
Research Report

208 -2

An Investigation Into Zone Pressure Diagnostic Protocols For Low Income Weatherization Crews

Phase I and Phase II Final Report Appendices

December 2001

Prepared by

Center for Energy and Environment
211 North 1st Street, Suite 455
Minneapolis, MN 55401
612-335-5858
Contact: David Bohac

Prepared for



**ENERGY CENTER
OF WISCONSIN**

We show you how

595 Science Drive
Madison, WI 53711-1076
Phone: 608.238.4601
Fax: 608.238.8733
Email: ecw@ecw.org
www.ecw.org

Copyright © 2001 Energy Center of Wisconsin
All rights reserved

This report was prepared as an account of work sponsored by the Energy Center of Wisconsin (ECW). Neither ECW, participants in ECW, the organization(s) listed herein, nor any person on behalf of any of the organizations mentioned herein:

- (a) makes any warranty, expressed or implied, with respect to the use of any information, apparatus, method, or process disclosed in this report or that such use may not infringe privately owned rights; or
- (b) assumes any liability with respect to the use of, or damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

Project Manager

Scott Pigg
Energy Center of Wisconsin

Appendix A. Zone Leakage Coefficient Equations

The following are the Hole and Flow Method equations used to solve the zone leakage coefficients for a hole added from the zone to the house and a hole added from the zone to the outside:

Opening Made to the Interior of the Zone

$$c_{i,hole} = \frac{1.06 A p_{e1}^{n_e} \sqrt{p_{i2}}}{p_{i1}^{n_i} p_{e2}^{n_e} - p_{i2}^{n_i} p_{e1}^{n_e}} \quad (A1)$$

$$c_{e,hole} = c_{i,hole} \frac{p_{i1}^{n_i}}{p_{e1}^{n_e}} \quad (A2)$$

$$c_{e,flow} = \frac{q_2 p_{h1}^{n_h} - q_1 p_{h2}^{n_h}}{p_{e2}^{n_e} p_{h1}^{n_h} - p_{e1}^{n_e} p_{h2}^{n_h}} \quad (A3)$$

$$c_{i,flow} = c_{e,flow} \frac{p_{e1}^{n_e}}{p_{i1}^{n_i}} \quad (A4)$$

Opening made to the Exterior of the Zone

$$c_{e,hole} = \frac{1.06 A p_{i1}^{n_i} \sqrt{p_{e2}}}{p_{e1}^{n_e} p_{i2}^{n_i} - p_{e2}^{n_e} p_{i1}^{n_i}} \quad (A5)$$

$$c_{i,hole} = c_{e,hole} \frac{p_{e1}^{n_e}}{p_{i1}^{n_i}} \quad (A6)$$

$$c_{i,flow} = \frac{q_2 p_{h1}^{n_h} - q_1 p_{h2}^{n_h}}{p_{i2}^{n_i} p_{h1}^{n_h} - p_{i1}^{n_i} p_{h2}^{n_h}} \quad (A7)$$

$$c_{e,flow} = c_{i,flow} \frac{p_{i1}^{n_i}}{p_{e1}^{n_e}} \quad (A8)$$

Notice that the second set of equations can be generated from the first set by a complete exchange of interior and exterior subscripts.

To derive the flow that will occur at a given house pressure p_h one needs to know what the zone's pressure will be in that condition by solving the simultaneous equations for the interior or exterior pressure:

$$p_i + p_e = p_h \quad (A9)$$

$$c_i p_i^{n_i} = c_e p_e^{n_e} \tag{A10}$$

This is a straightforward numerical problem since p_i and p_e are known to lie between 0 and p_h .

Appendix B. Agency Survey Instruments

Phone Interview of Eight State Agency Representatives

CONTACT INFORMATION

Name: _____ State: _____

Agency: _____

Title: _____

Phone: _____ Fax: _____

E-mail: _____

Call record: _____

Hi I'm Karen Linner from the Center for Energy and Environment in Minneapolis. I'm calling about the Zone Pressure Diagnostic study we are conducting with Michael Blasnik, Gary Nelson of the Energy Conservatory in addition to Jim Fitzgerald and Dave Bohac from our office. The study is initiated and funded by the Energy Center of Wisconsin and state weatherization offices in DOE's Chicago region. xx _____ from
xx _____ serves on the Advisory Committee for this project and he/she suggested that you would be the best person to ask about the use of Zone Pressure Diagnostics in <state>. Do you have about 30 to 40 minutes to complete this survey?

If not, when is a convenient time for me to call you back?

1. **Has your state agency developed any written protocols, procedures, manuals or forms for implementing Zone Pressure Diagnostics in the field? Zone Pressure Diagnostics may be called "series leakage measurements" or "Blasnik Methods" in your state.**

1a. For weatherization agency auditors?

No: _____ Don't Know: _____ Yes: _____ Please describe:

1b. For weatherization agency crews?

No: _____ Don't Know: _____ Yes: _____ Please describe:

1c. For weatherization agency quality control/inspectors?

No: _____ Don't Know: _____ Yes: _____ Please describe:

1d. For state agency monitors?

No: _____ Don't Know: _____ Yes: _____ Please describe:

2. (If yes for question 1) Would it be possible to send me a copy of the information you just described? (Give address and confirm send-to-date).

No: _____ Don't Know: _____ Yes: _____

Notes:

Send to date:

3. I'm going to list different people that are involved in the weatherization process. Tell me to the best of your knowledge whether using Zone Pressure Diagnostics is mandatory or optional according to state protocols.

	<i>Not required</i>	<i>Optional, but suggested</i>	<i>Mandatory</i>
<i>3a. Weatherization agency auditors</i>			
<i>3b. Weatherization crews</i>			
<i>3c. Weatherization agency quality control/inspectors</i>			
<i>3d. State monitors</i>			

4. I'm going to once again list different people that are involved in the weatherization process. Tell me to the best of your knowledge approximately how often are Zone Pressure Diagnostics routinely used by the following groups:

	<i>Up to 25% (of homes)</i>	<i>Over 25% less than 50% (of homes)</i>	<i>Over 50%, less than 75% (of homes)</i>	<i>Over 75% (of homes)</i>
<i>4a. Weatherization agency auditors</i>				
<i>4b. Weatherization crews</i>				
<i>4c. Weatherization agency quality control/inspectors</i>				
<i>4d. State monitors</i>				

5. To the best of your knowledge please describe any Zone Pressure Diagnostic protocols used by weatherization agency auditors. For example what type of measurement devices are used, which diagnostic methods do they use?

5a. Required _____

Recommended _____

Agency decides _____

5b. Check off list for equipment

	<i>Required</i>	<i>Suggested</i>	<i>Under what conditions?</i>
<i>Magnahelic</i>			
<i>Digital Micromanometer</i>			
<i>Pressure logger</i>			
<i>Up to agencies</i>			
<i>Other</i>			

5c. Check off list of methods

	Always	Sometimes	Conditions (sometimes)
<i>Method #1 – Add a hole</i>			
<i>Method # 2 – Open Door</i>			
<i>Method # 3 – Attic Vent</i>			
<i>Measuring Zone Pressures Without Performing Methods 1,2, or 3</i>			
<i>Other</i>			

6. To the best of your knowledge please describe any Zone Pressure Diagnostic protocols are used by weatherization crews in your state. For example what type of measurement devices are used, which diagnostic methods do they use?

6a. Required _____

Recommended _____

Agency decides _____

6b. Check off list for equipment

	<i>Required</i>	<i>Suggested</i>	<i>Under what conditions?</i>
<i>Magnahelic</i>			
<i>Digital Micromanometer</i>			
<i>Pressure logger</i>			
<i>Up to agencies</i>			
<i>Other</i>			

6c. Check off list of methods

	<i>Always</i>	<i>Sometimes</i>	<i>Conditions (sometimes)</i>
<i>Method #1 – Add a hole</i>			
<i>Method # 2 – Open Door</i>			
<i>Method # 3 – Attic Vent</i>			
<i>Measuring Zone Pressures Without Performing Methods 1,2, or 3</i>			
<i>Other</i>			

7. To the best of your knowledge please describe any Zone Pressure Diagnostic protocols used by weatherization agency quality control/inspectors. For example what type of measurement devices are used, which diagnostic methods do they use?

7a. Required

Recommended _____

Agency decides _____

7b. Check off list for equipment

	<i>Required</i>	<i>Suggested</i>	<i>Under what conditions?</i>
<i>Magnahelic</i>			
<i>Digital Micromanometer</i>			
<i>Pressure logger</i>			
<i>Up to agencies</i>			
<i>Other</i>			

7c. Check off list of methods

	<i>Always</i>	<i>Sometimes</i>	<i>Conditions (sometimes)</i>
<i>Method #1 – Add a hole</i>			
<i>Method # 2 – Open Door</i>			
<i>Measuring Zone Pressures Without Performing Methods 1,2, or 3</i>			
<i>Method # 3 – Attic Vent</i>			
<i>Other</i>			

8. To the best of your knowledge please describe any Zone Pressure Diagnostic protocols used by state agency monitors. For example what type of measurement devices are used, which diagnostic methods do they use?

8a. Required _____

Recommended _____

Agency decides _____

8b. Check off list for equipment

	<i>Required</i>	<i>Suggested</i>	<i>Under what conditions?</i>
<i>Magnahelic</i>			
<i>Digital Micromanometer</i>			
<i>Pressure logger</i>			
<i>Other</i>			

8c. Check off list of methods

	<i>Always</i>	<i>Sometimes</i>	<i>Conditions (sometimes)</i>
<i>Method #1 – Add a hole</i>			
<i>Method # 2 – Open Door</i>			
<i>Measuring Zone Pressures Without Performing Methods 1,2, or 3</i>			
<i>Method # 3 – Attic Vent</i>			
<i>Other</i>			

9. Same list, different question. Tell me to the best of your knowledge, how does the Zone Pressure Diagnostic information that is measured change the way a house is treated or evaluated in each step of the weatherization process?

9a. For weatherization agency auditors do Zone Pressure Diagnostics ever change the priorities or type of weatherization work?

No: _____ Don't Know: _____ Yes: _____ (If yes, How? Describe any specific standards:)

9b. For weatherization crews are specific guidelines for Zone Pressure Diagnostics ever used to indicate if further weatherization work should be done? (If yes, On all houses?)

No: _____ Don't Know: _____ Yes, on some houses: _____ Yes, on all houses: _____ (If yes, How? Describe any specific standards:)

9c. For weatherization agency quality control/inspectors do Zone Pressure Diagnostics ever help to assess whether weatherization work was done satisfactorily?

No: _____ Don't Know: _____ Yes: _____ (If yes, How? Describe any specific standards:)

9d. For state monitors do Zone Pressure Diagnostics ever help to assess whether weatherization work was done satisfactorily?

No: _____ Don't Know: _____ Yes: _____ (If yes, How? Describe any specific standards:)

10. Does your agency collect Zone Pressure Diagnostic data on a state level?

Yes: _____ No: _____ Don't Know: _____

(If "no" or "don't know") **Is there someone else I can contact who may know?**

Contact: _____

Agency/Dept.: _____

Title: _____

Phone: _____

E-mail: _____

11. What type of Zone Pressure Diagnostic data is collected on a state level?

12. Are the Zone Pressure Diagnostic data collected by the state stored in a central database? If so, are they recorded in electronic format?

Yes, electronic format: _____ Which database program is used? _____

Contact: _____

Phone: _____

E-mail: _____

No: _____

Don't know: _____

Who would know?

Contact: _____

Phone: _____

E-mail: _____

Yes, paper: _____

Who should I contact about these data?

Contact: _____

Phone: _____

E-mail: _____

Don't know: _____ **Who would know?**

Contact: _____

Phone: _____

E-mail: _____

13. Does your agency currently provide any training on Zone Pressure Diagnostics?

13a. No: _____ Don't Know: _____ Yes: _____ Please describe:

	<i>Optional</i>	<i>Mandatory</i>	<i>Description of training/frequency</i>
13b. Weatherization agency auditors			
13c. Weatherization crews			
13d. Weatherization agency quality control/inspectors			
13e. State monitors			

14. Do you know of any agencies in your state that have received training on Zone Pressure Diagnostics outside of what the state provides?

15. Is your agency planning or developing any Zone Pressure Diagnostics training opportunities in the future?

15a. No: _____ Don't Know: _____ Yes: _____ Please describe:

	<i>Optional</i>	<i>Mandatory</i>	<i>Training and timeline</i>
15b. Weatherization agency auditors			
15c. Weatherization crews			
15d. Weatherization agency quality control/inspectors			
15e. State monitors			

16. As part of the project we will interview a few of the weatherization agencies in each state that are most advanced in using Zone Pressure Diagnostic methods in the field.

Which three agencies would you say are leading the way in your state? Who is their director and what is his or her phone number?

Agency: _____

Director: _____

Phone: _____

Agency: _____

Director: _____

Phone: _____

Agency: _____

Director: _____

Phone: _____

If you are not sure, who else in your agency do you recommend I call to find out?

Contact: _____

Title: _____

Agency/Dept.: _____

Phone: _____

E-mail: _____

- 17. Can you recommend one or two weatherization agencies outside of DOE's Region V that are most advanced in using Zone Pressure Diagnostic methods in the field (in Iowa, Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin)?**

Agency: _____

Director: _____

Phone: _____

Agency: _____

Director: _____

Phone: _____

- 18. We will be sending out a short written survey to all weatherization agencies in DOE Region V. Whom can I call to track down a current mailing list of all the weatherization agencies in your state? Do you know if an electronic version is available? No: _____ Don't Know: _____ Yes: _____**

Contact: _____

Agency/Dept.: _____

Title: _____

Phone: _____

E-mail: _____

Thank you for your time. I appreciate all of your help.

Local Agency Mail Survey

Return this completed survey by February 2, 2000, and qualify to win a \$100 cash prize for your agency.

This survey should be completed by your agency's most experienced crew leader and returned using the enclosed self-addressed, stamped envelope by February 2, 2000.

Crew Leader Name:	Phone number ()
Title:	Number of years work experience in weatherization:
[xxWx Agency] [xxCity, State]	

1. How many single-family homes does your agency weatherize per year? (circle one)

1-10 11-25 26-75 75-100 Over 100

2. Do any of your auditors, crews, contractors or inspectors use Zone Pressure Diagnostic (ZPD) methods in the field (to measure pressure differences between different areas of a house)?

