Potential Effects of a Proposed Feedlot on Fish and Their Habitats in Onetree Creek and the Red Deer River, Alberta

A Report Prepared for
Newell Clean County Coalition

by

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Summary

I surveyed the pertinent literature, conducted a field examination, and considered the proposal documentation provided to me to assess the potential effects of a proposed feedlot operation on fish and their habitats in Onetree Creek and the Red Deer River near the mouth of Onetree Creek. Onetree Creek in the vicinity of the proposed feedlot continues to support three native species of fish, although at present it is severely degraded as fish habitat. The mouth of Onetree Creek is reported to be a spawning location for northern pike and possibly other sportfish species, and is the subject of a sport fishery. Lower Onetree Creek from the mouth upstream to at least the highway crossing west of Patricia is much larger, being navigable by canoes, and is almost certainly used by sportfishes from the Red Deer River, as well as forage species. The Red Deer River at and near the mouth of Onetree Creek holds important sport fish species, including at least one species at some conservation risk, and is the subject of a regionally-important sport fishery. Given the close proximity of the proposed feedlot to Onetree Creek, past experience of such operations as reported in the literature, the spreading of manure from the operation on extensive lands adjacent to the creek, its tributaries, and other tributaries of the Red Deer River, and existing nutrient loadings on the Onetree Creek watershed and other nearby small watersheds draining to the Red Deer River, I believe that there is a significant risk of contamination of Onetree Creek and the Red Deer River from manure and its derived nutrients produced by this proposed feedlot. The contamination could contribute to low winter oxygen levels in Onetree Creek and the Red Deer River near Onetree Creek, and have other effects detrimental to fish and fish habitat in those waters. In my view, such contamination would be deleterious to fish, and would create a harmful alteration of fish habitat, both of which could be actionable under the federal *Fisheries Act*. Deposition of a deleterious substance might also contravene the *Navigable Waters Protection Act*.

Introduction

Freshwater Research Limited has been engaged by the Newell Clean County Coalition to comment upon a proposal to build a feedlot near Brooks, Alberta, with respect to its possible effects on fish and fish habitat. I have surveyed the literature pertinent to this topic, examined the watercourses near the proposed site in the field, considered the documentation of the proposal provided to me, and have the following to report.

The Feedlot Development

The proposed feedlot is a finishing facility that will have a capacity of 30,000 head of beef cattle (Healy 2001). It will be located at NE26-19-14-W4, occupying approximately a quarter section of land, and will lie within a wide bend of Onetree Creek, which will surround it on three sides. A section of the creek will be channeled and re-routed to a small left-bank tributary to bypass water around the southwest corner of the facility. What I understand to be a holding pond or catch basin for site drainage and liquid manure will be constructed on the west side of the facility near the creek. I understand that manure from the operation will be temporarily stored both on- and off-site (Healy 2001), and eventually will be spread on the lands identified in a document entitled Alberts Farm Manure Management Plan 2001.

Onetree Creek and the Red Deer River

Onetree Creek is a perennial stream tributary to the Red Deer River, flowing for more than 20 miles below the feedlot site to enter that river at Dinosaur Provincial Park at a point about 2.5 miles above the provincial campground at the mouth of Little Sandhills Creek. Onetree Creek is used as part of the Eastern Irrigation District's system of drains and canals for water distribution, and has been substantially channeled and modified at numerous points along its mainstem and on its tributaries.

In the vicinity of the proposed feedlot Onetree Creek is very narrow, overarched and largely hidden by a species of tall grass (*Phalaris arundinacea*, reed canary grass; Wallis personal communication 6 September 2001). The bottom of the creek supports heavy growths of a thread-leaved pondweed, probably *Potamogeton pectinatus*. What appeared to be heron tracks were common on the mud, and herons are said to be common in the area (W. Alberts, personal communication 17 August 2001). Even though I recorded an air temperature of 34 °C at the time of my visit (17 August 2001), the water temperature in Onetree Creek was just 18 °C, and the water temperature of the tributary, which was largely open to the sun and very shallow, was still just 22°C. A

spring area of an acre or more discharges to the left bank of Onetree Creek more or less opposite the location where the feedlot catch basin apparently is to be constructed. Also on the left bank opposite the proposed feedlot site, and downstream from the spring area perhaps 100 m or more, water was trickling into Onetree Creek from a buried culvert draining from a field in which, I was told, drainage tiles had been installed years ago.

