Sodium and Sulfate Risks to Livestock – A Review

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Agenda

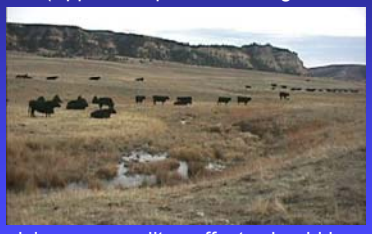
- Proposed ruling will update water quality criteria for livestock protection.
- This presentation addresses the constituents:

	Current		Proposed*
Sulfate	3,000 mg/L	→	1000 mg/L
Sodium	(none)	→	1000 mg/L

*Raisbeck et al. (2007)

What are we trying to protect?

- Prevent a **"measurable decrease"** in livestock production (Appx H, a, p H-1, draft Ag. Use Protection).



- Livestock is a commodity - effects should have livestock industry values in mind

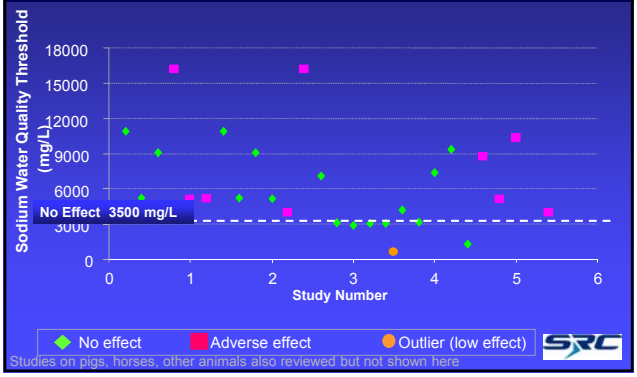
Relevant Toxicological Endpoints

- **Growth** – weight gain; prevention of loss
  - Intake rates (water, food) are not adequate measures of growth
  - Individual intake rates do not predict growth: Zinn 1994, Hickman 2002, Schwartzkopf-Genswein 2004; Grout et al. 2006; Loneragan et al. 2001; Johnson and Patterson 2004
- **Reproduction** – calving rates, etc
  - Indirect measures are not clear.
- **Acute effects** – short term (<96 hrs); affects marketability (disease, PEM, blindness, death)

A Review – Hunter 2007, 2008

- Incorporated all references provided by Raisbeck et al.
- Expanded database: over 200 citations reviewed in total.
- All literature considered for further analysis had to meet minimum criteria:
  - Peer-reviewed
  - Relevant endpoints: growth, reproduction, acute
  - Normal nutrition levels
  - Water quality consistent with current WY stds or EPA criteria
- Water quality thresholds determined by taking into account typical sodium, sulfate levels in WY forage

The Findings: Sodium Exposure to Cattle, Sheep



Studies on pigs, horses, other animals also reviewed but not shown here

The Findings: Sulfate Exposure for Cattle Growth

The Findings

- Sulfate safe at 3,000 mg/L to WY open range cattle
  - Growing cattle most sensitive
  - Growth not affected below 3,050 mg/L
  - Acute effects did not occur below 3,800 mg/L
- Sodium safe at 3,500 mg/L
  - Cattle most sensitive
  - Growth, reproduction not affected below 3,800 mg/L
  - Acute effects did not occur below 9,500 mg/L
- Applies to livestock, wildlife
  - Addresses long-term exposure
  - Applies to the conditions of Wyoming open range
- **The recommendation for limits of 1,000 mg/L sodium, sulfate are not supported by further evaluation of the literature.**

A Literature Review is not Enough

Why Is It Important?

- Wyoming conditions differ from toxicity studies
  - Johnson and Patterson (2004)
- Adaptation / inc'd tolerance can occur w/o long-term adverse effects
  - NRC (1974), Spafford (1941), Ballantyne (1957)

Livestock Producers in Bighorn and Powder River basins weigh in

- Thanks to: Flitners, McCarty, Patterson, Shepperson, Schlaf, Meike, and others

Livestock Producers' experiences

Thanks to: Flitners, McCarty, Patterson, Shepperson, Schlaf, Meike, and others

- No negative effects on livestock (cattle, sheep, horses) that drank water containing:
  - Sulfates **≤ 3,100** mg/L
  - Sodium **≤ 2,500** mg/L
- Adverse effects apparent when exposed to:
  - Sulfates ≥ 4,000 mg/L
  - Sodium ≥ 6,000 mg/L