- ☐ **No.** Thank you for your time. Please fold and return the survey in the self addressed, stamped envelope to be included in the drawing for the survey prize.
- ☐ **Yes.** Circle the appropriate answers to show when ZPD methods are used in your agency during the weatherization process:

Method	Auditors	Crews and Contractors	Inspectors
Method 1: Add a Hole or Leakage Area Matching Method/EQLA	Never Sometimes Always	Never Sometimes Always	Never Sometimes Always
Method 2: Open A Door	Never Sometimes Always	Never Sometimes Always	Never Sometimes Always
Method 3: Attic Vent Estimation	Never Sometimes Always	Never Sometimes Always	Never Sometimes Always
Measuring zone pressures without performing Method 1, 2, or 3 calculations. Briefly describe:	Never Sometimes Always	Never Sometimes Always	Never Sometimes Always

3. Which types of Zone Pressure Diagnostic equipment do your auditors, crews/contractors and inspectors use? Check all that apply:

Type of Equipment	Auditors	Crews/ Contractors	Inspectors
Magnehelic gauge			
Digital micromanometer (DG2, DG3 or other)			
Pressure logger (APT)			
Other, describe:			

4. Does your agency use any written protocols for using Zone Pressure Diagnostics and, if so, who developed them (check one)?

- ☐ No, written protocols are not used by our agency.
- ☐ Yes, protocols were developed by the state weatherization office.
- ☐ Yes, protocols were developed by our agency.
PLEASE INCLUDE A COPY OF THESE PROTOCOLS WITH YOUR RETURNED SURVEY.
- ☐ Yes, protocols were developed by _____.
PLEASE INCLUDE A COPY OF THESE PROTOCOLS WITH YOUR RETURNED SURVEY.

Thank you for taking the time to complete this survey. Your answers will be used to help create more streamlined Zone Pressure Diagnostic protocols.

Please return the survey in the enclosed self addressed, stamped envelope or mail to

Karen Linner
Center for Energy and Environment
211 N. 1st St, Suite 455
Minneapolis, MN 55401

The winner of the survey prize will be chosen at random and notified by February 11, 2000.
Call Karen Linner at 612-335-5877 if you have any questions about this survey.

Experienced Local Agency Phone Survey

CONTACT INFORMATION

Name: «First_Name» «Last_Name» State: «State»

Agency: «Agency»

Title: xx

Phone: «Phone» Fax: «Fax»

E-mail: _____

Call record: _____

Hi I'm Karen Linner from the Center for Energy and Environment in Minneapolis. I'm calling about the Zone Pressure Diagnostic study we are conducting with Michael Blasnik, Gary Nelson of the Energy Conservatory in addition to Jim Fitzgerald and Dave Bohac from our office. As part of this project we are doing a phone survey. Do you have about 30 minutes? If not, when is a convenient time for me to call you back?

The study is initiated and funded by the Energy Center of Wisconsin, the Department of Energy, and state weatherization offices in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin. Your agency has been chosen as one of 30 in the nation that is ahead of the curve in using zone pressure diagnostics in the field. The main purpose of the ZPD project is to develop, test, and refine a protocol to use pressure diagnostics most effectively in the field. Your answers will help us to create field protocols that can easily be used by weatherization crews.

When I use the term Zone Pressure Diagnostics I mean measuring pressure differences between different areas of a house. These questions are not about pressure pan tests for ducts.

1. Is your agency crew-based, contractor-based or is there a combination?

Crew Contractor Both

From now when I say crews I mean either crews or contractors

2. About how many single-family homes does your agency weatherize per year?

1-10 11-25 26-75 75-100 Over 100

3. To the best of your knowledge please describe how and when Zone Pressure Diagnostic methods are used by weatherization crews in your agency.

{Note: When necessary, use the following questions to complete the table below}

4. How often do your crews use ZPD Methods 1, 2, and 3? {List each method} Never, Sometimes or Always?

5. If so, under what conditions?

6. How do your crews calculate ZPD measurements for each method?

7. How reliable is each method? {Almost always, usually, rarely, almost never}

	<i>When is the method used?</i>			<i>How do you choose or under what conditions?</i>	<i>How are calculations done?</i>				<i>How reliable is the method?</i>			
	<i>Never</i>	<i>Sometimes</i>	<i>Always</i>		<i>Laptop program</i>	<i>Hand calculator</i>	<i>Paper charts</i>	<i>Other, describe:</i>	<i>Almost always</i>	<i>Usually</i>	<i>Rarely</i>	<i>Almost never</i>
<i>Method #1 – Add a hole</i>												
<i>Method #2 – Open Door</i>												
<i>Method #3 – Attic Vent</i>												

8. Do your crews ever use quick ZPD measurements between zones without doing calculations or using Method 1, 2, or 3?

Never *Sometimes* *Always*

Conditions:

9. (If yes in question 8) What guidelines do you use to make sense of the quick pressure measurements?

10. What type of equipment do your crews use to measure zone pressures?

	<i>Some crews</i>	<i>All crews</i>	<i>Comments</i>
<i>Magnahelic</i>			
<i>Digital Micromanometer</i>			
<i>Pressure logger</i>			
<i>Other</i>			

11. How does the zone pressure diagnostic information your crews collect affect the way houses are weatherized?

12. How often are the Zone Pressure Diagnostic results confusing? Tell me as a percent of the total times your agency take measurements?

13. How often are zone pressure diagnostic measurements inconsistent with your crew's observations or rules of thumb? Tell me in the percent of the number of houses your agency weatherizes.

14. Do your weatherization crews use laptop computers in the field?

No Yes, some crews Yes, all crews

(If yes) What operating system do they use?

Windows 2000 Windows 97 Windows 95 Windows 3.1 Don't know

15. What is the biggest barrier preventing your agency from using Zone Pressure Diagnostics more effectively in the field? (let the interviewee answer and check appropriate line)

USING ZPD

- ☐ *Deciding which test to use*
- ☐ *Performing calculations correctly*
- ☐ *Taking too much time to calculate results*
- ☐ *Having the right equipment. List: _____*
- ☐ *More clear/established/documented field protocol*
- ☐ *Other, describe: _____*

INTERPRETING RESULTS

- ☐ *Interpreting what the measurements mean*
- ☐ *Finding measurements that make sense*
- ☐ *Knowing how to apply the findings to weatherization work*
- ☐ *Other, describe: _____*

TRAINING

- ☐ *Lack of crew leader training*
- ☐ *Lack of crew/contractor training*
- ☐ *Other, describe: _____*

16. What would most help your agency overcome the barrier you just listed?

17. What is the second biggest barrier? (record above as #2)

18. What would most help your agency overcome the 2nd biggest barrier?

19. How helpful would a clearly written protocol on when to use ZPDs be to your agency?

extremely very helpful somewhat not
helpful helpful helpful helpful

20. How helpful would a clearly written protocol on how to use ZPDs be to your agency?

extremely helpful very helpful helpful somewhat helpful not helpful

21. How helpful would a clearly defined method for determining the reliability of ZPD be to your agency?

extremely helpful very helpful helpful somewhat helpful not helpful

22. How helpful would a laptop based computer program that calculates ZPD results be to your agency?

extremely helpful very helpful helpful somewhat helpful not helpful

23. How helpful would the following procedure be to your agency: a pressure logger attached to a blower door and laptop to automate the pressure test and calculation process?

extremely helpful very helpful helpful somewhat helpful not helpful

24. Does your agency collect Zone Pressure Diagnostic data that is stored in a computer system?

Yes, all houses Yes, some houses No

25. (If yes in 24) What type of Zone Pressure Diagnostic data are collected?

Whom can I talk to about this information?

Contact: _____

Agency/Dept.: _____

Title: _____

Phone: _____

E-mail: _____

26. To the best of your knowledge please describe how and when Zone Pressure Diagnostic methods are used by weatherization auditors in your agency.

{Note: When necessary, use the following questions to complete the table below}

- 27.** How often do your auditors use ZPD Methods 1, 2, and 3? {List each method} Never, Sometimes or Always?
- 28.** If so, under what conditions?
- 29.** How do your auditors calculate ZPD measurements for each method?
- 30.** How reliable is each method? {Almost always, usually, rarely, almost never}

	When is the method used?			How do you choose or under what conditions?	How are calculations done?				How reliable is the method?			
	Never	Someti mes	Always		Laptop progra m	Hand calcula tor	Paper charts	Other, describ e:	Almost always	Usually	Rarely	Almost never
Method #1 – Add a hole												
Method #2 – Open Door												
Method #3 – Attic Vent												

- 31.** Do your auditors ever use quick ZPD measurements between zones without doing calculations or using Method 1, 2, or 3?

Never *Sometimes* *Always*

Conditions:

- 32.** (If yes in question 31) What guidelines do auditors use to make sense of the pressure measurements?

- 33.** What type of equipment do your auditors use to measure zone pressures?

	<i>Some auditors</i>	<i>All auditors</i>	<i>Comments</i>
<i>Magnahelic</i>			
<i>Digital Micromanometer</i>			
<i>Pressure logger</i>			
<i>Other</i>			

- 34.** How does the zone pressure diagnostic information the auditors collect affect the way the priorities or type of weatherization work that are specified?

- 35.** Do your auditors use laptop computers in the field?

No *Yes, some auditors* *Yes, all auditors*

- 36.** To the best of your knowledge please describe how and when Zone Pressure Diagnostic methods are used by weatherization inspectors in your agency.

{Note: When necessary, use the following questions to complete the table below}

- 37.** How often do your inspectors use ZPD Methods 1, 2, and 3? {List each method} Never, Sometimes or Always?
- 38.** If so, under what conditions?
- 39.** How do your inspectors calculate ZPD measurements for each method?
- 40.** How reliable is each method? {Almost always, usually, rarely, almost never}

	When is the method used?			How do you choose or under what conditions?	How are calculations done?				How reliable is the method?			
	Never	Someti mes	Always		Laptop progra m	Hand calcula tor	Paper charts	Other, describ e:	Almost always	Usually	Rarely	Almost never
<i>Method #1 – Add a hole</i>												
<i>Method #2 – Open Door</i>												
<i>Method #3 – Attic Vent</i>												

- 41.** Do your inspectors use quick ZPD measurements between zones without doing calculations or using Method 1, 2, or 3?

Never Sometimes Always

Conditions:

- 42.** (If yes in question 41) What guidelines do inspectors use to make sense of the pressure measurements?

- 43.** What type of equipment do your inspectors use to measure zone pressures?

	<i>Some inspectors</i>	<i>All inspectors</i>	<i>Comments</i>
<i>Magnahelic</i>			
<i>Digital Micromanometer</i>			
<i>Pressure logger</i>			
<i>Other</i>			

44. How does the zone pressure diagnostic information the inspectors collect help to assess whether weatherization work was done satisfactorily?

No

Yes

If yes, How?

45. Do your inspectors use laptop computers in the field?

No

Yes, some inspectors

Yes, all inspectors

Thank you for your time. This information will be used to develop a more user-friendly use of Zone Pressure Diagnostics in the field.

Contact List

Agency	Contact	Title
City of Des Moines	Barb Ashton	
Mid Souix	Julie Colling	
Operation Threshold	Mark Bergmeier	
West Central Development Corp.	Marilyn Rodacker	
Woodbury County Community Action (Souix City)	Dennis Krause	
ICDA (Indiana Cap Directors Assn)	Dan Hartman	Director
Arrowhead Economic Opportunity Agency	Kim Hustad	
Mahube Community Council Inc.	Mike Hiemenz	Wx Director
Minneapolis CAM	Jack Bethke	Wx Director
Otter Tail Wadena	Mary Nielsen	
Sustainable Resource Center	Cindy Webster	Wx Director
Tri-Valley CAP	Phil Wold	Wx Director
Community Action Program	Cal Steiner	Director
Community Action Agency of Scioto County	Phil McKinney	Wx Director
Gallia-Meigs C.A.C	Larry Laudermlp	Wx Director
Jackson Vinton	John People	Wx Director
Licking County Economic Action Development	Terry Boehm	
Neighborhood Housing Service, Toledo	Dora Tharp	
Nohoco	Larry Vickers	Wx Director
Youngston Area Community Action Agency	Ted Sloban	
Central VA Area Agency on Aging	John Boltman	Wx coord
J & J Weatherization	John Langford	owner
New River Center for Energy Research Training (NCERT) Virginia Mountain Housing, Inc.	Bill Beachy	
People Inc.	Fred Gross	WX coord
BROC	Girard Miller	Wx Director
NETO	Jim Ryan	Wx Director
Building Performance Center	John Davies	Director
Energy Services/Housing Authority of Outgamie Co.	Hoss Hosmer	Auditor
Partners for Community Development, Inc.	John Tyler	
The City of Superior, Office of Planning & Development	Bob Benson	
West CAP	Robert Parkhurst	Trainer
Wisconsin Coulee CAP	Bob Pfeiffer	Crew Leader
Alternate list:		
Western Egyptian Economic Opportunity Council	Ray Zurban	Wx Director
Job Source	Steve Nall	
MICA (Mid-Iowa Community Action)	Magi York	
TRAIN	Roy Yoder	Wx Director
Polk County		
Rooftop of VA	Terry Atwell	Wx coord.
Crater District AAA	Bernard Jones	Wx coord.

Appendix C. Field Research Protocol Documents

Step By Step Instructions

1. Confirm that the house meets the selection criteria and that all major repairs are completed. The selection criteria are listed on the top of the first page of the Field Data Form or can be viewed by selecting House/Selection Criteria from the ZPD Data program menu.
2. Complete the *House Characteristics* section of the first page of the Data Form. Start the ZPD Data program and add a new house by selecting House/Add from the menu (an appropriate five character House number will be assigned automatically). Enter all the required information into the *House Characteristics* tab of the program.
3. Sketch a floor diagram of each floor of the house on the graph paper included with the Data Forms and take pictures as necessary to help identify zone locations.
4. When you have completed the data entry for the *House Characteristics* tab, the *Zone Characteristics* tab will be displayed. Select Zone/Add from the program menu to add a zone. Add a zone for all the primary and secondary zones in the house. Identify all primary and secondary transition zones and record zone characteristics information into *Zone Characteristics* tab of program. Note – you can select Zone/Delete to remove a zone from the program.
5. Install blower door and run hoses to zones. Record time required for each task – the top of the *Results Before Work* tab of program.
6. If the house needs side wall insulation, perform a single APT zone pressure measurement. Designate this test as a “Pre” test and use series #1.
7. If necessary, insulate the side walls.
8. Conduct house air leakage test and zone pressure measurements using digital manometer. All pressure and flow measurements should be measured using the long-term averaging feature of the DG-3 manometer to yield 30 second averages of the values (for step by step instructions see sheet *Using the DG-3 Digital Manometer for 30 Second Averages*). Also, the house pressure for the zone pressure measurements must be the same as that for the air leakage measurements. Record results and time required for each task in *Results Before Work* tab of program. Record crews’ feedback on how the zone pressure measurements changed their impression of the required air sealing: how closely you will look, leaks found, change in treatment plan.
9. Conduct open door or add-a-hole tests on each primary zone using digital manometer. **Note** – use your agencies protocol for determining whether to perform an add-a-hole or open door type test. If you conduct an add-a-hole type test you should create a large enough opening so that the zone pressure changes by 15 to 25Pa. Record results and time required for each test in *Results Before Work* tab of program. Record crews’ feedback on how the test results

changed their impression of the required air sealing: how closely you will look, leaks found, change in treatment plan.