Further downstream Onetree Creek is considerably larger. On 17 August 2001 the flow just above the mouth was perhaps 6 m wide and possibly up to 1 m deep, but was obviously well below the bankfull flow. Faxes of two photographs (Figures 1 and 2) were provided to me by W. B. Alberts (personal communication 31 August 2001) which show canoes on a stream he identified as Onetree Creek somewhere below the highway crossing west of Patricia, AB.

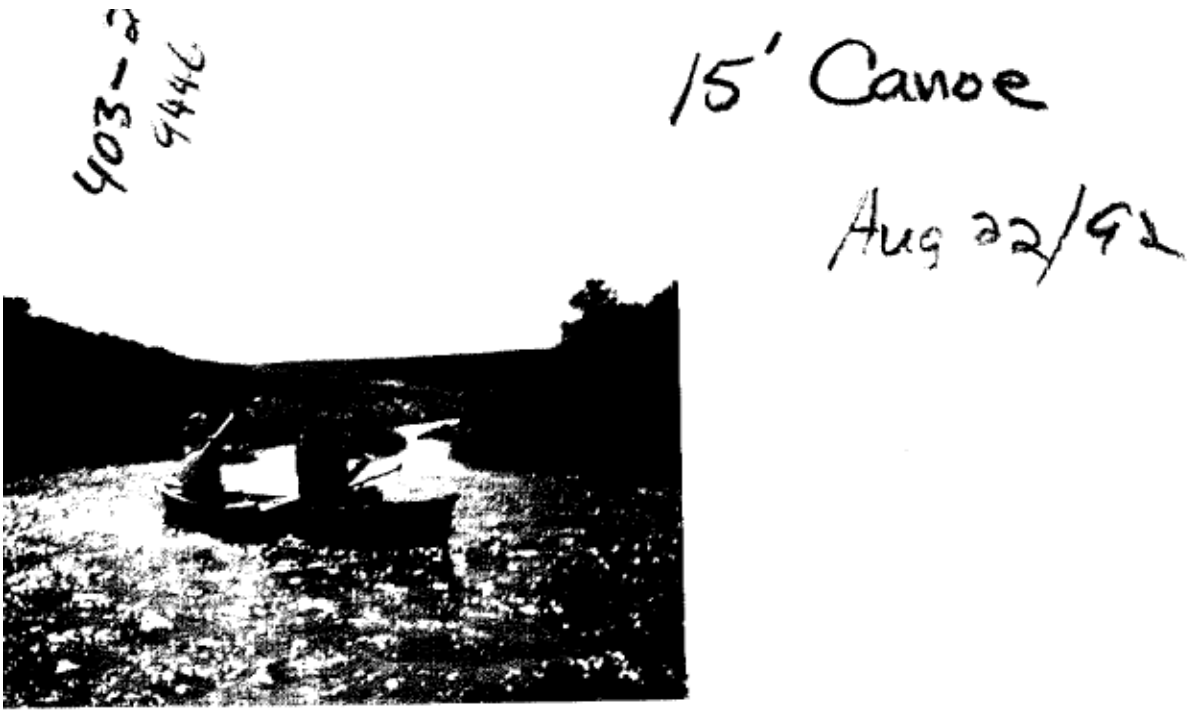

Figure 1. A 15-foot (~4.5 m) canoe on Onetree Creek somewhere below Patricia, AB, 22 August 1992.

Despite the poor quality of the fax images, it is clear that the stream was substantially wider than the length of the two canoes at that time, perhaps in the order of 15 m or more wide.

