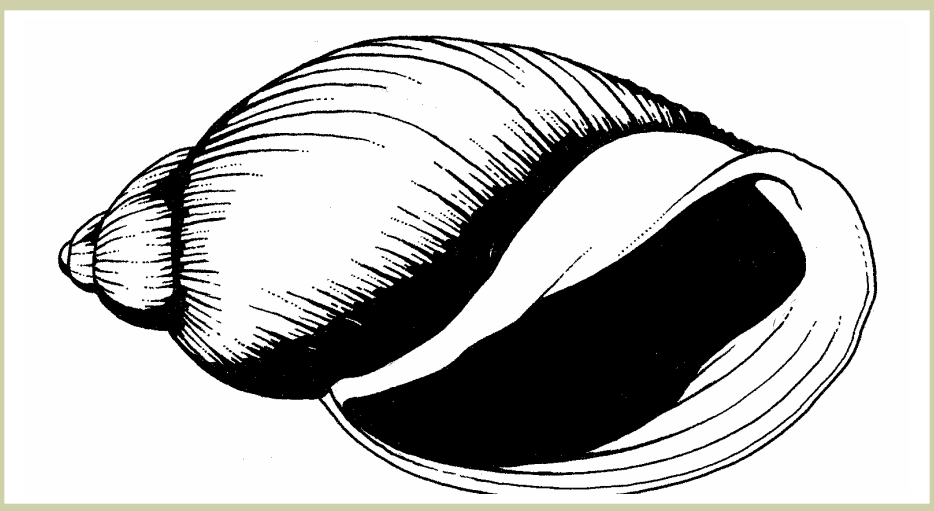
Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Hotwater Physa (*Physella wrighti*) in Canada

Hotwater Physa



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Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

About the Species at Risk Act Recovery Strategy Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003 and one of its purposes is *"to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."*

What is recovery?

In the context of species at risk conservation, **recovery** is the process by which the decline of an endangered, threatened or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered **recovered** when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37–46 of SARA (http://www.sararegistry.gc.ca/the_act/default_e.cfm) spell out both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

The series

This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the Species at Risk Act and recovery initiatives, please consult the SARA Public Registry (http://www.sararegistry.gc.ca/) and the web site of the Recovery Secretariat (http://www.speciesatrisk.gc.ca/recovery/default_e.cfm).

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DECLARATION

This Recovery Strategy for the Hotwater Physa in Canada has been prepared in cooperation with jurisdictions responsible for the species, as described in the Preface. Fisheries and Oceans Canada has reviewed and accepts this document as its Recovery Strategy for these species as required by the *Species at Risk Act*.

Success in the recovery of Hotwater Physa depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Fisheries and Oceans Canada or any other jurisdiction alone. In the spirit of the National Accord for the Protection of Species at Risk, the Minister of Fisheries and Oceans invites all Canadians to join Fisheries and Oceans Canada in supporting and implementing this strategy for the benefit of Hotwater Physa and Canadian society as a whole. Fisheries and Oceans Canada will support implementation of this strategy to the extent possible, given available resources and its overall responsibility for species at risk conservation. The Minister will report on progress within five years.

This strategy will be complemented by one or more Action Plans that will provide details on specific recovery measures to be taken to support conservation of this species. The Minister will take steps to ensure that, to the extent possible; Canadians interested in or affected by these measures will be consulted.

RESPONSIBLE JURISDICTIONS

The responsible jurisdiction for Hotwater Physa under the *Species at Risk Act* (SARA) is Fisheries and Oceans Canada. Hotwater Physa occur solely within the Liard Hotsprings Provincial Park under jurisdiction of the Province of British Columbia (BC). The Province of BC and Fisheries and Oceans Canada have cooperated in the development of this recovery strategy.

AUTHORS

The Province of BC and Fisheries and Oceans Canada have cooperated in the development of this recovery strategy.

ACKNOWLEDGMENTS

Scientific review and edit of the proposed recovery strategy was completed by Sue Salter. Subsequent revisions were the collaborative work of the BC Ministry of Environment (MOE) and Fisheries and Oceans Canada (DFO). Sue Salter has contributed data and

scientific expertise to this recovery strategy, and her independent research on this and other freshwater invertebrates is vital to these species' recovery in Canada. Additional review was completed by Sue Pollard, BC MOE, Brenda Costanzo BC MOE, Ted Down BC MOE, Ted Lea BC MOE, Carole Eros DFO, John Elliott BC MOE, Doug Biffard BC MOE, Mike Rowe BC MOE, Jim Boutillier DFO, Laurie Convey DFO and Jacquie Lee, independent malacologist.

STRATEGIC ENVIRONMENTAL ASSESSMENT

In accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*, the purpose of a Strategic Environmental Assessment (SEA) is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally-sound decision making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts on non-target species or habitats.

This Recovery Strategy will clearly benefit the environment by promoting the recovery of Hotwater Physa. The potential for the strategy to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this strategy will clearly benefit the environment and will not entail any significant adverse effects. Refer to the following sections of the document in particular: Needs of Hotwater Physa; Anticipated conflicts or challenges; Strategies to address threats and effect recovery; and Effects on other species.

RESIDENCE

SARA defines residence as: "*a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating*" [SARA S2(1)].

Residence descriptions, or the rationale for why the residence concept does not apply to a given species, are posted when available on the SARA public registry: http://www.sararegistry.gc.ca/plans/residence_e.cfm.

PREFACE

Hotwater Physa is a freshwater species under jurisdiction of the federal government under the *Species at Risk Act* (SARA). SARA (Section 37) requires the competent minister to prepare recovery strategies for listed extirpated, endangered or threatened species. The Hotwater Physa was listed as Endangered under SARA in June 2003. Fisheries and Oceans Canada – Pacific Region and the Province of British Columbia (BC) co-led the development of this recovery strategy. The proposed strategy meets SARA requirements (Sections 39-41) in terms of content and process.

EXECUTIVE SUMMARY

Hotwater Physa, *Physella wrighti*, is an aquatic snail known globally from one location at Liard River Hotsprings Provincial Park, a small hotsprings complex located in north-central British Columbia (BC). The snail was first collected in 1973 and scientifically described in 1985 (Te and Clarke 1985). Liard River Hotsprings Provincial Park is a unique system of thermal springs that provide consistently warm lotic and lentic habitat for several populations of locally endemic animals and plants. The warm shallow marsh and aquatic environments do not freeze and allow vegetation to thrive throughout the year.

Biologically, this species has likely persisted in the Liard River Hotsprings complex since the retreat of the glaciers (Remigio *et al*. 2001). However, the species has an isolated and localized occurrence and its distribution is limited to the Liard River hotsprings complex, which makes it vulnerable to the risk of extinction due to anthropogenic or catastrophic events.

The threats to Hotwater Physa are from potential changes to the hotsprings habitat resulting from recreational activities within the park. Future interest may arise outside the park for oil and gas exploration, or renew for hydroelectric development, in which case further assessment of the threat to the source of the geothermal water outside the park will be required.

The recovery goal for Hotwater Physa is to maintain and protect the population(s) of Hotwater Physa within its natural geographic range and within its current variation of abundance at Liard River Hotsprings. As such, recovery is considered biologically and technically feasible.

The short-term objectives on which the Hotwater Physa's recovery will be monitored over the next 5 years are 1) to observe that the species' current distribution within the Alpha and Beta pools and streams is maintained, and to refine the understanding of the current distribution to better quantify this objective by 2011; and 2) to observe that the species' current relative abundance is maintained, and to develop methodology that increases survey precision by 2011.

