Take-Home Message

· Manure contains nutrients, such as nitrogen and phosphorus that can contaminate surface and ground water resources if manure is mismanaged.
· The nutrients in manure are directly related to the nutrients in the horse's diet – higher intakes mean greater amounts excreted.
· You can lower the pollution risk of your horse's manure by avoiding over-supplementation of protein and minerals and selecting feeds that more closely match your horse's nutritional needs.
· Regardless of the diet fed, proper handling, storage and disposal of manure are *key* to minimizing negative environmental impacts.

In One End & Out the Other

Anyone who has spent time cleaning horse stalls knows that what goes in the front end eventually comes out the back end! The horse's diet contains nutrients such as protein and minerals that are necessary to maintain good health, to grow properly, to produce milk, or to perform well in the show ring. However, horses are not 100% efficient at digesting and extracting nutrients from the feeds they consume. Some nutrients remain undigested and pass out in the feces. Other nutrients might be absorbed, but may not be immediately needed by the body or capable of being stored. Such unutilized nutrients are then excreted either in the feces or in the urine. Sloughed cells, intestinal juices, and microbes that inhabit the horse's digestive system can also contribute to the nutrients excreted in the feces.

Depending on the nutrient and the form in which it appears in the diet, it is not uncommon for 25-80% of what a horse eats to be passed out in the manure. As a result, the nutrients in manure are directly related to the nutrients in the horse's diet. Unfortunately, many of the nutrients horses need in their diet are the same ones that can negatively impact the environment if the nutrient-rich manure is mismanaged.

The Road (Apple) to Pollution

The amount of manure produced by the horse varies with age, pregnancy, exercise, and diet (Lawrence et al 2003b). On average, an adult horse produces 2.8 kg feces and 1.6 kg of urine per 100 kg of body weight per day. Thus, an average 500-kg horse produces about 14 kg (30 Lbs) of feces and 8 liters of urine daily, which totals approximately 22 kg (50 Lbs) of raw manure per day. Over the course of a year, this horse will excrete 44 kg nitrogen, 8 kg phosphorus, and 22 kg potassium in its manure.

Animal manures have a long history of being used for fertilizer to support crop or pasture growth. Manure is nature's way of recycling nutrients. For example, a horse on pasture obtains nutrients from the grass it eats and poops out nutrients it can't digest from the grass and those that are in excess of the body's needs. This nutrient-rich manure then feeds the grass so it can grow and the horse can eventually eat it again. But just as the horse can't extract all of the nutrients from the grass it eats, the grass also can't extract all the nutrients from the manure. If too many horses are kept on the pasture, there can be an accumulation of nutrients in the soil. This accumulation of nutrients is accelerated when outside feed sources like hay and grain are "imported" onto the farm – that is to say, feeds that are grown somewhere else are brought in to feed the horse, adding to the nutrient load of the pasture/soil. If chemical fertilizers are also applied indiscriminately, nutrients in the soil accumulate even further. If such practices are continued, eventually the soil will contain more nutrients than the pasture grass can use.

When soils are saturated with nutrients, there is a greater risk for those nutrients to leach into ground water or be caught up in storm water runoff where they can enter rivers, streams and lakes. Similarly, storm water that comes in direct contact with manure storage areas can leach out nutrients, which eventually make their way to water sources. Manure can contain significant quantities of nitrogen, phosphorus, and potassium, and smaller amounts of nutrients such as copper, zinc and selenium. Such nutrients are known to degrade water quality by causing eutrophication, killing aquatic life, and negatively affecting water used for drinking and recreation.

In recent years, there has been increased monitoring and regulation of manure management practices due to recognized risks to water quality (in Alberta, manure management requirements are outlined in the Standards and Administration Regulation of the Agricultural Operation Practices Act; see Agdex Factsheet 096-7). In some species of livestock, this oversight has extended to the diets fed to the animals in an effort to minimize the nutrient content of manure. Although similar dietary restrictions have not been placed on the horse industry, some of the same strategies employed in food animal production can be proactively implemented by horse owners to improve environmental sustainability.

