I originally created this worksheet to help you understand the basics of what is in your hay and how you can correct major imbalances – while getting through the basic math. It is presented in a step by step form with no math shortcuts and you should be able to navigate easily with just a basic calculator.

This is not a substitute for professional advice. There are many factors which influence how your hay should be balanced that are beyond the scope of a simple worksheet – age and health of horse, breed, weight, use (work), pregnancy and lactation, medications, severe debilitation or obesity, etc. This worksheet should simply be considered a starting point you can use to begin learning and understanding the basic concepts of balancing and how the many different elements of the equine diet interact.

The "goals" or "targets" in this worksheet are based on those developed by Dr. Eleanor Kellon and NRC (National Research Council) recommendations. These guidelines are continually being refined as new information becomes available.

The science behind NRC requirements is many layered. This worksheet is simply the "math", there are several good resources that can help demystify the basic elements and nutrients.

The NRC *Nutrient Requirements of Horses* Sixth Revised Edition became available in 2007. It includes in depth discussions of most of the factors affecting equine nutrition. It's available directly from the National Academies press at http://books.nap.edu/catalog.php?record_id=11653.

A basic table of NRC Nutrient Requirements (from the 1989 edition) is available on the Equi-Analytical website, http://equi-analytical.com/nutrient-requirement-tables/

Current (2007) NRC Requirements can be calculated using the NRC online program at http://nrc88.nas.edu/nrh/.

If you've taken any of Dr. Eleanor Kellon, VMD's NRC Plus classes (http://drkellon.com/), you'll notice that I approach the math a bit differently and our final results may vary by a few milligrams here and there but there should be no substantial difference in the results. If you do get lost, you can reach me at DesertEquineBalance@gmail.com.

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HAY ANALYSIS BALANCING WORKSHEET – Use "As Fed " or "As Sampled" Basis Column

ESC = _____ % (simple sugar)
Starch = _____ %
Total S/S = _____ % (Target < 10% for IR horses)

Horse DE (Mcal) _____ Mcal/lb x _____ lbs = _____ Mcal (thousand calories)
Crude Protein (CP) _____% ÷ 100 =_____ x 453.6 =_____ x _____ lbs = _____ g Protein

CALCULATE THE MAJOR MINERALS IN YOUR HAY

Phosphorus (P) _____% ÷ 100 = _____ x 453.6 = _____ x _____ lbs = _____ g P
Calcium (Ca) _____% ÷ 100 = _____ x 453.6 = _____ x _____ lbs = _____ g Ca
Potassium (K) _____% ÷ 100 = _____ x 453.6 = _____ x _____ lbs = _____ g K
Magnesium (Mg) _____% ÷ 100 = _____ x 453.6 = _____ x _____ lbs = _____ g Mg
Sodium (Na) _____% ÷ 100 = _____ x 453.6 = _____ x _____ lbs = _____ g Na

MAJOR MINERAL RATIOS

Ca _____ g ÷ P _____ g = _____ Goal 1.5 to 2 *
Ca _____ g ÷ Mg _____ g = _____ Goal 1.5 to 2

Need to add: **

Ca _____ g ÷ 2 = _____ g – P _____ g = _____ gm Phosphorus needed
Ca _____ g ÷ 2 = _____ g – Mg _____ g = _____ gm Magnesium needed (maximum 24g)

* If the Ca:P ratio is less than 1:1 (an "inverted ratio"), additional Calcium needs to be added and the ratio rechecked.
**If you need to add Ca based on 1-1/2 to 2x NRC requirements or to correct the Ca: P ratio, recheck P and Mg needed based on the adjusted Ca (hay plus what you added).

CALCULATE THE TRACE MINERALS IN YOUR HAY

Copper (Cu) _____ppm ÷ 2.2 = _____ = mg/lb x _____ lbs fed = _____ mg Cu
Iron (Fe) _____ppm ÷ 2.2 = _____ = mg/lb x _____ lbs fed = _____ mg Fe
Zinc (Zn) _____ppm ÷ 2.2 = _____ = mg/lb x _____ lbs fed = _____ mg Zn
Manganese (Mn) _____ppm ÷ 2.2 = _____ = mg/lb x _____ lbs fed = _____ mg Mn
Molybdenum (Mo) _____ppm ÷ 2.2 = _____ = mg/lb x _____ lbs fed = _____ mg Mo

TRACE MINERAL RATIOS

✓ **Iron to Copper ratio – goal is 4 : 1**

Fe _____ mg ÷ Cu _____ mg = _____ The target is 4 (but less than 10:1 is acceptable, may be lower than 4:1 if Mn is high)

Copper Needed

Fe _____ mg ÷ 4 = _____ - Cu _____ mg in hay = _____ mg. This is how much Copper you need to add.

Total Copper

Add the Copper in your hay plus how much copper you need to add = mg **Total Copper**

✓ **Copper to Zinc ratio – goal is 1 : 3**

Total Cu _____ mg x 3 = _____ - Zn _____ mg in hay = _____ mg. This is how much Zinc you need to add.

Total Zinc

Add the Zinc in your hay plus how much zinc you need to add = mg **Total Zinc**

✓ **Manganese should be 50% of Zinc (see target notes)**

Total Zn _____ mg x 0.5 = _____ - Mn _____ mg in hay = _____ mg. This is how much Manganese you need to add.

If this is a negative number, you need to increase copper until Cu:Mn is 1:3 or less, and recheck the copper to zinc ratio.