Given the endemism of Hotwater Physa to this unique and localized stretch of habitat and the continued known persistence of this species below the weir since its initial recording in 1973, critical habitat is expected to be largely located within the park boundaries. However, additional work must be completed to determine the factors that define critical habitat for this species.

In addition to a schedule of studies to identify critical habitat, the strategies that are recommended to address threats and effect recovery of Hotwater Physa are: population monitoring; protection through the Liard River Hotsprings Park Master Plan and minimizing impacts from recreational use within the park; threat monitoring; filling knowledge gaps to support recovery; and education to minimize impacts from

recreational users within the park. An action plan, which provides the specific details for recovery implementation, will be completed by 2011. Currently, a single-species approach to recovery has been adopted, however, an ecosystem-based approach may eventually be warranted to include the entire hotsprings area.

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1 BACKGROUND

Hotwater Physa, *Physella wrighti*, is a freshwater snail globally endemic to Liard River Hotsprings located in Liard River Hotsprings Provincial Park, BC (Figure 1). The snail was first collected in 1973 and taxonomically described in 1985 (Te and Clarke 1985). Over 80 hotsprings are known throughout BC, and there have been few recent surveys of the invertebrate fauna at these hotsprings (e.g. Lee and Ackerman 1998; Salter 2001 and 2003; Remigio et al. 2001; Wethington and Guralnick 2004).

Figure 1. Global location of Hotwater Physa (Salter 2003).

1.1 Species Assessment Information

The Status Report and Assessment Summary for Hotwater Physa is available from the Committee on the Status for Endangered Wildlife in Canada (COSEWIC) Secretariat (www.cosewic.gc.ca).

Common name: Hotwater Physa

Scientific name: *Physella wrighti*

COSEWIC Status: Endangered April 1998.

SARA Status: Endangered June 2003.

Last Examination and Change: May 2000. No change.

Canadian Occurrence: British Columbia (BC).

Reason for designation: Small endemic population with narrow ecological requirements occurring in an extremely restricted area subject to threats resulting from human use of hot springs pools. Probability of extinction is high.

Status history: Last assessment based on existing status report.

1.2 Description

Hotwater Physa, *Physella wrighti* (Te and Clarke 1985), is a freshwater snail classified in the gastropod family Physidae (generally referred to as physids) (Pulmonata: Physidae). Hotwater Physa has a very small blackish/grey shell ranging from 3.25 – 9.1 mm. The shell is sinistrally (i.e., opening to the left) coiled with an ear-shaped aperture, an outer lip callus along its rim, a curved perimeter and a narrow elongate-ovate shape (Figure 2) (Lee and Ackerman 1998).

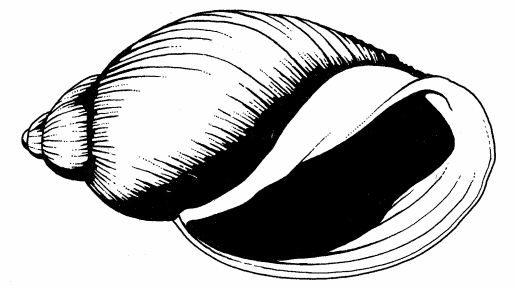

Figure 2a. Hotwater Physa, *Physella wrighti*.
Illustration by Trent Hoover, used with permission.

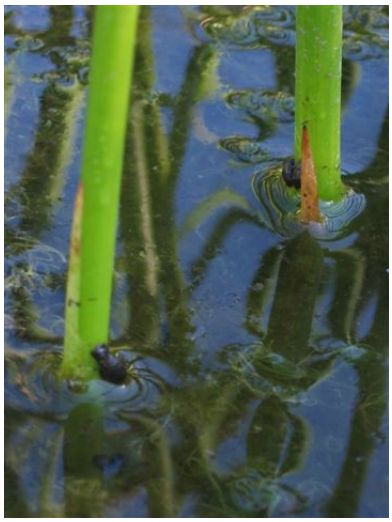

Figure 2b and c. Hotwater Physa on emergent vegetation.
Photos by Mike Rowe, used with permission.

The Hotwater Physa is currently acknowledged by the American Fisheries Society as a unique species. Te and Clarke (1985) used morphological, anatomical, cladistic and phenetic analyses to describe the species and concluded that "*P. wrighti* is certainly a primitive species not closely related to any other species in northwestern North American and it is virtually impossible that it could have evolved as such a distinct species since the end of the Pleistocene", and suggested that Hotwater Physa may have been at its type locality for 100,000 years.

Molecular systematic relationships have been completed between *P. wrighti* and *Physella johnsoni,* an endemic snail to Banff Hotsprings, Alberta. *P. johnsoni* is listed as Endangered by COSEWIC. The relationship between both *P. wrighti* and *P. johnsoni* has been examined to determine the origins of these two species and their inter-specific relationships. Remigio *et al*.'s (2001) molecular data supports continued recognition of Hotwater Physa as an endemic species but suggests the species probably arose from a population isolated during the most recent glacial retreat. Further, both species are endemic to their respective locations and that *P. wrighti* was likely the source ancestral population from which *P. johnsoni* was derived (Remigio *et al.* 2001).

More recently, molecular evidence has been used to assess species age and relationships and this has yielded contradictory results. Wethington (2002) found fault with Remigio *et al*.'s (2001) study design, and concluded from molecular data of physid hotspring endemics that there is not a monophyletic hot spring physid group and that members of the closely related *Physa gyrina* species group includes the putative Hotwater Physa. This group can invade or survive introduction to hot water environments and can develop distinctive shells in as few as five generations (Wethington and Guralnick 2004) and so are not distinct species but habituated populations. Taylor (2003) also regards Hotwater Physa to be a synonym of *P. gyrina*. An authoritative decision will probably not be available until the American Fisheries Society updates the mollusc species list that currently includes Hotwater Physa as a distinct species (Turgeon *et al*. 1998).

Physids are very common throughout North America and are very difficult to identify, it is possible that other species may occur within Liard River Hotsprings Provincial Park. Additional *Physella* species endemic to hotsprings complexes in BC and western Canada have yet to be fully studied. A snail of the family Physidae is present in Deer River hotspring, which is approximately 50 km from Liard River Hotsprings Provincial Park. Initial examinations by biologists determined this snail to be *Physella virginia*, but a genetic comparison of its relationship to *P.wrighti* has not been completed.

1.3 Populations and distribution

The Hotwater Physa is known globally from one location at Liard River Hotsprings complex in the Liard River Hotsprings Provincial Park, BC. The snail was initially reported from one breeding population along a 34 metre stretch of Alpha Stream, at the outlet of Alpha Pool (Figure 3) (Lee and Ackerman 1998). This outlet is also the type locality for the species (Te and Clarke 1985; Lee and Ackerman 1998).

The snail has since been observed to occupy additional habitats within the hotsprings complex, including Alpha and Beta Pools and the entire length of Alpha Stream (Figure 3) (Salter 2001, 2003). The area with the highest recorded density is downstream from the weir that impounds water flowing from Alpha Pool, specifically in a section from two metres below the weir at the head of the stream to 34 metres downstream (Salter, 2003). In 1997, the highest

concentrations of snails were observed approximately 20 metres downstream from the weir (Lee and Ackerman 1998). Alpha Pool and Beta Pool have distinct sources and the two outflows do not connect. In previous surveys (Lee and Ackerman 1998) there was no observation of snails in Beta Pool. The recent population expansion in to Beta Pool may be due to previous populations being overlooked or to recent passive dispersal by park users or wildlife.

