NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

NUTRIENT MANAGEMENT (ACRE)

CODE 590

DEFINITION

Nutrient Management is managing the amount, source, placement, form, and timing of the application of nutrients and soil amendments.

PURPOSE

- To budget and supply nutrients **and soil amendments** for plant production.
- To properly utilize manure or organic byproducts as a plant nutrient source.
- To minimize agricultural and non-point source pollution of surface and ground water resources.
- To maintain or improve the physical, chemical and biological condition of the soil.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all lands where plant nutrients and soil amendments are applied **including but not limited to organic wastes, commercial fertilizer, legume crops, crop residues, and biosolids**.

CRITERIA

General Criteria Applicable to All Purposes

Plans for nutrient management shall comply with all applicable federal, state and local laws and regulations.

Plans for nutrient management shall be developed in accordance with policy requirements of the NRCS General Manual Title 450, Part 401.03–Technical Guides, Policy and Responsibilities and Title 190, Part 402–Ecological Sciences, Nutrient Management, Policy); **Montana Amendment MT402**; technical requirements of the NRCS Field Office Technical Guide (FOTG), procedures contained in the National Planning Procedures Handbook (NPPH), and the NRCS National Agronomy Manual (NAM), Section 503.

Persons who review or approve plans for nutrient management shall be certified through any certification program acceptable to NRCS with the state. **In Montana nutrient management certification is obtained through job approval authority (JAA) policy and procedures.**

Plans for nutrient management that are elements of a more comprehensive conservation plan shall recognize other requirements of the conservation plan and be compatible with its other requirements **(i.e., FSA compliance plans, waste utilization, or integrated crop/pest management).**

The nutrient management plan is a dynamic tool and must be monitored and adjusted on an annual basis, if appropriate. As a minimum, a nutrient budget for nitrogen **(NO_3)**, phosphorus **(P_2O_5)**, and potassium **(K_2O)** shall be developed that considers all potential sources of nutrients including, but not limited to, animal manure and organic by-products, waste water, commercial fertilizer, crop residues, legume credits, **biosolids**, and irrigation water.

Develop a nutrient management plan specifically for crop(s) to be grown. The plan must include documentation of crop rotation, source and amount of plant nutrients that will be used to meet the crop yield goals.

NRCS, MT
August 2001

Conservation practice standards are reviewed periodically and updated if needed. To obtain the current version of this standard contact the Natural Resources Conservation Service.

NOTE: This type of font **(AaBbCcDdEe 123..)** indicates NRCS National Standards.
This type of font (AaBbCcDdEe 123..) indicates Montana Supplement.

Realistic yield goals shall be established based on soil productivity information, historical yield data, climatic conditions, level of management and/or local research on similar soil, cropping systems, and soil and manure/organic by product tests. For new crops or varieties, industry yield recommendations may be used until documented yield information is available.

Yield goals of cereals and safflower can be calculated using the following procedure:

Refer to FOTG, Section IV, Practice Standards and Specifications, 328–Conservation Crop Rotation to determine: (a) plant available soil moisture, and (b) growing season precipitation in inches based on 70 percent probability. Determine consumptive use from FOTG, Section I, Maps, Irrigation Climatic Areas for Montana, 1986. Then, estimate yields using TABLES 1, 2, 3, 4, or 5 for the specific crop.

Where available, other Montana State University (MSU) Extension Service approved yield data may also be used to calculate realistic yield goals.

Plans for nutrient management shall specify the form, source, amount, timing, and method of application of nutrients on each field to achieve realistic production goals, while minimizing nitrogen and/or phosphorus movement to surface and/or ground waters.

Erosion, runoff, and water management controls shall be installed, as needed, on fields that receive nutrients**. Water erosion prediction estimates must meet soil loss tolerance levels for the design soil during years when nutrients are applied**.

