Australian Government
Department of Health and Aged Care
Office of the Gene Technology Regulator

October 2022

Risk Assessment and Risk Management Plan (Consultation version) for

DIR 191

Commercial import and distribution of chrysanthemum genetically modified for altered flower colour

Applicant: International Flower Developments Pty Ltd

This RARMP is open for consultation until 20 December 2022.

Written comments on the risks to human health and safety and the environment posed by this proposed release are invited. You may make your submission

via mail to: The Office of the Gene Technology Regulator, MDP 54 GPO Box 9848, Canberra ACT 2601

or

via email to: ogtr@health.gov.au.

Please note that issues regarding food safety and labelling, the use of agricultural chemicals, and marketing and trade implications do **not** fall within the scope of these evaluations as they are the responsibilities of other agencies and authorities.

Summary of the Risk Assessment and Risk Management Plan (Consultation Version)

for

Licence Application No. DIR 191

Introduction

The Gene Technology Regulator (the Regulator) has received a licence application for intentional, commercial-scale import and distribution of genetically modified (GM) chrysanthemum cut flowers. The Regulator has prepared a Risk Assessment and Risk Management Plan (RARMP) for this application, which concludes that the proposed release poses negligible risks to human health and safety and the environment. Licence conditions have been drafted for the proposed release. The Regulator invites submissions on the RARMP, including draft licence conditions, to inform the decision on whether or not to issue a licence.

The application

Application number	DIR 191
Applicant	International Flower Developments Pty Ltd
Project title	Commercial import and distribution of chrysanthemum genetically modified for altered flower colour[1]
Parent organism	Chrysanthemum (*Chrysanthemum* x *morifolium*)
Introduced genes and modified traits	Two genes conferring blue or violet flower colour: • *F3'5'H* - flavonoid 3',5'-hydroxylase gene from *Campanula medium* • *A3'5'GT* - anthocyanin 3',5'-glucosyltransferase gene from *Clitoria ternatea* One selectable marker gene: • *nptII* – antibiotic resistance gene from *Escherichia coli*
Proposed locations	Australia-wide
Primary purpose	Commercial import and distribution of cut flowers of GM chrysanthemum for ornamental use

Risk assessment

The risk assessment concludes that risks to the health and safety of people or the environment from the proposed dealings, either in the short or long term, are negligible. No specific risk treatment measures are required to manage these negligible risks.

The risk assessment process considers how the genetic modification and activities conducted with the GMO might lead to harm to people or the environment. Risks are characterised in relation to both the seriousness and likelihood of harm, taking into account information in the application, relevant previous

[1] The title of the licence application submitted by International Flower Developments Pty Ltd is "Application for commercial import of flowers of five genetically modified chrysanthemum varieties; 2B, 3C, 4A, 5A and 8D".

approvals, current scientific knowledge and advice received from a wide range of experts, agencies and authorities consulted on the preparation of the RARMP. Both the short and long term risks are considered.

Credible pathways to potential harm that were considered included exposure of people or animals to the GM chrysanthemum cut flowers, transfer of the introduced genetic material to sexually compatible plants, and accidental or deliberate propagation of the GM chrysanthemums. The potential harms considered were increased toxicity, allergenicity or weediness of the GM chrysanthemums compared to unmodified plants.

The principal reasons for the conclusion of negligible risks are that the GM chrysanthemums will not be used in commercial human food or animal feed, pollinators would have little access to pollen from the GM chrysanthemum cut flowers, imported chrysanthemum cut flowers must be devitalised, the introduced proteins and their pigment products are not expected to be toxic or allergenic, and chrysanthemums have very low potential to survive outside cultivation.

Risk management

The risk management plan concludes that risks from the proposed dealings can be managed so as to protect people and the environment by imposing general conditions to ensure that there is ongoing oversight of the release.

Risk management is used to protect the health and safety of people and to protect the environment by controlling or mitigating risk. The risk management plan evaluates and treats identified risks and considers general risk management measures. The risk management plan is given effect through licence conditions.

As the level of risk is assessed as negligible, specific risk treatment is not required. However, the Regulator has drafted licence conditions regarding post-release review (PRR) to ensure that there is ongoing oversight of the release and to allow the collection of information to verify the findings of the RARMP. The draft licence, detailed in Chapter 4 of the consultation RARMP, also contains a number of general conditions relating to ongoing licence holder suitability, auditing and monitoring, and reporting requirements, which include an obligation to report any unintended effects.

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Abbreviations

the Act	The *Gene Technology Act 2000*
A3'5'GT	anthocyanin 3',5'-O-glucosyltransferase gene
cm	Centimetre(s)
DAFF	Department of Agriculture, Fisheries and Forestry
DIR	Dealing involving Intentional Release
DNA	Deoxyribonucleic acid
F3'5'H	Flavonoid 3',5'-hydroxylase gene
GM	Genetically modified
GMO	Genetically modified organism
HGT	Horizontal gene transfer
mg	Milligram(s)
nptII	Neomycin phosphotransferase gene
OECD	Organisation for Economic Co-operation and Development
OGTR	Office of the Gene Technology Regulator
PRR	Post release review
RAF	Risk Analysis Framework
RARMP	Risk Assessment and Risk Management Plan
Regulations	Gene Technology Regulations 2001
Regulator	Gene Technology Regulator
spp.	Species (plural)

Chapter 1 Risk assessment context

Section 1 Background

1. An application has been made under the *Gene Technology Act 2000* (the Act) for Dealings involving the Intentional Release (DIR) of genetically modified organisms (GMOs) into the Australian environment.

2. The Act and the Gene Technology Regulations 2001 (the Regulations), together with corresponding State and Territory legislation, comprise Australia's national regulatory system for gene technology. Its objective is to protect the health and safety of people, and to protect the environment, by identifying risks posed by or as a result of gene technology, and by managing those risks through regulating certain dealings with GMOs.

3. Section 50 of the Act requires that the Gene Technology Regulator (the Regulator) must prepare a Risk Assessment and Risk Management Plan (RARMP) in response to an application for release of GMOs into the Australian environment. Sections 50, 50A and 51 of the Act and sections 9 and 10 of the Regulations outline the matters which the Regulator must take into account and who must be consulted when preparing the RARMP.

4. The *Risk Analysis Framework* (RAF) (OGTR, 2013) explains the Regulator's approach to the preparation of RARMPs in accordance with the Act and the Regulations. The Regulator has also developed operational policies and guidelines that are relevant to DIR licences. These documents are available from the Office of the Gene Technology Regulator (OGTR) website.

5. Figure 1 shows the information that is considered, within the regulatory framework above, in establishing the risk assessment context. This information is specific for each application. Risks to the health and safety of people or the environment posed by the proposed release are assessed within this context. Chapter 1 provides the specific information for establishing the risk assessment context for this application.

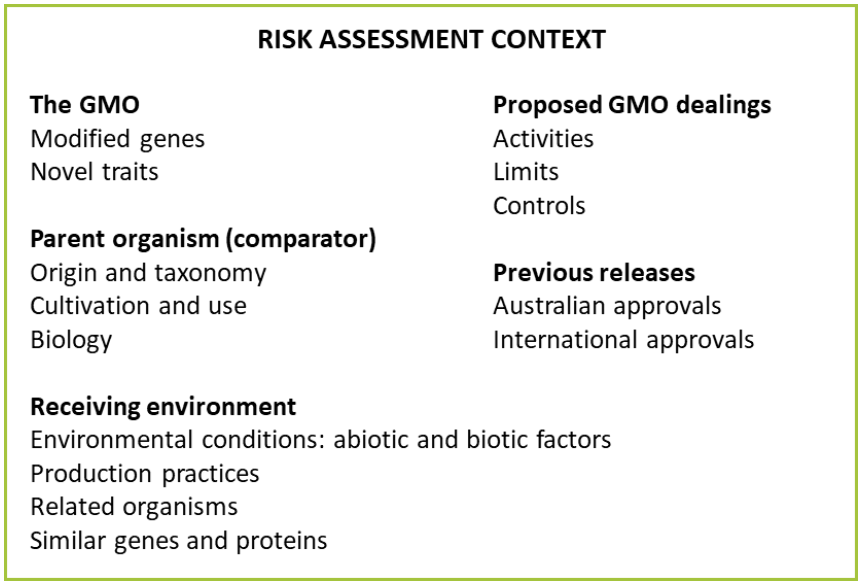

Figure 1 Summary of parameters used to establish the risk assessment context, within the legislative requirements, operational policies and guidelines of the OGTR and the RAF.

6. Since this application is for commercial purposes, it cannot be considered as a limited and controlled release application under section 50A of the Act. Therefore, under section 50(3) of the Act, the Regulator was required to seek advice from prescribed experts, agencies and authorities on matters relevant to the preparation of the RARMP. This first round of consultation included the Gene Technology

Technical Advisory Committee, State and Territory Governments, Australian Government authorities or agencies prescribed in the Regulations, all Australian local councils and the Minister for the Environment. A summary of issues contained in submissions received is provided in Appendix A.

7. Section 52 of the Act requires the Regulator, in a second round of consultation, to seek comment on the RARMP from the experts, agencies and authorities outlined above, as well as the public.

1.1 Interface with other regulatory schemes

8. Gene technology legislation operates in conjunction with other regulatory schemes in Australia. The GMOs and any proposed dealings may also be subject to regulation by other Australian government agencies that regulate GMOs or GM products, including Food Standards Australia New Zealand, the Australian Pesticides and Veterinary Medicines Authority, the Therapeutic Goods Administration, the Australian Industrial Chemicals Introduction Scheme and the Department of Agriculture, Fisheries and Forestry (DAFF). These dealings may also be subject to the operation of State legislation recognising an area as designated for the purpose of preserving the identity of GM crops, non-GM crops, or both GM crops and non-GM crops, for marketing purposes.

9. To avoid duplication of regulatory oversight, risks that have been considered by other regulatory agencies would not be re-assessed by the Regulator.

10. The DAFF regulates products imported into Australia to protect Australia from biosecurity risks in accordance with the *Biosecurity Act 2015*. The import of propagatable cut flowers must comply with import conditions developed by the DAFF and may require an import permit issued by the DAFF.

Section 2 The proposed release

11. International Flower Developments Pty Ltd proposes to import and distribute GM chrysanthemum cut flowers that have been genetically modified for altered flower colour. Five lines of GM chrysanthemums are included in the licence application. The OECD unique identifiers for these lines are NS-201806-5, NS-202201-4, NS-203701-1, NS-208133-5, and NS-212801-2.

12. The applicant is seeking approval to distribute the GM chrysanthemum flowers Australia-wide. Cut GM chrysanthemum flowers would be imported into Australia and sold to the public through florists and supermarkets, in the same way as non-GM flowers are imported and sold.

13. The applicant states that the GM chrysanthemums would not be used as commercial human food or animal feed.

14. The dealings involved in the proposed intentional release are to:

(a) import the GMOs

(b) transport the GMOs

(c) dispose of the GMOs

and the possession, supply or use of the GMOs for the purposes of, or in the course of, any of the above.

Section 3 The parent organism

15. The parent organism is chrysanthemum (*Chrysanthemum* x *morifolium* Ramat.), which is also known as florist's daisy, florist's chrysanthemum or mum. Chrysanthemums originated in China and are exotic to Australia.

3.1 Taxonomy

16. The *Chrysanthemum* genus belongs to the *Compositae* (alternatively *Asteraceae*) family, the *Anthemideae* tribe and the *Artemisiinae* subtribe. There are 37 members of the *Chrysanthemum* genus and their centre of diversity is in Asia (Oberprieler et al., 2022).

17. *Chrysanthemum* x *morifolium* cultivars are hexaploids resulting from hybridisation between several wild *Chrysanthemum* species (Ma et al., 2020; Qi et al., 2021).

3.2 Cultivation

18. Chrysanthemums are among the most popular flower crops in the world. They are grown as commercial cut flowers, pot plants, and domestic garden plants worldwide (Anderson, 2007; Lim, 2014a), including in Australia.

19. Although chrysanthemums are primarily cultivated for ornamental uses, the flowers and young leaves are edible, and are used in various dishes in Chinese, Japanese and Korean cuisine. In particular, chrysanthemum flowers are made into chrysanthemum tea. Small chrysanthemum flowers are used as a garnish in Japan. Chrysanthemum plants are also used in traditional Chinese medicine (Lim, 2014a).

