discretionary, discretionary (restricted) or non-complying activity, resource consent will be required. Check that the activity meets the relevant performance standards for the particular rules in the plan – it may be listed as a controlled activity but not meet the relevant standards and therefore needs to be considered against other more stringent activity status rules. If the activity is a prohibited activity, no resource consent can be granted and you should then consider whether one of the alternative regulatory pathways is available.

Once the activity status of the proposal is known, a preliminary assessment of environmental effects (AEE) should be completed to determine whether there are any 'show-stopper' effects that will prevent resource consent being approved. To assist in completing the preliminary AEE, consultation should have been undertaken with key stakeholders and people potentially affected by the proposal.

If the effects are likely to be more than minor, resource consent probably won't be approved and the alternative regulatory provisions should be explored. Where the effects are considered to be no more than minor, proceed to deciding whether there is sufficient time available for the resource consent process. If there is sufficient time available to follow the resource consent process, prepare a resource consent application and, if granted, apply Gemex™ according to the conditions of that consent. If the resource consent isn't approved by the council, investigate the Environment Court appeal process or consider alternative regulatory avenues.

Where the timeframes in which Gemex™ needs to be applied are urgent, the resource consent process is likely to be too time-consuming so alternative regulatory approaches should be investigated. Begin with examining whether the Resource Management Act 1991 (RMA) emergency provisions can be used. If they can, undertake the Gemex™ treatment and arrange for retrospective resource consent to be obtained. An alternative to the RMA emergency provisions are the provisions of the Biosecurity Act 1991 that allow the normal RMA provisions to be circumvented prior to Gemex™ treatment but retrospective resource consent will need to be obtained. A subsequent alternative is to use the Biosecurity Act 1991 emergency provisions where Gemex™ may be able to be used in accordance with the specific requirements of those provisions. The Hazardous Substances and New Organisms Act 1996 (HSNO Act) provides a further alternative in emergency situations.

If none of the regulatory alternatives support the use of Gemex™, it is likely that the use of Gemex™ is not able to occur lawfully and it should not be applied.

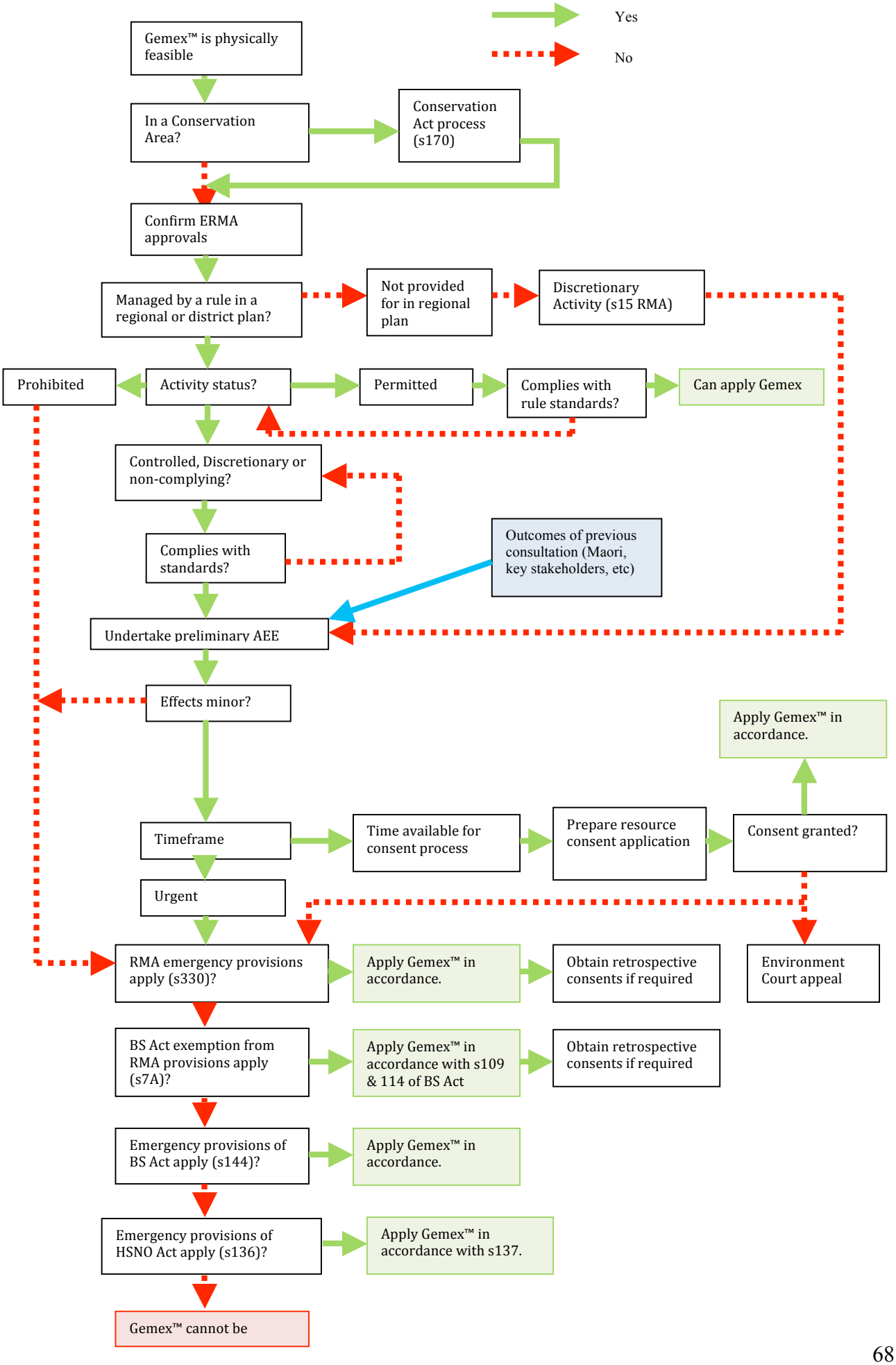

Yes
No
Gemex™ is physically feasible
In a Conservation Area?
Conservation Act process (s170)
Confirm ERMA approvals
Managed by a rule in a regional or district plan?
Not provided for in regional plan
Discretionary Activity (s15 RMA)
Prohibited
Activity status?
Permitted
Complies with rule standards?
Can apply Gemex
Controlled, Discretionary or non-complying?
Complies with standards?
Outcomes of previous consultation (Maori, key stakeholders, etc)
Undertake preliminary AEE
Effects minor?
Apply Gemex™ in accordance.
Timeframe
Time available for consent process
Prepare resource consent application
Consent granted?
Urgent
RMA emergency provisions apply (s330)?
Apply Gemex™ in accordance.
Obtain retrospective consents if required
Environment Court appeal
BS Act exemption from RMA provisions apply (s7A)?
Apply Gemex™ in accordance with s109 & 114 of BS Act
Obtain retrospective consents if required
Emergency provisions of BS Act apply (s144)?
Apply Gemex™ in accordance.
Emergency provisions of HSNO Act apply (s136)?
Apply Gemex™ in accordance with s137.
Gemex™ cannot be

Figure 2 (above) The Regulatory Process

7.2 Preliminary decision - Are treatment sites in a Conservation Area or covered by other regulations?

Conservation Areas

Some waterbodies that are being considered for treatment with Gemex™ may be within the conservation estate and therefore come under the management of the Minister of Conservation. Pursuant to Section 170 of the Conservation Act 1987, a concession is required from the Department of Conservation to undertake any activity in a Conservation Area except:

(c) any action or event necessary for the purposes of saving or protecting life or health, or preventing serious damage to property or avoiding an actual or likely adverse effect on the environment; or

(d) any activity that is carried out by the Minister or Director-General in the exercise of his or her functions, duties, or powers under this Act or any other Act.

Where the use of Gemex™ is proposed in a Conservation Area, confirmation should be sought from the Department of Conservation whether or not a concession is required. In most cases, use of Gemex™ in these areas will already be under consideration with the Department of Conservation as a key stakeholder and any permissions required will be addressed quickly.

To determine whether the proposed Gemex™ application site is within a conservation area, use the Department of Conservation's online mapping tool as follows:

1. Go to the DOC website http://gis.doc.govt.nz/website/Internet_NZMG_2005/viewer.htm
2. Turn on the Conservation Units map layer in the menu on the left of the window.

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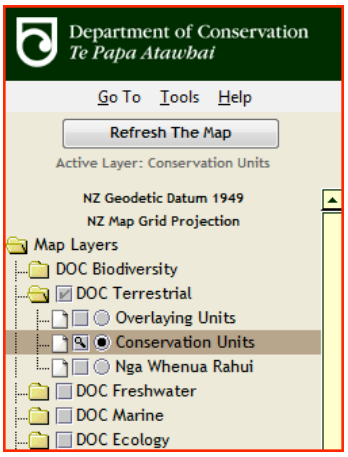
Figure 2. **Regulatory Assessment Process**



3. Zoom to the application site on the map.

4. Use the 'Identify' tool to find the name of the relevant Conservation Unit (if the Gemex™ application site is within one)

Other regulatory provisions

In some circumstances, other regulations or bylaws may have effect over the activities that are proposed. These are often specific to particular waterways or activities. An example is the Mount Cook National Park Bylaws 1981 which is specifically designed to manage activities within the Mount Cook National Park. Section 3 of that bylaw states:

- *No person shall—*
    - *(a) Willfully or carelessly pollute in any manner the waters of the park; or*
    - *(b) Willfully or carelessly spill or cause to be spilled any petrol, oil, or similar substance in the park.*

Approval may therefore be required form the Minister of Lands to discharge a contaminant into a waterway within the National Park.
Often bylaws and regulations specific to particular areas or activities will not be well publicised and it will be necessary to ask for advice from the relevant council. In most cases, councils will include relevant bylaws on their websites, but not always.
National bylaws, regulations and orders can be located at www.legislation.govt.nz
Local authority websites and contact details are available from http://www.lgnz.co.nz/lg-sector/maps/

Where other regulatory provisions are relevant, an assessment of their implications on the treatment process should be undertaken and the conclusion entered into the DSS Regulatory Section. Explain in sufficient detail (in the comments box in the DSS) the reasoning behind the decision made, with reference to the relevant regulation.

7.3 Confirm ERMA Approvals

The Environmental Risk Management Authority is responsible for controlling the manufacture, importation and use of chemicals that are not otherwise approved for general use within New Zealand. ERMA is able to grant approvals for the use of specific chemicals in specific situations. Currently, ERMA have granted approval for the use of Gemex™ when it is applied during a biosecurity emergency, however this may be modified to enable its use pursuant to a resource consent or via other regulatory pathways. If ERMA authority to use Gemex™ requires it to be used in accordance with a specific regulatory procedure, this will 'streamline' the regulatory assessment process. Contact MAFBNZ to determine the current status of Gemex™ permits.

7.4 Managed by a Rule in a Regional or District Plan?

This step in the regulatory decision-making process requires that the rules on the relevant regional and district plans are assessed. This will determine whether resource consent is required and, if one is required, indicate what scale of assessment will be required.

Regional Plans

Regional Plans are produced by regional councils to manage the natural and physical resources of each region. Regional Plans contain rules that control discharges and other activities associated with water and waterbodies. Rules can enable an activity, such as the discharge of Gemex™, as a permitted activity or they can require that a resource consent (for a controlled, discretionary

(restricted), discretionary or non-complying activity) is obtained from the Regional Council before the discharge can occur. In some instances, a regional plan will prohibit a particular activity, in which case it is definitely not able to occur. Where a regional plan does not contain a rule that addresses the proposed discharge (i.e. the type of material to be discharged may not have been anticipated by the regional council), resource consent for a discretionary activity is required. This is because the Resource Management Act 1991 does not allow any person to discharge a contaminant unless it is specifically allowed by a rule in a plan or a resource consent.

District Plans

District Plans are developed by district and city councils to manage the effects of land use. There is some cross-over between regional and district plans, particularly in relation to hazardous substances, but in general the roles of each plan are clearly defined.
The use of Gemex™ may involve incidental activities that may trigger rules in district plans. An example would be the transport, storage or mixing of hazardous substances. Gemex™, because of its corrosive and ecotoxic properties, will often be regarded as a 'hazardous substance' in district plans and its management will therefore need to meet the provisions of the district plan.
In contrast to discharges, most land use activities can occur *unless* they contravene a rule in a district plan. So if there is no rule in the relevant district plan controlling the activities proposed, resource consent is not required.

7.5 Activity Status

The following table briefly explains the status of activities in regional (and district) plans.

Activity Status	Requirement	Likelihood of Public Notification
Permitted	The activity can occur without resource consent, however it will generally have to comply with a set of standards listed in the Regional Plan.	Will not be publicly notified.
Controlled	Resource consent is required but the Council must grant it. Conditions can be attached to the consent that must be complied with.	Low
Discretionary (restricted)	Resource consent is required and it can be granted or refused. The Council can only refuse it in relation to the matters that it has restricted its discretion to. Conditions can be attached to the consent that must be complied with. Sometimes this is also referred to as 'Limited Discretionary'.	Low to medium.
Discretionary	Resource consent is required and it can be granted or refused. The Council it able to take into account any matters that are relevant to the assessment of the proposal. Conditions can be attached to the consent that must be complied with.	Medium to high
Non-complying	Resource consent is required and it can be granted or refused. Non-complying activities are generally unlikely to be granted unless there are unique or exceptional circumstances.	High
Prohibited	Resource consent cannot be granted. The Plan does not allow the activity to occur.	N/A

Activity Status in Regional Plan

Rules in regional plan relate to all land and water regardless of ownership. Even where the waterway is owned by the Crown or the regional council itself, the provisions of the regional plan are still relevant.

It is preferable that the interpretation of the rules in a regional plan is undertaken by somebody who is experienced in plan assessment. This may be a member of the Council's Consents Team.

Most Councils have their regional plans published on the internet. Regional council websites can be found on the following site: http://www.lgnz.co.nz/lg-sector/maps/

Each regional plan is constructed slightly differently and care should be taken to understand the way in which the relevant rules relate to each other.

If the activity is listed as a **Permitted Activity** in the regional plan, you will need to check that the details of the proposed Gemex™ discharge meet the standards specified for the permitted activity rule. If the standards will be complied with, you can apply Gemex™ without having to obtain resource consent. Note that the Council may encourage you to obtain a **Certificate of Compliance**, which is a written statement from the Council that your proposal complies with the permitted activity rules in the Plan. A Certificate of Compliance is not essential, but has the same effect as a resource consent and provides some protection to your activity if there are any changes to the regional plan provisions.

If the Gemex™ discharge falls within a **Controlled, Discretionary (Restricted), Discretionary or Non-complying** activity status, you will need to obtain a resource consent for the activity. The complexity and level of detail required in your application will depend both on the activity status and on the significance of the expected environmental effects. The following sections of this document will help you determine the significance of the potential effects and provide guidance on whether a resource consent is likely to be granted.

Figure 2 shows a feedback loop below the 'controlled, discretionary or non-complying' step. Most plans have specific standards that have to be met, even for controlled and discretionary activities. If, for example, an activity is listed as a controlled activity but does not meet one of the controlled activity standards, it will then fall under a more restrictive rule (it may become a discretionary activity). The feedback loop in the diagram represents this checking process. The same feedback loop applies to consideration of rules in district plans as well (see below for further discussion on district plans).