10. Perform APT Measurement Protocol. See sheet titled *APT Measurement Protocol* for description of type of ZPD tests to include.

Houses with basement living space and a basement door: For this set of APT tests (and only this set), add the basement as your last zone in the APT ZPD program and run a hose to the basement. Keep the basement door open for all tests EXCEPT for test #2. For test #2 close the basement door and record a baseline and measurement. Do not specify any openings for this test.

11. Perform air sealing work. As much as possible, focus work on one primary or secondary zone at a time. After the work for that zone is complete, measure pressures in ALL the primary and secondary zones using the APT program (i.e. test #1 only). Repeat this step for all primary and secondary zones until all WX work is complete and meets agency guidelines.
12. Perform APT Measurement Protocol (include orifice measurements). Review results to confirm that no further zone air sealing/insulation work is required. If additional work in zone is required, perform the air sealing/insulation work and repeat the APT Measurement Protocol.
13. Complete the *Results After Work* tab of the program.
14. Seal as many attic vents as possible. Perform APT Measurement Protocol.
15. **If an IR camera is available and normally used:** Perform IR scan and complete any additional air sealing work identified by the IR scan. Record the results of the IR scan. If any additional air sealing work was included, perform a single APT zone pressure measurement (i.e. test #1 only).
16. Perform air sealing between the house and outside (weatherstrip, pulley seals, rim joist, basement utility penetrations, ...). If any of this type of air sealing work was included, perform a single APT zone pressure measurement (i.e. test #1 only).

Definition of Primary and Secondary Zones

A transition zone is an air space that has a barrier to the living space and a barrier to the outside and/or other transition zones. Transition zones are divided into three different types:

Primary (Openings)

A transition zone is considered to be a primary type if a crew can make a measurable or significant opening between the zone and either the living space or the outside. It must also be possible to measure the pressure difference between the zone and either the living space or the outside. In other words, it must be possible to do an Add-A-Hole or Open Door type test in these

zones. These requirements enable estimates of the air leakage between the zone and the living space. Examples of primary zones include:

- Full, unfinished walk-up attic.
- Peak over slanted wall or ceiling. The zone must have either a hatch to the living space or an outside vent that will be removed or added to allow air sealing.
- Inaccessible space above a flat or cathedral ceiling. The space must have an outside vent that will be removed or added to allow air sealing.
- Enclosed kneewall.
- Attached, unheated porch.
- Basement. Must be unheated and an air barrier between basement and living space is in place or will be installed as part of air sealing.
- Enclosed crawl space.
- Attached garage with living space above.
- Attached garage with living space only to side.

Secondary (No Openings)

A transition zone is considered to be a secondary type if it is not possible to make a measurable or significant opening to the zone but it does meet the following three criteria:

1. An internal cavity or chase that has a large volume or is likely connected to other cavities that together makeup a large volume.
2. The volume is likely to have good thermal connection or air leakage to the outside.
3. It is possible to measure the pressure difference between the zone and either the living space or the outside.

For this type of zone it is not possible to quantify the air leakage to the living space. However, it is expected that there is significant air movement or heat transfer through these zones and zone pressure measurements will help determine air sealing requirements. Examples of secondary zones include:

- Porch attic that is likely to be connected to house floor joist cavities.
- Between floor cavity containing a duct and runs perpendicular to floor joists.
- Space above a drop ceiling that is connected into the end of floor joists.
- Peak attic with no vents and no access.

Non-applicable

There are numerous transitional zones that are not likely to have significant air leakage or heat transfer to the outside. No pressure measurements will be made in these zones. Examples of non-applicable zones include:

- A single wall cavity that is not likely connected to multiple other cavities.
- A single floor cavity that is not likely connected to multiple other cavities.

ZPD Data Program Notes

1. The program has been designed so that a **section (or tab) of data entry must be completed before the next section is displayed.** For example, after a new house is added the *House Characteristics* tab is displayed. All of the required data in the *House Characteristics* tab must be completed in order for the next section (*Zone Characteristics*) to be displayed.

-
2. The text in the **status bar at the bottom of the page** indicates whether or not the data entry for the displayed tab is complete and, if it is not complete, specifies what data entry is required.
 3. In many sections of the program **yellow “hint” boxes** will appear if you place the mouse cursor over a label or data entry box. These hint boxes can provide useful information on the type of data entry that is required for that section.
 4. Some sections of the program have an **aqua background color**. In these sections data is required for each zone of the house. For the *Zone Characteristics* and *Results After Work* tabs you must click on the right and left buttons directly to the left of the Zone # label to move forward and back between the zones for the house. In the Manual Zone Pressure Measurements and Manual Add-A-Hole and Open Door Measurements sections of the Results Before Work there is a separate row of information for each zone.
 5. **Yellow sections** are for data entry for the time required for a task. The time (specified as person-minutes – or the sum of the time required for each person to complete the task) can be entered manually using the up/down buttons to the right of the Time (person-min) label. You can also have the program track the time for you. Click on the **Start** button to have the program record the time that the crew started the task. Click on the **Done** button when the crew has completed the task – the program will record that time. Also, you need to enter the number of people that worked on the task. The program will compute the time required for the task by multiplying the elapsed time by the number of people. You can also manually enter the Start and Done times for the task (format – hh:mm am/pm)
 6. **Switching between houses:** You can move to the information for different houses by either clicking on the right and left buttons at the upper left of the screen (that will move you one house forward or back) or by selecting House/Select from the menu and entering the five character house identifier.
 7. Definition of living area and lower level: **Living area** – area of the house that is directly or indirectly heated and there is no air barrier between the area and the rest of the house. Note – do not include a crawlspace or garage. **Lower level** – below grade floor space that is the lowest level of the house. This will normally include the basement area or the lower level of a split entry house.
 8. **Leak inspection time:** For the *Time Spent Inspecting for Leaks in ALL Zones* (first yellow box in Zone Characteristics tab) include the time spent by the entire crew inspecting for leaks in all the zones. Do not include inspection time spent by agency auditors for developing the work specification.
 9. **Update zone pressure and Add-A-Hole/Open Door calculations:** There is a green Update button in the upper left portion of the Manual Zone Pressure Measurements and Manual Add-A-Hole and Open Door Measurements sections (Results Before Work tab). Click on the update button to update the calculations. Note – the calculations will only be updated for the selected zone (e.g. the row that has the dotted highlight around the outside).

10. **Screen Resolution and Windows Font Size:** The labels and windows will be displayed properly when the screen resolution is set to no less than 800x600 and the Windows Font Size is set to Small Fonts (see the Settings tab in the Display Properties icon in the Control Panel window).
11. **Gray check boxes:** There will be a gray check in a check box when the box has not yet been checked or unchecked. A gray check is only slightly lighter than a black check and can be difficult to distinguish from a black check. In almost all cases you must check or uncheck this box as appropriate in order for the data entry to be complete.
12. **APT Data Files tab:** This is the last tab on the right and is used for displaying a list of all the data files that have been saved from the APT ZPD program for the current house. For each data file the table displays the number of tests, the file name, and the type of test (pre, inter, or post). The box on the right displays a description of the test or test notes. The notes can be modified, but the rest of the information cannot. The data file can be displayed through the APT ZPD program by selecting the file (the arrow to the left specifies which file is selected) and clicking on the Show Results button.

APT Measurement Protocol

Perform zone pressure diagnostics on all primary zones using APT ZPD program. Determine which of the following openings are possible for each primary zone and perform ZPD measurements after creating each opening:

If there is a hatch or side attic door (not full-sized door) from the living space to the zone, create each of the following three openings:

- a) Open hatch or door to get 15 to 25Pa change in zone pressure (for the series of pre-work measurements: if an add-a-hole type test was performed as part of the manual measurements, use the same open area as that used for the manual add-a-hole type test).
- b) Use cardboard or similar to create an opening about the same size as (a) – this step is only required for the series of tests conducted after WX work is complete.
- c) Completely open the hatch or door

If there is a full-sized door from the zone to the outside:

- d) Completely open the door to the outside

If there is a full-sized door from the outside to the zone:

- e) Completely open the door to the zone

If a vent from the zone to the outside will be removed or added to allow air sealing:

- f) Open hole in sheet metal or similar to get 15 to 25Pa change in zone pressure
- g) Completely open the vent area

APT ZPD Program Notes

1. Update the wind speed, inside air temperature, and outside air temperature for each new series of measurements.
2. When conducting an add-a-hole or open door type test, change blower rings if the house pressure for full blower speed is less than 35Pa.
3. Recommended opening size uncertainties:
 - Orifice: 5% of hole size
 - Completely open hatch or door: 10% of opening size
 - Partially open hatch or door: minimum 25% of opening size
 - Hatch or door with irregular opening (i.e. fiberglass “pillow” on back of hinged hatch): 50% of opening size
4. All baseline measurements must be conducted with the blower covered and the opening to the zone the same size as will be used for the test measurement (i.e. if you are going to perform an open door type test for the garage, the baseline should be conducted with the door to the garage open).
5. When you are doing an add-a-hole type test and you do not know what size opening to make in order to get a change of 15 to 25Pa in the zone pressure, record the baseline measurement AFTER taking the pressure measurement with the blower on. That way, you will not have to repeat the test baseline if you change the size of the opening.
6. After you save the data file (File/Save from the program menu) you will have the option of saving the file information to a table. You should always select this option. When you select this option, summary information about the data file will be saved in a table and you will be able to view the table of files from the ZPD Data program (APT Data Files tab). Before you click on OK write a brief description of the test and any useful notes about the test.

ZPD Measurement Checklist

Every time that an APT ZPD measurement (fan on and baseline) is completed the following should be checked:

1. Review time graph of pressure and flow data to make sure that there are no “spikes” during the baseline or fan on measurement periods that could not reasonably be caused by wind. If there is a spike, repeat the measurement.
2. Review the Zone Connections graph for all of the zones. For the tests where an opening was made to a different zone, one of the blue triangles should be within the blue dashed lines or close to the lines. When this is not the case determine if it is reasonable that there is some connection between the two zones (the zone specified in the Select Zone box and the zone that had the opening for the test). Also, check to see if the reverse connection occurs. For

example, if the pressure in the west attic changes when you open the door to the east attic the pressure in the east attic should change when you open the door to the west attic. Finally, the adjusted zone pressure for a test should not be closer to zero than the adjusted pressure for test one. If you are performing a pressurization test, the top blue triangle should not be much below the lower blue dashed line. If you are performing a depressurization test, the bottom blue triangle should not be much above the top blue dashed line.

3. If you have just completed an add-a-hole type test, compare the adjusted zone pressure for the zone with the added hole to the adjusted pressure for test one. The difference between the two adjusted pressures should be at least 15 Pa.
4. If you have just completed an open-door type test, compare the adjusted pressure for the house/out and zone/out for the zone with the open door. If the door is a half or full-sized door there should be less than a 2 Pa. difference between the house and zone adjusted pressures – in most cases the difference will be less than 0.5 Pa. Look for problems with the hoses or zone opening if the difference is greater than 2 Pa.
5. When you go to make your next opening, make sure that the end of the pressure hoses are still in the correct zones (i.e. a hose has not slipped out of an attic space) and that the hoses are not completely pinched by a door or hatch. Also, confirm that the door(s) or hatch(es) to a zone are in the proper position. For example, if you just completed an open-door test to the west attic make sure the opening to that attic is open completely and the opening to the other attics are closed.

Note – check for obstructions in the pressure tubing (i.e. crimped hose or water in the hose) at the start of the tests.

Using the DG-3 Digital Manometer for 30 Second Measurements

The manual pressure and flow measurements should be taken using the long-term averaging feature of the DG-3 manometer to record 30 second averages. The following are the step by step instructions necessary to perform these measurements with the DG-3.

First Measurement

1. Turn the MODE dial to TIME SELECT. Press the SELECT toggle switch down (towards the TIME arrow) until L is displayed.
2. Turn the MODE dial to PRESSURE. The display will show the average pressure from the time that the dial was switched to PRESSURE. Wait for 30 seconds and record the pressure.

Additional Measurements

Turn the MODE dial back to TIME SELECT and confirm that L is displayed. Turn the MODE dial back to pressure when you are ready to start taking the measurement.

30 Second Blower Flow Measurements

The same procedure is used to record 30 second blower flow measurements. After switching the MODE dial to TIME SELECT, switch the dial to FLOW.

Adjusting the Blower Flow for House Air Leakage Measurements

When you need to adjust the blower flow for house air leakage (i.e. CFM50) or zone pressure measurements you will need to switch back to 1 or 5 second averages. To do that, switch the MODE dial back to TIME SELECT and press the SELECT toggle switch until 1 or 5 is displayed.

Field Data Form

Confirm that house meets the Selection Criteria

1. Site built, single family, detached residence.
2. At least one “primary” zone that has movable openings to house or outside.
3. Work scope includes air sealing of at least one zone.

Note - Repair major air leakage sites (missing windows, door, and interior wall surfaces) before the investigation and tests are conducted.

(generated by computer) Project House ID: _____

Agency: _____ Agency house identifier: _____

Technician ID: _____ Test Date, Start: _____ Complete: _____

House Characteristics

_____ Const Yr: _____

Street

City

Stories: **Ranch** **1 ½ story** **2 story** **2 ½ story** **Split** **Other** _____

Foundation: **Crawlspace** **Basement** **Slab** **Slab/Crawl** **Slab/Base.** **Crawl/Base.** **Other**

Garage: **Detached** **Tuck under** **Side/living space** **Side/living & attic** **None** **Other**

Framing: **Balloon** **Platform** **Combination** **Other** _____

Floor area (sq ft): Lower _____ First _____ Second _____ Third _____

(see definition of living area and lower level in Program Notes - #7)

Describe any weatherization repairs completed to house prior to testing

Additional house comments or notes

Will house sidewalls be insulated? **Yes** **No**

If yes:

1. Complete zone characteristics information for all zones (see following pages).
2. Setup blower door and run tubes to zones. Use APT program to zone pressures with house/out = 50Pa.
3. Insulate sidewalls.
4. Continue process from top of *Results Before Work* tab.