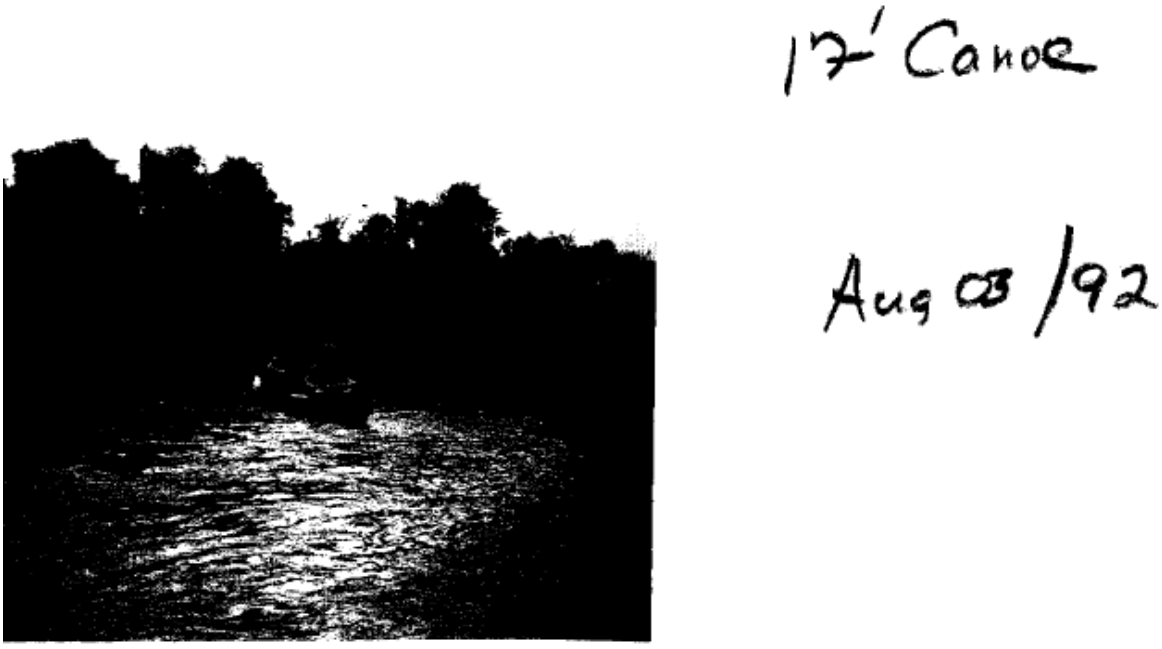

Figure 2. A seventeen-foot (~5 m) canoe on Onetree Creek somewhere below Patricia, AB, 3 August 1992.

Onetree Reservoir is formed by a dam on Onetree Creek approximately 1.5 miles above the proposed feedlot location. Headworks at the Onetree Dam control flows down Onetree Creek below that point. Eastern Irrigation District (EID) staff and local residents appear to disagree as to whether some water flow is normally maintained from the headworks down the creek. An EID representative (Earl Wilson, personal communication) told me that no records are kept, but asserts that the headworks are normally closed completely, as they were at the time of my visit on 17 August 2001. The reservoir receives the sewage of the Town of Brooks (population approximately 9,500) once a year, in the fall. According to Mr. Wilson, the dam is opened in the fall to flush this material through the reservoir, and may be flushed again in spring in dry years. Otherwise, the reservoir drains most of the growing season almost entirely through the canal at the northwest corner to supply water to irrigators. Judging from the map,

perhaps most of the water supplying Onetree Reservoir arrives through a sequence of irrigation canals from Lake Newell and Johnson Reservoir, which in turn receive water from the Bow River.

The Red Deer River at the mouth of Onetree Creek is broad and shallow, perhaps 200 m or more wide and probably about 1 m deep or less on 17 August 2001. Exposed sand and mud bars were extensive. Discharges at Drumheller and Bindloss during the period 4-6 September 2001 were approximately 21-22 m^3s^{-1} and 18 m^3s^{-1}, respectively (Alberta Environment 2001a preliminary data)[1]. Normal flows at Drumheller for this week would be 29 m^3s^{-1} to 47 m^3s^{-1} (Alberta Environment 2001b). Longterm mean annual discharge at Drumheller is 52.31 m^3s^{-1}, and maximum and minimum mean daily discharges are 130 m^3s^{-1} and 1.53 m^3s^{-1}, respectively (Nelson and Paetz 1992). Winter discharges in 1979, prior to the closing of the Dickson Dam, ranged from about 4 m^3s^{-1} to 12 m^3s^{-1} (Longmore and Stenton 1981). The mean gradient from Drumheller to Empress is only about 0.3 m km^{-1} (0.03%) (Longmore and Stenton 1981), so currents are slow.