20. Chrysanthemum cut flowers made up approximately 9% of total global exports of cut flowers in 2020. The two countries that export most chrysanthemum flowers are the Netherlands and Colombia (Rabobank and Royal Flora Holland, 2022).

21. Chrysanthemums are both commercially cultivated in Australia and imported as cut flowers. About a quarter of cut flowers sold in Australia are imported (Horticulture Innovation Australia Limited, 2022). Chrysanthemum cut flowers that are imported into Australia must be devitalised in accordance with Australian government biosecurity requirements, by immersion of stems in a 0.5% glyphosate solution for 20 minutes (Department of Agriculture and Water Resources, 2018).

22. Chrysanthemum development is photoperiod sensitive: long-day conditions promote vegetative growth and short-day conditions promote flower development (Crater, 1992; Kofranek, 1992; Anderson, 2007; Nair et al., 2021). Therefore, chrysanthemums grown outside flower in the autumn or early winter (Kofranek, 1992; Nair et al., 2021). However, commercial production of chrysanthemum cut flowers or flowering pot plants can continue year-round if the plants are grown in greenhouses and artificial lighting or shading are used to program blooming time (Crater, 1992; Kofranek, 1992; Nair et al., 2021).

23. After harvesting, cut chrysanthemum flowers are placed in a hydrating solution, and can then be stored dry for 3-8 weeks under refrigeration (Kofranek, 1992; Nair et al., 2021). Therefore, cut chrysanthemums can readily be transported long distances or exported under cold-chain conditions. Flowering potted chrysanthemums can be stored for up to two weeks under refrigeration (Crater, 1992).

3.3 Morphology

24. Chrysanthemums are perennial herbs up to 1 metre tall (Anderson, 2007; Lim, 2014a). Plant growth habit ranges from upright plants with few branches used for cut flower production to very bushy plants popular for garden use (Anderson, 2007; Spaargaren and van Geest, 2018). There are also dwarf cultivars grown as garden or potted plants (Anderson, 2007).

25. Chrysanthemum flowers have a wide range of shapes. Single flower forms have central hermaphrodite disc florets surrounded by larger female ray florets (Figure 2A). Double flower forms have increased numbers of ray florets at the expense of disc florets and usually have no disc florets visible (Figure 2B, C). Some double flowers have no disc florets and are male sterile (Kofranek, 1992; Anderson, 2007; Spaargaren and van Geest, 2018).

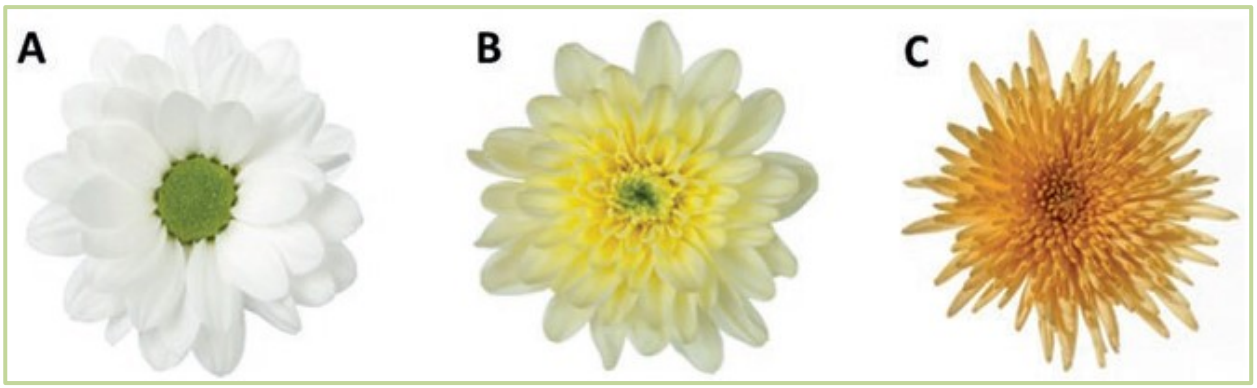

Figure 2 Three chrysanthemum flower shapes. A: single daisy type. B: double decorative type. C: double spider type. Adapted from Spaargen and van Geest (2018).

26. The applicant states that the parental cultivars of the five GM chrysanthemum lines included in this application are all double decorative (Figure 2B) or double pompon types. Pompon type flowers are similar to decorative type flowers but are globular rather than flat in shape (Kofranek, 1992).

27. Two of the parental cultivars, Sei Arabella and T37, have disc florets and have been successfully used as pollen donors in artificial crossing experiments (Aida et al., 2020). It is not known whether the other three parental cultivars have disc florets and produce pollen.

3.4 Reproduction

28. Chrysanthemums can reproduce either sexually or asexually.

29. Field-grown chrysanthemums can be pollinated by insects: the main pollinators are reported to be bees and butterflies (Wang et al., 2008). Chrysanthemums are not known to be wind pollinated and greenhouse experiments using fans were not able to disperse chrysanthemum pollen by wind (Shinoyama et al., 2008).

30. Chrysanthemums have high levels of self-incompatibility, and only a small proportion of cultivars are able to produce viable self-pollinated seed (Anderson, 2007; Wang et al., 2014). The two parental cultivars of the GM chrysanthemums that are known to produce pollen, Sei Arabella and T37, were reported to have no seed set in bagged flower heads, suggesting that they are self-incompatible (Aida et al., 2020).

31. Chrysanthemum cut flowers that are cross-pollinated by hand and allowed to senesce in water, in a method known as ‘water culture’, can produce viable seed (Anderson, 2007).

32. In commercial cultivation, chrysanthemums are asexually propagated, to retain the phenotype of the parental cultivar. Seeds are only generated for use in breeding schemes to develop new cultivars (Anderson, 2007; Spaargaren and van Geest, 2018).

33. The most common method for propagating chrysanthemums is by cuttings. Cuttings are 5-10 cm of stem with leaves, usually taken from terminal vegetative shoots (Crater, 1992; Kofranek, 1992; Nair et al., 2021). Unrooted cuttings can be stored in cool conditions for up to four weeks. Cuttings root best in porous soil under high humidity conditions (Crater, 1992; Kofranek, 1992). Most propagators apply rooting hormone to cuttings (Crater, 1992), but in a greenhouse study over 90% of chrysanthemum cuttings rooted well without hormone application (Cojocariu et al., 2018).

34. Most chrysanthemum cultivars produce suckers, which grow horizontally from the underground stem for a short distance then emerge. These chrysanthemum cultivars can be propagated by separating rooted suckers from the parent plant and replanting the suckers (Lindgren and Fitzgerald, 2007; Nair et al., 2021). Chrysanthemums can also be asexually propagated using tissue culture methods (Crater, 1992; Nair et al., 2021).

3.5 Toxicity and allergenicity

35. Chrysanthemums can cause contact dermatitis, both in people who are occupationally exposed to chrysanthemums and in recreational gardeners. The allergenic activity is primarily attributed to sesquiterpene lactones (Mitchell et al., 1970; Lim, 2014a; Paulsen and Andersen, 2020).

36. A study in the Netherlands found that about 20% of chrysanthemum greenhouse workers were sensitised to chrysanthemum pollen. The most common allergic symptoms in pollen-sensitised workers were rhinitis and conjunctivitis (Groenewoud et al., 2002).

37. *Compositae* family plants containing sesquiterpene lactones are known to induce contact dermatitis, mainly on the exposed skin of the hands, arms, neck and face (Amorim et al., 2013). In a North American study that tested over 5000 patients suspected of having allergic contact dermatitis, 1.3% of patients were found to be sensitised to *Compositae* mix and 0.6% of patients were sensitised to sesquiterpene lactone mix (Warshaw et al., 2008). Livestock that graze on some plants containing sesquiterpene lactones may suffer toxic effects including severe mucosal and gastro-intestinal irritation (Amorim et al., 2013).

38. A toxicity study of ethanolic extract of chrysanthemum flowers in rats did not detect any acute or long-term oral toxicity (Li et al., 2010).

39. Chrysanthemums are not listed in a report on poisonous garden plants in New South Wales (Johnson and Johnson, 2006). *Chrysanthemum* spp. are listed in a report on harmful garden plants in Western Australia (Department of Agriculture and Food Western Australia, 2005). This report classifies *Chrysanthemum* spp. as an irritant when touched, which probably refers to their potential to cause contact dermatitis.

40. The American Society for the Prevention of Cruelty to Animals website classifies chrysanthemum as a plant that is toxic to cats, dogs and horses. The listed symptoms of toxicity include dermatitis or mucosal and gastro-intestinal symptoms if the plant is ingested.

3.6 Weediness

41. Chrysanthemums have been grown in Australia as a horticultural crop and garden plants for many decades. However, chrysanthemums are not reported to be naturalised or a weed in Australia (Groves et al., 2003; Randall, 2017; White et al., 2022). The Atlas of Living Australia (accessed 17/8/22) includes only three reports of *Chrysanthemum* x *morifolium* or synonyms found in the Australian environment; these plants were all under cultivation.

42. Chrysanthemums are grown widely across the world, but they have only been reported as cultivation escapes, casual aliens or naturalised plants in a handful of countries (Randall, 2017).

Section 4 The GMOs – nature and effect of the genetic modification

4.1 Introduction to the GMOs

43. Five lines of GM chrysanthemums are proposed for release. The names of the parental cultivars for each GM line are shown in Table 1.

Table 1 Parental cultivars of each GM chrysanthemum line

Parental chrysanthemum cultivar	**Flower type** (Noda et al., 2020)	Unique OECD identifier of GM line
T37	Pompon	NS-201806-5
Sei Shawl	Decorative	NS-202201-4
T57	Decorative	NS-203701-1
Sei Arabella	Decorative	NS-208133-5
T10	Decorative	NS-212801-2

44. The five parental cultivars all produce flowers in hues of pink. The GM lines are genetically modified for altered flower colour and produce flowers in hues of violet or blue. An example is shown in Figure 3.

Figure 3 Flower of parental chrysanthemum cultivar T57 (left) compared to flower of transformed GM chrysanthemum line NS-203701-1 (right). Photo supplied by applicant.

4.2 The genetic modification

45. All five GM chrysanthemum lines were transformed using the construct pB423 (Noda et al., 2017). The introduced genetic elements, with their source organisms and functions, are listed in Table 2.

Table 2 Introduced genetic elements from right to left border

Genetic element	Description	Source	Intended function
nosp	Nopaline synthase gene promoter	*Agrobacterium tumefaciens*	Constitutive promoter
nptII	Neomycin phosphotransferase gene	*Escherichia coli*	Antibiotic resistance selectable marker
nost	Nopaline synthase gene terminator	*Agrobacterium tumefaciens*	Terminator
F3Hp	Flavanone 3-hydroxylase gene promoter	*Chrysanthemum* x *morifolium*	Petal-specific promoter
ADH-5'UTR	5' untranslated region of alcohol dehydrogenase gene	*Nicotiana tabacum*	Translational enhancer
F3'5'H	Flavonoid 3',5'-hydroxylase gene	*Campanula medium*	Altered flower colour
HSPt	Heat shock protein gene terminator	*Arabidopsis thaliana*	Terminator and expression enhancer
F3Hp	Flavanone 3-hydroxylase gene promoter	*Chrysanthemum* x *morifolium*	Petal-specific promoter
ADH-5'UTR	5' untranslated region of alcohol dehydrogenase gene	*Nicotiana tabacum*	Translational enhancer
A3'5'GT	UDP-glucose:anthocyanin 3',5'-O-glucosyltransferase gene	*Clitoria ternatea*	Altered flower colour
nost	Nopaline synthase gene terminator	*Agrobacterium tumefaciens*	Terminator

4.2.1 Method of genetic modification

46. All of the GM chrysanthemum lines were developed using *Agrobacterium tumefaciens*-mediated transformation. This method has been widely used in Australia and overseas for introducing genes into plants. More information can be found in the document *Risk Assessment Reference: Methods of Plant*

Genetic Modification on the Resources page on the OGTR website. After transformation, *Agrobacterium* was eliminated using the antibiotic carbenicillin, which is reported to be an effective method for eliminating *Agrobacterium* from chrysanthemum tissue culture (Teixeira da Silva and Fukai, 2001).

4.2.2 Genes for altered flower colour

47. The colours of chrysanthemum flowers depend on which pigments are present in the petals of the ray florets. The petal colours found in non-GM chrysanthemums are:

(a) yellow, due to carotenoid pigments,

(b) pink to red, due to cyanidin-based pigments,

(c) orange to red, due to a combination of carotenoid and cyanidin-based pigments,

(d) green, due to presence of chlorophyll, and

(e) white, due to an absence of coloured pigments (Ohmiya, 2018).