Sketch a floor diagram of each floor of the house and take pictures as necessary to define zone locations.

House Floor Diagrams

Include each floor (scale = 2' per grid)

The diagram is a large grid for drawing house floor plans. It consists of a 10x10 grid of squares. Each square represents 2 feet by 2 feet. The grid is divided into four 5x5 quadrants by a central vertical line and a central horizontal line. The quadrants are separated by thicker lines, while the individual squares are separated by thinner lines.

Zone Characteristics

Complete Zone Characteristics section for each primary (openings) and secondary (no openings) house zone. See sheet Definition of Primary and Secondary Zones for further information on zones to include.

Number: _____ Identifier: _____ Type: **Openings/Primary** **No Openings/Secondary**

Category: (Other) (Kneewall attic) (Peak attic w/vents) (Full attic, open floors) (Pk over 1 ¾ story)
(Above flat roof) (Above cath. ceiling) (Attached porch) (Tuck garage) (Side Garage) (Crawlspace)
(Porch attic) (Between floor cavity) (Above drop ceiling) (Peak attic no vents) (Basement)
(Full, floored attic)

Openings to house: **Hatch** **Sm door** **Full door** **Combination** **Other** **None**

Openings to outside: **Vents** **Sm door** **Full door** **Garage door** **Combination** **Other** **None**

General description of zone and additional comments _____

If vents to outside:		
Roof (#): _____	Gable physical area (sq in): _____	Ridge length (ft): _____
Turbines (#): _____ Powered attic fan? Yes No		

Air temp. (F): _____ Ductwork in zone? **Yes** **No** Air handler in zone? **Yes** **No**

Any identified air leaks in zone that need to be treated? **Yes** **No**

Insp. Time (per-min) _____ People _____ Start time: _____ Done time: _____
(Time required to inspect leaks in **ALL** zones)

If identified air leaks:	
Plumbing stk (#) _____	Dropped ceiling (sf) _____
Plumbing wall (ft) _____	Slant walls (sf) _____
Combust. stack (#) _____	Int. wall tops (ft) _____
Mas. chimney bypass (ft) _____	Ext. wall tops (ft) _____
Duct penetrations/registers (#) _____	T&G walls (sf) _____
Ductwork airsealing (ft) _____	T&G slants (sf) _____
Ex. fan penetration (#) _____	Open floored attic (sf) _____
Mech. chase (#) _____	Bathroom soffits (ft) _____
Recessed lights (#) _____	Kitchen soffits (ft) _____
Built-ins (#) _____	Garage/house conn. (si) _____
Attic hatch (ft) _____	Crawl perimeter (ft) _____
Stairwell drop (ft) _____	Open floor under knee (ft) _____
Door weatherstrip (ft) _____	Other _____
Additional comments: _____	
Description of required air sealing: _____	

Results Before Work

Blower Door Setup

Total Time (per-min) _____ People _____ Start time: _____ Done time: _____

Run Hoses to Zones

Total Time (per-min) _____ People _____ Start time: _____ Done time: _____

Air temp. (F), outside: _____ Inside: _____ Wind: **0-3 4-12 13-24 >24mph**

Air Leakage Test

House/out (Pa), Base: _____ Blower On: _____ Blower Flow (cfm) _____

Ring **Open A B C** Estimated pressure uncertainty (Pa): **0.5 1.0 1.5 2.0 >2.0**

Total Time (per-min) _____ People _____ Start time: _____ Done time: _____

Complete one section for each zone (use additional page if more than 3 zones)

Zone Pressure Measurement **1:** Zone ID: _____

Zone/out (Pa), Base: _____ Blower On: _____

Look for problems: **Much harder Little harder No change Little less Much less**

New problems found: **None Some small ones Some big ones Many big ones**

Change work in treatment plan: **Much less Little less No change Little more Much more**

Change in cost (negative for cost reductions) \$ _____

Zone Pressure Measurement **2:** Zone ID: _____

Zone/out (Pa), Base: _____ Blower On: _____

Look for problems: **Much harder Little harder No change Little less Much less**

New problems found: **None Some small ones Some big ones Many big ones**

Change work in treatment plan: **Much less Little less No change Little more Much more**

Change in cost (negative for cost reductions) \$ _____

Zone Pressure Measurement **3:** Zone ID: _____

Zone/out (Pa), Base: _____ Blower On: _____

Look for problems: **Much harder Little harder No change Little less Much less**

New problems found: **None Some small ones Some big ones Many big ones**

Change work in treatment plan: **Much less Little less No change Little more Much more**

Change in cost (negative for cost reductions) \$ _____

Affect leakage impressions: **Not at all A little Somewhat A fair amount A lot**

Comments on usefulness of measurements

ALL Zone Pressure Measurements

Total Time (per-min) _____ People _____ Start time: _____ Done time: _____

Complete one section for each **primary** zone (use additional page if more than 3 zones)

Add-A-Hole/Open Door Measurement	# _____	Zone ID: _____
Pressure w/Blower On: Zone/out _____	House/out _____	Ring Open A B C
Fan flow (cfm): _____	Hole area (si) _____	Hole to: Outside House
Look for problems: Much harder Little harder No change Little less Much less		
New problems found: None Some small ones Some big ones Many big ones		
Change work in treatment plan: Much less Little less No change Little more Much more		
Change in cost (negative for cost reductions) \$ _____		
Total Time (per-min) _____	People _____	Start time: _____ Done time: _____

Add-A-Hole/Open Door Measurement	# _____	Zone ID: _____
Pressure w/Blower On: Zone/out _____	House/out _____	Ring Open A B C
Fan flow (cfm): _____	Hole area (si) _____	Hole to: Outside House
Look for problems: Much harder Little harder No change Little less Much less		
New problems found: None Some small ones Some big ones Many big ones		
Change work in treatment plan: Much less Little less No change Little more Much more		
Change in cost (negative for cost reductions) \$ _____		
Total Time (per-min) _____	People _____	Start time: _____ Done time: _____

Add-A-Hole/Open Door Measurement	# _____	Zone ID: _____
Pressure w/Blower On: Zone/out _____	House/out _____	Ring Open A B C
Fan flow (cfm): _____	Hole area (si) _____	Hole to: Outside House
Look for problems: Much harder Little harder No change Little less Much less		
New problems found: None Some small ones Some big ones Many big ones		
Change work in treatment plan: Much less Little less No change Little more Much more		
Change in cost (negative for cost reductions) \$ _____		
Total Time (per-min) _____	People _____	Start time: _____ Done time: _____

Affect leakage impressions: **Not at all** **A little** **Somewhat** **A fair amount** **A lot**

Comments on usefulness of measurements

Results After Work

The following information should be entered after finishing the first full set of ZPD measurements that were performed when the zone work was completed and you confirmed that no further work is required

<i>Complete following section for information related to entire house</i>
Air sealing/insulation work performed on house that was not included in one of zones

Number of tech-hours to perform this air sealing/insulation work _____
Air sealing/insulation material costs \$ _____
Affect of meas. on your leakage work: Not at all A little Somewhat A fair amount A lot
Comments on usefulness of ZPD measurements

Was IR camera used for final inspection? Yes No
If yes, Were any additional treatment(s) identified as a result of the IR scan? Yes No
Description of findings from IR scan (if IR used)

Complete the following page for each primary and secondary zone

____ Zone ID: _____

Any identified air leaks in zone that need to be treated? **Yes No**

If Yes, complete information in the following box:

Identified air leaks:	
Plumbing stk (#) _____	Dropped ceiling (sf) _____
Plumbing wall (ft) _____	Slant walls (sf) _____
Combust. stack (#) _____	Int. wall tops (ft) _____
Mas. chimney bypass (ft) _____	Ext. wall tops (ft) _____
Duct penetrations/registers (#) _____	T&G walls (sf) _____
Ductwork airsealing (ft) _____	T&G slants (sf) _____
Ex. fan penetration (#) _____	Open floored attic (sf) _____
Mech. chase (#) _____	Bathroom soffits (ft) _____
Recessed lights (#) _____	Kitchen soffits (ft) _____
Built-ins (#) _____	Garage/house conn. (si) _____
Attic hatch (ft) _____	Crawl perimeter (ft) _____
Stairwell drop (ft) _____	Open floor under knee (ft) _____
Door weatherstrip (ft) _____	Other _____
Additional comments and/or description of air sealing/insulation work performed in zone:	

Look for problems: **Much harder Little harder No change Little less Much less**

New problems found: **None Some small ones Some big ones Many big ones**

Change work in treatment plan: **Much less Little less No change Little more Much more**

Change in cost (negative for cost reductions) \$ _____

Ver March 8, 2001

Appendix D. Sample ZPD Program Screens

The following is a sample of each of the four data entry screens for the ZPD Data program.

Figure D1. ZPD Data Program: House Characteristics Screen

LI WX ZPD Research Project

House Zone Test

Agency: Duluth House: C1002 Agency House ID: 072855 Tech ID: SB Test Start: 3/14/2001 Test Complete: 1/1/2001

House Characteristics | Zone Characteristics | Results Before Work | Results After Work | APT Data Files

Street: 3434 Great Test Blvd. City: Duluth Est Year of Const.: 1950 Primary Zones: 2 Secondary Zones: 0

Stories: Ranch Foundation: Basement Garage: Detached Framing: Combination

Living Space Floor Area (sf)

Lower Level	First Floor	Second Floor	Third Floor
672	672	294	0

Describe any WX agency repairs completed to house prior to testing

Replace furnace, remove wood stove, insulate walls.
Sealed the peak gable end vents (no peak attic).

Additional house comments or notes

☐ House side walls will be insulated?

Figure D2. ZPD Data Program: Zone Characteristics Screen

LI WX ZPD Research Project

House Zone Test

Agency: Duluth House: C1002 Agency House ID: 072855 Tech ID: SB Test Start: 3/14/2001 Test Complete: 1/1/2001

House Characteristics | Zone Characteristics | Results Before Work | Results After Work | APT Data Files

Zone #: 2 Identifier: South Type: Openings Category: Kneewall Attic Openings to House: Hatch Openings to Outside: Vents

General description of zone and additional comments

Total equivalent area (sq in): 48 Zone Vents ☐ powered attic fan present?

Number of roof vents: 1 Gable nominal open area: 190 Ridge vent length (ft): 0 Number of turbine vents: 0

☒ Any identified air leaks in zone that need to be treated? Zone air temp when first enter zone (F): 25 ☐ Ductwork travels through zone ☐ Airhandler is in zone

Time Spent Inspecting for Leaks in All Zones

Time (person-min): 10 Number of people: 1 Start Done

Identified Air Leaks

Type of Leak	Quantity	Unit
Plumbing stack	1	#
Attic hatch	3	ft
T&G walls	72	sq ft
T&G slants	162	sq ft
Open floor under kneewalls	3	ft

Check Data

Default type of leaks to select

Description	Units
Plumbing stack	#
Plumbing wall	ft
Combustion vent stack	#
Bypass adjacent to masonry chimney	ft
Duct penetrations/registers	#
Ductwork air sealing	ft

Additional comments about identified air leaks

Description of required treatment(s)

Figure D3. ZPD Data Program: Results Before Work Screen

LI WX ZPD Research Project

House Zone Test

Agency: Duluth House: C1002 Agency House ID: 072855 Tech ID: SB Test Start: 3/14/2001 Test Complete: 1/ 1/2001

House Characteristics | Zone Characteristics | **Results Before Work** | Results After Work | APT Data Files

Blower Door Setup

Time (person-min) 10 Start

Number of people 1 Done

Equipment Setup Time

Time (person-min) 10 Start

Number of people 1 Done

Run Hoses To Zones

Time (person-min) 10 Start

Number of people 1 Done

Test Conditions

Outside air temp (F) 35

Inside air temp (F) 69

Wind Speed Category: Gentle (4-12 mph)

flag does not extend, leaves/twigs in motion

Manual Air Leakage Test

House/out Pressure (Pa)

Baseline	Fan On	Adjusted	Fan Flow (cfm)	House air leakage (CFM50)
1.5	-50	-51.5	1750	1,661

Flow Ring: A

Press. Uncert. (Pa) 2.0

Time Required for Air Leakage Test

Time (person-min) 30 10:20:00 AM Start

Number of people 2 10:35:00 AM Done

Manual Zone Pressure Measurements

Update	Zone	Base	Fan On	Adj.	Vent Method	Path Flow	Look Problems	New Found	Change Plan	Chg Cost
	North	-0.4	-7.8	-7.4	149	No change	None	No change		\$0
	South	-0.6	-9.6	-9.0	165	No change	None	No change		\$0

How much did the zone pressure measurements affect your impression of the air leakage problems in this house? Not at all

Comments on usefulness of zone pressure measurements

Time Required for ALL Zone Pressure Measurements

Time (person-min) 14 Number of people 2 Start Done

Only required for primary zones (Openings) **Manual Add-A-Hole and Open Door Measurements**

Update	Zone	Loc	Fan On	Adj.	Fan Flow	Hole Area	Calc.	EQLA (si)	Path Leakage	Crew Feedback	
							Meth.	To House	To Out.	Hse/Zone Flow	Look Problems
	North	Zone	-46.0	-45.6	1,750	81	Hole	3	25	68	No change
		Flow Ring									
		Hole To									
	House		-50.0	-51.5			Flow	0	0	-99	Time 20 Pec
	South	Zone	-45.4	-44.8	1,750	81	Hole	10	28	86	No change
		Flow Ring									
		Hole To									
	House		-50.0	-51.5			Flow	0	0	-99	Time 20 Pec

Timer for Add-A-Hole and Open Door Measurements in EACH zone

Time (person-min) 20 Number of people 2 1:00:00 AM Start 1:10:00 AM Done

How much did the measurements affect your impression of the air leakage problems in this house? Not at all

Comments on usefulness of Add-A-Hole or Open Door measurements

Figure D4. ZPD Data Program: Results After Work Screen

LI WX ZPD Research Project

House Zone Test

Agency: Duluth House: C1002 Agency House ID: 072855 Tech ID: SB Test Start: 3/14/2001 Test Complete: 1/ 1/2001

House Characteristics | Zone Characteristics | Results Before Work | Results After Work | APT Data Files

The following information should be entered after finishing the first full set of ZPD measurements that were performed when the zone work was completed and you confirmed that no further work is required

Zone #: 1 Identifier: North ☒ Any air leaks that were treated? Complete following information for every zone

Treated Air Leaks

Type of Leak	Quantity	Unit
Plumbing stack	1	#
Attic hatch	3	ft
T&G walls	72	sq ft
T&G slants	162	sq ft
Open floor under kneewalls	27	ft

Check Data: << Add Delete

Default type of leaks to select

Description	Units
Plumbing stack	#
Plumbing wall	ft
Combustion vent stack	#
Bypass adjacent to masonry chimney	ft
Duct penetrations/registers	#
Ductwork air sealing	ft

Additional comments and/or description of air sealing/insulation work performed in zone

Number of tech-hours performing air sealing/insulation work: 28.0 Air sealing/insulation material costs: \$204.73

Did the measurements change how closely you looked for problems in this zone? No change

How many new problems did you find as a result of the measurements? None

Did the measurements change your treatments? No change

How much did the changes in treatments affect the cost of this job? \$0.00

Responses for Entire House

Air sealing/insulation work performed on house that was not included in one of zones above

Number of tech-hours to perform this air sealing/insulation work: 28 Air sealing/insulation material costs: \$204.73

Date entry COMPLETE All data entry complete

The following is a sample of the key data entry and results screens for the APT ZPD program.