Turning "Oats" into Environmentally-Friendly Road Apples

As discussed above, the nutrient composition of manure is influenced primarily by the nutrient content of the diet consumed. Therefore, feeding programs that reduce total nutrient output in manure, as well as dietary strategies that yield manure nutrients in a more environmentally-stable form have the potential to decrease nutrient loss to runoff and leaching.

Approaches for reducing nutrient excretion have been, and continue to be, studied extensively

in swine, poultry and cattle. By comparison, research in this area in horses is just beginning. This paper will highlight key nutrition concepts and offer some simple feeding strategies that can be implemented by horse owners in an effort to create more environmentally-friendly manure.

Strategy #1: Avoid Over-Supplementation of Minerals

One of the nutrients of major concern with respect to degradation of water quality is the mineral phosphorus. Phosphorus plays many important roles in the body, including serving as an element of bone and as a necessary component of energy metabolism, so the horse does require a daily supply of this mineral. Horses obtain phosphorus from forages, cereal grains (oats, corn, barley), and grain byproducts like wheat bran and rice bran. In addition, inorganic phosphorus sources (e.g., dicalcium phosphate) are often added to fortified commercial feeds and included in mineral supplements. Unfortunately, the availability of phosphorus from forages and grains, as well as inorganic sources can be fairly low (only 32-47% of the phosphorus is absorbed). Thus, to meet the horse's requirements, a higher level must be fed.

The amount of phosphorus excreted in manure is directly related to phosphorus intake (Lawrence et al 2003a,b). Feeding high levels of phosphorus not only results in greater phosphorus excretion, but also increases the amount and proportion of phosphorus that is water-soluble (Weir et al 2013; Westendorf & Williams 2011). Water-soluble phosphorus is the form of phosphorus that is most susceptible to loss in the environment. Thus, a simple and effective strategy for reducing phosphorus excretion is to minimize excess phosphorus in the diet. However, the characteristics of feeds commonly fed to horses may make some level of overfeeding unavoidable. For example, the phosphorus requirements of a mature, mostly sedentary horse are often exceeded simply by feeding the amount of hay necessary to meet their daily caloric needs. But if this same horse was also provided with a mineral supplement containing phosphorus, elimination of the supplement from the diet would be a good way to reduce phosphorus excretion into the environment.

Another approach to reduce phosphorus excretion is to improve the digestibility of phosphorus in the diet. Over two-thirds of the phosphorus in grains and grain byproducts is organically bound in the form of phytate-phosphorus. The enzyme phytase is needed to cleave off the phosphorus so it can be absorbed. This enzyme is not produced by animals, but it can be produced by the microorganisms that reside in the digestive tract. As a result, phytate-phosphorus poses little problem to cattle and other ruminants, due to the extensive microbial population of the rumen. In contrast, monogastric animals such as swine and poultry have less microbial activity in the gut, which lowers their ability to absorb phytate-bound phosphorus. In these species, the addition of exogenous phytase to the diet can greatly improve phosphorus availability, thereby permitting lower levels of phosphorus inclusion in the diet and simultaneously reducing phosphorus excretion in the manure. A handful of studies have evaluated the addition of phytase to the diet of horses; however, no improvements of phosphorus digestion or reductions in phosphorus excretion have been observed (Lamprecht et al 2013; Morris-Stroker et al 2001; Patterson et al 2002; van Doorn et al 2004). It is likely that the microbial population in the horse's hindgut provides sufficient phytase activity, similar to a cow. Given the low availability of phosphorus from common feed sources, other strategies for improving phosphorus absorption need to be investigated.

Trace minerals, including copper, zinc, manganese, and selenium are needed by horses in small amounts. These elements are also heavy metals, and are toxic to plants at high concentrations. Excessive intake or supplementation of these trace minerals, as well as digestive inefficiency and antagonism between other minerals in the diet, generally leads to greater trace mineral excretion. Excretion of trace minerals in manure may be relatively low compared to that generated by repeated use of metal-enriched chemicals and fertilizers and soil amendments consisting of sewage sludge and waste water; however, there is still concern that the soil where manure is applied or where animals are housed in concentrated numbers may become contaminated with heavy metals over time.

