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UDC Appendix

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Wisconsin Division of Safety and Buildings Wisconsin Stats. 101.63, 101.73	**WISCONSIN UNIFORM BUILDING PERMIT APPLICATION** **Instructions on back of second ply.** The information you provide may be used by other government agency programs [(Privacy Law, s. 15.04 (1)(m)]	Application No. Parcel No.

PERMIT REQUESTED ☐ Constr. ☐ HVAC ☐ Electric ☐ Plumbing ☐ Erosion Control Other:

Owner's Name	Mailing Address		Tel.
Contractor's Name: ☐Con ☐Elec ☐HVAC ☐Plbg	Lic/Cert#	Mailing Address	Tel. FAX#
Contractor's Name: ☐Con ☐Elec ☐HVAC ☐Plbg	Lic/Cert#	Mailing Address	Tel. FAX#
Contractor's Name: ☐Con ☐Elec ☐HVAC ☐Plbg	Lic/Cert#	Mailing Address	Tel. FAX#
Contractor's Name: ☐Con ☐Elec ☐HVAC ☐Plbg	Lic/Cert#	Mailing Address	Tel. FAX#

PROJECT LOCATION Lot area Sq. ft. ____ 1/4, ____ 1/4, of Section ____, T ____ N, R ____ E (or) W

Building Address	Subdivision Name	Lot No.	Block No.

Zoning District(s)	Zoning Permit No.	Setbacks: Front ft.	Rear ft.	Left ft.	Right ft.

1. PROJECT
☐ New ☐ Repair
☐ Alteration ☐ Raze
☐ Addition ☐ Move
☐ Other:

2. AREA INVOLVED
Unfin. Bsmt _____ Sq Ft
Living Area _____ Sq Ft
Garage _____ Sq Ft
Deck _____ Sq Ft.

3. OCCUPANCY
☐ Single Family
☐ Two Family
☐ Garage
☐ Other:

4. CONST. TYPE
☐ Site-Built
☐ Mfd: ☐ WI UDC ☐ U.S. HUD

5. STORIES
☐ 1-Story
☐ 2-Story
☐ Other:
☐ Plus Basement

6. ELECTRICAL
Entrance Panel Amps: ____
☐ Underground
☐ Overhead

7. FOUNDATION
☐ Concrete
☐ Masonry
☐ Treated Wood
☐ Other:

8. USE
☐ Seasonal
☐ Permanent
☐ Other:

9. HVAC EQUIPMENT
☐ Forced Air Furnace
☐ Radiant Basebd/ Panel
☐ Heat Pump
☐ Boiler
☐ Central Air Cond.
☐ Other:

10. SEWER
☐ Municipal
☐ Sanitary Permit No.:

11. WATER
☐ Municipal Utility
☐ Private On-Site Well

12. ENERGY SOURCE

Fuel	Nat Gas	LP	Oil	Elec	Solid	Solar
Space Htg						
Water Htg						

☐ Dwelling unit has 3 kilowatt or more in electric space heating equipment capacity.

13. HEAT LOSS
_____ BTU/HR Total Calculated Envelope and Infiltration Losses ("Maximum Allowable Heating Equipment Output" on Energy Worksheet; "Total Building Heating Load" on WIScheck report)

14. EST. BUILDING COST
$

I agree to comply with all applicable codes, statutes and ordinances and with the conditions of this permit; understand that the issuance of the permit creates no legal liability, express or implied, on the state or municipality; and certify that all the above information is accurate. If I am an owner applying for an erosion control or construction permit, I have read the cautionary statement regarding contractor financial responsibility on the reverse side of the last ply. I expressly grant the building inspector, or the inspector's authorized agent, permission to enter the premises for which this permit is sought at all reasonable hours and for any proper purpose to inspect the work which is being done.

APPLICANT'S SIGNATURE _____ **DATE SIGNED** _____

APPROVAL CONDITIONS This permit is issued pursuant to the following conditions. Failure to comply may result in suspension or revocation of this permit or other penalty. ☐ **See attached for conditions of approval.**

ISSUING JURISDICTION ☐ Town of ☐ Village of ☐ City of ☐ County of ☐ State Inspection Agency #: Municipality Number of Dwelling Location ___ ___ - ___ ___ ___

FEES:	**PERMIT(S) ISSUED**	**WIS PERMIT SEAL #**	**PERMIT ISSUED BY:**
Plan Review $ _____ Inspection $ _____ Wis. Permit Seal $ _____ Other $ _____ Total $ _____	☐ Construction ☐ HVAC ☐ Electrical ☐ Plumbing ☐ Erosion Control _____		Name _____ Date _____ Tel. _____ Cert No. _____

SBD-5823 (R.4/02) Distribution: ☐Ply 1 - Issuing Jurisdiction ☐Ply 2 - Municipality Forwards to State If New Dwelling ☐Ply 3 - Inspector ☐Ply 4 - Applicant

Sample

Removed by Register March 2007 No. 615. For current adm. code see: http://docs.legis.wisconsin.gov/code/admin_code.

INSTRUCTIONS

The owner, builder or agents shall complete the application form down through the Signature of Applicant block and submit it and building plans and specifications to the enforcing municipality. Permit application data is used for statewide statistical gathering on new one− and two−family dwellings, as well as for local code administration.

PERMIT REQUESTED

- Check off type of Permit Requested, such as structural, HVAC, Electrical or Plumbing.
- Fill in owner's current Mailing Address and Telephone Number.

PROJECT LOCATION

- Fill in Building Address (number and street or sufficient information so that the building inspector can locate the construction site.
- Fill in Contractor Information. Note, per s. 101.654 (1) Wis. Stats., an individual taking out an erosion control or construction permit shall enter his or her dwelling contractor financial responsibility certificate number, unless they reside or will reside in the dwelling. Per s. 101.63 (7) Wis. Stats., the master plumber name and license number must be entered before issuing a plumbing permit.
- Local zoning, land use and flood plain requirements must be satisfied before a building permit can be issued. County approval may be necessary.
- Fill in Zoning District, lot area and required building setbacks.

PROJECT DATA − Fill in all numbered project data blocks (1−14) with the required information. All data blocks must be filled in, including the following:

2. Area (involved in project):
   Basements − include unfinished area only
   Living area − include any finished area including finished areas in basements
   Two−family dwellings − include total combined areas
3. Occupancy − Check only "Single−Family" or "Two−Family" if that is what is being worked on. In other words, do not check either of these two blocks if only a new detached garage is being built, even if it serves a one or two family dwelling. Instead, check "Garage" and number of stalls. If the project is a community based residential facility serving 3 to 8 residents, it is considered a single−family dwelling.
9. HVAC Equipment − Check only the major source of heat, plus central air conditioning if present. Only check "Radiant Baseboard or Panel" if there is no central source of heat.
10. Plumbing − A building permit cannot be issued until a sanitary permit has been issued for any new or affected existing private on−site wastewater treatment system.
14. Estimated Cost − Include the total cost of construction, including materials and market rate labor, but not the cost of land or landscaping.

SIGNATURE − Sign and date this application form.

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CONDITIONS OF APPROVAL − The authority having jurisdiction uses this section to state any conditions that must be complied with pursuant to issuing the building permit.

ISSUING JURISDICTION: This must be completed by the authority having jurisdiction.

- Check off Municipality Status, such as town, village, city, county or state inspection agency.
- Fill in Municipality Name and Municipality Number or State Inspection Agency number of inspection authority.
- Fill in Municipality Number of Dwelling Location if different from municipality where inspection authority is located. (applies to county or state enforcement)
- Check off type of Permit Issued, such as construction, HVAC, electrical or plumbing.
- Fill in Wisconsin Uniform Permit Seal Number, if project is a new one− or two−family dwelling.
- Fill in Name and Inspector Certification Number of person reviewing building plans and date building permit issued.

PLEASE RETURN SECOND PLY WITHIN 30 DAYS AFTER ISSUANCE TO:
(You may fold along the dashed lines and insert this form into a window envelope.):

Safety & Buildings Division
P O Box 2509
Madison, WI 53701−2509

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CAUTIONARY STATEMENT TO OWNERS OBTAINING BUILDING PERMITS
(Part of Ply 4 for Applicants)

101.65 (1r) of the Wisconsin Statutes requires municipalities that enforce the Uniform Dwelling Code to provide an owner who applies for a building permit with a statement advising the owner that:

If the owner hires a contractor to perform work under the building permit and the contractor is not bonded or insured as required under s. 101.654 (2) (a), the following consequences might occur:

(a) The owner may be held liable for any bodily inquiry to or death of others or for any damage to the property of others that arises out of the work performed under the building permit or that is caused by any negligence of the contractor that occurs in connection with the work performed under the building permit.

(b) The owner may not be able to collect from the contractor damages for any loss sustained by the owner because of a violation by the contractor of the one− and 2− family dwelling code or an ordinance enacted under sub. (1) (a), because of any bodily injury to or death of others or damage to the property of others that arises out of the work performed under the building permit or because of any bodily injury to or death of others or damage to the property of others that is caused by any negligence by the contractor that occurs in connection with the work performed under the building permit.

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Work shall not proceed until the inspector has approved the various stages of construction or the 48 business hr. period since notification has elapsed. This permit will expire 24 months after the date of issuance if the building's exterior has not been completed. **Keep this card posted until final inspection has been made.** (WI Stats. 101.63) _____

WISCONSIN UNIFORM BUILDING PERMIT

affix uniform permit seal here (when applicable) Seal No _____

#

☐ const ☐ hvac ☐ elec ☐ plumb ☐ erosion

Project:

Issued to

OWNER (AGENT)	
BUILDING SITE ADDRESS	
CITY, VILLAGE, TOWN	

SITE INFO

SUBDIVISION _____

LOT NO. _____ BLOCK NO. _____

ZONING DISTRICT _____

_____ 1/4, _____ 1/4, SEC _____, T _____, N, R _____ E or W

PARCEL NO. _____

SETBACKS:

FRONT _____ ft REAR _____ ft

LEFT _____ ft RIGHT _____ ft

INSPECTIONS

PHASE	ROUGH	FINAL	EROSION
FOOTING			
FOUNDATION			
BSMT DRAIN TILES			
CONSTRUCTION			
PLUMBING			
HEAT/VENT/AC			
ELECTRICAL			
INSULATION			
OCCUPANCY			

CONTRACTORS

_____ # _____
G.C.

_____ # _____
HVAC

_____ # _____
ELECT.

_____ # _____
PLBG.

_____ #

Issued by

PERSON ISSUING		CERT. NO.
DATE ISSUED	TELEPHONE	

Comments: _____

NOTICE OF NONCOMPLIANCE: This issuing jurisdiction shall notify the applicant in writing of any violations to be corrected. All cited violations shall be corrected within 30 days of notification, unless extension time is granted.

SBD-5824 (R. 05/96)

Sample

Removed by Register March 2007 No. 615. For current adm. code see: http://docs.legis.wisconsin.gov/code/admin_code.

Submit to non-enforcing municipalities for new 1- and 2- family dwellings

WISCONSIN ADMINISTRATIVE BUILDING PERMIT APPLICATION
(Wis. Stats. 101.63 (7) & 101.65 (3))

State of Wisconsin
Safety and Buildings Division

SEE INSTRUCTIONS ON BACK OF SECOND PLY
Personal information you provide may be used for secondary purposes. [Privacy Law 15.04(1)(m)]

Sample

PERMIT APPLICANT

Last Name	First Name	Middle Initial

Street Address

City	State	Zip Code	Telephone No. (Include area code)

PROJECT LOCATION

Building Address	Subdivision Name	Lot #	Block #

Legal Description
_____ 1/4, _____ 1/4, Section _____ T _____ N, R _____ E or W

Parcel No.

1. PROJECT TYPE
☐ 1 Family
☐ 2 Family

2. HVAC EQUIPMENT
☐ Forced Air Furnace ☐ Radiant Baseboard or Panel ☐ Heat Pump
☐ Boiler ☐ Central AC ☐ Other:

3. ENERGY SOURCE

	Nat. Gas	L.P.	Oil	Elect.	Solid	Solar
Space Heating	☐	☐	☐	☐	☐	☐
Water Heating	☐	☐	☐	☐	☐	☐

4. CONSTRUCTION TYPE
☐ Site Constructed
☐ Manufactured (to the WI UDC; not U.S. HUD code)

5. FOUNDATION
☐ Concrete ☐ Masonry ☐ Treated Wood
☐ Other (specify):

6. AREA
Living area = Square Feet

7. ESTIMATED BUILDING COST
$

I vouch that all the above information is correct, and understand that the issuance of this permit is for administrative purposes only. I understand that onsite construction inspections will **not** be performed by the municipality, but that the Uniform Dwelling Code, Chapters Comm 20-25, still applies to all new 1- and 2-family dwellings and must be complied with. I understand that the issuance of this permit does not relieve me of compliance with other applicable codes and ordinances.

Applicant's Signature _____ Date Signed _____

MUST BE COMPLETED BY THE MUNICIPALITY BEFORE FORWARDING PLY 2 TO THE STATE DIVISION OF SAFETY AND BUILDINGS

ISSUING JURISDICTION:	☐ Town ☐ Village ☐ City ☐ County of:		
MUNICIPALITY NUMBER: of Dwelling Location	# ____ ____ - ____ ____ ____	**FEES:**	
PERMIT ISSUED BY:		**DATE ISSUED:**	

SBD-8254 (R.2/00) Distribution: ☐Ply 1 - Issuing Jurisdiction ☐Ply 2 - Municipality Forwards to State If New Dwelling ☐Ply 3 - Applicant

Removed by Register March 2007 No. 615. For current adm. code see: http://docs.legis.wisconsin.gov/code/admin_code.

INSTRUCTIONS

The owner, builder or agent shall complete and provide all required information on the application form down through the Signature of Applicant block. This data is used for statewide statistical gathering on new one− and two−family dwellings, as well as for local administration. Prior to submitting this application to the municipality, obtain any necessary sanitary or zoning permit from the county. After completing this application, submit it to the local municipality having jurisdiction. Plan review or building inspections will not be performed by the municipality.

PERMIT REQUESTED:

- Fill in building address.
- Fill in legal description of lot, subdivision name, lot number and block number.

PROJECT DATA:

- Fill in **all numbered** project data blocks (1−7) with the required information. All data blocks must be filled in, including the following:

1. **Type** − Check only "1−Family" or "2−Family" if that is what is being built. In other words, do NOT use this form if only a new detached garage is being built, even if it serves a one or two family dwelling.
2. **HVAC Equipment** − Check only the major source of heat, not any supplemental sources. Mark central air conditioning if present. Only check "Radiant Baseboard or Panel" if there is no central source of heat.
4. **Complete type of construction** − Use this form for site−built homes or homes built to the WI UDC requirements. Do NOT use this form for a manufactured home that was built to the U.S. HUD requirements.
6. **Living Area** − Include any finished area including finished areas in basements. For two−family dwellings, include total combined areas.
7. **Estimated Cost** − Include the total cost of construction, but not cost of land or landscaping.

SIGNATURE:

- Sign and date application form.

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- -

- -

- -

ISSUING JURISDICTION –
This must be completed by the AUTHORITY HAVING JURISDICTION.

- Check off MUNICIPALITY STATUS of issuing jurisdiction, such as town, village, city or county.
- Fill in MUNICIPALITY NUMBER OF DWELLING LOCATION. If issued by a county, indicate the specific municipality number where the dwelling will be built.
- Fill in name of person issuing permit and date building permit issued.

PLEASE FORWARD SECOND PLY WITHIN 30 DAYS AFTER ISSUANCE TO:
(You may fold along the dashed lines and insert this form into a window envelope.)

Safety & Buildings Division
P O Box 2509
Madison, WI 53701–2509

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INSPECTION REPORT AND NOTICE OF NONCOMPLIANCE

Report Date:	Inspection Date	Permit No.:	Parcel No:	
Project Address		Subdivision	Lot No.:	Block No.:

Inspection Type(s): ☐Footing ☐Erosion Control ☐Foundation ☐Bsmt Drain Tile ☐Underslab Plbg ☐Rough HVAC ☐Rough Plumbing ☐Rough Electrical ☐Construction ☐Insulation/Energy ☐Final ☐Other:

Area Inspected, if Partial Inspection:	If Final Inspection, Occupancy May: ☐ Take Place Now ☐ Not Take Place Until The Items Below Are Corrected and Inspected ☐ Other:

Owner:	**Contractor:**

Sample

AN INSPECTION OF THE ABOVE PREMISES HAS DISCLOSED THE FOLLOWING NONCOMPLIANCES:

ORDER NO.	CODE SECTION	FINDINGS AND REQUIREMENTS

IMPORTANT: Please report when violations are corrected. AVOID DELAY

NOTICE OF NONCOMPLIANCE: All cited violations shall be corrected within ____30__days after written notification unless an extension of time is granted. Each day that the violation continues after notice shall constitute a separate offense and is subject to remedies and penalties by the authority having jurisdiction. Appeals per ch. 68, WI Stats. and s. Comm 20.21.

Enforcement Jurisdiction: ☐Town ☐ Village ☐ City ☐ County **OF:** ☐State ☐ Insp Agency#		Authority By Municipal Ordinance Section::
Inspector's Name:	Violations Explained To:	Compliance Date:
Inspector's Address:	Office Hours:	Telephone No:

Distribution: ☐Ply 1 - Contractor ☐Ply 2 - Inspector ☐Ply 3 - Owner ☐Ply 4 - File

SBD-6025 (R 04/02) Page _____ Of _____

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DO NOT REMOVE

OFFICIAL MUNICIPAL NOTICE OF VIOLATION

LOCATION: _____

☐ **LACKING** _____ **PERMIT(S)** ☐ **NEED FOR** _____ **INSPECTION**
☐ **EXPIRED** _____ **PERMIT** ☐ **PREMISES HOUSEKEEPING**
☐ **UNFIT FOR HUMAN OCCUPANCY**
☐ **EROSION CONTROL PERIMETER MEASURES** ☐ INSTALL ☐ MAINTAIN
☐ **ROCK DRIVEWAY** ☐ INSTALL ☐ MAINTAIN
☐ **SEDIMENT CLEANUP** ☐ STREET & SIDEWALKS ☐ ADJOINING PROPERTY
OTHER: _____

_____

ACTION:

☐ **CONTACT INSPECTOR** ☐ NOW ☐ AFTER CORRECTIONS
☐ **CORRECT** ☐ NOW ☐ BY END OF TODAY(TRACKING CLEANUP)
☐ BY END OF NEXT WORKDAY (SEDIMENT CLEANUP)
☐ IN 72 HRS (EROSION CONTROLS) ☐ BY _____
☐ **STOP ALL WORK** ☐ EXCEPT CORRECTIONS

FAILURE TO COMPLY SUBJECTS YOU TO APPLICABLE FINES & PENALTIES

_____ _____ _____
MUNICIPAL INSPECTOR **PHONE NUMBER** **DATE**
SBD-10266 (N.10/95)

Sample

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Safety and Buildings Division
Bureau of Integrated Services

PETITION FOR VARIANCE
INFORMATION AND INSTRUCTIONS Comm 3

In instances where exact compliance with a particular code requirement cannot be met or alternative designs are desired, the Division has a petition for variance program where it reviews and considers acceptance of alternatives which are not in strict conformance with the letter of the code, but which meet the intent of the code. **A variance is not a waiver from a code requirement.** The petitioner must **provide an equivalency which meets the intent** of the code section petitioned to obtain a variance. Documentation of the rationale for the equivalency is requested below. Failure to provide adequate information may delay your petition. Pictures, sketches, and plans may be submitted to support equivalency. If the proposed equivalency does not adequately safeguard the health, safety, and welfare of building occupants, frequenters, firefighters, etc., the variance request will be denied. NOTE: A SEPARATE PETITION IS REQUIRED FOR EACH BUILDING AND EACH CODE ISSUE PETITIONED (i.e., 57.13 window issue cannot be processed on the same petition as 51.16 stair issue). It should be noted that **a petition for variance does not take the place of any required plan review submittal.**

The Division is unable to process petitions for variance that are not properly completed. Before submitting the application, the following items should be checked for completeness in order to avoid delays:

- Petitioner's name (typed or printed)
- Petitioner's signature
- The Petition for Variance Application must be signed by the owner of the building or system unless a Power of Attorney is submitted.
- Notary Public signature with affixed seal
- Analysis to establish equivalency, including any pictures, illustrations or sketches of the existing and proposed conditions to clearly convey your proposal to the reviewer.
- Proper fee
- Any required position statements by fire chief or municipal official

A position statement from the chief of the local fire department is required for fire safety issues. **No position statement is required for** nonfire safety topics such as sanitary, plumbing or POWTS systems and energy conservation. Position statements for both the fire department and municipality are required for barrier–free petitions. For rules relating to one– and two–family dwellings, only a position statement from the local enforcing municipality is required. Position statements must be completed and signed by the appropriate fire chief or municipal enforcement official. See the back of SBD–9890–X, Petition for Variance Application form for these position statement forms. Signatures or seals on all documents must be originals. Photocopies are not acceptable.

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Contact numbers and fees for the Division's review of the petition for variance are as follows:

Chapter (circle appropriate category)	Revenue Code	Review Office	Contact Number	Fee	Revision Fee
Comm 5, License, Certification, Registration		Madison	(608) 261–8500	$200	$100
Comm 10, Flammable liquids		Madison	(608) 266–7529	$250	$100
Comm 11–13, LPG, LNG, CNG tanks	8258	Waukesha	(262) 548–8617	$250	$100
Comm 16, Electrical	7631	Madison	(608) 266–7529	$250	$100
Comm 18, Elevators	8260	Waukesha	(262) 521–5444	$250	$100
Comm, 20–25 Uniform Dwelling Code	7655	Madison	(608) 267–5113	$125	$50
Comm 34, Amusement Rides	8266	Madison	(608) 267–4434	$250	$100
Comm, 41–42 Boilers and Pressure Vessels	8258	Waukesha	(262) 548–8617	$250	$100
Comm 50–64, Commercial Building Code	7648	All Offices	See Office Numbers Below	$500	$100
(For Fire System Petition for Variances – Contact the Madison or Waukesha offices)					
Comm 66, Uniform Multi–Family Dwellings	7648	All Offices	See Office Numbers Below	$500	$100
Comm 67–68, Rental Unit Energy Efficiency Code	7646	Madison	(608) 267–2240	$125	$50
Comm 69, Barrier–Free Requirements	7648	All Offices	See Office Numbers Below	$250	$100
Comm 70, Historic Building Code	7648	All Offices	See Office Numbers Below	$300	$100
Comm 80–82, General Plumbing	7657	All Offices	See Office Numbers Below	$225	$75
Comm 90, Swimming Pools	7650	Madison	(608) 267–3605	$250	$75
Comm 83 POWTS	7657	All Offices	See Office Numbers Below	$225	$75
All Other Chapters				$250	$100

Revisions are accepted only for 1 year after action on original petition.

Priority Review: The Department will schedule Petitions for Variance at the earliest available date, or the date requested at time of scheduling, which ever is later. Therefore, Priority Reviews are not generally available. In special circumstances, the Section Chief of the reviewing office may permit review prior to the scheduled date upon request by the submitter. If earlier review is permitted by the Section Chief, the Petition review fees will be doubled.

Except for special cases, the Division will review and make a determination on a petition for variance within 3 business days of the scheduled beginning date, provided all calculations, documents, and fees required for the review have been received.

Appointment and Scheduling Information:

It is strongly recommended that an appointment be made in advance. **For your convenience we have installed a 24 hour, toll free number dedicated to receiving fax plan review appointment request only. The number is 877−840−9172. Be sure to indicate whether you want the next available review statewide or prefer a choice of an office.** The petition review will be scheduled with the same office where the plan was/will be reviewed. You will receive a FAX back with an Appointment Date, Transaction ID No. and Assigned Reviewer. You may also email the request to PlanSchedule@commerce.state.wi.us. If you wish to schedule a review appointment by phone, you may call any of the full service offices. At the time of making an appointment, you may request review for a specific office of desired (beginning) date for review. Plans must be received in the office of the appointment no later than 2 working days before the confirmed appointment. Non−scheduled submittals or submittals received without a confirmed appointment date and transaction number on the form may be assigned to offices other than the receiving office depending on reviewer availability. To obtain a submittal checklist call the material order unit at 608−266−1818 or one of the full service offices listed below .. **Certain petitions may be limited to certain offices depending on the petition issues, see above table for appropriate office.**

Madison S&BD	Hayward S&BD	LaCrosse S&BD.	Shawano S&BD	Green Bay S&BD	Waukesha S&BD
201 W Washington Ave 53703 PO Box 7162 Madison WI 53707–7162 608–266–3151 Fax: 608–267–9566 TDD 608–264–8777 Email: PlanSchedule@ commerce.state.wi.us	10541N Ranch Rd Hayward WI 54843 715–634–4870 Fax: 715–634–5150 Email: PlanSche-dule@ com-merce.state.wi.us	4003 N Kinney Coulee Rd LaCrosse WI 54601–1831 608–785–9334 Fax: 608–785–9330 Email: PlanSche-dule@ com-merce.state.wi.us	1340 E Green Bay Shawano WI 54166 715–524–3626 Fax: 715–524–3633 Email: PlanSche-dule@ com-merce.state.wi.us	2331 San Luis Place Green Bay, W I 54304 920–492–5601 FAX: 920–492–5604 Email: PlanSchedule@ commerce.state.wi.us	141 NW Barstow St 4th Floor Waukesha WI 53186 262–548–8600 Fax: 262–548–8614 Email: PlanSchedule@ commerce.state.wi.us

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APPLICATION FOR REVIEW PETITION FOR VARIANCE SBD-9890X

-Complete all pages-

Safety & Buildings Division
Bureau of Integrated Services

This page may be utilized for fax appointments
Complete and indicate date plans will be in our office _____

1. Facility Information

Facility (Building) Name: _____

Number and Street _____ Zip: _____

Commerce Site Number (if known): _____

Legal Description: _____

County of: _____

( ) City ( ) Village ( ) Town of: _____

Complete for confirmed appointments*:

Transaction ID: _____

Previous Related Trans. ID: _____

Assigned Reviewer: _____

Assigned Office: _____

Review Start Date*: _____

***Submittal must be received in the office of the appointment no later than 2 working days before the confirmed appointment.**

NOTE: Personal information you provide may be used for secondary purposes [Privacy Law s. 15.04(1)(m), Stats.]

2. Owner Information	**Customer #**	**3. Designer Information**	**Customer #**
Name		Designer	
Company Name		Design Firm	
Number and Street		Number and Street	
City, State, Zip Code		City, State, Zip Code	
Contact Person		Contact Person	
Telephone Number	Fax Number	Telephone Number	Fax Number

4. Plan Review Status

☐ Plan submitted with petition
☐ Plan will be submitted after petition determination
☐ Requesting revision ☐ Other: _____
Commerce Transaction Number _____

Plan previously review by (please enclose a copy of review letter)
☐ State ☐ Municipality ☐ Approved ☐ Held ☐ Denied

Code Being Petitioned
☐ Building ☐ HVAC ☐ Plumbing ☐ Private Sewage System
☐ Swimming Pool ☐ Electrical

5. State the code section being petitioned AND the specific condition or issue you are requesting be covered under this petition for variance.

_____

_____

6. Reason why compliance with the code cannot be attained without the variance. _____

_____

_____

7. State your proposed means and rationale of providing equivalent degree of health, safety, or welfare as addressed by the code section petitioned.

_____

_____

8. List attachments to be considered as part of the petitioner's statements (i.e., model code sections, test reports, research articles, expert opinion, previously approved variances, pictures, plans, sketches, etc.).

_____

_____

. **VERIFICATION BY OWNER - PETITION IS VALID ONLY IF NOTARIZED WITH AFFIXED SEAL AND ACCOMPANIED BY REVIEW FEE**

Note: Petitioner must be the owner of the building or system or credential applicant for a Comm 5 petition. Tenants, agents, designers, contractors, attorneys, etc., shall not sign petition unless Power of Attorney is submitted with the Petition for Variance Application.

_____, being duly sworn, I state as petitioner that I have read the foregoing petition and I believe it is true and that I have significant ownership rights to the subject building or project.
Petitioner's Name (type or print)

Petitioner's Signature	Subscribed and sworn to before me this date	Notary Public	My commission expires on

Complete other side for variance requests from Comm 20-25 and Comm 61-65

MAKE CHECKS PAYABLE TO DEPT. OF COMMERCE **Attach check here.**	**TOTAL AMOUNT DUE** $ _____

SBD-9890X (R. 01/2003) (Check our website at http://www.commerce.state.wi.us/SB/SB-DivForms.html for the most current version of this form)

SBD-9890-X (R. 01/2003) THIS FORM IS VALID ONLY FROM 07/01/02 TO 01/01/04 (Check our website at http://www.commerce.state.wi.us/SB/SB-DivForms.html for the most current version of this form)

Sample

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Owner's Name	Project Location	Plan Number

Page 2 of _____

Fire Department Position Statement

To be completed for variances requested from Comm 61-65, Comm 10, and other fire related requirements.

I have read the application for variance and recommend: (check appropriate box)

☐ Approval ☐ Conditional Approval ☐ Denial ☐ No Comment

Explanation for recommendation including any conflicts with local rules and regulations and suggested conditions:

_____

_____

_____

_____

_____

Fire Department Name and Address	
Name of Fire Chief or Designee (type or print)	Telephone Number
Signature of Fire Chief or Designee	Date Signed

Sample

MUNICIPAL BUILDING INSPECTION RECOMMENDATION

To be completed for variances requested from Comm 20-23. Also to be used if Comm 61-65 plan review is by municipality or orders are written on the building under construction; optional in other cases. Please submit a copy of the orders

I have read the application for variance and recommend: (check appropriate box)

☐ Approval ☐ Conditional Approval ☐ Denial ☐ No Comment

Explanation for recommendation including any conflicts with local rules and regulations and suggested conditions:

_____

_____

_____

_____

Municipality Exercising Jurisdiction	
Name and Address of Municipal Official (type or print)	Telephone Number of Enforcement Official
Signature of Municipal Enforcement Official	Date Signed

SBD-9720 (R.01/2003)

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SANITARY PERMIT REQUIREMENTS

Section Comm 20.09 (5) (b) 3. refers to s. Comm 83.25 (2), which reads as follows:

Comm 83.25 (2) ISSUANCE OF BUILDING PERMITS. (a) *General.* Pursuant to s. 145.95, Stats., the issuance of building permits by a municipality for unsewered properties shall be in accordance with this subsection.

(b) *New construction.* A municipality may not issue a building permit to commence construction or installation of a structure that necessitates the use of a POWTS to serve the structure, unless:

1. The owner of the property possesses a sanitary permit for the installation of a POWTS in accordance with s. Comm 83.21; or

Note: Section Comm 83.21 outlines the procedures for the issuance of sanitary permits. Sections 145.135 and 145.19, Stats., mandate that no private sewage system may be installed unless the owner of the property holds a valid sanitary permit.

2. A POWTS of adequate capability and capacity to accommodate the wastewater flow and contaminant load already exists to serve the structure.

Note: See ss. Comm 83.02 and 83.03 concerning the application of current code requirements to existing POWTS.

(c) *Construction affecting wastewater flow or contaminant load.* 1. A municipality may not issue a building permit to commence construction of any addition or alteration to an existing structure when the proposed construction will modify the design wastewater flow or contaminant load, or both, to an existing POWTS, unless the owner of the property:

a. Possesses a sanitary permit to either modify the existing POWTS or construct a POWTS to accommodate the modification in wastewater flow or contaminant load, or both; or

b. Provides documentation to verify that the existing POWTS is sufficient to accommodate the modification in wastewater flow or contaminant load, or both.

2. For the purpose of this paragraph, a modification in wastewater flow or contaminant load shall be considered to occur:

a. For commercial facilities, public buildings, and places of employment, when there is a proposed change in occupancy of the structure; or the proposed modification affects either the type or number of plumbing appliances, fixtures or devices discharging to the system; and

b. For dwellings, when there is an increase or decrease in the number of bedrooms.

(d) *Documentation of existing capabilities.* Documentation to verify whether an existing POWTS can accommodate a modification in wastewater flow or contaminant load, or both, shall include at least one of the following:

1. A copy of the plan for the existing POWTS that delineates minimum and maximum performance capabilities and which has been previously approved by the department or the governmental unit.

2. Information on the performance capabilities for the existing POWTS that has been recognized through a product approval under ch. Comm 84.

3. A written investigative report prepared by an architect, engineer, designer of plumbing systems, designer of private sewage systems, master plumber, master plumber–restricted service or certified POWTS inspector analyzing the proposed modification and the performance capabilities of the existing POWTS.

(e) *Setbacks.* 1. A municipality may not issue a building permit for construction of any structure or addition to a structure on a site where there exists a POWTS, unless the proposed construction conforms to the applicable setback limitations under s. Comm 83.43 (8) (i).

2. The applicant for a building permit shall provide documentation to the municipality issuing the building permit showing the location and setback distances for the proposed construction relative to all of the following:

a. Existing POWTS treatment components.

b. Existing POWTS holding components.

c. Existing POWTS dispersal components.

Note: A municipality which issues building permits may delegate to the governmental unit responsible for issuing sanitary permits the determination of whether the proposed construction will affect or interfere with an existing POWTS relating to capability or location of the existing POWTS.

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MINIMUM FASTENER SCHEDULE TABLE

Other interior and exterior panel products and finishes installed per manufacturer requirements. For engineered connectors, use manufacturer's specified fasteners.

Description of Building Materials/Connection	Number and Type of Fastener[1 2 3]
Floor Framing	
Joist to joist, face nailed over support	2–12d
Joist to sill or girder, toe nail	2–16d, 3–8d
Band or rim joist to joist, end nail	*3–16d*
Band or rim joist to sill or top plate	*2–16d at 16" o.c.*
Bridging to joist, toe nail each end	2–8d
Built–up girder and beams, top loaded	10d at 32" o.c. at top and bottom and staggered and two at ends and at each splice
Built–up girder and beams, side–loaded	16d at 16" o.c. at top and bottom and staggered and two at ends and at each splice
Ledger strip to beam, face nail	3–16d each joist
Joist on ledger to beam, toe nail	3–8d
Wall Framing	
Sole plate to joist or blocking, face nail	16d at 16" o.c.
Top or sole plate to stud, end nail	2–16d
Stud to sole plate, toe nail	4–8d or 3–16d
Doubled studs, face nail	16d at 24" o.c.
Doubled top plates, face nail	16d at 16" o.c.
Top plates, laps and intersections, face nail	2–16d
Continuous header, two pieces	16d at 16" o.c. along each edge
Continuous header to stud, toe nail	4–8d
1" corner brace to each stud and plate, face nail	2–8d or 2 staples, 1 3/4"
Built–up corner studs	16d at 30" o.c., 16d at 24" o.c.
Roof/Ceiling Framing	
Ceiling joists to plate, toe nail	2–16d, 3–8d
Ceiling joist, laps over partitions, face nail	3–16d
Ceiling joist to parallel rafters, face nail	3–16d
Rafter to plate, toe nail (maximum 6' rafter span, engineered connector for longer)	2–16d, 3–8d
Roof rafters to ridge, valley or hip rafters, toe nail	4–16d
Roof rafters to ridge, valley or hip rafters, face nail	3–16d
Collar ties to rafters, face nail	3–8d
Boards and planks	
1" x 6" subfloor or less to each joist, face nail	2–8d or 2 staples, 1 3/4"
Wider than 1" x 6" subfloor toe to each joist, face nail	3–8d or 4 staples 1 3/4"
2" subfloor to joist or girder, blind and face nail	2–16d
1" x 6" roof sheathing to each bearing, face nail	2–8d or 2 staples, 1 3/4"
1" x 8" roof sheathing to each bearing, face nail	2–8d or 3 staples, 1 3/4"
Wider than 1" x 8" roof sheathing to each bearing, face nail	3–8d or 4 staples, 1 3/4"
2–inch planks	2–16d at each bearing

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Panel Sheathing			
		Spacing of Fastener	
Material	**Fastener**	**Edges**	**Intermediate Supports**
Engineered wood panel for subfloor and roof sheathing and wall corner wind bracing to framing			
5/16–inch to 1/2–inch	6d common or deformed nail or staple, 1 1/2”	6”	12” [4]
5/8–inch to 3/4–inch	8d smooth or common, 6d deformed nail, or staple, 14 ga. 1 ¾”	6”	12” [4]
7/8–inch to 1–inch	8d common or deformed nail	6”	12”
1 1/8–inch to 1 1/4–inch	10d smooth or common, or 8d deformed nail	6”	12”
Combination subfloor/ underlayment to framing			
3/4–inch or less	6d deformed or 8d smooth or common nail	6”	12”
7/8–inch to 1–inch	8d smooth, common or deformed nail	6”	12”
1 1/8–inch to 1 1/4–inch	10d smooth or common or 8d deformed nail	6”	12”
Wood panel siding to framing			
1/2–inch or less	6d corrosion–resistant siding and casing nails	6”	12”
5/8–inch	8d corrosion–resistant siding and casing nails	6”	12”

[1]All nails are smooth–common, box or deformed shank except where otherwise stated
[2]Nail is a general description and may be T–head, modified round head or round head.
[3]Staples are 16–gauge wire, unless otherwise noted, and have a minimum 7/16–inch o.d. crown width.
[4]Staples shall be spaced at not more than 10 inches o.c. at intermediate supports for floors.

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UDC Floor & Ceiling Joist and Roof Rafter Span Tables And Design Value Tables

Use the following Span Tables to determine the maximum spans for floor and ceiling joists and roof rafters. These spans are based on:

- simple, single spans (although the tables may be safely used for continuous two−span floor joists)
- uniformly distributed loads
- fully supported members with one edge properly sheathed and nailed
- for floor joists and roof rafters, the top edge shall be properly sheathed and nailed
- roof rafter slopes of at least 3:12

The criteria for each Span Table is given in the upper left hand corner and is also summarized in the table of Span Tables below. Choose the appropriate Span Table based on the member type and required loading. Select your desired member depth, member spacing and span to determine the minimum Fb value. Note that these tables include recommended deflection criteria. However, for strict code compliance, only the Fb strength requirements must be satisfied. The modulus of elasticity (E) values, would be met for serviceability purposes only.

Note that straight−line interpolation is permitted for intermediate spans and design values. Span is measured from face to face of supports plus one−half of the required bearing of $1^1/_2''$ on wood or metal and $3''$ on masonry or concrete at each end. For sloping rafters, the span is measured along the horizontal projection.

Section Comm 21.27 allows reduction of the snow live load for roof slopes greater than 30 degrees (7/12 slope) based on the formula Cs = 1 − (a−30)/40, where "a" is the slope of the roof expressed in degrees. Following is a table of tabulated values for certain roof slopes.

Slope	Angle in Degrees	Zone 1 Live Load (psf)	Zone 2 Live Load (psf)
7/12	30	40	30
10/12	40	30	22.5
12/12	45	25	18.8
14/12	50	20	15

Use the Design Value tables following the Span Tables to determine the acceptable species and grades to satisfy minimum Fb values obtained from the Span Tables. The Design Value tables assume at least three members spaced no more than 24" on center. Use the Normal Duration column Fb values for joists and the Snow Loading column Fb values for rafters.

See the following examples for further guidance.

Tables are reprinted courtesy of American Forest & Paper Association.

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Table No.	Member Type	Live Load (psf)	Dead Load (psf)	Condition	(Deflection)*
F−2	Floor Joists	40	10	−	L/360
C−1	Ceiling Joists	10	5	Drywall ceiling, no attic storage	L/240
C−2	Ceiling Joists	20	10	Attic storage	L/240
R−2	Roof Rafters	30 (Zone 2)	10	Maximum 2 layers of asphalt shingles or wood shakes/shingles	L/240
R−3	Roof Rafters	40 (Zone 1)	10	Maximum 2 layers of asphalt shingles or wood shakes/shingles	L/240
R−10	Roof Rafters	30 (Zone 2)	20	Heavy roof covering (clay tile)	L/240
R−11	Roof Rafters	40 (Zone 1)	20	Heavy roof covering (clay tile)	L/240
R−14	Roof Rafters	30 (Zone 2)	10	Maximum 2 layers of asphalt shingles or wood shakes/shingles	L/180
R−15	Roof Rafters	40 (Zone 1)	10	Maximum 2 layers of asphalt shingles or wood shakes/shingles	L/180
R−22	Roof Rafters	30 (Zone 2)	20	Heavy roof covering (clay tile)	L/180
R−23	Roof Rafters	40 (Zone 1)	20	Heavy roof covering (clay tile)	L/180

*Deflection criteria are optional. For roof rafters with drywall on the underside, use the stricter L/240 tables to limit deflection.

Example 1. Floor Joists. Assume a required single span of 12'−9", dead load of 10 psf and joists spaced 16 inches on center. Table F−2 (see following highlighted tables) shows that one solution is a grade of 2x8 having an Fb value of 1255 would allow a span of 12'−10 which satisfies the condition. (Note that the recommended E value to limit deflection would be 1,600,000.) Going to the Design Value Tables, we find that as an example, 2x8 Hem Fir grade No.1 has an Fb value of 1310 for normal duration. (It also has an E value of 1,500,000 which does **not** satisfy the recommended deflection criteria.)

Example 2. Rafters. Assume a horizontal projected span of 13'−0", a live load of 40 psf, dead load of 10 psf, a roof slope of 4/12 and rafters spaced 16 inches on center. Since the slope is shallower than 7/12, there is no allowable reduction of the snow live load. Table R−3 shows that a 2x8 having an Fb value of 1300 would allow a span of 13'−1" which satisfies the condition. (Note that the recommended E value to limit deflection would be 1,120,000.) Going to the Design Value Tables, we find that as an example, 2x8 Douglas Fir−Larch grade No.2 has an Fb value of 1390 for snow loading. (It also has an E value of 1,600,000 which satisfies the recommended deflection criteria.)

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Example 1

TABLE F- 2

FLOOR JOISTS WITH L/360 DEFLECTION LIMITS

DESIGN CRITERIA:
Deflection - For 40 psf live load.
Limited to span in inches divided by 360.
Strength - Live load of 40 psf plus dead load
of 10 psf determines the required bending design value.

Joist Size (in)	Spacing (in)	Modulus of Elasticity, E, in 1,000,000 psi																
		0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
	12.0	8- 6	8-10	9- 2	9- 6	9- 9	10- 0	10- 3	10- 6	10- 9	10-11	11- 2	11- 4	11- 7	11- 9	11-11	12- 1	12- 3
	16.0	7- 9	8- 0	8- 4	8- 7	8-10	9- 1	9- 4	9- 6	9- 9	9-11	10- 2	10- 4	10- 6	10- 8	10-10	11- 0	11- 2
2x 6	19.2	7- 3	7- 7	7-10	8- 1	8- 4	8- 7	8- 9	9- 0	9- 2	9- 4	9- 6	9- 8	9-10	10- 0	10- 2	10- 4	10- 6
	24.0	6- 9	7- 0	7- 3	7- 6	7- 9	7-11	8- 2	8- 4	8- 6	8- 8	8-10	9- 0	9- 2	9- 4	9- 6	9- 7	9- 9
	12.0	11- 3	11- 8	12- 1	12- 6	12-10	13- 2	13- 6	13-10	14- 2	14- 5	14- 8	15- 0	15- 3	15- 6	15- 9	15-11	16- 2
	16.0	10- 2	10- 7	11- 0	11- 4	11- 8	12- 0	12- 3	12- 7	12-10	13- 1	13- 4	13- 7	13-10	14- 1	14- 3	14- 6	14- 8
2x 8	19.2	9- 7	10- 0	10- 4	10- 8	11- 0	11- 3	11- 7	11-10	12- 1	12- 4	12- 7	12-10	13- 0	13- 3	13- 5	13- 8	13-10
	24.0	8-11	9- 3	9- 7	9-11	10- 2	10- 6	10- 9	11- 0	11- 3	11- 5	11- 8	11-11	12- 1	12- 3	12- 6	12- 8	12-10
	12.0	14- 4	14-11	15- 5	15-11	16- 5	16-10	17- 3	17- 8	18- 0	18- 5	18- 9	19- 1	19- 5	19- 9	20- 1	20- 4	20- 8
	16.0	13- 0	13- 6	14- 0	14- 6	14-11	15- 3	15- 8	16- 0	16- 5	16- 9	17- 0	17- 4	17- 8	17-11	18- 3	18- 6	18- 9
2x10	19.2	12- 3	12- 9	13- 2	13- 7	14- 0	14- 5	14- 9	15- 1	15- 5	15- 9	16- 0	16- 4	16- 7	16-11	17- 2	17- 5	17- 8
	24.0	11- 4	11-10	12- 3	12- 8	13- 0	13- 4	13- 8	14- 0	14- 4	14- 7	14-11	15- 2	15- 5	15- 8	15-11	16- 2	16- 5
	12.0	17- 5	18- 1	18- 9	19- 4	19-11	20- 6	21- 0	21- 6	21-11	22- 5	22-10	23- 3	23- 7	24- 0	24- 5	24- 9	25- 1
	16.0	15-10	16- 5	17- 0	17- 7	18- 1	18- 7	19- 1	19- 6	19-11	20- 4	20- 9	21- 1	21- 6	21-10	22- 2	22- 6	22-10
2x12	19.2	14-11	15- 6	16- 0	16- 7	17- 0	17- 6	17-11	18- 4	18- 9	19- 2	19- 6	19-10	20- 2	20- 6	20-10	21- 2	21- 6
	24.0	13-10	14- 4	14-11	15- 4	15-10	16- 3	16- 8	17- 0	17- 5	17- 9	18- 1	18- 5	18- 9	19- 1	19- 4	19- 8	19-11
F_b	12.0	718	777	833	888	941	993	1043	1092	1140	1187	1233	1278	1323	1367	1410	1452	1494
F_b	16.0	790	855	917	977	1036	1093	1148	1202	1255	1306	1357	1407	1456	1504	1551	1598	1644
F_b	19.2	840	909	975	1039	1101	1161	1220	1277	1333	1388	1442	1495	1547	1598	1649	1698	1747
F_b	24.0	905	979	1050	1119	1186	1251	1314	1376	1436	1496	1554	1611	1667	1722	1776	1829	1882

Note: The required bending design value, F_b, in pounds per square inch is shown at the bottom of each table and is applicable to all lumber sizes shown. Spans are shown in feet-inches and are limited to 26' and less. Check sources of supply for availability of lumber in lengths greater than 20'.

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Example 1

Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Eastern White Pine					
Select Structural	2x4	2155	2480	1,200,000	NELMA NSLB
No.1		1335	1535	1,100,000	
No.2		990	1140	1,100,000	
No.3		605	695	900,000	
Stud		570	655	900,000	
Construction		775	895	1,000,000	
Standard		430	495	900,000	
Utility		200	230	800,000	
Select Structural	2x6	1870	2150	1,200,000	
No.1		1160	1330	1,100,000	
No.2		860	990	1,100,000	
No.3		525	600	900,000	
Stud		520	595	900,000	
Select Structural	2x8	1725	1985	1,200,000	
No.1		1070	1230	1,100,000	
No.2		795	915	1,100,000	
No.3		485	555	900,000	
Select Structural	2x10	1580	1820	1,200,000	
No.1		980	1125	1,100,000	
No.2		725	835	1,100,000	
No.3		445	510	900,000	
Select Structural	2x12	1440	1655	1,200,000	
No.1		890	1025	1,100,000	
No.2		660	760	1,100,000	
No.3		405	465	900,000	
Hem Fir					
Select Structural	2x4	2415	2775	1,600,000	WCLIB WWPA
No.1 & Btr		1810	2085	1,500,000	
No.1		1640	1885	1,500,000	
No.2		1465	1685	1,300,000	
No.3		865	990	1,200,000	
Stud		855	980	1,200,000	
Construction		1120	1290	1,300,000	
Standard		635	725	1,200,000	
Utility		290	330	1,100,000	
Select Structural	2x6	2095	2405	1,600,000	
No.1 & Btr		1570	1805	1,500,000	
No.1		1420	1635	1,500,000	
No.2		1270	1460	1,300,000	
No.3		750	860	1,200,000	
Stud		775	895	1,200,000	
Select Structural	2x8	1930	2220	1,600,000	
No.1 & Btr		1450	1665	1,500,000	
No.1		1310	1510	1,500,000	
No.2		1175	1350	1,300,000	
No.3		690	795	1,200,000	
Select Structural	2x10	1770	2035	1,600,000	
No.1 & Btr		1330	1525	1,500,000	
No.1		1200	1380	1,500,000	
No.2		1075	1235	1,300,000	
No.3		635	725	1,200,000	
Select Structural	2x12	1610	1850	1,600,000	
No.1 & Btr		1210	1390	1,500,000	
No.1		1095	1255	1,500,000	
No.2		980	1125	1,300,000	
No.3		575	660	1,200,000	

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Example 2

TABLE R-3

RAFTERS WITH L/240 DEFLECTION LIMITATION

DESIGN CRITERIA:
Strength - Live Load of 40 psf plus
Dead Load of 10 psf determines the required bending design value.
Deflection - For 40 psf live load.
Limited to span in inches divided by 240.