Soil Sampling and Laboratory Analysis (Testing)

Nutrient planning shall **begin** based on current soil test results developed in accordance with **MSU Extension Service** guidance**. Proper testing for nutrient levels in the soil, irrigation water, and organic wastes that are to be applied in the field provide the information necessary to use the "Fertilizer Guidelines in Montana" handbook. The tables in the Fertilizer Guidelines for Montana represent total amounts of nutrients required. Proper soil testing technique is discussed in the MontGuide MT 8602.**

Soil samples shall be collected and prepared according to **MSU Extension Service** guidance.

Soil testing shall include analysis for any nutrients for which specific information is needed to develop the nutrient plan. Analyses pertinent to monitoring or amending the annual nutrient budget may include, for example, pH, electrical conductivity (EC), soil organic matter, nitrogen, phosphorus, potassium, **and micronutrients.**

Current soil tests must be used to effectively plan for nutrient application. Current soil tests are those that are no older than five years. **Nitrogen will be analyzed each year a crop is grown. Phosphorus and potassium will be completed once every three years until a baseline or consistent database is established. Application of micro-nutrients should be based on soil tests or plant analysis.**

Regular testing of soil nutrient availability is essential for proper nutrient management decision making. Soil tests should be completed as close as possible to time of seeding for best results. Organic matter (OM) will mineralize approximately 10–20 pounds of nitrate nitrogen for every one percent of organic matter. For nutrient budgeting purposes credit, credit OM with:

- **dry land—10 lbs. NO_3 per acre per 1% OM (maximum 30 lbs.)**
- **irrigated land—20 lbs. NO3 per acre per 1% OM (maximum 60 lbs.)**

Where annual precipitation is less than 14 inches, zero pounds of nitrate nitrogen credit for mineralization should be assigned.

Plant Tissue Testing

Tissue sampling and testing, where used, shall be done in accordance with **MSU** standards and recommendations.

Nutrient Application Rates

Soil amendments shall be applied, as needed, to adjust soil pH to the specific range of the crop for optimum availability and utilization of nutrients. **For amendments and rates to correct sodium affected soils see TABLE 10 for Gypsum Requirements of Sodium Affected Soils.**

Recommended nutrient application rates shall be based on **Fertilizer Guidelines for Montana, MSU Extension Service EB 104**, that consider current soil test results, realistic yield goals, and management capabilities.

The planned rates of nutrient application, as documented in the nutrient budget, shall be determined based on the following guidance:

- **Nitrogen Application**—Planned nitrogen application rates shall match the recommended rates as closely as possible, except when manure or other organic by products are a source of nutrients. When manure or other organic by products are a source of nutrients, see "Additional Criteria" below.
- **Phosphorus Application**—Planned phosphorus application rates shall match the recommended rates as closely as possible, except when manure or other organic by-products are a source of nutrients. When manure or other organic by-products are a source of nutrients, see "Additional Criteria" below.
- **Potassium Application**—Excess potassium shall not be applied in situations in which it causes unacceptable nutrient imbalances in crops or forages.
- **Other Plant Nutrients**—The planned rates of application of other nutrients shall be consistent with **Fertilizer Guidelines for Montana, MSU Extension Service EB 104.**
- **Starter Fertilizers**—Starter fertilizers containing nitrogen, phosphorus and potassium may be applied in accordance with **Fertilizer Guidelines for Montana, MSU Extension Service EB 104. When starter fertilizers are used, they shall be included in the nutrient budget.**

Nutrient Application Timing

Apply nutrients as close to the time of plant utilization as possible. Nitrogen application in the fall is not recommended except for fall seeded crops, with the exception of "starter fertilizer." Nutrient application is limited to the designed amounts based on crop and soil needs.

Nutrient Application Methods

Nutrients shall not be applied to frozen, snow covered, or saturated soil if the potential risk for runoff exists. **Potential runoff risk will be determined using the Revised Universal Soil Loss Equation (RUSLE) with site specific cropping system data. Potential risk for runoff will be considered negligible if map unit slopes are less than two percent and calculated soil loss prediction is less than five T/A/Y.**

Determine the vulnerability of nitrogen and phosphorus leaching or runoff for the specific location. Soil vulnerability maps, found in Section II, FOTG, Water Quantity and Quality Interpretations.