Figure D5. APT ZPD Program: Information Screen

Test Information

House # CS011 Series 1 Test Type Post Test Date 5/7/2001 Tester ID JP Extra file character

Wind Speed Strong (> 24 mph) Blower Location Front Blower Position DePress

large branches in motion, difficult to walk

Zone Configuration

Ch. #	Type	Identifier	Category	Vent Area	Reference
3	Openings	peak	Full attic, open floors	50	Outside
4	Openings	sideattic	Kneewall attic	0	Outside
5	No Openings	basement	Basement	0	Outside
6	Inactive	P6		0	Outside

Blower Type door Blower Starting Speed 4

Inside/Outside Air Temps Stop/Record

Start Outside 70.0 Start Inside 72.0

Turn off blower after measurement ☒ Auto save data file ☒ Auto zero interval (secs) 60

General Comments

post tests all work is done

7: OK 6: OK

Figure D6. APT ZPD Program: Time Graph



Figure D7. APT ZPD Program: Measurement Results Screen

CEE Automated Multi-ZPD

File Test View

Test Information Time Graph **Test Results** Multi-Zone Flows Zone Connections Single Zone Flows

Test Number 2 [Blower Flow \(cfm\)](#) 2248 +/- 26 ☒ Include test in analysis
☐ Use base from first test

Pressures (Pa, wrt outside)

Zone Label	Adjusted	Measured	Baseline
House	-42.1 +/- 0.9	-42.5 +/- 0.8	-0.4 +/- 0.4
EAST	-42.5 +/- 0.9	-43.0 +/- 0.8	-0.5 +/- 0.4
WEST	-12.1 +/- 0.8	-12.4 +/- 0.7	-0.4 +/- 0.3

Time Recorded

[Baseline](#)

Start 2.88
End 3.38

[Measured](#)

Start 3.94
End 4.44

Use Second **Openings Between Zones** height x width

From House Area (sq) 1344.00

First To EAST +/- 268.80 20% Type Sn. Door

Test Comments View Data Check ☒

Appendix E. Database Format

Table Name: House

General test information and house characteristics. One record for each test house.

Description	TYPE	Name
Weatherization agency (1:Duluth, 2:Virginia, 3:WestCAP, 4:CouleeCAP, 5:NEICAC, 6:Op. Threshold)	S	Agency *
Five char house ID (my format is C****, the number immediately after the C is the agency number, the following 3 numbers will be used in sequence – i.e. 001 for the first house)	A5	House *
House characterization information complete	L	HCharComp
Zone characterization information complete	L	ZCharComp
Before work results data entry complete	L	PreWorkComp
After work results data entry complete	L	AfterWorkComp
WX agency house ID	A15	WXID
Street address	A30	Street
City	A15	City
Lead technician ID	A3	TechID
Date test started	D	TestStart
Date test completed	D	TestEnd
ID of project member that reviewed results	C3	StaffID
Review date	D	RevDate
House type (1:ranch, 2:1 ½ story, 3:2 story, 4:2 ½ story, 5:split, 6:other)	S	HStory
Type of foundation (1:crawlspace, 2:basement, 3:slab on grade, 4:slab & crawl, 5:slab & basement, 6:crawl & basement, 7:other)	S	LowerLevel
Type of garage (1:detached, 2: tuck under, 3: side attached to living space, 4: side attached to living space and attic, 5:none, 6:other)	S	GarageType
Framing type (1:balloon, 2:platform, 3:comination, 4:other)	S	Framing
Year of construction (if known)	A4	ConstYear
Number of primary transition zones	S	PrmZnNm
Number of secondary transition zones	S	SecZnNm
General description of transition zones	M	ZoneNote
Approximate lower level floor area (sf), interior	N	FALow
Approx. first floor area (sf)	N	FAFirst
Approx. second floor area (sf)	N	FASecond
Approx. third floor area (sf)	N	FAThird
Description of any WX agency repairs completed before tests started	M	Repairs
Additional comments about house characteristics	M	HseNote
Sidewall insulation required?	L	SideInsul
Number of person-minutes required to perform zone leak inspection	S	InspTime
Number of people involved with zone leak inspection	S	InspPeps
Time starting performing zone leak inspection	T	InspStart
Time finished performing zone leak inspection	T	InspEnd

Number of person-minutes required to setup blower door equipment	S	BlowTime
Number of people involved with blower setup	S	BlowPeps
Time starting setting up blower door	T	BlowStart
Time finished setting up blower door	T	BlowEnd
Number of person-minutes required to run hoses to all transition zones	S	HoseTime
Number of people involved with hose setup	S	HosePeps
Time starting setting up hoses	T	HoseStart
Time finished setting up hoses	T	HoseEnd
First floor air temperature at start of testing (F)	N	IFFTemp
Outdoor temperature at start of test (F)	N	ITout
Wind speed category at start of test (1:Calm (0-3 mph), 2:Gentle (4-12 mph), 3:Moderate (13-24 mph), 4:Strong (> 24 mph))	S	IWindSpd
Initial air leakage test house pressure: baseline (Pa)	N	IHouseBase
Initial air leakage test measured house pressure (Pa) – not adjusted	N	IHousePres
Initial air leakage test blower flow rate (cfm)	N	IBlowFlow
Initial air leakage test blower ring (1: open, 2: A, 3: B, 4: C)	S	IBlowRing
Initial air leakage value (CFM50)	N	ICFM50
Number of minutes required to perform manual air leakage test and zone pressure tests	S	ICFM50Time
Number of people involved with initial air leakage test	S	ICFM50Peps
Time starting initial air leakage test	T	ICFMStart
Time finished initial air leakage test	T	ICFMEnd
Number of person-minutes required to perform manual zone pressure tests	S	IZPTime
Number of people involved with zone pressure tests	S	IZPPeps
Time starting zone pressure tests	T	IZPStart
Time finished zone pressure tests	T	IZPEnd
Estimated uncertainty of pressure measurements (1: +/-0.5Pa, 2:1Pa, 3:1.5Pa, 4:2Pa, 5:>2Pa)	S	PresUnc
<i>Note – zone pressure measurements are recorded in the Zone table</i>		
<i>After zone pressure measurements and before method 1 or 2 tests</i>		
How much did the zonal pressure measurements affect your impression of the air leakage problems in this house? (1:not at all, 2:a little, 3:somewhat, 4:a fair amount, 5:alot)	S	ZPmResp
Additional comments/feedback on usefulness of ZPD results.	M	ZPmNote
<i>After APT method 1 or 2 tests</i>		
How much did the zone method 1 and 2 measurements affect your impression of the air leakage problems in this house? (1:not at all, 2:a little, 3:somewhat, 4:a fair amount, 5:alot)	S	ZPcalcResp
Additional comments/feedback on usefulness of ZPD method 1 or 2 tests.	M	ZPcalcNote

After all air sealing work is complete		
Summary description of air sealing and insulation work performed on house (only include work that was not done in transition zones)	M	WorkDesc
House air sealing tech hours (only include work that was not done in transition zones)	N	SealHrs
Total air sealing material cost (only include work that was not done in transition zones)	\$	SealCost
<i>Note – the previous three fields are repeated for each zone in the Zone table. The fields in this table should only contain the work that was not specific to one of the transition zones</i>		
How much did the zone method 1 and 2 measurements affect your air leakage work at this house? (1:not at all, 2:a little, 3:somewhat, 4:a fair amount, 5:alot)	S	ZPfinResp
Additional comments/feedback on usefulness of ZPD method 1 or 2 tests.	M	ZPfinNote
Was IR camera used for final inspection of work?	L	IRused
Was any additional treatment identified as result of IR?	L	IRwork
Description of findings from IR scan	M	IRnote

* - key field

Field Type Key:

A – alpha numeric character string

C - currency

D – date

I – long integer

L – Boolean logic

M – memo

N – floating point number

S – short integer

T - time

Table name: Zone

Characteristics of each transition zone. One record for each primary or secondary zone.

Description	TYPE	Name
Five char house ID	A5	House
Zone number or sequence	S	ZnNm
Characterization information complete	L	CharComp
Before work results data entry complete	L	PreWorkComp
After work results data entry complete	L	AfterWorkComp
Zone ID	A10	ZnID
Type of zone (1: primary, 2:secondary)	S	PrimSec
General description of zone (info not included in following fields)	M	Desc
Zone type (1:Other, 2:Kneewall Attic, 3:Peak Attic w/vents, 4:Full Attic, 5:Peak over 1 3/4 story, 6:Above flat roof, 7:Above cath. Ceiling, 8:Attached porch, 9:Tuck Garage, 10:Side Garage, 11:Crawlspc, 12:Porch attic, 13:Between floor cavity, 14:Above drop ceiling, 15:Peak Attic no vents,	S	ZnType

16:basement)		
Intentional openings to living area (1:Hatch, 2:Sm. Door, 3:Full Door, 4:Combination, 5:Other, 6:None)	S	IntOpen
Intentional openings to outside (1:Vents, 2:Full Door, 3:Garage Door, 4:Combination, 5:Other, 6:None)	S	ExtOpen
Number of roof vents (25 si equivalent)	S	RoofVent
Gable vent nominal physical open area (si)	I	GableArea
Length of ridge vent (ft)	I	RidgeLen
Number of turbine vents	S	Turbines
Powered attic fan present?	L	PowerFan
Total equivalent vent area	N	VentArea
Ductwork in zone?	L	Ducts
Air handler in zone?	L	Airhandler
Air dry bulb temperature when first enter zone	N	AirTemp
Any identified leaks that need to be treated?	L	IdentLeaks
The following are the fields for a checklist of types of air leaks that appear to need to be treated. These are identified by a visual inspection before any pressure diagnostics.		
Additional comments about identified air leakage sites.	M	LeakNote
Description of required treatment(s)	M	TreatNote
Initial zone pressure measurement baseline	N	IBase
Initial zone pressure w/house @50Pa	N	IZnPres
Calculated vent method series leak flow (cfm @house/out = 50Pa), initial conditions	N	IMeth3Flow
<i>The following fields will be used <u>after</u> zone pressure measurements and <u>before</u> method 1 or 2 diagnostics</i>		
Did the measurements change how closely you will look for problems in different zones? (1:much harder, 2:little harder, 3:no change, 4:little less, 5:much less)	S	ZPmLook
How many new problems that need to be addressed did you find as a result of the measurements? (1:none,2:some small ones, 3:some big ones, 4: many big ones)	S	ZPmProbs
Did the measurements change your treatment plan? (1:much less work, 2: little less work, 3:no change, 4:little more work, 5:much more work)	S	ZPmWork
How much do you think the changes in treatments will affect the cost of this job?	C	ZPmCost
Size of hole added to zone (if applicable)	N	IHoleArea
Hole location (1:outside, 2:house)	S	IHoleLoc
Zone pressure w/house @50Pa and w/hole	N	IHoleZnPres
House pressure w/fan on & hole	N	IHoleHsPres
Blower flow for add hole or open door test	N	IHoleFlow
Blower flow ring for add hole/open door test (1: open, 2: A, 3: B,	S	IHoleBlowRing

4: C)		
Computed zone series flow by hole method, (cfm @house/out = 50Pa)	N	IHolePathHoleM
Computed zone series flow by flow method, (cfm @house/out = 50Pa)	N	IHolePathFlowM
Number of person-minutes required to perform traditional add-a-hole or open door test on zone	S	IHoleTime
Number of people involved with tests	S	IHolePeps
Time starting tests	T	IHoleStart
Time finished tests	T	IHoleEnd
<i>The following fields will be used for feedback after the manual method 1&2 measurements are complete.</i>		
Did the measurements change how closely you will look for problems in different zones? (1:much harder, 2:little harder, 3:no change, 4:little less, 5:much less)	S	ZPcalcLook
How many new problems that need to be addressed did you find as a result of the measurements? (1:none,2:some small ones, 3:some big ones, 4: many big ones)	S	ZPcalcProbs
Did the measurements change your treatment plan? (1:much less work, 2: little less work, 3:no change, 4:little more work, 5:much more work)	S	ZPcalcWork
How much do you think the changes in treatments will affect the cost of this job?	C	ZPcalcCost
<i>The following fields will be used for feedback after all the air sealing work is complete.</i>		
Did the measurements change how closely you looked for problems in different zones? (1:much harder, 2:little harder, 3:no change, 4:little less, 5:much less)	S	ZPfinLook
How many new problems did you find as a result of the measurements? (1:none,2:some small ones, 3:some big ones, 4: many big ones)	S	ZPfinProbs
Did the measurements change your treatment plan? (1:much less work, 2: little less work, 3:no change, 4:little more work, 5:much more work)	S	ZPfinWork
How much were the cost of the treatments affected by the ZPDs?	C	ZPfinCost
Any leaks treated in zone?	L	ZnSealed
Summary description of air sealing and insulation work performed on zone	M	ZnSealWork
Zone air sealing tech hours	N	ZnSealHrs
Zone air sealing material cost	\$	ZnSealCost

Table name: IdentLeaks

Crew identified leaks from initial visual inspection in each transition zone – specified after visual inspection and before any ZPD measurements. Multiple records for each primary or secondary zone.