Size (in)	Spacing (in)	Rafter Bending Design Value, F_b, (psi) 300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
2x 6	12.0	5-6	6-4	7-1	7-9	8-5	9-0	9-6	10-0	10-6	11-0	11-5	11-11	12-4	12-8	13-1	13-6	13-10	14-2				
	16.0	4-9	5-6	6-2	6-9	7-3	7-9	8-3	8-8	9-1	9-6	9-11	10-3	10-8	11-0	11-4	11-8	12-0	12-4	12-7	12-11		
	19.2	4-4	5-0	5-7	6-2	6-8	7-1	7-6	7-11	8-4	8-8	9-1	9-5	9-9	10-0	10-4	10-8	10-11	11-3	11-6	11-9	12-0	12-4
	24.0	3-11	4-6	5-0	5-6	5-11	6-4	6-9	7-1	7-5	7-9	8-1	8-5	8-8	9-0	9-3	9-6	9-9	10-0	10-3	10-6	10-9	11-0
2x 8	12.0	7-3	8-4	9-4	10-3	11-1	11-10	12-7	13-3	13-11	14-6	15-1	15-8	16-3	16-9	17-3	17-9	18-3	18-9				
	16.0	6-3	7-3	8-1	8-11	9-7	10-3	10-10	11-6	12-0	12-7	13-1	13-7	14-0	14-6	14-11	15-5	15-10	16-3	16-7	17-0		
	19.2	5-9	6-7	7-5	8-1	8-9	9-4	9-11	10-6	11-0	11-6	11-11	12-5	12-10	13-3	13-8	14-0	14-5	14-10	15-2	15-6	15-10	16-3
	24.0	5-2	5-11	6-7	7-3	7-10	8-4	8-11	9-4	9-10	10-3	10-8	11-1	11-6	11-10	12-2	12-7	12-11	13-3	13-7	13-11	14-2	14-6
2x10	12.0	9-3	10-8	11-11	13-1	14-2	15-1	16-0	16-11	17-9	18-6	19-3	20-0	20-8	21-4	22-0	22-8	23-3	23-11				
	16.0	8-0	9-3	10-4	11-4	12-3	13-1	13-10	14-8	15-4	16-0	16-8	17-4	17-11	18-6	19-1	19-7	20-2	20-8	21-2	21-8		
	19.2	7-4	8-5	9-5	10-4	11-2	11-11	12-8	13-4	14-0	14-8	15-3	15-10	16-4	16-11	17-5	17-11	18-5	18-11	19-4	19-10	20-3	20-8
	24.0	6-6	7-7	8-5	9-3	10-0	10-8	11-4	11-11	12-6	13-1	13-7	14-2	14-8	15-1	15-7	16-0	16-6	16-11	17-4	17-9	18-1	18-6
2x12	12.0	11-3	13-0	14-6	15-11	17-2	18-4	19-6	20-6	21-7	22-6	23-5	24-4	25-2	26-0								
	16.0	9-9	11-3	12-7	13-9	14-11	15-11	16-10	17-9	18-8	19-6	20-3	21-1	21-9	22-6	23-2	23-10	24-6	25-2	25-9			
	19.2	8-11	10-3	11-6	12-7	13-7	14-6	15-5	16-3	17-0	17-9	18-6	19-3	19-11	20-6	21-2	21-9	22-5	23-0	23-6	24-1	24-8	25-2
	24.0	7-11	9-2	10-3	11-3	12-2	13-0	13-9	14-6	15-3	15-11	16-7	17-2	17-9	18-4	18-11	19-6	20-0	20-6	21-1	21-7	22-0	22-6
E	12.0	0.14	0.22	0.31	0.41	0.51	0.63	0.75	0.88	1.01	1.15	1.30	1.45	1.61	1.77	1.94	2.12	2.30	2.48				
E	16.0	0.12	0.19	0.27	0.35	0.44	0.54	0.65	0.76	0.88	1.00	1.12	1.26	1.39	1.54	1.68	1.83	1.99	2.15	2.31	2.48		
E	19.2	0.11	0.18	0.24	0.32	0.41	0.50	0.59	0.69	0.80	0.91	1.03	1.15	1.27	1.40	1.54	1.67	1.81	1.96	2.11	2.26	2.42	2.58
E	24.0	0.10	0.16	0.22	0.29	0.36	0.44	0.53	0.62	0.71	0.81	0.92	1.03	1.14	1.25	1.37	1.50	1.62	1.75	1.89	2.02	2.16	2.30

Note: The required modulus of elasticity, E, in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million psi and less, and is applicable to all lumber sizes shown. Spans are shown in feet-inches and are limited to 26' and less. Check sources of supply for availability of lumber in lengths greater than 20'.

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Example 2

Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Cottonwood					
Select Structural	2x4	1510	1735	1,200,000	NSLB
No.1		1080	1240	1,200,000	
No.2		1080	1240	1,100,000	
No.3		605	695	1,000,000	
Stud		600	690	1,000,000	
Construction		805	925	1,000,000	
Standard		460	530	900,000	
Utility		200	230	900,000	
Select Structural	2x6	1310	1505	1,200,000	
No.1		935	1075	1,200,000	
No.2		935	1075	1,100,000	
No.3		525	600	1,000,000	
Stud		545	630	1,000,000	
Select Structural	2x8	1210	1390	1,200,000	
No.1		865	990	1,200,000	
No.2		865	990	1,100,000	
No.3		485	555	1,000,000	
Select Structural	2x10	1105	1275	1,200,000	
No.1		790	910	1,200,000	
No.2		790	910	1,100,000	
No.3		445	510	1,000,000	
Select Structural	2x12	1005	1155	1,200,000	
No.1		720	825	1,200,000	
No.2		720	825	1,100,000	
No.3		405	465	1,000,000	
Douglas Fir-Larch					
Select Structural	2x4	2500	2875	1,900,000	WCLIB WWPA
No.1 & Btr		1985	2280	1,800,000	
No.1		1725	1985	1,700,000	
No.2		1510	1735	1,600,000	
No.3		865	990	1,400,000	
Stud		855	980	1,400,000	
Construction		1150	1325	1,500,000	
Standard		635	725	1,400,000	
Utility		315	365	1,300,000	
Select Structural	2x6	2170	2495	1,900,000	
No.1 & Btr		1720	1975	1,800,000	
No.1		1495	1720	1,700,000	
No.2		1310	1505	1,600,000	
No.3		750	860	1,400,000	
Stud		775	895	1,400,000	
Select Structural	2x8	2000	2300	1,900,000	
No.1 & Str		1585	1825	1,800,000	
No.1		1380	1585	1,700,000	
No.2		1210	1390	1,600,000	
No.3		690	795	1,400,000	
Select Structural	2x10	1835	2110	1,900,000	
No.1 & Btr		1455	1675	1,800,000	
No.1		1265	1455	1,700,000	
No.2		1105	1275	1,600,000	
No.3		635	725	1,400,000	
Select Structural	2x12	1670	1920	1,900,000	
No.1 & Btr		1325	1520	1,800,000	
No.1		1150	1325	1,700,000	
No.2		1005	1155	1,600,000	
No.3		575	660	1,400,000	

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TABLE F− 2
FLOOR JOISTS WITH L/360 DEFLECTION LIMITS

DESIGN CRITERIA:
Deflection − For 40 psf live load.
Limited to span in inches divided by 360.
Strength − Live load of 40 psf plus dead load
of 10 psf determines the required bending design value.

Joist Size (in)	Spacing (in)	Modulus of Elasticity, E, in 1,000,000 psi																
		0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
	12.0	8− 6	8−10	9− 2	9− 6	9− 9	10− 0	10− 3	10− 6	10− 9	10−11	11− 2	11− 4	11− 7	11− 9	11−11	12− 1	12− 3
	16.0	7− 9	8− 0	8− 4	8− 7	8−10	9− 1	9− 4	9− 6	9− 9	9−11	10− 2	10− 4	10− 6	10− 8	10−10	11− 0	11− 2
2x 6	19.2	7− 3	7− 7	7−10	8− 1	8− 4	8− 7	8− 9	9− 0	9− 2	9− 4	9− 6	9− 8	9−10	10− 0	10− 2	10− 4	10− 6
	24.0	6− 9	7− 0	7− 3	7− 6	7− 9	7−11	8− 2	8− 4	8− 6	8− 8	8−10	9− 0	9− 2	9− 4	9− 6	9− 7	9− 9
	12.0	11− 3	11− 8	12− 1	12− 6	12−10	13− 2	13− 6	13−10	14− 2	14− 5	14− 8	15− 0	15− 3	15− 6	15− 9	15−11	16− 2
	16.0	10− 2	10− 7	11− 0	11− 4	11− 8	12− 0	12− 3	12− 7	12−10	13− 1	13− 4	13− 7	13−10	14− 1	14− 3	14− 6	14− 8
2x 8	19.2	9− 7	10− 0	10− 4	10− 8	11− 0	11− 3	11− 7	11−10	12− 1	12− 4	12− 7	12−10	13− 0	13− 3	13− 5	13− 8	13−10
	24.0	8−11	9− 3	9− 7	9−11	10− 2	10− 6	10− 9	11− 0	11− 3	11− 5	11− 8	11−11	12− 1	12− 3	12− 6	12− 8	12−10
	12.0	14− 4	14−11	15− 5	15−11	16− 5	16−10	17− 3	17− 8	18− 0	18− 5	18− 9	19− 1	19− 5	19− 9	20− 1	20− 4	20− 8
	16.0	13− 0	13− 6	14− 0	14− 6	14−11	15− 3	15− 8	16− 0	16− 5	16− 9	17− 0	17− 4	17− 8	17−11	18− 3	18− 6	18− 9
2x10	19.2	12− 3	12− 9	13− 2	13− 7	14− 0	14− 5	14− 9	15− 1	15− 5	15− 9	16− 0	16− 4	16− 7	16−11	17− 2	17− 5	17− 8
	24.0	11− 4	11−10	12− 3	12− 8	13− 0	13− 4	13− 8	14− 0	14− 4	14− 7	14−11	15− 2	15− 5	15− 8	15−11	16− 2	16− 5
	12.0	17− 5	18− 1	18− 9	19− 4	19−11	20− 6	21− 0	21− 6	21−11	22− 5	22−10	23− 3	23− 7	24− 0	24− 5	24− 9	25− 1
	16.0	15−10	16− 5	17− 0	17− 7	18− 1	18− 7	19− 1	19− 6	19−11	20− 4	20− 9	21− 1	21− 6	21−10	22− 2	22− 6	22−10
2x12	19.2	14−11	15− 6	16− 0	16− 7	17− 0	17− 6	17−11	18− 4	18− 9	19− 2	19− 6	19−10	20− 2	20− 6	20−10	21− 2	21− 6
	24.0	13−10	14− 4	14−11	15− 4	15−10	16− 3	16− 8	17− 0	17− 5	17− 9	18− 1	18− 5	18− 9	19− 1	19− 4	19− 8	19−11
F_b	12.0	718	777	833	888	941	993	1043	1092	1140	1187	1233	1278	1323	1367	1410	1452	1494
F_b	16.0	790	855	917	977	1036	1093	1148	1202	1255	1306	1357	1407	1456	1504	1551	1598	1644
F_b	19.2	840	909	975	1039	1101	1161	1220	1277	1333	1388	1442	1495	1547	1598	1649	1698	1747
F_b	24.0	905	979	1050	1119	1186	1251	1314	1376	1436	1496	1554	1611	1667	1722	1776	1829	1882

Note: The required bending design value, F_b, in pounds per square inch is shown at the bottom of each table and is applicable to all lumber sizes shown. Spans are shown in feet−inches and are limited to 26' and less. Check sources of supply for availability of lumber in lengths greater than 20'.

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TABLE C−1
CEILING JOISTS WITH L/240 DEFLECTION LIMITS

DESIGN CRITERIA:
Deflection − For 10 psf live load.
Limited to span in inches divided by 240.
Strength − Live Load of 10 psf plus
dead load of 5 psf determines the required fiber stress value.

Joist Size (in)	Spacing (in)	Modulus of Elasticity, E, in 1,000,000 psi																
		0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
	12.0	9−10	10−3	10−7	10−11	11−3	11−7	11−10	12−2	12−5	12−8	12−11	13−2	13−4	13−7	13−9	14−0	14−2
	16.0	8−11	9−4	9−8	9−11	10−3	10−6	10−9	11−0	11−3	11−6	11−9	11−11	12−2	12−4	12−6	12−9	12−11
2x 4	19.2	8−5	8−9	9−1	9−4	9−8	9−11	10−2	10−4	10−7	10−10	11−0	11−3	11−5	11−7	11−9	12−0	12−2
	24.0	7−10	8−1	8−5	8−8	8−11	9−2	9−5	9−8	9−10	10−0	10−3	10−5	10−7	10−9	10−11	11−1	11−3
	12.0	15−6	16−1	16−8	17−2	17−8	18−2	18−8	19−1	19−6	19−11	20−3	20−8	21−0	21−4	21−8	22−0	22−4
	16.0	14−1	14−7	15−2	15−7	16−1	16−6	16−11	17−4	17−8	18−1	18−5	18−9	19−1	19−5	19−8	20−0	20−3
2x 6	19.2	13−3	13−9	14−3	14−8	15−2	15−7	15−11	16−4	16−8	17−0	17−4	17−8	17−11	18−3	18−6	18−10	19−1
	24.0	12−3	12−9	13−3	13−8	14−1	14−5	14−9	15−2	15−6	15−9	16−1	16−4	16−8	16−11	17−2	17−5	17−8
	12.0	20−5	21−2	21−11	22−8	23−4	24−0	24−7	25−2	25−8								
	16.0	18−6	19−3	19−11	20−7	21−2	21−9	22−4	22−10	23−4	23−10	24−3	24−8	25−2	25−7	25−11		
2x 8	19.2	17−5	18−1	18−9	19−5	19−11	20−6	21−0	21−6	21−11	22−5	22−10	23−3	23−8	24−0	24−5	24−9	25−2
	24.0	16−2	16−10	17−5	18−0	18−6	19−0	19−6	19−11	20−5	20−10	21−2	21−7	21−11	22−4	22−8	23−0	23−4
	12.0	26−0																
	16.0	23−8	24−7	25−5														
2x10	19.2	22−3	23−1	23−11	24−9	25−5												
	24.0	20−8	21−6	22−3	22−11	23−8	24−3	24−10	25−5	26−0								
F_b	12.0	711	769	825	880	932	983	1033	1082	1129	1176	1221	1266	1310	1354	1396	1438	1480
F_b	16.0	783	847	909	968	1026	1082	1137	1191	1243	1294	1344	1394	1442	1490	1537	1583	1629
F_b	19.2	832	900	965	1029	1090	1150	1208	1265	1321	1375	1429	1481	1533	1583	1633	1682	1731
F_b	24.0	896	969	1040	1108	1174	1239	1302	1363	1423	1481	1539	1595	1651	1706	1759	1812	1864

Note: The required bending design value, F_b, in pounds per square inch is shown at the bottom of each table and is applicable to all lumber sizes shown. Spans are shown in feet−inches and are limited to 26' and less. Check sources of supply for availability of lumber in lengths greater than 20'.

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TABLE C−2
CEILING JOISTS WITH L/240 DEFLECTION LIMITS

DESIGN CRITERIA:
Deflection − For 20 psf live load.
Limited to span in inches divided by 240.
Strength − Live Load of 20 psf plus
dead load of 10 psf determines the required bending design value.

Joist Modulus of Elasticity, E, in 1,000,000 psi

Size (in)	Spacing (in)	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
	12.0	7−10	8− 1	8− 5	8− 8	8−11	9− 2	9− 5	9− 8	9−10	10− 0	10− 3	10− 5	10− 7	10− 9	10−11	11− 1	11− 3
	16.0	7− 1	7− 5	7− 8	7−11	8− 1	8− 4	8− 7	8− 9	8−11	9− 1	9− 4	9− 6	9− 8	9− 9	9−11	10− 1	10− 3
2x 4	19.2	6− 8	6−11	7− 2	7− 5	7− 8	7−10	8− 1	8− 3	8− 5	8− 7	8− 9	8−11	9− 1	9− 3	9− 4	9− 6	9− 8
	24.0	6− 2	6− 5	6− 8	6−11	7− 1	7− 3	7− 6	7− 8	7−10	8− 0	8− 1	8− 3	8− 5	8− 7	8− 8	8−10	8−11
	12.0	12− 3	12− 9	13− 3	13− 8	14− 1	14− 5	14− 9	15− 2	15− 6	15− 9	16− 1	16− 4	16− 8	16−11	17− 2	17− 5	17− 8
	16.0	11− 2	11− 7	12− 0	12− 5	12− 9	13− 1	13− 5	13− 9	14− 1	14− 4	14− 7	14−11	15− 2	15− 5	15− 7	15−10	16− 1
2x 6	19.2	10− 6	10−11	11− 4	11− 8	12− 0	12− 4	12− 8	12−11	13− 3	13− 6	13− 9	14− 0	14− 3	14− 6	14− 8	14−11	15− 2
	24.0	9− 9	10− 2	10− 6	10−10	11− 2	11− 5	11− 9	12− 0	12− 3	12− 6	12− 9	13− 0	13− 3	13− 5	13− 8	13−10	14− 1
	12.0	16− 2	16−10	17− 5	18− 0	18− 6	19− 0	19− 6	19−11	20− 5	20−10	21− 2	21− 7	21−11	22− 4	22− 8	23− 0	23− 4
	16.0	14− 8	15− 3	15−10	16− 4	16−10	17− 3	17− 9	18− 1	18− 6	18−11	19− 3	19− 7	19−11	20− 3	20− 7	20−11	21− 2
2x 8	19.2	13−10	14− 5	14−11	15− 5	15−10	16− 3	16− 8	17− 1	17− 5	17− 9	18− 1	18− 5	18− 9	19− 1	19− 5	19− 8	19−11
	24.0	12−10	13− 4	13−10	14− 3	14− 8	15− 1	15− 6	15−10	16− 2	16− 6	16−10	17− 2	17− 5	17− 9	18− 0	18− 3	18− 6
	12.0	20− 8	21− 6	22− 3	22−11	23− 8	24− 3	24−10	25− 5	26− 0								
	16.0	18− 9	19− 6	20− 2	20−10	21− 6	22− 1	22− 7	23− 1	23− 8	24− 1	24− 7	25− 0	25− 5	25−10			
2x10	19.2	17− 8	18− 4	19− 0	19− 7	20− 2	20− 9	21− 3	21− 9	22− 3	22− 8	23− 1	23− 7	23−11	24− 4	24− 9	25− 1	25− 5
	24.0	16− 5	17− 0	17− 8	18− 3	18− 9	19− 3	19− 9	20− 2	20− 8	21− 1	21− 6	21−10	22− 3	22− 7	22−11	23− 4	23− 8
F_b	12.0	896	969	1040	1108	1174	1239	1302	1363	1423	1481	1539	1595	1651	1706	1759	1812	1864
F_b	16.0	986	1067	1145	1220	1293	1364	1433	1500	1566	1631	1694	1756	1817	1877	1936	1995	2052
F_b	19.2	1048	1134	1216	1296	1374	1449	1522	1594	1664	1733	1800	1866	1931	1995	2058	2120	2181
F_b	24.0	1129	1221	1310	1396	1480	1561	1640	1717	1793	1866	1939	2010	2080	2149	2217	2283	2349

Note: The required bending design value, F_b, in pounds per square inch is shown at the bottom of each table and is applicable to all lumber sizes shown. Spans are shown in feet−inches and are limited to 26' and less.Check sources of supply for availability of lumber in lengths greater than 20'.

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TABLE R−2
RAFTERS WITH L/240 DEFLECTION LIMITATION

DESIGN CRITERIA:
Strength − Live Load of 30 psf plus
Dead Load of 10 psf determines the required bending design value.
Deflection − For 30 psf live load.
Limited to span in inches divided by 240.

Rafter Bending Design Value, F_b, (psi)

Size (in)	Spacing (in)	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
	12.0	6− 2	7− 1	7−11	8− 8	9− 5	10− 0	10− 8	11− 3	11− 9	12− 4	12−10	13− 3	13− 9	14− 2	14− 8	15− 1	15− 6	15−11				
	16.0	5− 4	6− 2	6−10	7− 6	8− 2	8− 8	9− 3	9− 9	10− 2	10− 8	11− 1	11− 6	11−11	12− 4	12− 8	13− 1	13− 5	13− 9	14− 1	14− 5		
2x 6	19.2	4−10	5− 7	6− 3	6−10	7− 5	7−11	8− 5	8−11	9− 4	9− 9	10− 1	10− 6	10−10	11− 3	11− 7	11−11	12− 3	12− 7	12−10	13− 2	13− 6	
	24.0	4− 4	5− 0	5− 7	6− 2	6− 8	7− 1	7− 6	7−11	8− 4	8− 8	9− 1	9− 5	9− 9	10− 0	10− 4	10− 8	10−11	11− 3	11− 6	11− 9	12− 0	12− 4
	12.0	8− 1	9− 4	10− 6	11− 6	12− 5	13− 3	14− 0	14−10	15− 6	16− 3	16−10	17− 6	18− 1	18− 9	19− 4	19−10	20− 5	20−11				
	16.0	7− 0	8− 1	9− 1	9−11	10− 9	11− 6	12− 2	12−10	13− 5	14− 0	14− 7	15− 2	15− 8	16− 3	16− 9	17− 2	17− 8	18− 1	18− 7	19− 0		
2x 8	19.2	6− 5	7− 5	8− 3	9− 1	9− 9	10− 6	11− 1	11− 8	12− 3	12−10	13− 4	13−10	14− 4	14−10	15− 3	15− 8	16− 2	16− 7	16−11	17− 4	17− 9	
	24.0	5− 9	6− 7	7− 5	8− 1	8− 9	9− 4	9−11	10− 6	11− 0	11− 6	11−11	12− 5	12−10	13− 3	13− 8	14− 0	14− 5	14−10	15− 2	15− 6	15−10	16− 3
	12.0	10− 4	11−11	13− 4	14− 8	15−10	16−11	17−11	18−11	19−10	20− 8	21− 6	22− 4	23− 1	23−11	24− 7	25− 4	26− 0					
	16.0	8−11	10− 4	11− 7	12− 8	13− 8	14− 8	15− 6	16− 4	17− 2	17−11	18− 8	19− 4	20− 0	20− 8	21− 4	21−11	22− 6	23− 1	23− 8	24− 3		
2x10	19.2	8− 2	9− 5	10− 7	11− 7	12− 6	13− 4	14− 2	14−11	15− 8	16− 4	17− 0	17− 8	18− 3	18−11	19− 6	20− 0	20− 7	21− 1	21− 8	22− 2	22− 8	
	24.0	7− 4	8− 5	9− 5	10− 4	11− 2	11−11	12− 8	13− 4	14− 0	14− 8	15− 3	15−10	16− 4	16−11	17− 5	17−11	18− 5	18−11	19− 4	19−10	20− 3	20− 8
	12.0	12− 7	14− 6	16− 3	17− 9	19− 3	20− 6	21− 9	23− 0	24− 1	25− 2												
	16.0	10−11	12− 7	14− 1	15− 5	16− 8	17− 9	18−10	19−11	20−10	21− 9	22− 8	23− 6	24− 4	25− 2	25−11							
2x12	19.2	9−11	11− 6	12−10	14− 1	15− 2	16− 3	17− 3	18− 2	19− 0	19−11	20− 8	21− 6	22− 3	23− 0	23− 8	24− 4	25− 0	25− 8				
	24.0	8−11	10− 3	11− 6	12− 7	13− 7	14− 6	15− 5	16− 3	17− 0	17− 9	18− 6	19− 3	19−11	20− 6	21− 2	21− 9	22− 5	23− 0	23− 6	24− 1	24− 8	25− 2
E	12.0	0.15	0.23	0.32	0.43	0.54	0.66	0.78	0.92	1.06	1.21	1.36	1.52	1.69	1.86	2.04	2.22	2.41	2.60				
E	16.0	0.13	0.20	0.28	0.37	0.47	0.57	0.68	0.80	0.92	1.05	1.18	1.32	1.46	1.61	1.76	1.92	2.08	2.25	2.42	2.60		
E	19.2	0.12	0.18	0.26	0.34	0.43	0.52	0.62	0.73	0.84	0.95	1.08	1.20	1.33	1.47	1.61	1.75	1.90	2.05	2.21	2.37	2.53	
E	24.0	0.11	0.16	0.23	0.30	0.38	0.46	0.55	0.65	0.75	0.85	0.96	1.08	1.19	1.31	1.44	1.57	1.70	1.84	1.98	2.12	2.27	2.41

Note: The required modulus of elasticity, E, in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million psi and less, and is applicable to all lumber sizes shown. Spans are shown in feet−inches and are limited to 26' and less. Check sources of supply for availability of lumber in lengths greater than 20'.

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TABLE R−3
RAFTERS WITH L/240 DEFLECTION LIMITATION

DESIGN CRITERIA:
Strength − Live Load of 40 psf plus
Dead Load of 10 psf determines the required bending design value.
Deflection − For 40 psf live load.
Limited to span in inches divided by 240.

Rafter Bending Design Value, F_b, (psi)

Size (in)	Spacing (in)	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
	12.0	5−6	6−4	7−1	7−9	8−5	9−0	9−6	10−0	10−6	11−0	11−5	11−11	12−4	12−8	13−1	13−6	13−10	14−2				
	16.0	4−9	5−6	6−2	6−9	7−3	7−9	8−3	8−8	9−1	9−6	9−11	10−3	10−8	11−0	11−4	11−8	12−0	12−4	12−7	12−11		
2x 6	19.2	4−4	5−0	5−7	6−2	6−8	7−1	7−6	7−11	8−4	8−8	9−1	9−5	9−9	10−0	10−4	10−8	10−11	11−3	11−6	11−9	12−0	12−4
	24.0	3−11	4−6	5−0	5−6	5−11	6−4	6−9	7−1	7−5	7−9	8−1	8−5	8−8	9−0	9−3	9−6	9−9	10−0	10−3	10−6	10−9	11−0
	12.0	7−3	8−4	9−4	10−3	11−1	11−10	12−7	13−3	13−11	14−6	15−1	15−8	16−3	16−9	17−3	17−9	18−3	18−9				
	16.0	6−3	7−3	8−1	8−11	9−7	10−3	10−10	11−6	12−0	12−7	13−1	13−7	14−0	14−6	14−11	15−5	15−10	16−3	16−7	17−0		
2x 8	19.2	5−9	6−7	7−5	8−1	8−9	9−4	9−11	10−6	11−0	11−6	11−11	12−5	12−10	13−3	13−8	14−0	14−5	14−10	15−2	15−6	15−10	16−3
	24.0	5−2	5−11	6−7	7−3	7−10	8−4	8−11	9−4	9−10	10−3	10−8	11−1	11−6	11−10	12−2	12−7	12−11	13−3	13−7	13−11	14−2	14−6
	12.0	9−3	10−8	11−11	13−1	14−2	15−1	16−0	16−11	17−9	18−6	19−3	20−0	20−8	21−4	22−0	22−8	23−3	23−11				
	16.0	8−0	9−3	10−4	11−4	12−3	13−1	13−10	14−8	15−4	16−0	16−8	17−4	17−11	18−6	19−1	19−7	20−2	20−8	21−2	21−8		
2x10	19.2	7−4	8−5	9−5	10−4	11−2	11−11	12−8	13−4	14−0	14−8	15−3	15−10	16−4	16−11	17−5	17−11	18−5	18−11	19−4	19−10	20−3	20−8
	24.0	6−6	7−7	8−5	9−3	10−0	10−8	11−4	11−11	12−6	13−1	13−7	14−2	14−8	15−1	15−7	16−0	16−6	16−11	17−4	17−9	18−1	18−6
	12.0	11−3	13−0	14−6	15−11	17−2	18−4	19−6	20−6	21−7	22−6	23−5	24−4	25−2	26−0								
	16.0	9−9	11−3	12−7	13−9	14−11	15−11	16−10	17−9	18−8	19−6	20−3	21−1	21−9	22−6	23−2	23−10	24−6	25−2	25−9			
2x12	19.2	8−11	10−3	11−6	12−7	13−7	14−6	15−5	16−3	17−0	17−9	18−6	19−3	19−11	20−6	21−2	21−9	22−5	23−0	23−6	24−1	24−8	25−2
	24.0	7−11	9−2	10−3	11−3	12−2	13−0	13−9	14−6	15−3	15−11	16−7	17−2	17−9	18−4	18−11	19−6	20−0	20−6	21−1	21−7	22−0	22−6
E	12.0	0.14	0.22	0.31	0.41	0.51	0.63	0.75	0.88	1.01	1.15	1.30	1.45	1.61	1.77	1.94	2.12	2.30	2.48				
E	16.0	0.12	0.19	0.27	0.35	0.44	0.54	0.65	0.76	0.88	1.00	1.12	1.26	1.39	1.54	1.68	1.83	1.99	2.15	2.31	2.48		
E	19.2	0.11	0.18	0.24	0.32	0.41	0.50	0.59	0.69	0.80	0.91	1.03	1.15	1.27	1.40	1.54	1.67	1.81	1.96	2.11	2.26	2.42	2.58
E	24.0	0.10	0.16	0.22	0.29	0.36	0.44	0.53	0.62	0.71	0.81	0.92	1.03	1.14	1.25	1.37	1.50	1.62	1.75	1.89	2.02	2.16	2.30

Note: The required modulus of elasticity, E, in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million psi and less, and is applicable to all lumber sizes shown. Spans are shown in feet−inches and are limited to 26' and less. Check sources of supply for availability of lumber in lengths greater than 20'.

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TABLE R−10
RAFTERS WITH L/240 DEFLECTION LIMITATION

DESIGN CRITERIA
Strength − Live Load of 30 psf plus
Dead Load of 20 psf determines the required bending design value
Deflection − For 30 psf live load.
Limited to span in inches divided by 240.

Rafter Bending Design Value, F_b, (psi)

Size (in)	Spacing (in)	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700
	12.0	5−6	6−4	7−1	7−9	8−5	9−0	9−6	10−0	10−6	11−0	11−5	11−11	12−4	12−8	13−1	13−6	13−10	14−2	14−7	14−11	15−3	15−7	15−11		
	16.0	4−9	5−6	6−2	6−9	7−3	7−9	8−3	8−8	9−1	9−6	9−11	10−3	10−8	11−0	11−4	11−8	12−0	12−4	12−7	12−11	13−2	13−6	13−9	14−0	14−3
2x 6	19.2	4−4	5−0	5−7	6−2	6−8	7−1	7−6	7−11	8−4	8−8	9−1	9−5	9−9	10−0	10−4	10−8	10−11	11−3	11−6	11−9	12−0	12−4	12−7	12−10	13−1
	24.0	3−11	4−6	5−0	5−6	5−11	6−4	6−9	7−1	7−5	7−9	8−1	8−5	8−8	9−0	9−3	9−6	9−9	10−0	10−3	10−6	10−9	11−0	11−3	11−5	11−8
	12.0	7−3	8−4	9−4	10−3	11−1	11−10	12−7	13−3	13−11	14−6	15−1	15−8	16−3	16−9	17−3	17−9	18−3	18−9	19−2	19−8	20−1	20−6	20−11		
	16.0	6−3	7−3	8−1	8−11	9−7	10−3	10−10	11−6	12−0	12−7	13−1	13−7	14−0	14−6	14−11	15−5	15−10	16−3	16−7	17−0	17−5	17−9	18−1	18−6	18−10
2x 8	19.2	5−9	6−7	7−5	8−1	8−9	9−4	9−11	10−6	11−0	11−6	11−11	12−5	12−10	13−3	13−8	14−0	14−5	14−10	15−2	15−6	15−10	16−3	16−7	16−10	17−2
	24.0	5−2	5−11	6−7	7−3	7−10	8−4	8−11	9−4	9−10	10−3	10−8	11−1	11−6	11−10	12−2	12−7	12−11	13−3	13−7	13−11	14−2	14−6	14−10	15−1	15−5
	12.0	9−3	10−8	11−11	13−1	14−2	15−1	16−0	16−11	17−9	18−6	19−3	20−0	20−8	21−4	22−0	22−8	23−3	23−11	24−6	25−1	25−7				
	16.0	8−0	9−3	10−4	11−4	12−3	13−1	13−10	14−8	15−4	16−0	16−8	17−4	17−11	18−6	19−1	19−7	20−2	20−8	21−2	21−8	22−2	22−8	23−1	23−7	24−0
2x10	19.2	7−4	8−5	9−5	10−4	11−2	11−11	12−8	13−4	14−0	14−8	15−3	15−10	16−4	16−11	17−5	17−11	18−5	18−11	19−4	19−10	20−3	20−8	21−1	21−6	21−11
	24.0	6−6	7−7	8−5	9−3	10−0	10−8	11−4	11−11	12−6	13−1	13−7	14−2	14−8	15−1	15−7	16−0	16−6	16−11	17−4	17−9	18−1	18−6	18−11	19−3	19−7
	12.0	11−3	13−0	14−6	15−11	17−2	18−4	19−6	20−6	21−7	22−6	23−5	24−4	25−2	26−0											
	16.0	9−9	11−3	12−7	13−9	14−11	15−11	16−10	17−9	18−8	19−6	20−3	21−1	21−9	22−6	23−2	23−10	24−6	25−2	25−9						
2x12	19.2	8−11	10−3	11−6	12−7	13−7	14−6	15−5	16−3	17−0	17−9	18−6	19−3	19−11	20−6	21−2	21−9	22−5	23−0	23−6	24−1	24−8	25−2	25−8		
	24.0	7−11	9−2	10−3	11−3	12−2	13−0	13−9	14−6	15−3	15−11	16−7	17−2	17−9	18−4	18−11	19−6	20−0	20−6	21−1	21−7	22−0	22−6	23−0	23−5	23−10
E	12.0	0.11	0.17	0.23	0.31	0.38	0.47	0.56	0.66	0.76	0.86	0.97	1.09	1.21	1.33	1.46	1.59	1.72	1.86	2.00	2.14	2.29	2.44	2.60		
E	16.0	0.09	0.14	0.20	0.26	0.33	0.41	0.49	0.57	0.66	0.75	0.84	0.94	1.05	1.15	1.26	1.37	1.49	1.61	1.73	1.86	1.99	2.12	2.25	2.39	2.53
E	19.2	0.09	0.13	0.18	0.24	0.30	0.37	0.44	0.52	0.60	0.68	0.77	0.86	0.95	1.05	1.15	1.25	1.36	1.47	1.58	1.70	1.81	1.93	2.05	2.18	2.31
E	24.0	0.08	0.12	0.16	0.22	0.27	0.33	0.40	0.46	0.54	0.61	0.69	0.77	0.85	0.94	1.03	1.12	1.22	1.31	1.41	1.52	1.62	1.73	1.84	1.95	2.06

Note: The required modulus of elasticity, E, in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million psi and less, and is applicable to all lumber sizes shown. Spans are shown in feet−inches and are limited to 26' and less. Check sources of supply for availability of lumber in lengths greater than 20'.

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TABLE R−11
RAFTERS WITH L/240 DEFLECTION LIMITATION

DESIGN CRITERIA:
Strength − Live Load of 40 psf plus
Dead Load of 20 psf determines the required bending design value.
Deflection − For 40 psf live load.
Limited to span in inches divided by 240.

Size (in)	Spacing (in)	Rafter Bending Design Value, F_b, (psi)																							
		300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700
	12.0	5−0	5−10	6−6	7−1	7−8	8−2	8−8	9−2	10−6	11−0	11−5	11−11	12−4	12−8	13−1	13−6	13−10	14−2	14−7	14−11	15−3	15−7	15−11		
	16.0	4−4	5−0	5−7	6−2	6−8	7−1	7−6	7−11	9−1	9−6	9−11	10−3	10−8	11−0	11−4	11−8	12−0	12−4	12−7	12−11	13−2	13−6	13−9	14−0	14−3
2x6	19.2	4−0	4−7	5−1	5−7	6−1	6−6	6−10	7−3	8−4	8−8	9−1	9−5	9−9	10−0	10−4	10−8	10−11	11−3	11−6	11−9	12−0	12−4	12−7	12−10	13−1
	24.0	3−7	4−1	4−7	5−0	5−5	5−10	6−2	6−6	7−5	7−9	8−1	8−5	8−8	9−0	9−3	9−6	9−9	10−0	10−3	10−6	10−9	11−0	11−3	11−5	11−8
	12.0	6−7	7−8	8−7	9−4	10−1	10−10	11−6	12−1	13−11	14−6	15−1	15−8	16−3	16−9	17−3	17−9	18−3	18−9	19−2	19−8	20−1	20−6	20−11		
	16.0	5−9	6−7	7−5	8−1	8−9	9−4	9−11	10−6	12−0	12−7	13−1	13−7	14−0	14−6	14−11	15−5	15−10	16−3	16−7	17−0	17−5	17−9	18−1	18−6	18−10
2x8	19.2	5−3	6−0	6−9	7−5	8−0	8−7	9−1	9−7	11−0	11−6	11−11	12−5	12−10	13−3	13−8	14−0	14−5	14−10	15−2	15−6	15−10	16−3	16−7	16−10	17−2
	24.0	4−8	5−5	6−0	6−7	7−2	7−9	8−1	8−7	9−10	10−3	10−8	11−1	11−6	11−10	12−2	12−7	12−11	13−3	13−7	13−11	14−2	14−6	14−10	15−1	15−5
	12.0	8−5	9−9	10−11	11−11	12−11	13−9	14−8	15−5	17−9	18−6	19−3	20−0	20−8	21−4	22−0	22−8	23−3	23−11	24−6	25−1	25−7				
	16.0	7−4	8−5	9−5	10−4	11−2	11−11	12−8	13−4	15−4	16−0	16−8	17−4	17−11	18−6	19−1	19−7	20−2	20−8	21−2	21−8	22−2	22−8	23−1	23−7	24−0
2x10	19.2	6−8	7−8	8−7	9−5	10−2	10−11	11−7	12−2	14−0	14−8	15−3	15−10	16−4	16−11	17−5	17−11	18−5	18−11	19−4	19−10	20−3	20−8	21−1	21−6	21−11
	24.0	6−0	6−11	7−8	8−5	9−1	9−9	10−4	10−11	12−6	13−1	13−7	14−2	14−8	15−1	15−7	16−0	16−6	16−11	17−4	17−9	18−1	18−6	18−11	19−3	19−7
	12.0	10−3	11−10	13−3	14−6	15−8	16−9	17−9	18−9	21−7	22−6	23−5	24−4	25−2	26−0											
	16.0	8−11	10−3	11−6	12−7	13−7	14−6	15−5	16−3	18−8	19−6	20−3	21−1	21−9	22−6	23−2	23−10	24−6	25−2	25−9						
2x12	19.2	8−1	9−4	10−6	11−6	12−5	13−3	14−1	14−10	17−0	17−9	18−6	19−3	19−11	20−6	21−2	21−9	22−5	23−0	23−6	24−1	25−2	25−8			
	24.0	7−3	8−5	9−4	10−3	11−1	11−10	12−7	13−3	15−3	15−11	16−7	17−2	17−9	18−4	18−11	19−6	20−0	20−6	21−1	21−7	22−0	22−6	23−0	23−5	23−10
E	12.0	0.11	0.17	0.24	0.31	0.39	0.48	0.57	0.67	0.76	0.86	0.97	1.09	1.21	1.33	1.46	1.59	1.72	1.86	2.00	2.14	2.29	2.44	2.60		
E	16.0	0.09	0.15	0.20	0.27	0.34	0.41	0.49	0.58	0.66	0.75	0.84	0.94	1.05	1.15	1.26	1.37	1.49	1.61	1.73	1.86	1.99	2.12	2.25	2.39	2.53
E	19.2	0.09	0.13	0.19	0.24	0.31	0.38	0.45	0.53	0.60	0.68	0.77	0.86	0.95	1.05	1.15	1.25	1.36	1.47	1.58	1.70	1.81	1.93	2.05	2.18	2.31
E	24.0	0.08	0.12	0.17	0.22	0.28	0.34	0.40	0.47	0.54	0.61	0.69	0.77	0.85	0.94	2.03	1.12	1.22	1.31	1.41	1.52	1.62	1.73	1.84	1.95	2.06

Note: The required modulus of elasticity, E, in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million psi and less, and is applicable to all lumber sizes shown. Spans are shown in feet−inches and are limited to 26’ and less. Check sources of supply for availability of lumber in lengths greater than 20’.

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TABLE R−14
RAFTERS WITH L/180 DEFLECTION LIMITATION

DESIGN CRITERIA:
Strength − Live Load of 30 psf plus
Dead Load of 10 psf determines the required bending design value.
Deflection − For 30 psf live load.
Limited to span in inches divided by 180.

Size (in)	Spacing (in)	Rafter Bending Design Value, F_b, (psi)																											
		200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000
	12.0	3−2	3−11	4−6	5−1	5−6	6−0	6−5	6−9	7−2	7−6	7−10	8−2	8−5	8−9	9−0	9−4	9−7	9−10	10−1	10−4	10−7	10−10	11−1						
	16.0	2−9	3−5	3−11	4−4	4−10	5−2	5−6	5−10	6−2	6−6	6−9	7−1	7−4	7−7	7−10	8−1	8−40	8−6	8−9	9−0	9−2	9−5	9−7	9−9	10−0				
2x4	19.2	2−6	3−1	3−7	4−0	4−4	4−9	5−1	5−4	5−8	5−11	6−2	6−5	6−8	6−11	7−2	7−4	7−7	7−9	8−0	8−2	8−5	8−7	8−9	8−11	9−1	9−3	9−5		
	24.0	2−3	2−9	3−2	3−7	3−11	4−3	4−6	4−10	5−1	5−4	5−6	5−9	6−0	6−2	6−5	6−7	6−9	7−0	7−2	7−4	7−6	7−8	7−10	8−0	8−2	8−4	8−5	8−7	8−9
	12.0	5−0	6−2	7−1	7−11	8−8	9−5	10−0	10−8	11−3	11−9	12−4	12−10	13−3	13−9	14−2	14−8	15−1	15−6	15−11	16−3	16−8	17−0	17−5						
	16.0	4−4	5−4	6−2	6−10	7−6	8−2	8−8	9−3	9−9	10−2	10−8	11−1	11−6	11−11	12−4	12−8	13−1	13−5	13−9	14−1	14−5	14−9	15−1	15−4	15−8				
2x6	19.2	4−0	4−10	5−7	6−3	6−10	7−5	7−11	8−5	8−11	9−4	9−9	10−1	10−6	10−10	11−3	11−7	11−11	12−3	12−7	12−10	13−2	13−6	13−9	14−0	14−4	14−7	14−10		
	24.0	3−7	4−4	5−0	5−7	6−2	6−8	7−1	7−6	7−11	8−4	8−8	9−1	9−5	9−9	10−0	10−4	10−8	10−11	11−3	11−6	11−9	12−0	12−4	12−7	12−10	13−1	13−3	13−6	13−9
	12.0	6−7	8−1	9−4	10−6	11−6	12−5	13−3	14−0	14−10	15−6	16−3	16−10	17−6	18−1	18−9	19−4	19−10	20−5	20−11	21−5	21−11	22−5	22−11						
	16.0	5−9	7−0	8−1	9−1	9−11	10−9	11−6	12−2	12−10	13−5	14−0	14−7	15−2	15−8	16−3	16−9	17−2	17−8	18−1	18−7	19−0	19−5	19−10	20−3	20−8				
2x8	19.2	5−3	6−5	7−5	8−3	9−1	9−9	10−6	11−1	11−8	12−3	12−10	13−4	13−10	14−4	14−10	15−3	15−8	16−2	16−7	16−11	17−4	17−9	18−1	18−6	18−10	19−3	19−7		
	24.0	4−8	5−9	6−7	7−5	8−1	8−9	9−4	9−11	10−6	11−0	11−6	11−11	12−5	12−10	13−3	13−8	14−0	14−5	14−10	15−2	15−6	15−10	16−3	16−7	16−10	17−2	17−6	17−10	18−1
	12.0	8−5	10−4	11−11	13−4	14−8	15−10	16−11	17−11	18−11	19−10	20−8	21−6	22−4	23−1	23−11	24−7	25−4	26−0											
	16.0	7−4	8−11	10−4	11−7	12−8	13−8	14−8	15−6	16−4	17−2	17−11	18−8	19−4	20−0	20−8	21−4	21−11	22−6	23−1	23−8	24−3	24−10	25−4	25−10					
2x10	19.2	6−8	8−2	9−5	10−7	11−7	12−6	13−4	14−2	14−11	15−8	16−4	17−0	17−8	18−3	18−11	19−6	20−0	20−7	21−1	21−8	22−2	22−8	23−1	23−7	24−1	24−6	25−0		
	24.0	6−0	7−4	8−5	9−5	10−4	11−2	11−11	12−8	13−4	14−0	14−8	15−3	15−10	16−4	16−11	17−5	17−11	18−5	18−11	19−4	19−10	20−3	20−8	21−1	21−6	21−11	22−4	22−9	23−1
E	12.0	0.06	0.11	0.17	0.24	0.32	0.40	0.49	0.59	0.69	0.79	0.91	1.02	1.14	1.27	1.39	1.53	1.66	1.80	1.95	2.10	2.25	2.40	2.56						
E	16.0	0.05	0.10	0.15	0.21	0.28	0.35	0.43	0.51	0.60	0.69	0.78	0.88	0.99	1.10	1.21	1.32	1.44	1.56	1.69	1.82	1.95	2.08	2.22	2.36	2.50				
E	19.2	0.05	0.09	0.14	0.19	0.25	0.32	0.39	0.47	0.54	0.63	0.72	0.81	0.90	1.00	1.10	1.21	1.32	1.43	1.54	1.66	1.78	1.90	2.03	2.15	2.28	2.42	2.55		
E	24.0	0.04	0.08	0.12	0.17	0.23	0.29	0.35	0.42	0.49	0.56	0.64	0.72	0.81	0.89	0.99	1.08	1.18	1.28	1.38	1.48	1.59	1.70	1.81	1.93	2.04	2.16	2.28	2.41	2.53

Note: The required modulus of elasticity, E, in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million psi and less, and is applicable to all lumber sizes shown. Spans are shown in feet−inches and are limited to 26’ and less. Check sources of supply for availability of lumber in lengths greater than 20’.

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TABLE R−15
RAFTERS WITH L/180 DEFLECTION LIMITATION

DESIGN CRITERIA:
Strength − Live Load of 40 psf plus
Dead Load of 10 psf determines the required bending design value.
Deflection − For 40 psf live load.
Limited to span in inches divided by 180.