Nutrient applications associated with **application through** irrigation systems **(fertigation)** shall be applied in accordance with the requirements of FOTG, Section IV, Practice Standards, 449–Irrigation Water Management.

Additional Criteria Applicable to Manure or Organic By-Products Applied as a Plant Nutrient Source.

Nutrient values of manure and organic by-products) excluding sewage sludge) shall be determined prior to land application based on laboratory analysis (**See Ag. Waste Management Field Manual, Chapter 16**). **If samples are not taken, refer to FOTG, Section IV, Practice Standards, 633–Agricultural for estimated N, P, and K. Additional nutrient values may be found in the NRCS Ag. Waste Management Field Handbook, Chapter 4–Agricultural Waste Characterizations.**

Nutrient Application Rates

The application rate (in/hr) for material applied through irrigation shall not exceed the soil intake/infiltration **rate (see Montana Irrigation Guide, APPENDIX A).** The total application shall not exceed the field capacity of the soil.

The planned rates of nitrogen and phosphorus application recorded in the plan shall be determined based on the following guidance:

- **Nitrogen Application** – When the plan is being implemented on a "phosphorus standard" **or basis**, manure or other organic by-products **(in consideration of nitrogen contents)** shall be applied at rates consistent with the phosphorus standard. In such situations, an additional nitrogen application, from non-organic sources, may be required to supply the recommended amounts of nitrogen.

  Manure or other organic by-products may be applied on legumes at rates equal to the estimated removal of nitrogen in harvested plant biomass. **(See NRCS Ag. Waste Field Handbook, Chapter 6–TABLE 6-6)**

- **Phosphorus Application** – When manure or other organic by-products are used, the planned rates of phosphorus application shall be consistent with Soil Test Phosphorus.

  – **Soil Test**. **Phosphorus will be applied according to nitrogen requirements until optimum levels are exceeded. If optimum levels are exceeded, phosphorus will be applied at crop removal rates. No manure will be applied on sites where soil test phosphorus levels are excessive. (See TABLE 9).**

A single application of phosphorus applied as manure may be made at a rate equal to the recommended phosphorus application or estimated phosphorus removal in harvested plant biomass for the crop rotation or multiple years in the crop sequence **(i.e. alfalfa, grasses)**. When such applications are made, the application rate shall:

– not exceed the recommended nitrogen application rate during the year of application, or

– not exceed the estimated nitrogen removal in harvested plant biomass during the year of application when there is no recommended nitrogen application, or

– not be made on sites considered vulnerable to off-site phosphorus transport unless appropriate conservation practices, best management practices, or management activities are used to reduce the vulnerability.

Field Risk Assessment

When animal manure or other organic by-products are applied, a site-specific assessment of the potential for phosphorus transport from the field shall be completed. This assessment may be done by using the **Phosphorus Index (PI). Refer to Agronomy Technical Notes, Nutrient Management 80.1 or** other recognized assessment tool as approved by the **state resource conservationist.**

In such cases, plans shall include:

- a record of the **Phosphorus Index (PI)** assessment rating for each field of sub-field, and
- information about conservation practices and management activities that can reduce the potential for phosphorus movement from the site.