48. The introduced *F3'5'H* gene in the GM chrysanthemum lines encodes a flavonoid 3',5'-hydroxylase enzyme. This enzyme converts a precursor molecule of pink to red cyanidin-based pigments in chrysanthemum into a precursor molecule of purple to blue delphinidin-based pigments (Noda et al., 2013; Ohmiya, 2018; Han et al., 2021). Introduction of the specific *F3'5'H* gene cassette used in the GM chrysanthemum lines was reported to convert up to 95% of cyanidin-type pigments in petals to delphinidin-type pigments (Noda et al., 2013).

49. The introduced *A3'5'GT* gene in the GM chrysanthemum lines encodes a UDP (uridine diphosphate)-glucose:anthocyanin 3',5'-O-glucosyltransferase enzyme from *Clitoria ternatea*. This enzyme efficiently glucosylates both cyanidin-type and delphinidin-type pigments (Kogawa et al., 2007; Noda et al., 2017). GM chrysanthemum petals containing 95% 3'5'-glucosylated delphinidin-type pigments were found to be blue in colour. In comparison, petals without expression of the *A3'5'GT* gene, which contained only delphinidin-type pigments without 3'5'-glucosylation, were purple in colour (Noda et al., 2017).

50. Expression of both the *F3'5'H* gene and the *A3'5'GT* gene is controlled by the *F3H* promoter from chrysanthemum. This promoter is reported to be petal-specific, supported both by its natural role in controlling a flower pigment biosynthesis gene and by experimental evidence that it drives transgene expression in petals, but not in leaves or stems (Noda et al., 2013).

4.2.3 Antibiotic resistance gene

51. The introduced *nptII* gene was used as a selectable marker in the laboratory to select transformed GM plants during early stages of development. This gene is derived from *Escherichia coli* and encodes a neomycin phosphotransferase enzyme. It provides resistance to neomycin, kanamycin, paromonycin and related aminoglycoside antibiotics. More information on *nptII,* including information regarding lack of toxicity or allergenicity, is available in the document *Risk Assessment Reference: Marker Genes in GM Plants* on the Resources page on the OGTR website.

4.2.4 Toxicity/allergenicity of the proteins encoded by the introduced genes

52. The introduced *F3'5'H* gene was isolated from the plant *Campanula medium*, commonly known as Canterbury bells. The University of California's database of Safe and Poisonous Garden Plants (accessed 6/9/22) classifies *Campanula* spp. as safe.

53. The introduced *A3'5'GT* gene was isolated from the plant *Clitoria ternatea*, commonly known as butterfly pea or blue pea. Butterfly peas have edible flowers that are popular in Asia in teas and desserts, and are used as a traditional herbal medicine (Lim, 2014b; Oguis et al., 2019). A clinical trial of doses of up to 2 g of aqueous *C. ternatea* extract, containing flower pigments and proteins, observed no adverse effects (Chusak et al., 2018). The United States Food and Drug Administration has approved use of an

aqueous extract of butterfly pea flower as a food colour additive (Roth, 2021). However, the food colour extract is prepared using ultrafiltration to remove proteins.

54. The applicant reports that bioinformatic analysis of the F3'5'H and A3'5'GT protein sequences did not find similarities to known toxic or allergenic proteins. The applicant searched the non-redundant protein sequences (nr) and UniProtKB/Swiss-Prot (swissprot) protein databases using the blastp algorithm for homology to known toxic proteins. The applicant searched the Food Allergy Research and Resource Program (FARRP) AllergenOnline database and the Comprehensive Protein Allergen Resource (COMPARE) database, using the 80-mer sliding window FASTA search, for homology to known allergenic proteins.

4.2.5 Toxicity of novel pigments produced in the GMOs

55. GM chrysanthemum lines transformed with the pB423 construct produce pigments that are not naturally present in chrysanthemums. The major novel molecules are delphinidin-based pigments with three glucose moieties (Noda et al., 2017).

56. Common blue or purple fruit and vegetables, such as blueberries, eggplants and Concord grapes, are rich in delphinidins. These delphinidin-type pigments contain between one and three sugar moieties (Wu et al., 2006; Fang, 2015). The daily intake of delphinidins is estimated to be 2.6 mg/person in the United States (Wu et al., 2006). This indicates that people regularly consume food constituents similar to the novel pigments produced in the GMOs.

4.3 Characterisation of the GMOs

4.3.1 Molecular characterisation

57. The applicant determined the number of copies of the introduced genetic construct in the GM chrysanthemum lines using Southern blot analysis, with a probe for the *F3'5'H* gene. The analysis indicated that lines NS-202201-4 and NS-208133-5 contain one copy, lines NS-201806-5 and NS-212801-2 contain two copies and line NS-203701-1 contains three copies. It is not known whether each insertion is a complete or partial copy of the genetic construct, as the insertions have not been sequenced.

58. The GM chrysanthemum lines have been vegetatively propagated since their transformation. The applicant states that there is stable expression of the introduced genetic modification through generations, demonstrated by maintenance of a consistent blue or violet flower colour phenotype in each line. Assessment of flower colour stability in all GM chrysanthemum lines found that less than 1% of florets were off-type (petals with a colour different to that expected from the line). The applicant found that the levels of off-type florets in the GM lines were not statistically different from the levels of off-type florets in the parental cultivars.

4.3.2 Phenotypic characterisation

59. The GM chrysanthemum lines and their parental cultivars were grown in three trials in Colombia, in commercial chrysanthemum greenhouses. The trials grew the chrysanthemums as either spray-type flowers (multiple flowers on each cut stem) or disbud flowers (single large flower on each cut stem). The phenotypic traits tested in the trials are shown in Table 3.

Table 3 Phenotypic traits of GM chrysanthemum lines. Percentages represent mean for the GM line divided by mean for the parental variety. Percentages in red font indicate a statistically significant difference between the GM line and the parental variety in a majority of trials that assessed the trait.

	NS-201806-5	NS-202201-4	NS-203701-1	NS-208133-5	NS-212801-2
Time to flower	101.1%	100%	100%	100%	98.1%
Flower stem length	98.7%	99.3%	**93.3%**	**83.7%**	93.5%
Flower diameter	**93.1%**	**95.4%**	96.5%	**94.7%**	99.4%
No. flowers per stem (spray-type)	**90.5%**	97.0%	100.5%	98.7%	95.2%

	NS-201806-5	NS-202201-4	NS-203701-1	NS-208133-5	NS-212801-2
Leaf width	97.6%	100.5%	99.2%	96.0%	96.6%
Plant height	**97.3%**	98.6%	**95.6%**	**88.5%**	93.9%
No. florets per inflorescence	92.6%	**103.6%**	99.0%	94.9%	91.0%

60. Overall, the GM chrysanthemum plants were found to be shorter than parental cultivars by an average of 5%. Flower stems were shorter in GM lines than parental cultivars by an average of 6%. Flower diameter was smaller in GM lines than parental cultivars by an average of 4%.

61. The finding that GM chrysanthemum lines are slightly shorter and smaller-flowered than their parental cultivars may indicate that the GM chrysanthemums have slightly reduced plant vigour.

62. In other traits, differences between the GM chrysanthemum lines and their parental cultivars were smaller and inconsistent in direction of the difference, so are unlikely to be biologically significant.

4.3.3 Vegetative reproduction potential

63. The applicant conducted three experiments to test the vegetative reproduction traits of the GM chrysanthemum lines and the potential for cut flowers to regrow into whole plants.

64. The first experiment tested survival of discarded vegetative material. Unrooted cuttings from the five GM chrysanthemum lines and their parental cultivars were planted (basal end pushed into the ground) in blocks of bare ground in Colombia. The cuttings were not treated with rooting hormone or watered. After two months, 11.8% of plants from the GM lines and 20.2% of plants from the parental cultivars had established. After six months, during which weeds encroached on the blocks and competed with the chrysanthemums, 4.4% of the GM plants and 5.3% of the non-GM plants survived.

65. The second experiment quantified root formation in the five GM chrysanthemum lines compared to their parental cultivars. Unrooted cuttings were placed flat on soil in greenhouses. The cuttings were not treated with rooting hormone but they were misted to prevent desiccation. An average of 87% of cuttings from the GM lines developed roots, compared to 82% of cuttings from the parental cultivars. Cuttings from the GM lines and parental cultivars had comparable root number and root length.

66. The third experiment tested the effect of glyphosate treatment on development of adventitious roots. Cut flowers from GM chrysanthemums transformed using the pB423 construct (also including lines not contained in this licence application) were treated by immersion in 0.25% glyphosate solution for 20 minutes, or by a control immersion in water. The cut flowers were then kept in water for four weeks. Adventitious root formation was observed in 0.88% of the GM cut flowers not treated with glyphosate, and in 0.43% of the GM cut flowers treated with glyphosate.

67. It is noted that the glyphosate treatment used in the third experiment used a 0.25% glyphosate solution. Chrysanthemum cut flowers that are imported into Australia must be treated by immersion of stems in a 0.5% glyphosate solution for 20 minutes (Department of Agriculture and Water Resources, 2018). This higher glyphosate concentrate would devitalise chrysanthemum cut flowers more effectively than the treatment used for the applicant's experiment. The Department of Agriculture, Fisheries and Forestry conducts random testing of propagatable species of imported cut flowers, including chrysanthemum, to verify that they have been devitalised.

Section 5 The receiving environment

68. The receiving environment forms part of the context in which the risks associated with dealings involving the GMOs are assessed. Relevant information about the receiving environment includes abiotic and biotic interactions of the plant with the environment where the release would occur; presence of plants that are sexually compatible with the GMO; and background presence of the gene(s) used in the genetic modification (OGTR, 2013).

69. The applicant has proposed to distribute and sell the GM chrysanthemum flowers Australia-wide. Therefore, for this licence application, it is considered that the receiving environment is all of Australia.

5.1 Relevant abiotic factors

70. Chrysanthemums prefer mild climates. Night temperatures below 10°C or day temperatures over 32°C impede plant development (Crater, 1992; Lim, 2014a). Most chrysanthemum cultivars are frost sensitive, but some garden cultivars that are bred to be winter hardy survive temperatures below -6°C (Anderson, 2007; Lim, 2014a). The parental cultivars of the GM chrysanthemums are greenhouse varieties which are not bred to be winter hardy. Some areas of Australia would be too cold in winter for frost sensitive chrysanthemum cultivars to survive as perennial plants.

71. Chrysanthemums have shallow roots, so they need frequent watering and are also sensitive to waterlogging. In open field cultivation or gardens, it is recommended to provide chrysanthemums with weekly irrigation or rainfall (Lindgren and Fitzgerald, 2007; Nair et al., 2021). Many areas of Australia would be too dry for chrysanthemums to survive long outside cultivation.

5.2 Relevant biotic factors

5.2.1 Presence of sexually compatible plants in the receiving environment

72. *Chrysanthemum* x *morifolium* is sexually compatible with other *C.* x *morifolium* plants, which are cultivated in Australia (see Section 3).

73. The Atlas of Living Australia (accessed 29/8/22) does not record occurrences of any *Chrysanthemum* species other than *C.* x *morifolium* in Australia.

74. *Chrysanthemum* is one of 25 genera in the *Artemisiinae* subtribe (Oberprieler et al., 2022). According to the Atlas of Living Australia (accessed 29/8/22), the only genera from this subtribe that are present in Australia are *Chrysanthemum* and *Artemisia*. Three examples of wide crosses between *C.* x *morifolium* and *Artemisia* species have been reported in the literature, but none of these crosses were possible outside a laboratory. Hybrids between *C.* x *morifolium* and *A. sieversiana* could only be produced by electrofusion of protoplasts (Furuta et al., 2004) and hybrids between *C.* x *morifolium* and *A. vulgaris* or *A. japonica* could only be produced by embryo rescue (Deng et al., 2010; Zhu et al., 2013). Thus, it is highly unlikely that *C.* x *morifolium* could spontaneously hybridise with *Artemisia* species or more distantly related species.

75. Therefore, the only plants in the receiving environment that are expected to be sexually compatible with the GM chrysanthemums are other chrysanthemums.