If the discharge of Gemex™ is specified as a **Prohibited** activity in the plan, you are not able to obtain resource consent for the discharge. The only real alternative in this situation is to investigate whether any of the emergency provisions of other acts may be available, which may avoid the need to comply with the Resource Management Act 1991. However, prohibited activities are usually only listed in plans if the activity is known to have a major adverse effect on the environment. In such cases, it is unlikely that use of the emergency provisions could be justified.

Considerations

- Regional plans are subject to change, so any previous assessment of the proposal against the rules should be checked to ensure that the relevant provisions have not altered.

- There may be two or more regional plans that apply to the one activity. In most cases this will be an operative (or transitional) plan and a proposed plan. Both plans will influence the proposed activity so both should be assessed. Seek advice from a planning expert or the Consents Team.

- Always confirm the assessment of the rules with a member of the Council's Consents Team to ensure that the correct interpretation has been undertaken.

- Some regional councils and district councils have combined to form unitary authorities. These authorities administer both regional and district roles from a single organisation, and may also combine the district and regional planning components into a single plan.

Activity Status in District Plan

Rules in district plans relate to all land and activities regardless of ownership. Even where the land in question is owned by the Crown or the regional council, the provisions of the district plan are still relevant

It is preferable that the interpretation of the rules in a district plan is undertaken by somebody who is experienced in plan assessment. This may be a member of the Council's Consents Team.

Most Councils have their district plans published on the internet. District council websites can be found on the following site: http://www.lgnz.co.nz/lg-sector/maps/

Each district plan is constructed slightly differently and care should be taken to understand the way in which the relevant rules relate to each other.

As discussed briefly above, the most likely component of the activity will be the storage, transportation and mixing of a hazardous substance (Gemex™). See 6.4 Is Gemex™ Toxic to Humans? for the hazard classification details for Gemex™ for use in assessment against district plan provisions.

A hazardous substance is a defined mixture of elements or compounds either naturally occurring or produced synthetically. Such substances can readily explode, burn, oxidise (accelerate the combustion of other material) or corrode (metals or biological tissue), and/or be toxic to people and ecosystems.[5]

District plans usually include rules that govern the use, transportation, storage and disposal of hazardous substances. These rules often use a hazardous rating system to determine the hazardousness of the particular substance and therefore what controls need to be put in place.

For more information on hazardous substances, please refer to the following websites.

http://www.ermanz.govt.nz

http://www.qualityplanning.org.nz/related-laws/faqs-hsno-rma.php

http://www.mfe.govt.nz/issues/hazardous/

[5] http://www.mfe.govt.nz/issues/hazardous/

Where resource consent/s is required under the relevant district plans, it may be most efficient to apply for both the regional and district consents at the same time. Regional and district councils are able to jointly assess applications for the same activity, which can streamline the consent process and reduce costs.

Considerations

- District plans are subject to change, so any previous assessment of the proposal against the rules should be checked to ensure that the relevant provisions have not altered.
- There may be two or more district plans that apply to the one activity. In most cases, this will be an operative (or transitional) plan and a proposed plan. Both plans will influence the proposed activity so both should be assessed.
- Always confirm the assessment of the rules with a member of the Council's Consents Team to ensure that the correct interpretation has been undertaken.
- Some regional councils and district councils have combined to form unitary authorities. These authorities administer both regional and district roles from a single organisation, and may also combine the district and regional planning components into a single plan.

7.6 Undertake Preliminary AEE

Now that it is confirmed that resource consent is required for the proposed Gemex™ treatment, consideration needs to be given to the likelihood of the success of the consent application. If the consent application is unlikely to be successful, spending significant time and money preparing an application and comprehensive assessment of effects is probably not justified.

Undertaking a preliminary assessment of environmental effects allows for consideration of the likelihood of the success of a resource consent application, and ultimately the likely impacts of the proposed activity on the environment. The preliminary AEE identifies whether there are any 'show-stoppers' – impacts that are likely to be so significant that they will cause the proposal to be abandoned. It does not take the place of a comprehensive AEE that will need to be completed as part of any resource consent application. The Environmental Assessment section of this document includes a template for preparing a preliminary AEE, and this should have already been completed by the time you reach this point in the decision process. You may find that some additional information is now available that wasn't at the time the preliminary AEE was completed, so the assessment should be revisited.

Where the preliminary AEE shows that there are likely to be some significant adverse effects from the proposal, a decision will need to be made whether to proceed with the resource consent process or to consider an alternative method of enabling the activity (using the emergency and other provisions of the RMA and other acts). Bear in mind that where the anticipated adverse effects of Gemex™ will be significantly greater than the potential effects of didymo itself, the decision may be made not to proceed with the Gemex™ treatment option at all.

Types of effects for this assessment

Significant effects that can't be managed. These are adverse effects that cannot be avoided, remedied or mitigated, or that cannot be off-set by the overall positive effects of managing didymo.

Significant effects that can be managed. These are adverse effects that are significant but can be managed in a way that avoids, remedies or mitigates their impact. This can include implementing measures that will resolve the problems caused by Gemex™, or may include situations where the natural processes will result in the adverse effects being short-lived. It can also include effects that will be off-set by the benefits achieved by eradicating/controlling didymo.

Minor effects. These include adverse effects that will have little impact or will have an impact for a very short period of time.

Preliminary consultation as part of AEE

Figure 2 includes a box representing outcomes of preliminary consultation being included in the process. Before completing the preliminary AEE, and ideally before proceeding through the Environmental and the Regulatory assessment modules, preliminary consultation with key stakeholders and potentially affected people should be undertaken. This will increase the likelihood of the actual impacts of the proposed Gemex™ treatment being better understood early on, and it also gives other people an opportunity to contribute ideas and information to the decision-making process. Further information and advice on undertaking consultation can be found in section 7.14 Consultation.

Considerations

- Any adverse effects that can't be managed will probably mean that Gemex™ is not appropriate to use or that there is a high chance that resource consent will not be granted for the discharge.

- The costs and feasibility of addressing adverse effects that are manageable should be considered against the anticipated Gemex™ benefits. Where the cost of avoiding, remedying or mitigating adverse effects is greater than the anticipated benefits to be gained from using Gemex™, it may be decided that use of Gemex™ is not justifiable. Where initially significant adverse effects can be avoided, remedied or mitigated, there is a high chance of resource consent being granted.

- Where most or all of the effects are considered to be no more than minor, resource consent is likely to be granted.

7.7 Assess Timeframes

This step in the regulatory assessment process assists with determining whether there is sufficient time available to follow the required resource consent process.

The Resource Management Act 1991 requires that proposals are notified where the effects are likely to be more than minor or where particular people are considered to be affected. The public notification process will, due to having to provide people with an opportunity to contribute to the assessment process, take significantly longer to complete than if the application is processed without notification (non-notified). At this stage in the regulatory assessment process, it will be useful to consider whether the time available before treatment of didymo is required will be sufficient to allow the resource consent to be assessed and (hopefully) granted. If there is insufficient time available to complete the resource consent process, the use of Gemex™ may need to be 'fast-tracked' through one of the alternative regulatory options (emergency provisions under

the Resource Management Act or Biosecurity Act). See Section 7.9 RMA Emergency Provisions if the timeframes available are limited.

The following table provides an indication of the timeframes likely for the various resource consent processes possible. These timeframes are indicative only and provide an estimated 'bad case' scenario. Every application is different and the time taken to process it will be influenced by a large number of variables, including the complexity of effects, adequacy of the application, scale or distribution of the effects, the number of submissions received, etc. Where a well-constructed application has been prepared and good pre-application consultation completed (in order to minimize the number of submissions through prior resolution of issues), the application assessment process may be significantly quicker.

Likely Application Process	Statutory Timeframe	Likely Total Timeframe (accounting for further information requests, hearings, etc)
Non-notified	20 working days	6 – 7 weeks
Limited notification (affected parties only)	70 working days	15 – 18 weeks
Public notification	70 working days	15 – 20 weeks
Environment Court Appeal		Previous time plus 3 – 6 months

Considerations

- Preparation of a good quality application that addresses the relevant issues will assist the Council greatly in making a quick decision.
- Discuss how the application is likely to be processed and ask for an estimate of timeframes from the Council's Consents Team. This will give a more accurate indication of time.
- Where the time available is limited, consider whether using the emergency provisions of the various acts would be a more appropriate course of action.
- Didymo infection may, or may not occur, but if it does the sooner Gemex™ is applied, the greater the chances of elimination. Making provision for Gemex™ application as a permitted activity within a Regional Plan, and/or preparing a Resource Consent in advance[6] for rivers most susceptible to didymo infection, would ensure that Gemex™ application could proceed quickly in the event an infection was discovered.

7.8 Prepare Resource Consent Application

If has been determined that there is sufficient time available to go through the resource consent process, and that the preliminary AEE has indicated that the effects of the proposed Gemex™ discharge can be managed, a resource consent application and full assessment of environmental effects will need to be prepared.

A resource consent is required for any activity that is not specified as a 'permitted activity' in a regional plan, or which contravenes a rule in a district plan. The resource consent process provides

[6] Because Resource consents generally lapse if not taken up within a defined period, such consents would need to be renewed at whatever period was specified by the Regional Council.

the relevant council, and others affected by the proposed activity, time to give it due consideration and to determine whether it will have adverse effects on them or the environment.

To apply for a resource consent, the Resource Management Act 1991 requires that details of the proposal and an assessment of environmental effects (AEE) are provided. The details of the AEE need to reflect the scale of the effects likely from the activity. So an activity that is very minor in scale and has little or no adverse effects will only need a small AEE, whereas a proposal that is of a significant scale or has the potential to affect a number of aspects of the environment will need a comprehensive AEE.

The speed at which a resource consent application is assessed is often related to the quality of the application submitted. Applications that provide minimal assessment or do not adequately address key issues will tend to be delayed as more information is requested and matters are clarified. Wherever possible, it is best to provide a sufficiently comprehensive AEE to minimise the possibility of processing delays.

Included in Appendix 1 of this documentation is a template to assist with the preparation of a resource consent application and AEE for the discharge of Gemex™. The template provides some generic background information on didymo and Gemex™, as well as some of the known effects of Gemex™. It is intended only as a guide to assist with preparing an application and will require significant input to take into account the local environment and site-specific issues.

A resource consent application and AEE should be prepared by someone who is experienced in preparing such documents, such as a resource management planner. This person will understand the standard of assessment expected by the council and will be able to ensure that the application is as complete as possible. Technical input from biologists, ecologists and other specialists is also likely to be required, particularly where there are sensitive species or activities present.

Resource consent applications must include certain details, and the template provided will provide guidance on these details. It is important to speak with the person at the Council who is likely to be processing the application, both before and during the application preparation process. They will be able to provide guidance on the key issues to address as well as assistance with specific legal requirements of the application.

If resource consent is granted, Gemex™ can then be applied in accordance with the conditions of that resource consent. If resource consent is not granted, two options are available. Either follow the Environment Court appeal process set out in the RMA, or investigate using one of the alternative regulatory methods described below.

Considerations

- Consider having the application prepared by a resource management planner or other professional who is experienced in preparing applications.
- Discuss the proposal with a consents officer at the council to understand the type and level of information required.
- Section 6 of this user manual and FAQs for stakeholders will provide a lot of useful information to assist in the preparation of the application. Some of this information has already been included in the application template, but there may be additional relevant information that could be of assistance.

- Consultation should be undertaken with people who may be affected by the proposal. Ask the Council's consents officer who they think might be considered as 'affected parties'. You may find the FAQ section useful for consultation, particularly the relevant FAQs and answers for specific interest groups such as Maori, water abstractors and recreational users.

- Consultation is an important tool for identifying potential adverse effects. Consult early to provide time to address any issues raised.

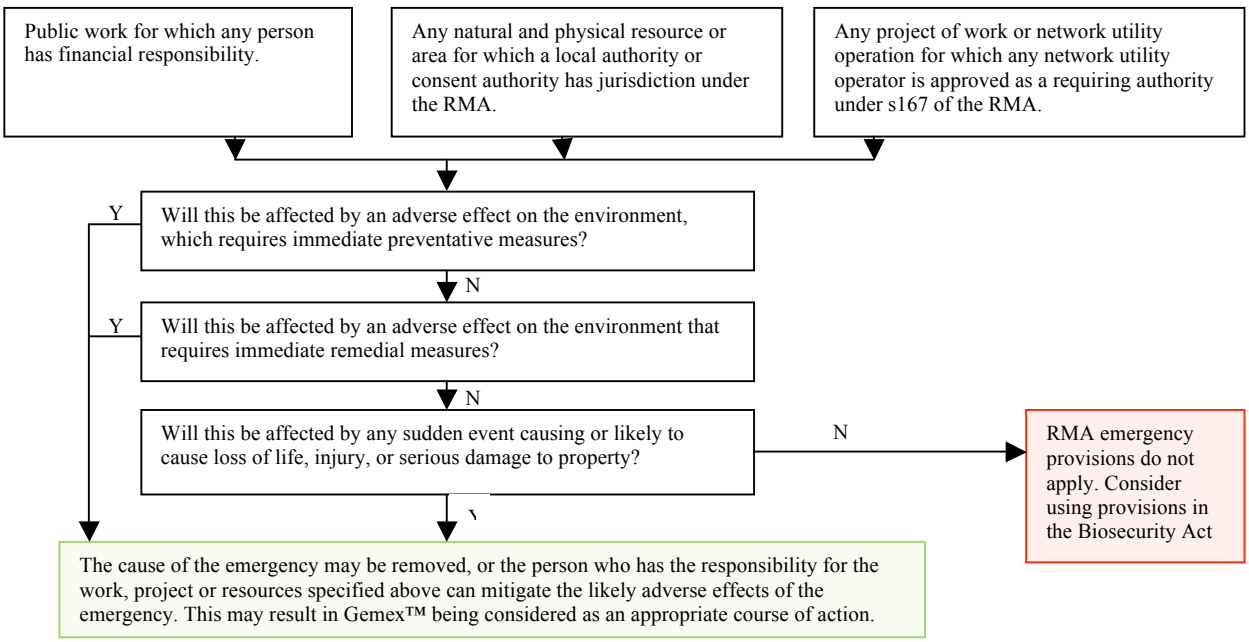
- The details of the proposal included in the application and AEE will become a requirement of the resource consent. Make sure that the details and methodology provided in the application reflects what will actually happen when the activity occurs.

7.9 RMA Emergency Provisions

Where the timeframes available are insufficient to obtain a resource consent, or the resource consent process is not considered appropriate for the use of Gemex™ in a particular situation, various acts provide opportunity for the requirement for resource consent to be avoided or at least delayed until after the treatment has occurred. This and the following sections outline how those alternative provisions work and when they can be used.

The Resource Management Act 1991 includes provisions to enable works or activities to be undertaken in an emergency. These provisions become relevant where any natural or physical resource or area is affected (or likely to be affected) by an adverse effect on the environment which requires immediate preventative or remedial measures. In these situations, resource consents do not need to be obtained prior to the emergency works being undertaken, however resource consents need to be applied for within 20 working days after the works have occurred.