Similar to other nutrients, the form of the trace mineral can affect its digestibility. Inorganic sources of trace minerals that are commonly included in livestock rations are in the form of sulfates or oxides (e.g., zinc sulfate, zinc oxide). The use of organic trace minerals sources, including minerals bound to amino acids or proteins has increased in recent years. Although there is variation in the response between different minerals (e.g., zinc, copper, manganese) and different organic forms (e.g., proteinate, chelate) from study to study, in general, research in ruminants, swine and poultry have shown that the availability of organic trace minerals is equal to or greater than the most digestible inorganic form of the same mineral (Guo et al 2001; Rojas et al 1996; Wedekind et al 1992, 1994). Comparison of trace mineral sources also been studied in horses (Miller et al 2003), but systematic evaluation of relative mineral digestibility between organic and inorganic mineral sources has yet to be addressed in horses, as it has in other livestock. Organic mineral sources are usually more expensive compared to their inorganic counterparts, which has limited their commercial application to just a fraction of the total trace mineral fortification in most products. Interestingly, the total concentration of trace minerals in commercial horse feeds and supplements has not been adjusted downward when organic mineral sources are included. In theory, if the organic forms of these minerals are more digestible, the mineral supply in the diet can be lowered. If mineral intake is lowered, then mineral excretion will be reduced.

Although research on strategies to reduce mineral excretion in horse manure is on-going, horse owners can act now by avoiding unnecessary supplementation. We are often tempted to follow the philosophy that if a little is good, more is better. However, we aren’t doing our horses (or the environment) any favors by providing minerals beyond the horse’s ability to use them. A few “rules of thumb” can be used to determine whether you really need an additional mineral supplement in your horse’s diet. If you are feeding a commercial concentrate and are feeding the minimum amount recommended by the manufacturer (usually 0.5% of body weight), then you probably don’t need to provide a mineral supplement. In contrast, if your horse only receives forage (hay or pasture) and no concentrate, if you feed unfortified grains like plain oats, or if you feed less than the minimum recommended amount of a fortified commercial concentrate, then you probably need to provide a trace mineral supplement containing copper and zinc (and possibly selenium, depending on your location), but you might not need a supplement that contains macro minerals like calcium or phosphorus. Remember to account for the minerals that might be in all the other dietary supplements you give your horse. For example, many hoof supplements contain significant amounts of zinc and other trace minerals. Consult with an equine nutritionist if you are unsure whether you are meeting your horse’s nutrient requirements.

Strategy #2: Minimize Over-Feeding of Protein

The other major nutrient of concern with respect to water pollution is nitrogen. The main source of nitrogen in the horse's diet is protein. Proteins are digested and absorbed as amino acids, urea, and ammonia (all containing nitrogen). Once absorbed, the amino acids can be made back into proteins that perform a variety of vital functions in the body. Absorbed amino acids that are not used for protein synthesis are deconstructed, and the nitrogen (in the form of urea) is excreted in the urine. Significant amounts of nitrogen are also excreted in the feces, as not all dietary protein is absorbed.

Similar to minerals, the higher the dietary intake of nitrogen (as protein and amino acids), the higher the excretion of nitrogen in manure (Lawrence et al 2003a,b). In practice, many horses are consuming diets well above their protein requirements. Some of this protein excess is unavoidable based on the types of feed ingredients commonly used in equine diets. For example, the protein to calorie ratios of most feedstuffs exceed the requirements for adult pleasure and performance horses. Therefore, when these horses are fed at a level to meet their calorie requirements, protein will be overfed. Similarly, the feeding of alfalfa to mature horses will often exceed their protein requirements (some of you can surely relate to the eye-watering, high-ammonia experience of a barn full of horses being fed alfalfa!) Additionally, commercially-prepared concentrate feeds are typically formulated to provide adequate nutrition, even when paired with low quality forages. As a result, excess protein intake can occur when these commercial feeds are fed with high quality forages. In other cases, horse owners intentionally overemphasize protein in the diet, usually due to a misunderstanding of when or why more protein might be needed. Feeding protein above established requirements does not confer any additional health benefits and won't make a horse grow faster or jump higher.