5.2.2 Presence of other biotic factors

76. Chrysanthemums are susceptible to a range of pests and diseases. The most serious pests of chrysanthemum cut flower production in Australia are western flower thrips (*Frankliniella occidentalis*) and two-spotted mites (*Tetranychus urticae*) (Manners et al., 2013). Worldwide, the most important fungal diseases in chrysanthemum are *Puccinia* rusts and soil-borne *Fusarium* and *Verticillium* wilts (Spaargaren and van Geest, 2018), which are all present in Australia. The economically important virus or virus-like diseases of chrysanthemum in Australia are chrysanthemum virus B, tomato aspermy virus, tomato spotted wilt virus and chrysanthemum stunt viroid (Agriculture Victoria: Virus diseases of chrysanthemums, accessed 31/8/22).

5.3 Presence of the introduced genes and encoded proteins in the receiving environment

77. The introduced genes were originally isolated from naturally occurring organisms that are already widespread in the environment.

78. The *F3'5'H* gene was isolated from *Campanula medium*, a popular ornamental garden plant in Australia (Hortflora: Horticultural Flora of South-eastern Australia, accessed 31/8/22).

79. The *A3'5'GT* gene was isolated from *Clitoria ternatea,* a pasture and ornamental plant that is also naturalised in Queensland, the Northern Territory and Western Australia (Atlas of Living Australia, Census of the Queensland Flora, FloraNT – Northern Territory flora online, Florabase - the Western Australian flora, accessed 31/8/22).

80. The *nptII* gene was isolated from *Escherichia coli*, a common bacterium that is widespread in human and animal digestive systems and in the environment in Australia (Gordon and Cowling, 2003).

Section 6 Previous approvals of the GM chrysanthemums

6.1 Australian approvals

81. The GM chrysanthemums proposed for release have not been previously approved for release in Australia.

82. Other GM chrysanthemum lines with altered flower colour were previously approved by the Genetic Manipulation Advisory Committee (a precursor of the Gene Technology Regulator) for a semi-contained trial under commercial glasshouse production conditions (PR-25, 1993).

6.2 International approvals

83. The GM chrysanthemums proposed for release are approved in Colombia (ICA Resolution 082360, 2020). The approval permits the GM chrysanthemums to be grown in greenhouses for the purpose of commercial production of cut flowers for export.

Chapter 2 Risk assessment

Section 1 Introduction

84. The risk assessment identifies and characterises risks to the health and safety of people or to the environment from dealings with GMOs, posed by or as the result of gene technology (Figure 4). Risks are identified within the established risk assessment context (Chapter 1), taking into account current scientific and technical knowledge. A consideration of uncertainty, in particular knowledge gaps, occurs throughout the risk assessment process.

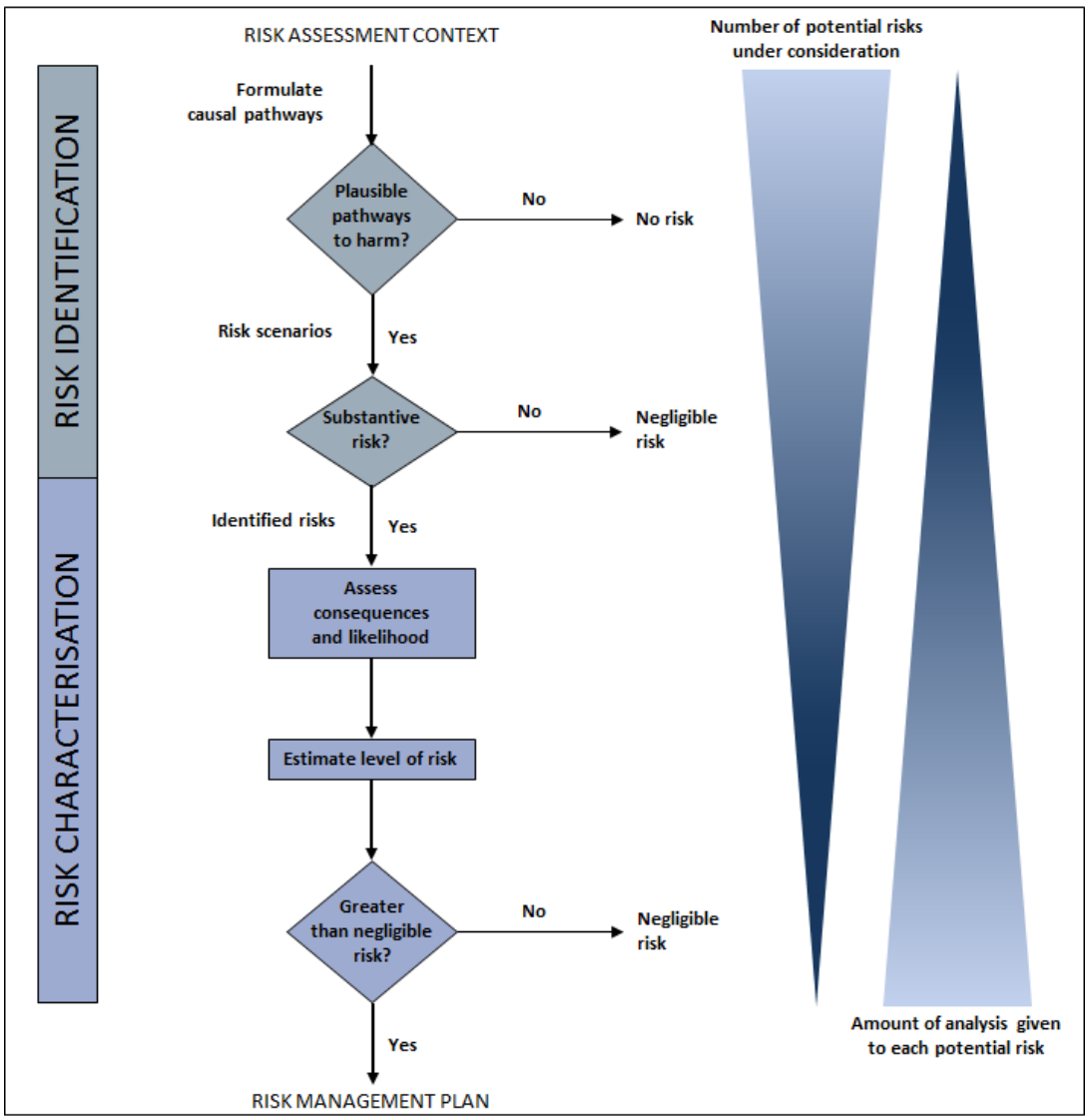

Figure 4 The risk assessment process

85. The Regulator uses a number of techniques to identify risks, including checklists, brainstorming, previous agency experience, reported international experience and consultation (OGTR, 2013).

86. Risk identification first considers a wide range of circumstances in which the GMO, or the introduced genetic material, could come into contact with people or the environment. This leads to postulating causal pathways that may give rise to harm for people or the environment from dealings with a GMO. These are called risk scenarios.

87. Risk scenarios are screened to identify substantive risks, which are risk scenarios that are considered to have some reasonable chance of causing harm. Risk scenarios that could not plausibly occur, or do not lead to harm in the short and long term, do not advance in the risk assessment process (Figure 4), i.e., the risk is considered no greater than negligible.

88. Risk scenarios identified as substantive risks are further characterised in terms of the potential seriousness of harm (consequence assessment) and the likelihood of harm (likelihood assessment). The consequence and likelihood assessments are combined to estimate the level of risk and determine whether risk treatment measures are required. The potential for interactions between risks is also considered.

89. A weed risk assessment approach is used to identify traits that may contribute to risks from GM plants, as this approach addresses the full range of potential adverse outcomes associated with plants. In particular, novel traits that may increase the potential of the GMO to spread and persist in the environment or increase the level of potential harm compared with the parental plant(s) are considered in postulating risk scenarios (Keese et al., 2014). Risk scenarios postulated in previous RARMPs prepared for licence applications for the same or similar GMOs are also considered.

Section 2 Risk identification

90. Postulated risk scenarios are comprised of three components (Figure 5):

i. The source of potential harm (risk source),

ii. A plausible causal linkage to potential harm (causal pathway), and

iii. Potential harm to people or the environment.

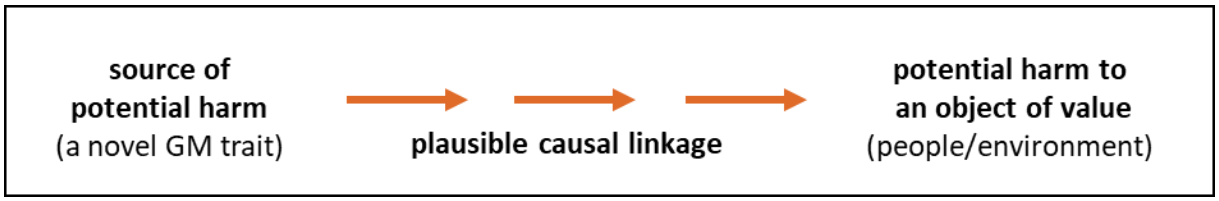

Figure 5 Components of a risk scenario

91. When postulating relevant risk scenarios, the risk context is taken into account, including the following factors detailed in Chapter 1:

- the proposed dealings,
- any proposed limits including the extent and scale of the proposed dealings,
- any proposed controls to limit the spread and persistence of the GMOs, and
- the characteristics of the parent organism(s).

2.1 Risk source

92. The sources of potential harms can be intended novel GM traits associated with one or more introduced genetic elements, or unintended effects/traits arising from the use of gene technology.

93. As discussed in Chapter 1, the GM chrysanthemum lines would contain the introduced genes *F3'5'H* derived from *C. medium* and *A3'5'GT* derived from *C. ternatea*. The intended effect of insertion of these genes is to modify the pigment profile in GM chrysanthemum flowers, leading to altered flower colour. These introduced genes are further considered as potential sources of risk.

94. The GM chrysanthemums would also contain the marker gene *nptII* from *E. coli* that confers antibiotic resistance and was used as a selectable marker gene. This gene and its product, when introduced into plants, have been extensively characterised and assessed as posing negligible risk to

human or animal health or to the environment by the Regulator, as well as by other regulatory agencies in Australia and overseas. Further information about this gene can be found in the document *Risk Assessment Reference: Marker Genes in GM Plants* on the Resources page on the OGTR website. As the gene has not been found to pose a substantive risk to either people or the environment, its potential effects will not be further considered for this application.

95. The introduced genes are controlled by introduced regulatory sequences. These are derived from the soil bacterium *Agrobacterium tumefaciens* and the plants chrysanthemum, *Arabidopsis thaliana* (thale cress) and *Nicotiana tabacum* (tobacco) (Table 2). Regulatory sequences are naturally present in all plants and the introduced sequences are expected to operate in similar ways to endogenous sequences. The regulatory sequences are DNA that is not expressed as a protein, so exposure is to the DNA only and dietary DNA has no toxicity (Delaney et al., 2018). Hence, potential for harm from the regulatory sequences will not be considered further.

96. The genetic modifications could cause unintended effects in several ways including altered expression of endogenous genes by random insertion of introduced DNA in the genome, increased metabolic burden due to expression of the introduced proteins, novel traits arising out of interactions with non-target proteins and secondary effects arising from altered substrate or product levels in biochemical pathways. However, these types of effects also occur spontaneously in plants generated by conventional breeding. Accepted conventional breeding techniques such as hybridisation, mutagenesis and somaclonal variation can have a much larger impact on the plant genome than genetic engineering (Schnell et al., 2015; Anderson et al., 2016). Plants generated by conventional breeding have a long history of safe use, and there are no documented cases where conventional breeding has resulted in the production of a novel toxin or allergen in a crop (Steiner et al., 2013). Therefore, unintended effects resulting from the process of genetic modification will not be considered further.

2.2 Causal pathway

97. The following factors are considered when postulating plausible causal pathways to potential harm:

- routes of exposure to the GMOs, the introduced gene(s) and gene product(s)
- potential exposure to the introduced gene(s) and gene product(s) from other sources in the environment
- the environment at the site(s) of release
- relevant floristry industry practices
- spread and persistence of the GM plants (e.g. reproductive characteristics, dispersal pathways and establishment potential)
- tolerance to abiotic conditions (e.g. climate, soil and rainfall patterns)
- tolerance to biotic stressors (e.g. pests, pathogens and weeds)
- tolerance to cultivation management practices
- gene transfer to sexually compatible organisms
- gene transfer by horizontal gene transfer
- unauthorised activities.