To determine whether the emergency provisions of the Resource Management Act 1991 are applicable, the following flow chart indicates the considerations that must be made. Start by determining which box in the top row best relates to the proposed activity, and then follow through each 'test' below.



The above assessment diagram is an interpretation of section 330 of the Resource Management Act 1991. This section of the Act should be referred to directly if the use of these emergency provisions is being contemplated. See http://www.legislation.govt.nz/ for the full text of New Zealand legislation.

If the emergency provisions are used, once the activity has taken place to manage the emergency a resource consent application needs to be made to the relevant consent authority within 20 working days after the activity. This is to regularize any non-compliances with regional or district plans and to address any adverse effects that may be occurring on the environment after the activity.

Considerations

- Use of the emergency provisions needs to be given careful consideration. Making a decision as to whether or not the presence of didymo in a particular area constitutes an 'emergency' must be supported by robust reasoning and argument.

- The emergency provisions are not intended to be used as a method for circumventing the normal planning processes. If the appearance of didymo is not an emergency, then these provisions are not intended to be used.

- Several people or organisations are able to use the emergency provisions. Full involvement of the consent authority and all other key stakeholders in the particular waterbody proposed to be treated should be involved in the decision making wherever possible.

- Consider whether the effects of didymo on the environment will actually be significant. Do the effects warrant immediate action?

- The likelihood of didymo spreading from the current location to a far more sensitive location may be a consideration. The effects on the presently affected water body may not be significant but the ease with which didymo may then spread to a more sensitive area may significantly increase as a result of this infestation, therefore the environmental effects may be significant and warrant immediate action.

- Consideration should be given to whether the proposed preventative/remedial measure (i.e. Gemex™) is going to have less of an adverse environmental effect that if didymo were allowed to remain/establish.

- Consideration should be given as to whether Gemex™ will actually be an effective remedial or preventative measure. If it is not likely to be effective in being remedial or preventative, then the discharge of it under the emergency provisions may not be justified.

- Any decision to use the emergency provisions should be comprehensively documented.

7.10 Biosecurity Act exemption from RMA Provisions

Where the emergency provisions of the Resource Management Act 1991 are not considered relevant or are not able to be applied, the provisions of the Biosecurity Act 1993 may apply.

The Biosecurity Act 1993 includes a provision (Section 7A) that enables the responsible Minister to waive the requirements of the Resource Management Act where steps are to be taken under Part 6 of the Biosecurity Act in an attempt to eradicate an organism. The power of exemption can only be exercised in specific circumstances. The exemption has a duration of up to 20 working days and may, after that period, be extended by making regulations for that purpose (see the Act for more details).

The decision to utilise the RMA exemption provisions is a decision that needs to be made by the Minister responsible for managing the didymo eradication effort. In most cases this will be the Minister of Biosecurity, but may also include the Minister of Conservation. Comprehensive discussions should be undertaken with the relevant Minister's advisors as part of this process.

In making a decision as to whether the RMA exemption provisions can be used, **all three** of the following tests need to be met.

1. The organism is not established in New Zealand, the organism is not known to be established in New Zealand, or the organism is established in New Zealand but is restricted to certain parts of New Zealand; **and**

2. The organism has the potential to cause all or any of significant economic loss, significant adverse effects on human health, or significant environmental loss if it becomes established in New Zealand or if it becomes established throughout New Zealand; **and**

3. It is in the public interest that action be taken immediately in an attempt to eradicate the organism.

Invoking this exemption may be successful for the first infection of didymo in the North Island, but is unlikely to succeed for a further infection in the South Island, even if in a new region.

Considerations

- The decisions whether to grant an exemption from the RMA specified RMA provisions is a decision that must be made by the relevant Minister.

- The determination as to whether didymo has the potential to cause significant economic loss, significant human health effects or significant environmental loss relates to the potential impact of didymo if it becomes established nation-wide. It is not necessarily the case that didymo will have any of those effects at the particular site where it is first discovered.

- Section 7A(9) of the Biosecurity Act requires that the adverse effects of the activity undertaken are avoided, remedied or mitigated once the activity has been completed. How this will be achieved should be a consideration in the assessment as to whether to use the RMA exemption provisions.

7.11 Biosecurity Act Emergency Provisions

The Biosecurity Act includes provisions to enable a response to a biosecurity emergency without the need to follow the normal regulatory procedures required by this and other acts. A biosecurity emergency can only be declared by the Governor-General on a recommendation by a Minister and a declaration can only be made in certain circumstances.

In the case of didymo, a biosecurity emergency could only be declared by the Governor-General and where the following tests are met.

1. Didymo is established in part of New Zealand and it has the potential to cause significant economic loss, significant environmental loss, or both, if it becomes established in other parts of New Zealand; **or**

2. Where didymo has previously thought to be of restricted distribution or abundance in New Zealand but is becoming or has become so distributed and abundant in New Zealand or any

part of New Zealand that it has the potential to cause significant economic loss, significant environmental loss, or both; **or**

3. Didymo is, or threatens to be, beyond control by the application of the national pest management strategy for that pest; **and**

4. It is in the public interest that action be taken immediately to manage, or eradicate the organism and sufficient powers are not otherwise available to enable the organism to be effectively managed, or eradicated.

There are several limitations and requirements associated with the use of the emergency provisions and these should be carefully considered (refer to Section 144 of the Biosecurity Act 1993). See http://www.legislation.govt.nz/ for full details of New Zealand Legislation.

As with the other regulatory options that avoid the resource consent process, full consultation with the consent authority should be undertaken.

Considerations

- Take particular note of point 4 above, which requires that for the emergency provisions to be used, sufficient powers should not otherwise available to enable the organism to be effectively managed or eradicated. This may mean that a biosecurity emergency may not be able to be declared where there is sufficiently available time and other means to manage or eradicate didymo (e.g. management via resource consents to use Gemex™).

- The Biosecurity Act emergency provisions eliminate any requirement to obtain resource consent or to manage the effects on the environment associated with the treatment method. Careful consideration should be given to the effects of treatment versus the benefits of managing didymo.

7.12 HSNO Act Emergency Provisions

Should the Resource Management Act and Biosecurity Act provisions be inappropriate to use, the Hazardous Substances and New Organisms Act 1996 includes provisions to manage the incursion of unwanted organisms into New Zealand.

The Hazardous Substances and New Organisms Act 1996 contains provisions that enable actions to be taken where a hazardous substance or new organism will result in an "(a) actual or imminent danger to human health or safety; or (b) a danger to the environment or chattels so significant that immediate action is required to remove the danger" (Section 135, HSNO Act). These provisions allow an emergency to be declared by an enforcement officer so that works and actions can be done to resolve the emergency.

Section 136 of the HSNO Act specifies the following assessment that must occur before an emergency can be declared.

(1) Where any enforcement officer has reasonable grounds to believe that---

(a) there is an emergency; and

(b) either,---

(i) no state of emergency has been declared under the Civil Defence Emergency Management Act 2002; or

(ii) the emergency is not being dealt with under the Fire Service Act 1975; or

(iii) no emergency has been declared under section 144 of the Biosecurity Act 1993; or

(iv) no other enforcement officer has declared an emergency under this Act; and

(c) all or any of the powers set out in section 137 should be exercised in order to---

(i) enter any premises or dwelling; or

(ii) remove the cause of the emergency; or

(iii) stabilise the situation to limit the actual or likely adverse effects of the emergency; or

(iv) protect the health and safety of people, chattels, or the environment from the actual or likely adverse effects of any emergency,---

the enforcement officer may declare a hazardous substance or new organisms emergency.

This and other provisions of this Act give specific but reasonably wide-ranging powers to address an incursion of an unwanted organism.

Considerations

- The intention appears to be that where the emergency is already being managed by the provisions of the Biosecurity Act or another of the listed acts, the HSNO Act emergency provisions do not apply.
- Careful consideration will need to be given to whether the appearance of didymo in a waterbody would meet the definition of an emergency. Will it cause a *danger* to the environment so significant that *immediate action* is required to remove the emergency?

7.13 Gemex™ Cannot be Applied

This last box in the Figure 2 flow chart is arrived at when all of the regulatory options for using Gemex™ have been exhausted. Reaching this point, despite the use of Gemex™ being considered to be feasible and to have manageable impacts on the environment, indicates that there are some wider issues that mean that Gemex™ cannot be applied.

Please note that the decision support tool only provides a suggested process for decision-making and that the ultimate decision is left to the user. Any decisions made should be documented so that they are reflected in the audit trail at the end of the decision making process.

7.14 Consultation

This section relates to consultation which should occur throughout the process of determining whether to use Gemex™.

Fully understanding the effects of a discharge of Gemex™ requires that the activities of people who may potentially be affected by the discharge are clearly understood. People's concerns about Gemex™ and its effects, or perceived effects, need to be taken into account when making a decision on whether or not to use Gemex™ as a treatment. To properly understand these effects, consultation with the potentially affected people should occur.

When to consult

Consultation should take place as early in the decision-making process as possible. By consulting early, some of the main concerns and issues will become apparent and will help in making a quick decision on the potential costs and benefits of the proposal. Consulting early also enables those people being consulted to have time to understand the potential effects of the proposal on their activities and gives them time to meaningfully contribute to the decision-making process. Pressure placed on people to make a quick decision on a potentially complex matter will tend to result in negative responses as a precautionary stance is adopted.

Who to consult

Every locality will be different, as there will be different land owners, water users and people interested in the particular waterbody. Discussions should be held with the consent authority to assist in identifying who may be potentially affected. The following list of people and groups should be considered, but there are likely to be others:

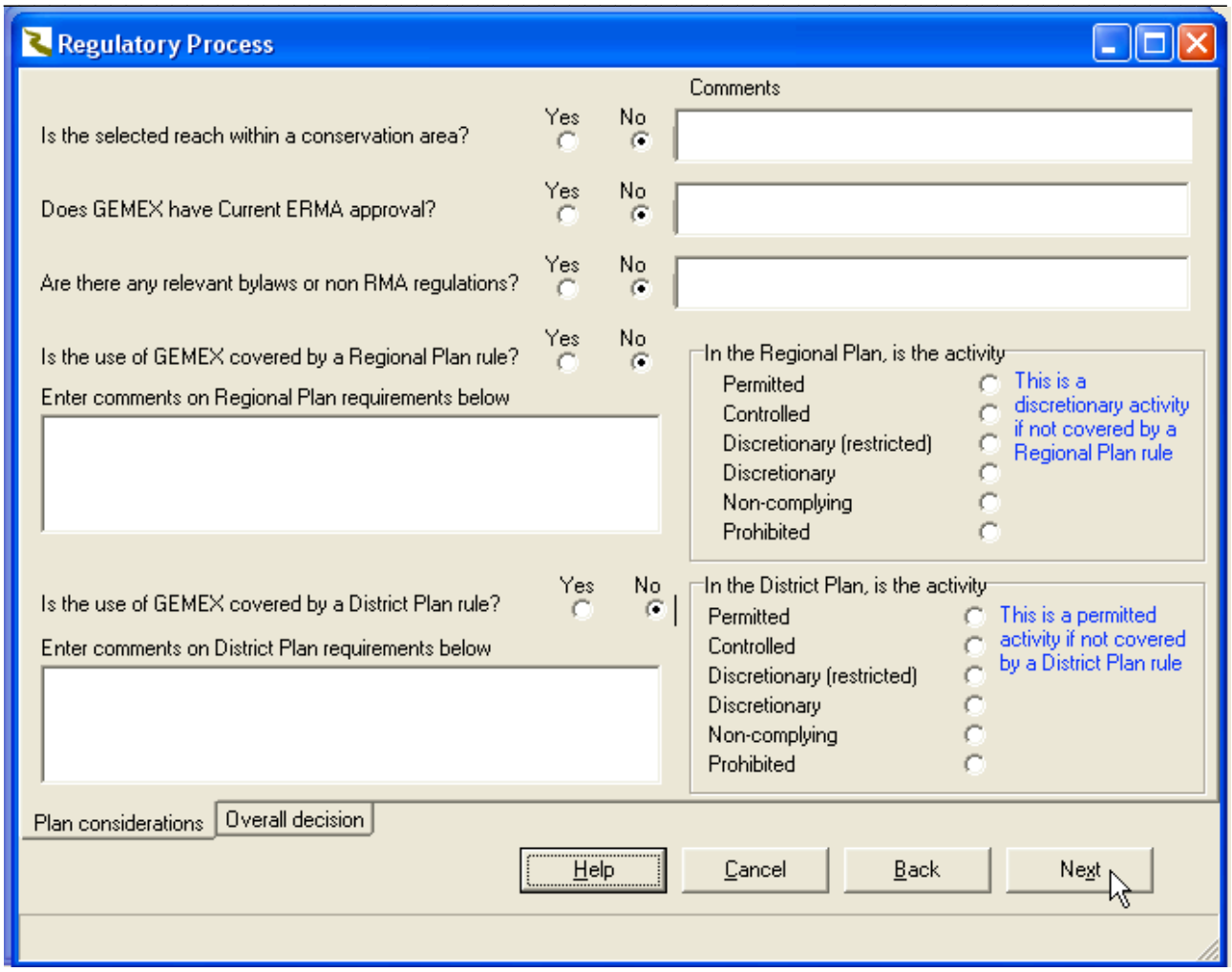
Department of Conservation	Fish and Game New Zealand
Local Iwi and hapu	Landowners who boundary the waterway
People who take water for irrigation	People who take water for water supplies
Industrial water users	Hydro electricity generators
Recreational users, including clubs and associations	People who gather food from the waterbody, including plants, fish and other animals.
People who use the water or the waterbody for aquaculture (e.g. salmon farming).	Local environmental groups
Tourism operators who utilise the waterbody	District councils (particularly in relation to town water supplies)
Regional council	