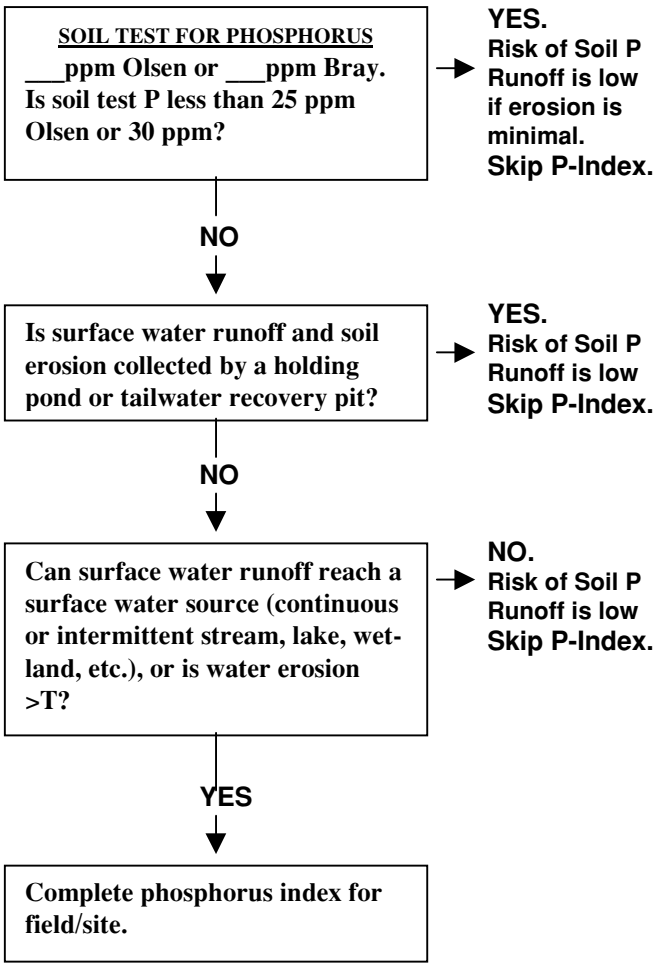
When such assessments are done, the results of the assessment and recommendations shall be discussed with the producer during the development of the plan.

When the phosphorus index (PI) assessment is N/A, low, or medium, nitrogen based phosphorus application plans will be developed such that manure application rates of nitrogen do not exceed crop needs based on the nutrient budget. (See TABLE 8)

When the phosphorus index (PI) rating is high, phosphorus-based plans will be developed (See TABLE 8) such that manure application rates of phosphorus do not exceed crop removal rates. (See TABLE 9)

When the phosphorus index (PI) rating is very high, phosphorus-based plans should be developed (See TABLE 8) such that manure application rates of phosphorus do not exceed crop removal rates or no application of manure will be recommended. (See TABLE 9)

Use the following preliminary screening tool to determine whether there is potential for phosphorus non-point source pollution:



Heavy Metals Monitoring

When sewage sludge is applied, the accumulation of potential pollutants (including arsenic, cadmium, copper, lead, mercury, selenium, and zinc) in the soil shall be monitored in accordance with the US Code, Reference 40 CFR, Parts 403 and 503, and/or any applicable state and local laws or regulations.

Additional Criteria to Minimize Agricultural Non-point Source Pollution of Surface and Ground Water Resources

In areas with an identified or designated nutrient-related water quality impairment, an assessment shall be completed of the potential for nitrogen and/or phosphorus transport from the field. The Leaching Index (LI) and/or Phosphorus Index (PI), or other recognized assessment tools may be used to make these assessments. The results of these assessments and recommendations shall be discussed with the producer and included in the plan.

Determine site specific vulnerability to leach soluble nitrates using the Leaching Index (LI) maps. Use the phosphorus index (PI) to determine vulnerability for phosphorus loss to surface runoff (solution and adsorption). "Soil Potential" maps for leaching, runoff, and adsorption is found in FOTG, Section I–Maps, for digitized soil survey areas.

Plans developed to minimize agricultural nonpoint source pollution of surface or ground water resources shall include practices and/or management activities that can reduce the risk of nitrogen or phosphorus movement from the field.