98. Although all of these factors are taken into account, some are not included in risk scenarios because they have been considered in previous RARMPs and are not expected to give rise to substantive risks.

99. The potential for horizontal gene transfer (HGT) and any possible adverse outcomes has been reviewed in the literature (Keese, 2008; Philips et al., 2022) and assessed in previous RARMPs. No risk greater than negligible was identified, due to the rarity of HGT events and because the gene

sequences (or sequences which are homologous to those in the current application) are already present in the environment and available for transfer via demonstrated natural mechanisms. Therefore, HGT will not be assessed further.

100. Previous RARMPs have considered the potential for unauthorised activities to lead to an adverse outcome. The Act provides for substantial penalties for non-compliance and unauthorised dealings with GMOs. The Act also requires the Regulator to have regard to the suitability of the applicant to hold a licence prior to the issuing of a licence. These legislative provisions are considered sufficient to minimise risks from unauthorised activities, and no risk greater than negligible was identified in previous RARMPs. Therefore, unauthorised activities will not be considered further.

2.3 Potential harm

101. Potential harms from GM plants are based on those used to assess risk from weeds (Standards Australia et al., 2006; Keese et al., 2014), including:

- harm to the health of people or desirable organisms, including toxicity/allergenicity
- reduced biodiversity for nature conservation
- reduced establishment or yield of desirable plants
- reduced products or services from the land use
- restricted movement of people, animals, vehicles, machinery and/or water
- reduced quality of the biotic environment (e.g. providing food or shelter for pests or pathogens) or abiotic environment (e.g. negative effects on fire regimes, nutrient levels, soil salinity, soil stability or soil water table).

102. Judgements of what is considered harm depend on the management objectives of the land where the GM plant may be present. For example, a plant species may have different weed risk potential in different land uses such as dryland cropping or nature conservation.

2.4 Postulated risk scenarios

103. Four risk scenarios were postulated and screened to identify substantive risk. These scenarios are summarised in Table 4 and discussed in depth in Sections 2.4.1 to 2.4.4. Postulation of risk scenarios considers impacts of the GM chrysanthemums on people undertaking the dealings, as well as impacts on people and the environment exposed to the GM chrysanthemums as the result of commercial use or spread and persistence of plant material.

104. In the context of the activities proposed by the applicant and considering both the short and long term, none of the four risk scenarios gave rise to any substantive risks.

Table 4 Summary of risk scenarios from the proposed dealings

Risk scenario	Risk source	Causal pathway	Potential harm	Substantive risk?	Reason
1	Introduced genes for altered flower colour	Import of GM chrysanthemums expressing the introduced genes for sale as cut flowers ⬇ Exposure of people and other organisms via skin contact, inhalation of pollen or ingestion	• Increased toxicity or allergenicity for people, or • Increased toxicity for other desirable organisms.	No	• Chrysanthemum pollen is not wind-borne • The GM chrysanthemums will not be used in commercial human food or animal feed • The introduced proteins and their pigment products are not expected to be toxic or allergenic

Risk scenario	Risk source	Causal pathway	Potential harm	Substantive risk?	Reason
2	Introduced genes for altered flower colour	Import of GM chrysanthemums for sale as cut flowers ⬇ Pollen from the GM chrysanthemums pollinates other chrysanthemums ⬇ Hybrid GM seeds are produced and grow into plants ⬇ Populations of GM chrysanthemums expressing the introduced genes establish in the environment	• Increased toxicity or allergenicity for people, or • Increased toxicity for other desirable organisms • Reduced establishment or yield of desirable plants, or • Increased reservoir for pests or pathogens	No	• Pollinators would have little access to pollen from the GM chrysanthemum cut flowers • GM chrysanthemums are highly unlikely to survive outside cultivation • The introduced proteins and their pigment products are not expected to be toxic or allergenic
3	Introduced genes for altered flower colour	Import of GM chrysanthemums for sale as cut flowers ⬇ Waste GM chrysanthemum stems are discarded on open ground ⬇ GM chrysanthemum stems root and grow into new plants ⬇ Populations of GM chrysanthemums expressing the introduced genes establish in the environment	• Increased toxicity or allergenicity for people, or • Increased toxicity for other desirable organisms • Reduced establishment or yield of desirable plants, or • Increased reservoir for pests or pathogens	No	• Imported chrysanthemum cut flowers must be devitalised • GM chrysanthemums are highly unlikely to survive outside cultivation • The introduced proteins and their pigment products are not expected to be toxic or allergenic
4	Introduced genes for altered flower colour	Import of GM chrysanthemums for sale as cut flowers ⬇ Purchasers deliberately propagate the GM chrysanthemums ⬇ GM chrysanthemums expressing the introduced genes are grown as pot plants or garden plants	• Increased toxicity or allergenicity for people, or • Increased toxicity for other desirable organisms, or • Increased reservoir for pests and pathogens	No	• Commercial chrysanthemum growers in Australia are not permitted to propagate imported cut flowers • Imported chrysanthemum cut flowers must be devitalised • The introduced proteins and their pigment products are not expected to be toxic or allergenic

2.4.1 Risk scenario 1

Risk source	Introduced genes for altered flower colour
Causal pathway	⬇ Import of GM chrysanthemums expressing the introduced genes for sale as cut flowers ⬇ Exposure of people and other organisms via skin contact, inhalation of pollen or ingestion ⬇
Potential harm	Increased toxicity or allergenicity for people OR Increased toxicity for other desirable organisms

Risk source

105. The source of potential harm for this postulated risk scenario is the two introduced genes for altered flower colour.

Causal pathway

106. The applicant proposes that cut GM chrysanthemum flowers would be imported, distributed to florists and supermarkets, and sold to the public across Australia. The introduced *F3'5'H* and *A3'5'GT* genes are both controlled by a petal-specific promoter (Chapter 1, Section 4.2.2) and would be expressed in the flowers of the GM chrysanthemums.

107. Many retailers and purchasers could have casual skin contact with the flowers of the GM chrysanthemums. Some people could have extensive skin contact with the GM chrysanthemum flowers, including florists or decorators who prepare flower bouquets, or people who make or wear traditional flower garlands. However, the introduced genes, the encoded enzymes and chrysanthemum pigments are all intracellular components (Li et al., 2021) that would only be released if flower cells were ruptured. In addition, the introduced genes, the encoded enzymes and the pigment products are all large molecules that would not be expected to pass through an intact skin barrier.

108. The GM chrysanthemum cut flowers may produce pollen, as at least two of the parent cultivars produce pollen (Chapter 1, Section 3.3). Chrysanthemums are not wind pollinated and chrysanthemum pollen grains do not readily disperse into air (see Chapter 1, Section 3.4). The genetic modifications to alter flower colour are not expected to increase the potential for pollen dispersal. The GM chrysanthemum lines all have double-type flowers, where male-fertile disc florets are usually covered by petals (Chapter 1, Section 3.3), which would further reduce the potential for pollen release into air. Nonetheless, people could inhale small quantities of pollen from the GM chrysanthemums, for example, if they brought their faces close to flowers to sniff the scent.

109. The applicant states that the GM chrysanthemums would not be used for commercial human food or animal feed. The GM chrysanthemums would be sold solely through the ornamental flower pathway. In any case, the Australian food and feed industries make minimal or no use of chrysanthemums. OGTR staff found that in a sample of five chrysanthemum tea brands available in Australia, all brands were imported, and in a sample of five Australian edible flower producers, no producer sold *Chrysanthemum* x *morifolium* flowers.

110. Individual purchasers of the GM chrysanthemums could use petals as a garnish for a food dish or dry the flowers to make chrysanthemum tea. It is inadvisable to use commercial cut flowers in food, as their pesticide residue levels are far higher than the maximum levels permitted in food products (Toumi et al., 2016), but some purchasers could be unaware of this risk.

111. If GM chrysanthemums are discarded in gardens or through another waste stream that is accessible to animals, domestic or wild animals could ingest the flowers. Soil organisms, such as earthworms, could ingest decomposing plant material.

Potential harm

112. Toxicity is the adverse effect of exposure to a substance (Klaassen and Watkins, 2010). The effect of a toxic agent depends on the dose, duration of exposure and exposure route. Responses may be either immediate or delayed. Allergic reactions are a type of adverse effect, resulting from sensitisation to a chemical, followed by an allergic response upon subsequent exposure (Klaassen and Watkins, 2010). Allergenicity is the potential for a chemical to be recognised by the body as a foreign substance and to elicit a (disproportionate) immunological reaction.

113. The potential harms considered for this risk scenario are the GM chrysanthemums having increased toxicity or allergenicity to people or increased toxicity to desirable organisms compared to non-GM chrysanthemums.

114. As discussed in Chapter 1, Section 4.2.4, the introduced *F3'5'H* and *A3'5'GT* genes were isolated from plants that are not known to be harmful. The applicant provided bioinformatic analyses showing that the introduced proteins are not homologous to known toxins or allergens. As discussed in Chapter 1, Section 4.2.5, the pigment products of the introduced genes are similar to pigments found in common fruits and vegetables, which have a history of safe use in food.

115. The *A3'5'GT* gene was isolated from butterfly pea (*C. ternatea*). Butterfly pea also contains a *F3'5'H* gene homologue (Togami et al., 2006). The major pigments in butterfly pea flowers are based on delphinidin 3,3',5'-triglucoside (Terahara et al., 1990), as are the major pigments in the GM chrysanthemums (Noda et al., 2017). Therefore, butterfly pea flowers contain homologues of all the elements involved in altered flower colour in the GM chrysanthemum lines.

116. Butterfly pea flowers are popular edible flowers in Asia (Lim, 2014b; Oguis et al., 2019). Dried butterfly pea flowers are also readily available in Australia as a herbal tea. Butterfly peas are widely used as a tropical legume pasture in northern Australia (Collins and Grundy, 2005). Therefore, butterfly pea flowers, which contain homologues of the introduced proteins and pigments in GM chrysanthemums, have a history of safe use in human food and animal feed.

117. Chrysanthemums naturally produce sesquiterpene lactones, which can cause contact dermatitis in people or mucosal and gastro-intestinal irritation if ingested by animals (Chapter 1, Section 3.5). The introduced *F3'5'H* and *A3'5'GT* genes encode enzymes that act on specific pigment or pigment precursor molecules (Chapter 1, Section 4.2.2), which are not related to sesquiterpene lactones. Therefore, the introduced genes are not expected to alter levels of sesquiterpene lactones in the GM chrysanthemums compared to non-GM chrysanthemums.

118. Based on the information above, there is no reasonable expectation that the GM chrysanthemums would be more toxic or allergenic than non-GM chrysanthemums.

Conclusion

119. Risk scenario 1 is not identified as a substantive risk because chrysanthemum pollen is not wind-borne, the GM chrysanthemums would not enter commercial human food or animal feed, and the introduced proteins and their pigment products are not expected to be toxic or allergenic. Therefore, this risk could not be greater than negligible and does not warrant further detailed assessment.

2.4.2 Risk scenario 2

Risk source	Introduced genes for altered flower colour
Causal pathway	⬇ Import of GM chrysanthemums for sale as cut flowers ⬇ Pollen from the GM chrysanthemums pollinates other chrysanthemums ⬇ Hybrid GM seeds are produced and grow into plants ⬇ Populations of GM chrysanthemums expressing the introduced genes establish in the environment ⬇
Potential harm	Increased toxicity or allergenicity for people OR Increased toxicity for other desirable organisms OR Reduced establishment or yield of desirable plants OR Increased reservoir for pests or pathogens

Risk source

120. The source of potential harm for this postulated risk scenario is the two introduced genes for altered flower colour.

Causal pathway

121. The applicant proposes that cut GM chrysanthemum flowers would be imported, distributed to florists and supermarkets, and sold to the public across Australia. The GM chrysanthemum cut flowers may produce viable pollen, as at least two of the parental cultivars produce viable pollen (Chapter 1, Section 3.3).

122. As discussed in Chapter 1, Section 3.4, chrysanthemums are insect pollinated. Chrysanthemums are not expected to naturally hybridise with any species present in Australia except other chrysanthemums (Chapter 1, Section 5.2.1).

123. The GM chrysanthemum lines all have double-type flowers, where male-fertile disc florets are usually covered by petals (Chapter 1, Section 3.3), which would impede insect pollinators from accessing pollen. In addition, most GM chrysanthemum cut flowers would be kept in an indoor environment, such as a shop or home, during their entire period of pollen production. This would further limit access by insect pollinators.