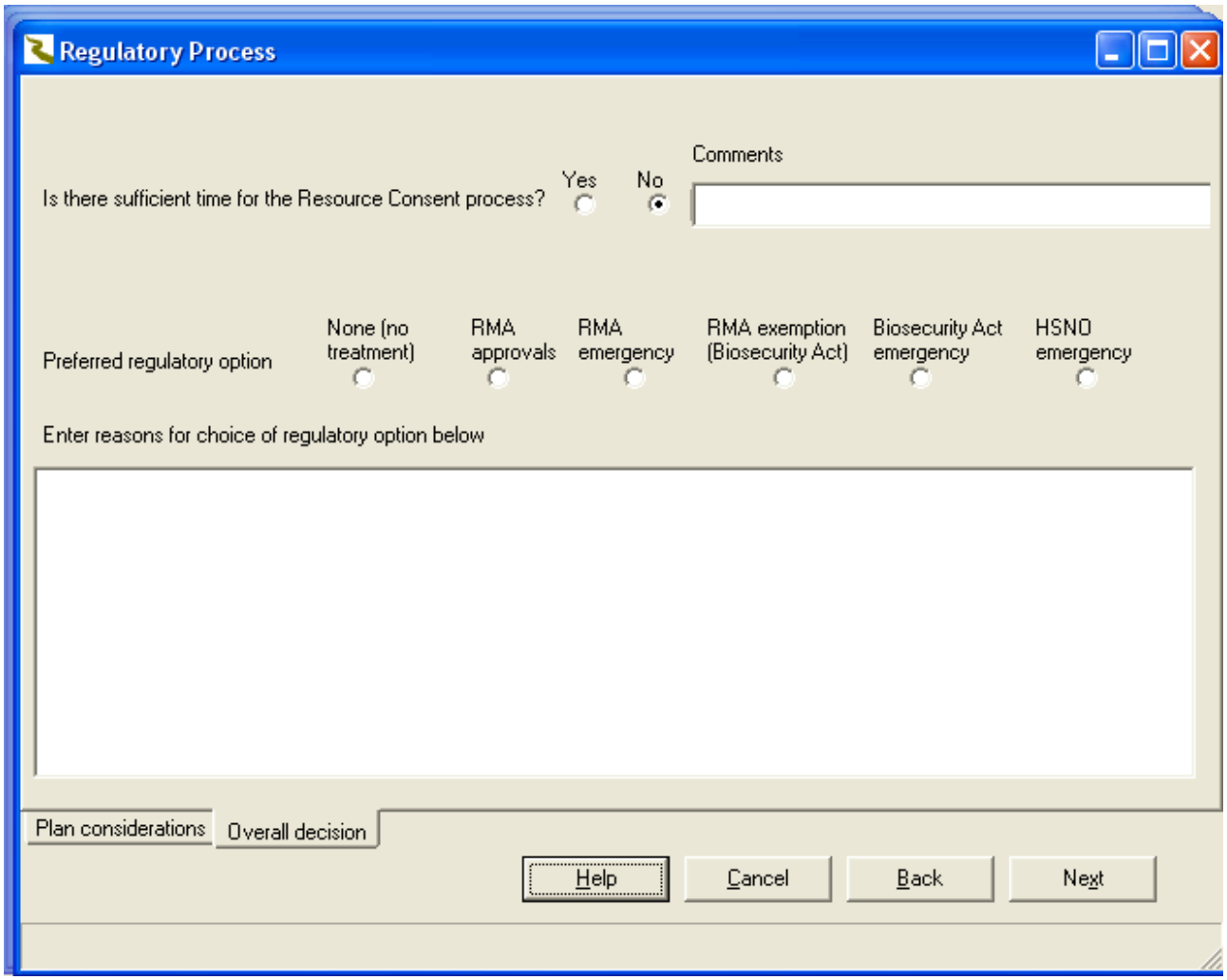
How to consult

More information on how to consult and what consultation involves can be found on the Ministry for the Environment's Quality Planning website (http://www.qualityplanning.org.nz/consents/consultation.php)

7.15 Decision on Regulatory Pathway

This section asks you to record your understanding of the regulatory situation with respect to the particular river reach and to make recommendations on the regulatory pathway to be pursued. This information will be recorded in the audit trail of decision making (Section 8).


Regulatory Process
Comments
Is the selected reach within a conservation area?
Yes
No
Does GEMEX have Current ERMA approval?
Are there any relevant bylaws or non RMA regulations?
Is the use of GEMEX covered by a Regional Plan rule?
Enter comments on Regional Plan requirements below
In the Regional Plan, is the activity
Permitted
Controlled
Discretionary (restricted)
Discretionary
Non-complying
Prohibited
This is a discretionary activity if not covered by a Regional Plan rule
Is the use of GEMEX covered by a District Plan rule?
Enter comments on District Plan requirements below
In the District Plan, is the activity
This is a permitted activity if not covered by a District Plan rule
Plan considerations
Overall decision
Help
Cancel
Back
Next


Regulatory Process
Is there sufficient time for the Resource Consent process?
Yes
No
Comments
Preferred regulatory option
None (no treatment)
RMA approvals
RMA emergency
RMA exemption (Biosecurity Act)
Biosecurity Act emergency
HSNO emergency
Enter reasons for choice of regulatory option below
Plan considerations
Overall decision
Help
Cancel
Back
Next

8. Audit Trail

8.1 Introduction

The purpose of the audit trail is to provide:

1. A means of storing the input data, which may be later restored for review, and,
2. A simple means of compiling a report on your decision whether Gemex™ is a suitable treatment.

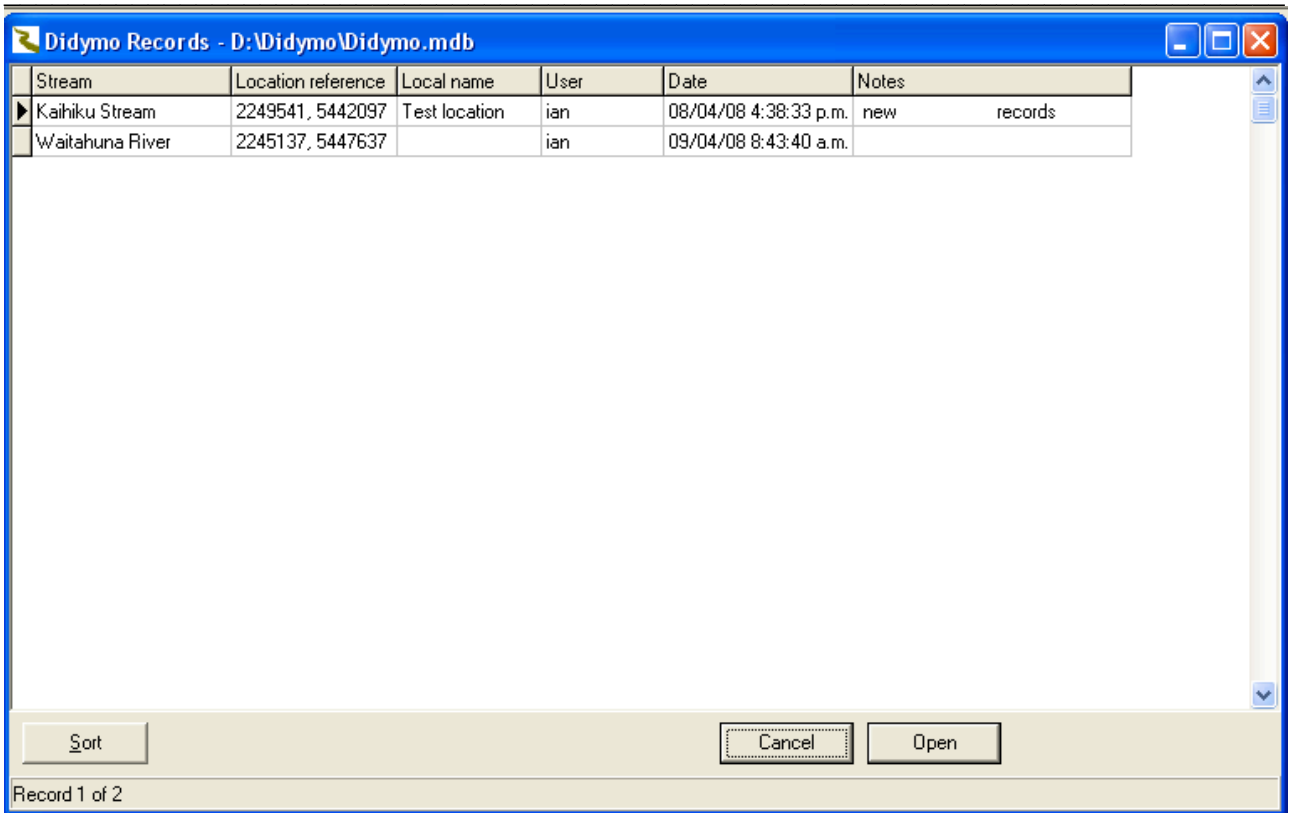
Didymo-Gemex also provides a number of mapping options that can be used to enhance your report.

8.2. Storage and retrieval

When you have finished evaluating a particular river reach you should save the record: **File …Save Infection Record.** If you forget to do this, Didymo-Gemex will prompt you to save when you exit Didymo-Gemex. A **Notes** window will also appear in which you can record notes relevant to the evaluation.

The data (maps references, hydrological data etc) and decisions from the evaluation will be saved along with any notes you make.

You can retrieve an evaluation at any time. **File .. Select Infection Record** displays a list of all evaluations carried out by the User.



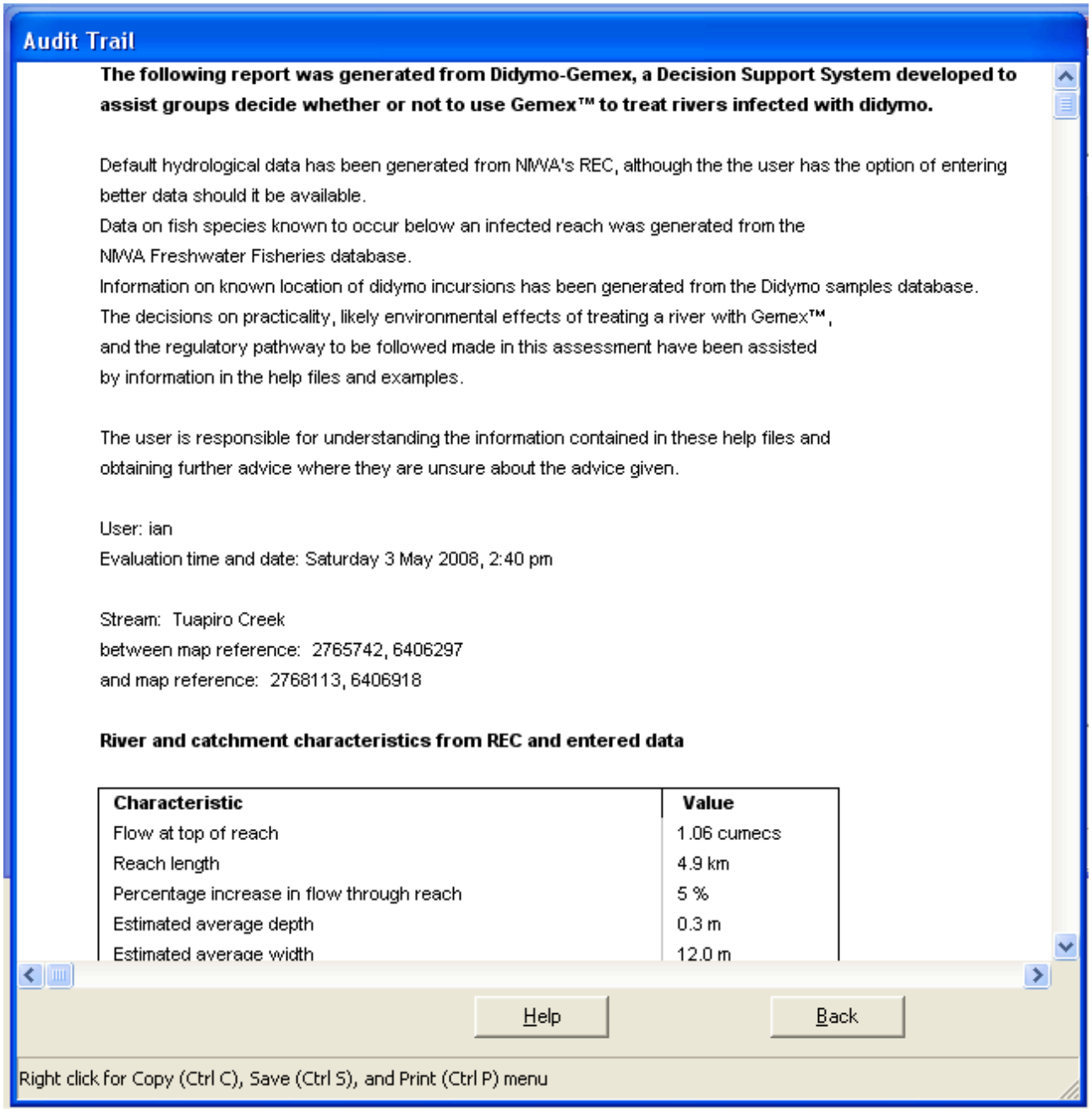
Clicking on a particular evaluation will open it, and you can carry on with or modify the evaluation.

8.3 Printing/exporting your report

The audit report contains all the input data, derived values and your decisions on the practical feasibility, likely environmental acceptability, and likely regulatory pathways[7]. You may copy, save, or print the audit trail report by right clicking anywhere in the window and choosing the appropriate option. The first part of a typical audit report is shown below. The report contains your name, the date of the assessment, your purpose in assessing the use of Gemex™ for treating didymo, and a statement on the sources of information within Didymo-Gemex and how it has been used to make a decision.

Saving the report saves it as a rich format text file (.rtf) that can be opened by virtually any word processing package. The advantage of saving it in this format is that you can subsequently add maps or other information to the report to enhance its readability.

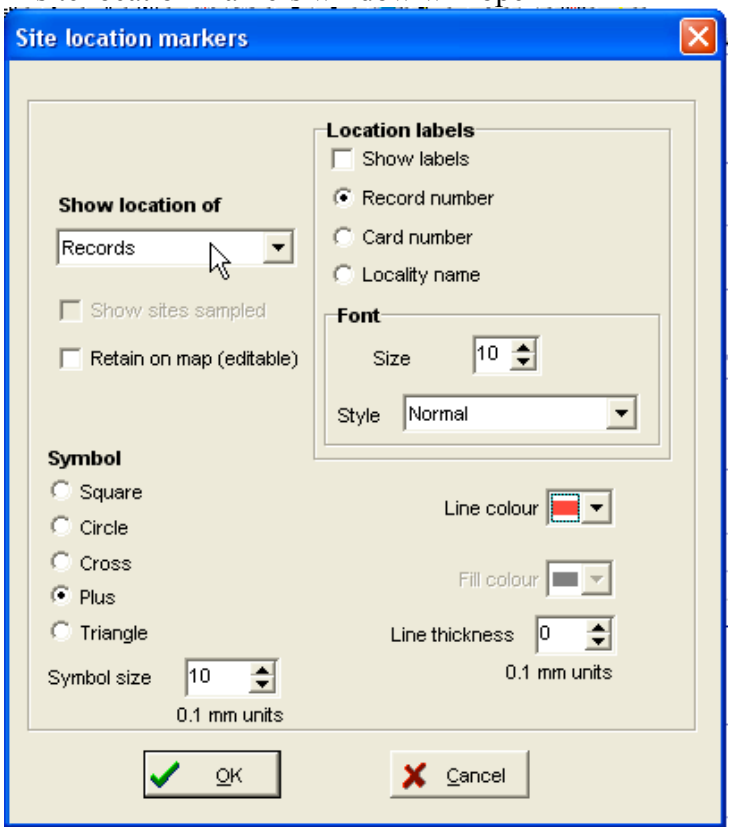
[7] Of course if you decide that Gemex™ is not worth considering further after the practical feasibility module, the audit trail will contain only information on practical feasibility. Likewise if the decision is that it is practically feasible, but not environmentally acceptable then the audit trail will contain information on those two modules but not regulatory considerations.