The water is commonly highly turbid in this reach of the Red Deer, and summer temperatures are said to average and occasionally exceed 25°C (M. Kraft, cited by Longmore and Stenton 1981). Prior to the closing of the Dickson Dam, winter dissolved oxygen (DO) concentrations upstream at Nevis and Drumheller often dropped below 5 mg l^{-1} (as low as 0.8 at Drumheller) (Kraft 1979, Environment Canada 1981, both cited by Longmore and Stenton 1981). These low winter DO levels were believed by Longmore and Stenton (1981) to be typical of the Drumheller-to-Empress reach of the river as well.

Fishes and the Sport Fishery

The fish species known to use Onetree Creek, and the Red Deer River in the vicinity of the mouth of Onetree Creek, are listed in Table 1.

[1]These data carry the following disclaimer:*"Data provided at this site are provisional and preliminary in nature and are not intended for use by the general public. They are automatically generated by remote equipment that may not be under Alberta Government control and have not been reviewed or edited for accuracy. These data may be subject to significant change when manually reviewed and corrected. Please exercise caution and carefully consider the provisional nature of the information provided. The Government of Alberta assumes no responsibility for the accuracy or completeness of these data and any use of them is entirely at your own risk."*

Table 1. Fish species reported from the study area. Species marked with an asterisk (*) are sportfish species; ? indicates a questionable or uncertain record. Common names are those recommended by Robins et al. (1991), where the scientific names are listed.

Species	Onetree Cr., dam to feedlot	Onetree Cr. mouth	Red Deer R. near Onetree Cr.	Source
lake sturgeon*			•	Nelson and Paetz 1992; Todd Irwin personal communication
goldeye*			•	Longmore and Stenton 1981; Nelson and Paetz 1992; Allan 1995; Todd Irwin personal communication
mooneye*			•	Longmore and Stenton 1981; Nelson and Paetz 1992
lake chub			•	Nelson and Paetz 1992
pearl dace			•	Nelson and Paetz 1992
emerald shiner			•	Nelson and Paetz 1992; Allan 1995
river shiner			•	Nelson and Paetz 1992;Allan 1995
fathead minnow	•		•	Nelson and Paetz 1992; this study
flathead chub			•	Nelson and Paetz 1992; Allan 1995
longnose dace			•	Nelson and Paetz 1992
quillback			•	Nelson and Paetz 1992; Allan 1995
longnose sucker		"suckers"	•	Nelson and Paetz 1992; Allan 1995; Todd Irwin pers. comm.(?)
white sucker	•	"suckers"	•	Nelson and Paetz 1992; Allan 1995; this study

continued...

Table 1. concluded

Species	Onetree Cr., dam to feedlot	Onetree Cr. mouth	Red Deer R. near Onetree Cr.	Source
shorthead redhorse			•	Paetz and Nelson 1992; Allan 1995
northern pike*		•	•	Longmore and Stenton 1981; Nelson and Paetz 1992; Allan 1995; C. Wolman and T. Irwin, pers. comms.
lake whitefish*			?	Longmore and Stenton 1981
mountain whitefish*			•	Nelson and Paetz 1992
rainbow trout*			?	Nelson and Paetz 1992
trout-perch			•	Nelson and Paetz 1992
burbot			•	Allan 1995
brook stickleback	•		•	Nelson and Paetz 1992; this study
sauger*			•	Nelson and Paetz 1992; Allan 1995
walleye*		?	•	Nelson and Paetz 1992; Allan 1995

Of special concern in Table 1 is the lake sturgeon. Lake sturgeon populations, like those of sturgeons generally, are vulnerable as a result of many aspects of their life history, and do not respond well to stressors in their environments (Birstein 1993).