Size (in)	Spacing (in)	Rafter Bending Design Value, F_b, (psi)																											
		200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000
	12.0	2−10	3−6	4−0	4−6	4−11	5−4	5−9	6−1	6−5	6−8	7−0	7−3	7−7	7−10	8−1	8−4	8−7	8−10	9−1	9−3	9−6	9−8	9−11	10−1					
	16.0	2−6	3−0	3−6	3−11	4−3	4−8	4−11	5−3	5−6	5−10	6−1	6−4	6−7	6−9	7−0	7−3	7−5	7−8	7−10	8−0	8−2	8−5	8−7	8−9	8−11	9−1			
2x4	19.2	2−3	2−9	3−2	3−7	3−11	4−3	4−6	4−10	5−1	5−4	5−6	5−9	6−0	6−2	6−5	6−7	6−9	7−0	7−2	7−4	7−6	7−8	7−10	8−0	8−2	8−4	8−5	8−7	
	24.0	2−0	2−6	2−10	3−2	3−6	3−9	4−0	4−3	4−6	4−9	4−11	5−2	5−4	5−6	5−9	5−11	6−1	6−3	6−5	6−7	6−8	6−10	7−0	7−2	7−3	7−5	7−7	7−8	7−10
	12.0	4−6	5−6	6−4	7−1	7−9	8−5	9−0	9−6	10−0	10−6	11−0	11−5	11−11	12−4	12−8	13−1	13−6	13−10	14−2	14−7	14−11	15−3	15−7	15−11					
	16.0	3−11	4−9	5−6	6−2	6−9	7−3	7−9	8−3	8−8	9−1	9−6	9−11	10−3	10−8	11−0	11−4	11−8	12−0	12−4	12−7	12−11	13−2	13−6	13−9	14−0	14−3			
2x6	19.2	3−7	4−4	5−0	5−7	6−2	6−8	7−1	7−6	7−11	8−4	8−8	9−1	9−5	9−9	10−0	10−4	10−8	10−11	11−3	11−6	11−9	12−0	12−4	12−7	12−10	13−1	13−3	13−6	
	24.0	3−2	3−11	4−6	5−0	5−6	5−11	6−4	6−9	7−1	7−5	7−9	8−1	8−5	8−8	9−0	9−3	9−6	9−9	10−0	10−3	10−6	10−9	11−0	11−3	11−5	11−8	11−11	12−1	12−4
	12.0	5−11	7−3	8−4	9−4	10−3	11−1	11−10	12−7	13−3	13−11	14−6	15−1	15−8	16−3	16−9	17−3	17−9	18−3	18−9	19−2	19−8	20−1	20−6	20−11					
	16.0	5−2	6−3	7−3	8−1	8−11	9−7	10−3	10−10	11−6	12−0	12−7	13−1	13−7	14−0	14−6	14−11	15−5	15−10	16−3	16−7	17−0	17−5	17−9	18−1	18−6	18−10			
2x8	19.2	4−8	5−9	6−7	7−5	8−1	8−9	9−4	9−11	10−6	11−0	11−6	11−11	12−5	12−10	13−3	13−8	14−0	14−5	14−10	15−2	15−6	15−10	16−3	16−7	16−10	17−2	17−6	17−10	
	24.0	4−2	5−2	5−11	6−7	7−3	7−10	8−4	8−11	9−4	9−10	10−3	10−8	11−1	11−6	11−10	12−2	12−7	12−11	13−3	13−7	13−11	14−2	14−6	14−10	15−1	15−5	15−8	15−11	16−3
	12.0	7−7	9−3	10−8	11−11	13−1	14−2	15−1	16−0	16−11	17−9	18−6	19−3	20−0	20−8	21−4	22−0	22−8	23−3	23−11	24−6	25−1	25−7							
	16.0	6−6	8−0	9−3	10−4	11−4	12−3	13−1	13−10	14−8	15−4	16−0	16−8	17−4	17−11	18−6	19−1	19−7	20−2	20−8	21−2	21−8	22−2	22−8	23−1	23−7	24−0			
2x10	19.2	6−0	7−4	8−5	9−5	10−4	11−2	11−11	12−8	13−4	14−0	14−8	15−3	15−10	16−4	16−11	17−5	17−11	18−5	18−11	19−4	19−10	20−3	20−8	21−1	21−6	21−11	22−4	22−9	
	24.0	5−4	6−6	7−7	8−5	9−3	10−0	10−8	11−4	11−11	12−6	13−1	13−7	14−2	14−8	15−1	15−7	16−0	16−6	16−11	17−4	17−9	18−1	18−6	18−11	19−3	19−7	20−0	20−4	20−8
E	12.0	0.06	0.11	0.17	0.23	0.31	0.38	0.47	0.56	0.66	0.76	0.86	0.97	1.09	1.21	1.33	1.46	1.59	1.72	1.86	2.00	2.14	2.29	2.44	2.60					
E	16.0	0.05	0.09	0.14	0.20	0.26	0.33	0.41	0.49	0.57	0.66	0.75	0.84	0.94	1.05	1.15	1.26	1.37	1.49	1.61	1.73	1.86	1.99	2.12	2.25	2.39	2.53			
E	19.2	0.05	0.09	0.13	0.18	0.24	0.30	0.37	0.44	0.52	0.60	0.68	0.77	0.86	0.95	1.05	1.15	1.25	1.36	1.47	1.58	1.70	1.81	1.93	2.05	2.18	2.31	2.43	2.57	
E	24.0	0.04	0.08	0.12	0.16	0.22	0.27	0.33	0.40	0.46	0.54	0.61	0.69	0.77	0.85	0.94	1.03	1.12	1.22	1.31	1.41	1.52	1.62	1.73	1.84	1.95	2.06	2.18	2.30	2.41

Note: The required modulus of elasticity, E, in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million psi and less, and is applicable to all lumber sizes shown. Spans are shown in feet−inches and are limited to 26’ and less. Check sources of supply for availability of lumber in lengths greater than 20’.

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TABLE R−22
RAFTERS WITH L/180 DEFLECTION LIMITATION

DESIGN CRITERIA:
Strength − Live Load of 30 psf plus
Dead Load of 20 psf determines the required bending design value.
Deflection − For 30 psf live load.
Limited to span in inches divided by 180.

Size (in)	Spacing (in)	Rafter Bending Design Value, F_b, (psi)																											
		200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000
	12.0	2−10	3−6	4−0	4−6	4−11	5−4	5−9	6−1	6−5	6−8	7−0	7−3	7−7	7−10	8−1	8−4	8−7	8−10	9−0	9−3	9−6	9−8	9−11	10−1	10−4	10−6	10−8	10−11	11−1
	16.0	2−6	3−0	3−6	3−11	4−3	4−8	4−11	5−3	5−6	5−10	6−1	6−4	6−7	6−9	7−0	7−3	7−5	7−8	7−10	8−0	8−2	8−5	8−7	8−9	8−11	9−1	9−3	9−5	9−7
2x4	19.2	2−3	2−9	3−2	3−7	3−11	4−3	4−6	4−10	5−1	5−4	5−6	5−9	6−0	6−2	6−5	6−7	6−9	7−0	7−2	7−4	7−6	7−8	7−10	8−0	8−2	8−4	8−5	8−7	8−9
	24.0	2−0	2−6	2−10	3−2	3−6	3−9	4−0	4−3	4−6	4−9	4−11	5−2	5−4	5−6	5−9	5−11	6−1	6−3	6−5	6−7	6−8	6−10	7−0	7−2	7−3	7−5	7−7	7−8	7−10
	12.0	4−6	5−6	6−4	7−1	7−9	8−5	9−0	9−6	10−0	10−6	11−0	11−5	11−11	12−4	12−8	13−1	13−6	13−10	14−2	14−7	14−11	15−3	15−7	15−11	16−2	16−6	16−10	17−1	17−5
	16.0	3−11	4−9	5−6	6−2	6−9	7−3	7−9	8−3	8−8	9−1	9−6	9−11	10−3	10−8	11−0	11−4	11−8	12−0	12−4	12−7	12−11	13−2	13−6	13−9	14−0	14−3	14−7	14−10	15−1
2x6	19.2	3−7	4−4	5−0	5−7	6−2	6−8	7−1	7−6	7−11	8−4	8−8	9−1	9−5	9−9	10−0	10−4	10−8	10−11	11−3	11−6	11−9	12−0	12−4	12−7	12−10	13−1	13−3	13−6	13−9
	24.0	3−2	3−11	4−6	5−0	5−6	5−11	6−4	6−9	7−1	7−5	7−9	8−1	8−5	8−8	9−0	9−3	9−6	9−9	10−0	10−3	10−6	10−9	11−0	11−3	11−5	11−8	11−11	12−1	12−4
	12.0	5−11	7−3	8−4	9−4	10−3	11−1	11−10	12−7	13−3	13−11	14−6	15−1	15−8	16−3	16−9	17−3	17−9	18−3	18−9	19−2	19−8	20−1	20−6	20−11	21−4	21−9	22−2	22−6	22−11
	16.0	5−2	6−3	7−3	8−1	8−11	9−7	10−3	10−10	11−6	12−0	12−7	13−1	13−7	14−0	14−6	14−11	15−5	15−10	16−3	16−7	17−0	17−5	17−9	18−1	18−6	18−10	19−2	19−6	19−10
2x8	19.2	4−8	5−9	6−7	7−5	8−1	8−9	9−4	9−11	10−6	11−0	11−6	11−11	12−5	12−10	13−3	13−8	14−0	14−5	14−10	15−2	15−6	15−10	16−3	16−7	16−10	17−2	17−6	17−10	18−1
	24.0	4−2	5−2	5−11	6−7	7−3	7−10	8−4	8−11	9−4	9−10	10−3	10−8	11−1	11−6	11−10	12−2	12−7	12−11	13−3	13−7	13−11	14−2	14−6	14−10	15−1	15−5	15−8	15−11	16−3
	12.0	7−7	9−3	10−8	11−11	13−1	14−2	15−1	16−0	16−11	17−9	18−6	19−3	20−0	20−8	21−4	22−0	22−8	23−3	23−11	24−6	25−1	25−7							
	16.0	6−6	8−0	9−3	10−4	11−4	12−3	13−1	13−10	14−8	15−4	16−0	16−8	17−4	17−11	18−6	19−1	19−7	20−2	20−8	21−2	21−8	22−2	22−8	23−1	23−7	24−0	24−6	24−11	25−4
2x10	19.2	6−0	7−4	8−5	9−5	10−4	11−2	11−11	12−8	13−4	14−0	14−8	15−3	15−10	16−4	16−11	17−5	17−11	18−5	18−11	19−4	19−10	20−3	20−8	21−1	21−6	21−11	22−4	22−9	23−1
	24.0	5−4	6−6	7−7	8−5	9−3	10−0	10−8	11−4	11−11	12−6	13−1	13−7	14−2	14−8	15−1	15−7	16−0	16−6	16−11	17−4	17−9	18−1	18−6	18−11	19−3	19−7	20−0	20−4	20−8
E	12.0	0.04	0.08	0.12	0.17	0.23	0.29	0.35	0.42	0.49	0.57	0.65	0.73	0.82	0.91	1.00	1.09	1.19	1.29	1.39	1.50	1.61	1.72	1.83	1.95	2.07	2.19	2.31	2.43	2.56
E	16.0	0.04	0.07	0.11	0.15	0.20	0.25	0.31	0.36	0.43	0.49	0.56	0.63	0.71	0.78	0.86	0.95	1.03	1.12	1.21	1.30	1.39	1.49	1.59	1.69	1.79	1.89	2.00	2.11	2.22
E	19.2	0.03	0.06	0.10	0.14	0.18	0.23	0.28	0.33	0.39	0.45	0.51	0.58	0.65	0.72	0.79	0.86	0.94	1.02	1.10	1.19	1.27	1.36	1.45	1.54	1.63	1.73	1.83	1.92	2.03
E	24.0	0.03	0.06	0.09	0.12	0.16	0.20	0.25	0.30	0.35	0.40	0.46	0.52	0.58	0.64	0.71	0.77	0.84	0.91	1.99	1.06	1.14	1.22	1.30	1.38	1.46	1.55	1.63	1.72	1.81

Note: The required modulus of elasticity, E, in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million psi and less, and is applicable to all lumber sizes shown. Spans are shown in feet−inches and are limited to 26’ and less. Check sources of supply for availability of lumber in lengths greater than 20’.

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TABLE R−23
RAFTERS WITH L/180 DEFLECTION LIMITATION

DESIGN CRITERIA:
Strength − Live Load of 40 psf plus
Dead Load of 20 psf determines the required bending design value.
Deflection − For 40 psf live load.
Limited to span in inches divided by 180.

Size (in)	Spacing (in)	Rafter Bending Design Value, F_b, (psi)																											
		200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000
	12.0	2−7	3−2	3−8	4−1	4−6	4−11	5−3	5−6	5−10	6−1	6−5	6−8	6−11	7−2	7−5	7−7	7−10	8−0	8−3	8−5	8−8	8−10	9−0	9−3	9−5	9−7	9−9	9−11	10−1
	16.0	2−3	2−9	3−2	3−7	3−11	4−3	4−6	4−10	5−1	5−4	5−6	5−9	6−0	6−2	6−5	6−7	6−9	7−0	7−2	7−4	7−6	7−8	7−10	8−0	8−2	8−4	8−5	8−7	8−9
2x4	19.2	2−1	2−6	2−11	3−3	3−7	3−10	4−1	4−4	4−7	4−10	5−1	5−3	5−5	5−8	5−10	6−0	6−2	6−4	6−6	6−8	6−10	7−0	7−2	7−3	7−5	7−7	7−9	7−10	8−0
	24.0	1−10	2−3	2−7	2−11	3−2	3−5	3−8	3−11	4−1	4−4	4−6	4−8	4−11	5−1	5−3	5−5	5−6	5−8	5−10	6−0	6−1	6−3	6−5	6−6	6−8	6−9	6−11	7−0	7−2
	12.0	4−1	5−0	5−10	6−6	7−1	7−8	8−2	8−8	9−2	9−7	10−0	10−5	10−10	11−3	11−7	11−11	12−4	12−8	13−0	13−3	13−7	13−11	14−2	14−6	14−9	15−1	15−4	15−7	15−11
	16.0	3−7	4−4	5−0	5−7	6−2	6−8	7−1	7−6	7−11	8−4	8−8	9−1	9−5	9−9	10−0	10−4	10−8	10−11	11−3	11−6	11−9	12−0	12−4	12−7	12−10	13−1	13−3	13−6	13−9
2x6	19.2	3−3	4−0	4−7	5−1	5−7	6−1	6−6	6−10	7−3	7−7	7−11	8−3	8−7	8−11	9−2	9−5	9−9	10−0	10−3	10−6	10−9	11−0	11−3	11−5	11−8	11−11	12−2	12−4	12−7
	24.0	2−11	3−7	4−1	4−7	5−0	5−5	5−10	6−2	6−6	6−10	7−1	7−5	7−8	7−11	8−2	8−5	8−8	8−11	9−2	9−5	9−7	9−10	10−0	10−3	10−5	10−8	10−10	11−0	11−3
	12.0	5−5	6−7	7−8	8−7	9−4	10−1	10−10	11−6	12−1	12−8	13−3	13−9	14−4	14−10	15−3	15−9	16−3	16−8	17−1	17−6	17−11	18−4	18−9	19−1	19−6	19−10	20−3	20−7	20−11
	16.0	4−8	5−9	6−7	7−5	8−1	8−9	9−4	9−11	10−6	11−0	11−6	11−11	12−5	12−10	13−3	13−8	14−0	14−5	14−10	15−2	15−6	15−10	16−3	16−7	16−10	17−2	17−6	17−10	18−1
2x8	19.2	4−3	5−3	6−0	6−9	7−5	8−0	8−7	9−1	9−7	10−0	10−6	10−11	11−4	11−8	12−1	12−5	12−10	13−2	13−6	13−10	14−2	14−6	14−10	15−1	15−5	15−8	16−0	16−3	16−7
	24.0	3−10	4−8	5−5	6−0	6−7	7−2	7−8	8−1	8−7	9−0	9−4	9−9	10−1	10−6	10−10	11−2	11−6	11−9	12−1	12−5	12−8	12−11	13−3	13−6	13−9	14−0	14−4	14−7	14−10
	12.0	6−11	8−5	9−9	10−11	11−11	12−11	13−9	14−8	15−5	16−2	16−11	17−7	18−3	18−11	19−6	20−1	20−8	21−3	21−10	22−4	22−10	23−5	23−11	24−5	24−10	25−4	25−10		
	16.0	6−0	7−4	8−5	9−5	10−4	11−2	11−11	12−8	13−4	14−0	14−8	15−3	15−10	16−4	16−11	17−5	17−11	18−5	18−11	19−4	19−10	20−3	20−8	21−1	21−6	21−11	22−4	22−9	23−1
2x10	19.2	5−5	6−8	7−8	8−7	9−5	10−2	10−11	11−7	12−2	12−9	13−4	13−11	14−5	14−11	15−5	15−11	16−4	16−10	17−3	17−8	18−1	18−6	18−11	19−3	19−8	20−0	20−5	20−9	21−1
	24.0	4−11	6−0	6−11	7−8	8−5	9−1	9−9	10−4	10−11	11−5	11−11	12−5	12−11	13−4	13−9	14−3	14−8	15−0	15−5	15−10	16−2	16−6	16−11	17−3	17−7	17−11	18−3	18−7	18−11
E	12.0	0.04	0.08	0.13	0.18	0.23	0.29	0.36	0.43	0.50	0.58	0.66	0.74	0.83	0.92	1.01	1.11	1.21	1.31	1.41	1.52	1.63	1.74	1.86	1.98	2.10	2.22	2.34	2.47	2.60
E	16.0	0.04	0.07	0.11	0.15	0.20	0.25	0.31	0.37	0.43	0.50	0.57	0.64	0.72	0.80	0.88	0.96	1.05	1.13	1.22	1.32	1.41	1.51	1.61	1.71	1.82	1.92	2.03	2.14	2.25
E	19.2	0.04	0.06	0.10	0.14	0.18	0.23	0.28	0.34	0.40	0.46	0.52	0.59	0.65	0.73	0.80	0.88	0.95	1.04	1.12	1.20	1.29	1.38	1.47	1.56	1.66	1.75	1.85	1.95	2.05
E	24.0	0.03	0.06	0.09	0.13	0.16	0.21	0.25	0.30	0.35	0.41	0.46	0.52	0.59	0.65	0.72	0.78	0.85	0.93	1.00	1.08	1.15	1.23	1.31	1.40	1.48	1.57	1.66	1.75	1.84

Note: The required modulus of elasticity, E, in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million psi and less, and is applicable to all lumber sizes shown. Spans are shown in feet−inches and are limited to 26’ and less. Check sources of supply for availability of lumber in lengths greater than 20’.

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Design Values for Joists and Rafters

These "Fb" values are for use where repetitive members are spaced not more than 24 inches. Values for surfaced dry or surfaced green lumber apply at 19% maximum moisture content in use.

Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Cottonwood					
Select Structural	2x4	1510	1735	1,200,000	NSLB
No.1		1080	1240	1,200,000	
No.2		1080	1240	1,100,000	
No.3		605	695	1,000,000	
Stud		600	690	1,000,000	
Construction		805	925	1,000,000	
Standard		460	530	900,000	
Utility		200	230	900,000	
Select Structural	2x6	1310	1505	1,200,000	
No.1		935	1075	1,200,000	
No.2		935	1075	1,100,000	
No.3		525	600	1,000,000	
Stud		545	630	1,000,000	
Select Structural	2x8	1210	1390	1,200,000	
No.1		865	990	1,200,000	
No.2		865	990	1,100,000	
No.3		485	555	1,000,000	
Select Structural	2x10	1105	1275	1,200,000	
No.1		790	910	1,200,000	
No.2		790	910	1,100,000	
No.3		445	510	1,000,000	
Select Structural	2x12	1005	1155	1,200,000	
No.1		720	825	1,200,000	
No.2		720	825	1,100,000	
No.3		405	465	1,000,000	
Douglas Fir−Larch					
Select Structural	2x4	2500	2875	1,900,000	WCLIB WWPA
No.1 & Btr		1985	2280	1,800,000	
No.1		1725	1985	1,700,000	
No.2		1510	1735	1,600,000	
No.3		865	990	1,400,000	
Stud		855	980	1,400,000	
Construction		1150	1325	1,500,000	
Standard		635	725	1,400,000	
Utility		315	365	1,300,000	
Select Structural	2x6	2170	2495	1,900,000	
No.1 & Btr		1720	1975	1,800,000	
No.1		1495	1720	1,700,000	
No.2		1310	1505	1,600,000	
No.3		750	860	1,400,000	
Stud		775	895	1,400,000	
Select Structural	2x8	2000	2300	1,900,000	
No.1 & Str		1585	1825	1,800,000	
No.1		1380	1585	1,700,000	
No.2		1210	1390	1,600,000	
No.3		690	795	1,400,000	
Select Structural	2x10	1835	2110	1,900,000	
No.1 & Btr		1455	1675	1,800,000	
No.1		1265	1455	1,700,000	
No.2		1105	1275	1,600,000	
No.3		635	725	1,400,000	
Select Structural	2x12	1670	1920	1,900,000	
No.1 & Btr		1325	1520	1,800,000	
No.1		1150	1325	1,700,000	
No.2		1005	1155	1,600,000	
No.3		575	660	1,400,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Douglas Fir−Larch (North)					
Select Structural	2x4	2245	2580	1,900,000	NLGA
No.1 /No.2		1425	1635	1,600,000	
No.3		820	940	1,400,000	
Stud		820	945	1,400,000	
Construction		1095	1255	1,500,000	
Standard		605	695	1,400,000	
Utility		290	330	1,300,000	
Select Structural	2x6	1945	2235	1,900,000	
No.1 /No.2		1235	1420	1,600,000	
No.3		710	815	1,400,000	
Stud		750	860	1,400,000	
Select Structural	2x8	1795	2065	1,900,000	
No.1 /No.2		1140	1310	1,600,000	
No.3		655	755	1,400,000	
Select Structural	2x10	1645	1890	1,900,000	
No.1 /No−2		1045	1200	1,600,000	
No.3		600	690	1,400,000	
Select Structural	2x12	1495	1720	1,900,000	
No.1 /No.2		950	1090	1,600,000	
No.3		545	630	1,400,000	
Douglas Fir−South					
Select Structural	2x4	2245	2580	1,400,000	WWPA
No.1		1555	1785	1,300,000	
No.2		1425	1635	1,200,000	
No.3		820	940	1,100,000	
Stud		820	945	1,100,000	
Construction		1065	1225	1,200,000	
Standard		605	695	1,100,000	
Utility		290	330	1,000,000	
Select Structural	2x6	1945	2235	1,400,000	
No.1		1345	1545	1,300,000	
No.2		1235	1420	1,200,000	
No.3		710	815	1,100,000	
Stud		750	860	1,100,000	
Select Structural	2x8	1795	2065	1,400,000	
No.1		1240	1430	1,300,000	
No.2		1140	1310	1,200,000	
No.3		655	755	1,100,000	
Select Structural	2x10	1645	1890	1,400,000	
No.1		1140	1310	1,300,000	
No.2		1045	1200	1,200,000	
No.3		600	690	1,100,000	
Select Structural	2x12	1495	1720	1,400,000	
No.1		1035	1190	1,300,000	
No.2		950	1090	1,200,000	
No.3		545	630	1,100,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Eastern Hemlock−Tamarack					
Select Structural	2x4	2155	2480	1,200,000	NELMA NSLB
No.1		1335	1535	1,100,000	
No.2		990	1140	1,100,000	
No.3		605	695	900,000	
Stud		570	655	900,000	
Construction		775	895	1,000,000	
Standard		430	495	900,000	
Utility		200	230	800,000	
Select Structural	2x6	1870	2150	1,200,000	
No.1		1160	1330	1,100,000	
No.2		860	990	1,100,000	
No.3		525	600	900,000	
Stud		520	595	900,000	
Select Structural	2x8	1725	1985	1,200,000	
No.1		1070	1230	1,100,000	
No.2		795	915	1,100,000	
No.3		485	555	900,000	
Select Structural	2x10	1580	1820	1,200,000	
No.1		980	1125	1,100,000	
No.2		725	835	1,100,000	
No.3		445	510	900,000	
Select Structural	2x12	1440	1655	1,200,000	
No.1		890	1025	1,100,000	
No.2		660	760	1,100,000	
No.3		405	465	900,000	
Eastern Softwoods					
Select Structural	2x4	2155	2480	1,200,000	NELMA NSLB
No.1		1335	1535	1,100,000	
No.2		990	1140	1,100,000	
No.3		605	695	900,000	
Stud		570	655	900,000	
Construction		775	895	1,000,000	
Standard		430	495	900,000	
Utility		200	230	800,000	
Select Structural	2x6	1870	2150	1,200,000	
No.1		1160	1330	1,100,000	
No.2		860	990	1,100,000	
No.3		525	600	900,000	
Stud		520	595	900,000	
Select Structural	2x8	1725	1985	1,200,000	
No.1		1070	1230	1,100,000	
No.2		795	915	1,100,000	
No.3		485	555	900,000	
Select Structural	2x10	1580	1820	1,200,000	
No.1		980	1125	1,100,000	
No.2		725	835	1,100,000	
No.3		445	510	900,000	
Select Structural	2x12	1440	1655	1,200,000	
No.1		890	1025	1,100,000	
No.2		660	760	1,100,000	
No.3		405	465	900,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Eastern White Pine					
Select Structural	2x4	2155	2480	1,200,000	NELMA NSLB
No.1		1335	1535	1,100,000	
No.2		990	1140	1,100,000	
No.3		605	695	900,000	
Stud		570	655	900,000	
Construction		775	895	1,000,000	
Standard		430	495	900,000	
Utility		200	230	800,000	
Select Structural	2x6	1870	2150	1,200,000	
No.1		1160	1330	1,100,000	
No.2		860	990	1,100,000	
No.3		525	600	900,000	
Stud		520	595	900,000	
Select Structural	2x8	1725	1985	1,200,000	
No.1		1070	1230	1,100,000	
No.2		795	915	1,100,000	
No.3		485	555	900,000	
Select Structural	2x10	1580	1820	1,200,000	
No.1		980	1125	1,100,000	
No.2		725	835	1,100,000	
No.3		445	510	900,000	
Select Structural	2x12	1440	1655	1,200,000	
No.1		890	1025	1,100,000	
No.2		660	760	1,100,000	
No.3		405	465	900,000	
Hem Fir					
Select Structural	2x4	2415	2775	1,600,000	WCLIB WWPA
No.1 & Btr		1810	2085	1,500,000	
No.1		1640	1885	1,500,000	
No.2		1465	1685	1,300,000	
No.3		865	990	1,200,000	
Stud		855	980	1,200,000	
Construction		1120	1290	1,300,000	
Standard		635	725	1,200,000	
Utility		290	330	1,100,000	
Select Structural	2x6	2095	2405	1,600,000	
No.1 & Btr		1570	1805	1,500,000	
No.1		1420	1635	1,500,000	
No.2		1270	1460	1,300,000	
No.3		750	860	1,200,000	
Stud		775	895	1,200,000	
Select Structural	2x8	1930	2220	1,600,000	
No.1 & Btr		1450	1665	1,500,000	
No.1		1310	1510	1,500,000	
No.2		1175	1350	1,300,000	
No.3		690	795	1,200,000	
Select Structural	2x10	1770	2035	1,600,000	
No.1 & Btr		1330	1525	1,500,000	
No.1		1200	1380	1,500,000	
No.2		1075	1235	1,300,000	
No.3		635	725	1,200,000	
Select Structural	2x12	1610	1850	1,600,000	
No.1 & Btr		1210	1390	1,500,000	
No.1		1095	1255	1,500,000	
No.2		980	1125	1,300,000	
No.3		575	660	1,200,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Hem−Fir (North)					
Select Structural	2x4	2245	2580	1,700,000	NLGA
No.1 /No.2		1725	1985	1,600,000	
No.3		990	1140	1,400,000	
Stud		980	1125	1,400,000	
Construction		1325	1520	1,500,000	
Standard		720	825	1,400,000	
Utility		345	395	1,300,000	
Select Structural	2x6	1945	2235	1,700,000	
No.1 /No.2		1495	1720	1,600,000	
No.3		860	990	1,400,000	
Stud		890	1025	1,400,000	
Select Structural	2x8	1795	2065	1,700,000	
No.1 /No.2		1380	1585	1,600,000	
No.3		795	915	1,400,000	
Select Structural	2x10	1645	1890	1,700,000	
No.1 /No.2		1265	1455	1,600,000	
No.3		725	835	1,400,000	
Select Structural	2x12	1495	1720	1,700,000	
No.1 /No.2		1150	1325	1,600,000	
No.3		660	760	1,400,000	
Mixed Maple					
Select Structural	2x4	1725	1985	1,300,000	NELMA
No.1		1250	1440	1,200,000	
No.2		1210	1390	1,100,000	
No.3		690	795	1,000.000	
Stud		695	Boo	1,000,000	
Construction		920	1060	1,100,000	
Standard		520	595	1,000,000	
Utility		260	300	900,000	
Select Structural	2x6	1495	1720	1,300,000	
No.1		1085	1245	1,200,000	
No.2		1045	1205	1,100,000	
No.3		600	690	1,000,000	
Stud		635	725	1,000,000	
Select Structural	2x8	1380	1585	1,300,000	
No.1		1000	1150	1,200,000	
No.2		965	1110	1,100,000	
No.3		550	635	1,000,000	
Select Structural	2x10	1265	1455	1,300,000	
No.1		915	1055	1,200,000	
No.2		885	1020	1,100,000	
No.3		505	580	1,000,000	
Select Structural	2x12	1150	1325	1,300,000	
No.1		835	960	1,200,000	
No.2		805	925	1,100,000	
No.3		460	530	1,000,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Mixed Oak					
Select Structural	2x4	1985	2280	1,100,000	NELMA
No.1		1425	1635	1,000,000	
No.2		1380	1585	900,000	
No.3		820	940	800,000	
Stud		790	910	800,000	
Construction		1065	1225	900,000	
Standard		605	695	800,000	
Utility		290	330	800,000	
Select Structural	2x6	1720	1975	1,100,000	
No.1		1235	1420	1,000,000	
No.2		1195	1375	900,000	
No.3		710	815	800,000	
Stud		720	825	800,000	
Select Structural	2x8	1585	1825	1,100,000	
No.1		1140	1310	1,000,000	
No.2		1105	1270	900,000	
No.3		655	755	800,000	
Select Structural	2x10	1455	1675	1,100,000	
No.1		1045	1200	1,000,000	
No.2		1010	1165	900,000	
No.3		600	690	800,000	
Select Structural	2x12	1325	1520	1,100,000	
No.1		950	1090	1,000,000	
No.2		920	1060	900,000	
No.3		545	630	800,000	
Mixed Southern Pine					
Select Structural	2x4	2360	2710	1,600,000	SPIB
No.1		1670	1920	1,500,000	
No.2		1500	1720	1,400,000	
No.3		865	990	1,200,000	
Stud		890	1020	1,200,000	
Construction		1150	1320	1,300,000	
Standard		635	725	1,200,000	
Utility		315	365	1,100,000	
Select Structural	2x6	2130	2450	1,600,000	
No.1		1490	1720	1,500,000	
No.2		1320	1520	1,400,000	
No.3		775	895	1,200,000	
Stud		775	895	1,200,000	
Select Structural	2x8	2010	2310	1,600,000	
No.1		1380	1590	1,500,000	
No.2		1210	1390	1,400,000	
No.3		720	825	1,200,000	
Select Structural	2x10	1730	1980	1,600,000	
No.1		1210	1390	1,500,000	
No.2		1060	1220	1,400,000	
No.3		605	695	1,200,000	
Select Structural	2x12	1610	1850	1,600,000	
No.1		1120	1290	1,500,000	
No.2		1010	1160	1,400,000	
No.3		575	660	1,200,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Northern Red Oak					
Select Structural	2x4	2415	2775	1,400,000	NELMA
No.1		1725	1985	1,400,000	
No.2		1680	1935	1,300,000	
No.3		950	1090	1,200,000	
Stud		950	1090	1,200,000	
Construction		1265	1455	1,200,000	
Standard		720	825	1,100,000	
Utility		345	395	1,000,000	
Select Structural	2x6	2095	2405	1,400,000	
No.1		1495	1720	1,400,000	
No.2		1460	1675	1,300,000	
No.3		820	945	1,200,000	
Stud		865	990	1,200,000	
Select Structural	2x8	1930	2220	1,400,000	
No.1		1380	1585	1,400,000	
No.2		1345	1545	1,300,000	
No.3		760	875	1,200,000	
Select Structural	2x10	1770	2035	1,400,000	
No.1		1265	1455	1,400,000	
No.2		1235	1420	1,300,000	
No.3		695	800	1,200,000	
Select Structural	2x12	1610	1850	1,400,000	
No.1		1150	1325	1,400,000	
No.2		1120	1290	1,300,000	
No.3		635	725	1,200,000	
Northern Species					
Select Structural	2x4	1640	1885	1,100,000	NLGA
No.1 /No.2		990	1140	1,100,000	
No.3		605	695	1,000,000	
Stud		570	655	1,000,000	
Construction		775	895	1,000,000	
Standard		430	495	900,000	
Utility		200	230	900,000	
Select Structural	2x6	1420	1635	1,100,000	
No. 1 / No.2		860	990	1,100,000	
No.3		525	600	1,000,000	
Stud		520	595	1,000,000	
Select Structural	2x8	1310	1510	1,100,000	
No.1/No.2		795	915	1,100,000	
No.3		485	555	1,000,000	
Select Structural	2x10	1200	1380	1,100,000	
No.1 /No.2		725	835	1,100,000	
No.3		445	510	1,000,000	
Select Structural	2x12	1095	1255	1,100,000	
No.1 /No.2		660	760	1,100,000	
No.3		405	465	1,000,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Northern White Cedar					
Select Structural	2x4	1335	1535	800,000	NELMA
No.1		990	1140	700,000	
No.2		950	1090	700,000	
No.3		560	645	600,000	
Stud		540	620	600,000	
Construction		720	825	700,000	
Standard		405	465	600,000	
Utility		200	230	600,000	
Select Structural	2x6	1160	1330	800,000	
No.1		860	990	700,000	
No.2		820	945	700,000	
No.3		485	560	600,000	
Stud		490	560	600,000	
Select Structural	2x8	1070	1230	800,000	
No.1		795	915	700,000	
No.2		760	875	700,000	
No.3		450	515	600,000	
Select Structural	2x10	980	1125	800,000	
No.1		725	835	700,000	
No.2		695	800	700,000	
No.3		410	475	600,000	
Select Structural	2x12	890	1025	800,000	
No.1		660	760	700,000	
No.2		635	725	700,000	
No.3		375	430	600,000	
Red Maple					
Select Structural	2x4	2245	2580	1,700,000	NELMA
No.1		1595	1835	1,600,000	
No.2		1555	1785	1,500,000	
No.3		905	1040	1,300,000	
Stud		885	1020	1,300,000	
Construction		1210	1390	1,400,000	
Standard		660	760	1,300,000	
Utility		315	365	1,200,000	
Select Structural	2x6	1945	2235	1,700,000	
No.1		1385	1590	1,600,000	
No.2		1345	1545	1,500,000	
No.3		785	905	1,300,000	
Stud		805	925	1,300,000	
Select Structural	2x8	1795	2065	1,700,000	
No.1		1275	1470	1,600,000	
No.2		1240	1430	1,500,000	
No.3		725	835	1,300,000	
Select Structural	2x10	1645	1890	1,700,000	
No.1		1170	1345	1,600,000	
No.2		1140	1310	1,500,000	
No.3		665	765	1,300,000	
Select Structural	2x12	1495	1720	1,700,000	
No.1		1065	1225	1,600,000	
No.2		1035	1190	1,500,000	
No.3		605	695	1,300,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Red Oak					
Select Structural	2x4	1985	2280	1,400,000	NELMA
No.1		1425	1635	1,300,000	
No.2		1380	1585	1,200,000	
No.3		820	940	1,100,000	
Stud		790	910	1,100,000	
Construction		1065	1225	1,200,000	
Standard		605	695	1,100,000	
Utility		290	330	1,000,000	
Select Structural	2x6	1720	1975	1,400,000	
No.1		1235	1420	1,300,000	
No.2		1195	1375	1,200,000	
No.3		710	815	1,100,000	
Stud		720	825	1,100,000	
Select Structural	2x8	1585	1825	1,400,000	
No.1		1140	1310	1,300,000	
No.2		1105	1270	1,200,000	
No.3		655	755	1,100,000	
Select Structural	2x10	1455	1675	1,400,000	
No.1		1045	1200	1,300,000	
No.2		1010	1165	1,200,000	
No.3		600	690	1,100,000	
Select Structural	2x12	1325	1520	1,400,000	
No.1		950	1090	1,300,000	
No.2		920	1060	1,200,000	
No.3		545	630	1,100,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Redwood					
Clear Structural	2x4	3020	3470	1,400,000	RIS
Select Structural		2330	2680	1,400,000	
Select Structural, open grain		1900	2180	1,100,000	
No.1		1680	1935	1,300,000	
No.1, open grain		1335	1535	1,100,000	
No.2		1595	1835	1,200,000	
No.2, open grain		1250	1440	1,000,000	
No.3		905	1040	1,100,000	
No.3, open grain		735	845	900,000	
Stud		725	835	900,000	
Construction		950	1090	900,000	
Standard		520	595	900,000	
Utility		260	300	800,000	
Clear Structural	2x6	2615	3010	1,400,000	
Select Structural		2020	2320	1,400,000	
Select Structural, open grain		1645	1890	1,100,000	
No.1		1460	1675	1,300,000	
No.1, open grain		1160	1330	1,100,000	
No.2		1385	1590	1,200,000	
No.2, open grain		1085	1245	1,000,000	
No.3		785	905	1,100,000	
No.3, open grain		635	730	900,000	
Stud		660	760	900,000	
Clear Structural	2x8	2415	2775	1,400,000	
Select Structural		1865	2140	1,400,000	
Select Structural, open grain		1520	1745	1,100,000	
No.1		1345	1545	1,300,000	
No.1, open grain		1070	1230	1,100,000	
No.2		1275	1470	1,200,000	
No.2, open grain		1000	1150	1,000,000	
No.3		725	835	1,100,000	
No.3, open grain		585	675	900,000	
Clear Structural	2x10	2215	2545	1,400,000	
Select Structural		1710	1965	1,400,000	
Select Structural, open grain		1390	1600	1,100,000	
No.1		1235	1420	1,300,000	
No.1, open grain		980	1125	1,100,000	
No.2		1170	1345	1,200,000	
No.2, open grain		915	1055	1,000,000	
No.3		665	765	1,100,000	
No.3, open grain		540	620	900,000	
Clear Structural	2x12	2015	2315	1,400,000	
Select Structural		1555	1785	1,400,000	
Select Structural, open grain		1265	1455	1,100,000	
No.1		1120	1290	1,300,000	
No.1, open grain		890	1025	1,100,000	
No.2		1065	1225	1,200,000	
No.2, open grain		835	960	1,000,000	
No.3		605	695	1,100,000	
No.3, open grain		490	560	900,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Southern Pine					
Dense Select Structural	2x4	3510	4030	1,900,000	SPIB
Select Structural		3280	3770	1,800,000	
Non−Dense Select Structural		3050	3500	1,700,000	
No.1 Dense		2300	2650	1,800,000	
No.1		2130	2450	1,700,000	
No.1 Non−Dense		1950	2250	1,600,000	
No.2 Dense		1960	2250	1,700,000	
No.2		1720	1980	1,600,000	
No.2 Non−Dense		1550	1790	1,400,000	
No.3		980	1120	1,400,000	
Stud		1010	1160	1,400,000	
Construction		1270	1450	1,500,000	
Standard		720	825	1,300,000	
Utility		345	395	1,300,000	
Dense Select Structural	2x6	3100	3570	1,900,000	
Select Structural		2930	3370	1,800,000	
Non−Dense Select Structural		2700	3110	1,700,000	
No.1 Dense		2010	2310	1,800,000	
No.1		1900	2180	1,700,000	
No.1 Non−Dense		1720	1980	1,600,000	
No.2 Dense		1670	1920	1,700,000	
No.2		1440	1650	1,600,000	
No.2 Non−Dense		1320	T520	1,400,000	
No.3		865	990	1,400,000	
Stud		890	1020	1,400,000	
Dense Select Structural	2x8	2820	3240	1,900,000	
Select Structural		2650	3040	1,800,000	
Non−Dense Select Structural		2420	2780	1,700,000	
No.1 Dense		1900	2180	1,800,000	
No.1		1730	1980	1,700,000	
No.1 Non−Dense		1550	1790	1,600,000	
No.2 Dense		1610	1850	1,700,000	
No.2		1380	1590	1,600,000	
No.2 Non−Dense		1260	1450	1,400,000	
No.3		805	925	1,400,000	
Dense Select Structural	2x10	2470	2840	1,900,000	
Select Structural		2360	2710	1,800,000	
Non−Dense Select Structural		2130	2450	1,700,000	
No.1 Dense		1670	1920	1,800,000	
No.1		1500	1720	1,700,000	
No.1 Non−Dense		1380	1590	1,600,000	
No.2 Dense		1380	1590	1,700,000	
No.2		1210	1390	1,600,000	
No.2 Non−Dense		1090	1260	1,400,000	
No.3		690	795	1,400,000	
Dense Select Structural	2x12	2360	2710	1,900,000	
Select Structural		2190	2510	1,800,000	
Non−Dense Select Structural		2010	2310	1,700,000	
No.1 Dense		1550	1790	1,800,000	
No.1		1440	1650	1,700,000	
No.1 Non−Dense		1320	1520	1,600,000	
No.2 Dense		1320	1520	1,700,000	
No.2		1120	1290	1,600,000	
No.2 Non−Dense		1040	1190	1,400,000	
No.3		660	760	1,400,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Spruce−Pine−Fir					
Select Structural	2x4	2155	2480	1,500,000	NLGA
No.1 /No.2		1510	1735	1,400,000	
No.3		865	990	1,200,000	
Stud		855	980	1,200,000	
Construction		1120	1290	1,300,000	
Standard		635	725	1,200,000	
Utility		290	330	1,100,000	
Select Structural	2x6	1870	2150	1,500,000	
No.1 /No.2		1310	1505	1,400,000	
No.3		750	860	1,200,000	
Stud		775	895	1,200,000	
Select Structural	2x8	1725	1985	1,500,000	
No. 1 / No.2		1210	1390	1,400,000	
No.3		690	795	1,200,000	
Select Structural	2x10	1580	1820	1,500,000	
No.1/No.2		1105	1275	1,400,000	
No.3		635	725	1,200,000	
Select Structural	2x12	1440	1655	1,500,000	
No.1 /No.2		1005	1155	1,400,000	
No.3		575	660	1,200,000	
Spruce−Pine−Fir (South)					
Select Structural	2x4	2245	2580	1,300,000	NELMA NSLB WCLIB WWPA
No.1		1465	1685	1,200,000	
No.2		1295	1490	1,100,000	
No.3		735	845	1,000,000	
Stud		725	835	1,000,000	
Construction		980	1125	1,000,000	
Standard		545	630	900,000	
Utility		260	300	900,000	
Select Structural	2x6	1945	2235	1,300,000	
No.1		1270	1460	1,200,000	
No.2		1120	1290	1,100,000	
No.3		635	730	1000,000	
Stud		660	760	1,000,000	
Select Structural	2x8	1795	2065	1,300,000	
No.1		1175	1350	1,200:000	
No.2		1035	1190	1,100,000	
No.3		585	675	1,000,000	
Select Structural	2x10	1645	1890	1,300,000	
No.1		1075	1235	1,200,000	
No.2		950	1090	1,100,000	
No.3		540	620	1,000,000	
Select Structural	2x12	1495	1720	1,300,000	
No.1		980	1125	1,200,000	
No.2		865	990	1,100,000	
No.3		490	560	1,000,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
Western Cedars					
Select Structural	2x4	1725	1985	1,100,000	WCLIB WWPA
No.1		1250	1440	1,000,000	
No.2		1210	1390	1,000,000	
No.3		690	795	900,000	
Stud		695	800	900,000	
Construction		920	1060	900,000	
Standard		520	595	800,000	
Utility		260	300	800,000	
Select Structural	2x6	1495	1720	1,100,000	
No.1		1085	1245	1,000,000	
No.2		1045	1205	1,000,000	
No.3		600	690	900,000	
Stud		635	725	900,000	
Select Structural	2x8	1380	1585	1,100,000	
No.1		1000	1150	1,000,000	
No.2		965	1110	1,000,000	
No.3		550	635	900,000	
Select Structural	2x10	1265	1455	1,100,000	
No.1		915	1055	1,000,000	
No.2		885	1020	1,000,000	
No.3		505	580	900,000	
Select Structural	2x12	1150	1325	1,100,000	
No.1		835	960	1,000,000	
No.2		805	925	1,000,000	
No.3		460	530	900,000	
Western Woods					
Select Structural	2x4	1510	1735	1,200,000	WCLIB WWPA
No.1		1120	1290	1,100,000	
No.2		1120	1290	1,000,000	
No.3		645	745	900,000	
Stud		635	725	900,000	
Construction		835	960	1,000,000	
Standard		460	530	900,000	
Utility		230	265	800,000	
Select Structural	2x6	1310	1505	1,200,000	
No.1		970	1120	1,100,000	
No.2		970	1120	1,000,000	
No.3		560	645	900,000	
Stud		575	660	900,000	
Select Structural	2x8	1210	1390	1,200,000	
No.1		895	1030	1,100,000	
No.2		895	1030	1,000,000	
No.3		520	595	900,000	
Select Structural	2x10	110	1275	1,200,000	
No.1		820	945	1,100,000	
No.2		820	945	1,000,000	
No.3		475	545	900,000	
Select Structural	2x12	1005	1155	1,200,000	
No.1		750	860	1,100,000	
No.2		750	860	1,000,000	
No.3		430	495	900,000	

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Species and Grade	Size	Design Value in Bending, "Fb"		Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading		
White Oak					
Select Structural	2x4	2070	2380	1,100,000	NELMA
No.1		1510	1735	1,000,000	
No.2		1465	1685	900,000	
No.3		820	940	800,000	
Stud		820	945	800,000	
Construction		1095	1255	900,000	
Standard		605	695	800,000	
Utility		290	330	800,000	
Select Structural	2x6	1795	2065	1,100,000	
No.1		1310	1505	1,000,000	
No.2		1270	1460	900,000	
No.3		710	815	800,000	
Stud		750	860	800,000	
Select Structural	2x8	1655	1905	1,100,000	
No.1		1210	1390	1,000,000	
No.2		1175	1350	900,000	
No.3		655	755	800,000	
Select Structural	2x10	1520	1745	1,100,000	
No.1		1105	1275	1,000,000	
No.2		1075	1235	900,000	
No.3		600	690	800,000	
Select Structural	2x12	1380	1585	1,100,000	
No.1		1005	1155	1,000,000	
No.2		980	1125	900,000	
No.3		545	630	800,000	
Yellow Poplar					
Select Structural	2x4	1725	1985	1,500,000	NSLB
No.1		1250	1440	1,400,000	
No.2		1210	1390	1,300,000	
No.3		690	795	1,200,000	
Stud		695	800	1,200,000	
Construction		920	1060	1,300,000	
Standard		520	595	1,100,000	
Utility		230	265	1,100,000	
Select Structural	2x6	1495	1720	1,500,000	
No.1		1055	1245	1,400,000	
No.2		1045	1205	1,300,000	
No.3		600	690	1,200,000	
Stud		635	725	1,200,000	
Select Structural	2x8	1380	1585	1,500,000	
No.1		1000	1150	1,400,000	
No.2		965	1110	1,300,000	
No.3		550	635	1,200,000	
Select Structural	2x10	1265	1455	1,500,000	
No.1		915	1055	1,400,000	
No.2		885	1020	1,300,000	
No.3		505	580	1,200,000	
Select Structural	2x12	1150	1325	1,500,000	
No.1		835	960	1,400,000	
No.2		805	925	1,300,000	
No.3		460	530	1,200,000	

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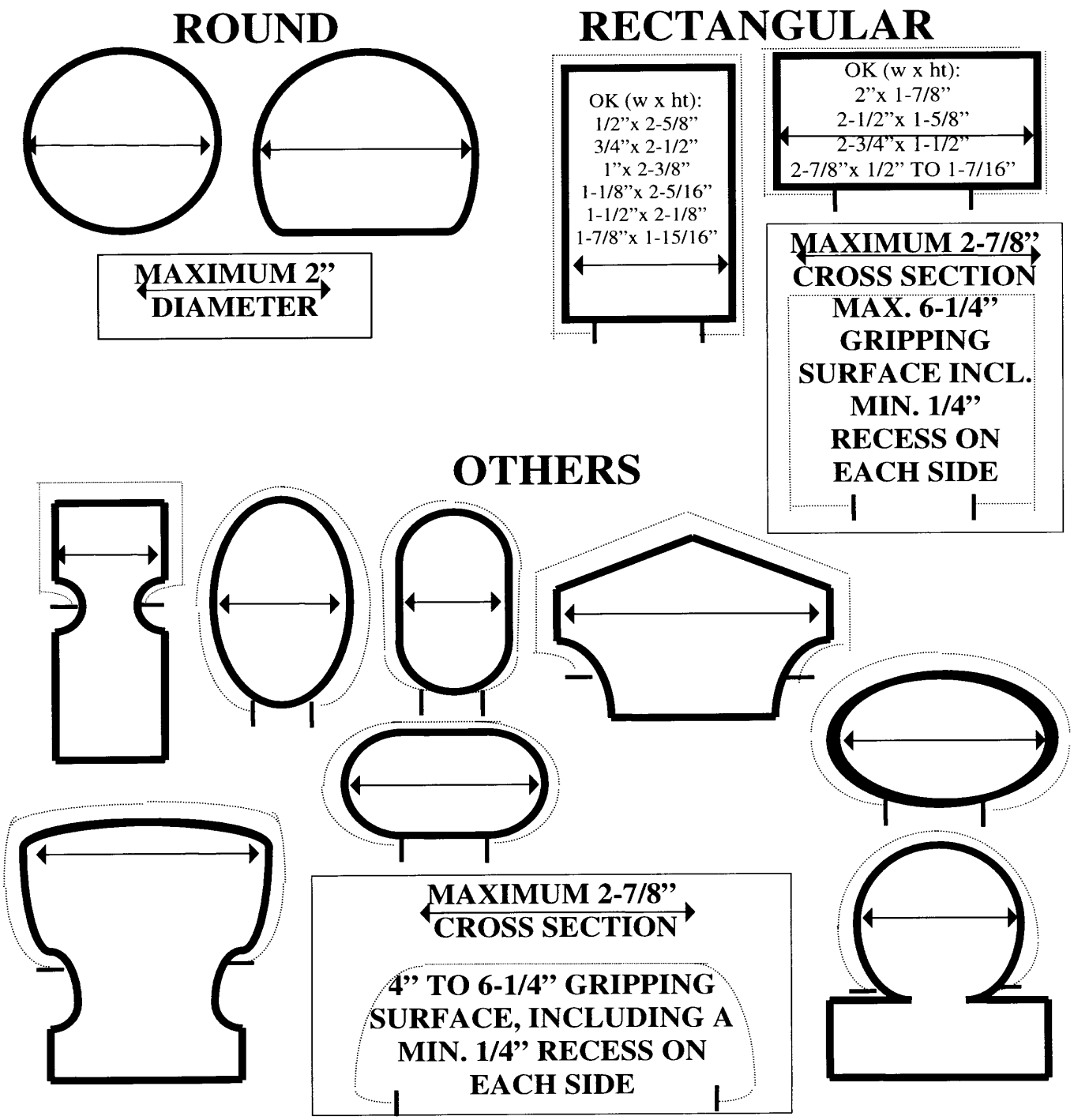
21.04(2)(a)5.
HANDRAIL SHAPES



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A−21.125 (3) CONTROL STANDARDS. The following are designs acceptable by the department to achieve compliance with the control standards of acceptable soil loss or percent reduction of sediment load in runoff from a site.