124. If an insect pollinator successfully collected pollen from a GM chrysanthemum flower, it would need to subsequently visit another chrysanthemum flower to effect pollination. It is plausible that a pollinator could visit a GM chrysanthemum cut flower and then another chrysanthemum cut flower (e.g. in the same bouquet). However, as chrysanthemum seeds take about eight weeks to mature (Boase et al., 1997), cut flowers are expected to be discarded and die before setting viable seed. It is possible that a pollinator could visit a GM chrysanthemum cut flower and then a flowering chrysanthemum pot plant or garden plant, and the pot or garden plant could set GM seed. It is implausible that a pollinator could visit a GM chrysanthemum cut flower and then a flowering commercial chrysanthemum crop, given that chrysanthemum crops are usually grown in enclosed greenhouses, and that they are typically harvested for sale before flowers fully open.

125. Even if hybrid GM seeds grew into chrysanthemum plants in a garden, it is highly unlikely that GM chrysanthemums could spread and establish populations in the wider environment. Although chrysanthemums have been grown in Australia for many decades, they are not reported to have spread outside cultivation (Chapter 1, Section 3.6). The altered flower colour trait of the GM

chrysanthemums would not be expected to increase their invasiveness. In fact, the GM chrysanthemum lines may be slightly less vigorous than their parental cultivars (Chapter 1, Section 4.3.2), so if the genetic modification had any effect on plant fitness, it would likely lead to a slightly reduced invasiveness potential compared to non-GM chrysanthemums.

Potential harm

126. Potential harms related to increased toxicity or allergenicity to people or increased toxicity to desirable organisms are considered in Risk Scenario 1.

127. Other potential harms considered in this risk scenario are that GM chrysanthemum populations could reduce establishment or yield of desirable plants or could provide an increased reservoir for pests or pathogens.

128. If GM chrysanthemum populations established in the environment, they could compete with desirable plants such as native plants in conservation areas or crop plants in agricultural areas. However, GM chrysanthemums are not expected to be very competitive. As described in Chapter 1, Section 4.3.3, the applicant conducted an experiment to test survival of GM chrysanthemum plants in an unmanaged environment. The GM chrysanthemums were initially allowed to establish on bare ground, but once weeds started to encroach on the plots and compete with the GM plants, more than 60% of the established GM chrysanthemum plants died over a four-month period.

129. Abiotic factors would also limit the persistence of GM chrysanthemum populations in the Australian environment. Chrysanthemums need frequent watering or rainfall (Chapter 1, Section 5.1), so could be killed by dry spells, which occur frequently in many areas of Australia. The GM chrysanthemums are derived from greenhouse cultivars, which are frost-sensitive (Chapter 1, Section 5.1), and would not survive winters in cold areas of Australia.

130. In addition, unwanted populations of GM chrysanthemum volunteers could be controlled by standard weed management practices for broad-leaf weeds. The introduced genes for altered flower colour are not expected to affect susceptibility to herbicides or physical weed management measures.

131. GM chrysanthemum populations in the environment could host pests or pathogens. It is noted that western flower thrips, which are a serious pest of chrysanthemums in Australia (Chapter 1, Section 5.2.2), are particularly attracted to the colour blue (Stukenberg et al., 2020). The blue flowers of GM chrysanthemums could become heavily infested with western flower thrips. However, the GM chrysanthemums would not provide objectively superior food or shelter to pests in comparison with non-GM chrysanthemums. Therefore, the GM chrysanthemums might cause redistribution of pests in the environment, but they are not expected to increase the overall reservoir of pests or pathogens.

Conclusion

132. Risk scenario 2 is not identified as a substantive risk because pollinators would have little access to pollen from the GM chrysanthemum cut flowers, GM chrysanthemums are highly unlikely to survive outside cultivation, and the introduced proteins and their pigment products are not expected to be toxic or allergenic. Therefore, this risk could not be greater than negligible and does not warrant further detailed assessment.

2.4.3 Risk scenario 3

Risk source	Introduced genes for altered flower colour
Causal pathway	⬇ Import of GM chrysanthemums for sale as cut flowers ⬇ Waste GM chrysanthemum stems are discarded on open ground ⬇ GM chrysanthemum stems root and grow into new plants ⬇ Populations of GM chrysanthemums expressing the introduced genes establish in the environment ⬇
Potential harm	Increased toxicity or allergenicity for people OR Increased toxicity for other desirable organisms OR Reduced establishment or yield of desirable plants OR Increased reservoir for pests or pathogens

Risk source

133. The source of potential harm for this postulated risk scenario is the two introduced genes for altered flower colour.

Causal pathway

134. The applicant proposes that cut GM chrysanthemum flowers would be imported, distributed to florists and supermarkets, and sold to the public across Australia. The applicant indicates that disposal of the GM chrysanthemums would not differ from standard industry practice.

135. Retailers and purchasers of the GM chrysanthemums would discard whole cut flowers that were damaged in transport or handling, short lengths of stem produced by recutting flowers for a vase or bouquet, and cut flowers that had reached or were nearing the end of their vase life. Some of this plant waste might be discarded on open ground, such as in a garden, with access to soil and sunlight.

136. As discussed in Chapter 1, Section 4.3.3, the applicant conducted an experiment to test survival of discarded GM plant material in an unmanaged environment. This found that about 12% of GM chrysanthemum cuttings (short lengths of stem with leaves) placed on bare ground in Colombia rooted and grew into new plants.

137. Propagation of GM chrysanthemum waste in Australia would be limited by the government biosecurity requirement for devitalisation of imported cut chrysanthemum flowers (Chapter 1, Section 4.3.3). Immersion of chrysanthemum stems in glyphosate solution at the correct concentration and following the correct procedure is expected to prevent the stems from propagating. It is possible that rare batches of GM chrysanthemums might retain some ability to propagate due to accidental failure to follow the correct devitalisation procedure. It is also possible that occasional individual GM chrysanthemum stems might retain some ability to propagate due to poor uptake of the glyphosate solution. For example, cutting height at harvest strongly affects the water uptake of cut chrysanthemum flowers, with stems cut at a lower height (closer to the root-shoot junction) absorbing less water (van Meeteren et al., 2005). The GM chrysanthemum stems might be cut at a slightly lower height than is usual for non-GM chrysanthemums, as the average flower stem length of the GM chrysanthemum lines is 6% shorter than the average flower stem length of their parental cultivars (Chapter 1, Section 4.3.2), and growers may cut the GM chrysanthemums closer to the root-shoot junction in order to retain commercially desirable long stem lengths.

138. Even if GM chrysanthemum waste grew into new plants in a garden or other suitable open area, it is highly unlikely that GM chrysanthemums could spread and establish populations in the wider environment. Although chrysanthemums have been grown in Australia for many decades, they are not reported to have spread outside cultivation (Chapter 1, Section 3.6). The altered flower colour trait of the GM chrysanthemums would not be expected to increase their invasiveness. In fact, the GM chrysanthemum lines may be slightly less vigorous than their parental cultivars (Chapter 1, Section 4.3.2), so may have slightly reduced invasiveness potential compared to non-GM chrysanthemums.

Potential harm

139. Potential harms related to increased toxicity or allergenicity to people or increased toxicity to desirable organisms are considered in Risk Scenario 1.

140. Potential harms related to reduced establishment or yield of desirable plants or an increased reservoir for pests or pathogens are considered in Risk Scenario 2.

Conclusion

141. Risk scenario 3 is not identified as a substantive risk because imported chrysanthemum cut flowers must be devitalised, GM chrysanthemums are highly unlikely to survive outside cultivation, and the introduced proteins and their pigment products are not expected to be toxic or allergenic. Therefore, this risk could not be greater than negligible and does not warrant further detailed assessment.

2.4.4 Risk scenario 4

Risk source	Introduced genes for altered flower colour
Causal pathway	⬇ Import of GM chrysanthemums for sale as cut flowers ⬇ Purchasers deliberately propagate the GM chrysanthemums ⬇ GM chrysanthemums expressing the introduced genes are grown as pot plants or garden plants ⬇
Potential harm	Increased toxicity or allergenicity for people OR Increased toxicity for other desirable organisms OR Increased reservoir for pests or pathogens

Risk source

142. The source of potential harm for this postulated risk scenario is the two introduced genes for altered flower colour.

Causal pathway

143. The applicant proposes that cut GM chrysanthemum flowers would be imported, distributed to florists and supermarkets, and sold to the public across Australia. Purchasers may find the GM chrysanthemum cut flowers attractive and want to grow them as plants.

144. Commercial chrysanthemum growers are not expected to propagate the GM chrysanthemums. The Department of Agriculture, Fisheries and Forestry discourages flower industry stakeholders from attempting to propagate imported cut flowers, as this creates a heightened biosecurity risk (Department of Agriculture Water and the Environment, 2021). Import of plant material intended for propagation requires a different authorisation pathway from import of cut flowers. In addition, the GM chrysanthemums have a very distinctive appearance, and a cursory internet search for blue chrysanthemums would discover that they are both GMOs and patented (Noda et al., 2020). These

factors should further reduce any interest of commercial chrysanthemum growers in propagating and growing the GM chrysanthemums.

145. Individual purchasers of the GM chrysanthemums could attempt to propagate and grow the GM chrysanthemums. The purchasers may not be aware that the GM chrysanthemums are imported or GMOs, and/or may not be aware that imported cut flowers or GMOs are subject to government regulation. The applicant is not proposing any labelling of the GM chrysanthemums. Even if the GM chrysanthemum cut flowers were labelled with a warning not to propagate them, purchasers may discard the packaging and care instructions for cut flowers unread.

146. The GM chrysanthemum cut flowers would be devitalised for import into Australia. As discussed in Risk Scenario 3, only a small proportion of GM chrysanthemum stems might retain some ability to propagate. The devitalisation treatment would frustrate almost all casual attempts to propagate the GM chrysanthemums.

147. However, if a skilled gardener made multiple attempts to propagate the GM chrysanthemums, they could eventually succeed. They could then grow a GM chrysanthemum as a pot plant or garden plant. The GM pot or garden plant could also serve as a parent plant for further propagation.

148. If GM chrysanthemums were grown in pots or gardens, the introduced genes would be expressed in their flowers, and people or animals could be exposed to the products of the introduced genes by pathways similar to those described in Risk Scenario 1.

Potential harm

149. Potential harms related to increased toxicity or allergenicity to people or increased toxicity to desirable organisms are considered in Risk Scenario 1.

150. Potential harm related to an increased reservoir for pests or pathogens is considered in Risk Scenario 2.

Conclusion

151. Risk scenario 4 is not identified as a substantive risk because commercial chrysanthemum growers in Australia are not permitted to propagate imported cut flowers, imported chrysanthemum cut flowers must be devitalised, and the introduced proteins and their pigment products are not expected to be toxic or allergenic. Therefore, this risk could not be greater than negligible and does not warrant further detailed assessment.

Section 3 Uncertainty

152. Uncertainty is an intrinsic property of risk and is present in all aspects of risk analysis. This is discussed in detail in the Regulator's *Risk Analysis Framework* (OGTR, 2013).

153. Uncertainty is addressed by approaches including balance of evidence, conservative assumptions, and applying risk management measures that reduce the potential for risk scenarios involving uncertainty to lead to harm. If there is residual uncertainty that is important to estimating the level of risk, the Regulator will take this uncertainty into account in making decisions.

154. Uncertainty can arise from data gaps. The applicant has not provided a full molecular and biochemical data package of the type that regulatory agencies would use to assess food and feed safety of the GM chrysanthemums. This is not a concern, as the GM chrysanthemums are not intended for use in food or feed.

155. Uncertainty can arise from changes over time. In Risk Scenarios 3 and 4, one of the reasons for the conclusion of negligible risks is that imported chrysanthemum cut flowers must be devitalised. If the Department of Agriculture, Fisheries and Forestry decided to cease requiring devitalisation of imported cut flowers, this could alter the level of risk for Risk Scenarios 3 and 4. If the Regulator issues

a licence for the current application, and subsequently the devitalisation requirement for import of cut chrysanthemum flowers is removed, this should trigger a post release review (Chapter 3, Section 5).

156. Post release review (PRR) will be also used to address uncertainty regarding future changes to knowledge about the GMOs or the receiving environment. PRR is typically required for commercial releases of GMOs, which generally do not have limited duration.