Researchers believe the distribution of the Hotwater Physa within Liard River Hotsprings complex varies spatially and temporally and the species likely occupies additional areas within the hotsprings complex (Salter, pers. comm.). It is unlikely that new occurrences found within the Liard River Hotsprings complex are another species, although there is a remote possibility that specimens of *P. gyrina* are indirectly or unknowingly brought into Liard River Hotsprings Provincial Park through wildlife or transfer by people. *P. wrighti* from *P. gyrina* can not be distinguished by the human eye. Currently, the only visual means of distinguishing these two species is through dissections by a trained individual.

The population trend has not been measured or tracked for Hotwater Physa. Some population estimates of Hotwater Physa in upper Alpha Stream have been calculated. On October 1, 1997, the conservative population estimate within Alpha Stream was 979 – 1735 individuals (Lee and Ackerman 1998). In August 2000 and January 2001 the population in Alpha Stream was estimated at 5185-7000 individuals (Salter 2001, 2003). There has been no evidence of a decline in the population (Salter, pers. comm.). It is possible the snails congregate based on a combination of temperature, abiotic factors and biological cycles. As population estimates and species range both have increased over time, this population appears to be stable or expanding. However, it is premature to calculate population estimates based on one or two-day sampling efforts taken years apart.

The distribution of the Hotwater Physa within the Liard River hotsprings complex has not been thoroughly studied. Salter (2003) noted larger numbers of snails in the cooler perimeter of Alpha Pool, Alpha Stream and Beta Pool. The temperature in Alpha Pool and Beta Pool has been recorded daily by data loggers since July 2004 (Rowe, pers. comm.). Alpha Pool was artificially created through the installation of a dam and a weir. The dam backs up water directly from the hotwater vent (source) and creates a pool < 1.5 metre depth at a temperature varying between 40° - 44.5° Celsius, with temperatures > 45° Celsius at the source in July 2004 (Rowe, pers. comm.). A weir installed approximately 5 metres below the dam also captures the flow of a small cool water creek reducing the water temperature in this secondary pool to 38° Celsius in July 2004. This mixed source water tumbles over the weir to form Alpha Stream. This mixing of two water sources has affected the temperature distribution at the micro-habitat level in the area immediately downstream of the weir, but it is not certain how this may have influenced Hotwater Physa distribution.

It is not known if snails congregate based on food sources alone, or more likely a combination of temperature, abiotic factors and biological cycles. The cyclical nature of Hotwater Physa populations is unstudied. Researchers believe this population has remained stable since its first recording in 1973 (Lee, pers. comm., Salter pers. comm.), although this statement is an educated guess and some of the threats (Section 1.5) have since increased.

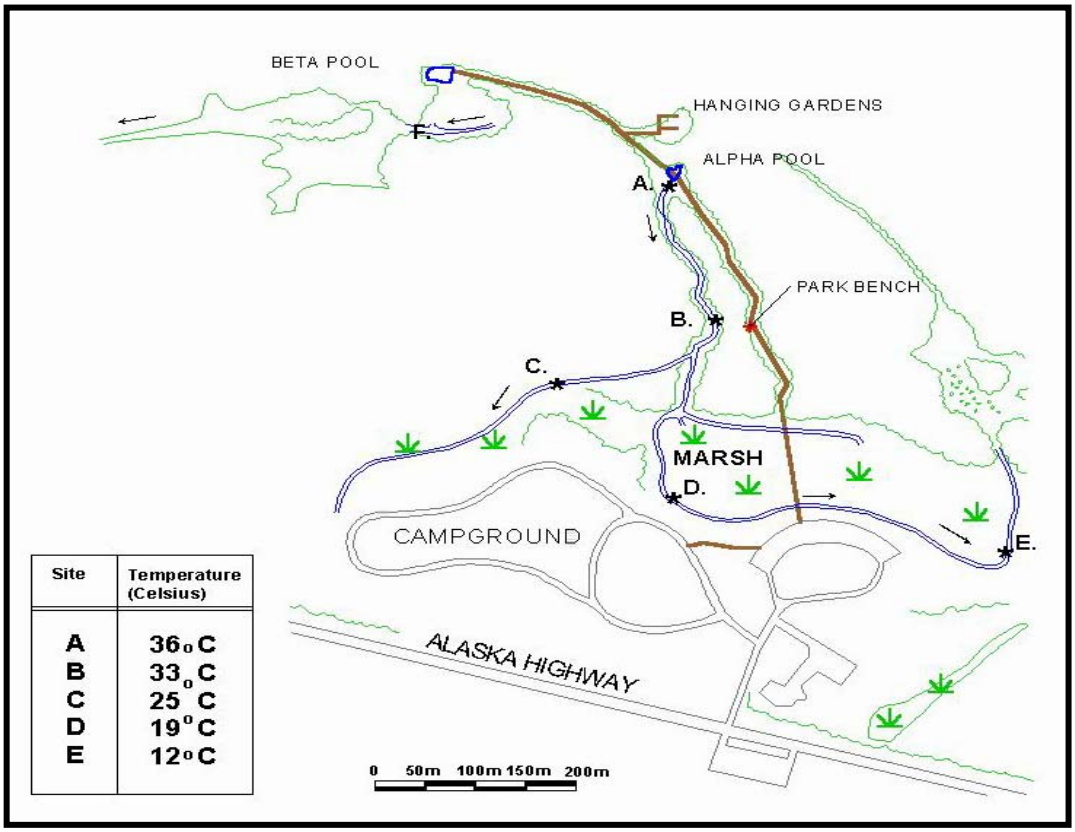

Figure 3. Liard River Hotsprings Provincial Park showing the sites within the hotsprings complex where Hotwater Physa is found (A, B & F) and where search efforts were made but no snails were found (C – E)(Salter 2003).

1.4 Needs of Hotwater Physa

1.4.1 Biological needs

Physids are generally considered to be detritivores and/or bacterial feeders (Brown 1991) and the habitat in which Hotwater Physa is found suggest that this is true for this species. There have been no in-depth species-specific studies conducted on Hotwater Physa, although *P. wrighti* kept in captivity lived and reproduced on a diet of mixed brewer's yeast and fish food (Lee and Ackerman 1998).

The snails in Liard River Hotsprings Provincial Park are found most densely on *Chara vulgaris. C. vulgaris* (or *Chara*) is an algae which grows at the shallow edges of hotwater springs on rocks, submerged branches, introduced garbage

and other submerged materials in the aquatic habitat (Salter pers. comm.) including rotting paper birch (*Betula papyrifera*) leaves (Lee and Ackerman 1998). This green algae (Class Charophyceae (Stoneworts)) and the outer cell layers are impregnated with calcium carbonate (Scagel *et al.* 1965) giving the plant a very crisp texture. *Chara* grows floating near the surface and forms dense mats attached at various intervals along the streamsides. When the spring water (high in calcium) cools, the calcium precipitates out onto the surface of the *Chara* and results in significant calcification of the plant, particularly those plants floating along the edges of the stream. Calcification of these plants and other surfaces eventually forms tufa, which is a crumbly and porous 'rock'. The snails are probably not feeding directly on any of these substrates but are grazing on the aufwuch, which is the organic material that comes to encrust submerged substrates.

There is no known information regarding species-specific reproduction of Hotwater Physa. The Physid family, in general, replace generations annually, thus an individual snail will likely live approximately one year. These snails are oviparous hermaphrodites that breed once; the young overwinter, mature into adults, lay eggs in the spring, and die after eggs are laid. However, these observations are from temperate areas and it is likely that physids living at constant warm temperature may lay eggs continuously until senescence. Reproduction of *P. wrighti* has only been observed in captive specimens. In a heated aquarium with water from the hotspring, *P. wrighti* laid "clear crescent-shaped gelatinous egg masses containing 6 to 18 eggs laid above the water line in a temperature of approximately 25° Celsius with hatching after nine days (Lee and Ackerman 1998).