Animals do not have a requirement for protein per se, but for the amino acids that make up the proteins. The closer the amino acid composition of the diet matches the horse's requirements, the less total protein the horse needs and the less nitrogen is excreted. Unfortunately, plant proteins rarely supply amino acids in the required ratio; therefore, feedstuffs are combined to meet the animal's needs for the most-limiting essential amino acids. This practice usually results in a higher than required protein content of the diet due to the presence of other, less essential amino acids in the feed.

Lysine and threonine are the two most limiting amino acids in equine diets, particularly for growth. Ingredients such as canola meal or soybean meal are considered good quality protein sources for horses, in part because they contain a relatively larger proportion of these amino acids. However, as mentioned above, these sources still supply a large amount of less essential amino acids. To improve the supply of key amino acids, crystalline amino acids such as lysine, methionine, and threonine are often added to commercial feed products (especially "growth" or "mare & foal formulas"). In principle, the addition of specific amino acids to a feed product should lower the need for high-protein ingredients like canola meal and soybean meal in the mix. The end result is that less total protein can be fed, ultimately reducing the nitrogen content of manure. Staniar et al. (2001) found no differences in the growth of weanlings fed either a 14% crude protein supplement or a 9% crude protein supplement fortified with 0.6% lysine and 0.4% threonine when combined with mixed grass and clover pasture. Although this study did

not assess excretion of nitrogen, it demonstrated that optimum growth can be obtained with lower total protein content when the diet is fortified with limiting amino acids. To determine the effects of a protein restricted diet on exercise performance, Graham-Thiers et al. (2000) fed mature horses either a 14% crude protein diet or a diet with 7.5% crude protein supplemented with 0.5% lysine and 0.3% threonine. Horses fed the lower protein diet fortified with amino acids performed similarly to those on the higher protein diet during conditioning and exercise testing. In addition, excretion of urea-nitrogen in urine was reduced nearly 50% when horses were fed the low protein diet augmented with amino acids.

Amino acid requirements have been studied extensively in swine and poultry, but not horses. Compared to rations fed to other monogastric species, equine diets are more variable in content and composition, posing greater challenges in determining the amino acid requirements of horses. Much more research is needed before we can take full advantage of feeding a specific amino acid profile in our efforts to reduce total protein intake and thereby reduce nitrogen excretion in the manure.

In the meantime, there are some feeding practices that horse owners can implement to minimize protein overfeeding. Firstly, reserve the use of alfalfa hay (and alfalfa/grass mix hays that are more alfalfa than grass) for horses that have high protein requirements, such as growing horses and lactating mares. For all other horses, a nice quality grass hay should suffice. Secondly, if you utilize a commercial fortified feed, be sure to select a product that has been formulated for the type of horse you will be feeding it to. Protein requirements are highest in growing horses and lactating mares, but are much lower for performance and idle horses. As discussed in the next section, feed manufacturers create different formulas to accommodate horses with differing nutrient needs. For example, a commercial feed formulated for growing horses would have a high level of protein, and thus wouldn't be an environmentally-sound choice for a 12-year old gelding used for barrel racing. If you want to go one step further, you can base your feed selection on the amino acid (eg, lysine) content, rather than how much crude protein is in the product. Commercial feeds suitable for weanlings, yearlings and lactating mares should have at least 0.7% lysine, whereas all other horses do well with 0.5% lysine (note: this assumes you are also feeding a reasonable quality forage). Finally, pay attention to the all the supplements you provide your horse, as many contain protein that can further increase nitrogen intake and excretion.