157. Overall, the level of uncertainty in this risk assessment is considered low and does not impact on the overall estimate of risk.

Section 4 Risk evaluation

158. Risk is evaluated against the objective of protecting the health and safety of people and the environment to determine the level of concern and, subsequently, the need for controls to mitigate or reduce risk. Risk evaluation may also aid consideration of whether the proposed dealings should be authorised, need further assessment, or require collection of additional information.

159. Factors used to determine which risks need treatment may include:

- risk criteria
- level of risk
- uncertainty associated with risk characterisation
- interactions between substantive risks.

160. Four risk scenarios were postulated whereby the proposed dealings might give rise to harm to people or the environment. The level of risk for each scenario was considered negligible, considering both the short and long term. The principal reasons for these conclusions are summarised in Table 4.

161. The *Risk Analysis Framework* (OGTR, 2013), which guides the risk assessment and risk management process, defines negligible risks as risks of no discernible concern with no present need to invoke actions for mitigation. Therefore, no controls are required to treat these negligible risks. The Regulator considers that the dealings involved in this proposed release do not pose a significant risk to either people or the environment[2].

[2] As none of the proposed dealings are considered to pose a significant risk to people or the environment, section 52(2)(d)(ii) of the Act mandates a minimum period of 30 days for consultation on the RARMP. However, the Regulator has allowed up to eight weeks for the receipt of submissions from prescribed experts, agencies and authorities and the public.

Chapter 3 Risk management plan

Section 1 Background

162. Risk management is used to protect the health and safety of people and to protect the environment by controlling or mitigating risk. The risk management plan addresses risks evaluated as requiring treatment and considers limits and controls proposed by the applicant, as well as general risk management measures. The risk management plan informs the Regulator's decision-making process and is given effect through proposed licence conditions.

163. Under section 56 of the Act, the Regulator must not issue a licence unless satisfied that any risks posed by the dealings proposed to be authorised by the licence are able to be managed in a way that protects the health and safety of people and the environment.

164. All licences are subject to three conditions prescribed in the Act. Section 63 of the Act requires that each licence holder inform relevant people of their obligations under the licence. The other statutory conditions allow the Regulator to maintain oversight of licensed dealings: section 64 requires the licence holder to provide access to premises to OGTR inspectors and section 65 requires the licence holder to report any information about risks or unintended effects of the dealing to the Regulator on becoming aware of them. Matters related to the ongoing suitability of the licence holder are also required to be reported to the Regulator.

165. The licence is also subject to any conditions imposed by the Regulator. Examples of the matters to which conditions may relate are listed in section 62 of the Act. Licence conditions can be imposed to limit and control the scope of the dealings and to manage risk to people or the environment. In addition, the Regulator has extensive powers to monitor compliance with licence conditions under section 152 of the Act.

Section 2 Risk treatment measures for substantive risks

166. The risk assessment of risk scenarios listed in Chapter 2 concluded that there are negligible risks to people and the environment from the proposed release of the GM chrysanthemum lines. These risk scenarios were considered in the context of the scale of the proposed release and the receiving environment. The risk evaluation concluded that no containment measures are required to treat these negligible risks.

Section 3 Dealings

167. The applicant proposes that the only dealings with the GM chrysanthemum cut flowers would be import, transport and disposal, along with the possession, supply or use of the GMOs in the course of any of these dealings.

168. However, the intended use of the GM chrysanthemums as ornamental cut flowers may involve other dealings that are regulated under the Act.

169. Chrysanthemum cut flowers are sometimes harvested as buds. The buds can be grown into mature flowers at the point of sale by placing the stems in a sugar solution in a lighted room for several days (Kofranek, 1992). Chrysanthemum cut flowers that are fertilised and allowed to senesce in water, in a method known as 'water culture', will produce viable seed (Anderson, 2007). The applicant found that GM cut chrysanthemum flowers kept in water sometimes grew adventitious roots (Chapter 1, Section 4.3.3), even after treatment with a low concentration of glyphosate. These examples show that chrysanthemum cut flowers are viable and continue to develop while being kept in a vase.

170. Retailers and purchasers of the GM chrysanthemum cut flowers are expected to deliberately place the GMOs in a suitable medium for them to survive and develop (vase water, with or without nutrient additives) and provide them with an energy source (light). Therefore, people using the cut flowers for their intended purpose as ornamental flowers could be considered to be conducting the dealing of culturing the GMOs for a short period of time.

171. For the reasons above, a draft licence condition permits the following dealings:

(a) import the GMOs as cut flowers;

(b) transport the GMOs;

(c) culture the GMOs as cut flowers;

(d) dispose of the GMOs;

and the possession, supply or use of the GMOs in the course of any of these dealings.

172. The applicant proposes that the GM chrysanthemums would not be used as commercial human food or animal feed, which limits exposure of people and animals to the GMOs (Risk Scenario 1). Therefore, for consistency with the context of the licence application, a draft licence condition states that plant material from the GM chrysanthemums must not be used as commercial human food or animal feed.

Section 4 General risk management

173. All DIR licences issued by the Regulator contain a number of conditions that relate to general risk management. These include conditions relating to:

- applicant suitability
- testing methodology
- identification of the persons or classes of persons covered by the licence
- reporting structures
- access for the purpose of monitoring for compliance.

4.1 Applicant suitability

174. In making a decision whether or not to issue a licence, the Regulator must have regard to the suitability of the applicant to hold a licence. Under section 58 of the Act, matters that the Regulator must take into account include:

- any relevant convictions of the applicant
- any revocation or suspension of a relevant licence or permit held by the applicant under a law of the Commonwealth, a State or a foreign country
- the capacity of the applicant to meet the conditions of the licence.

175. If a licence were issued, the conditions would include a requirement for the licence holder to inform the Regulator of any circumstances that would affect their suitability.

176. In addition, any applicant organisation must have access to a properly constituted Institutional Biosafety Committee and be an accredited organisation under the Act.

4.2 Testing methodology

177. If a licence were issued, International Flower Developments would be required to provide a method to the Regulator for the reliable detection of the GMOs, and the presence of the introduced genetic materials in a recipient organism. This instrument would be required prior to conducting any dealings with the GMOs.

4.3 Identification of the persons or classes of persons covered by the licence

178. If a licence were issued, any person, including the licence holder, could conduct any permitted dealing with the GMOs.

4.4 Reporting requirements

179. If issued, the licence would oblige the licence holder to report without delay any of the following to the Regulator:

- any additional information regarding risks to the health and safety of people or to the environment associated with the dealings
- any contraventions of the licence by persons covered by the licence
- any unintended effects of the release.

180. The licence holder would also be obliged to submit an Annual Report containing any information required by the licence.

181. There are also provisions that would enable the Regulator to obtain information from the licence holder relating to the progress of the commercial release (see Section 5, below).

4.5 Monitoring for compliance

182. The Act stipulates, as a condition of every licence, that a person who is authorised by the licence to deal with a GMO, and who is required to comply with a condition of the licence, must allow the Regulator, or a person authorised by the Regulator, to enter premises where a dealing is being undertaken for the purpose of monitoring or auditing the dealing.

183. In cases of non-compliance with licence conditions, the Regulator may instigate an investigation to determine the nature and extent of non-compliance. The Act provides for criminal sanctions of large fines and/or imprisonment for failing to abide by the legislation, conditions of the licence or directions from the Regulator, especially where significant damage to the health and safety of people or the environment could result.

Section 5 Post release review

184. Paragraph 10 of the Regulations requires the Regulator to consider the short and the long term when assessing risks. The Regulator takes account of the likelihood and impact of an adverse outcome over the foreseeable future, and does not disregard a risk on the basis that an adverse outcome might only occur in the longer term. However, as with any predictive process, accuracy is often greater in the shorter rather than longer term.

185. The Regulator engages in ongoing oversight of licences to take account of future findings or changes in circumstances. If a licence was issued, this ongoing oversight would be achieved through post release review (PRR) activities. The three components of PRR are:

- adverse effects reporting system (Section 5.1)
- requirement to collect additional specific information (Section 5.2)
- review of the RARMP (Section 5.3).

186. The outcomes of these PRR activities may result in no change to the licence or could result in the variation, cancellation or suspension of the licence.

5.1 Adverse effects reporting system

187. Any member of the public can report adverse experiences/effects resulting from an intentional release of a GMO to the OGTR through the Free-call number (1800 181 030), mail (MDP 54 – GPO Box 9848, Canberra ACT 2601) or via email to the OGTR inbox (ogtr@health.gov.au). Reports can be

made at any time on any DIR licence. Credible information would form the basis of further investigation and may be used to inform a review of a RARMP (see Section 4.3 below) as well as the RARMPs of future applications involving similar GMOs.

5.2 Requirement to collect additional specific information

188. Collection of additional specific information on an intentional release provides a mechanism for 'closing the loop' in the risk analysis process and for verifying findings of the RARMP.

189. This may involve monitoring specific indicators of harm that have been identified in the risk assessment. The term 'specific indicators of harm' does not mean that it is expected that harm would necessarily occur if a licence was issued. Instead, it refers to measurement endpoints which are expected to change should the authorised dealings result in harm. Should a licence be issued, the licence holder would be required to monitor these specific indicators of harm as mandated by the licence.

190. The triggers for this component of PRR may include risk estimates greater than negligible or significant uncertainty in the risk assessment.

191. The characterisation of the risk scenarios discussed in Chapter 2 did not identify any risks greater than negligible. Therefore, they were not considered substantive risks that warranted further detailed assessment. No specific indicators of harm have been identified in this RARMP for application DIR 191. However, specific indicators of harm may also be identified during later stages, e.g. following the consideration of comments received on the consultation version of the RARMP, or if a licence were issued, through either of the other components of PRR.

192. The discussion of uncertainty in Chapter 2, Section 3, found that if the Department of Agriculture, Fisheries and Forestry decided to cease requiring devitalisation of imported cut flowers, this could alter the level of risk for the proposed release. To address this uncertainty, a condition in the draft licence requires the licence holder to inform the Regulator without delay if the devitalisation requirement for import of cut chrysanthemum flowers is removed.

193. Conditions have also been included in the draft licence to allow the Regulator to request further information from the licence holder about any matter to do with the release, including research to verify predictions of the risk assessment.

5.3 Review of the RARMP

194. The third component of PRR is the review of RARMPs after a commercial/general release licence is issued. Such a review would take into account any relevant new information, including any changes in the context of the release, to determine if the findings of the RARMP remained current. The timing of the review would be determined on a case-by-case basis and may be triggered by findings from either of the other components of PRR, or by relevant new scientific information identified by the OGTR, or be undertaken after the authorised dealings have been conducted for some time. If the review findings justified either an increase or decrease in the initial risk estimate(s), or identified new risks to people or to the environment that require management, this could lead to changes to the risk management plan and licence conditions.

Section 6 Conclusions of the consultation RARMP

195. The risk assessment concludes that the proposed commercial release of the GM chrysanthemum lines poses negligible risks to the health and safety of people or the environment as a result of gene technology.

196. The risk management plan concludes that these negligible risks do not require specific risk treatment measures. However, if a licence were to be issued, general conditions are proposed to ensure that there is ongoing oversight of the release.

Chapter 4 Draft licence conditions

Section 1 Interpretations and Definitions

1. In this licence:

   (a) unless defined otherwise in this licence, words and phrases used in this licence have the same meaning as they do in the Act and the Gene Technology Regulations 2001;

   (b) words importing a gender include every other gender;

   (c) words in the singular number include the plural and words in the plural number include the singular;

   (d) expressions used to denote persons generally (such as “person”, “party”, “someone”, “anyone”, “no one”, “one”, “another” and “whoever”), include a body politic or corporate as well as an individual;

   (e) references to any statute or other legislation (whether primary or subordinate) are a reference to a statute or other legislation of the Commonwealth of Australia as amended or replaced from time to time and equivalent provisions, if any, in corresponding State law, unless the contrary intention appears;

   (f) where a word or phrase is given a particular meaning, other grammatical forms of that word or phrase have corresponding meanings;

   (g) specific conditions prevail over general conditions to the extent of any inconsistency.

2. In this licence:

‘**Act**’ means the *Gene Technology Act 2000* (Cth) or the corresponding State legislation under which this licence is issued.

‘**GM**’ means genetically modified.

‘**GMOs**’ means the genetically modified organisms that are the subject of the dealings authorised by this licence.