For example, let's take an example of a new infection in the Aorere River (Tasman), and let us make the assumption that you are particularly concerned about the effects of Gemex™ on Banded kokopu (*Galaxias fasciatus*). You can display sites where Banded kokopu. has been recorded by:

1. On the map menu **View .. Fish records**. All sites where fish records have been recorded on the freshwater fish database will be displayed. If you click on any sampling site the species found there will be displayed.
2. Click on the Marker button 

3. A site location markers window will open

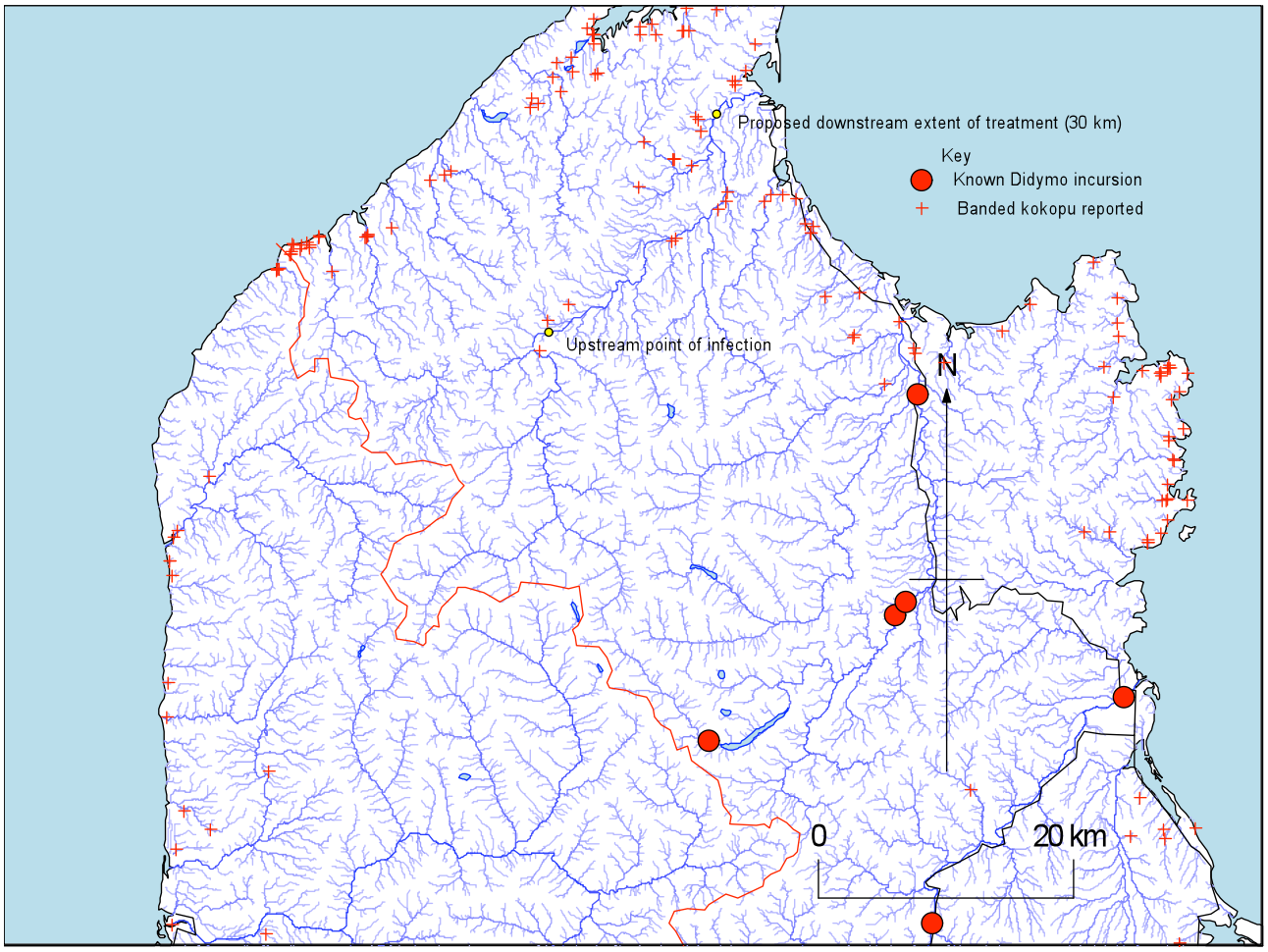


4. Pull down the menu "Show location of" to "galfas" (first three letters of each part of latin name)
5. Change the colour and shape of the symbol to how you want it to look (in this case a red plus sign)
6. Click OK and the locations of recorded Banded kokopu will be shown.

You can further enhance your map by labeling the upstream and downstream extent of infection (choose the Text (T) option on the map menu, click and type at the point where you want the text), and adding a key to symbols (**Insert ..Marker**) and add the shape and colour of marker corresponding to the information on your map.

The resulting map can be copied to the clipboard (**File … Copy to clipboard**) or Saving as a Windows metafile (*.wmf) by clicking on the Save icon The map can then be pasted or inserted within your audit report in the same way it has been inserted in this report below.

There are a variety of other options to enhance your map, which include showing towns, meteorological recording sites, even waterfalls. **(View … Place names)**. The best way to see all these options is to experiment.



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Appendix 1. Generic AEE for using Gemex™ in a river to treat didymo

Discharge of Gemex™ into a waterway for the purposes of managing an infestation of didymo

Some river

Resource Consent Application and Assessment of Environmental Effects

June 2008

This resource consent application and assessment of environmental effects template has been prepared as a guide only. It provides some generic information and headings, but should not be regarded as a complete template for every situation. Each environment and each regional council will have different requirements and issues. This variability cannot be encapsulated in a generic template and should be considered on a case-by-case basis. The assessment of environmental effects should be supported with reports from experts wherever possible.

This template has been prepared as part of the Didymo-Gemex DSS developed on behalf of MAF Biosecurity New Zealand by Diffuse Sources Ltd, Perception Planning Ltd and Ian Jowett. The template should be used in conjunction with the help file associated with the Gemex-Didymo DSS.

The resource consent application and assessment of environmental effects should ideally be prepared by a person who is suitably qualified and experienced in undertaking and/or managing a comprehensive resource consent application.

Report prepared by: ....

Date: ....

Contents

Application Form

Form 9
Application for Resource Consent
Section 88, Resource Management Act 1991

To [Local authority] [Where resource consents are required from more than one council, a joint application may be appropriate. This approach should be discussed with each of the consent authorities.]
I, [Full name of applicant], apply for the following types of resource consent:
[For an activity in the coastal marine area, state coastal permit. Otherwise, state one or more of the following: land use consent, subdivision consent, water permit, or discharge permit. Describe the activity for which the application relates.]
The names and addresses of the owner or occupier (other than the applicant) of land to which the application relates are as follows: [Details]
The location of the proposed activity is as follows:
[describe the location as it is commonly known and in a way that will enable it to be easily identified (e.g. street address, legal description, name of any relevant stream, river or other water body to which the application relates, proximity to any well-known landmark, and/or the grid reference]
No additional resource consents are needed for the proposed activity OR the following additional resource consents are needed for the proposed activity and have [or have not] been applied for. [Give details].
I attach, in accordance with the Fourth Schedule of the Resource Management Act 1991, an assessment of environmental effects in the level of detail that corresponds with the scale and significance of the effects that the proposed activity may have on the environment.
I attach any information required to be included in this application by the district plan, the regional plan, the Resource Management Act 1991, or any regulations made under that Act. [List all documents attached as appendices]

.....
Signature of applicant (or person authorised to sign on behalf of applicant).

.....
Date

Address for service of applicant:
[Enter a postal address]

Telephone:
Fax/email:
Contact person:

Introduction

This is a resource consent application and assessment of effects on the environment prepared in accordance with Section 88 and Schedule 4 of the Resource Management Act 1991 (RMA). The assessment of effects has been prepared to a level of detail that corresponds with the expected scale of the actual and/or potential effects of the proposed activity.

This proposal involves the discharge into a waterway of the product Gemex™, which is primarily a copper chelate solution. In favourable circumstances, Gemex™ has been shown to be an effective method for the management or eradication of didymo. Didymo is an exotic alga that has potentially-significant, adverse effects on waterways.

Background

Didymo

What is Didymo?

Didymosphenia geminata, *which is commonly known as* didymo, is a freshwater alga. A single cell of didymo is microscopic - it takes a number of cells to be present in the water before didymo is visible to the human eye.

Didymo attaches itself to streambeds by stalks. The stalks grow to form a thick brown mat on rocks, plants and other materials in the water. Established mats form flowing streamers that turn white at the ends and look similar to tissue paper.

Didymo can grow to form large mats on the bottom of streams, rivers and occasional lake edges where there is a wave action. Thick growths can adversely affect freshwater fish, plant and invertebrate species by reducing the number of suitable habitats. While it has no human health risk, it has potentially significant impacts on the amenity values of waterways and can be a nuisance for recreational users.

Where did it come from originally?

Didymo was first detected in New Zealand in the Lower Waiau River in Southland in October 2004 during a routine survey of the river. It has since been detected in several South Island rivers but has not yet been discovered in any North Island waterbodies. The Ministry of Agriculture and Forestry website contains a chronology of didymo discoveries in New Zealand[8].

While the exact means by which didymo arrived in New Zealand is unknown, it is considered most likely that it arrived here from overseas on contaminated recreational or industrial equipment.[9]

How is it spread

Didymo is a microscopic organism and a single cell is sufficient to establish a new infestation. Because of its size, didymo cells can be transported to new waterbodies on any equipment that remains wet. It can also be spread by transferring water from an infected waterbody to another waterbody.

Biosecurity New Zealand promotes a 'check, clean, dry' programme to encourage people to minimise the chances of didymo being transferred to new waterways. However, even with significant vigilance, didymo readily survives in or on items that have not been rigorously decontaminated.

[8] http://www.biosecurity.govt.nz/pest-and-disease-response/pests-and-diseases-watchlist/didymosphenia-geminata/incursion

[9] www.biosecurity.govt.nz/faq

Some river

What effects does it cause?

Thick growths can adversely affect freshwater fish, plant and invertebrate species by reducing the number of suitable habitats. Under favourable conditions for its establishment, it is likely to have a large impact on trout fisheries, hydro power schemes and irrigation takes. The brown carpet of didymo is also very unsightly and is likely to make swimming an unpleasant experience, and annoy anglers by fouling lines and lures. It has no known human health risk.

What management options are available?

The use of Gemex™ is one of several options available for the management of didymo. The currently available management options include the following:

Management Option	Positive	Negative
Do nothing	• No financial costs associated with treatment. • Avoids adverse effects associated with treatment options.	• Does not control didymo. • High likelihood that didymo will spread to other waterbodies • Existing species likely to be adversely affected by didymo. • Potentially high financial costs to water users through screen fouling, loss of production, etc
Exclude activities that might result in further spread	• May reduce the likelihood of didymo spreading to other waterbodies. • Relatively low financial cost to implement, although some cost associated with advertising and policing.	• Does not control didymo already within the waterway. • Existing species likely to be adversely affected by didymo. • Potentially high financial costs to water users through screen fouling, loss of production, etc • Does not prevent

		spread of didymo downstream. • Policing and enforcement likely to be difficult to prevent all activities.
Use a treatment agent to kill or manage didymo	• Likely to minimise the further spread of didymo. • Prevents didymo from adversely affecting other stream biota. • Protects water users from effects of didymo.	• May be a high financial cost of treatment. • Treatment agent may have adverse effects on biota. • Effectiveness may be limited by physical characteristics of the waterbody or by the nature of (re)infestation.

Gemex™

What is Gemex™?

Gemex™ is a copper based biocide, specifically designed to treat didymo, while minimizing impacts on non-target species.
It is a mixture of copper sulphate (which is also a common garden fungicide) with relatively simple organic molecules, which act as chelating agents (Clearwater et al. 2007b, ERMA 2007).
Copper and copper chelates have been commonly applied to treat waterways for aquatic weeds, especially in Florida. They are also commonly used as a treatment for fish diseases and to remove algae in aquaria.
The chelating agents themselves are not expected to be toxic: they are commonly found in living organisms, are metabolic by-products and are found in foodstuffs.

Who developed it?

Gemex™ was developed by the National Institute of Water and Atmospheric Research (NIWA) specifically for the treatment of didymo.

How is it used?

Before treatment commences, the personnel, equipment, and Gemex™ will be transported to the treatment site using trucks, boats or helicopters. There may be a requirement to redistribute some substance to larger tanks before distribution by the pumping equipment. A sub-surface diffuser would be placed across the width of the waterway at the treatment location. Gemex™ is metered into the waterway to a maximum target application rate of 20 mg Cu/L in receiving water.

Some river

Some hand-spraying may be undertaken of isolated, interconnected backwaters and moist fragments on shore. Gemex™ used for hand-spraying would be diluted to a maximum of 20 mg Cu/L before spraying.

Multiple strategic follow-up treatments by application to flowing water and hand spraying may be required. Between 3 and 10 follow-up treatments typically spaced 24 hours apart may be more effective than a single treatment.

Prior to commencing the application of Gemex™ to the waterway, the flow in the river is measured with dye tracing, using the non-toxic dye rhodamine This information is needed in order to accurately calculate the precise amount of Gemex™ needed to achieve the desired Gemex™ concentrations in the waterbody.

How does it work on Didymo?

GemexTM is thought to kill didymo cells through adsorption of the copper chelates into or onto cell walls.

This Site

When and how was didymo discovered?

[Describe how, when and where didymo was discovered in this particular area. Provide some background of its discovery and development.]

Project Description

Project Site

Location

[Describe the location of the discharge point, including; a site map, legal description, relevant map references, name of the waterway and a general description of the area surrounding the discharge point. Where consent is being sought to use Gemex™ in a number of waterbodies, describe the locations of those waterbodies.]

Physical location
Legal Description
Map Reference
Site Map
[Google Maps (http://maps.google.com) is a useful source of map images]

Physical characteristics

[Describe the current nature of the waterway, including; dimensions, volume, flow rate, water colour/clarity, bed and bank material. Much of this information will be able to be sourced from the Gemex™ DSS computer program. You may also need to source additional descriptive information from the Regional Council. A description of each of the waterways proposed to be treated should be included in the case of a global consent application.]

Description of didymo infestation

[Describe the extent of the didymo infestation, approximate area cover and location within waterway. Where didymo has not yet been discovered, describe the reaches of the waterbody that are considered most likely to be infested (based on physical characteristics or vector presence.]

Property ownership

[Please provide the details (name, address and phone number) of all property owners/occupiers at the point of and downstream from the Gemex™ discharge where physical access for treatment or monitoring will be required.]

Surrounding Environment

[Generally describe the nature of the catchment, topography, sensitivity of the receiving environment and surrounding landuses. Include the proximity of people, local iwi, parks, natural areas and other waterbodies.
The information provided in this section contributes to establishing the 'existing environment' so that the effects on that environment of the proposed discharge can be assessed. Without an accurate description of the state of the receiving environment, the scale and intensity of any adverse effects cannot be determined.]

Upstream environment

Physical characteristics

[Describe the current nature of the waterway upstream of the discharge point, including; dimensions, volume, flow rate, water colour/clarity, bed and bank material. This information can be obtained from the Gemex™ DSS software or from the Regional Council. Where the discharge point is not certain, there may be an area above which treatment is unlikely to be feasible (due to access, low risk of infestation, etc). In this case describe the relevant characteristics above the viable treatment area.]

Biota present

[Describe the plant and animal life of the waterway and riparian margins upstream of the discharge point. This information should be available from a freshwater scientist within your Regional Council, with some basic data available from the Gemex™ DSS software (fish only). In particular, species that are known to be susceptible to copper should be identified, as well as any rare or endangered species. This information both assists in establishing an environmental baseline for the monitoring of any effects of the proposed discharge, and also enables an understanding of the potential for natural recolonisation of the treated area.]