In addition, "Pike, suckers and some trout" have been observed below the Onetree Dam after water releases in past years (Les Schuett, personal communication 5 September 2001), apparently washed downstream out of the reservoir. It is not known whether any of these fish survive in this reach of the creek during low flows or over winter. At the proposed feedlot site I found large numbers of small fishes, mostly fathead minnows and brook stickleback, along with some young white suckers, in Onetree Creek and in the tributary entering Onetree Creek at that point, during my visit

(Table 1). Fourteen of twenty-five (56%) of the fathead minnows collected had swollen granular cream-coloured growths under and around the gills and within the head that were readily visible from 2 to 3 metres away before the fish were captured. One brook stickleback was grossly swollen with a growth or internal parasite in the body cavity.

At its mouth Onetree Creek is used by sportfish species (northern pike) for spawning in spring, and sauger have also been taken there (Cam Wolman, Alberta Sustainable Resource Development, personal communication 15 August 2001). Large numbers of suckers are also reported to use this part of the creek in spring (Todd Irwin, personal communication 17 August 2001). Similar creeks and creekmouths in this reach of the Red Deer River are known to be used at least seasonally by several important sportfish species, including pike, walleye, sauger and goldeye (Longmore and Stenton 1981). Anglers commonly fish at the mouth of Onetree creek, especially for goldeye (Todd Irwin, personal communication 17 August 2001), and the Red Deer River generally in this reach supports a regionally-important sport fishery (Longmore and Stenton 1981).

Assessment of Potential Effects on Fish

Of particular concern to fisheries from a feedlot development is the fate of the large quantities of nutrients, particularly nitrogen (N) and phosphorus (P), and organic material contained in the manure produced by the operation. Production of plant material in freshwaters is usually limited by the amount of P available, but in certain highly-productive systems N may be limiting. Addition of these nutrients to fresh waterbodies and watercourses, especially in combination, therefore will usually result in increased aquatic plant production, a process termed eutrophication.

If it proceeds far enough eutrophication can harm fish in a number of ways. For example, large algal blooms are promoted and massive standing crops of macrophytes may develop. Certain species of bloom-forming blue-green algae produce toxins. When plants die off and decompose, especially but not only under winter ice, oxygen can be depleted to such an extent that large die-offs of fish occur. In addition, anoxic (no oxygen) conditions over sediment can release nutrients and a variety of potentially toxic compounds (e.g., H_2S) and heavy metals to the water. The released nutrients then are available to support more plant growth, setting the stage for a continuing, even escalating, problem. The toxic chemicals released could kill or injure fish that suddenly come into contact with them (e.g., if anoxic ditchwater is suddenly released into a fish-bearing stream). Even if they are not killed outright, fish can be seriously harmed by sustained low dissolved oxygen levels or contact with sublethal concentrations of toxins.

In Alberta, water quality degradation of several types, including eutrophication from increased nutrient loading, increases as agricultural usage, including usage for livestock production, increases (CAESA 1998). According to the 2000 Code of Practice (Alberta Agriculture 2000), 30,000 beef cattle finishers can be expected to produce 64,800 tonnes of manure annually, containing 648,000 kg of nitrogen (as N) and 155,520 kg of phosphorus (as P). Other reasonable estimates based on conversion factors per animal from other Canadian jurisdictions (Chambers et al. 2001) would place these quantities much higher: as high as 1,674,000 kg of N and 486,000 kg P. To place these amounts in perspective, it has been estimated that beef cattle produce almost 17 times the weight of manure, holding about 11 times the amount of N and 14 times times the amount of P, as the equivalent number of humans produce (Fleming and Ford 2001). In effect, the proposed feedlot operation will have to dispose of an amount of waste and nutrients roughly equivalent to that produced by a population of 300,000 to 500,000 people, depending on the basis of measurement.

This is in addition to the loadings already being received by the basin. All of this material is going to be stored and then spread in the drainage basin of Onetree Creek and adjacent basins, all of which drain to the Red Deer River within a few miles of each other, within or just above Dinosaur Provincial Park. This drainage area is also presently storing and/or processing manure from several other sources, notably the human waste from the town of Brooks, the manure from the applicant's existing 6,000-head feedlot and very likely at least some of the manure from the 75,000-head feedlot operation of Lakeside Feeders.