Physids are pulmonate snails, which use a richly vascularized pulmonary cavity in the mantle to extract oxygen from air or water. Some physids rely on aerial respiration and are somewhat amphibious (Brown *et al*. 1998) whereas others fill the pulmonary cavity with water and use it as a derived gill (Russel-Hunter 1978). The relative reliance of the Hotwater Physa on aerial or dissolved oxygen is unknown but the snails are usually found on substrates near a water/air interface (Figure 2a & B) as these substrates offer secure anchoring surfaces, allow grazing on organic material, and allow access to the air/water interface for oxygen acquisition.

1.4.2 Biologically limiting factors

1. *Small and spatially isolated population:* Globally, the Hotwater Physa is endemic only to the Liard River Hotsprings complex. At least until the taxonomic uncertainty is clarified, the Hotwater Physa is a unique species and as such there is no possibility of a rescue effect from outside of this hotsprings complex. The population densities at sites within the Liard River Hotsprings complex vary, and the connectivity between these sites is limited.
2. *Small occupied area of population:* Concentrated subpopulations of the snail within the Liard River Hotsprings complex occupy small areas on

substrates at the edges of Alpha Pool, Alpha Stream and Beta Pool. Dispersal and occupancy of sites are likely due to temperature and substrate availability at depths where these pulmonate snails can access air and food.

3. *Habitat specificity:* Hotwater Physa is associated with hotwater springs; which may also be in demand from development and human use. This species is restricted to its type locality, which makes it particularly susceptible to habitat disturbance. Changes to temperature and flow regime would undoubtedly affect reproductive success.
4. *Interspecific competition:* Competition between Hotwater Physa and lymaeid and planorbid snails in other parts of the thermal spring ecosystem could be a limiting factor. However, the habitats of the physid and lymnaeid snails are distinct in cooler water habitats and appear not to overlap (Salter, 2003).
5. *Quality and quantity of food supply:* Food supply is likely to be a limiting factor on a given population. Direct and indirect effects on food sources may be limiting to Hotwater Physa, including changes to riparian vegetation and habitat adjacent to the streamside.

1.4.3 Habitat needs

The specific habitat needs of Hotwater Physa and the dependent relationship the snails have on their hotsprings habitat has not been studied. However, there are conclusions that can be drawn from knowledge of physids in general, and observations of Hotwater Physa *in situ*. The continued health of both the riparian and instream habitats are undoubtedly of vital importance to the survival of this species.

Aquatic Habitat

Aquatic habitat factors thought to affect the habitat needs of Hotwater Physa are listed below.

1. *Water temperature*: The geothermally heated water emerges from Alpha Pool at approximately 38^{o} Celsius year round. The water will naturally cool as it flows away from the emergence point and is further cooled by purposeful mixing within the pool. The water temperature undoubtedly influences many aspects of the life history of Hotwater Physa.
2. *Water flow:* At the site of the highest concentration of Hotwater Physa, in Alpha Stream, water enters over the weir at a rate of 80 – 81 litres/second (annual average)(Peepre 1990). While the initial observations of the Hotwater Physa's restriction to Alpha Stream could have been correlated to habitat requirements found only in the flowing water, subsequent observation of the snails within the pools negates this relationship.
3. *Mineral composition and the content of dissolved substances in the water:* The mineral composition of the water affects the amount of tufa formation and the surface area upon which bacterial and algal growth occurs.

4. *Chara, coarse woody debris and other substrates in the stream:* Hotwater Physa has been observed grazing on *Chara*, coarse woody debris and various other substrates. These substrates provide the surface area for the growth of algae and bacteria upon which the snail feeds, as well as an anchor in the water current of Alpha Stream. The abundance and distribution of these objects within the hotsprings habitat is likely important to the species.
5. *Stream dynamics:* The width, length and the depth of water throughout the hotsprings is variable, and it is not known if the snails will inhabit areas according to the stream dimensions. The stream will likely not become ice-covered, although the greatest temperature variation will occur in the winter months and will largely be in the pools and eddies. Research on the factors that influence the distribution of the Hotwater Physa within the hotsprings complex are included under the schedule of studies (Section 1.6.1).
6. *Oxygen Requirements:* The respiratory requirements of Hotwater Physa were previously described. Distribution throughout the hotsprings is probably influenced by the availability of suitable substrates at suitable depth for oxygen acquisition.

Riparian Habitat

The habitat needs of the snail are both terrestrial and aquatic, and the quality of riparian habitat is as much a component to the health of the ecosystem as the water quality itself. Riparian habitat factors thought to affect the habitat needs of Hotwater Physa are categorized below.

1. *Streambank stability:* Streambank stability and changes to this stability can affect Hotwater Physa habitat. Snails are known to congregate on *Chara*, which float in eddies as well as attach to the water bank edges. Soil compaction, disturbance and the removal of vegetation increases soil surface erosion into the hotsprings. In the first 60 metre section of Alpha Stream below the weir, there is a well defined, calcified channel with little sedimentation. However in the next 140 metres, the stream widens and slows due to an accumulation of sediment (presumably from Alpha Pool). This change may contribute to the habitat unsuitability for Hotwater Physa further downstream.
2. *Riparian vegetation and shade:* The dependence of Hotwater Physa on allochthonous inputs, such as leaves, is unknown, but the snails have been observed grazing on the aufwuch on paper birch leaves within Alpha Stream (Lee & Ackerman 1998). The riparian vegetation also affects the amount of light reaching stream edges, which may influence the density and distribution of Chara, which appears to be a preferred substrate for Hotwater Physa.

3. *Ambient air temperatures:* Outside air temperature will have an influence on the aquatic environment, although the effect on the temperature of the hotsprings is unknown.

1.5 Threats

Most threats to Hotwater Physa are a result of potential changes to the hotsprings habitat as a result of human activities, whether from recreational activities occurring within the park or the potential for industrial activities that could affect the source water entering the hotsprings complex. The threat from human activities is of particular concern given the biological factors that limit the species (Section 1.4.2).

1. *Change to the flow regime as a result of human activities*:
   - *Weir maintenance.* The natural flow of water from Alpha Stream to Alpha Pool has been changed due to the installation of the dam and weir prior to knowledge of the endemic snail. The mixed hot and cool water now exits through a narrow spillway in the top of the weir into the habitat colonized by Hotwater Physa. Failure of the dam or the weir could result in a large surge of water flowing down the stream, and this flash flooding could physically move snails into unsuitable habitat and significantly alter existing Hotwater Physa habitat. Alternately, a decrease in the flow of water during dam or weir maintenance activities could expose snails to drying and also result in altered water temperature in the area below the weir as the hot and the cold water sources would not be pre-mixed. Routine maintenance and repair of the dam and weir are conducted to maintain the integrity of Alpha Pool and Stream, and maintains Hotwater Physa habitat.
   - *Recreational activities.* Blockages, erosion or alterations to the weir or pool banks from recreational users may alter the flow of the stream. While these destructive activities are prohibited, park visitors have, for example, been known to block the outflow to the lower Alpha Pool. Temperature loggers in Alpha Stream during the September 2005 Labour Day weekend showed that water levels fell below the height of the temperature logger (Rowe, pers. comm.).
   - *Drilling activities for oil and gas exploration.* Although there is currently no specific application, drilling *activities* for oil and gas exploration could potentially affect the geothermally heated water from its source outside of the park boundaries to where it surfaces within the park. In the event an interest arises in oil and gas exploration in this area, a more detailed risk assessment will be required to determine specific high risk areas and to develop mitigation strategies.
   - *Hydroelectric development.* There were historic hydroelectric evaluations in the Liard River in the early 1990's and at least one site was identified outside the park boundaries on the Liard River. This proposal, titled Devil's Gorge Project, would flood the Liard Hotsprings

and most of the adjacent campground as it would raise the water elevation to greater than 420m. This flooding would also allow aquatic species to access the hotsprings marsh that is located on a bench above the Liard River and currently are not connected through waterways (Hill, pers. comm.). In the event there is a renewed interest in this or other projects in future, further assessment of the risk to Hotwater Physa and their habitat will be required.