Additional Criteria to Improve the Physical, Chemical, and Biological Condition of the Soil

Nutrients shall be applied in such a manner as not to degrade the soil's structure, chemical properties, or biological condition. Use of nutrient sources with high salt content will be minimized unless provisions are used to leach salts below the crop root zone. **High salt content sources are those that will produce salinity problems over time. (See FOTG, Section IV, Practice Standard 571–Salinity Management.)**

Nutrients shall not be applied to flooded or saturated soils when the potential for soil compaction and creation of ruts is high.

CONSIDERATIONS

Consider induced deficiencies of nutrients due to excessive levels of other nutrients.

Consider additional FOTG, Section IV, Practice Standards, such as 327–Conservation Cover, 412–Grassed Waterway, 332–Contour Buffer Strips, 393–Filter Strips, 449–Irrigation Water Management, 391A–Riparian Forest Buffer, 328–Conservation Crop Rotation, 340–Cover and Green Manure, and 329A–329–329C–344–Residue Management, to improve soil nutrient and water storage, infiltration, aeration, tilth, diversity of soil organisms and to protect or improve water quality.

Consider cover crops whenever possible to utilize and recycle residual nitrogen.

Consider application methods and timing that reduce the risk of nutrients being transported to ground and surface waters, or into the atmosphere. Suggestions include:

- split applications of nitrogen to provide nutrients at the times of maximum crop utilization,
- avoiding winter nutrient application for spring seeded crops,
- band applications of phosphorus near the seed row,
- applying nutrient materials uniformly to application areas or as prescribed by precision agricultural techniques, and/or
- immediate incorporation of land applied manure or organic by-products,
- delaying field application of animal manure or other organic by-products if precipitation capable of producing runoff and erosion is forecast within 24 hours of the time of the planned application.
- **applying nutrients as close as possible to time of use to reduce potential for surface and ground water contamination**.

Consider negative nutrient interactions and other growth factors that affect soil pH and the availability of nutrients in the soil solution.

If an irrigation water test has been completed, use TABLE 7, Nitrogen Contribution from Irrigation Water, to determine total pounds of nitrogen supplied from water.

Consider minimum application setback distances from environmentally sensitive areas, such as sinkholes, wells, gullies, ditches, surface inlets, or rapidly permeable soil areas.

Consider the potential problems from odors, associated with the land application of animal manure, especially when applied near or upwind of residences.

Consider nitrogen volatilization losses associated with the land application of animal manure. Volatilization losses can become significant, if manure is not immediately incorporated into the soil after application.

Consider utilizing tissue tests, in conjunction with soil testing, to adjust the fertilizer program for crops during the growing season.

Returning crop residue to the soil requires additional nitrogen due to microbial activity "tying up" some nitrogen especially when adding high-carbon organic residues. As a rule, approximately 7.5-10.0 pounds of nitrogen for every 1,000 pounds of residue over 3,000 pounds should be added to the soil to offset this tie-up if nitrogen is in deficit in the nutrient budget.

Consider the potential to affect National Register listed or eligible cultural resources.

To calculate the amount of nitrate nitrogen (NO_3) available for the next crop, use the following calculation:

$$\frac{\text{Soil sample depth (in.)}}{\text{6 (in.)}} \text{ x 2 x ppm = lbs./acre}$$

Where two soil samples are taken and analyzed at different depths, i.e. at 0–12" and at 12–24", calculate pounds of nitrogen using the above formula for each sample depth and add the results.

Example: To get a better representation soil was sampled at two depths and analyzed. Results were:

SAMPLE 1: 0–12" – 32ppm;

SAMPLE 2: 12–18" – 8 ppm

SAMPLE 1: $\frac{12"}{6"}$ **x 2 x 32 = 128 lbs./ac NO_3**

SAMPLE 2: $\frac{6"}{6"}$ **x 2 x 8 = 16 lbs./ac NO_3**

THEN 128 + 16 = 140 lbs./ac NO_3

Consider annual reviews to determine if changes in the nutrient budget are desirable (or needed) for the next planned crop.