Conditions for fish in Onetree Creek and the receiving reach of the Red Deer River suggest that they are prone to damage from eutrophication. Flows in Onetree Creek are presently severely restricted by the closure of Onetree Dam, reducing the amount of water available to support fish, and exposing the existing, already-stressed fish populations to, other risks — increased predation from herons, for example. Additional stress induced, for example, by further nutrient loading or instream construction of the bypass could kill large numbers of them. Reduced flows would simply amplify the effect of increased nutrient loadings. The Red Deer River is very shallow, flows are slow, the water is relatively warm, and it receives sewage loads from several urban areas upstream. It is therefore already under stress. The low DO levels noted by Longmore and Stenton (1981) are attributable in part to nutrient contributions from the city of Red Deer, the town of Drumheller and other sources, including cattle feedlot operations on upstream tributaries. While releases from the Dickson Dam have improved DO levels in recent years (Anne-Marie Anderson, , personal communication 6 September 2001), additional nutrient loading of sufficient magnitude could well

recreate the low winter DO problems of earlier years. The cumulative effect of upstream urban growth, additional future feedlot operations and many other sources of nutrients need to be carefully evaluated and the loadings need to be stringently controlled to avoid this problem.

These considerations highlight the need for very careful storage and handling of the manure from the proposed feedlot in question. In this respect there are at least three important concerns.

- The feedlot itself is surrounded on three sides by Onetree Creek. Regardless of the stipulations of the 2000 Code of Practice, the placement of a large feedlot in such a location is a high-risk proposition, because it maximizes the exposure of the creek to accidental spills and unplanned events. For example, drainage is to be designed for the 30-year event, a very low standard, in my opinion, given the concentration of manure and the potential consequences of its sudden release down the creek to the Red Deer River. Damaging spills from intensive livestock operations are all too common from extreme weather events and other causes including operator negligence, frequently resulting in substantial fish kills (USEPA 1998, Chambers et al. 2001).

- The lands proposed for disposal of the manure are often closely connected to, or even a part of, the drainage network of the Onetree basin and adjacent basins. It is proposed to spread manure on lands across Onetree Creek from the feedlot, lands in which drainage has been enhanced by the use of drainage tiles, and lands which impinge upon a substantial spring area. Even under the drought conditions pertaining in August 2001, water was draining from the tiled fields directly into Onetree Creek. Upstream from this point, an extensive active spring area indicates a shallow water table that should be a contra-indication for manure spreading above the spring catchment. Furthermore, much of this land is low relative to the creek, and subject to flooding. Other lands slated to receive the feedlot's manure are immediately adjacent to perennial watercourses. In at least one case (NE6-20-12-4) the entire quarter will receive manure even though it contains a perennial watercourse.

- More generally, I am not aware of data establishing firmly either that Onetree Creek, its basin or the Red Deer River is capable of safely handling the cumulatively large quantities of nutrients that it is presently being asked to process, much less the much greater quantities that are proposed to be added as a result of the proposed feedlot. It is important always to recognize that conditions in streams and rivers inevitably are defined by the conditions in the watersheds they drain (Hynes 1975).

As the use of land in a basin intensifies, the effects of the use is reflected in the organisms and their habitats in the watercourses which drain that land. The proposed feedlot and its operation will affect a substantial area of the Onetree Creek basin and adjacent drainage basins. Good management practice would require that some assessment be prepared of the basin's assimilative capacity for the cumulative total amount of nutrients applied to it. The land should then be managed to remain within that assimilative capacity.

At least two federal statutes may be relevant to these concerns. The *Fisheries Act*, sections 35(1) and 36(3); and the *Navigable Waters Protection Act*, sections 21 and 22.

The *Fisheries Act* states as follows.

"35. (1) No person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat.

"36. …
(3) Subject to subsection (4), no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any other deleterious substance that results from the deposit of the deleterious substance may enter any such water."