Description	TYPE	Name
Five char house ID	A5	House
Zone number or sequence	S	ZnNm
Type of air leakage site(references field LkNm in table LeakTypes)	S	LkType
Quantity of specified leakage (unit is for specified leak type is designated in LeakTypes table, field Unit)	I	LkQuant

Table name: TreatLeaks

Crew treated leaks in each transition zone – specified after all air sealing work and ZPD measurements are complete. Multiple records for each primary or secondary zone.

Description	TYPE	Name
Five char house ID	A5	House
Zone number or sequence	S	ZnNm
Type of air leakage site(references field LkNm in table LeakTypes)	S	LkType
Quantity of specified leakage (unit is for specified leak type is designated in LeakTypes table, field Unit)	I	LkQuant

Table name: LeakTypes

Types of default air leakage sites identified or treated by crews. Predefined records for which the crew selects from to designate identified (IdentZoneLk) or treated (TreatZoneLk) in each primary or secondary zone.

Description	TYPE	Name
Leak type number	S	LkNm
Short description of type of leak	A35	Desc
Type of units for specified quantity of air leakage (#, ft, sq ft, sq in)	A5	Unit

Table name: DataFiles

APT ZPD data files saved. Multiple records for each house.

Description	TYPE	Name
Five char house ID	A5	House
File sequence	S	Seq
Number of pressure tests in file	S	NmTests
Type of test (Pre, inter, post)	A5	Type
APT file name	A20	FName
General notes about test	M	Desc

Appendix F. Agency Survey Results

Phone Interview of 8 State Agency Representatives

Contacts

Illinois	Eddie Haber	IL Dept. of Commerce & Community Affairs	217-524-8032
Indiana	Maria Larson	Division of Family & Children	317-232-1997
Iowa	Mike Speed	Div. of Comm. Action Agencies/Wx Bureau	515-281-4586
Michigan	Doug Wilcox	Family Independence Agency	517-335-5931
Minnesota	Alan Chapman	Energy Programs Office	651-582-8323
Missouri	Ted Koenig	Missouri Dept. of Natural Resources	573-751-7158
Ohio	Tom Andrews	Office of Energy Efficiency	614-466-7400
Wisconsin	Martha Benewicz	Weatherization Bureau	715-967-2093

- 1. Has your state agency developed any written protocols, procedures, manuals or forms for implementing Zone Pressure Diagnostics in the field? Zone Pressure Diagnostics may be called “series leakage measurements” or “Blasnik Methods” in your state.**

The following four states do not have any Zone Pressure Diagnostic protocols. Some provide training see questions 3, 5-9, 13 - 15 for more information:

IL, IN, MI, MO

1a. For weatherization agency auditors?

No:

OH: *No, they don't recommend that the initial inspector to do testing, they would prefer ZPDs to be crew based.*

Yes:

IA: *It is left up to the discretion of wx agency auditors to determine when to use ZPD.*

MN: *Auditors are asked to record a pre weatherization ZPD reading in the job book for up to 6 locations in the house.*

WI: *It is left up to wx agency auditors to use their discretion when to use ZPD.*

1b. For weatherization agency crews?

IA: *It is left up to the discretion of wx agency crews and contractors to determine when to use ZPD.*

MN: *Crews and contractors are required to record a pre and post weatherization ZPD reading in the job book for up to 6 locations in the house.*

OH: *The crews may need to weatherize first. Then ZPDs testing is used on every house to identify bypasses or other problems. Crews are instructed that it is not cost-effective to address leakage less than 20 sq. in (200 cfm). (see page 3 of “Diagnostic Testing Methods: Zone Pressure Measurement Tests”).*

WI: *As of 01/2000, 2/3 of the wx agencies in the state have received ZPD training. All of the crews will be trained by 04/2000. After the initial training (Round 1) installers are required to use the initial ZPD estimate for every house. After the follow-up training (Round 2),*

installers will use ZPD at their discretion or when there is high fuel use, high cfm₅₀, or a complex house. They use Method #1 Add a Hole when it is physically possible. They also use Method #2 when conditions merit for walk-in attics, basements, and garages.

1c. For weatherization agency quality control/inspectors?

IA: *It is left up to the discretion of wx agency inspectors to determine when to use ZPD.*

MN: *Auditors are required to duplicate the post weatherization ZPD reading in the job book for up to 6 locations in the house using the same ZPD method.*

OH: *Auditors use ZPD tests on all final inspections. When the auditor cannot get the pressure reading down below 20 sq. in. they document that they have exhausted all visual attempts to find the problem.*

WI: *They are encouraged but not required to use a quick add a hole test to see if there is considerable drop in pressure.*

1d. For state agency monitors?

IA: *It is left up to the discretion of state agency monitors to determine when to use ZPD.*

MN: *Use of ZPDs on a case-by-case basis is up to individual monitors. All are trained to use ZPDs.*

OH: *Field representatives use ZPDs on a sample of homes when they can. It depends on blower door readings.*

WI: *Use of ZPDs on a case by case basis is up to individual monitors. All five monitors are trained, but are not required to use ZPDs*

2. (If yes for question 1) Would it be possible to send me a copy of the information you just described? (Give address and confirm send-to-date).

Notes: We received the following information on ZPD:

IA: *Training materials and example of "House Data Report".*

IL: *Draft copy of the "Assessing the Home As a System" manual.*

MN: *Job book, training materials and "Duct Sealing Pressure Balancing" page from the Minnesota Weatherization Manual.*

OH: *State of Ohio Weatherization Program Standards - Diagnostic Testing Methods: Zone Pressure Measurement Tests. Home Weatherization Assistance Program Data Collection Form. Field Representative Checklist.*

WI: *Diagnostic Technician 1 Training – Round 1 Power Point Slides, Introduction to the Diagnostic Technical Team and Three Year Training Plan. WI Wx Bureau Working Guidelines "When to Use Diagnostic Procedures." Worst Case Draft Test form and Zone Pressure Testing form.*

- 3. I'm going to list different people that are involved in the weatherization process. Tell me to the best of your knowledge whether using Zone Pressure Diagnostics is mandatory or optional according to state protocols.**

	<i>Not required</i>	<i>Optional, but suggested</i>	<i>Mandatory</i>
<i>3a. Weatherization agency auditors</i>	<i>IL, IN, OH, MI, MO</i>	<i>IA, WI (as appropriate)</i>	<i>MN</i>
<i>3b. Weatherization crews</i>	<i>IL, IN, MI, MO</i>	<i>IA</i>	<i>OH, MN, WI (for some buildings)</i>
<i>3c. Weatherization agency quality control/inspectors</i>	<i>IL, IN, MI, MO</i>	<i>IA, WI (as appropriate)</i>	<i>OH, MN</i>
<i>3d. State monitors</i>	<i>IL, IN, MI, MO, MN</i>	<i>IA, OH (highly suggested) WI (as appropriate)</i>	

- 4. I'm going to once again list different people that are involved in the weatherization process. Tell me to the best of your knowledge approximately how often are Zone Pressure Diagnostics routinely used by the following groups:**

	<i>0%</i>	<i>Up to 25% (of homes)</i>	<i>Over 25% less than 50% (of homes)</i>	<i>Over 50%, less than 75% (of homes)</i>	<i>Over 75% (of homes)</i>
<i>4a. Weatherization agency auditors</i>	<i>IL, IN, MI, MO</i>	<i>IA, OH, WI</i>			<i>MN</i>
<i>4b. Weatherization crews</i>	<i>IL, IN, MI, MO</i>	<i>IA</i>		<i>OH, WI</i>	<i>MN</i>
<i>4c. Weatherization agency quality control/inspectors</i>	<i>IL, IN, MI, MO</i>	<i>IA, WI</i>		<i>OH, MN</i>	
<i>4d. State monitors</i>	<i>IL, IN, MI, MO</i>	<i>IA, WI</i>	<i>MN</i>	<i>OH</i>	

5. To the best of your knowledge please describe any Zone Pressure Diagnostic protocols used by weatherization agency auditors. For example what type of measurement devices are used, which diagnostic methods do they use?

5a. See question 1a

5b. Check off list for equipment

	<i>Required</i>	<i>Suggested</i>	<i>Under what conditions?</i>
<i>Magnahelic</i>			<i>IA: not recommended</i> <i>OH: not recommended because of the long time needed for the needle to settle itself.</i>
<i>Digital Micromanometer</i>	<i>MN, all agencies were given one manometer for each auditor</i>	<i>IA, OH, WI</i>	
<i>Pressure logger</i>			
<i>Up to agencies</i>			
<i>Other</i>			

5c. Check off list of methods

	Always	Sometimes	Conditions (sometimes)
<i>Method #1 – Add a hole</i>		<i>IA, MN, OH, WI,</i>	<i>IA: considered the most accurate method by state, auditors choose which method to use.</i> <i>OH: determined by auditor, Method #2 more common</i> <i>MN: #2 when no vents are present</i> <i>WI: #1 when physically possible and Method #2 isn't warranted</i>
<i>Method # 2 – Open Door</i>		<i>IA, MN, OH, WI</i>	<i>IA: auditors choose which method to use.</i> <i>OH: determined by auditor, used more often than #1 because it's easier to perform.</i> <i>MN: #3 as a last resort when there is no access or a strange reading occurs.</i> <i>WI #2 primarily used on walk-in attics, basements, and garages.</i>
<i>Method # 3 – Attic Vent</i>		<i>IA, MN</i>	<i>IA: auditors choose which method to use.</i> <i>MN: #1 used most often.</i> <i>WI #3 is discouraged because it is too hard to accurately estimate air movement through openings.</i>

6. To the best of your knowledge please describe any Zone Pressure Diagnostic protocols are used by weatherization crews in your state. For example what type of measurement devices are used, which diagnostic methods do they use?

6a. See question 1b

MN: all agencies have ZPD equipment available.

IA: all agencies have digital micromanometer's

6b. Check off list for equipment

	<i>Required</i>	<i>Suggested</i>	<i>Under what conditions?</i>
<i>Magnahelic</i>			<i>OH: not recommended because of the long time needed for the needle to settle itself.</i> <i>IA: not recommended</i>
<i>Digital Micromanometer</i>	<i>MN, WI</i>	<i>IA, OH</i>	
<i>Pressure logger</i>			
<i>Up to agencies</i>			
<i>Other</i>			

6c. Check off list of methods

	<i>Always</i>	<i>Sometimes</i>	<i>Conditions (sometimes)</i>
<i>Method #1 – Add a hole</i>	<i>MN when another method isn't used by the auditor</i> <i>WI when another method isn't used</i>	<i>IA OH: considered to be more accurate, agency chooses</i>	<i>IA: considered most accurate method by state, crews/contractors choose which method to use.</i> <i>OH: state reinforces that ZPD results are still just one test and have to be considered with other variables.</i> <i>WI: when physically possible and Method #2 isn't warranted</i>
<i>Method # 2 – Open Door</i>	<i>WI when another method isn't used</i>	<i>IA MN when this method is used by the auditor</i> <i>OH: agency chooses</i>	<i>IA: crews/contractors choose which method to use.</i> <i>OH: state reinforces that ZPD results are still just one test and have to be considered with other variables.</i> <i>WI primarily used on walk-in attics, basements, and garages.</i>
<i>Method # 3 – Attic Vent</i>		<i>IA MN when this method is used by the auditor</i>	<i>IA: crews/contractors choose which method to use.</i> <i>OH: state reinforces that ZPD results are still just one test and have to be considered with other variables.</i> <i>WI use is discouraged because it is too hard to accurately estimate air movement through openings.</i>

7. To the best of your knowledge please describe any Zone Pressure Diagnostic protocols used by weatherization agency quality control/inspectors. For example what type of measurement devices are used, which diagnostic methods do they use?

7a. See question 1c.

7b. Check off list for equipment

	<i>Required</i>	<i>Suggested</i>	<i>Under what conditions?</i>
<i>Magnahelic</i>			<i>OH: not recommended because of the long time needed for the needle to settle itself.</i>
<i>Digital Micromanometer</i>	<i>MN</i>	<i>OH, WI, IA</i>	
<i>Pressure logger</i>			
<i>Up to agencies</i>			
<i>Other</i>			

7c. Check off list of methods

MN: inspector tries to match the post ZPD # that the crew recorded using the same testing method.

	<i>Always</i>	<i>Sometimes - conditions</i>
<i>Method #1 – Add a hole</i>		<i>IA: considered most accurate method by state, inspectors choose which method to use. MN: see above OH: considered most accurate, agency decides WI: when physically possible and Method #2 isn't warranted</i>
<i>Method # 2 – Open Door</i>		<i>IA: inspectors choose which method to use. MN: see above OH: agency decides WI primarily used on walk-in attics, basements and garages.</i>
<i>Method # 3 – Attic Vent</i>		<i>IA: inspectors choose which method to use. MN: see above OH: agency decides WI use is discouraged because it is too hard to accurately estimate air movement through openings.</i>

8. To the best of your knowledge please describe any Zone Pressure Diagnostic protocols used by state agency monitors. For example what type of measurement devices are used, which diagnostic methods do they use?

8a. See question 1d

8b. Check off list for equipment

	<i>Required</i>	<i>Suggested</i>	<i>Under what conditions?</i>
<i>Magnahelic</i>			<i>OH: not recommended because of the long time needed for the needle to settle itself.</i>
<i>Digital Micromanometer</i>	<i>OH, IN, WI, MN</i>	<i>IA</i>	
<i>Pressure logger</i>			
<i>Other</i>			

8c. Check off list of methods

MN: when state monitors use ZPD tests they try to duplicate the post reading found by the crew using the same method.

OH: State monitor decides. (1) Blower door test (house and fan pressures) (2) pressure readings to the zone (3) open hole (4) take second blower door reading (house and fan pressures) (5) if second blower door test was able to reach 50 pascal, take pressure readings to zone (6) are now able to run Test #1 & #2 (test #2 run if a strange reading is obtained from test #1).

	<i>Always</i>	<i>Sometimes</i>	<i>Conditions (sometimes)</i>
<i>Method #1 – Add a hole</i>		<i>IA, OH, WI</i>	<i>IA: considered most accurate method by state, monitors choose which method to use. OH: see above WI: when physically possible and Method #2 isn't warranted</i>
<i>Method #2 – Open Door</i>		<i>IA, IN, OH, WI</i>	<i>IA: monitors choose which method to use. IN – Method #1 is never used because it is not considered a valid method based on comments from experts (e.g.: a presentation by Blasnik). OH: see above WI primarily used on walk-in attics, basements and garages.</i>
<i>Method #3 – Attic Vent</i>		<i>IA</i>	<i>IA: monitors choose which method to use. WI use is discouraged because it is too hard to accurately estimate air movement through openings.</i>

9. Same list, different question. Tell me to the best of your knowledge, how does the Zone Pressure Diagnostic information that is measured change the way a house is treated or evaluated in each step of the weatherization process?