‘**OGTR**’ means the Office of the Gene Technology Regulator.

‘**Regulator**’ means the Gene Technology Regulator.

Section 2 Licence conditions and obligations

3. This licence does not authorise dealings with the GMOs that are otherwise prohibited as a result of the operation of State legislation recognising an area as designated for the purpose of preserving the identity of GM crops, non-GM crops, or both GM crops and non-GM crops, for marketing purposes.

4. This licence remains in force until it is suspended, cancelled or surrendered. No dealings with the GMOs are authorised during any period of suspension.

5. The licence holder is International Flower Developments Pty Ltd.

6. Any person, including the licence holder, may conduct any authorised dealing(s) with the GMOs.

7. The dealings authorised by the licence are to:

   (a) import the GMOs as cut flowers;

   (b) transport the GMOs;

   (c) culture the GMOs as cut flowers;

(d) dispose of the GMOs;

and the possession, supply or use of the GMOs in the course of any of these dealings.

Note: An example of culturing the GMOs is placing cut flower stems in a solution intended to extend flower longevity.

8. The licence holder must take reasonable steps to ensure that plant material from the GMOs is not used in commercial human food or animal feed.
9. The authorised dealings with the GMOs may be conducted in all areas of Australia.
10. This licence authorises dealings with the GMOs described in **Attachment A**.

2.1 General obligations of the licence holder

11. The licence holder must notify the Regulator as soon as practicable if any of its contact details change.

Note: please address correspondence to OGTR.M&C@health.gov.au.

Prior to issuing a licence, the Regulator considers suitability of the applicant to hold a licence. The following two conditions address ongoing suitability of the licence holder.

12. The licence holder must, at all times, remain an accredited organisation in accordance with the Act and must comply with its instrument of accreditation.
13. The licence holder must:
    (a) inform the Regulator as soon as practicable after any of these events occur:
        i. any relevant conviction of the licence holder; or
        ii. any revocation or suspension of a licence or permit held by the licence holder under a law of the Australian Government, a State or a foreign country, being a law relating to the health and safety of people or the environment; or
        iii. any event or circumstances that would affect the capacity of the licence holder to meet the conditions of the licence; and
    (b) provide any information related to the licence holder's ongoing suitability to hold a licence, if requested by the Regulator, within the timeframe stipulated by the Regulator.
14. The licence holder must inform any person covered by this licence, to whom a particular condition of the licence applies, of the following:
    (a) the particular condition (including any variations of it); and
    (b) the cancellation or suspension of the licence; and
    (c) the surrender of the licence.

2.2 Provision of new information to the Regulator

Licence conditions are based on the risk assessment and risk management plan developed in relation to the application using information available at the time of assessment. The following two conditions require that any new information that may affect the risk assessment is communicated to the Regulator.

15. The licence holder must inform the Regulator if the licence holder becomes aware of:
    (a) additional information as to any risks to the health and safety of people, or to the environment, associated with the dealings authorised by the licence; or
    (b) any contraventions of the licence by a person covered by the licence; or

(c) any unintended effects of the dealings authorised by the licence.

Note: The Act requires, for the purposes of the above condition, that:

(a) the licence holder will be taken to have become aware of additional information of a kind mentioned in condition 15 if he or she was reckless as to whether such information existed; and

(b) the licence holder will be taken to have become aware of contraventions, or unintended effects, of a kind mentioned in condition 15, if he or she was reckless as to whether such contraventions had occurred, or such unintended effects existed.

Note: Contraventions of the licence may occur through the action or inaction of a person.

16. The licence holder must inform the Regulator if the licence holder becomes aware that the Australian Government has ceased to require devitalisation of imported cut chrysanthemum flowers.

17. If the licence holder is required to inform the Regulator under conditions 15 or 16, the Regulator must be informed without delay.

Note: An example of informing without delay is contact made within a day of becoming aware of new information via the OGTR free call phone number 1800 181 030, which provides emergency numbers for incidents that occur out of business hours.

18. If at any time the Regulator requests the licence holder to collect and provide information about any matter to do with the progress of the dealings authorised by this licence, including but not confined to:

    (a) additional information as to any risks to the health and safety of people, or to the environment, associated with the dealings authorised by the licence, whether or not the licence holder has provided information to the Regulator under condition 15(a);

    (b) any contraventions of the licence by a person covered by the licence, whether or not the licence holder has provided information to the Regulator under condition 15(b);

    (c) any unintended effects of the dealings authorised by the licence, whether or not the licence holder has provided information to the Regulator under condition 15(c);

    (d) research, including by way of survey, to verify predictions of the risk assessment, or for any purpose related to risks to the health and safety of people, or to the environment;

    (e) scientific literature and reports in respect of the GMOs authorised by this licence, for a nominated period;

    (f) details of any refusals of applications for licences or permits (however described) to deal with the GMOs made pursuant to the regulatory laws of a foreign country;

and the request is reasonable, having regard to consistency with the Act and relevance to its purpose, then the licence holder must collect the information and provide it to the Regulator at a time and in the manner requested by the Regulator.

Note: The Regulator may invite the licence holder to make a submission on the reasonability of a request by the Regulator to collect and provide information relevant to the progress of the dealings with the GMOs.

2.3 Obligations of persons covered by the licence

19. Persons covered by this licence must not deal with the GMOs except as expressly permitted by this licence.

20. If a person is authorised by this licence to deal with the GMOs and a particular condition of this licence applies to the dealing by that person, the person must allow the Regulator, or a person authorised by the Regulator, to enter premises where the dealing is being undertaken, for the purposes of auditing or monitoring the dealing.

Section 3 Reporting and documentation

3.1 Annual Report

21. The licence holder must provide an annual report to the Regulator by the end of September each year covering the previous financial year. An annual report must include:

    (a) information about any adverse impacts, unintended effects, or new information relating to risks, to human health and safety or the environment caused by the GMOs or material from the GMOs;

    (b) information about the volumes of the GMOs imported and distributed annually in each State and Territory.

3.2 Testing methodology

22. At least 14 days prior to conducting any dealings with the GMOs, the licence holder must provide to the Regulator a written methodology to reliably detect the GMOs, or the presence of the genetic modifications described in this licence in a recipient organism. The detection method(s) must be capable of identifying, to the satisfaction of the Regulator, each genetic modification event described in this licence.

Note: please address correspondence to OGTR.M&C@health.gov.au.

ATTACHMENT A

DIR No: 191

Full Title: Commercial import and distribution of chrysanthemum genetically modified for altered flower colour

Organisation Details

Postal address: International Flower Developments Pty Ltd

802/454 Saint Kilda Road

Melbourne VIC 3004

Accreditation No: 211

GMO Description

GMOs covered by this licence

Five chrysanthemum lines genetically modified by the introduction of only the genes listed below, known by the OECD unique identifiers NS-201806-5, NS-202201-4, NS-203701-1, NS-208133-5, and NS-212801-2.

Parent Organism

Common Name: Chrysanthemum

Scientific Name: *Chrysanthemum* x *morifolium* Ramat.

Modified traits

Category: Altered flower colour

Selectable marker - antibiotic

Description: The GMOs contain two introduced genes conferring blue or violet flower colour and one introduced selectable marker gene (Table 1, below)

Purpose of the dealings with the GMO

The purpose of the dealings is commercial import and distribution of GM chrysanthemum cut flowers in all areas of Australia. The GM flowers are intended for ornamental use. The licence does not permit growing the GMOs in Australia or use of the GMOs in commercial human food or animal feed.

Table 1 Introduced genes in the GM chrysanthemum lines

Gene	Description	Source	Intended function
nptII	Neomycin phosphotransferase gene	*Escherichia coli*	Antibiotic resistance selectable marker
F3'5'H	Flavonoid 3',5'-hydroxylase gene	*Campanula medium*	Altered flower colour
A3'5'GT	UDP-glucose:anthocyanin 3',5'-O-glucosyltransferase gene	*Clitoria ternatea*	Altered flower colour

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Appendix A: Summary of submissions

The Regulator received several submissions from prescribed experts, agencies and authorities[3] on matters relevant to preparation of the RARMP. All issues raised in submissions relating to risks to the health and safety of people and the environment were considered. These issues, and where they are addressed in the consultation RARMP, are summarised below.

Submission	Summary of issues raised	Comment
1	Has no official policy on GM chrysanthemum but would like this to be undertaken in a way that is safe to both the public and the environment.	Noted.
2	Does not have any comments on this matter.	Noted.
3	Agrees that the following matters should be considered in the RARMP: • the potential for the GM chrysanthemum cut flowers to be harmful to people through toxicity or allergenicity • the potential for the GM chrysanthemum cut flowers to be harmful to other organisms through toxicity • the potential for harm to result from cross-pollination between the GM chrysanthemum and related species • the potential for harm to result from accidental or deliberate propagation and growth of the GM chrysanthemum. The Regulator should consider the effectiveness of the Department of Agriculture, Water and the Environment mandated glyphosate treatment.	The potential for the GM chrysanthemum cut flowers to have increased toxicity or allergenicity to people or increased toxicity to other desirable organisms is addressed in Chapter 2, Section 2.4.1 (Risk scenario 1). The potential for the GM chrysanthemum cut flowers to cross-pollinate with sexually compatible plants is addressed in Chapter 2, Section 2.4.2 (Risk scenario 2). The potential for unintended propagation and growth of GM chrysanthemum waste is addressed in Chapter 2, Section 2.4.3 (Risk scenario 3). The potential for deliberate propagation and growth of GM chrysanthemums is addressed in Chapter 2, Section 2.4.4 (Risk scenario 4). The effectiveness of the government mandated glyphosate treatment to devitalise imported cut chrysanthemum flowers is considered in Chapter 1, Section 4.3.3, and is further discussed in Chapter 2, Section 2.4.3 (Risk scenario 3).

[3] Prescribed experts, agencies and authorities include the Gene Technology Technical Advisory Committee, State and Territory Governments, relevant local governments, Australian government agencies and the Minister for the Environment.

Submission	Summary of issues raised	Comment
4	Interested to know if the GM chrysanthemum has any risk of becoming an environmental weed and posing a threat to native bushland areas. Will it have any viable seed or spread vegetatively if disposed of incorrectly (dumped in bushland)?	The potential for GM chrysanthemums to establish in the environment and compete with native plants is addressed in Chapter 2, Section 2.4.2 (Risk scenario 2). The GM chrysanthemums will be imported into Australia as cut flowers and will have been treated with glyphosate. Cut flowers are expected to be discarded and die before setting viable seed. The potential for GM chrysanthemum cut flowers to cross-pollinate other chrysanthemum plants and produce viable GM seed is discussed in Chapter 2, Section 2.4.2 (Risk scenario 2). The potential for GM chrysanthemum waste to propagate vegetatively and spread is addressed in Chapter 2, Section 2.4.3 (Risk scenario 3).
5	At this stage, do not have any concerns with the licence application and have no further input into the preparation of the RARMP.	Noted.
6	At this stage of the application process, does not have specific advice on risks to the health and safety of people and the environment to be considered in the development of the consultation RARMP. Notes that there will be an opportunity to comment on the draft RARMP and would welcome this opportunity.	Noted.

Submission	Summary of issues raised	Comment
7	• What are the reproduction/pollination prospects or capabilities of the cut flowers should they be imported? Will they be able to spread and grow wildly? • Is there a possibility for the GM chrysanthemums to become invasive if they are able to spread? • If they are imported, will this impact any surrounding certified organic farms with regard to possible cross pollination? If so how would this be mitigated?	The potential for the GM chrysanthemum cut flowers to cross-pollinate with sexually compatible plants is addressed in Chapter 2, Section 2.4.2 (Risk scenario 2). The potential for unintended propagation and growth of GM chrysanthemum waste is addressed in Chapter 2, Section 2.4.3 (Risk scenario 3). The potential for deliberate propagation and growth of GM chrysanthemums is addressed in Chapter 2, Section 2.4.4 (Risk scenario 4). The potential for GM chrysanthemums to spread in the environment or become invasive is addressed in Chapter 2, Section 2.4.2 (Risk scenario 2). As discussed in Chapter 2, Section 2.4.2, it is not plausible that GM chrysanthemum cut flowers could cross-pollinate commercial chrysanthemum crops. As discussed in Chapter 1, Section 5.2.1, chrysanthemums are not sexually compatible with any other crop grown in Australia. Therefore, the GM chrysanthemum cut flowers could not cross-pollinate any crops on organic farms.