Less than one acre disturbance (regardless of the lot or property size).

A. Mandated practices:

1. A method to prevent or reduce soil from leaving a site via entries or roads**.** This may include a tracking pad or tire washing stand designed and installed to meet DNR Standard 1057. Other means of compliance include a gravel mulch, frozen soil, bedrock or some other physical means to prevent soil from leaving the site on vehicle tires which is equivalent to the tracking pad or tire washing stand.

2. Storm water inlet protection. Inlet protection may be accomplished by using DNR Technical Standard, number 1050, "Storm Drain Inlet Protection for Construction Sites". The protection of stormwater inlets in the code is specific to "on−site" inlets; however an off−site inlet may create a direct conduit to a water of the state, which links any inlet that leads to a water of the state to the #3 mandated practice. In that case, special care should be taken to protect both types of inlets from sediment in runoff from a construction site.

3. Protection of adjoining waters of the state. The installation of practices is necessary if runoff from the disturbance could impact a water of the state. Practices may include channel erosion mats, silt fences, vegetative buffers or any other practices applicable to the specific site.

4. Drainage way protection. Any ditches or drainage ways that flow off site must be protected with appropriate best management practices (BMPs). This may include but is not limited to ditch checks, channel erosion control mats or riprap.

5. Dewatering activity sediment reduction**.** Any dewatering necessary on the construction site must include measures to reduce the sediment in the water leaving the site. Dewatering BMPs may include filters, fiber rolls or gravel bag berms.

6. Stockpile protection. Any soil stockpiles which are left more than 7 days must be protected by seeding and mulching, erosion mat, silt fencing, covering or other methods. This does not include fill or topsoil piles that are in active use.

B. In addition to mandated practices, the owner/contractor or designer must choose one or more of the following methods in order to achieve compliance with the standards.

1. The Revised Universal Soil Loss Equation may be used to determine the amount of soil lost from a site in order to stay below the 5 tons/acre/year for sand, loamy sand, sandy loam, loam, sandy clay loam, clay loam, sandy clay, silty clay or clay textures or the 7.5 tons/acre/year soil loss for silt, silty clay loam or silt loam textures. The Commerce−accepted version of an Excel worksheet that is used to calculate the soil loss is available at: http://commerce.wi.gov/SB/SB−SoilErosionControlProgram.html

2. Silt fence may be placed in accordance with the DNR Technical Standard 1056 and remain on the site until the pervious area is stabilized. This practice, in addition to the mandated practices in part "A" is accepted by the Department of Commerce as compliant with the 40% reduction in sediment load goal.

3. The site may be seeded and mulched, erosion control mat may be installed or polymers may be applied. The erosion control BMPs must be applied within one week of disturbance. Seeding must be accomplished in accordance with DNR Technical Standard 1059 and mulching with DNR Technical Standard 1058. Erosion control mat must be installed in accordance with DNR Technical Standards 1052 & 1053. Polymer application must be done in accordance with DNR Technical Standard 1051. This method is only acceptable when the maximum slope length is 300 feet and the maximum slope is no more than that specified in Table A−21.125−1 and Table A−21.125−2.

4. Practices may be included in the erosion and sediment control plan for the site that achieve compliance with the 40% reduction in sediment load in the runoff from the site. Table A−21.125−3 lists several erosion and sediment control BMPs and the USEPA (United States Environmental Protection Agency) efficiency rating for that BMP.

5. A unique design may be submitted with the UDC permit application for review.

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Table A−21.125−1

Slope Limitations for Permissible Soil Loss with max. 300' slope length[1]

When sites are seeded, mulched or otherwise stabilized within one week of disturbance[2]

Soil Texture	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
7.5 tons/acre/year allowable soil loss												
Silt loam or Silty clay loam	20%	20%	16%	9%	6%	5%	6%	8%	12%	17%	20%	20%
5 tons/acre/year allowable soil loss												
Sand	20%	20%	20%	14%	10%	8%	9%	12%	19%	20%	20%	20%
Loamy sand	20%	20%	20%	13%	9%	8%	9%	11%	17%	20%	20%	20%
Sandy loam	20%	20%	16%	9%	7%	5%	6%	8%	16%	17%	20%	20%
Loam, Sandy clay loam, Clay loam, Sandy clay	20%	20%	13%	8%	5%	4%	5%	6%	10%	17%	20%	20%
Silty clay	20%	20%	16%	9%	7%	5%	6%	8%	13%	17%	20%	20%
Clay	20%	20%	15%	9%	6%	5%	5%	7%	12%	16%	20%	20%

[1] The information in the table is derived from Grant County rainfall information and the use of the Revised Universal Soil Loss Equation. The slope limitation refers to the maximum slope permitted in order to achieve code compliance for the site specifics in the table. Opening date is the 15th of each month and closing is the 22nd. End date is 60 days past closing date.

[2] Stabilization may be accomplished by temporary seeding & mulching, permanent seeding and mulching, application of polymers or placement of erosion control mats. Additionally, the mandated practices specific to the site must be in place.

Table A21−125−2

Slope Limitations for Permissible Soil Loss with max. 300' slope length[1]

When sites are seeded, mulched or otherwise stabilized within four weeks of disturbance[2]

Soil Texture	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
7.5 tons/acre/year allowable soil loss												
Silt loam or Silty clay loam	18%	11%	8%	4%	3%	2%	3%	4%	6%	10%	15%	20%
5 tons/acre/year allowable soil loss												
Sand	20%	20%	17%	12%	7%	5%	4%	4%	6%	10%	15%	20%
Loamy sand	20%	20%	16%	11%	6%	4%	4%	4%	5%	9%	14%	20%
Sandy loam	20%	18%	11%	8%	4%	3%	2%	3%	4%	6%	10%	16%
Loam, Sandy clay loam, Clay loam, Sandy clay	20%	9%	6%	4%	2%	2%	4%	3%	5%	8%	13%	20%
Silty clay	18%	11%	8%	4%	3%	2%	4%	6%	6%	10%	15%	20%
Clay	17%	11%	7%	4%	3%	2%	4%	6%	6%	9%	14%	20%

[1] The information in the table is derived from Grant County rainfall information and the use of the Revised Universal Soil Loss Equation. The slope limitation refers to the maximum slope permitted in order to achieve code compliance for the site specifics in the table. Opening date is the 15th of each month and closing is the 15th.of the following month End date is 60 days past closing date.

[2] Stabilization may be accomplished by temporary seeding & mulching, permanent seeding and mulching, application of polymers or placement of erosion control mats. Additionally, the mandated practices specific to the site must be in place.

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One acre or more disturbed (regardless of the lot or property size).

A. Mandated practices:

1. A method to prevent or reduce soil from leaving a site via entries or roads. This may include a tracking pad or tire washing stand designed and installed to meet DNR Standard 1057. Other means of compliance include a gravel mulch, frozen soil, bedrock or some other physical means to prevent soil from leaving the site on vehicle tires which is equivalent to the tracking pad or tire washing stand.

2. Storm water inlet protection. Inlet protection may be accomplished by using DNR Technical Standard, number 1050, "Storm Drain Inlet Protection for Construction Sites". The protection of stormwater inlets in the code is specific to "on−site" inlets; however an off−site inlet may create a direct conduit to a water of the state, which links any inlet that leads to a water of the state to the #3 mandated practice. In that case, special care should be taken to protect both types of inlets from sediment in runoff from a construction site.

3. Protection of adjoining waters of the state. The installation of practices is necessary if runoff from the disturbance could impact a water of the state. Practices may include channel erosion mats, silt fences, vegetative buffers or any other practices applicable to the specific site.

4. Drainage way protection. Any ditches or drainage ways that flow off site must be protected with appropriate best management practices (BMPs). This may include but is not limited to ditch checks, erosion control mats or riprap.

5. Dewatering activity sediment reduction. Any dewatering necessary on the construction site must include measures to reduce the sediment in the water leaving the site. Dewatering BMPs may include filters, fiber rolls or gravel bag berms.

6. Stockpile protection. Any soil stockpiles which are left more than 7 days must be protected by seeding and mulching, erosion mat, silt fencing, covering or other methods. This does not include fill or topsoil piles that are in active use.

B. In addition to mandated practices, the owner/contractor or designer must choose one or more of the following methods in order to achieve compliance with the standards.

1. The Revised Universal Soil Loss Equation may be used to determine the amount of soil lost from a site in order to stay below the 5 tons/acre/year for sand, loamy sand, sandy loam, loam, sandy clay loam, clay loam, sandy clay, silty clay or clay textures or the 7.5 tons/acre/year soil loss for silt, silty clay loam or silt loam textures. The Commerce−accepted version of an Excel worksheet that is used to calculate the soil loss is available at:
http://commerce.wi.gov/SB/SB−SoilErosionControlProgram.html

2. The site may be seeded and mulched, erosion control mat may be installed or polymers may be applied. The erosion control BMPs must be applied within one week of disturbance. Seeding must be accomplished in accordance with DNR Technical Standard 1059 and mulching with DNR Technical Standard 1058. Erosion control mat must be installed in accordance with DNR Technical Standards 1052 & 1053. Polymer application must be done in accordance with DNR Technical Standard 1051. This method is only acceptable when the maximum slope length is 300 feet and the maximum slope is no more than that specified in Table A−21.125−1.

3. Practices may be included in the erosion and sediment control plan for the site that achieve compliance with the 80% reduction in sediment load in the runoff from the site. Table A−21.125−2 lists several erosion and sediment control BMPs and the USEPA (United States Environmental Protection Agency) efficiency rating for that BMP.

4. A unique design may be submitted with the UDC permit application for review.

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Table A−21.125−2
Erosion/Sediment Control BMP Efficiency[1]

Practice	Type of Practice	Standard Number[2]	Recognized Efficiency
Straw Bales	Sediment Control	1055	10%[4]
Fiber Rolls	Sediment Control		40%
Sediment Traps	Sediment Control		40%
Silt Fence	Sediment Control	1056	Sand 80% Other soils 40%
Compost Blankets	Erosion Control	See std 1058 for Wisconsin	80%
Polymers	Erosion Control	1050	80%
Sodding	Erosion Control		80%
Seeding	Erosion Control	1059	80%
Mulching	Erosion Control	1058	80%
Non channel control mat‘	Erosion Control	1052	80%[3]

[1] BMP efficiency is derived from information provided on the Environmental Protection Construction Erosion Control website in August, 2006 and only when the BMP is installed per the listed standard.

[2]Standard Number refers to the Wisconsin Department of Natural Resources Conservation Practice Standard number.

[3]This efficiency measure is provided by the Department of Commerce, Safety and Buildings Division.

[4]This efficiency measure is provided by the Department of Commerce, Safety and Buildings Division and only for a short duration as described in the standard.

There are several BMPs that do not have an efficiency assigned by the EPA. These include mandatory controls such as inlet protection, drainage way protection (rip rap) and tracking pads. Diversions, both temporary and permanent are also not included in Table 1−21.125−2. Diversions impact the erosion on a site by shortening the length of slope in the Revised Universal Soil Loss Equation (RUSLE).

Following is an example of an erosion and sediment control plan (figure A−21.125). This plan may be used for reference, however each site is unique and each plan will address the site−specific issues.

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Figure 125.125–1
Erosion Control Plan

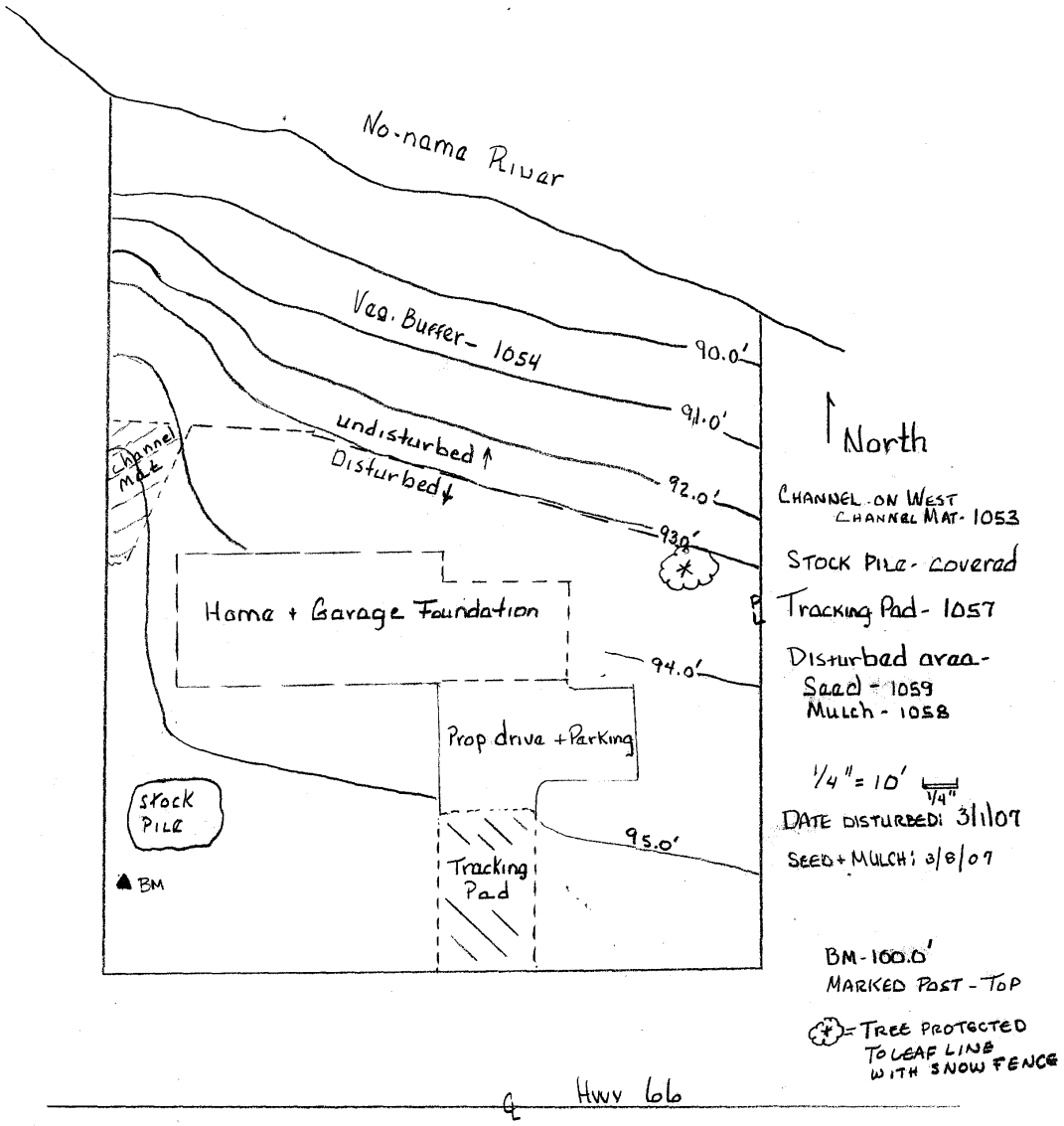

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Figure 125.125−2
Sample Page from Erosion Control Checklist

Y	N	N/A	Seeding for Erosion Control − 1059
			Topsoil depth 2 in. for temporary seeding?
			Topsoil depth 4 in. for permanent seeding?
			Rocks, twigs and foreign material removed?
			Clods < 2 inch?
			Seed sown < 1/4 in. deep?
			Temporary species and rates per table?

Species	Lbs/Acre	% Purity	Season
Oats	131	98	Spring & Summer
Cereal Rye	131	97	Fall
Winter Wheat	131	95	Fall
Annual Ryegrass	80	97	Fall

Y	N	N/A	Mulching for Const. Sites 1058
			Area under mulch free of gullies and rills?
			Mulch not in concentrated flow channels?
			Erosion occurring in mulched areas?
			Natural biodegradable materials?
			Free of toxic, noxious or diseased substances?
			Marsh hay only on upland sites?
			Crimped straw or hay fiber length > 6 in.?
			No bark or wood chips on seeded sites?
			Mulch covers 80% of unseeded areas?
			Mulch covers 70% of seeded areas?
			Mulch 1/2 to 1−1/2 in. thick in seeded areas?
			Mulch 1−1/2 to 3 in. thick for unseeded areas?
			Wood chips 1/2 to 1−1/2 in. thick?
			Mulch anchors w/crimping, matting & tackifier?

Note: The entire checklist can be found at: *www.commerce.wi.gov*

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Vegetative Buffer For Construction Sites

(1054)

Wisconsin Department of Natural Resources
Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in IX. Definitions. The words are italicized the first time they are used.

I. Definition

An area of *dense vegetation*[1] intended to slow runoff and trap sediment. Vegetative Buffers are commonly referred to as filter or buffer strips.

II. Purpose

The purpose of this practice is to remove sediment in *sheet flow* by velocity reduction.

III. Conditions Where Practice Applies

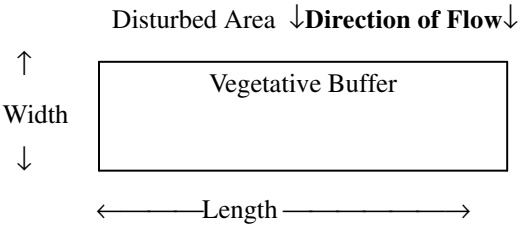
This practice applies to areas where sediment delivery is in the form of *sheet and rill erosion* from disturbed areas.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of a vegetative buffer. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.



A. The vegetative buffer shall be located along the entire length of the down slope edge of the entire disturbed area for which the practice is being applied.

B. The vegetative buffer shall be located on the contour.

C. The width of the vegetative buffer shall have slopes less than 5 %.

D. The disturbed area draining to the vegetative buffer shall have slopes of 6 % or less.

E. The vegetative buffer shall have a minimum *width* of 25 feet. 25 feet is adequate for disturbed areas up to 125 feet upslope from the vegetative buffer. An additional one foot of width shall be added to the buffer for every 5 feet exceeding 125 feet upslope of the disturbed area draining to the vegetative buffer.

F. To minimize compaction and destruction of the vegetative cover, designate the vegetative buffer as an area of no disturbance. Construction equipment shall be excluded from the designated area. Vegetative buffers shall be clearly shown on plans and marked in the field.

G. Vegetative buffers shall be densely vegetated prior to upslope soil disturbance.

VI. Considerations

A. Maintaining sheet flow is critical to the function of a vegetative buffer. In some conditions, a *level spreader* may need to be constructed at the upslope side of the vegetative buffer to minimize concentrated flow.

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B. Vegetative buffers may require large land areas compared to other erosion control practices.

C. Trees should not be cut down to establish a vegetative buffer. Other erosion control measures are preferred.

VII. Plans and Specifications

A. Plans and specifications for vegetative buffers shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Location of vegetative buffer.
2. Limits and slopes of disturbed area and any additional contributory drainage area.
3. Dimensions and slope of vegetative buffer.

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Vegetative buffers shall be inspected for proper distribution of flows, sediment accumulation and signs of rill formation. Vegetative buffers shall at a minimum be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24−hour period.

B. If the vegetative buffer becomes silt covered, contains rills, or is otherwise rendered ineffective, other perimeter sediment control measures shall be installed. Eroded areas shall be repaired and stabilized. Repair shall be completed as soon as possible with consideration to site conditions.

C. A stand of dense vegetation shall be maintained to a height of 3 – 12 inches.

D. Prior to land disturbance the perimeter of vegetative buffers shall be flagged or fenced to prevent equipment from creating ruts, compacting the soil and to prevent damage to vegetation.

IX. Definitions

Dense vegetation (I): is defined as an existing stand of 3 – 12 inch high grassy vegetation that uniformly covers at least 90 % of a representative 1 square yard plot. Woody vegetation shall not be counted for the 90% coverage. No more than 10% of the overall buffer can be comprised of woody vegetation.

Level Spreader (VI.A): Level spreaders disperse flows over a wide area, dissipating the energy of the runoff and creating sheet flow. Common types of level spreaders are weirs and stone trenches.

Sheetflow (II)*:* Sheet flow is over plane surfaces, where runoff water flows in a thin uniform sheet across the land before it collects in a concentrated flow.

Sheet and Rill Erosion (III): Sheet and rill erosion is the removal of soil by the action of rainfall and shallow overland runoff. It is the first stage in water erosion. As flow becomes more concentrated rills occur. As soil detachment continues or flow increases, rills will become wider and deeper.

Width (V.E): Is measured in the direction of flow.

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Channel Erosion Mat

(1053)

Wisconsin Department of Natural Resources

Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in XI. Definitions. The words are italicized the first time they are used.

I. Definition

A protective soil cover of straw, wood, coconut fiber or other suitable plant residue, or plastic fibers formed into a mat, usually with a plastic or biodegradable mesh on one or both sides. Erosion mats are rolled products available in many varieties and combination of materials and with varying life spans.

II. Purpose

The purpose of this practice is to protect the channel from erosion or act as turf reinforcement during and after the establishment of grass or other vegetation in a channel. This practice applies to both *Erosion Control Revegative Mats* (*ECRM*[1]) and *Turf−Reinforcement Mats* (*TRM*).

III. Conditions Where Practice Applies

This standard applies where runoff channelizes in intermittent flow and vegetation is to be established. Some products may have limited applicability in projects adjacent to navigable waters.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of erosion mat. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements. To complete the shear calculations, a 2 year, 24 hour storm event shall be used to calculate depth of flows for an ECRM. For sizing a TRM, use the depth of flow corresponding to the maximum design capacity of the channel.

Only mats listed in the Wisconsin Department of Transportation (WisDOT) Erosion Control Product Acceptability List (PAL) will be accepted for use in this standard.

To differentiate applications WisDOT organizes erosion mats into three classes of mats, which are further broken down into various Types.

A. Class I: A short−term duration (minimum of 6 months), light duty, organic ECRM with plastic or biodegradable netting.

1. Type A – Only suitable for slope applications, not channel applications.
2. Type B – Double netted product for use in channels where the calculated (design) shear stress is 1.5 lbs/ft^2 or less.

B. Class II: A long−term duration (three years or greater), organic ECRM.

1. Type A – Jute fiber only for use in channels to reinforce sod.
2. Type B – For use in channels where the calculated (design) shear stress is 2.0 lbs/ft^2 or less. Made with plastic or biodegradable mat.
3. Type C – A woven mat of 100% organic material for use in channels where the calculated (design) shear stress is 2.0 lbs/ft^2 or less. Applicable for use in environmentally sensitive areas where plastic netting is inappropriate.

C. Class III: A permanent 100% synthetic ECRM or TRM. Class I, Type B erosion mat or Class II, Type B or C erosion mat must be placed over a soil filled TRM.

1. Type A – An ECRM for use in channels where the calculated (design) shear stress of 2.0 lbs/ft^2 or less.
2. Type B – A TRM for use in channels where the calculated (design) shear stress of 2.0 lbs/ft^2 or less.

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3. Type C – A TRM for use in channels where the calculated (design) shear stress of 3.5 lbs/ft^2 or less.
4. Type D – A TRM for use in channels where the calculated (design) shear stress of 5.0 lbs/ft^2 or less.

VI. Installation

A. ECRM shall be installed after all topsoiling, fertilizing, liming, and seeding is complete.

B. Erosion mats shall extend for whichever is greater: upslope one−foot minimum vertically from the ditch bottom or 6 inches higher than the design flow depth.

C. The mat shall be in firm and continuous contact with the soil. It shall be anchored, overlapped, staked and entrenched per the manufacturer's recommendations.

D. TRM shall be installed in conjunction with the topsoiling operation and shall be followed by ECRM installation.

E. At time of installation, document the manufacturer and mat type by saving material labels and manufacturer's installation instructions. Retain this documentation until the site is stabilized.

VII. Considerations

A. Erosion mats shall be selected so that they last long enough for the grass or other vegetation to become densely established.

B. Consider using Class II, Type C mats adjacent to waterways where trapping small animals is to be avoided.

C. Class III TRM may be appropriate as a replacement for riprap as a channel liner. Check the shear stress criteria for the channel to determine mat applicability.

D. Once a gully has formed in a channel, it is difficult to stabilize due to loss of soil structure. Even when the gully is filled with topsoil and reseeded, the soil has a tendency to dislodge in the same pattern. If gully formation continues to be a problem the design should be reevaluated, including other mat classes or riprap.

E. It may be difficult to establish permanent vegetation and adequate erosion protection in a channel with continuous flow. Consider riprap or planting wetland species with an ECRM.

F. Documentation of materials used, monitoring logs, project diary, and weekly inspection forms including erosion and stormwater management plans, should be provided to the authority charged with long term maintenance of the site.

G. Channel cross sections may be parabolic, v−shaped or trapezoidal. The use of "V" channels is generally discouraged due to erosion problems experienced.

H. To help determine the appropriate channel liner, designers can refer to the design matrix in the back of the WisDOT PAL. However, for channels not conforming to the typical section shown in the channel matrix or having a depth of flow greater than 6 inches (150 mm), the designer will need to design for an appropriate channel liner. One way to do this is to use the "tractive force" method presented in FHWA's Hydraulic Engineering Circular (HEC) No. 15. This method requires that the calculated maximum shear stress of a channel is not to exceed the permissible shear stress of the channel liner. To use this method, permissible shear stress values are stated next to each device listed in the channel matrix.

VIII. Plans and Specifications

A. Plans and specifications for installing erosion mat shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Location of erosion mat
2. Installation sequence
3. Material specification conforming to standard

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

IX. Operation and Maintenance

A. Erosion mats shall at a minimum be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24−hour period.

B. If there are signs of rilling under the mat, install more staples or more frequent anchoring trenches. If rilling becomes severe enough to prevent establishment of vegetation, remove the section of mat where the damage has occurred. Fill the

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eroded area with topsoil, compact, reseed and replace the section of mat, trenching and overlapping ends per manufacturer's recommendations. Additional staking is recommended near where rilling was filled.

C. If the reinforcing plastic netting has separated from the mat, remove the plastic and if necessary replace the mat.

D. Maintenance shall be completed as soon as possible with consideration to site conditions.

X. References

WisDOT "Erosion Control Product Acceptability List" is available online at http://www.dot.wisconsin.gov/business/engrserv/pal.htm.

XI. Definitions

Channel Erosion: The deepening and widening of a channel due to soil loss caused by flowing water. As rills become larger and flows begin to concentrate, soil detachment occurs primarily as a result of shear.

Erosion Control Revegative Mats (*ECRM)* (II): Erosion control revegetative mats are designed to be placed on top of soil.

Turf−Reinforcement Mats (*TRM)* (II): Turf−reinforcement mats are permanent devices constructed from various types of synthetic materials and buried below the surface to help stabilize the soil. TRMs must be used in conjunction with an ECRM or an approved soil stabilizer Type A (as classified in the WisDOT PAL)

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Construction Site Diversion

(1066)

Wisconsin Department of Natural Resources

Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in IX. Definitions. The words are italicized the first time they are used.

I. Definition

A *temporary*[1] berm or channel constructed across a slope to collect and divert runoff.

II. Purpose

To intercept, divert, and safely convey runoff at construction sites in order to divert clean water away from disturbed areas, or redirect sediment laden waters to an appropriate sediment control facility.

III. Conditions Where Practice Applies

A. This practice is applicable to construction sites where temporary surface water runoff control or management is needed. Locations and conditions include:

1. Above disturbed areas, to limit runoff onto the site.
2. Across slopes to reduce slope length.
3. Below slopes to divert excess runoff to stabilized outlets.
4. To divert sediment−laden water to sediment control facilities.
5. At or near the perimeter of the construction area to keep sediment from leaving the site.

B. This standard does not pertain to permanent diversions. Refer to appropriate design criteria and local regulations when designing permanent diversions.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of this practice. This standard does not contain the text of federal, state, or local laws.

V. Criteria

A. The diversion shall have stable side slopes and shall not be overtopped during a 2−year frequency, 24−hour duration storm. The minimum berm cross section shall be as follows:

1. Side slopes of 2:1 (horizontal:vertical) or flatter.
2. Top width of two feet.
3. Berm height of 1.5 feet.

B. Sediment−laden runoff from disturbed areas shall be diverted into a sediment control practice. For typical sediment control practices see WDNR Conservation Practice Standards Sediment Trap (1063) or Sediment Basin (1065) for design criteria.

C. When diverting clean water the diversion channel and its outfall shall be immediately *stabilized* for the 2−year frequency, 24−hour duration storm. Build and stabilize clean water diversions before initiating down slope land−disturbing activities.

D. Diversions shall be protected from damage by construction activities. At all points where diversion berms or channels will be crossed by construction equipment, the diversion shall be stabilized or shaped appropriately. Temporary culverts of adequate capacity may be used.

E. For diversions that are to serve longer than 30 days, the side slopes including the ridge, and down slope side the diversion shall be stabilized as soon as they are constructed. The diversion channel should be stabilized (i.e. erosion mat) or a larger sediment control practice shall be needed. For diversions serving less than 30 days, the down slope side of the diversion shall be stabilized as soon as constructed.

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VI. Considerations

A. The channel cross section may be parabolic, v−shaped or trapezoidal. The use of "V" channels is generally discouraged due to potential erosion problems.

B. Ditch checks may be used to enhance sediment removal. Ditch checks shall be designed in accordance with WDNR Conservation Practice Standard Ditch Check (1062).

C. For diversion berms consider designing an emergency overflow section or bypass area to limit damage from storms that exceed the 2−year frequency 24−hour duration storm. The overflow section may be designed as a stabilized weir with riprap protection.

VII. Plans and Specifications

A. Plans and specifications for installing diversions shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Diversion location.
2. Channel grade or elevations.
3. Typical cross section.
4. Channel stabilization if required.

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Diversions shall, at a minimum, be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24−hour period.

B. Maintenance shall be completed as soon as possible with consideration to site conditions.

C. Accumulated sediment shall be removed when it reaches one half the height of the diversion berm. Properly dispose of any sediment removed from the diversion.

D. Diversions shall be removed and the area stabilized according to construction plans.

IX. Definitions

Temporary (I): an erosion control measure that is utilized during construction and grading operations prior to final stabilization.

Stabilized (V.C): means protecting exposed soil from erosion.

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Ditch Check (Channel)

(1062)

Wisconsin Department of Natural Resources
Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used.

I. Definition

A temporary dam constructed across a swale or drainage ditch to reduce the velocity of water flowing in the channel. *Ditch checks*[1] can be constructed out of stone, a double row of straw bales or from engineered products found on the Wisconsin Department of Transportation (WisDOT) Erosion Control Product Acceptability List (PAL).

II. Purpose

The purpose of this practice is to reduce flow velocity and to pond water, thereby reducing active channel erosion and promoting settling of suspended solids behind the ditch check.

III. Conditions Where Practice Applies

This Standard applies where grading activity occurs in areas of channelized flows and a temporary measure is needed to control erosion of the channel until permanent stabilization practices can be applied.

Under no circumstance shall ditch checks be placed in intermittent or perennial stream without permission from WDNR. This Practice may not be substituted for major perimeter trapping measures.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of ditch checks. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Height

1. Installed, the minimum height of ditch checks shall be 10 inches and shall not exceed a maximum height of 16 inches for manufactured or biodegradable materials and 36 inches for stone (or other inorganic materials).
2. Ditch checks must be installed with the center lower than the sides forming a weir. If this is not done stormwater flows are forced to the edge of the ditch check thus promoting scour, or out of the channel causing excessive erosion.
3. Stone ditch checks shall have a minimum top width of 2−feet measured in the direction of flow with maximum slopes of 2:1 (2 horizontal to 1 vertical) on the upslope side and 2:1 on the down slope side.

B. Placement

1. At a minimum install one ditch check for every two feet of drop in the channel.
2. Ditch checks shall be placed such that the resultant ponding will not cause inconvenience or damage to adjacent areas.

C. Material Specifications

1. Stone ditch checks shall be constructed of a well−graded angular stone, a D_{50} of 3 inch or greater, sometimes referred to as breaker run or shot rock.
2. Ditch checks may be constructed of other approved materials but must be capable of withstanding the flow velocities in the channel. Manufactured products listed in WisDOT's PAL are also acceptable for temporary ditch checks.

   Note: Silt fence and single rows of straw bales are ineffective as ditch checks and are not permitted.

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D. Construction − Refer to Figure 1 & 2

1. Ditch checks shall be utilized during rough grading and shall be removed once the final grading and channel stabilization is applied, unless intended to be part of a permanent stormwater management plan.

2. Channel erosion mat or other non−erodible materials shall be placed at the base of a ditch check, and extended a minimum of 6 feet, to prevent scour and washing out the toe of the ditch check. DNR Conservation Practice Channel Erosion Mat (1053) contains criteria for the placement of erosion mat in this location.

3. Chink or seal stone and rock ditch checks to minimize the flow through the ditch check.

VI. Considerations

A. For added stability, the base of a stone or rock ditch check should be keyed into the soil to a depth of 6−inches.

B. Stone ditch checks may be underlain by a nonwoven geotextile fabric to ease installation and removal. If the geotextile fabric is extended, it can serve purpose specified in section V.D.2

C. Ditch checks installed in grass lined channels may kill the vegetation if water is ponded for extended periods or excessive siltation occurs. Proper maintenance is required to keep areas above and below the ditch check stabilized.

D. The best way to prevent sediment from entering the storm sewer system is to stabilize the disturbed area of the site as quickly as possible, preventing erosion and stopping sediment transport at its source.

E. When placing ditch checks in swales adjacent to roadways consider designating a 'clear zone' free of obstacles posing a threat to out of control vehicles.

F. Mowing operations may throw stones from ditch checks causing a potential safety hazard.

VII. Plans and Specifications

A. Plans and specifications for installing ditch checks shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Location and spacing of ditch check

2. Schedules and sequence of installation and removal

3. Standard drawings and installation details

4. Rock gradation

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Ditch checks shall, at a minimum, be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24 hour period.

B. Unless incorporated into a permanent stormwater management system, ditch checks shall be removed once the final grading and channel stabilization is applied.

C. Sediment deposits shall be removed when deposits reach 0.5 the height of the barrier. Removal of sediment may require replacement of stone. Maintenance shall be completed as soon as possible with consideration to site conditions.

IX. References

WisDOT "Erosion Control Product Acceptability List" is available online at: *http://www.dot.wisconsin.gov/business/engrserv/pal.htm* Printed copies are no longer distributed.

X. Definitions

D_{50} (V.C.1): The particle size for which 50% of the material by weight is smaller than that size.

Ditch Checks (I) Are commonly referred to as temporary check dams. Stone ditch checks refer to those made out of either stone or rock.

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DEWATERING

Code No.

(1061)

Wisconsin Department of Natural Resources

Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used.

I. Definition

A compartmented container, settling basin, filter, or other appropriate best management practice through which sediment−laden water is conveyed to trap and retain the sediment.

II. Purposes

The purpose of this standard is to determine appropriate methods and means to remove sediment from water generated during dewatering activities prior to discharging off−site or to waters of the state. Practices identified in this standard shall be deemed to meet the de−watering performance standard to prevent the discharge of sediment to the maximum extent practicable (MEP) as defined in s. NR 151.11 (6) (c).

III. Conditions where Practice Applies

This practice applies where sediment laden water needs to be removed for construction or maintenance activities. Dewatering practices shall be in keeping with the effective operating and applicability criteria listed on Figure 2, Dewatering Practice Selection Matrix.

This practice does not apply to:

- Water being discharged directly to groundwater or *karst features*[1]. Refer to NR140
- Well dewatering systems. Refer to NR 812

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of this practice. This may include activities performed under NR 216 and Chapter 30 permits, for water bodies with *targeted performance standards* per NR 151.004, 303d waterbodies or others. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum allowable limits for design parameters, installation and performance requirements.

Dewatering practices shall be selected based on the predominant soil texture encountered at the dewatering site with consideration given to pumping or flow rates, volumes and device effectiveness. Refer to Figure 1 USDA Soil textural triangle to assist with soil classifications at the site. Figure 2, Dewatering Practice Selection Matrix illustrates acceptable dewatering options and their effective ranges. Practices selected that are not on the matrix must provide an equivalent level of control, with justification provided to the reviewing authority.

A. Site Assessment − A site assessment shall be conducted and documented to determine the physical site characteristics that will affect the placement, design, construction and maintenance of dewatering activities. The site assessment shall identify characteristics such as ground slopes, soil types, soil conditions, bedrock, sinkholes, drainage patterns, runoff constituents, proximity to regulated structures, natural resources, and specific land uses. The site assessment shall include the following:

- Sanitary and storm sewer locations
- Potential contamination − Odor or discoloration other than sediment, or an oily sheen on the surface of the sediment laden water. If contamination is present, notify DNR Spills Reporting
- Soil textural class for areas where dewatering will occur. Soil investigation shall extend below grading and trenching activities
- Depth to the seasonally highest water table

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- Discharge outfall locations
- Distance and conveyance method to receiving waters

B. General Criteria Applicable To All Dewatering Activities

1. Contact the WDNR when the discharge from a dewatering practice will enter a WDNR listed *Exceptional Resource Water (ERW), Outstanding Resource Water (ORW)*, or a wetland in an area of special natural resource interest as identified in NR 103.

2. Contact the owner or operator of the municipal separate stormwater system if the discharge is to a municipal storm water conveyance system. The allowable discharge rate shall be limited by the capacity of the system or requirements of the system owner.

3. When practical, dewatering effluent shall be collected in a pump truck for transport to a *treatment facility* or discharged directly to a treatment facility.

4. For surface dewatering, utilize a floating suction hose, or other method, to minimize sediment being sucked off the bottom.

5. For discharges that will be directed to locations on−site verify that the anticipated volume of water can be fully contained.

6. The topography and condition of the ground cover between the pump discharge point and potential receiving waters shall be evaluated for potential erosion. Appropriate stabilization measures shall be incorporated to prevent erosion.

7. When discharge to a karst feature or other direct groundwater connection can not be avoided, the dewatering system must be designed and operated to maintain compliance with the groundwater quality standards contained in applicable regulations, including ch. NR 140 Wis. Adm. Code.

8. If the discharge directly or indirectly enters a stream, the discharge flow rate shall not exceed 50 percent of the peak flow rate of the 2−year 24−hour storm event.

C. Geotextile Bags

1. Geotextile bags shall meet the criteria listed in Table 1.

Table 1: Properties for Geotextile Bags

Property	Test Method	Type I Value	Type II Value
Maximum Apparent Opening Sizes	ASTM D−4751	0.212 mm	0.212 mm
Grab Tensile Strength	ASTM D−4632	200 lbs.	300 lbs.
Mullen Burst	ASTM D−3786	350 psi	580 psi
Permeability	ASTM D−4491	0.28 cm/sec	0.2 cm/sec
Fabric	Nominal Representative Weight	8 oz	12 oz

2. Geotextile bags shall be sized according to the particle size being trapped, expected flow or pumping rate (gallons per minute) per square foot of fabric and a 50% clogging factor. The footprint of the bag shall be no smaller than 100 square feet.

3. Geotextile bags shall be securely attached to the discharge pipe.

4. Polymers can be used to enhance the efficiency of geotextile bags. If polymer is used, the polymer shall be approved by the WDNR and meet the criteria stipulated in WDNR Conservation Practice Standard 1051, Sediment Control Water Application of Polymers. The polymer supplier or applicator shall provide certifications showing that products have met the performance requirements of Standard 1051. If the manufacturer has not completed the required testing, the project may be used to gain that certification provided it meets the site requirements of Standard 1051. Any such testing will be monitored by DNR or WisDOT, with testing done by a qualified third party.

D. Gravity Based Settling Systems

Gravity based systems rely on settling of particles as the primary means of treatment. To effectively accomplish this, quiescent conditions should exist with sufficient detention time. Practices include portable sediment tanks, sediment traps, sediment basins and wet detention basins.

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If polymer is used to enhance settling, the polymer shall be approved by the WDNR and meet the criteria stipulated in WDNR Conservation Practice Standard 1051, Sediment Control Water Application of Polymers. The polymer supplier or applicator shall provide certifications showing that products have met the performance requirements of Standard 1051. If the manufacturer has not completed the required testing, the project may be used to gain that certification provided it meets the site requirements of Standard 1051. Any such testing will be monitored by DNR or WisDOT, with testing done by a qualified third party.

1. Portable Sediment Tank: These tanks are intended to settle only sands, loamy sands, and sandy loams. If polymer is added, these tanks will also be appropriate for settling loams, silt loams and silts. Portable sediment tanks shall have a minimum of two baffled compartments, and be a minimum of three feet deep. The inlet and outlet pipe shall be a minimum diameter of three inches. Use one of the following methods to size a tank:

   a. Settling: Account for settling of the suspended sediments with the following equation:

      $Sa = 1.83 * Q;$

   where

      Sa = Tank surface area (sq ft)

      Q = Pumping rate (gallons per minute)

      Note: 1.83 is a factor that includes the conversion from gpm to cfs (1 gpm = 0.0022 cfs) and the particle settling velocity for Soil Class 1 (0.0012 ft/sec) from WDNR Conservation Practice Standard 1064 Sediment Basin.

   b. Filtration: Build the first chamber as large as possible to aid in settling. Flow capacity shall be determined by the end area of the filter media (fabric) and the flow rate (gallons per minute) per square foot of the finest filter media and a 50% clogging factor.

2. Sediment Trap or Sediment Basin: This device is a temporary sediment control device. The design, installation, and operation of the sediment trap or basin shall meet the requirements stipulated in WDNR Conservation Practice Standard 1063 Sediment Trap or Standard 1064 Sediment Basin.

3. Wet Detention Basin: This device is generally a permanent structure designed to address post−construction pollutant reduction requirements. The design, installation, and operation of the wet detention basin shall meet the requirements stipulated in WDNR Conservation Practice Standard 1001 Wet Detention Basin.

E. Passive Filtration Systems

Passive filtration systems rely on filtration as the primary method of removing particles. Sediment removal efficiency will be related to the particle size distribution in the stormwater. Practices include manufactured filters, filter tanks, filter basins, vegetative filters, grass swales, and filtration fabric.

Filter fabric sediment removal efficiency shall be based on the properties specified in Table 1.

1. Manufactured Filters: Filters shall be sequenced from the largest to the smallest pore opening. Sand media filters are available with automatic backwashing features that can filter to 50 µm particle size. Screen or bag filters can filter down to 5 µm. Fiber wound filters can remove particles down to 0.5 µm.

2. Filter Tank (portable): Install, operate and maintain according to manufacturer recommendations.

3. Filter Basin: Install, operate and maintain according to Wisconsin Department of Transportation technical guidance.

4. Vegetative Filter: Refer to WDNR Conservation Practice Standard 1054 Vegetated Buffer for Construction Sites.

F. Pressurize Filtration Systems

Pressurized filtration systems differ from passive systems in that the water flowing through the media is pressurized and the filter media is designed to handle higher flow rates. Practices include portable sand filters, wound cartridge units, membranes and micro−filtration units.

Pressurized filters typically have automatic backwash systems that are triggered by a pre−set pressure drop across the filter. If the backwash water volume is small or substantially more turbid than the stormwater stored in the holding pond or tank, returning backwash water to the pond or tank may be appropriate. However, land application or another means of treatment and disposal may be necessary.

Screen, bag, and fiber filters must be cleaned and/or replaced when they become clogged.

1. Portable Sand Filter: Install, operate and maintain according to manufacturer recommendations.

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2. Wound Cartridge Units: Secondary filtration of sediments using high efficiency filter cartridges may be necessary to remove fine particles such as clays. Install, operate and maintain according to manufacturer recommendations.

3. Membranes and Micro−filtration: Install, operate and maintain according to manufacturer recommendations.

4. If polymer is used to enhance settling, the polymer shall be approved by the WDNR and meet the criteria stipulated in WDNR Conservation Practice Standard 1051, Sediment Control Water Application of Polymers. The polymer supplier or applicator shall provide certifications showing that products have met the performance requirements of Standard 1051. If the manufacturer has not completed the required testing, the project may be used to gain that certification provided it meets the site requirements of Standard 1051. Any such testing will be monitored by DNR or WisDOT, with testing done by a qualified third party.

VI. Considerations

A. It may be necessary to clean the municipal storm drainage system prior to and after discharging to the system to prevent scouring solids from the drainage system.

B. Geotextile bags are generally not appropriate when discharging to ORW, ERW, waterbodies supporting cold water communities, trout streams, or to *highly susceptible* and *less susceptible wetlands*.

C. Pressurized filtration systems are the most efficient for removing fine sediments.

D. Portable sediment tanks may be appropriate when other sediment trapping practices cannot be installed due to lack of space or other reasons.

E. Filtration is not an efficient treatment of water with heavy sediment loads. Use a settling tank or sand filter as pretreatment when possible.

F. It may be necessary to use a combination of dewatering practices to achieve the intended results.

VII. Plans and Specifications

All plans, standard detail drawings, or specifications shall include the schedule for installation, inspection, and maintenance and shall be kept on−site with the erosion control plan.

VIII. Operation and Maintenance

A. Sediment shall be removed from devices to maintain effectiveness. All sediment collected in dewatering devices shall be properly disposed of to prevent discharge to waters of the state.

B. The following monitoring shall be conducted. Test results shall be recorded on a daily log kept on site:

1. Discharge duration and specified pumping rate

2. Observed water table at time of dewatering

3. If used, type and amount of chemical used for pH adjustment

4. If used, type and amount of polymer used for treatment

5. Maintenance activities

IX. References

The American Association of State Highway Officials (AASHTO) Soil Classification System

X. Definitions

Exceptional Resource Waters (ERW) (V.B.1): are waters listed in s. NR 102.11.

Highly susceptible wetland (VI.B): include the following types: fens, sedge meadows, bogs, low prairies, conifer swamps, shrub swamps, other forested wetlands, fresh wet meadows, shallow marshes, deep marshes and seasonally flooded basins.

Karst feature (III): are an area or geologic feature subject to bedrock dissolution so that it is likely to provide a conduit to groundwater, and may include caves, enlarged fractures, mine features, exposed bedrock surfaces, sinkholes, springs, seeps or swallets.

Less susceptible wetland (VI.B)*:* include degraded wetlands dominated by invasive species such as reed canary grass.

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Outstanding Resource Waters (ORW) (V.B.1): are waters listed in s. NR 102.10.

Targeted performance standard (IV): means a performance standard that will apply in a specific area, where additional practices beyond those contained in NR 151 are necessary to meet water quality standards.

Treatment facility (V.B.3): includes wastewater treatment plants or wet detention basins constructed in accordance with WDNR Conservation Practice Standard 1001 Wet Detention Basin or other approved land application sites.

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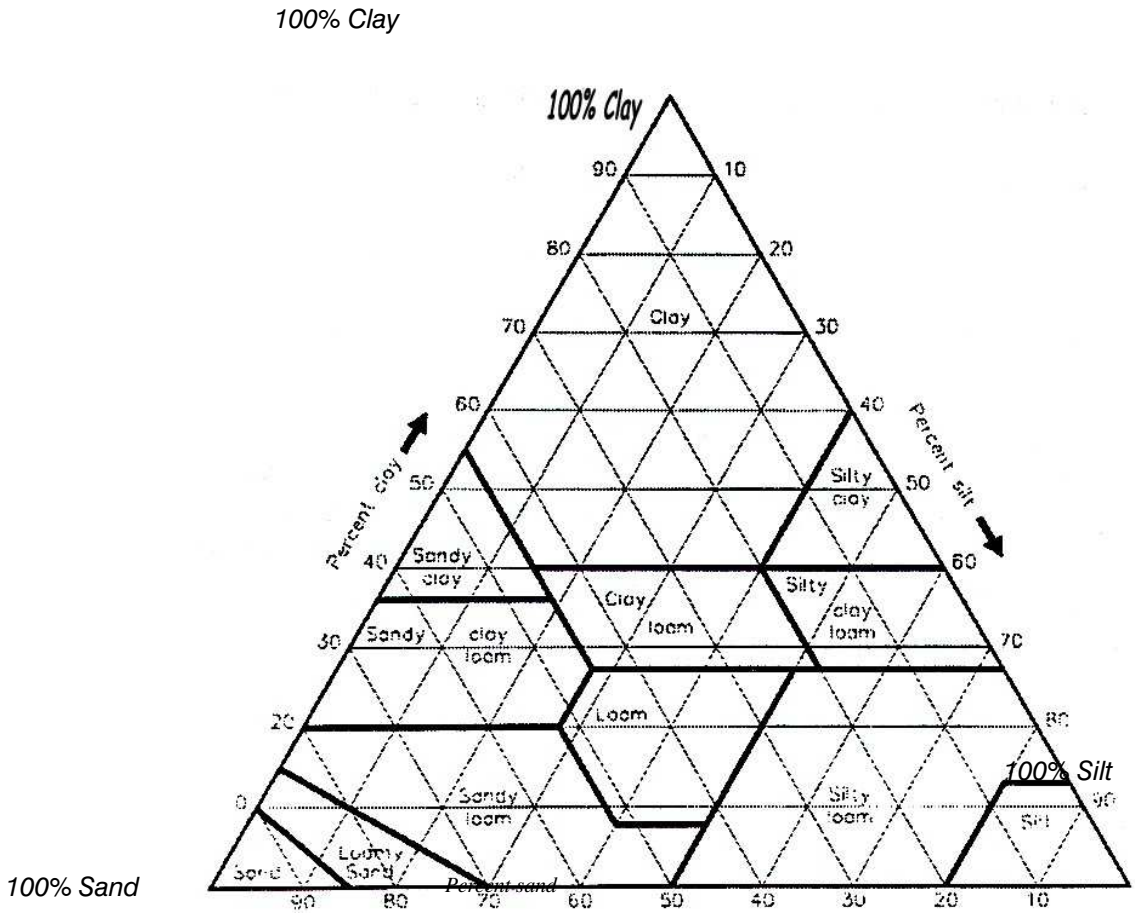

Figure 1: USDA Soil Textural Triangle

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Interim Sediment Control Water Application of Polymers

(1051)

Wisconsin Department of Natural Resources

Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in IX. Definitions. The words are italicized the first time they are used.