9a. For weatherization agency auditors do Zone Pressure Diagnostics ever change the priorities or type of weatherization work?

Yes:

MN: The auditor may change the total expenditure for air sealing and stress this for the crew. For contractor based bids the auditor would expect a higher bid.

WI, IA: Auditors pay more attention to where air is coming in and going out instead of just focusing on air sealing in general. They may direct crews to focus on specific areas because of initial pressure readings resulting in a change in job orders.

9b. For weatherization crews are specific guidelines for Zone Pressure Diagnostics ever used to indicate if further weatherization work should be done? (If yes, On all houses?)

Yes, on all houses

MN: For most houses where ZPDs are used the results help the crews determine what they thought they could achieve through air sealing.

OH: Indicates leakage that they need to address or document /indicate that the leakage can't be found or fixed.

WI: Crew leaders use a preprogrammed calculator to determine cost effective guidelines. After the sidewalls are blown the crew leader is instructed to take a one-point test and make zone estimations. This information helps crew leaders and crews determine where to seal and if they seal cost effectively.

9c. For weatherization agency quality control/inspectors do Zone Pressure Diagnostics ever help to assess whether weatherization work was done satisfactorily?

Yes:

IA, MN: If pressure readings and other information indicates that more work needs to be done a crew or contractor may be sent back to the home.

OH: Depends on what inspector finds in the house.

WI: As part of their quality control measures inspectors sometimes use a gross one point pressure test along with infra red camera results. The pressure test includes sliding a scuttle open (when possible) and measuring if the pressure drops significantly. If significant bypasses are found these are focused on.

9d. For state monitors do Zone Pressure Diagnostics ever help to assess whether weatherization work was done satisfactorily?

Yes:

MN: State monitors will recheck strange results. Will test hole sizing when there are significant differences in job book.

IA, OH: Zone test to find leakage from specific area + final blower door # + visual check = helps to determine if crews should return to the house.

WI: Sometimes a quick pressure test is used as needed (slide a scuttle open and check pressure drop).

10. Does your agency collect Zone Pressure Diagnostic data on a state level?

Yes:

IA (for 5 of the 18 agencies)

No:

IL, IN, MI, MO, OH, WI

MN – no data collected on a state level. Two agencies: Koochiching and Arrowhead Duluth collect job book data electronically (including pressure #s). Other agencies are starting to use the automated form.

11. What type of Zone Pressure Diagnostic data is collected on a state level?

IA: beginning cfm/final cfm of the attic leakage; ZPD method that they are using. 5 agencies have been sending the state data for approximately ½ year. Contact Gwen Howe 515-281-3988.

OH: agencies collect ZPD info: pre/post blower door #s and zone testing information. Data is not in electronic format and is “not user friendly.”

12. Are the Zone Pressure Diagnostic data collected by the state stored in a central database? If so, are they recorded in electronic format?

Yes: *IA*

No: *ALL states except IA*

13. Does your agency currently provide any training on Zone Pressure Diagnostics?

13a. No:

MI, MO

13a. Yes:

IA: Hands on training is given to auditors and crews on all 3 ZPD Methods when requested by agencies. 3-4 agencies are trained per year. Method #1 is emphasized for its accuracy.

IL: Approximately 60% of all weatherization agency auditors, crew leaders (80% of wx work is crew based), and all 7 state monitors have gone through a 1.5 day workshop by Larry Hasterok on ZPD including: air leakage, building tightness limits, depressurization, 3 ZPD methods, pressure pan duct test, worst case back drafting test, and calculating house depressurization limit.

IN: 2-3 times each quarter the state gives a 2 day, hands-on training class called “Applying Pressure Differentials,” Method 2 is the focus. Almost 85% of weatherization agencies have received training. All five state monitors took a 2-day training on Method 2 in 1999.

MN: The state trains 4-6 agencies per year at the agency’s request or if state field representatives suggest training. A statewide training for weatherization crews contractors, auditors and inspectors was provided 5 years ago. Pressure diagnostics has been a session at four of the last five annual statewide training conferences.

OH: A 3-day, hands-on House Diagnostics Course is offered once every few months. It covers ZPD methods, accuracy, & equipment. Also every few months as requested by agencies/contractors a Pressure Training Course is given by the four state monitors that includes combustion testing, pressure pan testing, and ZPD; includes weatherizing houses. 10% of the weatherization agencies have had this training. It’s been given 8 times, 4-5 in ’99.

WI: 2/3 of the weatherization agencies had 5 people (mostly auditors and crew leaders) who were trained on Round 1 of the state's ZPD protocol (as of 1/2000; 100 % will be trained as of 4/2000). Round 1 includes: How to estimate air leakage; how air moves in houses; how to do ZPD methods #1 & #2; and how to perform a worst case draft test. All training was completed locally.

Please describe:

	<i>Optional</i>	<i>Mandatory</i>	<i>Description of training/frequency</i>
<i>13b. Weatherization agency auditors</i>	<i>IA, IN, MN, OH, WI: 2/3 of agencies had 5 people per agency; 100% of agencies as of 4/2000.</i>	<i>IL: for 60% of agencies</i>	<i>See 13a above</i>
<i>13c. Weatherization crews</i>	<i>IA, IN, MN, OH</i>	<i>WI: for 2/3 of agencies</i>	<i>See 13a above</i>
<i>13d. Weatherization agency quality control/inspectors</i>	<i>IA, IN, MN, OH WI: 2/3 of agencies had 5 people per agency trained</i>	<i>IL: for 60% of agencies</i>	<i>See 13a above</i>
<i>13e. State monitors</i>		<i>MN: for all monitors WI: for all 5 monitors. IL: for all 7 state monitors</i>	<i>See above WI: see above. Train the trainer OH: see above also learn on the job.</i>

14. Do you know of any agencies in your state that have received training on Zone Pressure Diagnostics outside of what the state provides?

IA: Affordable Comfort, regional meetings

IL: Affordable Comfort

IN: Affordable Comfort (5-6 agencies) and national DOE conference (80% of agencies)

MI: Affordable Comfort

MN: Affordable Comfort, regional and national DOE conferences

OH: Affordable Comfort; ZPD course at state conferences in '95 & '97 – trainers include: Fitzgerald, Tooley, Davis, DeKieffer, Keefe, Karg, Jones. No state conference in '99 because they are hosting Affordable Comfort 2000.

WI: Prior to Round 1 training initiative, the state paid for statewide and regional trainings from Jim Fitzgerald, Michael Jones, John Tooley, and Larry Hasterok. Plus additional sessions at Affordable Comfort (including Gary Nelson and Collin Olson).

15. Is your agency planning or developing any Zone Pressure Diagnostics training opportunities in the future?

15a. No:

IN: Continue with current training. Hesitant to go further with trainings because State Weatherization Director said experts in the field say they are unsure about the reliability of ZPD readings.

MI

MN: Want to wait for results of this study first.

Don't Know:

IA: Depends on staffing in the future. State monitors will be sent to regional conferences and Affordable Comfort. May discontinue training until this study is completed.

MO: The state is developing a training program using input from the agencies. It isn't know yet whether ZPDs will be included.

Yes:

IL: In March 2000 the remaining weatherization auditors and crew leaders from 30% of the agencies will be trained using the ZPD protocols described in question 13. The state will also add certification classes for blower doors and ZPD as part of their training. In Spring 2000 state monitors will conduct demonstration projects in the field using blower doors and ZPD protocols

OH: ZPD Training is given every 3 months at state training center. Wants CEE to present at 2000 & 2002 Affordable Comfort

WI: Round 2 training was delivered in the first quarter of 2000 for 2/3 of the agencies who participated in Round 1. Round 2 focuses on when to use ZPD and when not to use them with additional information on dense packing. State monitors will also be trained. In April Round 1 and 2 will be given to the remaining 1/3 of agencies in the state (5 people per agency). Follow-up training will continue through the year 2000.

	Optional	Mandatory	Training and timeline
15b. Weatherization agency auditors	<i>WI: All agencies will send up to 5 people for training.</i>	<i>IL: for remaining 30% of agencies</i>	<i>OH: see above WI: see above</i>
15c. Weatherization crews		<i>WI: all agencies</i>	<i>OH: see above WI: see above</i>
15d. Weatherization agency quality control/inspectors	<i>WI: All agencies will have up to 5 people trained.</i>	<i>IL: for remaining 30% of agencies</i>	<i>OH: see above WI: see above</i>
15e. State monitors		<i>WI: all monitors</i>	<i>WI: see above</i>

Local Agency Mail Survey

Mailed to 248 local agencies in DOE Chicago Region in January 2000.

Number of agencies responding	Percent	Number
All agencies		90
Yes, use ZPD	69%	62
No, don't use ZPD	31%	28

Agency responses by State				Of agencies that responded	
State	# of agencies in each state	# of agencies that responded to survey	% of agencies that responded to survey	# agencies that use ZPD	% of agencies that use ZPD
Iowa	18	9	50%	9	100%
Illinois	35	11	31%	1	9%
Indiana	24	6	25%	5	83%
Michigan	32	14	44%	1	7%
Minnesota	33	13	39%	13	100%
Missouri	18	5	28%	3	60%
Ohio	66	20	30%	20	100%
Wisconsin	22	12	55%	10	83%
Total	248	90	36%	62	69%

The answers and percentages that follow refer to the 62 agencies that use ZPD

How many single-family homes does your agency weatherize per year?

	Percent
1-10	0%
11-25	0%
26-75	27%
75-100	18%
Over 100	55%

Circle the appropriate answers to show when ZPD methods are used in your agency during the weatherization process (all data summarized)

		Never	Sometimes	Always
Method 1: Add a Hole or Leakage Area Matching Method/EQLA	Auditors	55%	34%	11%
	Crews/Contractors	40%	40%	19%
	Inspectors	42%	37%	21%

		Never	Sometimes	Always
Method 2: Open A Door	Auditors	52%	44%	5%
	Crews/Contractors	37%	52%	11%
	Inspectors	42%	50%	8%

		Never	Sometimes	Always
Method 3: Attic Vent Estimation	Auditors	56%	35%	8%
	Crews/Contractors	58%	35%	6%
	Inspectors	55%	37%	8%

Circle the appropriate answers to show when ZPD methods are used in your agency during the weatherization process (auditors only)

	Auditors		
	Never	Sometimes	Always
Method 1: Add a Hole	55%	34%	11%
Method 2: Open A Door	52%	44%	5%
Method 3: Attic Vent Estimation	56%	35%	8%

Circle the appropriate answers to show when ZPD methods are used in your agency during the weatherization process (crews/contractors only)

	Crews/Contractors		
	Never	Sometimes	Always
Method 1: Add a Hole	40%	40%	19%
Method 2: Open A Door	37%	52%	11%
Method 3: Attic Vent Estimation	58%	35%	6%

Circle the appropriate answers to show when ZPD methods are used in your agency during the weatherization process (inspectors only)

	Inspectors		
	Never	Sometimes	Always
Method 1: Add a Hole	42%	37%	21%
Method 2: Open A Door	42%	50%	8%
Method 3: Attic Vent Estimation	55%	37%	8%

Alternate method

Circle the appropriate answers to show when ZPD methods are used in your agency during the weatherization process

		Never	Sometimes	Always
Measuring zone pressures without performing Method 1, 2, or 3 calculations.	Auditors	n/a	18%	16%
	Crews/Contractors	n/a	24%	11%
	Inspectors	n/a	16%	13%

When is alternate method used?			Description of measuring without ZPD calculation methods
Auditors	Crews / Contractors	Inspectors	
always	always	always	Standard Procedure
always	always	always	1 point blower door test at 50 pascals
always	always	always	Comparison of pre & post wx readings -no estimating of leakage area
always	always	n/a	When doing homes (mostly mobiles) we just test attic and crawl. Don't use the above methods to determine equivalent size. We are just looking for 0 leakage.
always	sometimes	always	auditors: Wall/floor cavities, baseline room pressures, CA pressures; inspectors: more critical in tighter homes
always	n/a	always	CAZ WRT outside room to room w/ furnace fan on
always	n/a	n/a	check pressures to attics and attached garages during audits and inspections
always	n/a	n/a	Check pressures difference room to room to locate by-passes and any motor duct leaks
n/a	n/a	always	Pan listing - mobile homes
When is alternate method used?			Description of measuring without ZPD calculation methods
Auditors	Crews / Contractors	Inspectors	
sometimes	always	sometimes	We like to get pressure difference as close as possible, but we have no written protocol as to what's good or bad
sometimes	sometimes	sometimes	Check H0Z and Z-O and H-O
sometimes	sometimes	sometimes	just take a PA reading from an enclosed space
sometimes	sometimes	sometimes	If blower door 1 pt CFM50 is low and walls are full, no major structure problems
sometimes	sometimes	sometimes	Taking quick PA difference from zone outside
sometimes	sometimes	sometimes	only if attic is not accessible
sometimes	n/a	n/a	Throw a hose in a room and close the door. Measure the difference in pascals. See how leaky
n/a	sometimes	sometimes	Quick check to determine linked zones
n/a	sometimes	sometimes	zone WRT outside "is there a pressure boundary?"
always	always	always	no description given
always	always	always	no description given
sometimes	sometimes	sometimes	no description given
sometimes	sometimes	sometimes	no description given
sometimes	sometimes	n/a	no description given
sometimes	n/a	n/a	no description given
n/a	sometimes	n/a	no description given
n/a	sometimes	n/a	no description given
n/a	sometimes	n/a	no description given
n/a	sometimes	n/a	no description given

Which types of Zone Pressure Diagnostic equipment do your auditors, crews/contractors and inspectors use? Check all that apply:

Type of Equipment	Auditors	Crews/Contractors	Inspectors
Magnehelic gauge	32%	47%	37%
Digital micromanometer (DG2, DG3 or other)	61%	69%	74%
Pressure logger	6%	6%	8%
Other: describe	0%	0%	0%

Note: Some agencies use more than one type of equipment

Does your agency use any written protocols for using Zone Pressure Diagnostics and, if so, who developed them?