✓ **Check Your Copper to Molybdenum ratio**

Total Cu _____ mg ÷ Mb _____ mg in hay = _____ This should be larger than 6. If less than 6, need to increase copper.

SUMMARY

Mineral	Hay Provides	Need to Add	Total
Phosphorus (P	_____ g	_____ g	_____ g
Calcium (Ca)	_____ g	_____ g	_____ g
Potassium (K)	_____ g		
Magnesium (Mg)	_____ g	_____ g	_____ g
Sodium (Na)	_____ g	_____ g	_____ g
Iron (Fe)	_____ mg		
Copper (Cu)	_____ mg	_____ mg	_____ mg
Zinc (Zn)	_____ mg	_____ mg	_____ mg
Manganese (Mn)	_____ mg	_____ mg	_____ mg

FINAL RATIOS - use mineral totals from summary above

Ratio	Target	Final Ratios
Calcium to Phosphorus	1.5 to 2 : 1	Ca ÷ P = _____ : 1
Calcium to Magnesium	1.5 to 2 : 1	Ca ÷ Mg = _____ : 1
Iron to Copper	4 : 1	Fe ÷ Cu = _____ : 1
Copper to Zinc	1 : 3	Zn ÷ Cu = 1 : _____
Copper to Manganese	less than 1 : 3	Mn ÷ Cu = 1 : _____
Zinc to Manganese	1 : 1 or lower	Zn ÷ Mn = _____ : 1

Targets

Acceptable **simple sugar (ESC) plus starch target levels** for IR horses have been continually adjusted downward as we have learned more about how these affect the IR and Cushing's horse. The goal is simple **sugar plus starch less than 10%.**

Protein 8-12%. Protein requirements depend on age, weight, use and reproductive status of the horse, and the quality and digestibility of the protein. Higher protein for maintenance isn't harmful but may increase urination and contribute to loss of electrolytes (major minerals).

Horse DE (Digestible Energy - calories) is presented in Mcal. Again, requirements vary with age, weight, use, reproductive status, body structure and individual metabolism. The source of the energy (fermentable fiber vs. carbohydrates vs. fats) and health status of the horse will also affect how nutrients are digested and utilized. The NRC estimated requirement for a 400kg/880lb mature horse in maintenance is 13.4 Mcal/day.

Calcium should be about 1.5 to 2 times the current NRC published requirements. This requirement varies depending on weight, age, use and reproductive status. The NRC requirement for a 400kg/880lb mature horse in maintenance is 16 grams Ca, so target would be at least 24 grams of Calcium.
Ca to P Ratio - Calcium should be 1-1/2 to 2 times phosphorus (1.5 to 2 : 1 ratio)
There should never be an inverted Ca:P ratio (more Phosphorus than Calcium). Mature horses can tolerate a Ca:P ratio of up to 6:1 for a short time as long as they are receiving sufficient Phosphorus but this should not be maintained for a long period of time. Growing horses require a Ca:P ratio below 2:1 to avoid developmental orthopedic problems (ideal is 1.5 to 1.7:1).
Ca to Mg Ratio - Calcium should also be 1-1/2 to 2 times magnesium (1.5 to 2 : 1 ratio) but added magnesium may be capped at 20-24 grams if calcium is very high.

Iron should ideally be about 4 times **Copper** (4:1 ratio) or less, but not more than 10 times Copper.
If large amounts of Copper are required to achieve this ratio – more than 4 or 5x NRC, your work should be checked with someone experienced in mineral balancing.

Copper to Zinc to Manganese 1 : 3 : 1.5
Zinc should be approximately 3 times the Copper level (Cu:Z 1:3).
Manganese should be around 1.5x NRC, at least 50% of Zinc and not higher than Zinc. If manganese levels are higher than zinc, you'll need to balance for a Cu:Mn ratio of 1:3 or less – the resulting Fe:Cu ratio may end up being quite low.
High Molybdenum (Mo) levels are rare. Copper should be at least 6 times Mo.

Long standing (chronic) deficiencies/excesses, toxic levels of some minerals (such as aluminum or arsenic) or problem geographical growing areas (such as acid rain) may require that different ratios be used or that higher than normal supplementation of some specific minerals is used. If any nutrient varies greatly from these goals, or if large amounts of a mineral (more than 4-5 x NRC values) are required to get within target ranges, major minerals may need to also be adjusted.

Other nutrients

Ensure that you are also meeting your horse's requirements for sodium (salt), iodine, selenium, vitamin E and Omega-3 fatty acids. While the requirements for these are not large they are vitally important. Salt and iodine, especially, are frequently overlooked and fear of over supplementing often results in a deficiency of selenium. The "average" horse should receive an ounce of salt year round to provide sodium and chloride, 3 to 6 mg of iodine per day and can safely be given 2 mg of selenium per day if the selenium status of your forage is unknown. (Over-supplementation is usually caused by combining multiple supplements.) As vitamin E and Omega-3 fatty acids are rapidly depleted from cured hay, these should be supplemented when there is no access to active growing pasture.

Most other vitamins and minerals do not require supplementation for healthy horses receiving a quality forage-based diet as they are either abundantly available or manufactured or stored in the body but special conditions or issues may make supplementing additional nutrients advisable. Old hay (more than six to twelve months since curing) may no longer provide sufficient vitamin A and horses not exposed to sunlight may require some vitamin D. Older horses may no longer produce sufficient B-vitamins in their gut

If in doubt – be safe and have someone check your work.