On sites where there are special environmental concerns, consider other sampling techniques. (For example: Soil profile sampling for nitrogen or soil surface sampling for phosphorus accumulation or pH changes.)

Consider ways to modify the chemistry of animal manure, including modification of the animal's diet to reduce the manure nutrient content, to enhance the producer's ability to manage manure effectively.

PLANS AND SPECIFICATIONS

Plans and specifications shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose(s), using nutrients to achieve production goals and to prevent or minimize water quality impairment.

The following components shall be included in the nutrient management plan:

- aerial photograph or map and a soil map of the site,
- current and/or planned plant production sequence or crop rotation,
- results of soil, plant, water, manure or organic by-product sample analyses,
- realistic yield goals for the crops in the rotation,
- quantification of all nutrient sources,
- recommended nutrient rates, timing, form, and method of application and incorporation,
- location of designated sensitive areas or resources and the associated, nutrient management restriction,
- guidance for implementation, operation, maintenance, record keeping, and,
- complete nutrient budget, MT-ECS-112, for nitrogen, phosphorus, and potassium for the rotation or crop sequence.
- MT-CPA-224, Nutrient Checklist with appropriate data.

If increases in soil phosphorus levels are excepted, plans shall document:

- the soil phosphorus levels at which it may be desirable to convert to phosphorus based implementation **(See TABLE 9)**;
- the relationship between soil phosphorus levels and potential for phosphorus transport from the field **(See TABLE 8)**; and,
- when applicable, plans shall include other practices or management activities as determined by specific regulation, program requirements, or producer goals.

In addition to the requirements described above, plans for nutrient management shall also include:

- discussion about the relationship between nitrogen and phosphorus transport and water quality impairment. The discussion about nitrogen should include information about nitrogen leaching into shallow ground water and potential health impacts. The discussion about phosphorus should include information about phosphorus accumulation in the soils, the increased potential for phosphorus transport in soluble form, and the types of water quality impairment that could result from phosphorus movement into surface water bodies.
- discussion about how the plan is intended to prevent the nutrients (nitrogen and phosphorus) supplied for production purposes from contributing to water quality impairment.
- a statement that the plan was developed based on the requirements of the current standard and any applicable Federal, state, or local regulations or policies; and that changes in any of these requirements may necessitate a revision of the plan.

OPERATION AND MAINTENANCE

The owner/client is responsible for safe operation and maintenance of this practice including all equipment. Operation and maintenance addresses the following:

- periodic plan review to determine if adjustments or modifications to the plan are needed. As a minimum, plans will be reviewed and revised with each soil test cycle **(every two years for N, and every 3 years for P).**

- Protection of fertilizer and organic by-product storage facilities from weather and accidental leakage or spillage.
- Calibration of application equipment to ensure uniform distribution of material at planned rates. **Calibration shall be to within ± 15%.**
- Documentation of the actual rate at which nutrients were applied. When the actual rates used differ from or exceed the recommended and planned rates, records will indicate the reasons for the differences.

Maintaining records to document plan implementation. As applicable, records include:

- Soil test results and recommendations for nutrient application,
- Quantities, analyses and sources of nutrients applied,
- Dates and method of nutrient applications,
- Crops planted, planting and harvest dates, yields, and crop residues removed,
- Results of water, plant, and organic by-products analyses, and
- Dates of review, person performing the review, and recommendations that resulted form the review.

Records should be maintained for five years; or for a period longer than five years if required by other Federal, state, or local ordinances, or program or contract requirements.

Use soil test information no older than one year when developing new plans, particularly if animal wastes are planned to be utilized.

Workers should be protected from and avoid unnecessary contact with chemical fertilizers and organic by-products. Protection should include the use of protective clothing when working with plant nutrients. Extra caution must be taken when handling ammonia sources of nutrients, or when dealing with organic wastes stored in unventilated

The disposal of material generated by the cleaning of nutrient application equipment should be accomplished properly. Excess material should be collected and stored or field applied in an appropriate manner. Excess material should not be applied on areas of high potential risk for runoff and leaching.