I. Definition

The application of products containing *polymers*[1] to *sediment control structures*.

II. Purpose

The purpose of this practice is to settle out or remove suspended *sediment* from water within sediment control structures.

III. Conditions Where Practice Applies

This practice shall be used with self−contained sediment control structures, on a temporary basis for construction sites, in an emergency for post−construction sites and only continually at sites holding an individual permit, if needed to improve the sediment removal efficiency of the structure. Polymers shall not be directly applied to *surface waters of the state*. Sediment control structures may be within, or discharge to, surface waters of the state.

IV. Federal, State and Local Laws

Water applications of polymer shall comply with all federal, state, and local laws, rules or regulations governing polymers. The operator is responsible for securing required permits. This standard does not contain the text of the federal, state, or local laws governing polymers.

V. Criteria

A. Toxicity Criteria

If used in accordance with the use restriction, the polymer mixture shall meet an acceptable level of risk such that the product can be used without significant harm to organisms that inhabit or come in contact with the aquatic environment. Every attempt shall be made to eliminate the use of any chemicals known to be environmentally toxic within a polymer mixture. Polymer mixtures shall be non−combustible.

The manufacturer shall supply toxicity testing data to the Wisconsin Department of Natural Resources (WDNR) based on the polymer mixture, including any binding or buffering agents, catalyst or any other additives.

1. The use of cationic *polyacrylamide* shall be avoided where there is danger of impacting aquatic organisms because its toxicity to aquatic test species occurs at very low concentrations.

2. Anionic polymer mixtures shall have ≤ .05% free acrylamide monomer by weight as established by the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA).

3. Each manufacturer shall provide to the WDNR toxicity information (including acute and chronic water column toxicity test data) from a certified lab, as defined in ch. NR 149 Wis.Adm.Code, for the polymer mixture.

   This data shall include all raw and statistical data regarding death, sub−lethal observations such as immobility, and any other test observations. *Standardized toxicity testing* procedures should be used and referenced. A *use restriction* will be calculated by WDNR using the information in Appendix I.

4. Users of polymer mixtures shall obtain and follow all *Material Safety Data Sheet (MSDS)* requirements, manufacturer's recommendations, and WDNR use restrictions.

B. Application Criteria

1. Maximum application rates, per storm event, in pounds per acre−feet shall be the lesser of WDNR's use restriction multiplied by 1.35 or the manufacturer's recommended application rate (1.35 is a conversion factor that is used to change the use restriction from ppm to an application rate in pounds per acre−feet).

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2. Neither the manufacturer's written application rate recommendations, nor the application rate shall exceed the WDNR use restriction. The manufacturer or distributor shall provide for the applicator:

   a. Labels affixed to the polymer mixture containers that indicate the recommended application rate and the maximum application rate based on the use restriction.

   b. A product expiration date for the polymer mixture based on product expiration dates of the polymer.

   c. General written application methods.

   d. Written instructions to provide proper safety, storage, and mixing of their product.

3. The application method shall provide for uniform distribution of the product in the sediment control structure and shall consist of either:

   a. Passive Applications*:* Polymers applied by non−mechanically dosing the sediment−laden inflow prior to it entering the impoundment area of the sediment control structure. The manufacturer shall base passive application rates on the dissolution rate and/or the dead storage volume of the sediment control structure.

   or

   b. Active or Mechanical Applications*:* Polymer applied by mechanically or hydraulically mixing directly into a sediment control structure.

4. The applicator of the polymer mixture shall at the time of application, document the following:

   - Name of applicator
   - Application rate in pounds per acre−feet of stormwater runoff
   - Date applied
   - Product type
   - Weather conditions during application
   - Method of application

   Copies of this documentation shall be entered into the contractor's monitoring log or a project diary and made available upon request.

C. Product Approval Criteria

The manufacturer shall certify, through independent sampling and test results, that their product performs as per the following requirements. (The product approval process is depicted in flow chart form in Figure 1.)

1. The toxicity information required in section V.A.3. of this standard shall be reviewed by the WDNR and used to generate a written product use restriction for the polymer mixture. Appendix I outlines the information that needs to be submitted as a part of this review, and states where they must be submitted.

2. Polymer mixtures shall achieve = 95% sediment reduction as measured by the standpipe method outlined in Appendix II.

3. Performance criteria − active and passive applications shall be field tested and submitted separately:

   a. The performance of polymer mixtures shall be verified and field−tested in a body of water that is not discharging directly into the waters of the state. The body of water shall be a minimum of 1/3−acre surface area and an average depth of at least 3 feet.

   b. The total suspended solids prior to the polymer treatment must be tested and verified by an independent testing lab, and must have a minimum value of 800 ppm or equivalent N*ephelometric Turbidity Units (NTU)* and be visibly turbid. The relationship between total suspended solids (TSS) and NTU is site−specific and the derivation of a unique TSS−NTU relationship shall be conducted for each sediment control structure. A minimum of two samples per acre−foot of water shall be taken from random locations within the test site.

   c. Within 48 hours from the initial treatment of the water body, the total suspended solids must have a maximum of 80 ppm, or equivalent NTU.

   d. Testing sites may not be used for subsequent testing for a period of 3 months from the time of initial application.

   e. The Wisconsin Department of Transportation (WisDOT) shall be notified at least 7 days prior to testing, and WisDOT and/or WDNR staff shall be allowed to monitor any such testing.

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4. The WisDOT Erosion Control Storm Water/Product Acceptability List Committee will review and approve products as per the process set forth in WisDOT's Product Acceptability List (PAL).
5. The polymer mixture must be resubmitted if any portion of the mixture is altered subsequent to its approval. Such alterations may include:
   a. The amendment of base polymers and/or any other additives
   b. The ratios of individual components

VI. Considerations

The following are additional recommendations, which may enhance the use of, or avoid problems with, the practice.

A When using products in impoundments immediately adjacent to, or within waters of the state, consider using products for which the manufacturer's recommended application rate is considerably lower than the use restriction.

B. The applicator should use the least amount of polymer mixture to achieve optimal performance.

C. Polymer mixtures should be applied in conjunction with other erosion control BMPs and under an erosion and sediment control or stormwater management plan.

D. Test the pH of the water in the sediment control structure and follow the manufacturer's recommended pH range for their polymer mixture, as pH will impact the effectiveness of polymer mixtures.

E. Ethylene glycol, propylene glycol or any other known environmental toxicants should not be included in the polymer mixture.

F. Care must be taken to prevent spills of polymer mixtures. Follow the manufacturer's recommended cleanup procedures in the event of a spill.

G. Inhaling granular polymer may cause choking or difficulty breathing. Persons handling and mixing polymer should use personal protective equipment of a type recommended by the manufacturer.

H. Polymer mixtures combined with water are very slippery and can pose a safety hazard.

I. Polymer mixtures should be considered as an aid to removing solids from dredge slurries.

J. Where polymer mixtures are used with sediment control structures in the stream, such as during bridge construction, the structure should not be removed until the water is clarified. If the resulting sediment floc is more than a half a foot deep it should be excavated or filtered out.

VII. Specifications

Erosion and sediment control and stormwater management plans specifying polymer mixtures for sediment control shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

VIII. Operation and Maintenance

Sediment levels on the bottom of the sediment control structure shall be monitored to measure the loss of storage capacity over time due to enhanced sedimentation by the polymer mixture.

IX. Definitions

Material Safety Data Sheets (MSDS) (V.A.3) Provide basic information on a material or chemical product intended to help someone work safely with the material. This includes a brief synopsis of the hazards associated with using a material, how to use it safely, and what to do if there is an emergency. The retail distributor and/or manufacturer as per OSHA's Hazard Communication Standard, 29 CFR 1910.1200, must provide MSDS, with the purchase of potentially hazardous products.

Nephelometric Turbidity Units (NTU) (V.C.3.b) A measure of the amount of light scattered by suspended and dissolved materials in the sample.

Polyacrylamide (V.A.1) A generic term for polymers made up of many repeating units of the monomer acrylamide (a simple organic compound).

Polymer (I) Polymers are materials that are either natural or synthetic and that have a chain of carbon molecules that are identical, repeating units. Polymers can be positively charged (cationic), negatively charged (anionic) or have no charge (non−ionic).

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Polymer Mixture (V.A) Any reference to polymer mixtures refers to the whole manufactured product, including the polymer and any additives. Additional calcium or lime may be added as a buffering agent without being considered part of the whole manufactured product.

Sediment (II) refers to settleable soil, rock fragments and other solids suspended in runoff.

Sediment control structure (I.) A sediment control structure is an impoundment designed to intercept and detain sediment carried in runoff, prior to the runoff reaching the main channel of a waterway or body of water. Placement of these structures must be outside of the main channel of a waterway and shall not span opposing stream banks in channelized flow. The sediment control structure must provide for dedicated sediment storage to at least a depth of two feet, such that the sediment will not be subject to re−suspension during high velocity flow conditions.

Impoundments may be created by a cofferdam, turbidity barrier, earthen berm, sheet piling, self−contained filtering systems or similar material. Examples include properly maintained construction or post−construction sediment ponds, discharging directly or eventually to a water body. They may also include surface water impoundments that are immediately adjacent to a waterway, whose function is to treat stormwater or dredging material. Another potential application is to isolate localized areas surrounding bridge and culvert construction.

Standardized toxicity testing (V.A.2) Examples of such include, but are not limited to, those outlined in the *State of Wisconsin Aquatic Life Toxicity Testing Methods Manual* (Fleming, et.al, 1996) or *Short−term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms* (Lewis, et.al, 1994). The WDNR use restriction shall be developed from this data.

Surface Waters of the State (III) "Surface" refers to the sub portion of the waters of the state that discharge at the surface. Waters of the state, as defined by s. 283.01(20), Wis. Stats means those portions of Lake Michigan and Lake Superior within the boundaries of Wisconsin, all lakes, bays, rivers, streams, springs, ponds, wells, impounding reservoirs, marshes, water courses, drainage systems and other surface water or groundwater, natural or artificial, public or private within the state or under its jurisdiction, except those waters which are entirely confined and retained completely upon the property of the person.

Use Restriction (V.A.2) Identifies the concentration below which a product is not expected to cause acute toxicity in the aquatic environment.

X. References

Voluntary Use Of Polymers In DNR Programs (A Field Guide) For copies of this companion document contact Mary Anne Lowndes, Water Resources Engineer Bureau of Watershed Management 101 S. Webster St., Box 7921, Madison, WI 53707−7921 Phone (608) 261−6420 *MaryAnne.Lowndes@dnr.state.wi.us*

Fleming, K., P. Hubbard, N. Krause, R. Masnado, D. Piper, W. Repavich, G. Searle, S. Thon, "State of Wisconsin Aquatic Life Toxicity Testing Methods Manual, Edition 1." Bureau of Watershed Management, Wisconsin Department of Natural Resources, Madison, 1996 (WI. PUBL−WW−033−96).

Lewis, P.A., D.J. Klemm, J.M. Lazorchak, T.J. Norberg−King, W.H. Peltier, and M.A. Heber, "Short−Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, 3rd Edition." Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH, 1994 (EPA/600/4−91/002).

Roa−Espinosa, A., Bubenzer, G.D. and Miyashita, E., "Sediment and Runoff Control on Construction Sites Using Four Application Methods of Polyacrylamide Mix." National Conference on Tools for Urban Water Resource Management and Protection, Chicago, pp. 278, February 7−10, 2000.

Roa, A., "Are there Safety Concerns or Environmental Concerns with PAM?" Dane County Land Conservation Department, 1997.

Sojka, R.E. and Lentz, R.D., "A PAM Primer: A brief history of PAM and PAM related issues." Kimberly, ID: USDA−ARS Northwest Irrigation and Soils Research Lab, 1996. http://kimberly.ars.usda.gov/pamprim.ssi

Wirtz, J, R., "The Pros and Cons of the Use of Anionic Polyacrylamides to Control Erosion and Sedimentation in the Lake Mendota Priority Watershed". University of Wisconsin−Madison, MS Thesis, 2000.

WisDOT's Product Acceptability List (PAL). State DOT web site: *http://www.dot.wisconsin.gov/business/engrserv/pal.htm* Questions regarding product approvals may be sent to: New Products Engineer, WisDOT, Technology Advancement, 3502 Kinsman Blvd., Madison, WI 53704.

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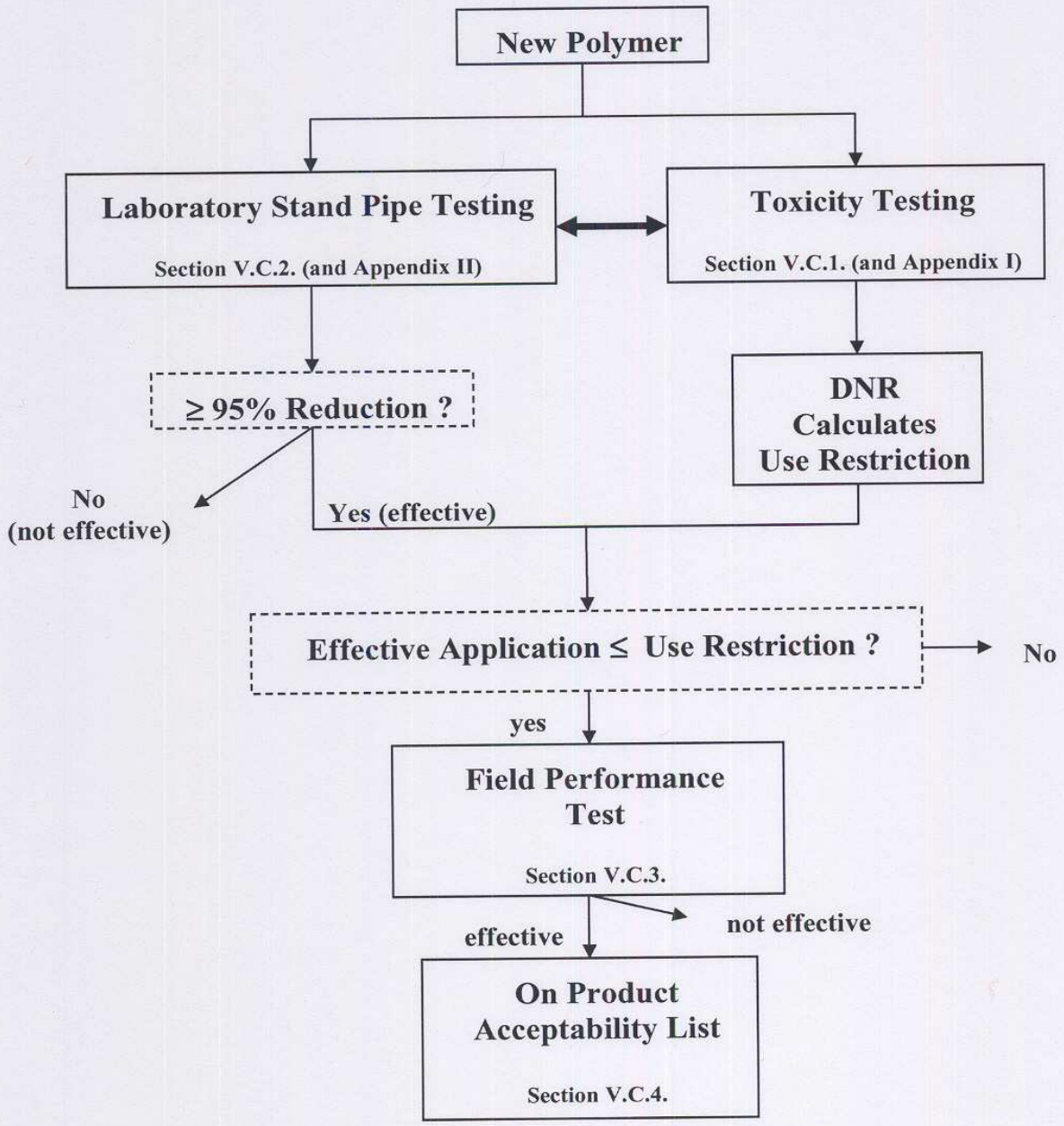
FIGURE I

POLYMER APPROVAL PROCESS



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APPENDIX I

REQUIRED TOXICITY INFORMATION FOR WDNR REVIEW

Toxicity information shall be reviewed by the WDNR and will be used to generate a written product use restriction for the polymer. With Chapter 1.7 of the *Whole Effluent Toxicity Program Guidance Document* (Fleming et. al., 2000) as a basis, the following toxicological information/data is required:

a. Manufacturer of the polymer.

b. Chemical name of the polymer.

c. Active Ingredient(s) (if not proprietary information).

d. Chemical Abstracts Service (CAS) #(s) of the polymer and/or active ingredients.

e. Material Safety Data Sheet (MSDS) and/or official toxicity test results listing available aquatic life toxicity data for the WHOLE PRODUCT. Toxicity data for active ingredients is not acceptable for use in calculating a use restriction. The following types of data is acceptable:

Species	Endpoint of Concern
Ceriodaphnia dubia (Cladoceran)	48−hour LC_{50} or EC_{50}/IC_{25}
Daphnia magna (Cladoceran)	48−hour LC_{50} or EC_{50}/IC_{25}
Lepomis macrochirus (Bluegill Sunfish)	96−hour LC_{50} or EC_{50}/IC_{25}
Pimephales promelas (Fathead Minnow)	96−hour LC_{50} or EC_{50}/IC_{25}
Oncorhynchus mykiss (Rainbow Trout)	96−hour LC_{50} or EC_{50}/IC_{25}

LC_{50} = the estimated concentration of polymer that would cause 50% mortality to the test population following the given time period

EC_{50} = the estimated concentration of polymer that would cause a given effect in 50% of the test population following a given time period

IC_{25} = the estimated concentration of polymer that would cause a 25% reduction in some biological measurement of the test population following a given time period

NOTE: To calculate a use restriction it is necessary to have data from at least one of the cladoceran species and at least one of the fish species (according to s. NR 106.10 (1)).

a. Complete listing of toxicity test conditions. Examples to follow include Tables 11 – 14 in Weber (1993).

b. Standardized test methodology (name of a specific method & its reference may be listed for this, such as "Acute Toxicity Test Procedures for *Daphnia magna*" in Weber (1993). If a modification to a standardized method was used, provide the reference of the specific method along with a specific listing of and reasons for the modifications).

c. Any noted observations from the toxicity tests.

Toxicity test results shall be submitted to: Water Quality Standards Section, WDNR, 101 South Webster Street, P.O. Box 7921, Madison, WI 53707, as one prequalification for field testing.

References:

Weber, C. 1993. *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, 4th Edition*. Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH. EPA/600/4−90/027F.

Fleming, K., S. Geis, E. Korthals, R. Masnado, G. Searle. 2000. *Whole Effluent Toxicity Program Guidance Document, Revision #3*. Wisconsin Department of Natural Resources, Chapter 1.7.

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APPENDIX II

LABORATORY STANDPIPE TEST METHODOLOGY

1. Place 40 grams of oven dried "soil" in 2 liters of distilled water within a 2 liter graduated cylinder with stopper. The 40 grams of "soil" represents a "realistic" runoff suspended solids load of 20,000 mg/L (20,000 mg/L x 2 L) according to data collected from commercial and residential construction sites (Owens, et. al. 2000). Repeat a minimum of four times so that there are a minimum of five replicates. The "soil" used in the standpipe test may be characterized by one of the following three options:

   Clays A clay "soil" is characterized as having greater than 20% of its particles < 2 µm in size. This option is appropriate for those seeking approval* of a polymer for use in any soil condition (clay, silt, or other).

   Silts A silt "soil" is characterized as having less than 20% of its particles < 2 µm in size AND greater than 20% of its particles 2−25 µm in size. This option is appropriate for those seeking approval* of a polymer for use only in silt soils. The 2−25 µm size is representative of fine to medium silt soils.

   Site−Specific Use of a site−specific "soil" provides an alternative for those seeking approval* of a polymer that may be customized for optimum performance (in both terms of suspended sediment removal and amount of polymer used) at a particular site. The results of a mechanical soil analysis characterizing the site soil sample particle size composition must be provided. The results of this analysis should be submitted with the results of the standpipe test entered on the "Standpipe Test Data Sheet." This option is provided since each site will have at least slight differences, if not significant differences, in soil chemical and physical characteristics. These differences may influence the effectiveness of any given polymer.

   Indicate which "soil" type is used in the standpipe test on the data sheet under "√ Soil Type Used."

   * Note that final approval of a polymer is granted only after it is demonstrated through both the standpipe and field tests that the polymer is effective and can be effectively applied.

2. Mix the solutions by completely inverting each graduated cylinder 3 times.

3. Add polymer mixture to each graduated cylinder. The volume and concentration of polymer added is the manufacturer's or supplier's choice, but must include a set volume and a gradient of "low" to "high" concentrations. The volume and each polymer concentration must be recorded on the data sheet. The purpose is to determine the lowest polymer mixture concentration needed to achieve effective removal of suspended solids. Ultimately the least amount of polymer mixture needed to achieve optimal performance should be used in the field.

   A minimum gradient of five polymer mixture concentrations is used to achieve the above stated purpose. The purpose of the five concentration gradient is to attempt to pinpoint the concentration that achieves optimal removal of suspended solids (i.e. least amount of polymer mixture required to remove a minimum of 95% of the suspended solids). This gradient should be sufficiently wide to show a range of effectiveness in removing suspended solids (with at least one, but preferably more, meeting the 95% removal level). A second goal of using a minimum of five concentrations is to avoid the occurrence of false negative outcomes in the polymer approval process. By having more concentrations across a gradient it is more likely to find truly effective concentrations that are less than the use restriction value. As is graphically depicted in Figure I, a polymer mixture will not be approved for field testing, and thus for inclusion on the PAL if its effective concentration (as determined in this laboratory stand pipe test) is greater than the use restriction value.

4. Mix the solutions by completely inverting each graduated cylinder 3 times.

5. Let the solution in each graduated cylinder settle for 5 minutes.

6. Determine the percent suspended solids reduction in each graduated cylinder as follows:

   a. Heat/dry one evaporating or drying dish at 103 – 105°C for 1 hour for each graduated cylinder. Store the dishes in a desiccator until needed (steps b).

   b. Weigh a dish out to at least one, and preferably more decimal points. Record this weight on the data sheet.

   c. Collect 20 ml from within one of the graduated cylinders at the 1 liter mark and place in a preweighed evaporating or drying dish (from step a). Repeat steps b and c for each of the other graduated cylinders.

   d. Evaporate and dry each of the 20 ml samples from step b at 98 °C for at least 1 hour.

   e. Cool each dish with sample in a desiccator to balance temperature

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f. Weigh each dish with sample. Record this weight on the data sheet.

g. Subtract the weight of the dried dish (from step b) to determine the weight of the solids from the sample. Record this weight on the data sheet.

* These methods follow, with slight modification, those of Standard Methods 2540 B. (1989).

7. The polymer passes this effectiveness test if it achieves ≥ 95 % reduction of suspended solids. Thus, **≥ 95 % reduction is achieved if the weight of the solids from the sample is ≤ 0.2 mg.**

$$\frac{2000\text{ ml}^{1}}{1000\text{ mg/L}^{2}} = \frac{20\text{ ml}^{3}}{X^{4}} \quad ; \qquad X = 10\text{ mg/L}$$

[1] = volume of solution in the cylinder

[2] = suspended solids concentration in the cylinder at ≥ 95 % reduction

[3] = volume of sample taken from 1 L mark of the cylinder

[4] = sample solids concentration needed to achieve ≥ 95 % reduction

$$\frac{10\text{ mg}}{\text{L}} \times \frac{\text{L}}{1000\text{ ml}} \times \frac{20\text{ ml}}{} = \mathbf{0.2\text{ mg}}$$

8. A photocopy of the completed data sheet should be sent to the following address for WisDOT review: New Products Engineer, WisDOT, Technology Advancement, 3502 Kinsman Blvd., Madison, WI 53704.

References:

Owens, D.W., P. Jopke, D.W. Hall, J. Balousek, and A. Roa. 2000. *Soil erosion from two small construction sites, Dane County, Wisconsin*. U.S. Geological Survey Fact Sheet FS−109−00, 4 p.

Standard Methods Committee. 1989. 2540 Solids. In L.S. Clesceri, A. E. Greenberg, and R.R. Trussell, eds., *Standard Methods for the Examination of Water and Wastewater, 17th Edition*. American Public Health Association, Washington, DC. pp. 2−72 − 2−73.

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STANDPIPE TEST DATA SHEET

Date(s): _____

Testing Laboratory: _____

Analyst(s) Initials: _____

Polymer Name: _____

Manufacturer Name: _____

Volume of Polymer Mixture Used: _____

√ **Soil Type Used:** ☐ **Clay** ☐ **Silt** ☐ **Site–Specific Soil**
(mechanical analysis results enclosed)

Polymer Mixture Concentration (mg/L or % solution)	Weight of Evaporating/Drying Dish		Final Weight of Solids Sample
	Pre	With Sample	

Which polymer mixture concentration(s) achieved effective (≥ 95%) reduction of suspended solids (i.e. final weight ≤ 0.2 mg solids)?

_____ _____ _____ _____

Notes/Comments:

Please send a photocopy of this completed data sheet to:

New Products Engineer, WisDOT, Technology Advancement, 3502 Kinsman B

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Mulching For Construction Sites

(1058)

Wisconsin Department of Natural Resources

Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used.

I. Definition

Mulching is the application of organic material to the soil surface to protect it from raindrop impact and overland flow. Mulch covers the soil and absorbs the erosive impact of rainfall and reduces the flow velocity of runoff.

II. Purpose

This practice may be used to:

- Reduce soil erosion
- Aid in seed germination and establishment of plant cover
- Conserve soil moisture

III. Conditions Where Practice Applies

This practice may be applied on exposed soils as a temporary control where soil grading or landscaping has taken place or in conjunction with temporary or permanent seeding. Mulching is generally not appropriate in areas of concentrated flow.

IV. Federal, State, and Local Laws

Users of this standard shall comply with applicable federal, state and local laws, rules, regulations or permit requirements governing mulching. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Site Preparation:

Soil surface shall be prepared prior to the application of mulch in order to achieve the desired purpose and to ensure optimum contact between soil and mulch. All areas to be mulched shall be reasonably free of rills and gullies.

B. Materials:

Mulch shall consist of natural biodegradable material such as plant residue (including but not limited to straw, hay, wood chips, bark and wood cellulose fiber), or other equivalent materials of sufficient dimension (depth or thickness) and durability to achieve the intended effect for the required time period.

Mulch shall be environmentally harmless to wildlife and plants. Materials such as gravel, plastic, fabric, sawdust, municipal solid waste, *solid waste byproducts*[1], shredded paper, and non−biodegradable products shall not be used.

Mulch shall be free of diseased plant residue (i.e. oak wilt), *noxious weed* seeds, harmful chemical residues, heavy metals, hydrocarbons and other known environmental toxicants.

Marsh hay shall not be used as mulch in lowland areas but may be used on upland sites to prevent the spread of invasive, non−native species (i.e. reed canary grass) commonly found in marsh hay.

Straw and hay mulch that will be crimped shall have a minimum fiber length of 6 inches.

Wood chips or wood bark shall only be used for sites that are not seeded.

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C. Application Rate:

1. Mulch shall cover a minimum of 80% of the soil surface for unseeded areas. For seeded areas, mulch shall be placed loose and open enough to allow some sunlight to penetrate and air to circulate but still cover a minimum of 70% of the soil surface.

2. Mulch shall be applied at a uniform rate of 1½ to 2 tons per acre for sites that are seeded, and 2 to 3 tons per acre for sites that are not seeded. This application results in a layer of ½ to 1½ inches thick for seeded sites, and 1½ to 3 inches thick for sites not seeded.

3. Wood chips or wood bark shall be applied at a rate of 6 to 9 tons per acre to achieve a minimum of 80% ground cover. This application should result in a layer of wood chips or wood bark ½ to 1½ inches thick.

D. Mulch Anchoring Methods

Anchoring of mulch shall be based on the type of mulch applied, site conditions, and accomplished by one of the following techniques:

1. Crimping

Immediately after spreading, the mulch shall be anchored by a mulch crimper or equivalent device consisting of a series of dull flat discs with notched edges spaced approximately 8 inches apart. The mulch shall be impressed in the soil to a depth of 1 to 3 inches.

2. Polypropylene Plastic, or Biodegradable Netting

Apply plastic netting over mulch application and staple according to manufacturer's recommendations.

3. Tackifier

Tackifier shall be sprayed in conjunction with mulch or immediately after the mulch has been placed. Tackifiers must be selected from those that meet the WisDOT Erosion Control Product Acceptability List (PAL). Asphalt based products shall not be applied.

The tackifiers shall be applied at the following minimum application rates per acre:

a. Latex−Base: mix 15 gallons of adhesive (or the manufacturer's recommended rate which ever is greater) and a minimum of 250 pounds of recycled newsprint (pulp) as a tracer with 375 gallons of water.

b. Guar Gum: mix 50 pounds of dry adhesive (or the manufacturer's recommended rate which ever is greater) and a minimum of 250 pounds of recycled newsprint (pulp) as tracer with 1,300 gallons of water.

c. Other Tackifiers: (Hydrophilic Polymers) mix 100 pounds of dry adhesive (or the manufacturer's recommended rate which ever is greater) and a minimum of 250 pounds of recycled newsprint (pulp) as a tracer with 1,300 gallons of water.

VI. Considerations

A. Wood products typically absorb available soil nitrogen as they degrade, thus making it unavailable for seed.

B. The use of mulch behind curb and gutter may not be desirable unless anchored by netting, because air turbulence from nearby traffic can displace the mulch. Consider the use of erosion mat or sod as an alternative.

C. In areas where lawn type turf will be established, the use of tackifiers is the preferred anchoring method. Crimping will tend to leave an uneven surface and plastic netting can become displaced and entangled in mowing equipment.

D. A heavier application of mulch may be desired to prevent seedlings from being damaged by frost.

E. It may be beneficial to apply polyacrylimide in addition to mulch. Refer to WDNR Conservation Practice Standard (1050) Erosion Control Land Application of Anionic Polyacrylamide for information about the advantages and proper use of polymers.

F. Concentrated flows above the site where mulch is applied should be diverted.

G. Mulch should be placed within 24 hours of seeding.

H. Mulching operations should not be performed during periods of excessively high winds that would preclude the proper placement of mulch.

I. Materials such as gravel may be effective for erosion control but are not considered mulches.

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VII. Plans and Specifications

A. Plans and specifications for mulching shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Type of mulch used
2. Application rate
3. Timing of application
4. Method of anchoring

B. All plans, standard detail drawings, or specifications shall include schedules for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

Mulch shall, at a minimum, be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24 hour period.

Mulch that is displaced shall be reapplied and properly anchored. Maintenance shall be completed as soon as possible with consideration to site conditions.

IX. References

WisDOT's Erosion Control Product Acceptability List (PAL) can be found on the WisDOT web site:

http://www.dot.wisconsin.gov/business/engrserv/pal.htm Printed copies are no longer being distributed.

X. Definitions

Noxious weed (V.B): Any weed a governing body declares to be noxious within its respective boundaries. The State of Wisconsin list of noxious weeds can be found in s. 66.0407, Stats.

Solid Waste Byproducts (V.B): Includes industrial, commercial, residential, and agricultural wastes that have been processed, incinerated, or composted and still contain inorganic wastes such as glass and metals and organic wastes including plastics, textiles, rubber, leather, and other miscellaneous organic wastes which may be toxic or hazardous in nature.

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Non–Channel Erosion Mat

(1052)

Wisconsin Department of Natural Resources
Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used.

I. Definition

A protective soil cover made of straw, wood, coconut fiber or other suitable plant residue, or plastic fibers formed into a mat, usually with a plastic or biodegradable mesh on one or both sides. Erosion mats are rolled products available in many varieties and combinations of material and with varying life spans.

II. Purpose

The purpose of this practice is to protect the soil surface from the erosive effect of rainfall and prevent *sheet erosion* [1] during the establishment of grass or other vegetation, and to reduce soil moisture loss due to evaporation. This practice applies to both *Erosion Control Revegetative Mats (ECRM*) and *Turf−Reinforcement Mats* (*TRM*).

III. Conditions Where Practice Applies

This standard applies to erosion mat selection for use on erodible slopes.

This standard is not for channel erosion; for channel applications reference WDNR Conservation Practice Standard (1053) Channel Erosion Mat.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of erosion mat. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum allowable standards for design, installation and performance requirements. Only Wisconsin Department of Transportation (WisDOT) Erosion Control Product Acceptability List (PAL) approved mats will be accepted for use in this standard.

Slope and slope length shall be taken into consideration. This information can be found in the Slope Erosion Control Matrix located in the PAL.

To differentiate applications Erosion mats are organized into three Classes of mats, which are further broken down into various Types.

A. Class I: A short−term duration (minimum of 6 months), light duty, organic mat with photodegradable plastic or biodegradable netting.

   1. Type A – Use on erodible slopes 2.5:1 or flatter.

   2. Type B – Double netted product for use on erodible slopes 2:1 or flatter.

B. Class I, Urban: A short−term duration (minimum of 6 months), light duty, organic erosion control mat for areas where mowing may be accomplished within two weeks after installation.

   1. Urban, Type A – Use on erodible soils with slopes 4:1 or flatter.

   2. Urban, Type B – A double netted product for use on slopes 2.5:1 or flatter.

C. Class II: A long−term duration (three years or greater), organic erosion control revegetative mat.

   1. Type A – Jute fiber only for use on slopes 2:1 or flatter for sod reinforcement.

   2. Type B – For use on slopes 2:1 or greater made with plastic or biodegradable net.

   3. Type C – A woven mat of 100% organic fibers for use on slopes 2:1 or flatter and in environmentally and biologically sensitive areas where plastic netting is inappropriate.

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D. Class III: A permanent 100% synthetic ECRM or TRM. Either a soil stabilizer Type A or Class I, Type A or B erosion mat must be placed over the soil filled TRM.

1. Type A – An ECRM for use on slopes 2:1 or flatter.
2. Type B or C – A TRM for use on slopes 2:1 or flatter.
3. Type D – A TRM for use on slopes 1:1 or flatter.

E. Material Selection

1. For mats that utilize netting, the netting shall be bonded to the parent material to prevent separation of the net for the life of the product.
2. For urban class mats the following material requirements shall be adhered to:
   a. Only 100% organic biodegradable netted products are allowed, including parent material, stitching, and netting.
   b. The netting shall be stitched with biodegradable thread/yarn to prevent separation of the net from parent material.
   c. All materials and additive components used to manufacture the anchoring devices shall be completely biodegradable as determined by ASTM D 5338.
   d. Mats with photodegradable netting shall not be installed after September 1st.

F. Installation

1. ECRMs shall be installed after all topsoiling, fertilizing, liming and seeding is complete.
2. The mat shall be in firm and intimate contact with the soil. It shall be installed and anchored per the manufacturer's recommendation.
3. TRM shall be installed in conjunction with the topsoiling operation and shall be followed by ECRM installation.
4. At time of installation, document the manufacturer and mat type by retention of material labels and manufacturer's installation instructions. Retain this documentation until the site has been stabilized.

VI. Considerations

A. Urban mats may be used in lieu of sod.

B. Documentation of materials used, monitoring logs, project diary and weekly inspection forms, including erosion and stormwater management plans, should be turned over to the authority charged with long term maintenance of the site.

VII. Plans and Specifications

A. Plans and specifications for installing erosion mat shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Location of erosion mat
2. Installation Sequence
3. Material specification conforming to standard

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Erosion mat shall at a minimum be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24−hour period.

B. If there are signs of rilling under the mat, install more staples or more frequent anchoring trenches. If rilling becomes severe enough to prevent establishment of vegetation, remove the section of mat where the damage has occurred. Fill the eroded area with topsoil, compact, reseed and replace the section of mat, trenching and overlapping ends per manufacturer's recommendations. Additional staking is recommended near where rilling was filled.

C. If the reinforcing plastic netting has separated from the mat, remove the plastic and if necessary replace the mat.

D. Maintenance shall be completed as soon as possible with consideration to site conditions.

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IX. References

WisDOT "Erosion Control Product Acceptability List" is available online at *http://www.dot.wisconsin.gov/business/engrserv/pal.htm* Printed copies are no longer distributed.

X. Definitions

Sheet and Rill Erosion (II): Sheet and rill erosion is the removal of soil by the action of rainfall and shallow overland runoff. It is the first stage in water erosion. As flow becomes more concentrated rills occur. As soil detachment continues or flow increases, rills will become wider and deeper forming gullies.

Erosion Control Revegetative Mats (ECRM) (II): Erosion control revegetative mats are designed to be placed on the soil surface.

Turf−Reinforcement Mats (TRM) (II): Turf−reinforcement mats are permanent devices constructed from various types of synthetic materials and buried below the surface to help stabilize the soil. TRMs must be used in conjunction with an ECRM or an approved Type A soil stabilizer.

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Sediment Basin

(1064)

Wisconsin Department of Natural Resources

Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used.

I. Definition

A sediment control device constructed with an engineered outlet, formed by excavation or embankment to intercept sediment−laden runoff and retain the sediment.

II. Purposes

Detain sediment−laden runoff from disturbed areas for sufficient time to allow the majority of the sediment to settle out.

III. Conditions Where Practice Applies

Sediment basins are utilized in areas of concentrated flow or points of discharge during construction activities. Sediment basins shall be constructed at locations accessible for clean out. Site conditions must allow for runoff to be directed into the basin.

Sediment basins are designed to be in place until the contributory drainage area has been *stabilized*[1]. Sediment basins are temporary and serve drainage areas up to 100 acres however other conservation practices are often more economical for smaller drainage areas. For drainage areas smaller than 5 acres sediment traps or ditch checks may be applicable; for design criteria refer to WDNR conservation Practice Standard Sediment Trap (1063) or Ditch Check (1062).

Design to WDNR Conservation Practice Standard Wet Detention Basin (1001) when a permanent stormwater basin is required.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of sediment basins. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements. Sediment basins meeting these design criteria are deemed 80% effective by design in trapping sediment.

A. Timing – Sediment basins shall be constructed prior to disturbance of up−slope areas and placed so they function during all phases of construction. Sediment basins shall be placed in locations where runoff from disturbed areas can be diverted into the basin.

B. Sizing Criteria – Properly sized sediment basins are more effective at trapping fine−grained particles than sediment traps. Specific trapping efficiency varies based on the surface area and the particle size distribution of the sediment entering the device. See Figure 1 for clarification of terms. Attachment 1 includes a sample design problem.

Treatment Surface Area – The surface area of the sediment basin measured at the invert of the lowest outlet. The treatment surface area shall be sized based on the texture of the soil entering the device and the peak outflow during the 1−year, 24−hour design storm using Equation 1:

$$\mathbf{S_a} = 1.2 * (q_{out} / v_s)$$

Where:

$\mathbf{S_a}$ = Treatment surface area measured at the invert of the lowest outlet of sediment basin (square feet)

$\mathbf{q_{out}}$ = Peak outflow (cubic feet / second) during the 1−year, 24−hour design storm for the principal outlet

$\mathbf{v_s}$ = Particle settling velocity (feet/second)

1.2 = EPA recommended safety factor

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Particle settling velocities (*V*s) shall be based on representative soil class as follows:

a. Soil Class 1: $v_s = 1.2*10^{-3}$ ft/sec

b. Soil Class 2: $v_s = 7.3*10^{-5}$ ft/sec

c. Soil Class 3: $v_s = 1.2*10^{-5}$ ft/sec

Note: Particle settling velocities calculated assuming a specific gravity of 2.65 and a water temperature of 68 degrees Fahrenheit.

Soil Class 1 includes particles greater than 20 microns generally corresponding to sand, loamy sand, and sandy loam.

Soil Class 2 includes particles between 5 and 20 microns generally corresponding to loam, silt, and silt loam aggregates as transported in runoff.

Soil Class 3 includes particles between 2 and 5 microns generally corresponding to clay loam, silty clay, and clay aggregates as transported in runoff.

The representative soil class shall be selected based on the dominant textural class of the soil entering the device.

The treatment surface area of sediment basins can be reduced when used in conjunction with water applied polymers. When employing polymers, size the treatment surface area for controlling fine soils (Class 3) using the settling velocity for medium soils (Class 2). When designing for medium sized soils (Class 2) use the settling velocity for coarse soils (Class 1). See WDNR Conservation Practice Standard Sediment Control Water Application of Polymers (1051) for criteria governing the proper use and selection of polymers.

Depth below Treatment Surface Area – The depth below the treatment surface area as measured from the invert of the lowest outlet of the sediment basin shall be a minimum of 5 feet deep (2 feet for sediment storage plus 3 feet to protect against scour/ resuspension) and a maximum of 10 feet deep to limit the potential for thermal stratification.

Due to side slope requirements and safety shelf considerations it maybe difficult to maintain 5 feet of depth for the entire treatment surface area. Therefore, 50% of the total treatment surface area shall be a minimum of 5 feet deep. For basins less than 5,000 square feet, maximize the area of 5 feet depth.

Interior side slopes below the lowest invert shall be 2:1 (horizontal: vertical) or flatter to maintain soil stability.

While a permanent pool of water below the lowest invert may form, it is not required to be maintained through irrigation or installation of a liner system.

Active Storage Volume – The volume above the treatment surface area shall be calculated using one of the following methods:

a. The method outlined in TR−55 for determining the storage volume for detention basins. This can be accomplished by using Figure 2 where:

q_o = Peak outflow (cubic feet / second) during the 1−year, 24−hour design storm for the principal outlet calculated using Equation 1 (see section V.B.1).

q_i = Calculated peak inflow or runoff rate (cubic feet / second) during the 1−year, 24−hour design storm.

Vr = Calculated volume of runoff from the 1−year 24−hour design storm for the entire contributory area with the maximum area of disturbance characterized as bare soil.

Vs = Is the required active storage volume determined using Figure 2.

b. The active storage volume may be calculated based on routing the 1−year, 24−hour storm provided the principal outlet requirements stipulated in section V.D.2 are maintained. This method will require the use of a model.

Note: Both these methods require iterative calculations.

Shape – The length to width ratio of the flow path shall be maximized with a goal of 3:1 or greater. The flow path is considered the general direction of water flow within the basin including the treatment surface area and any forebay.

C. Embankments – Earthen embankments shall be designed to address potential risk and structural integrity issues such as seepage and saturation. All constructed earthen embankments shall meet the following criteria.

1. The base of the embankment shall be stripped of all vegetation, stumps, topsoil and other organic matter.

2. Side slopes shall be 3:1 or flatter. The minimum embankment top width shall be adequate to provide structural stability. Where applicable the top width shall be wide enough to provide maintenance access.

3. There shall be a core trench or key−way along the embankment.

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Any pipes extending through the embankment shall be bedded and backfilled with equivalent soils used to construct the embankment. The bedding and backfill shall be compacted in lifts and to the same standard as the original embankment. Excavation through a completed embankment shall have a minimum side slope of 1:1 or flatter.

Measures shall be taken to minimize seepage along any conduit buried in the embankment.

D. Outlet – Sediment basins shall have both a principal outlet and an overflow spillway.

1. Timing – Outlets must be constructed in conjunction with the remainder of the basin and must be constructed prior to the basin receiving runoff. Sediment basins are ineffective until the outlet is constructed.

2. Principal Water Quality Outlet – The principal water quality outlet shall be designed to pass the 1−year 24−hour storm without use of the overflow spillway or other outlet structures. The maximum outflow (q_o) from the principal water quality outlet shall be less than or equal to the q_o used in Equation 1 (V.B.1). If the sediment basin is to serve as a permanent stormwater basin, the principal outlet structure can be modified (i.e. removable plates) to meet flow requirements encountered during and after construction; separate outlet structures do not need to be constructed.

   Note: Local ordinances may require control of larger storm events such as the 2−year 24 hour storms. In these cases, additional or compound outlets maybe required.

3. Overflow (Emergency) Spillway – An overflow spillway shall be provided consisting of an open channel constructed adjacent to the embankment and built over a stabilized area. The spillway shall be designed to carry the peak rate of runoff expected from a 10−year, 24−hour design storm or one commensurate with the degree of hazard, less any reduction due to flow in the principal outlet. The top of the embankment shall be at least one foot above the design high water level and a minimum of 1 foot above the invert of the overflow spillway. The overflow spillway shall be protected from erosion. Flow from the overflow spillway shall be directed away from the embankment.

4. Outlet Protection – All outlet designs shall incorporate preventive measures for ice damage, trash accumulation, and erosion at the outfall. For orifices less than 8−inches in diameter, or equivalent, additional measures to prevent clogging are required.

E. Inlet Protection – Inlets shall be designed to prevent scour and reduce velocities during peak flows. Possible design options include flow diffusion, plunge pools, directional berms, baffles, or other energy dissipation structures.

F. Location – Temporary sediment basins should be located to provide access for cleanout and disposal of trapped sediment.

G. Removal – Temporary sediment basins shall be removed after the contributing drainage area has been stabilized. Complete final grading and restoration according to the site plans. If standing water needs to be removed it shall be done in accordance with WDNR Conservation Practice Standard Dewatering (1061).

VI. Considerations

A. When constructing a sediment basin that will also serve as the long−term stormwater detention pond, build the sediment basin to the larger of the two sizes required either for stormwater control or erosion control. In addition, when sizing the outlet structure first design the outlet for the long−term stormwater management requirements then check to satisfy the flow requirements for sediment control during construction. If additional flow restriction is needed consider use of a temporary restriction plates or other measures to avoid having to construct separate outlet structures for the sediment basin and stormwater basin.

B. Over−excavation beyond the required depth in the sediment storage area of the sediment basin may allow for less frequent maintenance. Addition of other measures in the contributing drainage area may reduce sediment accumulation and associated maintenance requirements.

C. The use of a sediment forebay can extend the useful life of the main sediment storage area by trapping the majority of sediment in the forebay area. Separation of the forebay from the rest of the basin requires construction of a submerged shelf (if wet) or a stone or stabilized earthen embankment. The forebay should have a surface area equal to at least 12% of the total basin area.

D. In addition to soil stability issues, interior slopes of sediment basins should be selected based on safety issues commensurate with the degree of hazard.

VII. Plans and Specifications

A. Plans and specifications for installing sediment basins shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

1. Location of sediment basin

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2. Schedules and sequence of installation and removal
3. Standard drawings and installation details
4. Control structure detail and layout
5. Sizing of sediment storage area
6. Maintenance requirements

B. All plans, standard detail drawings, or specifications shall include sequence for installation, inspection, and maintenance requirements. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Sediment basins shall, at a minimum, be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24−hour period.

B. Sediment shall be removed to maintain the three foot depth of the treatment surface area as measured from the invert of the principal outlet. Sediment may need to be removed more frequently.

C. If the outlet becomes clogged it shall be cleaned to restore flow capacity.

D. Provisions for proper disposal of the sediment removed shall be made.

E. Maintenance shall be completed as soon as possible with consideration to site conditions.

IX. References

Chapter NR 333, Dam and Design Construction.

Hann, Barfield, and Hayes. Design Hydrology and Sedimentology for Small Catchments. Academic Press Inc., 1994.

Robert E. Pitt, Small Storm Hydrology.

US Bureau of Reclamation, Design of Small Dams. http://www.usbr.gov/pmts/hydraulics_lab/pubs/index.cfm.

USDA, Natural Resources Conservation Service, Ponds – Planning, Design, Construction. Agriculture Handbook No. 590, Revised September 1997.

WDNR Conservation Practice Standard 1001 Wet Detention Basin.

X. Definitions

Active Storage Volume (V.B.3) – Is measured from the invert of the lowest outlet to the invert of the emergency spillway.