Strategy #3: Match the Feed to the Horse

The final strategy for making those road apples more environmentally-friendly is to more closely match the nutrients in the feed with the nutrient requirements of the horse. This can be accomplished by selecting a hay and a fortified commercial feed (if needed) that are best suited for your horse.

Nutrient requirements vary due to age, growth rate, level of activity, pregnancy, milk production, and gender (see Table 1). Growing horses (nursing foals, weanlings, yearlings) and lactating mares generally have the highest requirements for protein and minerals. Next in line are pregnant mares, young horses entering training, and mature horses performing heavy work. Sedentary horses and those performing light to moderate work have lower protein and mineral

requirements.

TABLE 1: Daily nutrient requirements of a horse weighing 550

Class of Horse	Total Daily Feed Intake (% body wt)	Digestible Energy (Mcal)	Crude protein (grams)	Lysi (gran
Sedentary	2.0	18.3	693	
Light work	2.0	22.0	769	
Moderate work	2.25	25.6	845	
Heavy work	2.5	29.3	948	
Stallion	2.0	24.0	868	
Early gestation	2.0	19.2	774	
Late gestation	2.0	23.5	982	
Lactation	2.5	34.9	1689	
6 month old weanling	2.5	17.1	744	
12-month old yearling	2.5	20.7	930	
18-month old	2.5	21.2	879	
2-year old in training	2.5	27.3	977	

When it comes to selecting hay, alfalfa and grass/alfalfa mix hays are more suitable for growing horses and broodmares. Legume forages like alfalfa are usually much higher in protein than grass forages, making them a better match for horses that have higher protein requirements. By comparison, most other classes of horses can do well on a reasonable quality grass hay, which usually has a more moderate level of protein. Use of a grass hay for horses that have lower protein requirements helps to lessen protein excess in the diet, ultimately reducing nitrogen output in feces and urine.

Because nutrient requirements differ between different classes of horses, most feed companies offer at least 3 primary formulations: 1) “mare & foal” (or “growth”) formula suitable for lactating mares, weanlings and yearlings; 2) “performance horse” formula suitable for stallions, pregnant mares, and horses performing moderate to heavy work; and 3) “maintenance” formula suitable for stallions and horses performing light to moderate work. Many aspects of these formulas can differ (eg, starch, fat and fiber content), however when it comes to the protein and mineral fortification, they typically align with the type of horse the feed was created for. Thus, a “mare & foal” formula would have higher levels of protein, lysine, and minerals, because growing horses and lactating mares have higher requirements for these nutrients. At the other end of the spectrum, a “maintenance” formula usually has comparatively lower levels of protein and minerals. If you match your horse with the appropriate feed product, and feed that product correctly (according to manufacturer directions), you can meet your horse’s requirements and lessen nitrogen and mineral excretion in manure.

Several feed companies offer feeds and mineral supplements that are designed to complement either grass forages or legume forages, which allows further fine-tuning of protein and mineral intake. Because legumes like alfalfa contain more protein, the products designed to be paired with them generally have less protein (and minerals like calcium) than those designed to accompany grass forages. The end result is a reduction in overall protein intake (and thus, nitrogen output in the manure).

Don’t Forget to Properly Manage the Road Apples!

While sound feeding practices can reduce nutrient excretion in manure, all of your dietary adjustments will be for naught if you fail to properly manage your horse manure. **Proper handling, storage and disposal of manure are key to minimizing negative environmental impacts.** Manure should be stored in a manner that prevents storm water from leaching or carrying away nutrients where they can enter water bodies. Pastures should undergo regular soil testing and appropriate rates of fertilizer (chemical or manure) applied at the appropriate time of the year and at an appropriate distance from potable water wells, streams, sloughs, rivers and lakes. Additionally, manure should be removed on a regular basis from high density areas where horses congregate in pastures or in small corrals and paddocks where there is no grass to utilize the nutrients. For more information on good manure and pasture management practices, refer to Agdex publication 460/27-1 “Manure and Pasture Management for Horse Owners” and Agdex factsheet 096-7 “Manure Management Regulations for Horse Owners”).

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