2. *Introduction of deleterious substances*: It is estimated that Liard River Hotsprings Provincial Park currently receives over 40,000 bathers to the springs each year (Rowe, pers. comm.). While bathers are asked to shower before entering the hotsprings and are prohibited from using soaps and shampoos while bathing, the introduction of insect repellents sunblock, shampoos, soaps, and bath oils is still possible. Water contamination likely has cumulative and possibly detrimental effects directly to the snails or their habitat.
3. *Physical habitat destruction or alteration*: The boardwalks and trail structure established within the park discourages people from creating new trails to the stream edges. However, trampling and/or direct disturbance of the riparian areas and/or the *Chara* floating plant mats is possible from people walking within the aquatic habitats and downstream of Alpha Pool or Beta Pool, or from the stream edges through the riparian areas. Natural events, such as windthrow resulting in falling trees and changes to the riparian or channel structure, could also result in changes to the aquatic habitat that could be detrimental.
4. *Introduced species*: The introduction of exotic plants or animals into the hotsprings could pose a threat to Hotwater Physa. In the past two years, there have been two known introductions of turtles into the hotsprings (Hansen, pers. comm.; Elliott, pers. comm.), although these animals were found and removed. Evidence from other hotsprings shows a high potential for devastating ecological effects from the introduction of exotic species with a tolerance for warm water. For example, the introduction of a mosquito fish (*Gambusia affinis*) into Banff Hotsprings for mosquito control resulted in the extinction of a subspecies of the Banff longnose dace (*Rhinichthys cataractae* smithi) in 1987 (Environment Canada 2006).
5. *Collecting*: Periodic inventory studies that involve work within the hotsprings complex require both a fish collection permit under the *Wildlife Act* (BC) and a Park Use Permit under the *Parks Act* (BC) as well as a permit under the *Species at Risk Act* (Canada) all of which ensure collections are conducted to standards that minimize harm. Illegal collection by park visitors has the potential to impact the Hotwater Physa population, although currently it is not likely a significant factor.

1.6 Critical Habitat

Hotwater Physa were initially reported from a 34 metre stretch of Alpha Stream at the outlet of Alpha Pool (Lee and Ackerman 1998). This is also the type locality for the species (Te and Clarke 1985). Hotwater Physa are maintained by the specific conditions in this section of the stream, including the amount of tufa formation and *Chara* growth, and the surface area upon which bacterial and algal growth occurs (food). The geothermally heated water emerging from Alpha Pool does not vary significantly in temperature, emerging at approximately 38^{o}C year round, and water enters Alpha Stream from Alpha Pool through a man-made weir at a rate of 80 – 81 litres/second (Peepre 1990). Given the endemism of Hotwater Physa to this unique and very localized stretch of habitat and the continued known persistence of the species below the weir since its initial recording in 1973, the critical habitat is expected to be largely located within the park boundaries.

Additional work must be completed to identify if additional Hotwater Physa habitat may be present within or outside of the park boundaries. A schedule of studies to identify critical habitat is outlined below (Section 1.6.1). These activities are not exhaustive and may lead to the discovery of further knowledge gaps that will need to be addressed. Until Critical Habitat can be defined, the areas listed in the currently occupied habitat (Section 1.3) are considered the most important areas in need of conservation.

1.6.1 Schedule of studies to identify critical habitat

Further information is required before locations within the hotsprings complex may be considered critical habitat for Hotwater Physa. The following schedule of studies (Table 1) lists the activities recommended over the next 5 years to identify critical habitat.

Table 1. Schedule of studies recommended to identify critical habitat for Hotwater Physa.

Description of Activity	Outcome/Rationale	Timeline
Develop assessment methodology	• Standard survey protocol specifically to determine population abundance. Methodology needs to be repeatable and with minimal disturbance to the snails and habitat.	2006 – 2007
	• Surveys within the hotsprings aquatic habitat, to document habitat use patterns, abundance and population structure.	2006 – 2011
Distribution surveys	• Determine if there are additional viable populations/subpopulations of snails.	2006 – 2011
	• Delineate parameters of habitat use and relate to population fluctuations. These factors will help define the components of the aquatic habitat that are critical to	2006 – 2011

Description of Activity	Outcome/Rationale	Timeline
Identify critical habitat elements	the snail. • Define the abiotic (including water temperature and flow, and tufa formation) and biotic (including *Chara* and aufwich occurrence) factors and compare to snail distribution as determined from surveys. • Determine the influence that stream dimensions, dynamics, pools and eddies and coarse woody debris and other substrates may have on the distribution of the snail • Identify elements considered to be critical to the snail's survival.	2007 – 2011

1.7 Actions already completed or underway

1.7.1 Protection

Hotwater Physa and their occupied habitat are contained within the Liard River Hotsprings Provincial Park, although the source of the geothermally heated water extends outside the park boundaries. Under the *Park Act* (BC) the disturbance or destruction of habitat within parks is prohibited except for the development of recreational services. Hotwater Physa has been incorporated into management activities in the Liard River Hotsprings Park Master Plan, although it has been a number of years since the plan has been updated (Elliott, pers. comm.). Since the last update, there have been a series of improvements in monitoring of recreational activities, including having parks staff present at the main publicly used sites, as well as considerable signage to park users. Bathers must shower (to clean off potentially deleterious substances such as sunblock and insect repellent) before entering the hotsprings, and park users must stay on marked trails and boardwalks and not block the weirs, alter stream flow, damage park facilities or riparian vegetation. There is currently little signage specific to the snails, however, as there is concern that signs may inadvertently encourage recreational users to search for the snail and take specimens from the park.

The *Fisheries Act* (Canada) prohibits works which may result in harmful alteration, disruption or destruction of fish habitat (Section 35) and prohibits the release of deleterious substances, such as contaminants, into fish-bearing waters (Section 36). The *Fisheries Act* applies to all fish habitat, therefore, it will provide protection of the source water from development inside and outside the park.

Hotwater Physa are protected under SARA from killing, harming, harassing, capturing or taking and from the destruction of their critical habitat once identified. Exceptions may be made under SARA to permit activities that benefit the species or are required to enhance its chances of survival in the wild. Such activities would include dam and weir maintenance that is required to maintain the integrity

of Alpha Pool and Alpha Stream. SARA (Section 73) requires that such activities do not jeopardize survival or recovery of the species and are conducted in a manner that minimizes harm.

1.7.2 Population Monitoring

Revised Status Report on the Hotwater Physa in Canada is in preparation by Jacquie Lee, independent malacologist, for COSEWIC. Fieldwork is occurring in summer 2006.

1.8 Knowledge Gaps

Threats

- The effects of changes to the aquatic and riparian habitats on Hotwater Physa.
- Changes to water quality – it is unknown to what level the introduction of substances by bathers, including shampoos, soaps, sunblock, bath oils, and urine, and natural elements of the water, including mineral content, pH, temperature shifts, sediment disturbances, organic debris and changes to streamside structure alter the water quality and how this may affect Hotwater Physa.
- The source of the geothermally heated water has been identified as being outside the park and the route that it takes before emerging within the park is unknown. Drilling into the source water at any point may markedly affect the flow of hot water within the Park. Mitigating the risks from drilling activities will require additional assessment and the development of new standards and guidelines.
- Effects of introduced species.