The *Navigable Waters Protection Act* further states

"21. No person shall throw or deposit or cause, suffer or permit to be thrown or deposited any sawdust, edgings, slabs, bark or like rubbish of any description whatever that is liable to interfere with navigation in any water, any part of which is navigable or that flows into any navigable water.

"22. No person shall throw or deposit or cause, suffer or permit to be thrown or deposited any stone, gravel, earth, cinders, ashes or other material or rubbish that is liable to sink to the bottom in any water, any part of which is navigable or that flows into any navigable water, where there are not at least twenty fathoms of water at all times, but nothing in this section shall be construed so as to permit the throwing or depositing of any substance in any part of a navigable water where that throwing or depositing is prohibited by or under any other Act."

I believe that nutrient loadings from the proposed feedlot operation, and possibly instream work proposed during the development of the operation, could contravene one or more of these provisions.

Conclusion

Based on the information I have concerning the proposed feedlot, Onetree Creek and the Red Deer River, I believe that

1. there would a significant risk of a spill of manure and contaminated runoff into Onetree Creek, and ultimately the Red Deer River, as a consequence of the feedlot proposed location being surrounded closely on three sides by Onetree Creek;

2. that there is a significant risk of substantial quantities of manure and manure-derived N- and P-type nutrients entering the Onetree Creek stream network, adjacent streams, and ultimately the Red Deer River under the proposed Alberts Farm Manure Management Plan;

3. that the ability of the Onetree Creek drainage basin, adjacent basins and the Red Deer River to assimilate the manure and its contained nutrients has not been established.

As a corollary of these conclusions, I believe that the materials from these sources would be, immediately or eventually, deleterious to fish in the streams and in the Red Deer River, and that they would harmfully alter the habitat for fish in these waters, in contravention of sections 36(3) and 35(1) of the *Fisheries Act*. Alternatively, such deposition might well contravene sections 21 and 22 of the *Navigable Waters Protection Act*.

FWR FRESHWATER RESEARCH LIMITED
(signed)
David W. Mayhood, President

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Potential Effects of a Proposed Feedlot on Fish and Their Habitats in Onetree Creek and the Red Deer River, Alberta: Additional Notes

Addendum to a Report Prepared for
Newell Clean County Coalition

by

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17 September 2001

Introduction

The following notes are based on my further work since 10 September into selected topics covered by the original report. This document is intended as a supplement to the report, and can be appended as an addendum.

Fishes and the Sport Fishery

The lake sturgeon, found in the Red Deer River, is designated as Not at Risk in Canada (COSEWIC 2001). Alberta maintains a retention sportfishing season for the species in the South Saskatchewan drainage, including the Red Deer (ABSRD 2001). Nevertheless, the species is considered Threatened throughout its entire range, including Alberta by the American Fisheries Society (Williams e al. 1989), while the IUCN-World Conservation Union deems it Vulnerable throughout its r ange (Hilton-Taylor 2000).

Assessment of Potential Effects on Fish

The report emphasizes the potential for, and effects of, eutrophication as the result of increased nutrient loading. As it also notes, there are other problems arising from feedlot operations that may potentially damage fish and their habitats as well. These are elaborated upon further below.

- **Oxygen demand.** The organic matter in manure decomposes as a result of bacterial action, consuming oxygen in the process. When this happens in water (e.g., as the result of a spill or from runoff), dissolved oxygen concentrations can be reduced to the point that fish are injured or killed.

- **Organic solids.** Solids from manure can increase turbidity while in suspension in surface waters. Fish may be injured or killed directly, depending on the concentration and exposure time (Newcombe and Jensen 1996). Solids which settle out can smother fish or their eggs, and fill in critical habitat used for shelter or spawning. Solids may enter the creek in runoff from the feedlot itself, or from the fields on which the manure is spread.

- **Nitrogen species.** Nitrogen occurs in manure mainly as organic nitrogen and ammonia nitrogen. Organic nitrogen is ordinarily not available as a plant nutrient until microbial processes transform it into ammonium and nitrate (NO_3^-) forms. It is primarily in these forms that N becomes a potential eutrophying nutrient in fresh waters. Nitrate is highly mobile in soils and may enter surface waters by erosion, or dissolved in runoff water or groundwater.