Stabilized (III) – Means protecting exposed soil from erosion.

Treatment Surface Area (V.B.1) – Is the surface area of the sediment basin measured at the invert of the lowest outlet.

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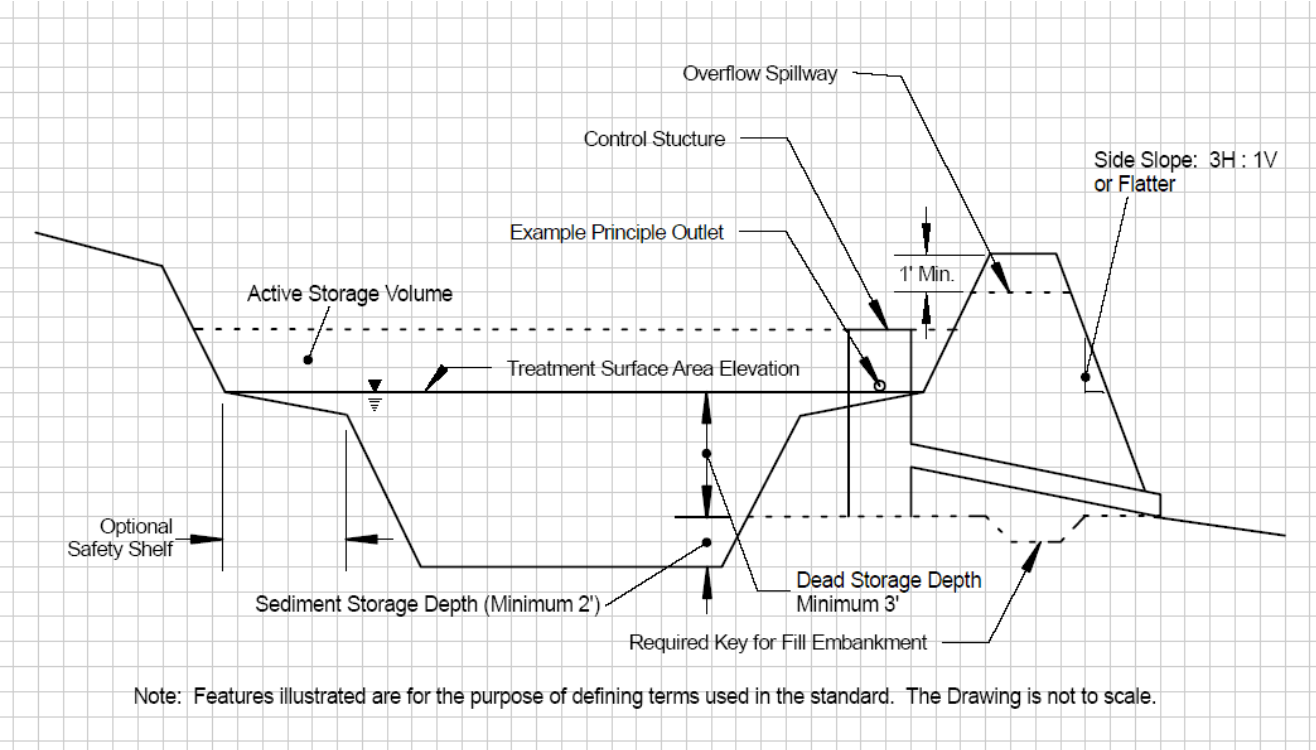
Figure 1

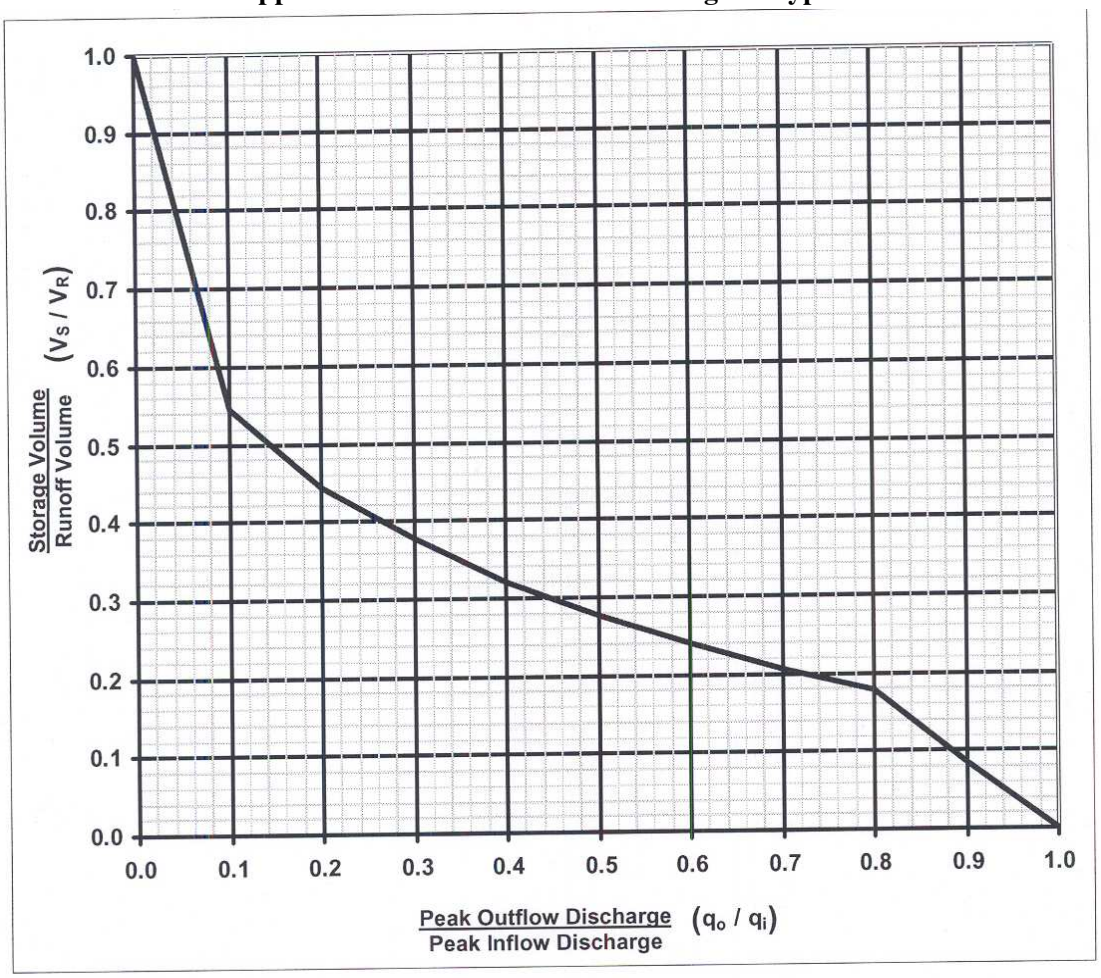
Clarification of Sediment Basin Terminology



Removed by Register March 2007 No. 615. For current adm. code see: http://docs.legis.wisconsin.gov/code/admin_code.

Figure 2

Approximate Detention Basin Routing for Type II Storms



Source: Technical Release 55, United States Department of Agriculture, Natural Resources Conservation Service. Washington D.C. 1988.

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Rainfall Quantities:

Table 1 provides a summary of the 1−year, 24−hour rainfall totals using NRCS mandated TP−40 which has not been updated since 1961. Table 2 provides a summary of more current data from the Rainfall Frequency Atlas of the Midwest published in 1992. Local requirements may dictate the use of one dataset over the other.

Table 1
Rainfall for Wisconsin Counties for a 1−year, 24−hour Rainfall[1]

Inches of Rainfall	County
2.1 in.	Door, Florence, Forest, Kewaunee, Marinette, Oconto, Vilas
2.2 in.	Ashland, Bayfield, Brown, Calumet, Douglas, Iron, Langlade, Lincoln, Manitowoc, Menominee, Oneida, Outagamie, Price, Shawano, Sheboygan
2.3 in.	Barron, Burnett, Dodge, Fond du Lac, Green Lake, Marathon, Milwaukee, Ozaukee, Portage, Racine, Rusk, Sawyer, Taylor, Washburn, Washington, Waukesha, Waupaca, Waushara, Winnebago, Wood
2.4 in.	Adams, Chippewa, Clark, Columbia, Dane, Dunn, Eau Claire, Jackson, Jefferson, Juneau, Kenosha, Marquette, Pepin, Pierce, Polk, Rock, St. Croix, Walworth
2.5 in.	Buffalo, Green, Iowa, La Crosse, Monroe, Richland, Sauk, Trempealeau, Vernon
2.6 in.	Crawford, Grant, Lafayette

[1]TP − 40 − Rainfall Frequency Atlas of the United States, U.S. Department of Commerce Weather Bureau.

Table 2
Rainfall for Wisconsin Counties for a 1−year, 24−hour Rainfall[2]

Zone	Inches of Rainfall	County
1	2.22	Douglas, Bayfield, Burnett, Washburn, Sawyer, Polk, Barron, Rusk, Chippewa, Eau Claire
2	2.21	Ashland, Iron, Vilas, Price, Oneida, Taylor, Lincoln, Clark, Marathon
3	1.90	Florence, Forest, Marinette, Langlade, Menominee, Oconto, Door, Shawano
4	2.23	St. Croix, Dunn, Pierce, Pepin, Buffalo, Trempealeau, Jackson, La Crosse, Monroe
5	2.15	Wood, Portage, Waupaca, Juneau, Adams, Waushara, Marquette, Green Lake
6	1.96	Outagamie, Brown, Kewaunee, Winnebago, Calumet, Manitowoc, Fond Du Lac, Sheboygan
7	2.25	Vernon, Crawford, Richland, Sauk, Grant, Iowa, Lafayette
8	2.25	Columbia, Dodge, Dane, Jefferson, Green, Rock
9	2.18	Ozaukee, Washington, Waukesha, Milwaukee, Walworth, Racine, Kenosha

[2] Bulletin 71: Rainfall Frequency Atlas of the Midwest, Midwest Climate Center and Illinois State Water Survey, 1992.

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Attachment 1

Sample Sediment Basin Design Problem

The proper sizing and design of a sediment basin will often require iterative calculations. The technical standard for sizing sediment basins was written to give the designer as much flexibility as possible in designing the basin while meeting water quality requirements. The governing equation relates the surface area of the sediment basin to the outflow and critical particle settling velocity. The larger the sediment basin outflow, the larger the surface area required to settle the particle. As the outflow is reduced, a smaller surface area is required however the required storage volume dictates how small a surface area can become through the storage depth or hydraulic head acting on the outlet.

The particle settling velocities are listed in the standard requiring the designer to either start with a desired outflow based on an outlet size or an estimated starting surface area. The sample equation below starts with an estimated surface area.

Sample Problem:

A 10 acre site is being developed into condos. Eight acres of the site are being disturbed while 2 acres of forest are remaining undisturbed. The dominate soils on the site are silt loam. The 1−year, 24−hour design storm is 2.25 inches.

Step 1: Calculate runoff volume and peak using TR−55 or approved method.

From TR−55 the curve number (CN) for the disturbed area is 86 and the CN for the forested area is 55 resulting in a composite CN of 80. Using TR−55, the runoff volume calculated for the 1−year 24−hour design storm is 0.7 inches (0.6 acre−feet for the entire 10−acre site). The time of concentration was calculated as 0.4 hours resulting in a peak flow of 6 cfs.

Step 2: Begin sizing sediment basin using Equation 1. The technical standard lists silt loam under particle class 2 with a settling velocity of $7.3*10^{-5}$ ft/sec. We are also going to assume a starting surface area of 0.25 acres (10,890 ft^2). An alternative approach is to assume an outflow velocity.

$SA = 1.2 * (q_{out} / v_s)$

Solve for q_{out}: $10{,}980\ ft^2 = 1.2 * (q_{out} / 7.3*10^{-5}\ ft/sec)$

$q_{out} = 0.67$ cfs

Step 3: Using Figure 2: Approximate Detention Basin Routing for Type II Storms determines the volume of storage (V_S) needed.

$q_{out} = 0.67$ cfs (calculated in Step 2)

$q_{in} = 6.0$ cfs (peak flow calculated using TR−55 in Step 1)

$V_R = 0.6$ acre−feet (volume of runoff calculated using TR−55 in Step 1)

$q_{out} / q_{in} = 0.67$ cfs / 6.0 cfs = 0.11. Using Figure 2 with a $q_{out} / q_{in} = 0.11$, the V_S/V_R is determined to be 0.54. Therefore the $V_S = 0.54 * 0.6$ acre−feet = 0.324 acre−feet (14,113 ft^3)

Step 4: Check configuration: Calculate maximum head on outlet using surface area and volume.

SA = 10,890 ft^2 and a V_S = 14,113 ft^3 we get a depth (H) of 1.29 feet = 14,113 ft^3 / 10,890 ft^2

Step 5: Size Outlet: Assuming an orifice type outlet calculate the size needed to meet the q_{out} calculated in Step 1 and the H calculated in Step 4.

Using the orifice equation: $q_{out} = C*A*(2gH)^{1/2}$ with C=0.6 (coefficient) , A = Area = ft^2, g = 32.2, and H = hydraulic head expressed in feet.

$q_{out} = 0.6*A*(2*32.2*H)^{1/2}$ so $0.66 = 0.6*A*(2*32.2*1.29)^{1/2}$ therefore A = .12 ft^2

An area of 0.12 ft^2 corresponds to an orifice outlet of 4.7 inches in diameter.

Step 6: Iteration: While the above solution works, the sediment basin has not been optimally sized and we have an orifice diameter that is not a standard pipe size. An iterative approach can be used to reduce the surface area of the sediment basin and obtain a more common orifice diameter. We can assume a 4−inch orifice since it is close to diameter calculated in Step 5 and we can start with the depth we calculated in Step 4. The iterations below each represent Steps 2 through 5.

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Iteration 1:

q_{out} = 0.43 (H) $^{1/2}$ = 0.43 (1.29) $^{1/2}$ = 0.48 cfs which is less than the 0.66 cfs calculated in Step 1. Therefore, we can go back to Step 1 and repeat the sizing procedure and downsize the sediment basin.

SA = 1.2 * (q_{out} / v_s) = 1.2 * (0.48 cfs / 7.3*10^{-5} ft/sec) = 7,890 ft^2

Using Figure 2:

q_{out} = 0.48 cfs

q_{in} = 6.0 cfs (peak flow calculated using TR−55 in Step 1)

V_R = 0.6 acre−feet (volume of runoff calculated using TR−55 in Step 1)

q_{out} / q_{in} = 0.48 cfs / 6.0 cfs = 0.08. Using Figure 2 with a q_{out} / q_{in} = 0.08, the V_S/V_R is determined to be 0.62. Therefore the V_S = 0.62 * 0.6 acre−feet = 0.372 acre−feet (16,204 ft^3)

SA = 7,890 ft^2 and a V_S = 16,204 ft^3 we get a depth (H) of 2.05 feet = 16,204 ft^3 / 7,890 ft^2

q_{out} = 0.43 (H) $^{1/2}$ = 0.43 (2.05) $^{1/2}$ = 0.61 cfs which is more than the 0.48 cfs we used so iterate.

Iteration 2:

SA = 1.2 * (q_{out} / v_s) = 1.2 * (0.61 cfs / 7.3*10^{-5} ft/sec) = 10,027 ft^2

Using Figure 2:

q_{out} = 0.61 cfs

q_{in} = 6.0 cfs (peak flow calculated using TR−55 in Step 1)

V_R = 0.6 acre−feet (volume of runoff calculated using TR−55 in Step 1)

q_{out} / q_{in} = 0.61 cfs / 6.0 cfs = 0.10 Using Figure 2 with a q_{out} / q_{in} = 0.10, the V_S/V_R is determined to be 0.54. Therefore the V_S = 0.54 * 0.6 acre−feet = 0.324 acre−feet (14,113 ft^3)

SA = 10,027 ft^2 and a V_S = 14,113 ft^3 we get a depth (H) of 1.41 feet = 14,113 ft^3 / 10,027 ft^2

q_{out} = 0.43 (H) $^{1/2}$ = 0.43 (1.41) $^{1/2}$ = 0.51 cfs which is less than the 0.61 cfs we used so we are OK or we can iterate again until we have q_{out} that are almost identical.

After Iteration 2, we have a sediment basin with a SA = 10,027 ft^2 and a V_S = 14,113 ft^3. We have a principal water quality outlet consisting of a 4−inch orifice. This design meets the water quality requirements of the technical standard.

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Seeding For Construction Site Erosion Control

(1059)

Wisconsin Department of Natural Resources

Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used.

I. Definition

Planting seed to establish temporary or permanent vegetation for erosion control.

II. Purpose

The purpose of *temporary seeding*[1] is to reduce runoff and erosion until permanent vegetation or other erosion control practices can be established. The purpose of *permanent seeding* is to permanently stabilize areas of exposed soil.

III. Conditions Where Practice Applies

This practice applies to areas of exposed soil where the establishment of vegetation is desired. Temporary seeding applies to disturbed areas that will not be brought to final grade or on which land−disturbing activities will not be performed for a period greater than 30 days, and requires vegetative cover for less than one year. Permanent seeding applies to areas where perennial vegetative cover is needed.

IV. Federal, State and Local Laws

Users of this standard shall be aware of all applicable federal, state and local laws, rules, regulations or permit requirements governing seeding. This standard does not contain the text of federal, state or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Site and Seedbed Preparation

Site preparation activities shall include:

1. Temporary Seeding

   a. Temporary seeding requires a seedbed of loose soil to a minimum depth of 2 inches.

   b. Fertilizer application is not generally required for temporary seeding. However, any application of fertilizer or lime shall be based on soil testing results.

   c. The soil shall have a pH range of 5.5 to 8.0.

2. Permanent Seeding

   a. Topsoil installation shall be completed prior to permanent seeding.

   b. Permanent seeding requires a seedbed of loose topsoil to a minimum depth of 4 inches with the ability to support a *dense* vegetative cover.

   c. Application rates of fertilizer or lime shall be based on soil testing results.

   d. Prepare a tilled, fine, but firm seedbed. Remove rocks, twigs foreign material and clods over two inches that cannot be broken down.

   e. The soil shall have a pH range of 5.5 to 8.0.

B. Seeding

1. Seed Selection

   a. Seed mixtures that will produce dense vegetation shall be selected based on soil and site conditions and intended final use. Section IX References, lists sources containing suggested seed mixtures.

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b. All seed shall conform to the requirements of the Wisconsin Statutes and of the Administrative Code Chapter ATCP 20.01 regarding noxious weed seed content and labeling.

c. Seed mixtures that contain potentially invasive species or species that may be harmful to native plant communities shall be avoided.

d. Seed shall not be used later than one year after the test date that appears on the label.

e. Seed shall be tested for purity, germination and noxious weed seed content and shall meet the minimum purity and germination requirements as prescribed in the current edition of Rules for Testing Seed, published by the Association of Official Seed Analysts.

2. Seed Rates

a. Temporary Seeding (Cover Crop)

Areas needing protection during periods when permanent seeding is not applied shall be seeded with annual species for temporary protection. See Table 1 for seeding rates of commonly used species. The residue from this crop may either be incorporated into the soil during seedbed preparation at the next permanent seeding period or left on the soil surface and the planting made as a no−till seeding.

Table 1 − Temporary Seeding Species and Rates

Species	Lbs/Acre	Percent Purity
Oats	131[1]	98
Cereal Rye	131[2]	97
Winter wheat	131[2]	95
Annual Ryegrass	80[2]	97

[1] Spring and summer seeding

[2] Fall seeding

b. Permanent Seeding

Rates shall be based on pounds or ounces of Pure Live Seed (PLS) per acre. Section IX contains some possible reference documents that provide seeding rates. Permanent seeding rates may be increased above the minimum rates shown in the reference documents to address land use and environmental conditions.

If a *nurse crop* is used in conjunction with permanent seeding, the nurse crop shall not hinder establishment of the permanent vegetation.

A nurse crop shall be applied at 50% its temporary seeding rate when applied with permanent seed.

3. Inoculation

Legume seed shall be inoculated in accordance with the manufacturer's recommendations. Inoculants shall not be mixed with liquid fertilizer.

4. Sowing

Seed grasses and legumes no more than ¼ inch deep. Distribute seed uniformly. Mixtures with low seeding rates require special care in sowing to achieve proper seed distribution.

Seed may be broadcast, drilled, or hydroseeded as appropriate for the site.

Seed when soil temperatures remain consistently above 53° F. *Dormant seed* when the soil temperature is consistently below 53° F (typically Nov. 1st until snow cover). Seed shall not be applied on top of snow.

VI. Considerations

A. Consider seeding at a lower rate and making two passes to ensure adequate coverage.

B. Compacted soil areas may need special site preparation prior to seeding to mitigate compaction. This may be accomplished by chisel plowing to a depth of 12 inches along the contour after heavy equipment has left the site.

C. Sod may be considered where adequate watering is available.

D. When working in riparian areas refer to the NRCS Engineering Field Handbook, Chapter 16, Streambank and Shoreline Protection and Chapter 18, *Soil Bioengineering* for Upland Slope Protection and Erosion Reduction.

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E. A site assessment should be conducted to evaluate soil characteristics, topography, exposure to sunlight, proximity to natural plant communities, proximity to nuisance, noxious and/or invasive species, site history, moisture regime, climatic patterns, soil fertility, and previous herbicide applications.

F. Use *introduced species* only in places where they will not spread into existing natural areas.

G. Lightly roll or compact the area using suitable equipment when the seedbed is judged to be too loose, or if the seedbed contains clods that might reduce seed germination.

H. See Section IX. References for suggested seed mixes (NRCS, WisDOT, UWEX) or use their equivalent.

I. Turf seedlings should not be mowed until the stand is at least 6 inches tall. Do not mow closer than 3 inches during the first year of establishment.

J. Seeding should not be done when the soil is too wet.

K. Consider watering to help establish the seed. Water application rates shall be controlled to prevent runoff and erosion.

L. Prairie plants may not effectively provide erosion control during their establishment period without a nurse crop.

M. Topsoil originating from agricultural fields may contain residual chemicals. The seedbed should be free of residual herbicide or other contaminants that will prevent establishment and maintenance of vegetation. Testing for soil contaminants may be appropriate if there is doubt concerning the soil's quality.

N. Consider using mulch or a nurse crop if selected species are not intended for quick germination. When mulching refer to WDNR Conservation Practice Standard Mulching for Construction Sites (1058).

VII. Plans and Specifications

Plans and specifications for seeding shall be in keeping with this standard and shall describe the requirements for applying this practice.

All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. During construction areas that have been seeded shall at a minimum be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24−hour period. Inspect weekly during the growing season until vegetation is densely established or permit expires. Repair and reseed areas that have erosion damage as necessary.

B. Limit vehicle traffic and other forms of compaction in areas that are seeded.

C. A fertilizer program should begin with a soil test. Soil tests provide specific fertilizer recommendations for the site and can help to avoid over−application of fertilizers.

IX. References

A. Seed Selection References

United States Department of Agriculture – Natural Resource Conservation Service Field Office Technical Guide Section IV, Standard 342, Critical Area Planting.

UWEX Publication A3434 Lawn and Establishment & Renovation.

WisDOT, 2003. State of Wisconsin Standard Specifications For Highway and Structure Construction. Section 630, Seeding.

B. General References

Association of Official Seed Analysts, 2003. Rules for Testing Seed. http://www.aosaseed.com.

Metropolitan Council, 2003. Urban Small Sites Best Management Practice Manual, Chapter 3, Vegetative Methods 3−85 – 3−91. Minneapolis.

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The State of Wisconsin list of noxious weeds can be found in Statute 66.0407.

United States Department of Agriculture – Natural Resources Conservation Service. Engineering Field Handbook, Chapters 16 and 18.

UWEX Publication GWQ002 Lawn & Garden Fertilizers.

X. Definitions

Dense (V.A.2.b) A stand of 3−inch high grassy vegetation that uniformly covers at least 70% of a representative 1 square yard plot.

Dormant seed (V.B.4): Seed is applied after climatic conditions prevent germination until the following spring.

Introduced Species (VI.F) Plant species that historically would not have been found in North America until they were brought here by travelers from other parts of the world. This would include smooth bromegrass and alfalfa. Some of these species may have a wide distribution such as Kentucky bluegrass.

Nurse Crop (V.B.2.b): Also known as a companion crop; is the application of temporary (annual) seed with permanent seed.

Permanent seeding (II) Seeding designed to minimize erosion for an indefinite period after land disturbing construction activities have ceased on the site.

Soil Bioengineering (VI.D) Practice of combining mechanical, biological and ecological concepts to arrest and prevent shallow slope failures and erosion.

Temporary Seeding (II) Seeding designed to control erosion for a time period of one year or less that is generally removed in order to perform further construction activities or to permanently stabilize a construction site.

Topsoil (V.A.2.a) Consists of loam, sandy loam, silt loam, silty clay or clay loam humus−bearing soils adapted to sustain plant life with a pH range of 5.5 – 8.0. Manufactured topsoil shall through the addition of sand or organic humus material, peat, manure or compost meet the above criteria.

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Silt Curtain

(1070)

Wisconsin Department of Natural Resources

Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used.

I. Definition

A temporary permeable fabric installed in a waterway or waterbody to minimize sediment transport. A silt curtain does not extend to the bottom of the channel and is placed parallel or perpendicular to the direction of flow.

II. Purposes

The purpose of this practice is to provide sediment containment while construction activities are occurring in or directly adjacent to a waterway or waterbody.

III. Conditions Where Practice Applies

This practice applies where construction activities intrude or are directly adjacent to a waterway or waterbody. This includes but is not limited to bridge construction, rip rap placement, utility work, streambank restoration, boat launches and dredging.

Silt curtain is intended for calm water conditions where it will not be subjected to wind, wave, or current. Silt curtains are appropriate to settle out coarse and granular soils where water depth at the time of construction is greater than or equal to 4 feet. For applications in finer sediment or moving water see WDNR Technical Standard 1069 Turbidity Barrier.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of silt curtains. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Installation – Details of construction not listed in the text shall conform to the pertinent requirements of Figure 1.

1. The silt curtain shall be installed before construction activities are initiated in or adjacent to the waterway or waterbody. Install the silt curtain as close to the construction as practical. The curtain shall remain in place and be maintained until the construction activity is completed and the disturbed area is *stabilized* [1].

2. The ends of the silt curtain shall be securely anchored and keyed into the shoreline to fully enclose the area where sediment may enter the water.

3. A 2−foot gap shall exist between the weighted lower end of the curtain and the bottom of the waterway or waterbody.

4. Bottom anchors shall be used to hold the silt curtain in the same position relative to the bottom the waterway or waterbody without interfering with the function of the curtain. Anchors shall either be driven into the bottom of the waterway or waterbody or be weighted and attached to the curtain floatation device via an anchor line. Manufacture's recommendations shall be followed for the number and spacing of anchors.

5. Danger buoys shall be used as directed by the Coast Guard or DNR permit when working in navigable waters.

B. Material:

1. Reusable components of the silt curtain system shall be clean and free of potential exotic species. Fabric cannot be reused.

2. The silt curtain shall be constructed from heavy woven filter fabric to allow water to pass through the barrier yet retain sediment. All fabric seams shall be heat sealed or sewn. Silt curtain fabric shall conform to the specifications in Table 1.

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Table 1

Requirement	Value
Thickness	15 mils (0.38 mm)
Min. grab tensile strength (ASTM D 4632)	120 lb (550 N)
Min. equivalent opening	No. 170 sieve (90 µm)

3. Flotation devices shall be flexible, buoyant units contained in an individual floatation sleeve or collar attached to the curtain. Use expanded polystyrene logs or equivalent having a 49 square inch minimum end area. Do not use polystyrene beads or chips. Buoyancy provided by the floatation device shall be sufficient to support the weight of the curtain and maintain a freeboard of at least 3 inches above the water surface level.

4. Top load lines shall consist of 5/16 inch steel cable.

5. Bottom load lines shall consist of a minimum ¼−inch steel chain incorporated into the bottom hem of the curtain. Larger chain sizes may be used where additional weight to serve as ballast to hold the curtain in a vertical position is required.

VI. Considerations

A. Sediment that has settled out by the silt curtain should only be removed as directed by the regulatory authority because re−suspension of sediment will likely occur during the removal process. Use of polymers may help prevent resuspension of sediment. See WDNR Technical Standard 1051 Sediment Control Water Application of Polymers for further guidance.

B. Silt curtains are meant to manage sediment in the waterbody. The best way to prevent sediment from entering the waterbody is through the implementation of effective upland erosion control, stopping sediment transport at its source.

VII. Plans and Specifications

Plans and specifications for installing a silt curtain shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose:

A. Location of silt curtain.

B. Material specification conforming to standard.

C. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Silt curtains shall be inspected daily and repaired if necessary.

B. Regardless of upland stabilization conditions silt curtains shall not be removed until the water behind the curtain has equal or greater clarity than the waterway or waterbody. Soil particles shall be allowed to settle for a minimum of 24 hours prior to removal of the curtain.

C. Care shall be taken when removing the silt curtain to minimize the release or re−suspension of accumulated sediment.

D. To prevent the spread of exotic species silt curtains shall not be reused on other sites. Buoys and chains can be reused but shall be either disinfected with vinegar or cleaned with hot water greater than 104 deg. F then allowed to completely dry for a minimum period of five days. If there are any questions about the occurrence of zebra mussels, Eurasian water−milfoil, or other aquatic invasive species in a waterbody that you are working in or intend to work in contact your local DNR staff.

IX. References

Virginia Erosion and Sediment Control Handbook, Third Edition, 1992

WisDOT Facilities Development Manual: Chapter 10, Section 10, Subject 43, Silt Screen

X. Definitions

Stabilized (V.A.1): Means that all land disturbing construction activities at the construction site have been completed, and that a uniform perennial vegetative cover has been established with a density of at least 70% of the cover for the unpaved areas and areas not covered by permanent structures, or that employ equivalent stabilization measures.

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Silt Fence

(1056)

Wisconsin Department of Natural Resources

Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used.

I. Definition

Silt fence is a temporary sediment barrier of entrenched permeable geotextile fabric designed to intercept and slow the flow of sediment−laden sheet flow runoff from small areas of disturbed soil.

II. Purpose

The purpose of this practice is to reduce slope length of the disturbed area and to intercept and retain transported sediment from disturbed areas.

III. Conditions Where Practice Applies

A. This standard applies to the following applications:

1. Erosion occurs in the form of *sheet and rill erosion*[1]. There is no concentration of water flowing to the barrier (*channel erosion*).
2. Where adjacent areas need protection from sediment−laden runoff.
3. Where effectiveness is required for one year or less.
4. Where conditions allow for silt fence to be properly entrenched and staked as outlined in the Criteria Section V.

B. Under no circumstance shall silt fence be used in the following applications:

1. Below the ordinary high watermark or placed perpendicular to flow in streams, swales, ditches or any place where flow is concentrated.
2. Where the maximum gradient upslope of the fence is greater than 50% (2:1).

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of silt fence. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Placement

1. When installed as a stand−alone practice on a slope, silt fence shall be placed on the contour. The parallel spacing shall not exceed the maximum slope lengths for the appropriate slope as specified in Table 1.

Table 1.

Slope	Fence Spacing
< 2%	100 feet
2 to 5%	75 feet
5 to 10%	50 feet
10 to 33%	25 feet
> 33%	20 feet

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2. Silt fences shall not be placed perpendicular to the contour.

3. The ends of the fence shall be extended upslope to prevent water from flowing around the ends of the fence.

B. Height – Installed silt fences shall be a minimum 14 inches high and shall not exceed 28 inches in height measured from the installed ground elevation.

C. Support – Silt fences shall be supported by either steel or wood supports as specified below:

1. Wood supports

a. The full height of the silt fence shall be supported by 1 1/8 inches by 1 1/8 inches air or kiln dried posts of hickory or oak.

b. The silt fence fabric shall be stapled, using at least 0.5−inch staples, to the upslope side of the posts in at least 3 places.

c. The posts shall be a minimum of 3 feet long for 24−inch silt fence and a minimum of 4 feet for 36−inch silt fence fabric.

2. Steel supports

a. The full height of the silt fence shall be supported by steel posts at least 5 feet long with a strength of 1.33 pounds per foot and have projections for the attachment of fasteners.

b. The silt fence fabric shall be attached in at least three places on the upslope side with 50 pound plastic tie straps or wire fasteners. To prevent damage to the fabric from fastener, the protruding ends shall be pointed away from the fabric.

3. The maximum spacing of posts for non−woven silt fence shall be 3 feet and for woven fabric 8 feet.

4. Silt fence shall have a support cord.

5. Where joints are necessary, each end of the fabric shall be securely fastened to a post. The posts shall then be wrapped around each other to produce a stable, secure joint or shall be overlapped the distance between two posts.

6. A minimum of 20 inches of the post shall extend into the ground after installation.

D. Anchoring – Silt fence shall be anchored by spreading at least 8 inches of the fabric in a 4 inch wide by 6 inch deep trench, or 6 inch deep V−trench on the upslope side of the fence. The trench shall be backfilled and compacted. Trenches shall not be excavated wider and deeper than necessary for proper installation.

On the terminal ends of silt fence the fabric shall be wrapped around the post such that the staples are not visible.

E. Geotextile Fabric Specifications – The geotextile fabric consists of either woven or non−woven polyester, polypropylene, stabilized nylon, polyethylene, or polyvinylidene chloride. Non−woven fabric may be needle punched, heat bonded, resin bonded, or combinations thereof. All fabric shall meet the following requirements as specified in Table 2.

Table 2

Test Requirement	Method	Value[1]
Minimum grab tensile strength in the machine direction	ASTM D 4632	120 lbs. (550 N)
Minimum grab tensile strength in the cross machine direction	ASTM D 4632	100 lbs. (450 N)
Maximum apparent opening size equivalent standard sieve	ASTM D 4751	No. 30 (600 µm)
Minimum permittivity	ASTM D 4491	0.05 scc^{-1}
Minimum ultraviolet stability percent of strength retained after 500 hours of exposure	ASTM D 4355	70%

(WisDOT Standard Specifications for Road and Bridge Construction, 2001)

[1] All numerical values represent minimum / maximum average roll values. (For example, the average minimum test results on any roll in a lot should meet or exceed the minimum specified values.)

Silt fence shall have a maximum flow rate of 10−gallons/minute/square foot at 50mm constant head as determined by multiplying permittivity in 1/second as determined by ASTM D−4491 by a conversion factor of 74.

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F. Removal – Silt fences shall be removed once the disturbed area is permanently stabilized and no longer susceptible to erosion.

VI. Considerations

A. Improper placement as well as improper installation and maintenance of silt fences will significantly decrease the effectiveness of this practice.

Silt fences should be considered for trapping sediment where sheet and rill erosion may be expected to occur in small drainage areas. Silt fences should not be placed in areas of concentrated flow.

B. Silt fences should be installed prior to disturbing the upslope area.

C. Silt fences should not be used to define the boundaries of the entire project. Silt fence should be placed only in areas where it is applicable due to its cost and the fact that it is not biodegradable. For example, silt fence should not be placed in locations where the natural overland flow is from an undisturbed area into disturbed areas of the project. It should also not be used as a diversion.

D. Silt fence should not be used in areas where the silt fence is at a higher elevation than the disturbed area.

E. When placing silt fence near trees, care should be taken to minimize damage to the root system. Avoid compaction and root cutting within 1.5 feet multiplied by the inch diameter of the tree (for example: for 10−inch trees keep out a 15−foot radius from the trunk). Refer to UWEX publication Preserving Trees During Construction for more information.

F. To protect silt fence from damage in areas of active construction or heavy traffic, silt fence should be flagged, marked, or highlighted to improve visibility.

G. Silt fence effectiveness is generally increased when used in conjunction with other upslope erosion control practices. To further strengthen the silt fence, straw / hay bales can be placed on the down slope side.

H To help ensure effectiveness, silt fence should be inspected and repaired as necessary prior to forecasted rain events.

I. Where installation with wood posts is difficult, such as when hard or frozen ground is encountered, the use of steel post is recommended.

J. Silt fence can be mechanically installed with a plow type device provided that the silt fence is trenched in a manner such that equivalent performance is achieved to that specified in Section V.D.

VII. Plans and Specifications

A. Plans and specifications for installing silt fence shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Location of silt fence
2. Contributory drainage area
3. Schedules
4. Material specification conforming to standard
5. Standard drawings and installation details
6. Restoration after removal

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Silt fences shall at a minimum be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24 hour period.

B. Damaged or decomposed fences, undercutting, or flow channels around the end of barriers shall be repaired or corrected.

C. Sediment shall be properly disposed of once the deposits reach ½ the height of the fence.

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IX. References

UWEX Publication A0327 "Preserving Trees During Construction"

X. Definitions

Channel Erosion (III.A.1): The deepening and widening of a channel due to soil loss caused by flowing water. As rills become larger and flows begin to concentrate, soil detachment occurs primarily as a result of shear.

Sheet and Rill Erosion (III.A.1): Sheet and rill erosion is the removal of soil by the action of rainfall and shallow overland runoff. It is the first stage in water erosion. As flow becomes more concentrated rills occur. As soil detachment continues or flow increases, rills will become wider and deeper forming gullies.

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Stone Tracking Pad and Tire Washing

(1057)

Wisconsin Department of Natural Resources

Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in IX. Definitions. The words are italicized the first time they are used.

I. Definition

A stabilized pad of stone aggregate or tire washing station located at any point where traffic will egress a construction site.

II. Purpose

The purpose of this standard is to reduce off−site sedimentation by eliminating the tracking of sediment from construction sites.

III. Conditions Where Practice Applies

Either a stone tracking pad or tire washing station shall be used at all points of construction egress. This standard applies where construction traffic is likely to transport sediment off site.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of this practice. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Tracking Pad:

1. The tracking pad shall be installed prior to any traffic leaving the site.
2. The aggregate for tracking pads shall be 3 to 6 inch clear or washed stone. All material to be retained on a 3−inch sieve.
3. The aggregate shall be placed in a layer at least 12 inches thick. On sites with a high water table, or where saturated conditions are expected during the life of the practice, stone tracking pads shall be underlain with a WisDOT Type R geotextile fabric to prevent migration of underlying soil into the stone.
4. The tracking pad shall be the full width of the egress point. The tracking pad shall be at a minimum 50 feet long.
5. Surface water must be prevented from passing through the tracking pad. Flows shall be diverted away from tracking pads or conveyed under and around them by using a variety of practices, such as culverts, *water bars*[1], or other similar practices.

B. Tire washing: If conditions on the site are such that the sediment is not removed from vehicle tires by the tracking pad, then tires shall be washed utilizing pressurized water before entering a public road.

1. The washing station shall be located on−site in an area that is stabilized and drains into suitable sediment trapping or settling device.
2. The wash rack shall consist of a heavy grating over a lowered area. The rack shall be strong enough to support the vehicles that will cross it.

C. Rocks lodged between the tires of dual wheel vehicles shall be removed prior to leaving the construction site.

VI. Considerations

A. Vehicles traveling across the tracking pad should maintain a slow constant speed.

B. The best approach to preventing off−site tracking is to restrict vehicles to stabilized areas.

C. It is always preferable to prevent sediment from being deposited upon the road than cleaning the road later. Sediment on a road can create a safety hazard as well as a pollution problem.

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D. Any sediment tracked onto a public or private road should be removed by street cleaning, not flushing, before the end of each working day.

VII. Plans and Specifications

A. Plans and specifications for installing tracking pads shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Location of all points of egress with tracking pad locations shown
2. Material specifications conforming to standard
3. Schedule for installation and removal
4. Standard drawings and installation details
5. Stabilization after removal

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Tracking pads and tire washing stations shall, at a minimum, be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24−hour period.

B. The tracking pad performance shall be maintained by scraping or top−dressing with additional aggregate.

C. A minimum 12−inch thick pad shall be maintained.

IX. Definitions

Water bar (V.A.5): A shallow trench or diversion dam that diverts surface water runoff into a dispersion area.

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Storm Drain Inlet Protection For Construction Sites

(1060)

Wisconsin Department of Natural Resources

Conservation Practice Standard

I. Definition

A temporary barrier installed around a storm drain inlet, drop inlet or curb inlet.

II. Purposes

The purpose of this practice is to reduce sediment from entering storm drains before stabilizing the contributing drainage area.

III. Conditions Where Practice Applies

This practice applies where runoff from construction sites enters conveyance system structures such as drain inlets, drop inlets, and curb inlets. Inlet protection devices are for drainage areas of one acre or less. Runoff from areas larger than one acre should be routed through a properly designed sediment trapping or settling practice upstream of the inlet.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of storm drain inlet protection. This standard does not contain the text of federal, state, or local laws.

V. Design Criteria

This section establishes the minimum standards for design, installation and performance requirements.

The appropriate type of inlet protection barrier shall be installed once the drain, drop, or curb inlet can receive runoff. The device shall remain in place and be maintained until the disturbed area is stabilized.

A. General Criteria that is applicable to all inlet protection devices

1. Ponding water to settle sediment is encouraged; however ponding shall not interfere with the flow of traffic, create a safety hazard, or cause property damage. All devices shall have provisions such as weep holes or “emergency spillways” to safely pass water if the device becomes clogged.

2. The contributing drainage area to the inlet protection device shall be one acre or less. In instances were a larger contributing drainage area exists, runoff shall be routed through a properly designed sediment trapping or settling device upstream of inlet.

3. Other than Type D inlet protection devices, no gaps shall be left in the material used that would allow the flow of water to bypass the inlet protection device.

4. All fabrics used as part of an inlet protection device must be selected from the list of approved fabrics certified for inlet protection, Geotextile Fabric, Type FF in the current addition of the WisDOT Product Acceptability List (PAL).

B. Criteria Applicable to Unpaved areas or the Pre−Paving Phase of Construction

1. Inlet Protection Barriers include, but are not limited to, straw bales, sandbags, other material filled bags and socks, and stone weepers. These devices can be used to either settle sediments or divert flows.

a. Manufactured bags, when used, shall conform to the standards in Table 1.

Table 1	
Minimum Size	14 x 26 inches
Grab Tensile strength of fabric, ASTM D−4632	95 lb. min.
UV stability, ASTM D−4355	70 % min.
Note: To provide sufficient strength, fabric shall be sewn together with double stitching.	

b. Straw Bale installation shall conform to the criteria outlined in the WDNR Conservation Practice Standard (1055) Sediment Bale Barrier (Non−Channel).

c. Stone weeper installation shall conform to the criteria in WDNR Conservation Practice Standard (1063) Sediment Trap.

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2. Filter Fabric Barrier Criteria − See Figure 1 Inlet Protection

   a. Inlet protection Type A devices shall be utilized around inlets and unpaved areas until permanent stabilization methods have been established. Type A devices shall be utilized on inlets prior to installation of curb and gutter or pavement, and where safety considerations are not compromised on the site.

   b. Type B shall be utilized after the casting and grate are in place.

   c. Type D shall be utilized in areas where other types of inlet protection are identified as incompatible with roadway and traffic conditions, causing possible safety hazards when ponding occurs at the inlet. Type D shall only be used after castings are in place on top of the inlet boxes.

      Type D inlet protection shall conform to the standard drawing as shown in the plans. There shall be a three−inch space between the bag and the sides of the inlet to prevent the inlet sides from blocking the overflow; and shall only be used in inlets deeper than 30 inches from the top of grate to bottom of the inlet. If such clearance is not available, cinch or tie the sides of the bag (with rope or ties) to provide clearance.

C. Criteria Applicable to the Post−Paving / Curbing Phase of Construction

1. Inlet protection Types B, C, and D are applicable to post paving construction. See Figure 1 Inlet Protection.

   - Type B shall be utilized on inlets without curb box.
   - Type C shall be utilized on street inlets with curb heads. A 1½″ x 3 ½″ (37mm by 87 mm) minimum, piece of wood shall be wrapped and secured in the fabric and placed in front of the curb head as shown in the plans. The wood shall not block the entire opening of the curb box and be secured to the grate with wire or plastic ties.
   - Type D

VI. Considerations

A. When site conditions allow, inlets should be temporarily closed or sealed to prevent entrance of runoff and sediment.

B. The best way to prevent sediment from entering the storm sewer system is to stabilize the disturbed area of the site as quickly as possible, preventing erosion and stopping sediment transport at its source.

C. Storm drain inlet protection consists of several types of inlet filters and traps and should be considered as only one element in an overall erosion control plan. Each type differs in application with selection dependent upon site conditions and inlet type. Not all designs are appropriate in all cases. The user must carefully select a design suitable for the needs and site conditions.

D. Inlet protection is only as effective as the filter or barrier used around the inlet. Effectiveness decreases rapidly if the inlet protection is not properly maintained. In general, inlet protection provides relatively good removal of coarse and medium−sized soil particles from runoff however, most fine silt and clay particles will pass through the filtering mechanisms.

E. Properly maintaining inlet protection can be difficult and often inlets can become clogged. Field experience has shown that inlet protection that causes excessive ponding in an area of high construction activity may become so inconvenient that it is simply removed or bypassed, thus transmitting sediment−laden flows unchecked. In such situations, a structure with an adequate overflow mechanism should be utilized instead of simply removing the inlet protection device.

F. Inlet protection devices can be enhanced by additional excavation to increase the storage capacity around the inlet.

G. Good construction site housekeeping measures, such as keeping the gutters clean, and street sweeping are important.

VII. Plans and Specifications

Plans and specifications for installing inlet protection shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose:

A. Location of inlet protection and type employed

B. Material spec conforming to standard

C. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

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VIII. Operation and Maintenance

A. Remove inlet protection devices once the contributing drainage area is stabilized with appropriate vegetation or impervious area.

B. Inlet protection shall be at a minimum inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24−hour period.

C. Sediment deposits shall be removed and the inlet protection device restored to its original dimensions when the sediment has accumulated between 1/3 to 1/2 the design depth of the device, or when the device is no longer functioning as designed. Removed sediment shall be deposited in a suitable area and stabilized.

D. Due care shall be taken to ensure sediment does not fall into the inlet and impede the intended function of the device. Any material falling into the inlet shall be removed.

IX. References

WisDOT "Erosion Control Product Acceptability List" is available online at: *http://www.dot.wisconsin.gov/business/engrserv/pal.htm* Printed copies are no longer distributed.

Removed by Register March 2007 No. 615. For current adm. code see: http://docs.legis.wisconsin.gov/code/admin_code.

Temporary Grading Practices For Erosion Control

(Surface Roughening and Temporary Ditch Sumps)

(1067)

Wisconsin Department of Natural Resources

Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used.

I. Definition

Temporary[1] grading practices used to minimize construction site erosion. These practices include, but are not limited to surface roughening (directional tracking and tillage) and temporary ditch sumps.

II. Purpose

The purpose of these practices are to minimize erosion and sediment transport during grading operations on construction sites.

III. Conditions Where Practice Applies

These practices apply where land disturbing activities occur on construction sites. These practices shall be used in conjunction with other erosion control practices.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing these practices. This standard does not contain the text of federal, state, or local laws.

V. Criteria

These interim practices may be employed in addition to the approved grading plan to reduce erosion and sediment transport.

A. Surface Roughening − Surface roughening is abrading the soil surface with horizontal ridges and depressions across the slope to reduce runoff velocities.

1. Directional Tracking − The process of creating ridges with tracked vehicles on unvegetated slopes. This method is used for short durations on sites actively being grad and shall be used in conjunction with other practices. This practice shall be in place at the end of each workday.

   Directional tracking involves driving a tracked vehicle up and down a slope. The tracks create horizontal grooves and ridges. The rough surface slows sheet runoff and helps to prevent rills from forming. (Conversely, if the tracked vehicle is driven along the contour the tracks create vertical grooves and ridges for the water to follow, increasing erosion.)

2. Tillage − Utilizing conventional tillage equipment to create a series of ridges and furrows on the contour no more than 15 inches apart.

B. Temporary Ditch Sump − Temporary ditch sumps are ½ to 5 cubic yard excavations made in a drainageway during earthmoving operations. Their purpose is to slow and pond runoff during the time that drainageways are being graded. Sumps shall be in place prior to anticipated rain events.

   Construction involves excavating sumps (holes) in the rough ditch grade, and using the excavated material to form a dike on the downstream side of the sump.

   Temporary ditch sumps are not effective perimeter controls. Other sediment control practices shall be utilized prior to channels discharging into public waterways.

VI. Considerations

A. Directional tracking may compact the soil, therefore additional seedbed preparation may be required. Refer to WDNR Conservation Practice Standard Seeding for Construction Site Erosion Control (1059) for seedbed preparation and seeding criteria.

B. When constructing a temporary ditch sump, compacting the dike provides additional stability.

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C. Consider at a minimum excavating ½ cubic yard per 1% gradient, for every 500 feet of channel when constructing temporary ditch sumps.

VII. Plans and Specifications

Due to the interim nature of these practices, and the fact that location determinations are made in the field, they need only be referenced in the erosion control plan narration or general notes.

VIII. Operation and Maintenance

These practices shall be inspected and repaired or reinstalled after every runoff event.

IX. References

Virginia Department of Conservation and Recreation. 1992. Virginia Erosion and Sediment Control Handbook, Third Edition. Chapter 3 – 3.29 Surface Roughening.