Critical habitat

- Spatial and temporal distribution of the snail within the hotsprings complex and the ability of the snail to disperse between areas. Subpopulations of the snail within the Liard River Hotsprings complex occupy small areas and are known to congregate spatially and temporally at certain sites (Alpha Pool, Alpha Stream and Beta Pool). It is unknown what factors limit the dispersal and occupancy of sites, in-between sites, or elsewhere within the hotsprings complex.
- Habitat specificity, abiotic and biotic needs.

1.9 Importance to people

The Hotwater Physa is endemic to Liard River Hotsprings and, like so many endemic species, it therefore holds distinctive adaptations of special scientific and conservation interest (Scudder 1989). The species is not known to have any commercial value.

First Nations

There is no evidence of its use by First Nations or other people of BC. However, both the Fort Nelson First Nation and the Kaska Nation include Liard River Hotsprings within their traditional territories. The Kaska Nation is represented by five member bands located in northern BC. The Fort Nelson First Nation is part of the Treaty 8 Tribal Association.

Recreational users of Liard River Hotsprings

It is estimated that Liard River Hotsprings Provincial Park receives over 40,000 bathers to the hotsprings each year (Rowe, pers. comm.) and is a popular stop-over for visitors traveling the Alaska highway.

1.9.1 Anticipated conflicts or challenges

In the short-term, priority recovery activities will involve inventory and continued protection within the park, and there are few anticipated conflicts with these activities. Protection of habitat at known sites and management of this hotsprings habitat will likely require minimal changes to current practices however conflicts with recreational use of these areas is possible. Identifying the underground route of the geothermally heated water from source to the hotsprings represents a significant challenge. Mitigative measures to ensure that oil and gas or geothermal exploration do not impact on the hot water source has the potential for conflict. A potential long-term challenge will be to garner public support and research interest in this group of animals as there are currently few active researchers for these snails.

2 RECOVERY

Biologically, the species has likely persisted in this hotsprings complex since the retreat of the glaciers approximately 8,000 years before present and may have persisted throughout glacial events (Section 1.2). The species has continued to perpetuate itself within this ecosystem since its initial recording in 1973. However, a small and spatially isolated population, small occupied area of population, and habitat specificity make the species vulnerable to stochastic events.

2.1 Recovery Goal

The recovery goal for Hotwater Physa is to maintain and protect the population(s) of Hotwater Physa within its natural geographic range and within its current variation of abundance at the Liard River Hotsprings complex.

There is no current or historic evidence of a population decline, and therefore the recovery goal is to maintain the current population. Since the species has presumably been located at Liard River Hotsprings since the last glacial event, the species presumably is able to maintain its current population provided the threats to the species are minimized.

2.2 Rationale for Recovery Feasibility

The recovery of Hotwater Physa is considered feasible. The following criteria (summarized in Table 2) were used to make this assessment.

Table 2. Recovery criteria used to assess technical and biological feasibility of recovery for Hotwater Physa.

Recovery Criteria	Hotwater Physa
1. Are individuals capable of reproduction currently available to improve the population growth rate or population abundance?	Yes. See discussion below.
2. Is sufficient habitat available to support the species or could it be made available through habitat management or restoration?	Yes. See discussion below.
3. Can significant threats to the species or its habitat be avoided or mitigated through recovery actions?	Yes. See discussion below.
4. Do the necessary recovery techniques exist and are they known to be effective?	Yes. See discussion below.

1. Are individuals capable of reproduction currently available to improve the population growth rate or population abundance?

The population(s) within the park appears to be self-replacing, as the species is stable or increasing (Section 1.3), and it is not necessary to supplement these populations at this time.

2. Is sufficient habitat available to support the species or could it be made available through habitat management or restoration?

The snail is surviving and appears to be stable in its current habitat. This habitat is largely intact, at least since the dam development at Alpha Pool prior to 1973. It is not clear if any modifications or habitat restoration associated with the dam or weir would provide a net benefit to the Hotwater Physa as the current known habitat relies on the integrity of these man-made structures. Further development within the hotsprings complex is not planned, and efforts to protect the fragile ecosystem, hotsprings marsh and aquatic habitat are ongoing. Examples to avoid habitat destruction could include elevated boardwalks connecting the hotsprings habitats, limited access to hotsprings waters, and no expansion of the camping facilities within the park.

3. Can significant threats to the species or its habitat be avoided or mitigated through recovery actions?

The feasibility of mitigating the major threats to the snail is highly possible. The species is protected under current legislation and changes to management activities are possible, although some strategies may be socially controversial as this is one of the most popular destinations in northern BC.

4. Do the necessary recovery techniques exist and are they known to be effective?

The recovery techniques that exist are likely to be effective. Techniques used to recover this species are similar to the recovery planning applied to

species with similar threats, issues and requirements, both from ecological and social perspectives. There are no highly experimental recovery techniques proposed. Currently, captive breeding to supplement wild populations and locations is not thought necessary for the recovery of Hotwater Physa, although captive bred populations could be used to gain knowledge regarding this species life history and reproductive capabilities if required.

2.3 Recovery Objectives

The current understanding of abundance of Hotwater Physa and distribution within the Liard River Hotsprings is limited and quantification of population abundance and/or distribution objectives is not possible at this time. The population estimates that have been calculated (COSEWIC 2000) are not sufficient on which to set measurable objectives at this time due to the uncertainty around repeatability of sampling methodology. Further studies and the development of a standard sampling protocol will allow population estimates to be better determined (Section 2.4).

The short term objectives that will be used to monitor recovery of the Hotwater Physa over the next 5 years are:

1. to observe that the species current distribution within the Alpha and Beta pools and streams is maintained, and to refine the understanding of the current distribution to better quantify this objective by 2011; and
2. to observe that the species current relative abundance is maintained, and to develop methodology that increases survey precision by 2011.

2.4 Strategies to address threats and effect recovery

The Hotwater Physa and its habitat is contained and protected within the Liard River Hotsprings Provincial Park and also protected under SARA. However, there is a need to make sure that the population remains stable (or increasing) and does not decline as a result of the identified, or new, threats. The broad strategies taken to address threats to Hotwater Physa and effect recovery are:

1. *Monitoring* - develop standardized population and habitat assessment protocols to monitor the population.
2. *Protection* - review the Liard River Hotsprings Park Master Plan and consider additional options to protect habitat within the park, develop habitat restoration plans, if required, and develop guidelines to protect the geothermally heated water from its source to where it surfaces within the Park.
3. *Threats monitoring* - monitor the threats to Hotwater Physa.
4. *Knowledge gaps* - determine through genetic studies whether there are other populations of *P. wrighti* outside Liard hotsprings that may provide a possible rescue effect. Provide support to the identification of new threats in the event there is decline in the population from unknown cause(s).

5. *Park education* - minimize impacts to the Hotwater Physa and their habitat from recreational users within the park.

Table 3 lists the types of recovery activities to be considered in the development of the action plan (Section 2.7).

Table 3. Summary of the broad approach/strategy, specific activities and outcomes or deliverables to be considered for the recovery of Hotwater Physa.