The disposal or recycling of nutrient containers should be done according to state and local guidelines or regulations.

NRCS, MT
August 2001

REFERENCES

Fertilizer Guidelines for Montana, Montana State University, Extension Service Bulletin EB 104, March 1997.

USDA–Natural Resources Conservation Service, Field Office Technical Guide, Section IV, Practice Standard 328–Conservation Crop Rotation, October 1988.

USDA–Natural Resources Conservation Service, National Engineering Handbook, Agricultural Waste Management Field Handbook, Part 651, Chapter 4, 6, 11 and 16.

USDA–Natural Resources Conservation Service, Field Office Technical Guide, Section I, Maps, Irrigation Climatic Areas for Montana, 1986.

Montana State University Extension Service, Department of Plant, Soil, & Environmental Science, Soil Testing Procedures, Interpretation and Fertilizer Sources, Montguide MT 8704, Bozeman, Montana.

Amber Waves, Washington State University, College of Agriculture and Home Economics Research Center, XB 1025, June 1992.

Montana State University Extension Service, Department of Plant, Soil, & Environmental Science, Soil Sampling, Montguide MT 8602, Bozeman, Montana.

Best Management Practices for Wheat, A Guide to Profitable and Environmentally Sound Production,

The National Association of Wheat Growers Foundation, November 1994.

Soil and Plant Analysis Registry, Montana Extension Service Bulletin EB 150, 1998

TABLE 1. ESTIMATED SPRING WHEAT YIELDS[a] BASED ON STORED SOIL WATER AND GROWING SEASON PRECIPITATION[a]

CONSUMPTIVE USE AREA	STORED SOIL WATER + GROWING SEASON PRECIPITATION. (IN.) 4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	BUSHELS PER ACRE[bc]														
1 High	0	6	10	15	20	24	29	34	39	43	48	53	57	62	67
2 Moderate High	0	6	11	16	21	27	32	37	42	47	52	57	62	67	72
3 Moderate	0	7	13	19	24	30	36	42	48	53	59	65	71	77	82
4 Moderate Low	0	7	13	20	26	32	38	44	50	56	62	68	74	80	87

TABLE 2. ESTIMATED BARLEY YIELDS[a] BASED ON STORED SOIL WATER AND GROWING SEASON PRECIPITATION[a]

CONSUMPTIVE USE AREA	STORED SOIL WATER + GROWING SEASON PRECIPITATION. (IN.) 4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	BUSHELS PER ACRE[bc]														
1 High	6	13	20	27	34	41	48	55	62	69	76	83	90	97	104
2 Moderate High	7	14	22	30	37	45	52	60	68	75	83	90	98	106	113
3 Moderate	8	16	25	33	42	50	59	67	76	84	93	101	110	118	127
4 Moderate Low	8	17	26	35	44	53	62	71	80	89	98	107	116	125	134

[a] Estimated yields reflect consumptive use data from Huntley, Havre, Sidney, Conrad, Kalispell, Bozeman, and Moccasin.

[b] Yields may vary from estimates due to climatic conditions, weeds, disease, insects, lodging, or stand density.

[c] When rooting depths are limited by rocks, gravel, or impermeable layers such as shale, yields may vary.

TABLE 3. ESTIMATED WINTER WHEAT YIELDS[a] BASED ON STORED SOIL WATER AND GROWING SEASON PRECIPITATION[a]

CONSUMPTIVE USE AREA	STORED SOIL WATER + GROWING SEASON PRECIPITATION. (IN.) 4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	BUSHELS PER ACRE[bc]														
1 High	0	6	11	17	22	28	33	38	44	49	55	60	65	71	76
2 Moderate High	0	6	12	18	24	30	35	41	47	53	59	64	70	76	82
3 Moderate	0	7	14	20	27	34	40	47	53	60	67	73	80	86	93
4 Moderate Low	0	8	15	22	29	36	43	50	57	64	71	78	85	92	99