Dane County. 2002. Dane County Erosion Control and Stormwater Manual, First Edition. Appendix Surface Roughening S−16.1.

X. Definitions

Temporary (I): An erosion control measure that is utilized during construction site grading activities.

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Turbidity Barrier

(1069)

Wisconsin Department of Natural Resources

Conservation Practice Standard

Note: Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used.

I. Definition

A temporary fabric barrier with very low permeability, installed in or near the bed of a waterway or waterbody to minimize sediment transport and is installed parallel to flow. Turbidity barrier cannot be installed perpendicular to a moving channel.

II. Purposes

The purpose of this practice is to provide sediment containment while construction activities are occurring in or directly adjacent to a waterway or waterbody.

III. Conditions Where Practice Applies

This practice applies where construction activities intrude or are directly adjacent to a waterway or waterbody. This includes but is not limited to bridge construction, rip rap placement, utility work, streambank restoration, boat launches and dredging.

Use turbidity barriers in conditions with fine soils and flow velocities not exceeding 5 feet per second, unless additional reinforcement is installed.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of turbidity barriers. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Installation – Details of construction not listed in the text shall conform to the pertinent requirements of Figures 1 and 2.

1. The barrier shall be installed before construction activities are initiated in, or adjacent to the waterway or waterbody. Install the turbidity barrier as close to the construction as practical. The barrier shall remain in place and be maintained until the construction activity is completed and the disturbed area *stabilized* [1].

2. The ends of the barrier shall be securely anchored and keyed into the shoreline to fully enclose the area where sediment may enter the water.

3. Driven steel posts shall be used to hold the barrier in position. The maximum spacing between posts shall be 10 feet. When barrier height exceeds 8 feet, post spacing may need to be decreased.

   When bedrock prevents the installation of posts, float devices may be used. Flotation devices shall be flexible, buoyant units contained in an individual flotation sleeve or collar attached to the turbidity barrier. Use solid expanded polystyrene logs or equivalent having a 49 square inch minimum end area. Do not use polystyrene beads or chips. Buoyancy provided by the flotation devices shall be sufficient to support the weight of the turbidity barrier and maintain a freeboard of at least three inches above the water surface. Refer to Figure 1.

4. The barrier and steel posts shall extend from the bottom of the waterway or waterbody to an elevation 2 feet above the anticipated high water level during the time of year and duration the barrier will be in place. The elevation shall not exceed the top of bank.

5. Ballast shall be used to hold the barrier in a vertical position. Bottom load lines shall consist of a chain incorporated into the bottom hem of the screen, of sufficient weight to serve as ballast to hold the screen in a vertical position. Additional anchorage shall be provided if necessary.

6. Danger buoys shall be used as directed by the Coast Guard or DNR permit when working in navigable waters.

7. Turbidity barriers shall be installed parallel to the direction of flow and shall not be installed across channels.

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B. Material

1. Reusable components of the turbidity barrier system shall be clean and free of potential exotic species. Fabric cannot be reused.

2. Top load lines shall consist of 5/16 inch steel cable.

3. Fabric shall be selected according to the specifications in Table 1.

Table 1

Requirement	Method	Value
Min. grab tensile strength	ASTM D 4632	200 lb (890 N)
Min. puncture strength	ASTM D 4833	90 lb (400 N)
Maximum permeability	ASTM D 4491	= $1X10^{-7}$ cm/s
Min. ultraviolet stability	ASTM D 4355	70%

Source: WisDOT Spec 628.2.10.

VI. Considerations

A. The 5 feet per second flow velocity specified in Section III can be the base flow of the stream or the base flow plus the addition of storm event runoff. Base flow can be used alone for short term projects (typically one day duration, i.e. culvert installation) when the chance of precipitation is low. Longer term projects (i.e. bridge work) should consider storm flow in addition to base flow (typically the two year event).

B. If the current exceeds 5 feet per second, other methods to divert flow away from the turbidity barrier such as temporary concrete traffic barriers, coffer dams, pumping, or sheet piling should be considered.

C. Sediment that has been settled out by the turbidity barrier should only be removed if so directed by the regulatory authority because re−suspension of sediment will likely occur during the removal process. Use of polymers may help prevent resuspension of sediment. See WDNR Technical Standard 1051 Sediment Control Water Application of Polymers for further guidance.

D. Turbidity barriers are meant to manage sediment in the waterbody. The best way to prevent sediment from entering the waterbody is through the implementation of effective upland erosion control, stopping sediment transport at its source.

E. Turbidity barriers should not be used to reduce the conveyance capacity of the channel. An example is use on bridge projects where the turbidity barrier is installed adjacent to each abutment simultaneously.

F. Turbidity barriers may be installed on the banks of a waterway or waterbody if higher water levels are anticipated during construction.

VII. Plans and Specifications

Plans and specifications for installing a turbidity barrier shall be in keeping with this standard and attached detail drawing and shall describe the requirements for applying the practice to achieve its intended purpose:

A. Location of turbidity barrier.

B. Material specification conforming to standard.

C. All plans, standard detail drawings, or specifications shall include schedule sequence or notes for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Turbidity barriers shall be inspected daily and repaired if necessary.

B. Turbidity barriers shall not be removed until the water behind the barrier has equal or greater clarity than the waterway or waterbody.

C. Care shall be taken when removing the barrier to minimize the release or re−suspension of accumulated sediment.

D. To prevent the spread of exotic species turbidity barriers shall not be reused on other sites. Buoys and chains can be reused but shall be either disinfected with vinegar or cleaned with hot water greater than 104 deg. F then allowed to completely dry for a minimum period of five days. If there are any questions about the occurrence of zebra mussels, Eurasian water−mil-

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foil, or other aquatic invasive species in a waterbody that you are working in, or intend to work in, contact your local DNR staff.

IX. References

WisDOT Facilities Development Manual: Chapter 10, Section 10, Subject 45, Turbidity Barrier

X. Definitions

Stabilized (V.A.1): Means that all land disturbing construction activities at the construction site have been completed, and that a uniform perennial vegetative cover has been established with a density of at least 70% of the cover for the unpaved areas and areas not covered by permanent structures, or that employ equivalent stabilization measures.

(Figures are available on DNR website.)

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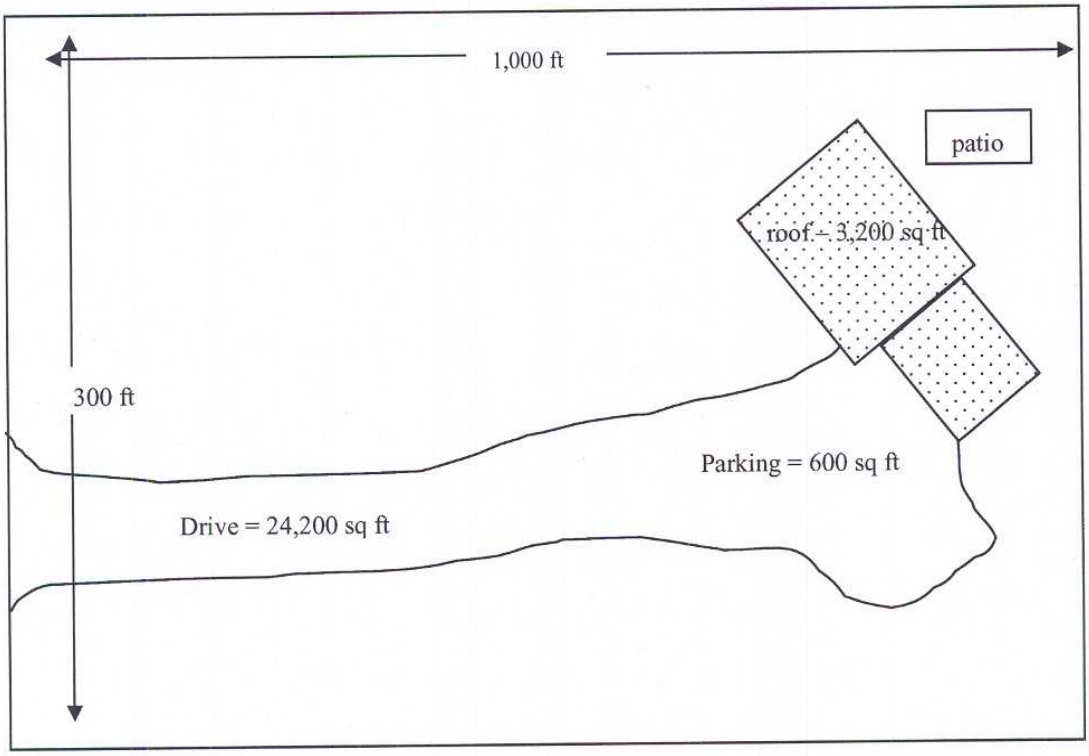
A−21.126 STORM WATER MANAGEMENT. The following examples are three exemptions to the requirements for a post construction stormwater management plan. This means the owners of these sites are **not** required to develop and implement a post construction stormwater management plan.

1. Redevelopment with no increase in area for exposed parking or roads. Redevelopment is defined as "areas where development is replacing older development."
2. The installation of underground utilities such as sewers, water services, electrical services, etc.
3. Sites with less than 10% connected imperviousness when parking lots and roofs total an area of less than one acre. Following is an equation that may be used to evaluate a site for this exemption:

   Total area of a completed building site X 0.1 = Maximum area permitted to be connected via impervious flow path or sewer.

Following are design examples acceptable by the department which achieve compliance with the NR 151.12 (2) (d), Wis. Adm. Code exemption to the post−construction stormwater requirements. The following diagram illustrates a residential site that meets this exemption.

Figure A−21.126−1
Sample site plan that meets exemption for post construction stormwater plan



The total area of the site is 300,000 sq ft or 6.9 acres. Disturbed area = 2 acres.

The roof & parking is 3,800 sq ft which is less than 1 acre (43,560 sq ft)

300,000 sq ft X 0.1 = 30,000 sq ft allowable connected imperviousness

In this example the entire parking, drive and roof area is connected imperviousness via storm piping to the road and drive.

The patio is disconnected imperviousness. The connected imperviousness is 28,000 sq ft.

This example would not be required to develop a stormwater management plan because the exemption found in NR 151.12(2)(d), Wis. Adm. Code applies.

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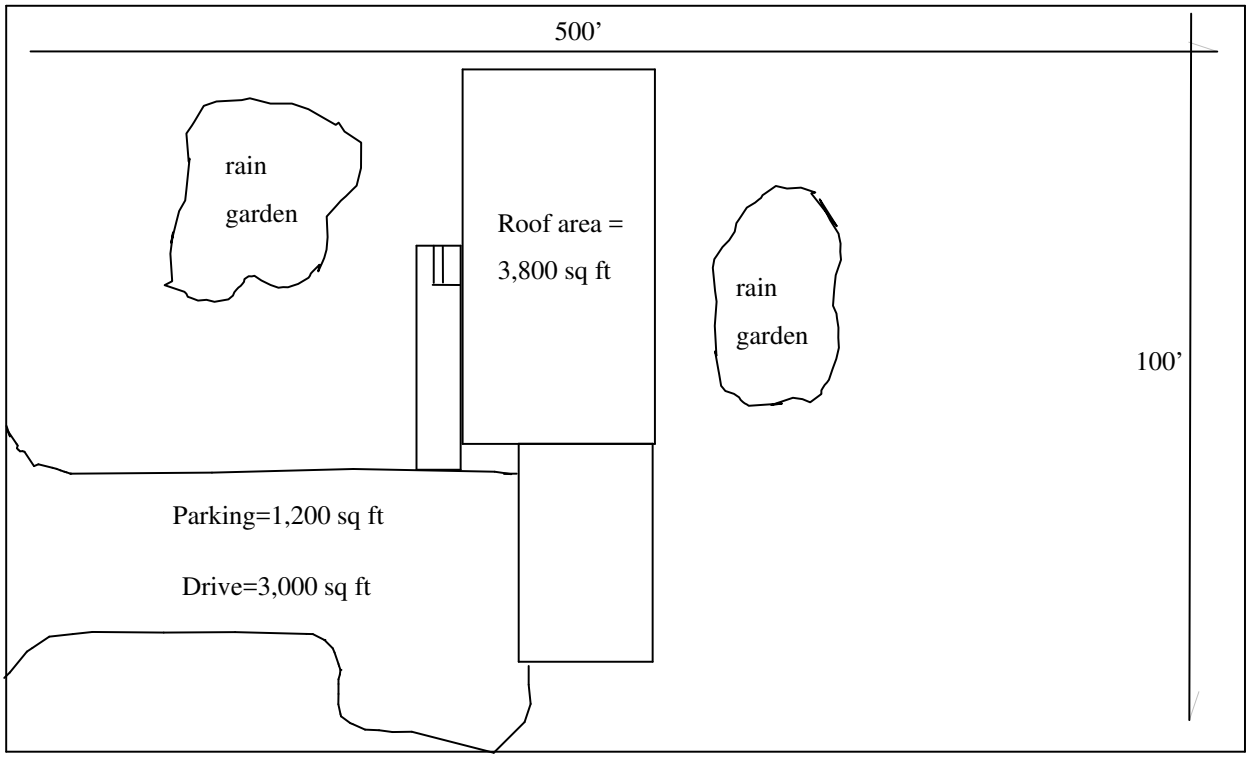
The previous example was a long driveway on a very large rural lot. Following is a small site in an urban setting that would also meet the exemption for post construction stormwater management.

Figure A−21.126−2
Sample site plan that meets exemption for post construction stormwater plan



The lot is 50,000 sq ft or approximately 1.1 acres. The entire site (except for the rain garden areas) will be disturbed during construction.

The roof & parking is 5,000 sq ft which is less than 1 acre (43,560 sq ft)

50,000 sq ft X 0.1 = 5,000 sq ft allowable connected imperviousness

In this example the entire roof area discharges to two rain gardens. Only the parking and driveway is connected imperviousness via the road (parking 1,200 sq ft + drive 3,000 sq ft = 4,200 sq ft).

This example would not be required to develop a stormwater management plan because the exemption found in NR 151.12(2)(d), Wis. Adm. Code applies.

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An acceptable Stormwater Operation and Maintenance Plan should be based on the following outline:

I. Introduction and general information

A. Contact information

B. Overview of site

II. Practices (BMPs) utilized on the site

A. Construction

B. Plans and narrative of stormwater management

III. Normal Operating Procedures

A. Relationship of one practice to another

B. Effectiveness of functioning practices

IV. Maintenance

A. Contact information for responsible maintenance person or persons

B. Copies of any agreements for maintenance or easement

C. Description of routine maintenance

D. Sample inspection and monitoring protocol

E. Description of replacement plans or repair procedures for failed practices

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s. Comm 21.16

Frost Protected Shallow Footings

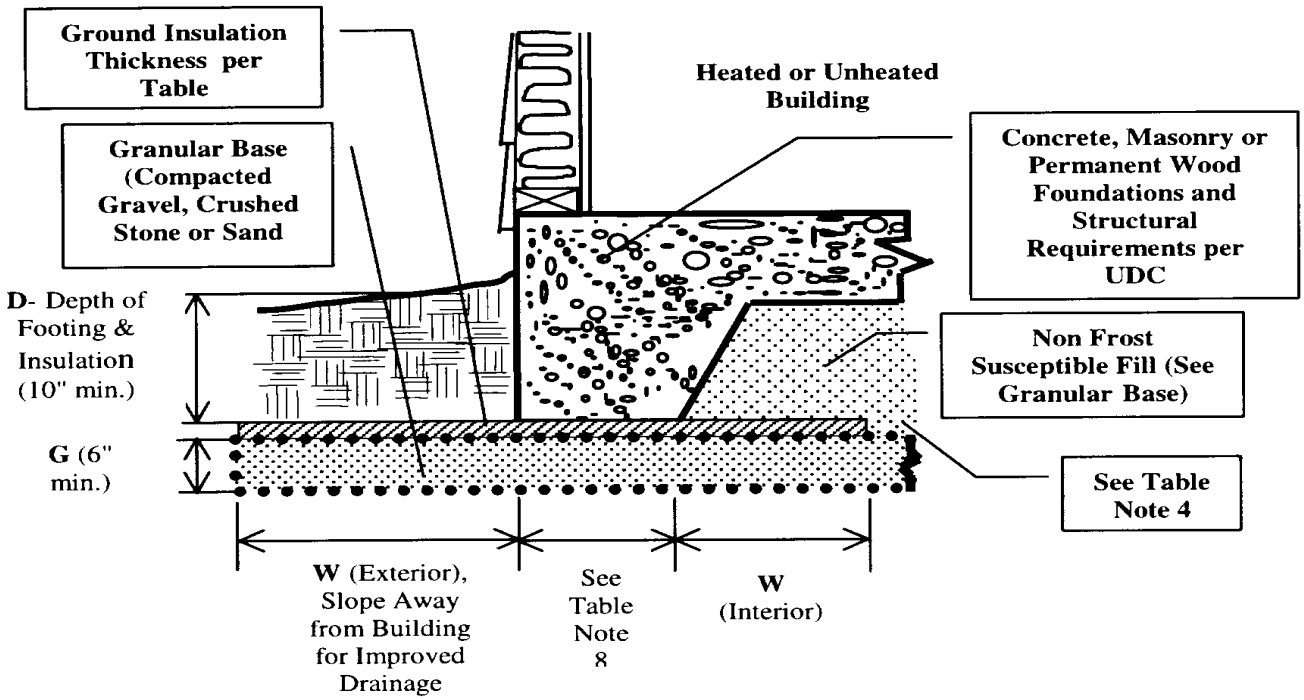
In lieu of frost walls, the following is an acceptable method.

Minimum Ground Insulation Requirements (1)

		Mean Annual Temperature (2,6)			Minimum Footing Depth (7,8)	
Air Freezing Index (F−days) (3)	**W−Insulation Width from Edge of Footing (4,5)**	**38**	**40**	**≥41**	**D− Concrete Depth**	**G− Granular Base Thickness**
2250 or less	63″	NA	NA	2.5″	10″	6″
2251−3000	79″	4″	3.5″	3.5″	10″	6″
3001−3750	91″	5″	NA	NA	10″	6″

Notes:

1. Also see s. Comm 22.26 for additional slab−edge insulation requirements.
2. Units are degrees Fahrenheit. See estimate provided on Mean Annual Temperature contour Map.
3. Air freezing index shall be based on maximum year expected for a 100 year return period. See estimate provided on AFI Contour Map.
4. Ground insulation to the building interior can be extended beneath the entire slab where it is desired to protect the entire slab from frost heave action.
5. Ground insulation to the building interior can be in one horizontal plane (as shown in the detail) and covered with non frost−susceptible fill or the insulation maybe placed directly beneath the slab.
6. Insulation thickness recommendations are for extruded polystyrene (XPS) insulation.
7. The minimum depth of concrete footing and horizontal insulation is 10". A 6" drainage layer is required under the insulation.
8. Insulation placed directly beneath the footing shall be Type IV or Type VI XPS in accordance with ASTM C578. Maximum deadload placed on the Type IV insulation shall be 1200 pounds/square foot. Maximum deadload placed on the Type IV insulation shall be 1200 pounds/square foot. Maximum deadload placed on Type VI shall be 1900 psf.



See p. 166 for slab−edge insulating details

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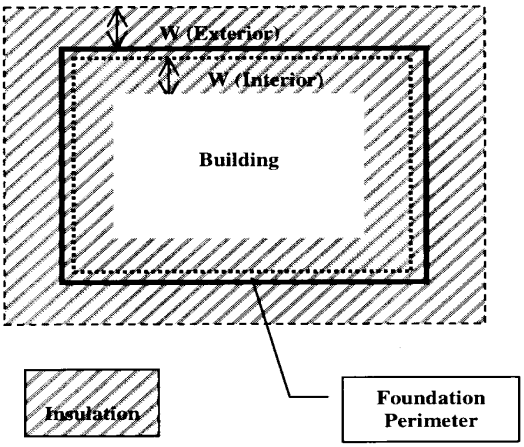
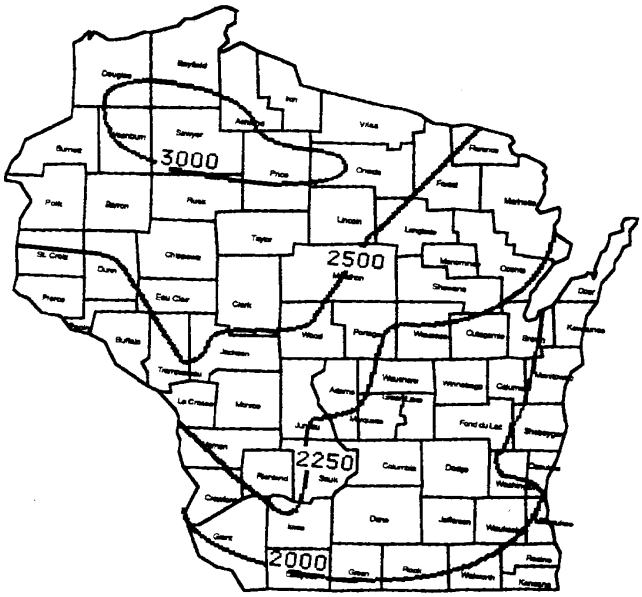
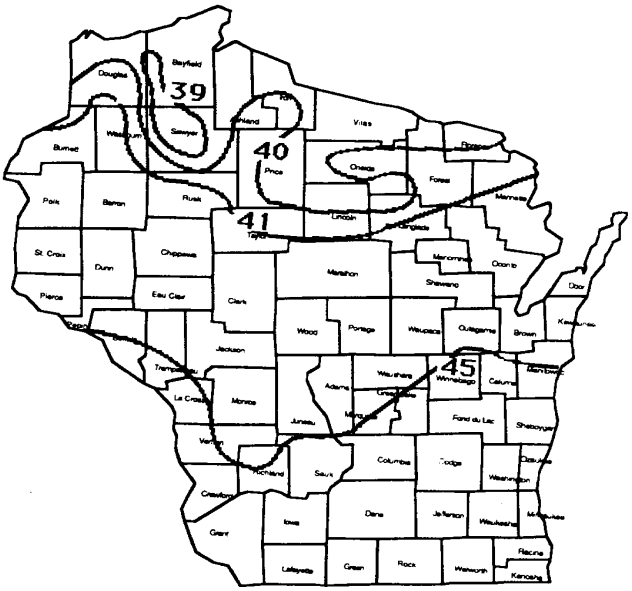
Plan View





Air-Freeze Index Contour Map



Mean Annual Temperature Contour Map

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UDC Energy Worksheet

The UDC Energy Worksheet is required to be submitted with building plans for plan review prior to issuance of a building permit. Following is a sample dwelling and completed Energy Worksheet and a blank worksheet after that. **The sample completed worksheet has been completed for both the Prescriptive Package and System Design Methods for demonstration purposes. Normally only one method is required to be completed for showing code compliance.**

Sample dwelling: Non-Electrically heated single-family dwelling located in Dane County (Zone 3). Has 1,500 square feet and 186 linear feet of perimeter building thermal envelope. Garage is not heated. Estimated infiltration rate is .3 air changes per hour. There will be 170 cfm of installed exhaust ventilation.

Gross Above-Foundation Walls:

Wall = 8.09' (97"-1/8") x 186 linear feet = 1,504 square feet

Box sill = 0.81 feet (9-3/4 inches deep: sill, header, subfloor) x 186 linear feet = 151 square feet

Wood 1 x 8-inch drop siding	R = 0.79
1-inch extruded polystyrene sheathing	**R = 5**
R13 batt insulation	**R = 13**
2 x 4 framing, 16 inches O.C.	R = 4.4
1/2-inch drywall finish	R = 0.56

Door area = 38 sq ft

Insulated steel doors	**U = 0.35**

Windows:

Above-Foundation Windows - 150 sq ft

Wood, low-E, argon-filled, double-pane with 1/2" air space, rated by NFRC	**U = 0.35**

Foundation wall window area = 20 square feet

Operable metal w/o thermal break, double pane	**U = 0.87**

Foundation - 8 ft high, 1 ft exposed

8-inch poured concrete	R = 0.8
1-inch extruded polystyrene for full height	**R = 5**

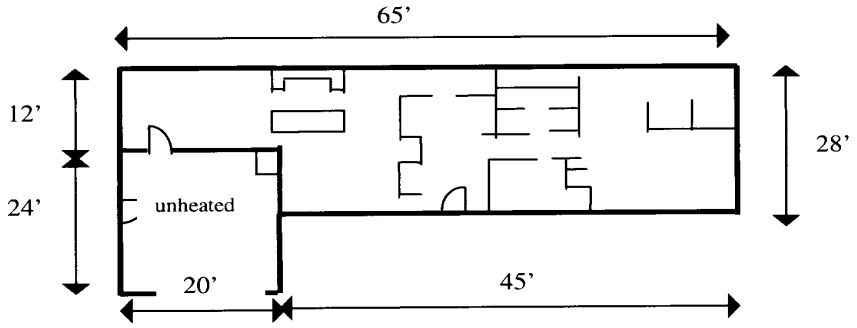
Ceiling - 1,500 square feet, standard roof trusses (no raised heel)

2 x 4 trusses, 24 inches O.C.	R = 4.4
Blown fiberglass insulation	R/inch = 2.5
Insulation in cavity, 16 inches	**R = 40**
Insulation over framing, 12.5 inches	R = 31.25
5/8-inch drywall finish	R = 0.56

Heating Plant

Gas-Fired Hot Air, 90% AFUE	**High Efficiency**

tk\h:\udc\gentech



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Submit completed worksheet pages 3-6 with dwelling plans to local enforcing municipality.

Project Address: *Sample - Zone 3*

Builder: _____ Owner: _____

Worksheet Completed By: _____ Date: _____

Does dwelling unit have three kilowatts or more input capacity of permanently installed electrical space heating equipment?

☐ YES (see below) ☒ NO

You will need to apply the stricter standards shown for electrically-heated homes if you answered "YES" to the above question.

A. Area Calculations

Enter appropriate dimensions to obtain area values. Some calculations will not be necessary depending on home design or calculation method. These calculated areas are referenced elsewhere on this worksheet, for example, "(A.1.)".

1. Window, Skylight & Patio Door Area (overall unit area) a. In Above- Foundation Walls: *150* sq. ft. b. In Foundation Walls: *20* sq. ft. c. Total (a. + b.) = *170*	2. Opaque Door Area a. In Above- Foundation Walls: *38* sq. ft. b. In Foundation Walls: *0* sq. ft. c. Total (a. + b.) = *38*
3. Gross Exposed Basement Wall Area *1' x 186'* *186* sq. ft.	4. Basement Wall Area Below Grade *7' x 186'* *1302* sq. ft.
5. Opaque [1] Basement Wall Area (A.3. + A.4. - A.1.b.- A.2.b.) *186 + 1302 - 20 - 0* *1468* sq. ft. If the exposed area of A.3.is greater than the below grade area of A.4., add A.5. to A.7 and cross out the number in this cell.	6. Gross Heated Above-Foundation Wall Area, **including boxsill** *1504 + 151* *1655* sq. ft.
7. Above Foundation Code Wall Area (A.6. + A1.b. + A.2.b.) *1655 + 20 + 0* *1675* sq. ft.	8. Opaque [1] Above-Foundation Wall Area (A.6. - A1.a. - A.2.a.) *1655 - 150 - 38* *1467* sq. ft.
9. Floor Area Over Interior Unconditioned Spaces Less Than 50° *0* sq. ft.	10. Insulated Roof Or Ceiling (less skylights) *28 x 45 = 1260* *12 x 20 = 240* *1500* sq. ft.
11. Exterior Floor Area (Overhangs) *0* sq. ft.	12. Crawl Space Wall Area *0* sq. ft.
13. Slab On Grade (above or less than 12 inches below grade) *0* lineal feet of slab perimeter	14. Total Heated Envelope Area (A.5 + A.7 + A.9 + A.10 +A.11 + A.12 +(A.13. X 2')) *1468 + 1675 + 0 + 1500 + 0 + 0 + 0* *4643* sq. ft.
15. Percent Glazing (for Prescriptive Package Method, Section B, only) (A.1.c. ÷ A.7. X 100%) *170 ÷ 1675 x 100%* *10.2* %	16. Windows Description - Above-Foundation Windows: Frame type: ☒ Wood or Wood Clad ☐ Vinyl ☐ Metal Glazing type: ☒ Dual ☐ Triple ☐ Dual w/storm panel Dual-Glazing Air Space: ☐ 1/4' ☐ 3/8" ☒ 1/2" or more Features: ☒ Low-E ☒ Argon-filled ☐ Suspended film Foundation Windows: ☐ Vinyl ☒ Metal

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B. Prescriptive Package Method (Skip this section if using the System Design Method of Sections C-F)
The prescriptive package method is the simplest method for determining compliance with the UDC insulation and window requirements. To use the prescriptive package method, enter your actual design values in the "Actual " row below. **For a component, with two or more areas of different insulation levels, such as windows,** either use the least insulating value for both areas or use the Weighted Average tables below. Multiply your % glazing by the glazing U-value to obtain your "Glazing Factor". Find the Prescriptive Table that applies to your space heating fuel and sheathing type. Select a package from the table that most closely matches the construction indicated on your plans. **Do not exceed the package U-values or glazing factor or fall below the package R-values with your design.** Transfer the R-Values and U-values to the blank table below in the "Allowed" row. Then proceed to Section F. See page 2 for detailed instructions for this section.

	Package #	% glazing	U glazing	Glazing Factor (% glazing × U glazing)	R wall	R ceiling	R Bsmt Crawl Space, Slab or Floor	U door	U overall	Equip. Eff.
Actual	------	*10.2* % (A.15)	*0.41*	*0.042*	*R13 + 5*	*R40*	*R5*	*0.35*	----------	*High*
Allowed	*45*	----------	----------	*0.0504* Max	*R18, I* Min	*R40* Min	*R5* Min	*0.35* Max	*0.086*	*High*

(Please go to Section F.)

Optional R-Value/U-Value Weighted Average Table for Component: ***Windows***

Component Construction Description	R Value	U-Value (1÷R Value)	Area (sq ft)	U-Value × Area (UA)
Basement windows		*0.87*	*20*	*17.4*
Above-foundation windows		*0.35*	*150*	*52.5*
			Total Area = *170*	Total UA = *69.9*

69.9 (Total UA) ÷ *170* (Total Area) = *0.41* (Weighted Average U-Value (for windows or doors))

_____ (Total Area) ÷ _____ (Total UA) = _____ (Weighted Average R-Value (for all other components))

Optional R-Value/U-Value Weighted Average Table for Component:

Component Construction Description	R Value	U-Value (1÷R Value)	Area (sq ft)	U-Value × Area (UA)
			Total Area =	Total UA =

_____ (Total UA) ÷ _____ (Total Area) = _____ (Weighted Average U-Value (for windows or doors))

_____ (Total Area) ÷ _____ (Total UA) = _____ (Weighted Average R-Value (for all other components))

Because the sample house fit a Package, you would normally skip ahead to Section F. For demonstration purposes here, the System Design Method is also completed.

C. Code-Allowed Heat Loss For System Design Method
Enter area values from Section A as notated and temperature differences per footnote 2 into this table and then multiply across by the electric or non-electric code-required U-value. Total the right column to find the total allowed heat loss factor.

Component	Area From Sect A.	× Required U-Value		= Heat Loss UA
		☒ NON-ELEC	☐ ELECTRIC	
1. Opaque Basement Wall [2]	*1468* (A.5.)	0.077 [3]	0.077 [3]	*113*
2. Above Foundation Code Wall	*1675* (A.7.)	0.110	0.080	*184*
3. Floor Over Interior Unconditioned Space	(A.9.)	0.050	0.050	
4. Roof or Ceiling	*1500* (A.10.)	0.026	0.020	*39*
5. Floor Over Exterior	(A.11.)	0.033	0.033	
6. Crawl Space Wall	(A.12.)	0.060	0.060	
7. Slab On Grade ☐ Unheated ☐ Heated [3]	(A.13.) Lin. ft.	0.72 'F' 0.70 'F'	0.68 'F' 0.68' F'	
8. Subtotal				*336*
9. Credit for High Efficiency Heating Plant: 1.18 for furnace or boiler >90% AFUE; 1.15 for heat pump> 7.8 HPSF, Otherwise use 1.0				× *1.18*
10.		**Total Code-Allowed Heat Loss Factor**		*396.5*

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D. System Design Method - Actual 'U' Values Of Your Home's Components

D.1. Above-Foundation Components - If applicable, check the appropriate typical component constructions listed below, and use the pre-calculated U values. If your wall construction is not listed, you may obtain a pre-calculated U value from the default U-Value tables in the UDC Appendix. (Note that the default Table 2 Wood Frame U-values assume no insulating sheathing which penalizes you if your wall does have insulating sheathing, then you may need to use the Manual Calculation section below.) If you are using exterior metal framing, then you must use the Metal-Frame Wall U-Values of the UDC Appendix. If your component construction is not listed here or in the default tables, you need to use the Manual Calculation section below to manually enter R-values for the different layers of building materials from the Typical Thermal Properties of Building Materials Table of the UDC Appendix, ASHRAE Fundamentals Manual or manufacturer's specifications. Total them across and then obtain the U-value by taking the reciprocal (1/R) of the total R-value.

Above-Foundation Walls	☐ 2X4, 16" O.C., R-13 batt, R-1 board: U - .079 ☐ 2X6, 16" O.C., R-19 batt, R-1 board: U - .059	☐ 2X4, 16" O.C., R-13 batt, R-5 board: U - .061 ☐ 2X6, 16" O.C., R-19 batt, R-5 board: U - .049	
☐ Other - describe:		U -	from Default Table
Roof or Ceiling	☐ 2X4 truss, 24" O.C., with R-38 insulation: U - .030 ☐ 2X12 cathedral ceiling, 16" O.C., with R-38 insulation U - .027	☐ 2X4 truss, 24" O.C., with R-52 insulation: U - .025	
☒ Other - describe: ***R40 with regular trusses***		U - ***0.029***	from Default Table ***1***
Floor Over Exterior or Unconditioned Space	☐ 2X10 joists, 16" O.C., R-19 batt: U - .047		
☐ Other - describe:		U -	from Default Table

Optional Manual U-Value Calculation (if assembly not listed above)

Component Name	Cavity Or Solid If Applicable	Ext. Air Film*	Ext. Finish	Insulation Over Framing	Shea-thing	Framing Or Solid	Insulation Within Cavity	Inter-ior Finish	Int. Air Film*	Total R-Value	U-Value
Above Foundation Wall	Cavity	***.17***	***0.79***	***5.0***		---------	***13***	***0.56***	***.68***	***20.2***	***.050***
	Solid	***.17***	***0.79***	***5.0***		***4.4***	----------	***0.56***	***.68***	***11.6***	***.086***
	Cavity					---------					
	Solid						----------				

*** Air Film R-Values**

Location	Heat Flow Direction		
	Upwards	Horizontal	Downwards
Exterior	.17	.17	.17
Interior	.61	.68	.92

D.2. Foundation And Slab-On-Grade Components - Check appropriate boxes for planned type of construction to determine pre-calculated overall 'U-value' including air films, wall, insulation, soil and cavity/solid differences. Slab on grade F-values are per lineal foot of slab perimeter.

Component Type	U-Value	
Foundation Wall	**Basement**	**Crawl Space**
☐ Masonry or concrete wall without insulation	0.360	0.477
☒ Masonry or concrete wall with R-5 insulation board for full height	0.115	0.136
☐ Masonry or concrete wall with R-10 insulation board or R-11 insulation batt and 2X4's for full height	0.072	0.081
☐ Permanent wood foundation with R-19 batt for full height	0.054	0.059
☐ Basement or crawl space floor without insulation	0.025	0.025
☐ Basement floor with R-5 insulation	0.022	0.022
Slab-On-Grade (or within 12" of grade)	**F-Value**	
☐ Slab-on-grade without insulation	1.04	
☐ Slab-on-grade with R-5 insulation for 48" total horizontal and vertical application	0.74	
☐ Slab-on-grade with R-10 insulation board for 48" total application	0.68	

D.3. Windows And Doors - Use manufacturer's specifications for window and glazed door values, if they were determined per NFRC Std 100, to enter into Table E. Otherwise see default tables of UDC s. Comm 22.05 for U-values.

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E. System Design Method - Calculated Envelope Heat Loss Factor Of Your Home

Enter values into table from elsewhere on this worksheet and multiply across to find the actual heat loss factor of each component. If using pre-calculated component U-values, **do not calculate separate cavity and solid figures or apply wood frame factors**. Total component heat loss factors in right column to find total envelope heat loss factors.

Component	Cavity Or Solid If Applicable	Area From Sect. A	× Wood Frame Factor**	× Actual 'U' Value From Sect. D	= Heat Loss Factor (UA)
Above-Foundation Windows	----------	150 (A.1.a.)	----------	0.35	52.5
Foundation Windows	----------	20 (A.1.b)	----------	0.87	17.4
Doors	----------	38 (A.2.c)	----------	0.35	13.3
Opaque Basement Wall	----------	1468 (A.5.)	----------	0.115	168.8
Opaque Above-Foundation Wall	Cavity		.75	.050	55
	Solid	1467 (A.8.)	.25	.086	31.5
Floor Over Unconditioned Spaces	Cavity				
	Solid	(A.9.)			
Roof or Ceiling	Cavity				
	Solid	1500 (A.10.)		0.029	43.5
Floor Over Exterior	Cavity				
	Solid	(A.11.)			
Crawl Space Wall	----------	(A.12.)	----------		
Slab On Grade	----------	(A.13.)Lin. ft.	----------	F-Value	
Total Calculated Envelope Heat Loss Factor- Not to exceed Total Code Allowed Heat Loss Factor of line 10 of Section C. (Enter here: 396.5)by more than 1%					382

** Adjustment Factors For Wood-Framed Components - Do not apply if your are using a pre-calculated or default U-Value.

Spacing Of Framing Members	Stud Walls		Joists/Rafters	
	Cavity	Solid	Cavity	Solid
12"	.70	.30	.86	.14
16"	.75	.25	.90	.10
24"	.78	.22	.93	.07

F. Heat Loss Factor Due to Air Infiltration (for heating equipment sizing)

Enter appropriate values. A maximum infiltration air change rate of 0.5 per hour is allowed in addition to ventilation losses.

Floor Level	Area (sq ft)	× Height (ft)	Fan Capacity (cfm)	× Constant	× Air Changes Per Hour	= Heat Loss Factor(UA)
Basement	1500	8	---------	.018	0.3	64.8
Level 1	1500	8	---------	.018	0.3	64.8
Level 2			---------	.018		
Level 3			---------	.018		
Ventilation	----------	----------	170	.432	----------	73.4
Total Infiltration & Ventilation Heat Loss Factor						203

G. Heating Equipment Sizing

Enter appropriate value to determine the maximum and minimum allowable heating equipment capacity in BTUs/HR. A more detailed calculation may be submitted to the local code official. [4]

Prescriptive Package Method:	0.086 **U overall** from selected Prescriptive Package of Section B	×	4643 Total Envelope Area (A.14.)	= 399.3
OR System Design Method: Calculated Heat Loss Factor from Sect. E.				
Infiltration & Ventilation Heat Loss Factor (from Sect. F.)				+ 203
Total Heat Loss Factor (UA)				= 602.3
Temperature Difference from Zone Table on page 1				× 85
Minimum Heating Equipment Output				= 51,196
Allowable Heating Equipment Size Margin Multiplier				× 1.15
Maximum Allowable Heating Equipment Output [5]				= 58,875
Planned Furnace Output Or Boiler IBR Rating				60,000
Make & Model if High Efficiency Credit has been taken: Acme XLH60K				

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Prescriptive Package Tables (Corrected)

(See notes on page 2 of Energy Worksheet; I = insulating sheathing, RT = raised heel roof truss)

Table B-1 Prescriptive packages, Non-electric Heat, Structural Sheathing only

Package	Glazing Factor	R wall	R ceiling	R basement	U door	U overall	HVAC Equipment Efficiency
1	0.0370	R21	R42	R7	0.35	0.073	Normal
2	0.0264	R21	R51, RT	R5	0.35	0.073	Normal
3	0.0333	R15	R42	R10	0.35	0.073	Normal
4	0.0440	R19	R33	R10	0.35	0.073	Normal
5	0.0330	R13	R42	R11	0.35	0.073	Normal
6	0.0480	R19	R33	R11	0.35	0.073	Normal
7	0.0600	R21	R47	R11	0.35	0.073	Normal
8	0.0407	R13	R44	R13	0.35	0.073	Normal
9	0.0600	R19	R42	R13	0.35	0.073	Normal
10	0.0680	R21	R38, RT	R13	0.35	0.073	Normal
11	0.0296	R13	R49	R5	0.35	0.086	High
12	0.0440	R19	R30	R5	0.35	0.086	High
13	0.0520	R21	R33	R5	0.35	0.086	High
14	0.0720	R13	R47	R10	0.35	0.086	High
15	0.0784	R19	R38	R10	0.47	0.086	High
16	0.0640	R13	R33	R11	0.47	0.086	High
17	0.0896	R19	R49	R11	0.35	0.086	High
18	0.0896	R21	R34	R11	0.35	0.086	High
19	0.0920	R19	R34	R11	0.47	0.086	High
20	0.0840	R13	R49	R13	0.35	0.086	High
21	0.0840	R19	R30	R13	0.47	0.086	High
22	0.0896	R21	R31	R13	0.47	0.086	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R crawl**	**U door**	**U overall**	**HVAC Equipment Efficiency**
23	0.0520	R19	R34	R19	0.47	0.070	Normal
24	0.0672	R13	R36	R19	0.47	0.083	High
25	0.0720	R13	R33	R19	0.47	0.083	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R slab**	**U door**	**U overall**	**HVAC Equipment Efficiency**
26	0.0560	R21	R36	R5	0.47	0.103	Normal
27	0.0728	R13	R36	R5	0.47	0.121	High
28	0.0760	R13	R34	R5	0.47	0.121	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R heated-slab**	**U door**	**U overall**	**HVAC Equipment Efficiency**
29	0.0560	R21	R47	R5	0.47	0.101	Normal
30	0.0728	R13	R42	R5	0.47	0.120	High
31	0.0760	R13	R38	R5	0.47	0.120	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R floor**	**U door**	**U overall**	**HVAC Equipment Efficiency**
32	0.0480	R19	R47	R19	0.35	0.065	Normal
33	0.0728	R19	R36	R19	0.47	0.077	High
34	0.0560	R13	R34	R19	0.47	0.077	High

Table B-2 Prescriptive packages, Non-electric Heat, Insulating Sheathing

Package	Glazing Factor	R wall	R ceiling	R basement	U door	U overall	HVAC Equipment Efficiency
35	0.0370	R20, I	R42	R7	0.35	0.073	Normal
36	0.0363	R28, I	R38, RT	R5	0.35	0.073	Normal
37	0.0552	R18, I	R44	R10	0.35	0.073	Normal
38	0.0560	R20, I	R47	R10	0.35	0.073	Normal
39	0.0560	R23, I	R34	R10	0.35	0.073	Normal
40	0.0560	R18, I	R47	R11	0.35	0.073	Normal
41	0.0616	R23, I	R42	R11	0.35	0.073	Normal
42	0.0546	R18, I	R44	R11	0.35	0.073	Normal
43	0.0672	R23, I	R40	R13	0.35	0.073	Normal
44	0.0720	R25, I	R36	R13	0.35	0.073	Normal
45	0.0504	R18, I	R40	R5	0.35	0.086	High
46	0.0560	R19, I	R47	R5	0.35	0.086	High
47	0.0560	R23, I	R38	R5	0.47	0.086	High
48	0.0600	R25, I	R38	R5	0.47	0.086	High
49	0.0680	R26, I	R42	R5	0.35	0.086	High
50	0.0680	R28, I	R47	R5	0.47	0.086	High
51	0.0672	R26, I	R47	R5	0.35	0.086	High
52	0.0672	R28, I	R38	R5	0.35	0.086	High
53	0.0720	R20, I	R42	R7	0.47	0.086	High
54	0.0855	R18, I	R36	R11	0.35	0.086	High

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Wisconsin Uniform Dwelling Code
Energy Worksheet

Instructions: This worksheet is a Safety & Buildings Division (S&BD)-approved method of manually showing compliance with the energy conservation and heating equipment sizing requirements of the Uniform Dwelling Code (UDC), for new dwelling permits **submitted on or after February 1, 1999**. It may be necessary for the user to purchase a copy of the UDC from State Document Sales, (608)266-3358. Additional information is printed in the UDC Commentary, which is available for a fee, as are blank copies of this form, from S&BD at POB 2509, Madison, WI 53701, Tel. 608-267-4405. **Earlier editions of this worksheet may NOT be used**. Numbers in brackets, [1], refer to the footnotes printed on page 2.

You may also submit completed worksheets from the computer program WIS*check*, which is available for free download from http://www.energycodes.org/ on the Internet.

A required U-value is the **maximum** acceptable heat transmittance for an element. A required insulation R-value is the **minimum** acceptable level of resistance to heat transmittance. (U-values and R-values are reciprocals of each other.) If a component includes two or more areas of different insulation levels, either use the less insulating value for both areas, or use the Optional Weighted Average table in the **Prescriptive Package Method** section or enter separate areas and insulation values in the **System Design Method**. All "U" values must be carried to four places after the decimal point, rounded to three places. Other values may be rounded to the whole number.

Window and door U-values must be tested and documented by the manufacturer in accordance with the National Fenestration Rating Council (NFRC) test procedures or be taken from the glazing U-value table in s. Comm 22.05. Center-of-glass U-values cannot be used. If a door contains glass and an aggregate U-value rating for that door is not available, include the glass area of the door with your windows and use the opaque door U-value to determine compliance of the door.

The code gives credit for **high-efficiency heating equipment**. "High-Efficiency" means a furnace with an AFUE of 90% or more, or a heat pump with an HSPF of 7.8 or more without the use of electric resistance backup heat of greater than 3 kilowatts. If you plan to install more than one piece of heating equipment, the equipment with the lowest efficiency must exceed the efficiency required by the selected package.

Choice of Method: You have the choice of using the Prescriptive Package Method or the System Design Method to show code compliance. For the simpler **Prescriptive Package Method** , which is recommended for standard designs, complete Sections **A., B., F., and G**. Instructions are on page 2. You will be first calculating component areas, then comparing your planned insulation levels to the required insulation levels of the Prescriptive Packages. You will then calculate infiltration and ventilation heat losses to size your heating equipment. If you cannot comply with one of the prescriptive packages, you may be able to show compliance by the System Design Method.

For the **System Design Method**, which is recommended for alternative designs in which more insulation is installed in one component to offset less in another, complete **Sections A., C., D., E., F. and G.** You will be first calculating component areas, then a code-allowed heat loss factor, then component U- and R-values and then your calculated heat loss factor which you will compare to the code-allowed heat loss factor. You will then calculate infiltration and ventilation heat losses to size your heating equipment.

The **County Zone Table** below is use for determining the temperature difference for sizing your heating plant in Section G. You may submit to your local code official more exact calculations to size your heating equipment.

Zone 1 - 95 degrees	Zone 2 - 90 degrees	Zone 3 - 85 degrees	Zone 4 - 80 degrees
Ashland, Barron, Bayfield, Burnett, Chippewa, Douglas, Dunn, Florence, Forest, Iron, Lincoln, Oneida, Pierce, Polk, Price, Rusk, Saint Croix, Sawyer, Taylor, Vilas, Washburn	Adams, Buffalo, Clark, Eau Claire, Jackson, Juneau, LaCrosse, Langlade, Marathon, Marinette, Menominee, Monroe, Portage, Shawano, Oconto, Pepin, Trempeleau, Vernon, Waupaca, Wood	Brown, Calumet, Columbia, Crawford, Dane, Dodge, Door, Fond du Lac, Grant, Green, Green Lake, Iowa, Kewaunee, LaFayette, Manitowoc, Marquette, Outagamie, Richland, Sauk, Sheboygan, Waushara, Winnebago	Jefferson, Kenosha, Milwaukee, Ozaukee, Racine, Rock, Walworth, Washington, Waukesha

SBD-5518 (R. 12/98) Corr.

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Detailed Instructions for Section B. Prescriptive Package Method:

R-value requirements are for insulation only and do not include structural components.

For a component with two or more areas of different insulation levels, either use the least insulating value for both areas or use the Weighted Average tables on page 4.

Wall R-values represent the sum of the wall cavity insulation plus insulating sheathing, if used. Do not include exterior siding, structural sheathing or interior drywall. For example, an R-20 requirement could be met *EITHER* by R-15 cavity insulation plus R-5 sheathing *OR* R-13 cavity insulation plus R-7 sheathing. Note that there are separate tables for walls with structural sheathing only and for walls with insulating sheathing. To use a table for insulating sheathing, the sheathing used must be at least R-4, except that at least R-2 insulation may be provided over corner bracing. Table wall R-Values apply to wood-frame or mass (concrete, masonry, log) wall assemblies, but not to metal-frame construction. If metal frame is planned, use the adjusted R-Values from the Metal-Frame Wall Tables of the UDC Appendix. Table wall values apply to boxsills.