Broad Strategy	Recovery Objective Number	Threat	Priority	Specific Activities	Outcomes or Deliverables
1. Monitoring	1, 2	All	High	• Establish a standardized protocol for population monitoring, habitat occupancy and distribution surveys. Protocol should include habitat where the snail is not known to occur • Map the distribution and population information throughout the hotsprings complex	• Allows park staff to make informed decisions about where to limit accessibility to hotsprings (e.g. strategic placement of boardwalks, fences and interpretive signs), and thus prevent the public from destroying the hotsprings aquatic and riparian habitat where snail densities are highest. Identify high priority sites requiring further protection. • Assessment and monitoring of population status and recovery. • Mapped population densities and information about habitat specificity (critical habitat).
2. Protection	1, 2	All	Medium	• Update the Liard River Hotsprings Provincial Park Master Plan and include provisions for the construction of boardwalks, as necessary • Develop a quick response plan for retrieving snails in the event of a natural catastrophic event • Record and assess the impact of physical changes to the habitat by humans (physical destruction of habitat, trampling, etc) • Apply to obtain a water license for conservation purposes on the hotsprings output	• Documentation of mortality of snails, *Chara* and destruction of tufa as a direct result of humans (e.g. trampling). • Documented observations regarding the effects of natural barriers, changes in channel structure, riparian vegetation, etc., and how it affects flow regime. • Park staff and those concerned with changes to the weir can make informed decisions regarding changes to the in-stream structures. • Protection of the source water system. • Protection of critical habitat within the park.

Broad Strategy	Recovery Objective Number	Threat	Priority	Specific Activities	Outcomes or Deliverables
				• In the event an interest in oil and gas or geothermal exploration arises, develop and implement guidelines to mitigate the potential impacts to geothermal sources. • Develop a weir maintenance protocol for park staff • Evaluate necessity and means to restrict public access to critical habitat	
3. Threats Monitoring	1, 2	1, 2, 3, 4	Medium	• Evaluate the effectiveness of measures used to prevent deleterious substances entering the hotsprings water (e.g., water sampling or monitoring of park users' habits) • In the event the levels of deleterious substances are found to be a concern, evaluate the effect on the snail • Monitor the introduction of natural sedimentation and changes to riparian structure into the hotsprings complex • Document introduction of invasive species and if invasive species are introduced develop an invasive species management strategy • In the event there is an interest in	• Documentation of infractions to the deleterious substance policy for park users. • Documentation of the effects of bathers on the habitat, and how infrastructure can be improved to mitigate destruction caused by direct human causes. • Information for establishing an invasive species management strategy for the park. • Control of introduced vegetation and plants within the park. • Document the rate of colonization, expansion or occupancy of introduced species and the likely effects on the snails.

Broad Strategy	Recovery Objective Number	Threat	Priority	Specific Activities	Outcomes or Deliverables
				development (e.g oil and gas exploration or hydroelectric), define the risks to the source water from the industrial activity outside of the park boundaries	
4. Knowledge Gaps	1, 2	All	Low-Medium	• Undertake genetic studies to confirm that *P. wrighti* is a distinct species • In the event population surveys determine that there is a decline in the population, and the cause can not be identified, develop a research plan to identify the cause	• In the event *P. wrighti* is not a distinct species, this may establish the existence of a pool of individuals for re-establishment of the Liard hotspring population given a transient catastrophic event. • Clarification of the threats to the species and the severity when these threats are combined with the biologically limiting factors. • Information on biologically limiting factors.
5. Park Education	1, 2	All	Medium	• Develop a communications strategy, as necessary, to minimize impact from recreational users	• Strategically placed signage for park users. • Information and signage to public users regarding the intentional/ unintentional introduction of species into hotsprings complex. • Accurate information to bathers. • Support to the park Master Plan.

2.5 Effects on other species

Recovery activities that will protect Hotwater Physa may also protect additional invertebrate and plant species at risk within the park. The only BC location for *Ischnura damula* (Order Odonata) commonly known as the plains forktail damselfly is found at Liard River Hotsprings. The mayfly *Caenis youngi*, known to occur in the Yukon, Northwest Territories and Alaska was found within the Liard river hotsprings complex within the park (Salter 2003). The Hotwater Physa is known to be globally rare (G1 rating) and is ranked critically imperilled because of extreme rarity (S1 rating) in BC.

The lake chub fish, *Couesius plumbeus,* at Liard River Hotsprings Provincial Park have received special attention. Although not a distinct species, the chub at Liard are physically isolated, adapted to their thermally enhanced environment and have been examined by COSEWIC and designated as data deficient (COSEWIC 2004). Hotwater Physa and Lake Chub habitat overlap in many areas of the hotsprings complex.

The plants found at Liard River Hotsprings Provincial Park include the provincially blue-listed *Carex heleonastes* (Hudson Bay sedge), *Carex tenera* (tender sedge), *Malaxis brachypoda* (white adder's-mouth orchid) and *Lupinis kuschei* (Yukon lupine). There is also *Sanicula marilandica* (snake root), *Urtica dioca* ssp*. lyallii* (stinging nettle) and *Mimulus guttatus* (monkeyflower), which are only present at this latitude because of the thermal hotsprings environment.

2.6 Evaluation

The goals, objectives and strategies that are outlined herein will be reviewed within five years of the Recovery Strategy's acceptance by the Minister. The following performance measures will be used to assess the effectiveness of the objectives and strategies, and to determine whether recovery remains feasible. Detailed performance measures will be identified more fully during the development of the action plan.

Objective-based evaluation criteria that will be used to measure whether the species' status is heading towards meeting the recovery goal are:

- Was Hotwater Physa's current distribution within the Alpha and Beta pools complexes and outlet streams maintained through 2011? Is there a better understanding towards quantifying this objective by 2011?
- Was Hotwater Physa's current relative abundance maintained through 2011? Was a methodology developed to increase survey precision by 2011?

Strategy-based evaluation criteria that will be used to evaluate progress towards meeting the recovery goal are:

- Was population monitoring carried out? Was a standardized protocol for population monitoring and habitat assessment developed?
- Was the Liard River Hotsprings Park Master Plan reviewed? Were additional options to protect habitat within the park considered?

- Has the understanding of threats to Hotwater Physa been improved? How?
- Were any genetic studies undertaken and, if so, did the distinct species status of Hotwater Physa change? In what way? Does this knowledge assist the recovery plans for Hotwater Physa? Was there a decline in the population that requires new research studies to be identified? What studies are needed or were carried out?
- Did awareness of the Hotwater Physa and their habitat improve protection?

2.7 Statement on Action Plans

An action plan provides the specific details for recovery implementation, including measures to monitor and implement recovery, address threats and achieve recovery objectives, and when these measures are to take place. The action plan also includes an identification of critical habitat(s), to the extent possible, and examples of activities that are likely to result in its destruction. It also recommends measures to protect critical habitat(s) and identifies any portions of critical habitat(s) that have not been protected. An evaluation of the socio-economic costs of the action plan and benefits to be derived from its implementation is also included. An action plan will be completed by 2011.

2.8 Recommended Approach for Recovery Implementation

Currently, a single-species approach has been adopted. However, an ecosystem-based approach may be necessary to protect the entire hotsprings area. The Liard River Hotsprings ecosystem has unique flora and fauna at a regional and national level and there is the possibility that additional species in this ecosystem type will be designated at risk by COSEWIC. Where species occupy similar habitat and face similar threats, the activities required for their recovery will be common. The integration of research activities will ensure more efficient use of effort.

Hotwater Physa is currently integrated into the Liard River Hotsprings Provincial Park Master Plan. Provisions for this species' protection and management are outlined in the plan, with the ability to adapt management objectives according to new information.