TABLE 4. ESTIMATED OAT YIELDS[a] BASED ON STORED SOIL WATER AND GROWING SEASON PRECIPITATION[a]

CONSUMPTIVE USE AREA	STORED SOIL WATER + GROWING SEASON PRECIPITATION. (IN.)														
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	BUSHELS PER ACRE[bc]														
1 High	0	2	11	21	30	39	49	58	68	77	86	96	105	115	124
2 Moderate High	0	2	12	23	33	43	54	64	74	84	95	105	115	126	136
3 Moderate	0	2	14	26	37	49	61	72	84	96	108	119	131	143	154
4 Moderate Low	0	2	15	28	40	52	65	78	90	102	115	128	140	152	165

TABLE 5. ESTIMATED SAFFLOWER YIELDS[a] BASED ON STORED SOIL WATER AND GROWING SEASON PRECIPITATION[a]

CONSUMPTIVE USE AREA	STORED SOIL WATER + GROWING SEASON PRECIPITATION. (IN.)														
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	228
	POUNDS PER ACRE[bc]														
2 Moderate High	115	279	443	607	771	935	1,099	1,263	1,427	1,591	1,755	1,919	2,083	2,247	2,411

[a] Estimated yields reflect consumptive use data from Huntley, Havre, Sidney, Conrad, Kalispell, Bozeman, and Moccasin.

[b] Yields may vary from estimates due to climatic conditions, weeds, disease, insects, lodging, or stand density.

[c] When rooting depths are limited by rocks, gravel, or impermeable layers such as shale, yields may vary.

TABLE 6. NITROGEN FIXATION ESTIMATES FOR DRYLAND CONDITIONS[1]

LEGUME	N FIXATION (LB./ACRE)
Alfalfa (after harvest)	40-80
Alfalfa (green manure)	80-90
Spring Pea	40-90
Winter Pea	70-100
Lentil	30-100
Chickpea	30-90
Fababean	50-125
Lupin	50-55
Hairy Vetch	90-100
Sweetclover (ANNUAL)	15-20
Sweetclover (BIENNIAL)	80-150
Red Clover	50-125
Black Medic	15-25

[1] The large variation in estimates is attributed to different years, climate, management, etc.

TABLE 7. NITROGEN CONTRIBUTION FROM IRRIGATION WATER

N IN WATER (PPM)	Water Application Rate (ACRE-FEET) 0.5	1.0	1.5	2.0
	LBS N/ACRE)			
2	3	5	8	11
4	5	11	16	22
6	8	16	24	32
8	11	22	32	43
10	13	27	40	54

TABLE 8. PHOSPHORUS APPLICATION BASED ON PI

PHOSPHORUS RISK RATING	PHOSPHORUS APPLICATION
Low Risk	Nitrogen Based
Medium Risk	Nitrogen Based
High Risk	Phosphorus Based (up to crop removal amounts)
Very High Risk	Phosphorus based or no application

TABLE 9. PHOSPHORUS APPLICATION FROM SOIL TEST RESULTS

SOIL TEST PHOSPHORUS (PPM)	PHOSPHORUS APPLICATION
≤8.0	Nitrogen Based
8.1 – 25.0	Nitrogen Based
25.1 – 100.0	Phosphorus Based
100.1 – 150.0	Phosphorus Based (up to crop removal)
>150.0*	No Application

* Estimate; subject to modification based on the development of new research relevant to Montana

TABLE 10. GYPSUM REQUIREMENTS FOR SODIUM AFFECTED SOILS

SAR*	GYPSUM ($CaSO_4 \cdot 2H_2O$) lbs/10,000 ft^2
0 – 12	0
12 – 21	50
21 – 31	100
31 – 40	150

***SAR** = Sodium adsorption ratio, 0 – 6 inch sample depth