Ceiling R-values represent the sum of the cavity insulation plus insulating sheathing, if used. For ventilated ceilings, any insulating sheathing must be placed between the conditioned space and the ventilated portion of the roof. Ceiling R-values with **"RT"** indicates that a raised-heel truss or oversized truss construction must be used so that the insulation achieves the full insulation thickness over the exterior walls.

Floor requirements apply to floors over unconditioned spaces (such as un-insulated crawlspaces, basements and garages). Floors over outside air shall have a Uoverall = 0.033 or R-30 added insulation.

"Heated-Slab" requirements apply to slabs that contain heat ducts or pipes. All slab insulation must extend at least 48 inches either 1) down from the top of the slab, or 2) down from the top of the slab to the bottom of the slab and then horizontally underneath the slab, or 3) down from the top of the slab to the bottom of the slab and then horizontally away from the slab, with pavement or at least 10 inches of soil covering the horizontal insulation.

Walls of basements below un-insulated floors must be insulated from the top of the basement wall to the level of the basement floor. Conditioned basement windows and glass doors must be included with the other glazing. Exterior basement doors must meet the door U-value requirements. If more than 50% of the basement is exposed, then all of the basement walls must instead meet the above-foundation wall requirements.

Crawl space wall R-value requirements are for walls of unventilated crawlspaces. The crawlspace wall insulation must extend from the top of the wall (including the sill plate) to at least 12 inches below the outside finished grade. If the distance from the outside finished grade to the top of the footing is less than 12 inches, the insulation must extend a total vertical plus horizontal distance of 24 inches from the outside finished grade.

Footnotes for worksheet:

[1] Opaque wall area is wall area minus opening areas of doors and windows.

[2] These below-grade U-values have the insulating value of the soil added to the code-required U-values which apply to the building materials only. See Sect. D.2. for typical insulated component U-values.

[3] These slab-on-grade F-values are derived from the code-required U-values and include the heat loss through the edge and body of the slab. See Sect. D.2. Temperature difference is the same as for above-grade spaces.

[4] For building additions, show that the existing heating equipment, if used to heat the addition, is large enough. To do so, you must calculate the heat loss of the whole building.

[5] If desired manufacturer does not have a furnace of this size, then a designer may select the manufacturer's next larger size.

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Submit completed worksheet pages 3-6 with dwelling plans to local enforcing municipality.

Project Address: _____

Builder: _____ Owner: _____

Worksheet Completed By: _____ Date: _____

Does dwelling unit have three kilowatts or more input capacity of permanently installed electrical space heating equipment?

☐ YES (see below) ☐ NO

You will need to apply the stricter standards shown for electrically-heated homes if you answered "YES" to the above question.

A. Area Calculations

Enter appropriate dimensions to obtain area values. Some calculations will not be necessary depending on home design or calculation method. These calculated areas are referenced elsewhere on this worksheet, for example, "(A.1.)".

1. Window, Skylight & Patio Door Area (overall unit area) a. In Above-Foundation Walls _____ sq. ft. b. In Foundation Walls _____ sq. ft. c. Total (a. + b.) = _____	2. Opaque Door Area a. In Above- Foundation Walls _____ sq. ft. b. In Foundation Walls _____ sq. ft. c. Total (a. + b.) = _____
3. Gross Exposed Basement Wall Area _____ sq. ft.	4. Basement Wall Area Below Grade _____ sq. ft.
5. Opaque [1] Basement Wall Area (A.3. + A.4. - A.1.b.- A.2.b.) _____ sq. ft. If the exposed area of A.3.is greater than the below grade area of A.4., add A.5. to A.7 and cross out the number in this cell.	6. Gross Heated Above-Foundation Wall Area, **including boxsill** _____ sq. ft.
7. Above Foundation Code Wall Area (A.6. + A1.b. + A.2.b.) _____ sq. ft.	8. Opaque [1] Above-Foundation Wall Area (A.6. - A1.a. - A.2.a.) _____ sq. ft.
9. Floor Area Over Interior Unconditioned Spaces Less Than 50° _____ sq. ft.	10. Insulated Roof Or Ceiling (less skylights) _____ sq. ft.
11. Exterior Floor Area (Overhangs) _____ sq. ft.	12. Crawl Space Wall Area _____ sq. ft.
13. Slab On Grade (above or less than 12 inches below grade) _____ lineal feet of slab perimeter	14. Total Heated Envelope Area (A.5 + A.7 + A.9 + A.10 +A.11 + A.12 +(A.13. × 2')) _____ sq. ft.
15. Percent Glazing (for Prescriptive Package Method, Section B, only) (A.1.c. ÷ A.7. × 100%) _____ %	16. Windows Description - Above-Foundation Windows: Frame type: ☐ Wood or Wood Clad ☐ Vinyl ☐ Metal Glazing type: ☐ Dual ☐ Triple ☐ Dual w/storm panel Dual-Glazing Air Space: ☐ 1/4' ☐ 3/8" ☐ 1/2" or more Features: ☐ Low-E ☐ Argon-filled ☐ Suspended film Foundation Windows: ☐ Vinyl ☐ Metal

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B. Prescriptive Package Method (Skip this section if using the System Design Method of Sections C-F)
The prescriptive package method is the simplest method for determining compliance with the UDC insulation and window requirements. To use the prescriptive package method, enter your actual design values in the "Actual " row below. **For a component, with two or more areas of different insulation levels, such as windows,** either use the least insulating value for both areas or use the Weighted Average tables below. Multiply your % glazing by the glazing U-value to obtain your "Glazing Factor". Find the Prescriptive Table that applies to your space heating fuel and sheathing type. Select a package from the table that most closely matches the construction indicated on your plans. **Do not exceed the package U-values or glazing factor or fall below the package R-values with your design.** Transfer the R-Values and U-values to the blank table below in the "Allowed" row. Then proceed to Section F. See page 2 for detailed instructions for this section.

	Package #	% glazing	U glazing	Glazing Factor (% glazing × U glazing)	R wall	R ceiling	R Bsmt, Crawl Space, Slab or Floor	U door	U overall	Equip. Eff.
Actual	------	% (A.15)							----------	
Allowed		----------	----------	Max	Min	Min	Min	Max		

(Please go to Section F.)

Optional R-Value/U-Value Weighted Average Table for Component:

Component Construction Description	R Value	U-Value (1÷R Value)	Area (sq ft)	U-Value × Area (UA)
			Total Area =	Total UA =

_____ ÷ _____ = _____
(Total UA) (Total Area) (Weighted Average U-Value (for windows or doors))

_____ ÷ _____ = _____
(Total Area) (Total UA) (Weighted Average R-Value (for all other components))

Optional R-Value/U-Value Weighted Average Table for Component:

Component Construction Description	R Value	U-Value (1÷R Value)	Area (sq ft)	U-Value × Area (UA)
			Total Area =	Total UA =

_____ ÷ _____ = _____
(Total UA) (Total Area) (Weighted Average U-Value (for windows or doors))

_____ ÷ _____ = _____
(Total Area) (Total UA) (Weighted Average R-Value (for all other components))

C. Code-Allowed Heat Loss For System Design Method
Enter area values from Section A as notated and temperature differences per footnote 2 into this table and then multiply across by the electric or non-electric code-required U-value. Total the right column to find the total allowed heat loss factor.

Component	**Area From Sect A.**	**× Required U-Value**		**= Heat Loss UA**
		☐ NON-ELEC	☐ ELECTRIC	
1. Opaque Basement Wall [2]	(A.5.)	0.077 [3]	0.077 [3]	
2. Above Foundation Code Wall	(A.7.)	0.110	0.080	
3. Floor Over Interior Unconditioned Space	(A.9.)	0.050	0.050	
4. Roof or Ceiling	(A.10.)	0.026	0.020	
5. Floor Over Exterior	(A.11.)	0.033	0.033	
6. Crawl Space Wall	(A.12.)	0.060	0.060	
7. Slab On Grade ☐ Unheated ☐ Heated [3]	(A.13.) Lin. ft.	0.72 'F' 0.70 'F'	0.68 'F' 0.68' F'	
8. Subtotal				
9. Credit for High Efficiency Heating Plant: 1.18 for furnace or boiler >90% AFUE; 1.15 for heat pump> 7.8 HPSF, Otherwise use 1.0				×
10.		**Total Code-Allowed Heat Loss Factor**		

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D. System Design Method - Actual 'U' Values Of Your Home's Components

D.1. Above-Foundation Components - If applicable, check the appropriate typical component constructions listed below, and use the pre-calculated U values. If your wall construction is not listed, you may obtain a pre-calculated U value from the default U-Value tables in the UDC Appendix. (Note that the default Table 2 Wood Frame U-values assume no insulating sheathing which penalizes you if your wall does have insulating sheathing, then you may need to use the Manual Calculation section below.) If you are using exterior metal framing, then you must use the Metal-Frame Wall U-Values of the UDC Appendix. If your component construction is not listed here or in the default tables, you need to use the Manual Calculation section below to manually enter R-values for the different layers of building materials from the Typical Thermal Properties of Building Materials Table of the UDC Appendix, ASHRAE Fundamentals Manual or manufacturer's specifications. Total them across and then obtain the U-value by taking the reciprocal (1/R) of the total R-value.

Above-Foundation Walls	☐ 2X4, 16" O.C., R-13 batt, R-1 board: U - .079 ☐ 2X6, 16" O.C., R-19 batt, R-1 board: U - .059	☐ 2X4, 16" O.C., R-13 batt, R-5 board: U - .061 ☐ 2X6, 16" O.C., R-19 batt, R-5 board: U - .049
☐ Other - describe:		U - from Default Table
Roof or Ceiling	☐ 2X4 truss, 24" O.C., with R-38 insulation: U - .030 ☐ 2X12 cathedral ceiling, 16" O.C., with R-38 insulation U - .027	☐ 2X4 truss, 24" O.C., with R-52 insulation: U - .025
☐ Other - describe:		U - from Default Table
Floor Over Exterior or Unconditioned Space	☐ 2X10 joists, 16" O.C., R-19 batt: U - .047	
☐ Other - describe:		U - from Default Table

Manual U-Value Calculation (if assembly not listed above)

Component Name	Cavity Or Solid If Applicable	Ext. Air Film*	Ext. Finish	Insulation Over Framing	Shea-thing	Framing Or Solid	Insulation Within Cavity	Inter-ior Finish	Int. Air Film*	Total R-Value	U-Value
	Cavity					----------					
	Solid						----------				
	Cavity					----------					
	Solid						----------				

*** Air Film R-Values**

Location	Heat Flow Direction		
	Upwards	Horizontal	Downwards
Exterior	.17	.17	.17
Interior	.61	.68	.92

D.2. Foundation And Slab-On-Grade Components - Check appropriate boxes for planned type of construction to determine pre-calculated overall 'U-value' including air films, wall, insulation, soil and cavity/solid differences. Slab on grade F-values are per lineal foot of slab perimeter.

Component Type	U-Value	
Foundation Wall	**Basement**	**Crawl Space**
☐ Masonry or concrete wall without insulation	0.360	0.477
☐ Masonry or concrete wall with R-5 insulation board for full height	0.115	0.136
☐ Masonry or concrete wall with R-10 insulation board or R-11 insulation batt and 2X4's for full height	0.072	0.081
☐ Permanent wood foundation with R-19 batt for full height	0.054	0.059
☐ Basement or crawl space floor without insulation	0.025	0.025
☐ Basement floor with R-5 insulation	0.022	0.022
Slab-On-Grade (or within 12 " of grade)	**F-Value**	
☐ Slab-on-grade without insulation	1.04	
☐ Slab-on-grade with R-5 insulation for 48" total horizontal and vertical application	0.74	
☐ Slab-on-grade with R-10 insulation board for 48" total application	0.68	

D.3. Windows And Doors - Use manufacturer's specifications for window and glazed door values, if they were determined per NFRC Std 100, to enter into Table E. Otherwise see default tables of UDC s. Comm 22.05 for U-values.

SBD-5518 (R. 12/98) Corr

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E. System Design Method - Calculated Envelope Heat Loss Factor Of Your Home

Enter values into table from elsewhere on this worksheet and multiply across to find the actual heat loss factor of each component. If using pre-calculated component U-values, **do not calculate separate cavity and solid figures or apply wood frame factors**. Total component heat loss factors in right column to find total envelope heat loss factors.

Component	Cavity Or Solid If Applicable	Area From Sect. A	× Wood Frame Factor**	× Actual 'U' Value From Sect. D	= Heat Loss Factor (UA)
Above-Foundation Windows	----------	(A.1.a.)	----------		
Foundation Windows	----------	(A.1.b)	----------		
Doors	----------	(A.2.c)	----------		
Opaque Basement Wall	----------	(A.5.)	----------		
Opaque Above-Foundation Wall	Cavity				
	Solid	(A.8.)			
Floor Over Unconditioned Spaces	Cavity				
	Solid	(A.9.)			
Roof or Ceiling	Cavity				
	Solid	(A.10.)			
Floor Over Exterior	Cavity				
	Solid	(A.11.)			
Crawl Space Wall	----------	(A.12.)	----------		
Slab On Grade	----------	(A.13.)Lin. ft.	----------	F-Value	
Total Calculated Envelope Heat Loss Factor- Not to exceed Total Code Allowed Heat Loss Factor of line 10 of Section C. (Enter here: _____)by more than 1%					

** Adjustment Factors For Wood-Framed Components - Do not apply if your are using a pre-calculated or default U-Value.

Spacing Of Framing Members	Stud Walls		Joists/Rafters	
	Cavity	Solid	Cavity	Solid
12"	.70	.30	.86	.14
16"	.75	.25	.90	.10
24"	.78	.22	.93	.07

F. Heat Loss Factor Due to Air Infiltration (for heating equipment sizing)

Enter appropriate values. A maximum infiltration air change rate of 0.5 per hour is allowed in addition to ventilation losses.

Floor Level	Area (sq ft)	× Height (ft)	Fan Capacity (cfm)	× Constant	× Air Changes Per Hour	= Heat Loss Factor(UA)
Basement			---------	.018		
Level 1			---------	.018		
Level 2			---------	.018		
Level 3			---------	.018		
Ventilation	----------	----------		.432	----------	
Total Infiltration & Ventilation Heat Loss Factor						

G. Heating Equipment Sizing

Enter appropriate value to determine the maximum and minimum allowable heating equipment capacity in BTUs/HR. A more detailed calculation may be submitted to the local code official. [4]

Prescriptive Package Method: _____ **U overall** from selected Prescriptive Package of Section B × _____ Total Envelope Area (A.14.) =	
OR System Design Method: Calculated Heat Loss Factor from Sect. E.	
Infiltration & Ventilation Heat Loss Factor (from Sect. F.)	+
Total Heat Loss Factor (UA)	=
Temperature Difference from **County Zone Table** on page 1	×
Minimum Heating Equipment Output	=
Allowable Heating Equipment Size Margin Multiplier	× 1.15
Maximum Allowable Heating Equipment Output [5]	=
Planned Furnace Output Or Boiler IBR Rating	
Make & Model if High Efficiency Credit has been taken:	

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Prescriptive Package Tables (Corrected)

(See notes on page 2 of Energy Worksheet: I = insulating sheathing, RT = raised heel roof truss)

Table B-1 Prescriptive packages, Non-electric Heat, Structural Sheathing only

Package	Glazing Factor	R wall	R ceiling	R basement	U door	U overall	HVAC Equipment Efficiency
1	0.0370	R21	R42	R7	0.35	0.073	Normal
2	0.0264	R21	R51, RT	R5	0.35	0.073	Normal
3	0.0333	R15	R42	R10	0.35	0.073	Normal
4	0.0440	R19	R33	R10	0.35	0.073	Normal
5	0.0330	R13	R42	R11	0.35	0.073	Normal
6	0.0480	R19	R33	R11	0.35	0.073	Normal
7	0.0600	R21	R47	R11	0.35	0.073	Normal
8	0.0407	R13	R44	R13	0.35	0.073	Normal
9	0.0600	R19	R42	R13	0.35	0.073	Normal
10	0.0680	R21	R38, RT	R13	0.35	0.073	Normal
11	0.0296	R13	R49	R5	0.35	0.086	High
12	0.0440	R19	R30	R5	0.35	0.086	High
13	0.0520	R21	R33	R5	0.35	0.086	High
14	0.0720	R13	R47	R10	0.35	0.086	High
15	0.0784	R19	R38	R10	0.47	0.086	High
16	0.0640	R13	R33	R11	0.47	0.086	High
17	0.0896	R19	R49	R11	0.35	0.086	High
18	0.0896	R21	R34	R11	0.35	0.086	High
19	0.0920	R19	R34	R11	0.47	0.086	High
20	0.0840	R13	R49	R13	0.35	0.086	High
21	0.0840	R19	R30	R13	0.47	0.086	High
22	0.0896	R21	R31	R13	0.47	0.086	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R crawl**	**U door**	**U overall**	**HVAC Equipment Efficiency**
23	0.0520	R19	R34	R19	0.47	0.070	Normal
24	0.0672	R13	R36	R19	0.47	0.083	High
25	0.0720	R13	R33	R19	0.47	0.083	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R slab**	**U door**	**U overall**	**HVAC Equipment Efficiency**
26	0.0560	R21	R36	R5	0.47	0.103	Normal
27	0.0728	R13	R36	R5	0.47	0.121	High
28	0.0760	R13	R34	R5	0.47	0.121	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R heated-slab**	**U door**	**U overall**	**HVAC Equipment Efficiency**
29	0.0560	R21	R47	R5	0.47	0.101	Normal
30	0.0728	R13	R42	R5	0.47	0.120	High
31	0.0760	R13	R38	R5	0.47	0.120	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R floor**	**U door**	**U overall**	**HVAC Equipment Efficiency**
32	0.0480	R19	R47	R19	0.35	0.065	Normal
33	0.0728	R19	R36	R19	0.47	0.077	High
34	0.0560	R13	R34	R19	0.47	0.077	High

Table B-2 Prescriptive packages, Non-electric Heat, Insulating Sheathing

Package	Glazing Factor	R wall	R ceiling	R basement	U door	U overall	HVAC Equipment Efficiency
35	0.0370	R20, I	R42	R7	0.35	0.073	Normal
36	0.0363	R28, I	R38, RT	R5	0.35	0.073	Normal
37	0.0552	R18, I	R44	R10	0.35	0.073	Normal
38	0.0560	R20, I	R47	R10	0.35	0.073	Normal
39	0.0560	R23, I	R34	R10	0.35	0.073	Normal
40	0.0560	R18, I	R47	R11	0.35	0.073	Normal
41	0.0616	R23, I	R42	R11	0.35	0.073	Normal
42	0.0546	R18, I	R44	R11	0.35	0.073	Normal
43	0.0672	R23, I	R40	R13	0.35	0.073	Normal
44	0.0720	R25, I	R36	R13	0.35	0.073	Normal
45	0.0504	R18, I	R40	R5	0.35	0.086	High
46	0.0560	R19, I	R47	R5	0.35	0.086	High
47	0.0560	R23, I	R38	R5	0.47	0.086	High
48	0.0600	R25, I	R38	R5	0.47	0.086	High
49	0.0680	R26, I	R42	R5	0.35	0.086	High
50	0.0680	R28, I	R47	R5	0.47	0.086	High
51	0.0672	R26, I	R47	R5	0.35	0.086	High
52	0.0672	R28, I	R38	R5	0.35	0.086	High
53	0.0720	R20, I	R42	R7	0.47	0.086	High
54	0.0855	R18, I	R36	R11	0.35	0.086	High

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55	0.0896	R23, I	R33	R11	0.47	0.086	High
56	0.0861	R18, I	R36	R13	0.47	0.086	High
57	0.1000	R23, I	R33	R13	0.47	0.086	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R crawl**	**U door**	**U overall**	**HVAC Equipment Efficiency.**
58	0.0546	R18, I	R38	R19	0.47	0.070	Normal
59	0.0784	R15, I	R30	R19	0.47	0.083	High
60	0.0880	R15, I	R38	R19	0.47	0.083	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R slab**	**U door**	**U overall**	**HVAC Equipment Efficiency**
61	0.0640	R23, I	R36	R5	0.47	0.103	Normal
62	0.0896	R15, I	R36	R5	0.47	0.121	High
63	0.0960	R15, I	R38	R5	0.47	0.121	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R heated-slab**	**U door**	**U overall**	**HVAC Equipment Efficiency**
64	0.0640	R23, I	R34	R5	0.47	0.101	Normal
65	0.0840	R15, I	R31	R5	0.47	0.121	High
66	0.0920	R15, I	R33	R5	0.47	0.121	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R floor**	**U door**	**U overall**	**HVAC Equipment Efficiency**
67	0.0480	R20, I	R44	R19	0.35	0.065	Normal
68	0.0728	R20, I	R36	R19	0.47	0.077	High
69	0.0560	R14, I	R38	R19	0.47	0.078	High

Table B-3 Prescriptive packages, Electric Heat, Structural Sheathing Only

Package	**Glazing Factor**	**R wall**	**R ceiling**	**R basement**	**U door**	**U overall**	**HVAC Equipment Efficiency**
E 70	0.0396	R21	R37, RT	R19	0.35	0.059	Normal
E 71	0.0429	R21	R42, RT	R19	0.35	0.059	Normal
E 72	0.0520	R21	R49	R13	0.35	0.068	High
E 73	0.0640	R19	R42, RT	R19	0.35	0.068	High
E 74	0.0693	R21	R49, RT	R19	0.47	0.068	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R crawl**	**U door**	**U overall**	**HVAC Equipment Efficiency**
E 75	0.0429	R21	R54, RT	R30	0.35	0.054	Normal
E 76	0.0480	R21	R45, RT	R19	0.35	0.062	High
E 77	0.0627	R21	R54, RT	R30	0.47	0.062	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R slab**	**U door**	**U overall**	**HVAC Equipment Efficiency**
E 78	0.0396	R26	R51, RT	R10	0.35	0.083	Normal
E 79	0.0480	R21	R49	R7	0.35	0.095	High
E 80	0.0528	R21	R49, RT	R5	0.35	0.095	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R floor**	**U door**	**U overall**	**HVAC Equipment Efficiency**
E 81	0.0363	R21	R54, RT	R30	0.35	0.052	Normal
E 82	0.0520	R21	R49	R30	0.35	0.060	High
E 83	0.0528	R21	R44, RT	R30	0.47	0.060	High

Table B-4 Prescriptive packages, Electric Heat, Insulating Sheathing

Package	**Glazing Factor**	**R wall**	**R ceiling**	**R basement**	**U door**	**U overall**	**HVAC Equipment Efficiency**
E 84	0.0480	R25, I	R48, RT	R16	0.35	0.059	Normal
E 85	0.0495	R25, I	R48, RT	R16	0.35	0.059	Normal
E 86	0.0462	R28, I	R40	R16	0.35	0.059	Normal
E 87	0.0429	R25, I	R36	R18	0.35	0.059	Normal
E 88	0.0528	R23, I	R58, RT	R18	0.35	0.059	Normal
E 89	0.0462	R25, I	R42	R18	0.35	0.059	Normal
E 90	0.0560	R25, I	R46, RT	R10	0.35	0.068	High
E 91	0.0640	R23, I	R48, RT	R13	0.35	0.068	High
E 92	0.0600	R25, I	R42	R13	0.35	0.068	High
E 93	0.0600	R23, I	R37	R18	0.47	0.068	High
E 94	0.0759	R25, I	R46, RT	R18	0.47	0.068	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R crawl**	**U door**	**U overall**	**HVAC Equipment Efficiency**
E 95	0.0429	R25, I	R48, RT	R23	0.35	0.054	Normal
E 96	0.0520	R23, I	R38	R23	0.35	0.062	High
E 97	0.0561	R25, I	R44	R23	0.47	0.062	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R slab**	**U door**	**U overall**	**HVAC Equipment Efficiency**
E 98	0.0396	R25, I	R48, RT	R10	0.35	0.083	Normal
E 99	0.0560	R23, I	R44	R7	0.35	0.095	High
E 100	0.0594	R25, I	R46, RT	R5	0.47	0.095	High
Package	**Glazing Factor**	**R wall**	**R ceiling**	**R floor**	**U door**	**U overall**	**HVAC Equipment Efficiency**
E 101	0.0429	R25, I	R46, RT	R30	0.35	0.052	Normal
E 102	0.0560	R23, I	R44	R30	0.35	0.060	High
E 103	0.0627	R25, I	R44, RT	R30	0.47	0.060	High

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Default Assembly R and U Value Tables

(All U–values include framing factors, finish materials and air films.)

Table 1. Ceiling U–Values[a]

Insulation R–Value	Standard Truss U–Value	Raised Truss[b] U–Value	Insulation R–Value	Standard Truss U–Value	Raised Truss[b] U–Value
R–0	0.568	0.568	R–33	0.033	0.029
R–7	0.119	0.119	R–34	0.032	0.028
R–8	0.108	0.108	R–35	0.032	0.028
R–9	0.098	0.098	R–36	0.031	0.027
R–10	0.089	0.089	R–37	0.031	0.026
R–11	0.082	0.082	R–38	0.030	0.025
R–12	0.076	0.076	R–39	0.030	0.025
R–13	0.070	0.070	R–40	0.029	0.024
R–14	0.066	0.066	R–41	0.029	0.024
R–15	0.062	0.061	R–42	0.028	0.023
R–16	0.059	0.058	R–43	0.028	0.023
R–17	0.056	0.055	R–44	0.027	0.022
R–18	0.053	0.052	R–45	0.027	0.022
R–19	0.051	0.049	R–46	0.027	0.021
R–20	0.048	0.047	R–47	0.026	0.021
R–21	0.047	0.045	R–48	0.026	0.020
R–22	0.045	0.043	R–49	0.026	0.020
R–23	0.043	0.041	R–50	0.026	0.020
R–24	0.042	0.040	R–51	0.025	0.019
R–25	0.040	0.038	R–52	0.025	0.019
R–26	0.039	0.037	R–53	0.025	0.019
R–27	0.038	0.035	R–54	0.025	0.018
R–28	0.037	0.034	R–55	0.024	0.018
R–29	0.036	0.033	R–56	0.024	0.018
R–30	0.035	0.032	R–57	0.024	0.018
R–31	0.034	0.031	R–58	0.024	0.017
R–32	0.034	0.030	R–59	0.024	0.017

(a) R–values represent the sum of the ceiling cavity insulation plus the R–value of insulating sheathing (if used). For example, R–19 cavity insulation plus R–2 sheathing is reported as R–21 ceiling insulation. For ventilated ceilings, insulating sheathing must be placed between the conditioned space and the ventilated portion of the roof (typically applied to the trusses or rafters immediately behind the drywall or other ceiling finish material).

(b) To receive credit for a raised truss, the insulation must achieve its full insulation thickness over the exterior walls.

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Table 2. Wood–Frame Wall U–Values[a,b]

Insulation R–Value[c]	16–in. O.C. Wall U–Value	24–in. O.C. Wall U–Value
R–0	0.238	0.241
R–7	0.105	0.104
R–8	0.099	0.097
R–9	0.094	0.092
R–10	0.090	0.088
R–11	0.089	0.087
R–12	0.085	0.083
R–13	0.082	0.080
R–14	0.079	0.077
R–15	0.077	0.074
R–16	0.066	0.064
R–17	0.064	0.062
R–18	0.062	0.060
R–19	0.060	0.059
R–20	0.059	0.057
R–21	0.057	0.056
R–22	0.056	0.054
R–23	0.055	0.053
R–24	0.054	0.052
R–25	0.053	0.051
R–26	0.052	0.050
R–27	0.051	0.049
R–28	0.050	0.048

(a) U–values are for uncompressed insulation.
(b) U–values in this Table were developed for wood–frame walls, but the 16–in. O.C. Wall U–Value column can also be used for above–grade concrete, masonry, and log walls. Mass wall R–value to U–value conversion tables are planned for future versions of the MECcheck Manual. TM
(c) Wall R–values are the sum of the cavity insulation plus insulating sheathing (if used).

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Table 3. 16–in. O.C. Metal–Frame Wall U–Values and Equivalent Prescriptive Package Wall R–Values (Use the U–values below for the System Design Method of the Energy Worksheet. Use the equivalent R–value below to choose an Energy Worksheet Prescriptive Package with a wall R–value that is less than or equal to it. If you have an equivalent R–value without an "I" listed after it, then you must use a Package wall R–value without an "I" designation.)

Cavity R–Value	**Insulating Sheathing R–Value**										
	R–0	**R–1**	**R–2**	**R–3**	**R–4**	**R–5**	**R–6**	**R–7**	**R–8**	**R–9**	**R–10**
R–0	U–0.270	U–0.258	U–0.205	U–0.170	U–0.146	U–0.127	U–0.113	U–0.101	U–0.092	U–0.084	U–0.078
R–11	U–0.120	U–0.118	U–0.106	U–0.096	U–0.087	U–0.080	U–0.074 R15	U–0.069 R15I	U–0.065 R16I	U–0.061 R18I	U–0.057 R20I
R–13	U–0.114	U–0.111	U–0.100	U–0.091	U–0.084	U–0.077 R15	U–0.072 R15	U–0.067 R15I	U–0.063 R17I	U–0.059 R19I	U–0.056 R22I
R–15	U–0.109	U–0.107	U–0.096	U–0.088	U–0.081	U–0.075 R15	U–0.070 R15	U–0.065 R16I	U–0.061 R18I	U–0.058 R19I	U–0.054 R22I
R–19	U–0.101	U–0.099	U–0.090	U–0.083	U–0.077 R15	U–0.071 R15	U–0.066 R15I	U–0.062 R17I	U–0.059 R19I	U–0.055 R20I	U–0.052 R22I
R–21	U–0.098	U–0.096	U–0.088	U–0.081 R13	U–0.075 R15	U–0.070 R15	U–0.065 R16I	U–0.061 R18I	U–0.058 R19I	U–0.054 R20I	U–0.052 R22I
R–25	U–0.094	U–0.093	U–0.085	U–0.078 R13	U–0.073 R15	U–0.068 R15I	U–0.063 R17I	U–0.060 R19I	U–0.056 R20I	U–0.053 R20I	U–0.051 R23I

Table 4. 24–in. O.C. Metal–Frame Wall U–Values and Equivalent Prescriptive Package Wall R–Values (Use the U–values below for the System Design Method of the Energy Worksheet. Use the equivalent R–value below to choose an Energy Worksheet Prescriptive Package with a wall R–value that is less than or equal to it. If you have an equivalent R–value without an "I" listed after it, then you must use a Package wall R–value without an "I" designation.)

Cavity R–Value	**Insulating Sheathing R–Value**										
	R–0	**R–1**	**R–2**	**R–3**	**R–4**	**R–5**	**R–6**	**R–7**	**R–8**	**R–9**	**R–10**
R–0	U–0.270	U–0.258	U–0.205	U–0.170	U–0.146	U–0.127	U–0.113	U–0.101	U–0.092	U–0.084	U–0.078 R13
R–11	U–0.106	U–0.104	U–0.095	U–0.086	U–0.080 R13	U–0.074 R15	U–0.069 R15I	U–0.064 R17I	U–0.060 R18I	U–0.057 R20I	U–0.054 R20I
R–13	U–0.100	U–0.098	U–0.090	U–0.082 R13	U–0.076 R15	U–0.071 R15	U–0.066 R15I	U–0.062 R17I	U–0.058 R19I	U–0.055 R20I	U–0.052 R22I
R–15	U–0.094	U–0.093	U–0.085	U–0.078 R13	U–0.073 R15	U–0.068 R15I	U–0.063 R17I	U–0.060 R19I	U–0.056 R20I	U–0.053 R20I	U–0.051 R23I
R–19	U–0.088	U–0.086	U–0.080 R13	U–0.074 R15	U–0.069 R15I	U–0.064 R17I	U–0.060 R19I	U–0.057 R20I	U–0.054 R20I	U–0.051 R23I	U–0.049 R24I
R–21	U–0.085	U–0.084	U–0.077 R15	U–0.072 R15	U–0.067 R15I	U–0.063 R17I	U–0.059 R19I	U–0.056 R20I	U–0.053 R20I	U–0.050 R23I	U–0.048 R24I
R–25	U–0.081 R13	U–0.080 R13	U–0.074 R15	U–0.069 R15	U–0.064 R17I	U–0.060 R19I	U–0.057 R20I	U–0.054 R20I	U–0.051 R23I	U–0.049 R23I	U–0.046 R24I

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Table 5. Floor U–Values

Insulation R–Value	Floor U–Value
R–0	0.249
R–7	0.096
R–11	0.072
R–13	0.064
R–15	0.057
R–19	0.047
R–21	0.044
R–26	0.037
R–30	0.033

Table 6. Basement U–Values[(a)]

Insulation R–Value	Basement Wall U–Value	Insulation R–Value	Basement Wall U–Value
R–0	0.360	R–10	0.072
R–1	0.244	R–11	0.067
R–2	0.188	R–12	0.062
R–3	0.155	R–13	0.059
R–4	0.132	R–14	0.055
R–5	0.115	R–15	0.052
R–6	0.102	R–16	0.050
R–7	0.092	R–17	0.047
R–8	0.084	R–18	0.045
R–9	0.077	R–19	0.043
		R–20	0.041

(a) Insulation R–values represent the sum of exterior and/or interior insulation. Basement walls must be insulated from the top of the basement wall to 10 ft below ground level or to the floor of the basement, whichever is less.

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Table 7. Slab F−Values

Perimeter Insulation R−Value	**Slab F−Value**	
	24−in. Insulation Depth	**48−in. Insulation Depth**
R−0	1.04	1.04
R−1	0.91	0.89
R−2	0.86	0.83
R−3	0.83	0.79
R−4	0.82	0.76
R−5	0.80	0.74
R−6	0.79	0.73
R−7	0.79	0.71
R−8	0.78	0.70
R−9	0.77	0.69
R−10	0.77	0.68
R−11		0.68
R−12		0.67
R−13		0.66
R−14		0.66
R−15		0.65
R−16		0.65
R−17		0.65
R−18		0.64
R−19		0.64
R−20		0.64

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Table 8. Crawl Space Wall U–Values

Insulation R–Value	Crawl Space Wall U–Value
R–0	0.477
R–1	0.313
R–2	0.235
R–3	0.189
R–4	0.158
R–5	0.136
R–6	0.120
R–7	0.107
R–8	0.096
R–9	0.088
R–10	0.081
R–11	0.075
R–12	0.069
R–13	0.065
R–14	0.061
R–15	0.057
R–16	0.054
R–17	0.051
R–18	0.049
R–19	0.047
R–20	0.045

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Table 9. U–Values for Windows, Glazed Doors, and Skylights[(a)]

Frame/Glazing Features	**Single Pane**	**Double Pane**
Metal Without Thermal Break		
Operable	1.27	0.87
Fixed	1.13	0.69
Garden Window	2.60	1.81
Curtain Wall	1.22	0.79
Door	1.26	0.80
Skylight	1.98	1.31
Site–Assembled Skylight	1.36	0.82
Metal With Thermal Break		
Operable	1.08	0.65
Fixed	1.07	0.63
Curtain Wall	1.11	0.68
Door	1.10	0.66
Skylight	1.89	1.11
Site–Assembled Skylight	1.25	0.70
Reinforced Vinyl or Metal–Clad Wood		
Operable	0.90	0.57
Fixed	0.98	0.56
Door	0.99	0.57
Skylight	1.75	1.05
Wood/Vinyl/Fiberglass		
Operable	0.89	0.55
Fixed	0.98	0.56
Garden Window	2.31	1.61
Door	0.98	0.56
Skylight	1.47	0.84
Glass Block Assemblies	0.60	

(a) The U–values in these tables can be used in the absence of test U–values. The product cannot receive credit for a feature that cannot be clearly detected. Where a composite of materials from two different product types is used, the product must be assigned the higher U–value.

Table 10. U–Value Table for Non–Glazed Doors[(a)]

Steel Doors		
Without Foam Core	0.60	
With Foam Core	0.35	
Wood Doors	**Without Storm**	**With Storm**
Panel With 7/16–in. Panels	0.54	0.36
Hollow Core Flush	0.46	0.32
Panel With 1–1/8–in. Panels	0.39	0.28
Solid Core Flush	0.40	0.26

(a) The U–values in these tables can be used in the absence of test U–values. The product cannot receive credit for a feature that cannot be clearly detected. Where a composite of materials from two different product types is used, the product must be assigned the higher U–value.

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Typical Thermal Properties of Building Materials−−Design Values[a]

Description	Density, lb/ft^3	Resistance (R) Per Inch Thickness °F . ft^2 . h	Resistance (R) For Thickness Listed
SHEATHING			
Gypsum or plaster board . . . . . 1/2".	50	—	0.45
Gypsum or plaster board . . . . . 5/8".	50	—	0.56
Plywood (Douglas Fir) . . . . . 1/2".	34	—	0.62
Plywood (Douglas Fir) . . . . . 5/8".	34	—	0.77
Plywood or wood panels . . . . . 3/4".	34	—	0.93
Vegetable fiber board			
Sheathing, regular density . . . . . 1/2".	18	—	1.32
Hardboard			
Medium density	50	1.37	—
Particleboard			
Medium density	50	1.06	—
FINISH FLOORING MATERIALS			
Carpet and rubber pad	—	—	1.23
INSULATING MATERIALS			
Blanket and Batt			
Mineral fiber, fibrous form processed from rock, slag, or glass			
approx. 3−4 in.	0.4−2.0	—	11
approx. 3.5 in	0.4−2.0	—	13
approx. 3.5 in	1.2−1.6	—	15
approx. 5.5−6.5 in.	0.4−2.0	—	19
approx. 5.5 in.	0.6−1.0	—	21
approx. 6−7.5 in.	0.4−2.0	—	22
approx. 8.25−10 in.	0.4−2.0	—	30
approx. 10−13 in.	0.4−2.0	—	38
Board and Slabs			
Glass fiber, organic bonded	4.0−9.0	4.00	—
Expanded polystyrene, extruded (smooth skin surface)	1.8−3.5	5.00	—
Expanded polystyrene, molded beads	1.0	3.85	—
	1.25	4.00	—
	1.5	4.17	—
	1.75	4.17	—
	2.0	4.35	—
Cellular polyurethane/polyisocyanurate	1.5	6.25−5.56	—
Cellular polyisocyanurate (CFC−11 exp.) (gas−impermeable facers)	2.0	7.04	—
Mineral fiberboard, wet felted			
Acoustical tile	18.0	2.86	—
Loose Fill			
Cellulosic insulation (milled paper or wood pulp)	2.3−3.2	3.70−3.13	—
Perlite, expanded	2.0−4.1	3.7−3.3	—
	4.1−7.4	3.3−2.8	—
	7.4−11.0	2.8−2.4	—
Mineral fiber (rock, slag, or glass)			
approx. 3.75−5 in.	0.6−2.0	—	11.0
approx. 6.5−8.75 in.	0.6−2.0	—	19.0
approx. 7.5−10 in.	0.6−2.0	—	22.0
approx. 10.25−13.75 in.	0.6−2.0	—	30.0
Mineral fiber (rock, slag, or glass)			
approx. 3.5 in. (closed sidewall application)	2.0−3.5	—	12.0−14.0
Vermiculite, exfoliated	7.0−8.2	2.13	—
	4.0−6.0	2.27	—
Spray Applied			
Polyurethane foam	1.5−2.5	6.25−5.56	—
Ureaformaldehyde foam	0.7−1.6	4.55−3.57	—
Cellulosic fiber	3.5−6.0	3.45−2.94	—
Glass fiber	3.5−4.5	3.85−3.70	—

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ROOFING			
Asphalt shingles	70	—	0.44
PLASTERING MATERIALS			
Cement plaster, sand aggregate	116	0.20	—
0.75 in.	—	—	0.15
MASONRY MATERIALS			
Masonry Units			
Brick, fired clay	150	0.12−0.10	—
Concrete blocks			
Normal weight aggregate (sand and gravel)			
8 in., 33−36 lb, 126−136 lb/ft^3 concrete, 2 or 3 cores	—	—	1.11−0.97
Same with perlite filled cores	—	—	2.0
Same with vermiculite filled cores	—	—	1.92−1.37
12 in., 50 lb, 125 lb/ft^3 concrete, 2 cores	—	—	1.23
Concretes			
Sand and gravel or stone aggregate concretes	150	0.10	—
SIDING MATERIALS (on flat surface)			
Siding			
Asphalt roll siding	—	—	0.15
Hardboard siding, 7/16”	—	—	0.67
Wood, drop, 1 by 8 in.	—	—	0.79
Aluminum, steel, or vinyl, over sheathing			
Hollow−backed	—	—	0.61
Insulating−board backed nominal 3/8”	—	—	1.82
Insulating−board backed nominal 3/8”, foil backed	—	—	2.96
WOOD			
Maples, oak and similar materials	45	0.91	
Fir, pine and similar materials	32	1.25	
3/4”	32	0.94	
1−1/2”	32	1.9	
3−1/2”	32	4.4	
5−1/2”	32	6.9	
7−1/4”	32	9.1	
9−1/4”	32	11.6	
11−1/4”	32	14.1	

[a]Values are for a mean temperature of 75°F. Representative values for dry materials are intended as design (not specification) values for materials in normal use. Thermal values of insulating materials may differ from design values depending on their in−situ properties (e.g., density and moisture content, orientation, etc.) and variability experienced during manufacture. For properties of a particular product, use the value supplied by the manufacturer or by unbiased tests in accordance with s. Comm 22.31.

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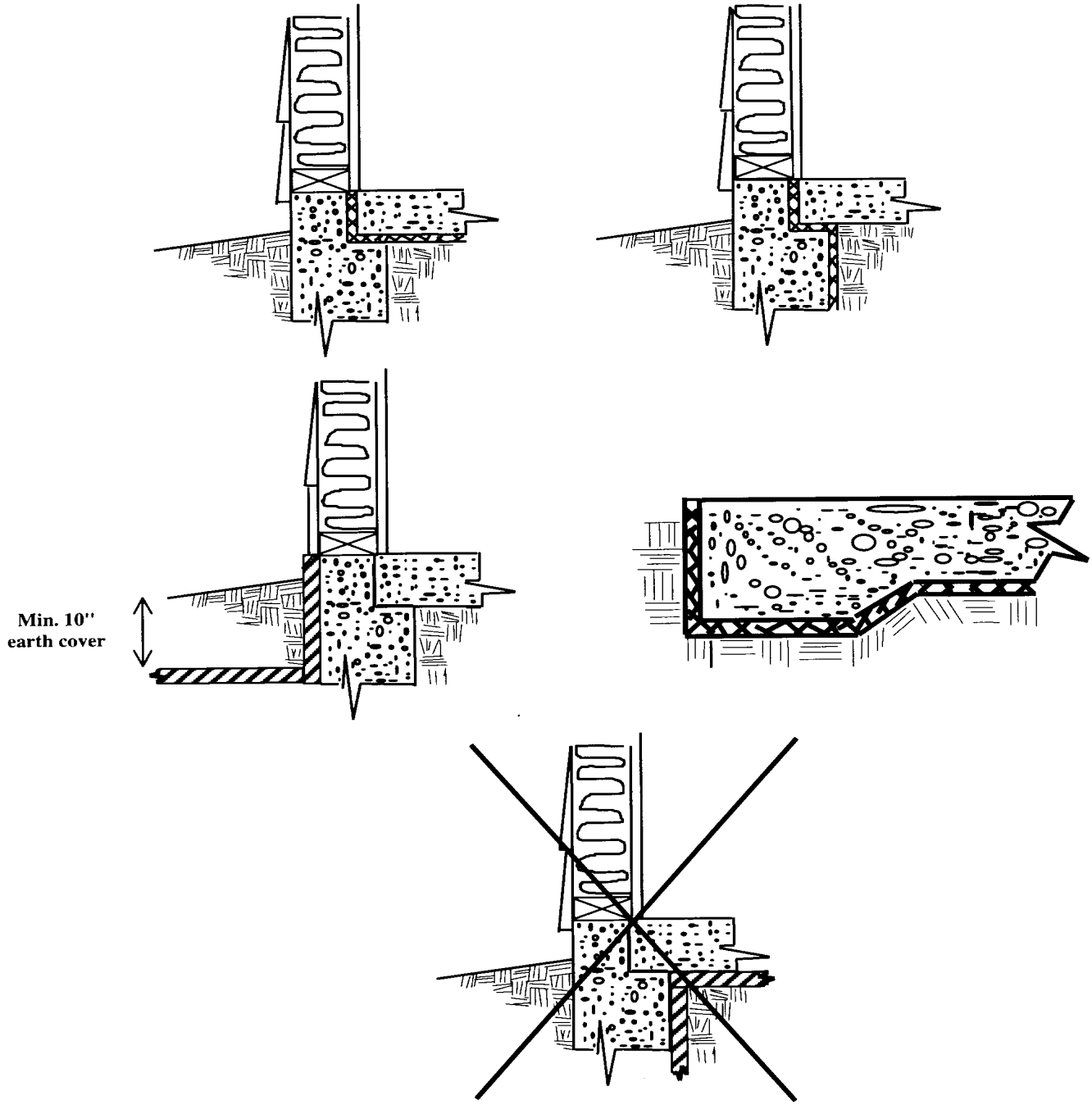
s. Comm 22.26
Slab-On-Grade Insulation Details



Insulation shall extend vertically and horizontally for a total of 48". In all cases the insulation shall insulate to the top edge of the floor perimeter. The last diagram is not an acceptable method.

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Model Ordinance For Adoption Of Wisconsin Uniform Dwelling Code

It is intended that this model will assist local jurisdictions, working with corporation counsel, through regular procedures, in adopting a local ordinance. The Wisconsin Division of Safety and Buildings also offers a more comprehensive model building code. Upon adoption of a new building code, send a certified copy to: Safety & Buildings Division, P.O. Box 7969, Madison, Wisconsin 53707, Telephone (608)267-7586. An electronic version of this model ordinance is also available.

Sample

Town, Village, City, County of _____.

ORDINANCE#

CONTENTS

1.1 Authority
1.2 Purpose
1.3 Scope
1.4 Adoption of Wisconsin Uniform Dwelling Code
1.5 Building Inspector
1.6 Building Permit Required
1.7 Building Permit Fees
1.8 Penalties
1.9 Effective Date

1.1 AUTHORITY. These regulations are adopted under the authority granted by s. 101.65, Wisconsin Statutes

[IF COUNTY ORDINANCE] This ordinance shall apply in any municipality of over 2500 population without a Uniform Dwelling Code enforcement program and the following other municipalities requesting county enforcement: _____.

1.2 PURPOSE. The purpose of this ordinance is to promote the general health, safety and welfare and to maintain required local uniformity with the administrative and technical requirements of the Wisconsin Uniform Dwelling Code.

1.3 SCOPE. The scope of this ordinance includes the construction and inspection of one- and two-family dwellings built since June 1, 1980. **[Note that additional language is necessary to expand the scope to cover garages and other residential outbuildings or to alterations and additions to dwellings built prior to June 1, 1980.]**

1.4 WISCONSIN UNIFORM DWELLING CODE ADOPTED. The Wisconsin Uniform Dwelling Code, Chs. Comm 20-25 of the Wisconsin Administrative Code, and all amendments thereto, is adopted and incorporated by reference and shall apply to all buildings within the scope of this ordinance.

1.5 BUILDING INSPECTOR. There is hereby created the position of Building Inspector, who shall administer and enforce this ordinance and shall be certified by the Division of Safety & Buildings, as specified by Wisconsin Statutes, Section 101.66(2), in the category of Uniform Dwelling Code Construction Inspector. Additionally, this or other assistant inspectors shall possess the certification categories of UDC HVAC, UDC Electrical, and UDC Plumbing. (**NOTE**: Contact the Division of Safety & Buildings at (608)261-8500 for certification information.)

1.6 BUILDING PERMIT REQUIRED. No person shall alter, in excess of **[INSERT AMOUNT]** $_____ value in any twelve month period, build, add onto or alter any building within the scope of this ordinance without first obtaining a building permit for such work from the building inspector. Any structural changes or major changes to mechanical systems that involve extensions shall require permits.

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Restoration or repair of an installation to its previous code- compliant condition as determined by the building inspector is exempted from permit requirements. Residing, re-roofing, finishing of interior surfaces and installation of cabinetry shall be **[CHOOSE OPTION]** included/exempted from permit requirements.

(**NOTE**: Fill in the threshold amount above which permits are required. Also decide whether new interior and exterior surfaces or cabinetry shall be included or exempted.)

1.7 BUILDING PERMIT FEE. The building permit fees shall be determined by resolution.

1.8 PENALTIES. The enforcement of this section and all other laws and ordinances relating to building shall be by means of the withholding of building permits, imposition of forfeitures and injunctive action. Forfeitures shall be not less than **[INSERT AMOUNT]** nor more than **[INSERT AMOUNT]** for each day of noncompliance.

1.9 EFFECTIVE DATE. This ordinance shall be effective _____, upon passage and publication as provided by law.

Sample

Adopted this _____ day of _____,

_____
(Mayor, President, Chairperson)

Attest: _____

Published: _____

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