Livestock Producers' experiences

Thanks to: Flitners, McCarty, Patterson, Shepperson, Schlaf, Meike, and others

- Flitners: 7-year weaning rate averages as good or better w/ produced water
  - 2,700 mg/L sulfate
  - 1000 mg/L sodium
- Mr. McCarty: No adverse effects w/ produced water
  - body condition, mortality

Year	Dry Creek	Potato Ridge	Home Place	Whistle Creek
1999	**473**	451	469	483
2000	**501**	492	476	500
2001	**462**	454	473	465
2002	**487**	509	512	525
2003	**522**	503	497	503
2004	**515**	498	526	486
2005	**526**	482	501	492
Average:	**498**	**484**	**493**	**493**

An Overwhelming Weight of Evidence: Current standards protect livestock

ppm = mg/L or mg/kg

1. Our independent review shows 3,500 mg/L sodium, 3,000 mg/L sulfate will not cause measurable decrease in livestock production
2. NRC 1980, 2005 - Sodium:
   - 4% NaCl is upper limit in cattle, sheep = ~10,000 mg/L Na per day
   - Range: 6,700 ppm (poultry) to 23,600 ppm (horses)
3. NRC, 2005 - Sulfate:
   - 2,500 mg/L safe for cattle – based on fewer studies, S, all feedlot.
   - Important, substantial toxicity differences between sulfate and other S forms!
   - NRC gives example: 834 mg/L S = 2,500 mg/L SO_4.
4. USEPA 1976 up to 7,000 mg/L sodium.
5. Canada WQL up to 3,000 mg/L sulfate.
6. 30 years of field experience:
   - 30 years of anecdotal evidence that current limits are adequate.
   - Ranchers' testimonies indicate water is safe and manageable.

★**Current WY criteria are safe for Wyoming livestock.**

Why do the recommendations differ?

ppm = mg/L or mg/kg

- Sulfate:
- Feed, water intake rates considered a relevant effect even if growth not affected
- Differences between feedlot and open range not considered.
- Some studies evaluated other S forms, not sulfate
  - Important, substantial toxicity differences between sulfate and other S forms!

Why do the recommendations differ?

ppm = mg/L or mg/kg

- Sodium:
- Study reviews do not recognize total sodium intake (feed, etc)
- Ultimate recommendation appears to be based on milk production in dairy cows, specifically a study by Jaster et al. (1978):
  - Dairy cows given 1,000 mg/L sodium in water, milk production measured
  - Marginal declines ($0.05<p<0.08$) observed
  - Study subtly notes:
  - Cows additionally consumed 30,000 mg NaCl supplement per day
  - Feed contained 12,800 mg/kg sodium in the food
  - Forage for WY open range estimated at ~800 mg/kg
  - **Total sodium exposure = 14,000 ppm sodium per day**
- Remaining studies cited by Raisbeck et al. (2007) do not show toxicity below 6,000 ppm sodium

Are the Raisbeck et al. recommendations appropriate to set new limits?

- The study "Is a reasonable starting point"; however,
- It is not exhaustive
  - Key studies appear to be missing from Raisbeck et al for sulfate; additional studies found for sodium
- Does not consider variables applicable to WY
  - The study does not account for conditions under which livestock are raised in WY
  - adaptability, feed sources and quality, frequency of water use
- It is not risk-based
  - The study does not consider WY statutory balancing criteria:

Are the Raisbeck et al. recommendations appropriate to set new limits?

- Probability of risk must be put into context of relevancy to Wyoming's citizens and their livestock industry as mandated by the state (W.S. 35-11-302):
  - **(A) the character and degree of injury to or interference with the health and well-being of people, animals, wildlife, aquatic life and plant life affected;**
  - **No incremental reduction in risk**
  - **(B) the social and economic value of the source of pollution;**
  - **The water is beneficial to livestock, wildlife, agriculture and industry**
  - **(C) the priority of location in the area involved;**
  - **Produced water tends to be discharged in areas where little natural water is available.**
  - **(D) the technical practicability and economic reasonableness of reducing or eliminating the source of pollution;** and
  - **The 1000 mg/L recommendation would eliminate sources of water relied upon by agriculture producers.**
  - **(E) the effect upon the environment.**
  - **Water of adequate quality is better than no water.**

Conclusions

- Current limits protect against a measurable decrease in livestock production.
- Changing the criteria to levels recommended by Raisbeck et al. will not result in any incremental risk reduction to livestock.
- Should water quality limits be tightened, there will be a reduction in water availability on the open range and corresponding decrease in livestock production.

Thank you.