Other waterway users upstream

[Describe the activities of other relevant waterway users upstream of the discharge point, including activities such as water abstractions, other discharges and hydro electricity generation activities. Some activities upstream of the discharge point may influence the water quality and quantity downstream and therefore influence the timing or effectiveness of any treatment.]

Downstream environment

Physical characteristics

[Describe the current nature of the waterway downstream of the discharge point, including; dimensions, volume, flow rate, water colour/clarity, bed and bank material. This information can be obtained from the Gemex™ DSS software or from the Regional Council. Data on multiple waterbodies may be able to be tabulated. Describe how the waterbody interacts with groundwater and/or other waterbodies. This may also include how managed diversions will be controlled]

Biota present

[Describe the plant and animal life of the waterway and riparian margins upstream of the discharge point. This information should be available from a freshwater scientist within your Regional Council, with some basic data available from the Gemex™ DSS software (fish only). In particular, species that are known to be susceptible to copper should be identified, as well as any rare or endangered species. This information assists in establishing an environmental baseline for the monitoring of any effects of the proposed discharge.]

Other waterway users

[Describe the activities of other relevant waterway users downstream of the discharge point, including activities such as water abstractions, other discharges, recreation activities, food gathering and any culturally or spiritually significant sites or practices. In determining who may be affected, the distance downstream from the Gemex™ discharge point will need to be considered. It may be appropriate to consider only those water users that will be using water where the concentrations of copper in the waterbody will be higher than the New Zealand Drinking Water Standard (2mg/l), however concentrations below that level may still be of cultural concern. Activities that may be affected by a contaminant in the waterway should be identified here so that they can be included in the following assessment of effects. Consider discussing with the Regional Council's consents team]

Proposed Activity

Summary

It is proposed to discharge the algaecide Gemex™ into the [*enter water body name*] at [*enter the proposed discharge locations*] in order to eradicate/manage an infestation of Didymo. It is proposed to discharge approximately [*enter volume of Gemex™ to be discharged*] at a rate of [*enter approximate discharge rate*] to achieve a concentration of Gemex™ in the water body of [*enter the concentration of Gemex™ desired for the treatment*]. The discharge will occur for a period of one hour and will be discharged via a diffuser pipe installed across the bed of the waterbody. [Describe in more detail how the discharge will take place in the following section.]

Reason for discharge

The discharge of Gemex™ into the subject waterbody is considered necessary to control a didymo infestation, thereby minimising the adverse effects of didymo on the environment and waterway users. Gemex™ has been shown to be an appropriate and feasible method for managing an infestation in the specified waterbodies through an initial feasibility analysis using the Gemex™ DSS application software. A summary report of the initial feasibility analysis is attached.

Amount, rate and duration

[Describe the details of application volumes, rates and durations proposed. This information can be sourced from the Gemex™ DSS software, but should be confirmed using appropriate calculations by experts. Where the application is for a global consent and the details of the exact dosages are not yet known, include details to a level of accuracy to enable the Council and potentially affected parties to understand the quantities of Gemex™ likely to be involved. In many cases, the exact dosage of Gemex™ will need to be varied depending on the exact flows in the waterbody at the time of discharge. Care should be taken when preparing the consent application that sufficient flexibility in dosage rates is provided for, to enable variable dosage without having to amend the resource consent. It may be appropriate to specify a maximum discharge volume/rate/duration.

Describe also whether the resource consent is for a single application of Gemex™ or whether multiple applications are proposed. It may be appropriate to enable a number of applications to occur.]

Discharge technique

An experienced chemical application contractor will be selected and contracted to provide application equipment, personnel and expertise for the application. The contractor will be required to hold the 'Growsafe' chemical applicators certificates.
Gemex™ will be applied to the waterway using a sub-surface chemical diffuser placed across the width of the waterway to be treated. The diffuser is a pipe with a series of controlled outlets that enables the Gemex™ solution to be emitted at sufficient concentrations across the waterway to enable full treatment of the water column. The Gemex™ solution will be pumped into the diffuser apparatus using a sealed pump. The length, number of diffuser heads and pumping equipment will be adjusted depending on the requirements of the waterway width, flow volumes and the distance upstream of the target area.
Full details of the discharge apparatus are included in [*Appendix X*] of this report.

Discharge rate computations

Tracer Dye

[If it is proposed to include a tracer dye with the discharge, or to discharge a tracer dye separately but as part of the overall treatment procedure, describe the details of the dye and its use here. Explain why the dye needs to be used, what it is made from and whether it is a commonly used dye or one specifically designed for use with Gemex™.]

Dilution

Prior to the discharge of the Gemex™ solution, gauging of the waterway will be taken to enable an accurate calculation of the required dosage rate and period that is required to effectively treat the waterway, as described above. The Gemex™ application rate will be determined using the following calculation:
[Enter discharge rate calculation]
Delete this because already specified above and below???

Timing

[Describe when the discharge is expected to take place, for how long, and at what frequency. The timing of the Gemex™ application will be dictated by the urgency with which it is required. A new infestation that requires emergency action will prompt a rapid response in a short timeframe. Where Gemex™ is to be used to manage an existed infestation, the timing of the treatment is more likely to be restricted to a period of low flow to enable maximum treatment effectiveness with the minimum amount of Gemex™.]

Transport and storage of Gemex™

The Gemex™ required for the treatment will be transported to the site in sealed containers already mixed at the required concentration for application. The containers will hold [*Enter volume of Gemex™ each container holds*] and will be transported to the discharge site/s using a [*enter the method of transport*].
The Gemex™ solution will be placed on a flat area close to the waterway to be treated and a temporary bund established around the storage area to ensure that any spills are prevented from entering a waterway. The temporary bund will either be a proprietary spill bund or a bund constructed using soil from the surrounding area. The bund will be designed to contain any spills from the storage containers or the application pump and will be of sufficient size to hold the entire volume of the storage containers. The pump to be used to transfer the Gemex™ solution from the storage vessel to the diffuser apparatus will also be within the bunded area.

Management of spills

To minimise the potential for spills and to ensure that the transportation, storage and use of Gemex™ is undertaken in an appropriate manner, a Gemex™ Application Management Plan will be prepared prior to Gemex™ being transported to the discharge site. The Gemex™ Application Management Plan will include a description of the risks and hazards associated with Gemex™ and the sites where it will be used. The Plan will also include a procedures manual for the safe transportation, storage and use of Gemex™ for each application.
Any spillage of Gemex™ from the pumping and storage of Gemex™ at the application sites will be contained within the bunded areas to prevent uncontrolled discharge of the chemical into waterways. Where possible, spilled Gemex™ will be collected and placed into an appropriate contained to be disposed of at an appropriate facility. Where significant amounts of Gemex™ soak into the underlying soil, the Consent Authority will be contacted and an assessment will be made as to the most appropriate method for containing or removing the contaminated soil will be. The consent holder will be responsible for undertaking any necessary cleanup work.

Gemex™ authorisations

[Describe the current status of Gemex™ under the Hazardous Substances and New Organisms Act and whether it has Environmental Risk Management Authority approval for the proposed use. Note that these approvals are subject to change and review so the current status needs to be confirmed. Document any specific use conditions that apply.]

Evaluation of Options

Available options

[Describe the available options for the controlling the infestation of didymo in this particular location or area. Refer to the options in the previous sections (see Table) for possible inclusions.

Evaluation of options

[Evaluate the options that have been considered for controlling the infestation of didymo. Outline the advantages and disadvantages of each option in relation to this particular infestation, its location and surrounding environment. Once the options have been identified, describe why the use of Gemex™ is considered to be the most favourable. This may relate to effectiveness, cost, feasibility, urgency, etc.]

Regional Plan Provisions

Introduction

Regional plans are prepared by Regional Councils to assist them in carrying out their functions under the Resource Management Act 1991 (the RMA). Regional plans contain rules, methods, objectives and policies that guide resource users and the Council in the use and management of natural and physical resources.
The following sections identify the relevant rules of the relevant regional plans, and specify the objectives and policies in those plans that will later be addressed as part of the Assessment of Environmental Effects.

Relevant Regional Plan and Status

Plan or Plan Change/Variation	Status
[List the names of each of the regional plans that apply to this proposal. Include any transitional, operative and proposed plans, and any plan changes/variations. Seek assistance from a Resource Management Planner where necessary.]	Specify the current status of each of the plans. Explain the level of weighting that should be attributed to the relevant provisions of the plan/s.
Example: **Regional Freshwater Plan for the Wellington Region (incorporating Plan Change 2)**	Plan made operative 17 December 1999. Plan Change 2 made operative 31 January 2007. The Plan is fully operative and all provisions carry full weighting.

Operative Regional Plan Requirements

Rule Assessment

The following table identifies the relevant operative rules and standards applicable to this proposal and specifies the level of compliance achieved [this example uses provisions from the Wellington Region, which will not be relevant to other regions].

Plan Provision	Rule Activity Status	Compliance	Comment
Rule 1 Discharges of water and minor contaminants The discharge of contaminants, or water, into surface water, other than the discharge of stormwater,] is a Permitted Activity provided the discharge complies with the conditions specified below. Conditions (1) the discharge is not to any wetland, lake or river being managed in its natural state (Appendix 2, part A); and (2) the discharge shall not contain any contaminants other than	Permitted	Discharge does not comply	Gemex™ contains contaminants additional to those listed in the rule, therefore its discharge is not a permitted activity.

Some river

[contaminants at concentrations specified in] conditions (3) to (7) below; and (3) concentrations of free or combined residual chlorine in the discharge shall be no more than 0.5 g/m3; and (4) concentrations of suspended solids in the discharge shall be no more than 50 g/m³; and (5) concentrations of acid-soluble aluminium in the discharge shall be no more than 0.15g/m³; and (6) concentrations of fluoride in the discharge shall be no more than 1.5 g/m3; and (7) the discharge temperature shall not differ from the ambient temperature of the receiving water by more than 5° Celsius; and (8) the discharge does not cause erosion at the point of discharge; and (9) the discharge does not alter the natural course of the river or stream.			
Rule 5 All remaining discharges to fresh water The discharge of any contaminant or water into fresh water: • that is not provided for in Rules 1, 2, 3, and 4; and • which cannot meet the requirements of Rules 1, 2, 3, and 4; and • which is not a non-complying activity in Rule 6; is a Discretionary Activity.	Discretionary	This rule applies to the discharge.	This rule includes any discharges not provided for in the permitted activity above. The proposed discharge of Gemex™ is a Discretionary Activity

Based on the above analysis, the proposed activity is assessed to be a [***Discretionary***] activity under the operative plan provisions.

Objectives and Policies

Based on the above analysis, the following objectives and policies of the operative plan are relevant to the assessment of this application.

[The following table should be completed for the relevant plan/s that control the proposed discharge. The table includes examples of relevant objectives and policies from the Wellington Regional Freshwater Plan.]

Relevant Objectives	Relevant Policies
5.1.1 The quality of fresh water meets the range of uses and values for which it is required while the life supporting capacity of water and aquatic ecosystems is safeguarded. 5.1.2 The quality of fresh water has the potential to meet the reasonably foreseeable needs of future generations.	5.2.3 To manage water quality for trout fishery and fish spawning purposes in those rivers, or parts of rivers, identified in Appendix 4 (subject to Policy 5.2.10). 5.2.4 To manage water quality for contact recreation purposes in those water bodies identified in Appendix 5 (subject to Policy 5.2.10), excluding Lake Waitawa (managed according to Policy 5.2.6) and Lake Wairarapa (managed according to Policies 5.2.2 and 5.2.6)

Relevant Objectives	Relevant Policies
5.1.3 The quality of water is, as far as practicable, consistent with the values of the tangata whenua.	5.2.6 Except for rivers and streams identified in Appendix 7, to manage the water quality of all surface water bodies in the Region for aquatic ecosystem purposes (subject to Policy 5.2.10). 5.2.7 To manage all groundwater in the Wellington Region so that there are no net adverse affects on its quality as a result of discharges to surface water or groundwater (subject to Policy 5.2.10). 5.2.8 To have regard to the relevant guidelines in Appendix 8 when deciding whether a discharge is able to satisfy Policies 5.2.1 to 5.2.7 (above) when considering applications for resource consents (subject to Policy 5.2.10). 5.2.10 To allow the discharge of contaminants to fresh water which do not satisfy Policies 5.2.1 to 5.2.9, whichever is (are) relevant, only where: (1) the discharge is of a temporary nature; or (2) the discharge is associated with necessary maintenance works; or (3) exceptional circumstances justifying the granting of a permit; or (4) the discharge: • was present at the time the Plan was notified; and • is not likely to cause a decrease in the existing quality of water at that site and the person responsible for the discharge has defined a programme of work for upgrading the discharge within a specified timeframe; or (5) that in any event, it is consistent with the purpose of the Act to allow the discharge. 5.2.11 To ensure that any zones allowed on a discharge permit for reasonable mixing of contaminants or water with the receiving water are determined by having regard to: • the purpose for which the receiving water is being managed, and any effects of the discharge on that management purpose; and • any tangata whenua values that may be affected; and • the volume of water or concentration of contaminants being discharged, and the area of receiving water that could potentially be

Some river

Relevant Objectives	Relevant Policies
	affected; and • the physical, hydraulic and hydrological characteristics of the receiving water. 5.2.16 To minimise the adverse effects of accidental spills on water quality.

[Complete the above section with any other provisions of other relevant regional plans as appropriate]

Regional Plan Summary

Based on the analysis undertaken above, it has been assessed that the proposed activity is to be assessed as a ..... activity.

Issues for Assessment

The assessment of plan compliance and the relevant objectives and policies indicates that the following assessment issues are present in relation to this proposal.
[*List the key assessment issues that are apparent from the rules and the objectives and policies. These will generally be those standards of a permitted activity rule that cannot be complied with, and the relevant outcomes intended by the objectives and policies. This section should summarise the key issues that will be assessed in the following AEE section.*]

- Effect on water quality for water users.
- Effects on trout fishery and spawning
- Effects on aquatic ecosystems
- Effects on future generations
- Effects on the values of tangata whenua
- Effects on contact recreation
- Effects on groundwater
- Measurement against the specified water quality guidelines
- Relevance of a mixing zone
- Whether there are any exceptional circumstances or justifications for any effects related to the above.

District Plan Provisions

[The purpose of District Plans is to assist District Councils in carrying out their functions under the Resource Management Act. The most common district planning matters for the discharge of Gemex^{TM} will relate to hazardous substances, but there may be other requirements depending on the activities associated with the Gemex^{TM} application (e.g earthworks to cut access tracks to application sites, vegetation clearance, etc)]

Introduction

The proposed application site is with the [*enter district/s name/s*]. The following provisions of the district plans for those districts are relevant.

Relevant District Plan and Status

[The Wellington RC examples in the following tables are for illustrative purposes only.]

Plan or Plan Change/Variation	Status
Operative South Wairarapa District Plan	Fully operative. Weighting attributed to each provision will vary depending on the status attributed to corresponding provisions in the Proposed Plan.
Proposed Combined Wairarapa District Plan	Proposed. Decisions on submissions have been released but the appeal period has not yet closed. Any provisions of this plan that are not appealed will be regarded as being operative and therefore will supersede the provisions they replace in the operative plan. Any provisions under appeal will result in the respective provisions in the Operative plan still carrying some weight.