  Ammonia nitrogen may exist as ionized ammonium (NH_4^+) or un-ionized ammonia (NH_3). Ammonium and ammonia, especially the latter, are toxic to fish. Ammonium - ammonia concentrations can build to very high levels in decomposing manure. Large spills of manure into surface waters can be expected to cause fish kills due to ammonium - ammonia toxicity. Ammonia also has a high biochemical oxygen demand (BOD). It can be expected rapidly to depress dissolved oxygen concentrations upon entering surface water, to the detriment of fish and other organisms. Manure ammonia can enter surface waters mainly through erosion in runoff, directly through a manure spill, or even through the atmosphere (either by direct deposition or dissolved in rain).

- **Phosphorus.** Phosphorus is the most frequent limiting nutrient in fresh water; therefore increased loading of phosphorus to surface waters usually will tend to

cause their eutrophication. Although mineralized phosphates in soils are ordinarily strongly adsorbed to charged mineral particles and are likely to enter surface waters, if at all, mainly through erosion, manure phosphorus held in organic compounds, many of which are water-soluble (Gerritse 1977, cited in USEPA 1998), can readily enter surface waters through runoff or possibly via the groundwater after leaching. Once in these waters the phosphorus then becomes available as a nutrient through various pathways. Furthermore, manure phosphorus applied at agronomic rates based on the N content of manure is likely to eventually exceed the phosphate adsorption capacity of the soil (USEPA 1998, Gillund 2001), so that the excess phosphates can readily enter surface waters via runoff even when erosion is controlled. Phosphorus from feedlot manure therefore may be more likely to enter surface waters when the manure is spread on the land than has heretofore been believed.

- **Pathogens.** There is a report that avian cholera and avian botulism caused by bacteria in livestock waste kill thousands of migratory waterfowl each year (USEPA 1998), but I have been unable to obtain the original reference to confirm this. I do not know whether pathogens in cattle manure can infect fish, or whether fish pathogen populations in surface waters are affected by inputs of cattle manure. A fish pathologist would best be consulted to deal with these questions.

- **Salts and trace elements.** Salts and trace elements can be elevated in soils by longterm spreading of manures above agronomically-usable levels (USEPA 1998, Gillund 2001). It seems likely that this could lead to elevated levels in surface waters through surface runoff, erosion and via groundwater after leaching. There is at least one report cited of a fishkill caused by copper and zinc poisoning from a spill of hog manure (USEPA 1998).

- **Antibiotics, pesticides and hormones.** There appears to be no specific information of the potential for damage to fish from these compounds due to livestock operations. There is growing concern for the general problem of antibiotics and hormones or hormone mimics in the environment, however, including their effects on fish (Laghi 2001).

- **Odours.** Many fish are exceedingly sensitive to odour, and can apparently detect odiferous compounds in minute amounts. These are often used by salmonids, for example, to locate their natal streams for spawning. It is conceivable that manure deposition in streams could disrupt this ability in fish.

- **Spills and Catastrophic Runoff.** The USEPA (1998) listed 245 spills and catastrophic runoff events from animal feeding operations in the United States based on a "non-exhaustive" literature search. Of these, at least 26% resulted in fish kills, almost one-third of them killing tens of thousands to hundreds of thousands of fish. Of an additional 33 longer-term or cumulative effects situations recorded, 10 resulted in one to several fish kills (some in the hundreds of thousands to as much as one billion fish), while in a total of 12 cases eutrophication resulted, often in conjunction with fish kills..

  Fish kills from livestock operations are not restricted to the USA. Chambers et al. (2001) cited data for 274 manure spills in Ontario alone, occurring between 1988 and 1998. Of these, 53 (19.3%) resulted in fish kills (numbers of fish not recorded) resulting from deoxygenation, ammonia poisoning or both. Nearly all of these were caused by mismanagement; few were truly accidental.

FWR FRESHWATER RESEARCH LIMITED
(signed)
David W. Mayhood, President

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