3 References Cited

Websites:

British Columbia Ministry of Sustainable Resource Development Resource Inventory Standards Committee http://srmwww.gov.bc.ca/risc/o_docs/aquatic/029/029tran-23.htm

Canadian Wildlife Service Species At Risk website http://www.speciesatrisk.gc.ca/search/speciesDetails_e.cfm?SpeciesID=548

Committee on the Status of Endangered Wildlife in Canada www.cosewic.gc.ca

Environment Canada accessed March 2006. Banff longnose dace. http://www.speciesatrisk.gc.ca/search/speciesDetails_e.cfm?SpeciesID=71

Natureserve accessed March 2006 http://www.natureserve.org/explorer/servlet/NatureServe?loadTemplate=tabular_report.wmtandpaging=homeandsave=allandsourceTemplate=reviewMiddle.wmt

Scientific Publications:

Brown, K.M., J.E. Alexander and J.H. Thorp. 1998. Differences in the ecology and distribution of lotic pulmonate and prosobranch gastropods. American Malacological Bulletin 14(2): 91 - 101.

Lee, Jacqueline S. and J.D. Ackerman. 1998. Status of Hotwater Physa, *Physella wrighti* (Te and Clarke, 1985). Report accepted by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 1998.

Lee, J.S. 2001. Freshwater Molluscs of British Columbia Assessments for All Recorded or Potential Taxa. A report prepared for the BC Conservation Data Centre Resource Inventory Branch, Wildlife Inventory Section. 109pp.

Porsild, A.E. and H.A. Crum. 1959. The vascular flora of Liard River Hotsprings, BC, with notes on some bryophytes. National Museum of Canada, Bulletin No. 171.

Peepre. J.S., P. Jordan and J. Nathan. 1990. Liard Hotsprings Provincial Park Master Plan. Ministry of Parks, British Columbia.

Remigio, E., D. Lepitzki, J. Lee and P. Hebert. 2001. Molecular systematic relationships and evidence for a recent origin of the thermal spring endemic snails *Physella johnsoni* and *Physella wrighti* (Pulmonata: Physidae). Canadian Journal of Zoology 79: 941 – 1950.

Russell-Hunter, W.D. 1978. Ecology of freshwater pulmonates. Pages 336 - 383 in Pulmonates. Volume 2A: Systematics, Evolution and Ecology. V. Fretter and J. Peake (eds). Academic Press, London.

Salter, S. 2001. Management of Hot Water Physa (*Physella wrighti*) in Liard River Hot Springs with Observations on the Deer River and Grayling River Hotsprings. Prepared for British Columbia Parks, Peace-Liard District, Ministry of the Environment, Lands and Parks. Fort St. John, B.C.

Salter, S. 2003. Invertebrates of selected thermal springs of British Columbia. Project report submitted to the Habitat Conservation Trust Fund, British Columbia. 88pp.

Scudder, G.G.E. 1989. The adaptive significance of marginal populations: A general perspective. Can. Spec. Publ. Fish. Aquat. Sci. 105:180–185Taylor, D.W. 2003. Introduction to Physidae (Gastropoda: Hygrophila); biogeography, classification, morphology. Revista de Biología Tropical Volume 51, Supplemental 1:1-287.

Te, G.A., and A.H. Clarke. 1985. *Physella (Physella) wrighti* (Gastropoda: Physidae), a new species of tadpole snail from Liard River Hotsprings, British Columbia. Canadian Field Naturalist 99: 295 – 299.

Turgeon, D.D., J.F. Quinn, A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P.M. Mikkelson, R.J. Neeves, C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F.G. Thompson, M. Vecchione, and J.D> Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: molluscs. 2nd edition. Special publication 26. American Fisheries Society, Bethesda, Maryland.

Wethington, A.R. 2002. Conservation issues concerning the endangered Physa (Physella) johnsoni, the Banff Springs Snail. Abstracts - American Malacological Society, Charleston 2002

Wethington, A. and R. P. Guralnick. 2004. Are populations of physids from different hot-springs distinctive lineages? American Malacological Bulletin 19(1/2):135-144.

Personal Communication

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4 Glossary of terms

Term	Definition
Allochthonous	• Substances originating outside the immediate habitat.
Blue list (blue-listed)	• Species not immediately threatened, but of concern because of characteristics that make them particularly sensitive to human activities or natural events.
Chara	• *Chara vulgaris*. Floating leaf-like plant that is actually an algae. Often called muskgrass or skunkweed due to the strong odour the algae exudes. *Chara* is often confused with submerged plants, and usually does not extend above the water surface. The plant is an overall grey-green with whorled branches.
COSEWIC	• Committee on the Status of Endangered Wildlife in Canada (www.COSEWIC.gc.ca).
critical habitat	• The habitat necessary for the survival and recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species.
DFO	• Fisheries and Oceans Canada.
ecological	• Of, or having to do with, the environments of living things or with the pattern of relations between living things and their environments; of or relating to the interdependence of organisms.
ecosystem	• An ecological community considered together with the nonliving factors of its environment considered as a unit.
endangered	• Facing imminent extirpation or extinction.
extirpated	• No longer existing in the wild in Canada, but occurring elsewhere.
G1	• Critically imperilled, at very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors (Natureserve 2006).
hermaphrodites	• Species containing both sexual organs.
in situ	• In its original place.
lentic	• Standing water environments.
lotic	• Moving water environments.
oviparous	• Animal reproduction whereby the eggs are laid by the female and develop outside the body.
precautionary approach	• Recognizing that the reduction or loss of the species should not be postponed for lack of full scientific certainty.
recovery	• The process by which the decline of an endangered, threatened or extirpated species is stopped or reversed, and threats reduced to improve the likelihood of the species' persistence in the wild.
S1	• Critically imperilled in the nation or state/province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state/province (Natureserve 2006).

SARA	• The federal *Species at Risk Act*.
Stochastic	• Patterns or processes resulting from random factors.
threatened	• Likely to become endangered if limiting factors are not reversed.
tufa	• Tufa is a rough, thick, rock-like calcium carbonate deposit that forms by precipitation from bodies of water with high dissolved calcium content (http://en.wikipedia.org/wiki/Tufa)
viable	• Capable of living.

APPENDIX Record of Cooperation and Consultation

Hotwater Physa is a freshwater species under provincial jurisdiction, managed by MOE, and occurring solely within the Liard River Hotsprings Provincial Park. As an aquatic species under SARA, Hotwater Physa is under federal jurisdiction, managed by Fisheries and Oceans Canada (DFO): 200 - 401 Burrard Street, Vancouver, BC., V6C 3S4.

There are few people in Canada with scientific, traditional or local knowledge of Hotwater Physa due to its isolated occurrence in northern BC and its profile is not high. To assist in the development of this recovery strategy, MOE and DFO brought together a small group of experts, to develop an initial draft of this recovery strategy. An invitation was sent to the Kaska First Nations and Treaty 8 Tribal Association and Fort Nelson First Nation, seeking their interest in the development of the recovery strategy. There are no wildlife management boards that function within the distribution of these species.

Additional input was sought through the internet, both the initial draft (March 2006) of this proposed recovery strategy and a feedback form were available. A public notice was placed in local newspapers announcing the development of the recovery strategy, and soliciting feedback. The web site was also distributed to a specific group of potentially interested individuals, including Jacquie Lee, independent malacologist, North Vancouver, BC. and Philip Lambert, malacologist, Royal British Columbia Museum, Victoria, BC.

The Kaska Dena Council responded with their support for the research proposed in the recovery strategy and expressed an interest in being involved in the research through training opportunities for their youth. They also requested to be kept up to date on the results of the research and involved in any decisions regarding the use of the Liard Hotsprings as a result of the research. The technical input received (see Acknowledgments) has been incorporated into this document. No other comments were received.

No comments were received during the 60-day public registry consultation period on the proposed version of this recovery strategy.