Operative and Proposed District Plan Requirements

Rule Assessment

The following table identifies the relevant operative and proposed rules and standards applicable to this proposal and specifies the level of compliance achieved.

Plan Provision	Rule Activity Status	Compliance	Comment
21.1.19 Hazardous Substances and Facilities (a) The total quantity of hazardous substances on the site shall not exceed the quantities for the relevant zone specified as a Permitted Activity in "Appendix 2.1: Hazardous Facilities Consent Status Table", and shall comply with the following standards: (i) Site Design Any part of a hazardous facility which is involved in the manufacture, mixing, packaging, storage, loading, unloading, transfer, use or handling of hazardous substances must be designed, constructed and operated in a manner which prevents: (1) The occurrence of adverse off-site effects from the above listed activities on people, ecosystems, physical structures and/or other parts of the environment unless permitted by a resource consent; (2) The contamination of air, land and/or water (including aquifers, potable water supplies and surface waters) in the event of a	Permitted	Will not meet the volume limit for permitted activity.	NIWA estimated the hazard classification of Gemex™, based on data on copper sulphate anhydrous. This reference substance is regarded to be more toxic than Gemex™. ERMA has not undertaken a full hazard classification of the substance, but based on the concentration of the chelated copper present within Gemex™ and the pH of the formulated product, considers the substance to trigger the following classifications (ERMA 2007 clause 4.24): • 8.3A Eye Corrosiveness • 8.2C Skin

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Plan Provision	Rule Activity Status	Compliance	Comment
spill or other type of release of hazardous substances. (ii) Site Layout The hazardous facility must be designed in a manner to ensure that separation between on-site facilities and the property boundary is sufficient for the adequate protection of neighbouring facilities, land uses and sensitive environments. (iii) Site Drainage Systems Site drainage systems must be designed, constructed and operated in a manner that prevents the entry of hazardous substances into the stormwater and/or sewerage systems unless permitted to do so by the network utility operator responsible for those stormwater and/or sewerage systems. (iv) Spill Containment Systems Any parts of the hazardous facility site where a hazardous substances spill may occur must be serviced by suitable spill containment systems that are: (1) Constructed from impervious materials resistant to the hazardous substances used, stored, manufactured, mixed, packaged, loaded, unloaded or otherwise handled on the site; (2) For liquid hazardous substances: (a) Able to contain the maximum volume of the largest container present plus an allowance for stormwater or fire water; and (b) Where the substances are stored in drums or other small packaging that the spill containment system is able to contain 50% of the maximum volume of substances stored plus an allowance for stormwater or fire water; (3) Able to prevent the entry of any spill or other unintentional release of hazardous substances, or any contaminated stormwater and/or fire water into site drainage systems unless permitted to do so by a network utility operator; For the purposes of this rule, 'suitable' shall mean compliance with the above include graded floors and surfaces, bunding, roofing, sumps, fire water catchments, overfill protection and alarms, and similar systems. ... The following are exempt from complying with the above standards: (v) Agrichemical use, storage, transportation and disposal where these activities are carried out in compliance with NZS8409:2004 Management of Agrichemicals.			Corrosiveness • 9.1A Aquatic Ecotoxicity Appendix 2.1 of the Plan limits the amount of Gemex™ with the above hazard classifications to less than 0.1 tonnes within 30 m of a water course. The proposed amount of Gemex™ to be used exceeds this volume. Note: 'Agrichemical' is not defined in the District Plan. Definition from the Regional Discharges to Land Plan is: "means any substance, registered under the Pesticides Act 1979 or Hazardous Substances and New Organisms Act 1996 as a pesticide. (This includes any herbicide, fungicide, insecticide, vertebrate pest control chemical, or other biocide. For the avoidance of doubt, it does not include fertilisers or lime and other soil conditioners, or agricultural effluent.)." Gemex™ is not currently registered as a pesticide under either of those acts.
k)(n) Any hazardous facility where the total quantity of hazardous substances of any hazard classification on the site is in the range	Discretionary	Complies	Proposed use of Gemex™ will be undertaken to meet the

Plan Provision	Rule Activity Status	Compliance	Comment
of the quantities for the relevant zone specified as a Discretionary Activity in the Hazardous Facilities Consent Status Table (Appendix 2), and the activity complies with the permitted activity performance standards in Rule 21.1.1921.1.1921.1.19 above.			specified standards.

Based on the above analysis, the proposed activity is assessed to be a [*Discretionary*] activity under the Proposed District Plan provisions.

Objectives and Policies

Based on the above analysis, the following objectives and policies of the operative and proposed plan are relevant to the assessment of this application.

Relevant Objectives	Relevant Policies
15.3.1 Objective Haz1 – Adverse Effects of Hazardous Substances **To protect the natural and physical environment, including community safety and health, from the adverse effects of hazardous substances.**	**15.3.2 Haz1 Policy** **(a) Establish thresholds of acceptable risks from the use, storage, transportation and disposal of hazardous substances on the health and safety of people, and the environment.** **(b) Establish controls to ensure that potentially hazardous facilities are located, designed, constructed and managed to avoid, remedy or mitigate adverse effects from hazardous substances, including unacceptable risks, to the environment and/or human health.** **(c) Promote better understanding of the potential adverse effects of hazardous substances, and the methods and controls for avoiding remedying or mitigating such effects.**

District Plan Summary

Based on the analysis undertaken above, it has been determined that the proposed activity is to be assessed as a ..... activity.

Issues for Assessment

The assessment of District Plan compliance and the relevant objectives and policies indicates that the following assessment issues are present in relation to this proposal.

[List the key assessment issues that are apparent from the rules and the objectives and policies. These will generally be those standards of a permitted activity rule that cannot be complied with, and the relevant outcomes intended by the objectives and policies. This section should summarise the key issues that will be assessed in the following AEE section.]

- Risks to the environment and people from the transportation, storage and use of Gemex™.
- Management of the risks of spills and accidental discharges.

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Relevant Regional Policy Statement Provisions

Introduction

Regional Policy Statements are prepared by regional councils to provide a region-wide policy direction on key issues. Any council preparing a district or regional plan within the region 'shall have regard to' the Regional Policy Statement. Likewise, Section 104 of the RMA requires that a consent authority shall have regard to the Regional Policy Statement.

Relevant Regional Policy Statement and Status (Wellington example)

Regional Policy Statement	Status – operative/under review
Regional Policy Statement for the Wellington Region	Operative. Currently under review however only a draft of the revised version has been released at the date of writing. The provisions of the operative RPS are attributed full weight for the purposes of this assessment.

Regional Policy Statement Requirements

Regional Policy Statement Requirements	Objectives	Policies
Chapter 5 Fresh Water	**Objective 2** ***The quality of fresh water meets the range of uses and values for which it is required, safeguards its life supporting capacity, and has the potential to meet the reasonably foreseeable needs of future generations.***	**Policy 4** *To maintain and protect the quality of fresh water so that it is available for a range of uses and values, and:* *(1) Its life supporting capacity is safeguarded; and* *(2) Its potential to meet the reasonably foreseeable needs of future generations is sustained; and* *(3) For surface water, any adverse effects on aquatic and riparian ecosystems are avoided, remedied, or mitigated.*
	Objective 3 *Freshwater resources of significance or of high value for cultural, spiritual, scenic, ecosystem, natural, recreational, or other amenity reasons are protected or enhanced.*	
		Policy 6 *To ensure that the effects of contaminants contained in point source discharges on the quality of fresh water and aquatic ecosystems are avoided,*

Regional Policy Statement Requirements	Objectives	Policies
		remedied, or mitigated and allowing for reasonable mixing: *(1) Do not render any fresh water unsuitable for any purpose specified in any regional plan for that water;* *(2) Do not prevent the receiving fresh water from meeting any standards established in any regional plan for that water;* *(3) Do not render any water in the coastal marine area unsuitable for any purpose specified in a regional coastal plan for the Wellington Region.*
		Policy 11 ***To ensure that, in respect of all water bodies not covered by Fresh Water Policy 10, any adverse effects on amenity values or the intrinsic values of ecosystems which may result from any use and development, and on any natural or near natural areas, are avoided, remedied, or mitigated.***
		Policy 13 ***To recognise the cultural relationship of the tangata whenua with rivers, lakes, wetlands, and other water bodies, and to promote the management of fresh water in ways that take into account iwi values and beliefs. In addition, to promote the protection and management of sites of significance to iwi within the beds of water bodies.***
		Policy 15 ***To protect water resources used for public water supply from abstractions of water and discharges of contaminants, which may affect the suitability of those waters for water supply purposes.***

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Regional Policy Statement Requirements	Objectives	Policies
Chapter 9 - Ecosystems	**Objective 1** *The overall quality of ecosystems in the Region is increased.*	**Policy 4** ***To avoid, remedy or mitigate the adverse effects of activities on ecosystems, and in particular, to avoid, remedy or mitigate any of the following effects:*** ***(1) Reduction in the indigenous biodiversity of an ecosystem;*** ***(2) Prevention of the natural processes of an ecosystem, including nutrient cycles and energy flows, from operating effectively;*** ***(3) Simplification of the structure of indigenous ecosystems; and*** ***(4) Reduction in the quality or quantity of the non-living parts of an ecosystem (e.g., decaying plant and animal remains, water, air, soil) to a level which adversely affects the life supporting capacity of the ecosystem.***

Issues for Assessment

The assessment of relevant Regional Policy Statement objectives and policies indicates that the following assessment issues are present in relation to this proposal.

- Effects of Gemex^{TM} on aquatic ecosystems.
- Effects on life-supporting capacity.
- Effects on human health and well-being.
- Effects on cultural values, particularly those of Maori

Consultation

Clause 1(h) of Schedule 4 of the RMA requires that an assessment of environmental effects should include:

(h) identification of the persons affected by the proposal, the consultation undertaken, if any, and any response to the views of any person consulted.

People Potential Affected by the Proposal

The following people or groups have been identified as being potentially affected by the proposal.

Name	Address	Reason
Joe Bloggs	123 Swamp Road, Someplace	Abstracts water from the waterbody downstream of the treatment area.
Pete Piper	345 Swamp Road, Someplace	Abstracts water for domestic use.
Jack Flash	25 Lightening Road, Someplace	Commercial rafting operator who runs rafting trips down treatment waterbody.
Local runanga	Someplace	Traditional food gathering from waterway. Cultural significance.

Consultation Undertaken

While there is no duty to consult with people as part of an application (neither the consent authority nor the applicant is obliged to consult according to s36A of the RMA), the Applicant has chosen to consult the following parties.

Consulted Party	Views Expressed

Response to Consultation issues

[Describe the adjustments and any changes that have been made to the proposal in response to consultation that has been undertaken. Refer here to any specific controls or proposed conditions that are suggested to satisfy the concerns of affected people.]

Assessment of Effects

The following assessment of effects addresses the matters that are required to be assessed by the relevant district and regional planning documents and by the RMA.
Section 104 of the RMA requires the following:
(1)When considering an application for a resource consent and any submissions received, the consent authority must, subject to Part 2, have regard to–
(a)any actual and potential effects on the environment of allowing the activity; and
(b)any relevant provisions of—
(i)a national policy statement:
(ii)a New Zealand coastal policy statement:
(iii)a regional policy statement or proposed regional policy statement:
(iv)a plan or proposed plan; and
(c)any other matter the consent authority considers relevant and reasonably necessary to determine the application.

Activity Status

The proposed activity has been identified in **Section** 0 as a ..... as assessed against the rules of the relevant planning documents. The Plan has limited control/discretion to the following matters:

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The following assessment has been undertaken addressing those matters over which the Council has control/discretion or which are required to be assessed by the RMA. The assessment focus on the assessment issues that have been identified through the analysis of the relevant plans and policy documents that will guide the consent authority in making its decision on this application.

Actual and Potential Effects

This assessment considers the effects of the proposed activity *on the environment*. To undertake this assessment, the proposal must be measured against the existing environment to determine whether there are likely to be any effects on that environment. Previous sections of this report have described the existing environment and have specified the 'baseline' against which the effects of the proposal are to be assessed. The following assessment considers how the proposed activity will impact on that existing environment.

Water Quality

Where there are specific water quality guidelines specified in a plan or other policy document, identify those guidelines and assess how the proposed discharge will compare.

Colour

When discharged, Gemex™ is a colourless liquid that will not alter the colour of the water below the discharge point. [Only include the following comments if a dye tracer will be used] However it is proposed to introduce a tracer dye to the discharge to enable the pattern of chemical distribution within the waterway to be easily observed. The tracer dye will change the colour of the water quite distinctly close to the discharge point. As the dye/Gemex™ solution dilutes as it moves downstream, the colour change in the water will be less pronounced. The effect on the colour of the water from the tracer dye will eventually become imperceptible as dilution and dispersion takes effect and the discharge of the dye ceases.

The dye is an inert substance and will only be present in the waterway for as long as it takes for dilution to take effect after the discharge has stopped. Figure 1 below shows tracer dye being released into a small waterway in a manner similar to how the substance is proposed to be discharged as part of this proposal. The short duration of dye presence in the water body and the lack of toxicity to aquatic species means that the use of dye will have no more than minor adverse effects on the environment.

Figure 1: Neil Blair (NIWA) watches as a non-toxic tracer dye is released in a preliminary trial to test distribution and finalise the water-quality monitoring schedule. Photo: Kevin Trainor, Southern Technical Services Ltd. Source: www.biosecurity.govt.nz

Temperature

It is possible that the temperature of the solution to be discharged will be at a different temperature than the receiving water due to the Gemex™ being held in a controlled environment. This would include both temperature alternatives – the receiving waters being warmer than the discharge or being cooler than the discharge.

Any changes in water temperature are expected to be limited to that area immediately downstream of the discharge point. Any temperature difference will progressively and rapidly reduce to background levels.

In most cases, because there is a thousand-fold dilution [2% = 20 g/L – dilute to 20 mg/L) of the Gemex™ stock solution at the application point, the discharge substance will not alter the temperature of the receiving water by more than 3 degrees Celsius. To ensure that this is achieved, the temperature of the receiving waterway and the solution to be discharged will be measured and the discharge will only occur where the temperature difference is within a range that will ensure that the water temperature in the receiving waterway below the discharge point will not be altered by more than 3 degrees Celsius.

Turbidity

Gemex™ and the tracer dye contain only dissolved contaminants and the chelating agents keep Cu in solution after discharge. The turbidity of the receiving waterway will not be adversely affected as a result of the discharge itself.

There may some minimal sediment disturbance by people walking on the bed of the waterway as the diffuser pipe is installed, however any disturbed sediment will quickly dissipate and will not cause an adverse effect on the waterway.

Dissolved Oxygen

Describe the effects on dissolved oxygen as a result of the discharge. Refer to the Didymo-Gemex help file for supporting information. Gemex™ will only have very minor effects on DO levels (due to any differences between the Do content of the Gemex™ stock solution and stream/river water. Because of the 1000-fold dilution, this is minor.

pH

Describe the effects on pH as a result of the discharge. Refer to the Didymo-Gemex help file for supporting information.

Water hardness

Describe the effects on water hardness as a result of the discharge. Refer to the Didymo-Gemex help file for supporting information. Gemex™ is not expected to affect water hardness as defined by Ca^{2+} and Mg^{2+} concentrations.

Nutrients

Describe the effects on nutrient as a result of the discharge. Refer to the Didymo-Gemex help file for supporting information. Do not expect any significant affect on nutrient concentrations as adding Gemex™ other than any nutrient librated from dead didymo cells (which is already part of the river ecosystem and would be expected to be recycled in time anyway).

Micro-organisms

Gemex™ and the associated tracer dye do not include any micro organisms.

Ecosystems

The discharge of contaminants into a waterway can result in adverse effects on the flora and fauna that rely on the waterway for habitat, food and water. In assessing the effects of the proposed discharge on the ecosystem values of the waterway, consideration is given to the existing species present and the potential impacts of the proposed discharge. Consideration of the effects of on those same species will also be considered where relevant, particularly where they may be a potentially significant adverse effect from Gemex™.

Aquatic Plants

[Specify any significant aquatic plants that may be adversely affected by Gemex™. In most cases, Gemex™ has little or no known adverse effect on aquatic plants other than alga. Where there are

Some river

rare or endangered aquatic plant species present downstream of the discharge point, specialist input should be sought and included as part of this assessment.]
In the absence of rare or endangered aquatic plant species present downstream of the discharge point, there will be short - term inhibition of some non-target algae. However, rapid recovery is expected by the existing algae in treated reach and through recolonisation from upstream. The magnitude of the impacts is expected to be comparable to impacts that occur in the normal hydrological cycle.

Invertebrates

Some short - term negative effects on benthic invertebrates may occur. This can include the removal of some sensitive species such as the spiny-gilled mayfly Coloboriscus, affect other invertebrates during sensitive life stages and may impact on small invertebrates. However such an impact can be regarded as acceptable because invertebrates normally undergo wide fluctuations in population, e.g., from flow perturbations. NIWA expects rapid recolonisation from resistant life stages and from drift from upstream, which will result in any adverse effects of the discharge being resolved through natural processes.
[Further details on the potential effects of Gemex™ on invertebrates can be found in Section 6.3 of the user manual]. Further input into the effects of Gemex™ on invertebrates within a specific waterway being treated may need to be contributed by an expert.]

Trout

Gemex™ can be toxic to trout in some cases. Predicting impacts on trout is complex and depend on the rate of loss of Gemex™ downstream and the water pH and hardness.
Most NZ freshwaters are soft and the following will apply to most NZ rivers. Gemex™ is quite acidic, so it lowers the pH at the application site. This low pH results in high trout survival, and because exposure times are short, the low pH is not toxic itself. However, as pH increases downstream and the Gemex™ dose is spread out, the copper becomes more toxic and significant impacts to trout may occur. The zone of impact is from ~1 km to ~4 km for reaches with a high algal biomass and may be longer for rivers with a low algal biomass, and hence less adsorption and removal of Gemex™.
In hard waters, the effects are yet untested. The high alkalinity buffers the water, so pH is higher (and this enhances Cu toxicity) but this is offset by the inhibition of Cu toxicity by high concentrations of hardness ions Ca^{2+} and Mg^{2+}.
[Baseline recording of the existing water quality should provide data on the hardness of the water in the particular receiving environment. This data will assist in determining the likely effects of Gemex™ on the trout population present. A description of that potential impact should be included, along with an assessment of the significance of those effects. The adverse effects on the trout population in a particular waterway may be off-set by the ability for recolonisation.]

Native Fish

Effects are expected to be insignificant on common galaxiids. Bullies (a non-migratory species) appear to be intermediate in sensitivity to Gemex™ compared to juvenile rainbow trout and galaxiids On the basis of the known toxicity of copper to eels, Gemex™ is expected to pose minimal risk for eel populations. Gemex™ will probably be more toxic to juvenile life stages of all species (e.g., migrating whitebait), so an increased impact of a Gemex™ treatment during spawning or larval recruitment seasons would be expected.
[Further information of effects on native fish can be found in Section 6.3 of the User Manual]

Mussels, snails and koura

NIWA studies indicate that a Gemex™ treatment will have minimal effects on koura populations or will present minimal risk to human consumers of adult koura. NIWA studies demonstrated no mortality in snails exposed to Gemex™ for 1-8 hours The snails avoided exposure by retreating into their shells; a similar response is expected of freshwater mussels. [See Section 6.3 of the User Manual for details and references.]

Birds

Birds are not sensitive to copper and no effects are expected. There may be some issues associated with effects of low pH on wading or swimming birds but there have been no studies to quantify these effects.

Riparian Plants

Riparian plants are not expected to be sensitive because of the limited exposure route to Gemex™ (i.e., short-lived exposure).

Riparian animals (including rare and endangered species)

Riparian animals are not expected to be sensitive because of the limited exposure route to Gemex™ (i.e., short-lived exposure).

Earthworks and Vegetation Clearance

[Assess the effects of any activities such as vegetation clearance and earthworks to create access to application sites. In most cases earthworks and vegetation clearance will not be required as existing access tracks will be used. However where there will be new tracking activity or significant vegetation clearance to enable access to a treatment site, consideration should be given to the effects of sediment runoff, erosion, discharges to water and impact on flora and fauna.]

Effects on other waterbody users

[A range of other users of the water body may need to be considered when completing this assessment. In particular, users that are likely to be consuming or coming into contact with the water during a treatment should be considered. The assessment of effects on those users should address the nature of the use, the potential impact on those users and how those impacts will be avoided, remedied or mitigated. It may be necessary, particularly where there are sensitive users or large numbers of users, to develop a management plan to guide notification of those people and the management of any problems or complaints. Refer to the FAQs in the Didymo-Gemex™ DSS help file for information on the effects on particular users (e.g. irrigation, stock water, etc)]

Natural Hazards

[Assess any risk to the neighbourhood, the community, or the environment through natural hazards, particularly flooding during or immediately after a discharge. This is highly unlikely to be a concern in most cases, as Gemex™ will generally be applied during low flow periods when stable weather is forecast, because high flows will render Gemex™ ineffective.]

Hazardous Substances

[Describe the effects of Gemex™ as a hazardous substance. In particular areas where food may be gathered (such as watercress and fish) and human consumption is involved. Handling of the chemical and the method of storage, transport and application should be discussed in detail, with the risks identified and managed. It may be appropriate to develop a hazardous substances management plan which details how use, storage and transportation of the chemical will take place for each application site, including procedures for managing and cleaning up any accidental spills.]

Groundwater

[Assess whether Gemex™ will make its way into groundwater and what the potential effects of this might be. It may be necessary to seek expert input to assess the potential scale of groundwater contamination and the potential effects.]

Economic Impacts

Section 5 of the RMA states that a component of 'sustainable management' is enabling "*... people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety...*" The following assessment considers whether the proposal will enable this to occur within the context of the proposed development.

[Assess the potential economic effects on other waterbody users of the use of Gemex^{TM}. This may include consideration of the cost to water abstractors of having to shut down their intakes for a period of time. Consideration should also be given to the potential economic effects on tourism business, which may need to avoid using the waterway for a period of time and therefore suffer a loss of business. This can be balanced against the economic benefits of managing didymo in this particular waterbody.]

Amenity Values

[Some waterbodies will have significant amenity value. They may be particularly picturesque or be visible to a large number of people. In most cases, Gemex^{TM} will be in the water body for a very short period of time and, unless a die tracer is used, will not be visible to observers. It is unlikely that Gemex^{TM} will result in any significant impact on visual amenity.
Consideration should be given to whether there will be an odour effect once the didymo has died. There may be a large quantity of dead didymo decaying which may result in odours. This will need to be assessed on a case by case basis, and will only be relevant where there are people within close proximity to the waterbody being treated.]

Health and safety

[A significant assessment of the health and safety effects will have been addressed in the hazardous substances section above. However consideration should be given to any health and safety effects that have not previously been considered.]

Cultural Values

[Cultural values relate to activities, practices or beliefs associated either with a specific area or with a resource. Maori especially place cultural significance on waterbodies and on the ecosystems that they support. Consultation with local iwi and runanga representatives should occur to develop an understanding of the potential effects of the discharge on those values.
Cultural values may also be associated with other users. People that have traditionally used an area for whitebaiting or food gathering, or who may hold a section of the waterbody in high regard should also be considered and their concerns addressed where appropriate.

Summary of Effects

The following actual and potential effects on the environment have been identified:
[List the identified effects identified above]

Relevant National Policy Statement Provisions

Relevant National Coastal Policy Statement Provisions

[The New Zealand Coastal policy Statement will only be relevant where Gemex^{TM} is likely to affect coastal or estuarine waters. Where the NZCPS is relevant, an assessment of the proposal against its relevant policies should be undertaken.]

[At the time of preparing this guide, there are no other national policies statements relevant to the discharge of Gemex^{TM}, however a national policy statement for freshwater management is in the process of being developed and may be relevant to this assessment.]

Part II Assessment

Section 5 Assessment

Section 5 of the RMA specifies the purpose of the Act as being:
"...to promote the sustainable management of natural and physical resources."
'Sustainable management' is thereafter defined as:
"*In this Act, sustainable management means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while—*
(a)Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
(b)Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and
(c)Avoiding, remedying, or mitigating any adverse effects of activities on the environment."
[Provide an overall assessment of the proposal against the provisions of s5 of the RMA, with a summary statement in relation to (a), (b) and (c).

Sections 6, 7 and 8 Assessment

Section 6, 7 and 8 identify 'matters of national importance', 'other matters' and Treaty of Waitangi' respectively.
Section 6 requires that all persons exercising functions and powers in achieving the purpose of the RMA shall 'recognise and provide for' the matters listed in (a) to (g). Of those matters, the following are considered relevant to the assessment of this proposal:
(a)The preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development:
(b)The protection of outstanding natural features and landscapes from inappropriate subdivision, use, and development:
(c)The protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna:
(d)The maintenance and enhancement of public access to and along the coastal marine area, lakes, and rivers:
(e)The relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga.
(f)the protection of historic heritage from inappropriate subdivision, use, and development.
(g)the protection of recognised customary activities.
[Include a summary assessment of each of the relevant points above. Explain how these matters have been recognised and provided for in the proposal.]

Section 7 lists the matters that all persons exercising functions and powers under the Act shall have particular regard to. Of those matters, the following are considered to be relevant to the assessment of this proposal:
(a)Kaitiakitanga:
(aa)The ethic of stewardship:
(b)The efficient use and development of natural and physical resources:
(ba)the efficiency of the end use of energy:

(c)The maintenance and enhancement of amenity values:
(d)Intrinsic values of ecosystems:
(e)Repealed.
(f)Maintenance and enhancement of the quality of the environment:
(g)Any finite characteristics of natural and physical resources:
(h)The protection of the habitat of trout and salmon:
(i)the effects of climate change:
(j)the benefits to be derived from the use and development of renewable energy.

[Include a summary assessment of each of the relevant points above. Explain how these matters have been recognised and provided for in the proposal.]

Section 8 of the Act requires that all persons exercising functions and powers shall take into account the principles of the Treaty of Waitangi.

Summary of Part II Assessment

[Include a summary assessment of Part 2 as a whole.]

Section 104A, 104B, 104C and 104D Assessment

The RMA specifies the matters that must be addressed when assessing controlled (s104A), discretionary or non-complying activities (s104B), restricted discretionary activities (s104C) and non-complying activities (s104D).

As this is an application for a ..... activity, the following of the abovementioned sections are relevant.

104A Determination of applications for controlled activities

After considering an application for a resource consent for a controlled activity, a consent authority—
(a)must grant the resource consent, unless it has insufficient information to determine whether or not the activity is a controlled activity; and
(b)may impose conditions on the consent under section 108 for matters over which it has reserved control in its plan or proposed plan.

104B Determination of applications for discretionary or non-complying activities

After considering an application for a resource consent for a discretionary activity or non-complying activity, a consent authority—
(a)may grant or refuse the application; and
(b)if it grants the application, may impose conditions under section 108.

104C Particular restrictions for restricted discretionary activities

When considering an application for a resource consent for a restricted discretionary activity, a consent authority—
(a)must consider only those matters specified in the plan or proposed plan to which it has restricted the exercise of its discretion; and
(b)may grant or refuse the application; and
(c)if it grants the application, may impose conditions under section 108 only for those matters specified in the plan or proposed plan over which it has restricted the exercise of its discretion.

104D Particular restrictions for non-complying activities

(1)Despite any decision made for the purpose of section 93 in relation to minor effects, a consent authority may grant a resource consent for a non-complying activity only if it is satisfied that either—
(a)the adverse effects of the activity on the environment (other than any effect to which section 104(3)(b) applies) will be minor; or
(b)the application is for an activity that will not be contrary to the objectives and policies of—
(i)the relevant plan, if there is a plan but no proposed plan in respect of the activity; or

(ii)the relevant proposed plan, if there is a proposed plan but no relevant plan in respect of the activity; or
(iii)both the relevant plan and the relevant proposed plan, if there is both a plan and a proposed plan in respect of the activity.
(2)To avoid doubt, section 104(2) applies to the determination of an application for a non-complying activity.

Notification

[The RMA requires that all resource consent applications be publicly notified unless they come within specified exceptions. If a resource consent application is not notified, interested parties have no right to make submissions on the application, or to appeal the decision of the consent authority to the Environment Court. The Act also makes provision for limited notification where only people who are adversely affected by the proposed activity are notified and given the opportunity to lodge a submission]
[Adversely affected parties are people who have an interest greater than the public generally. This will normally include neighbours, downstream resource users and often also iwi authorities, but exclude public interest groups such as environmental organisations (however, some locally based environmental groups may be considered affected parties.
Discussions with council consents staff should assist in identifying who will be considered to be an affected party.]
Section 93(1) of the RMA states that an application for resource consent must be notified unless the following criteria are achieved:
(a)the application is for a controlled activity; or
(b)the consent authority is satisfied that the adverse effects of the activity on the environment will be minor.
If notification is not required by s93(1), s94 of the Act requires that:
(1)If notification is not required under section 93(1), the consent authority must serve notice of the application on all persons who, in the opinion of the consent authority, may be adversely affected by the activity, even if some of those persons have given their written approval to the activity.
(2)However, a consent authority is not required to serve notice of the application under subsection (1) if all persons who, in the opinion of the consent authority, may be adversely affected by the activity have given their written approval to the activity.

Mitigation Measures

In order to avoid, remedy or mitigate actual or potential adverse effects on the environment as a result of the proposal, the following measures have been proposed. These measures have been assessed as reducing the adverse effects of the proposal to a level that is no more than minor.

Proposed Conditions of Consent

In order to avoid, remedy or mitigate actual or potential adverse effects on the environment, the following conditions of consent are proposed.
[You may choose to recommend conditions of consent or you may choose to simply summarise the measures you propose to put in place for the consent authority to prepare conditions on. Measures could include: prepare and implement management plans for managing hazardous substances, river access, pre-treatment notification, etc.

Appendices

[It may be appropriate to commission specialist reports on particular aspects of the proposal. This could include reports on waterway ecology, treatment methodology, etc. It would also be appropriate to include background details on Gemex™ and didymo.]