Written Protocols?	Percent	# of agencies	Comments
No	11%	7	IA = 2, IN = 1, MN = 2, MO = 1, OH = 1
Yes, developed by state weatherization office	82%	51	States represented: IA, IL, IN, MO, OH, MI, MN, WI
Yes, developed by agency	5%	3	IA = 1, MO = 2
Yes, developed by COAD	2%	1	OH = 1

Experienced Local Agency Phone Survey

Phone survey answered by 29 local weatherization agencies in February – March 2000.

Is agency crew or contractor based?

	Percent	Number
Crew based	69%	20
Contractor based	28%	8
Both	3%	1
Total	100%	29

How many single-family homes are weatherized per year (DOE wx jobs)?

	Percent	Number
1-10	0%	0
11-25	0%	0
25-75	24%	7
75-100	14%	4
Over 100	62%	18

How often are the following Zone Pressure Diagnostics methods are used during the weatherization audit:

	Never	Sometimes	Always
Method #1: Add-A-Hole	62%	28%	10%
Method #2: Open-A-Door	72%	28%	0%
Method #3: Estimate Attic Vents	83%	17%	0%

How often the following Zone Pressure Diagnostics methods are used during weatherization work:

	Never	Sometimes	Always
Method #1: Add-A-Hole	41%	41%	17%
Method #2: Open-A-Door	59%	41%	0%
Method #3: Estimate Attic Vents	76%	24%	0%

How often the following Zone Pressure Diagnostics methods are used during the post weatherization inspection:

	Never	Sometimes	Always
Method #1: Add-A-Hole	41%	45%	14%
Method #2: Open-A-Door	59%	41%	0%
Method #3: Estimate Attic Vents	72%	28%	0%

How often are each of the different ZPD methods used by the auditors, crews/contractors and inspectors in your agency?

		Never	Sometimes	Always
Method 1: Add a Hole or Leakage Area Matching Method/EQLA	Auditors	62%	28%	10%
	Crews/Contractors	41%	41%	17%
	Inspectors	41%	45%	14%

		Never	Sometimes	Always
Method 2: Open A Door	Auditors	72%	28%	0%
	Crews/Contractors	59%	41%	0%
	Inspectors	59%	41%	0%

		Never	Sometimes	Always
Method 3: Attic Vent Estimation	Auditors	83%	17%	0%
	Crews/Contractors	76%	24%	0%
	Inspectors	72%	28%	0%

How often are quick zone pressure tests used by the auditors, crews/contractors and inspectors in your agency?
(Note: quick tests only measure ZPD - no calculation methods)

		Never	Sometimes	Always
Quick ZPD tests	Auditors	52%	24%	24%
	Crews/Contractors	31%	31%	38%
	Inspectors	55%	21%	24%

ZPDs are used in a variety of ways by agencies. The following data represent a quick look at the different patterns of when calculated and quick ZPD results are used by auditors, crews/contractors, and inspectors.

	Methods 1 - 3* ONLY	Quick tests ONLY	Methods 1-3* and Quick Tests	No ZPDs
Crews	17%	28%	41%	14%
Auditors	24%	31%	17%	28%
Inspectors	31%	14%	31%	24%

*At least one Method is used

These following results are NOT mutually exclusive.

Agencies that only use quick tests	21%
Agencies that only use calculated methods	24%
All calculation methods and quick ZPDs are used by auditors, crews/contractors, and inspectors	14%

The following results apply only to ZPD calculation methods

Used only by crew/contractors	14%
Used only by auditors	0%
Used only by inspectors	0%
Used only by crews and auditors	0%
Used only by crews and inspectors	24%
Used only by auditors and inspectors	21%

How do the auditors, crews/contractors and inspectors in your agency calculate ZPD results for the different methods?

		Laptop Program	Hand held calculator	Paper charts	Other*
Calculations for Method #1	Auditors	9%	73%	9%	9%
	Crews/Contractors	0%	88%	12%	0%
	Inspectors	6%	76%	12%	6%

*Other readings taken directly from MN Blower Door

		Laptop Program	Hand held calculator	Paper charts	Other*
Calculations for Method #2	Auditors	13%	50%	25%	13%
	Crews/Contractors	0%	83%	17%	0%
	Inspectors	8%	58%	25%	8%

*Other readings taken directly from MN Blower Door

		Laptop Program	Hand held calculator	Paper charts	Other*
Calculations for Method #3	Auditors	0%	40%	40%	20%
	Crews/Contractors	0%	86%	14%	0%
	Inspectors	0%	50%	38%	13%

*Other readings taken directly from MN Blower Door

How reliable are each of the ZPD methods? (asked for crew/contractors only)

		Almost always	Usually	Rarely	Almost never
Reliability	Method #1	50%	50%	0%	0%
	Method #2	25%	58%	17%	0%
	Method #3	0%	0%	86%	14%

What type of equipment do your auditors, crews/contractors and inspectors use to measure ZPDs?

		Magnahelic	Digital Micromano-meter	Pressure logger	n/a
Equipment used to measure ZPDs	Auditors	3%	66%	0%	28%
	Crews/Contractors	10%	72%	0%	14%
	Inspectors	0%	76%	0%	24%

How often are the ZPD results confusing to your crews?

	0%	1-5%	10%	20%	30%	75%	90%	100%
Confusing results	10%	21%	17%	14%	7%	3%	3%	3%

Note: these answers refer to both calculated ZPD methods and quick ZPD methods. The lower percentages do not necessarily correlate to crews/contractors who only use quick methods.

Do your auditors, crews/contractors and inspectors use laptop computers in the field?

		No	Yes, some	Yes, all
Laptops in the field	Auditors	83%	7%	10%
	Crews/Contractors	83%	7%	10%
	Inspectors	90%	3%	7%

How helpful would a clearly written protocol on when to use ZPDs be to your agency?

	Extremely helpful	Very helpful	Helpful	Somewhat helpful	Not helpful
Written protocol - how to use	21%	38%	17%	14%	10%

How helpful would a clearly written protocol on how to use ZPDs be to your agency?

	Extremely helpful	Very helpful	Helpful	Somewhat helpful	Not helpful
Written protocol - when to use	21%	28%	28%	17%	7%

How helpful would a clearly defined method for determining the reliability of ZPD be to your agency?

	Extremely helpful	Very helpful	Helpful	Somewhat helpful	Not helpful
Method to determine reliability	21%	34%	31%	14%	0%

How helpful would a laptop based computer program that calculates ZPD results be to your agency?

	Extremely helpful	Very helpful	Helpful	Somewhat helpful	Not helpful
Laptop program	17%	17%	14%	14%	38%

How helpful would a the following procedure be to your agency: a pressure logger attached to a blower door and laptop to automate the pressure test and calculation process?

	Extremely helpful	Very helpful	Helpful	Somewhat helpful	Not helpful
Automated process	10%	31%	10%	14%	34%

Does your agency collect ZPD data that is stored in a computer system?

	No	Yes, all houses	Yes, some houses
Electronic ZPD data	69%	28%	3%

Describe how and when ZPDs are used by your auditors:

Calculated ZPDs

3 types of ZPD tests are used in each house (1) house to attic; (2) house to garage; (3) Ducts into unheated spaces.

Auditor uses ZPD on every house and records for contractor. House to attic; house to attached garage.

A pre test is done on every house if the attic can be accessed.

The auditor tries to use ZPD on every house. About 90% are tested (Some people don't let us put a hole in the ceiling.) House to attic; House to attached garage.

ZPD calculation methods are used on every house.

Method #3 is used on every house when there is only one auditor available. They can also use Method #1 or #2 when the gauges with long hoses are available.

Pre test done as part of every audit. Sometimes more than one test is used.

Do ZPD test on attic and combustion zones for every house

Auditors always do a pre test on every house. Also quick ZPDs.

Try to use ZPD on all houses. 95% of the time.

ZPD test used mainly on homes with kneewall attics or if the pre blower door cfm reading is high.

Used whenever possible if there is access to the attic without drilling a hole. 95% of houses.

NO ZPDs Used

Auditors never use ZPD

Auditors never use ZPD

Auditors never use ZPD

Auditors do not use ZPD.

ZPDs are never used by auditors

Not used by auditors

Never used by auditors

ZPD calculation methods are never used during the audit

Never used during the audit since auditors may come 2 to 3 months before the crew does.

Representative of the contractor does a walk-through with the auditor. ZPD calculation methods aren't used.

ZPD calculation methods are never used during the audit

Used whenever possible if there is access to the attic without drilling a hole. 95% of houses.

Describe how and when ZPDs are used by your crews:

Calculated ZPDs

Very seldom if ever used. Of the 6 contractors only 2 have blower doors and only one contractor can use it competently

If crews can't get cfm50 number down below 2400 for a 2 story or 1400-1500 for a one story. About 33% of houses are tested.

Crews use ZPD on every house. Fill in job book information. Also do garage to house; slab to attic; house to outside; attic to outside

Pre tests are done on every house. They check attic zones, kneewalls, etc. Post tests are only done on some houses if blower door numbers are still high or something else looks suspicious. Eventually they would like to phase out of mandatory pre-tests and use pre-tests only for houses that seem problematic due to blower doors and crew judgement about the house.

Crews do a pre and post test.

Pre test mostly in attics when its possible. Roof condition is so bad on housing stock that only 30-40% of houses can be tested and only 5-10% of crawlspaces can be tested. They usually use all three methods on each house they can test; attic to outside, zone to crawlspace, CAZ.

Pre and post test on every house. Sometimes more than one method is used.

On every house pre and post ZPD tests are taken for attics crawlspaces, and kneewalls.

Crews use a post test to check their work on every house.

As required by the state quick ZPD zonal tests are used after sealing all of the bypasses.

After air sealing quick ZPD measurements are used on every house; house to attic; house to basement; 2nd story floors; sidewalls; slopes; attached porches.

After weatherization crews do post test by repeating method used by the auditor.

ZPDs are used on all houses except those that have attics that are so interconnected that the results would be useless.

ZPDs are used on every house. Before and after house to zone, zone to outside. On really confusing houses they also use a blower door.

A ZPD pre and post test is done on every house by the contractor unless they can't get the house up to 50 pascals.

Depends on the house. Used on complex houses with many zones. Used as a tool not a protocol.

The crews are still learning to use ZPDs. Pre and Post ZPD test are required on every house but the crews only test 25% of them.

A pre and post ZPD test is used if the initial blower door reading is high.

Crews use quick ZPDs. If they find a strange pressure differential then they use method #1 or #2. They use the test methods in puzzling situations.

Quick ZPD methods are used on every house pre and post for attic, kneewalls, crawlspaces. If there is a problem with post wx readings then one of the methods is used.

NO ZPDs Used

Crews never use any of the methods

ZPD calculation methods are never used by crews

How do your crews/contractors choose which method to use?

Method #1

Most common method. Use a hatch when possible.

Used when you can't do #2, when there is no door

Used when they have attic access.

After weatherization they do a quick ZPD, if the pressure differential is strange or a low cfm drop from initial blower door reading they use method #1 or #2. They are taught to use ZPDs as a qualitative not quantitative measure.

Best method to use. If attic isn't accessible they use an attic vent.

Used most often considered most accurate.

Most houses 90%

Used on every house

Most common 70%. Most accurate method.

2nd most common. Repeat method used by auditor.

This method is used whenever possible. If there is attic access. 90% of the time. The crews usually duplicate the method used by the auditor.

Use it when they can 70%

Normally have attic access, if not they create a hole.

Used on 90% of the houses.

Method #1 used if they can't use method #2

Method #1 used if they can't use method #2

Method #2

Least used method.

Most common method used by crew. Answer shows total magnitude of all the holes but not the number of holes

Usually used for basements with outside access.

Used if #1 doesn't work

If can't use #1 - 10% of houses

Also used when they can't get a house to 50 pascals. Used on 30% of houses.

20% of houses

This method is used if #1 won't work. 10% of the time. The crews usually duplicate the method used by the auditor.

Use when #1 doesn't work -25%

Used when #1 doesn't work or on nice tight garages or to test zone in basements or large walk-in attics. However, when used in basements since there are so many variables, readings are more general. Least used method.

Used for walk up attics and for basement zones

Most common method

How do your crews/contractors choose which method to use? (continued)

Method #3

2nd most common method; harder to estimate correctly.

Auditor already does this method

Used if other methods don't work

Run to see if its coming close to the others. Its used almost 100% of the time.

Not that accurate

10% of houses

Most common. Repeat method used by auditor.

Use it when the other 2 methods are impossible 5%

Used when #1 is impossible

Very difficult in old housing stock to get accurate readings.

Describe how and when ZPDs are used by your inspectors

Calculated ZPDs

3 types of ZPD tests are used in each house (1) house to attic; (2) house to garage; (3) Ducts into unheated spaces. Same tests and method as auditor uses.

ZPDs are used on every house. House to attic; house to attached garage; combustion zone (post only).

A post test is done on every house if the attic can be accessed.

Used on every house. Attic, kneewall, crawlspace

Every house using whichever calculation method is easier

Used to verify that the job is done or isn't done. Used on every house.

Inspector does final inspection when crew is still there usually on 75% of houses.

Inspector does ZPD on every house. After crew has left.

Repeats post test that was used by crew after weatherization. Crew is on-site about 50% of time the crew is there during the post test.

ZPDs are done on every house. If the total leakage is over 200 the inspector will spend more time at the house.

Used on every house. Crew is there when house is inspected. Attic, crawlspace, and combustion zones.

Describe how and when ZPDs are used by your inspectors

NO ZPDs Used

Never.
ZPD calculation methods are never used by inspectors
Never. There is no official post-inspection process.
ZPD calculation methods are never used.
ZPDs are not used during the inspection process
Never used by inspectors
Never used by inspectors
ZPD calculation methods are never used by inspectors

How do your inspectors choose which method to use?

Method #1

85% of houses
Used on 100% of houses except when there is no attic access.
most common method. Used when its possible.
Most common especially with accessible attics
Least common method
In attics. 50-60% of houses
Use method used by crew
use method(s) crew used
70% of houses
Repeat test used by crew (unless crew is there)
Duplicates the contractor test.
Use what crew used
Used when #2 can't be.
Use method used by auditor

How do your inspectors choose which method to use? (continued)

Method #2

10% of houses those with side attics; also used for combustion zone.
Used least often
Used when Add-A-Hole is impossible.
Most common method if crews couldn't get pressure down to 50
Used on basements or crawlspaces with outside entrances. 50-60% of houses.
Use method used by crew
use method(s) crew used
20% of houses
Inspector chooses. No guidelines.
Use what crew used
Most common
Use method used by auditor

Method #3

5%. Used when Add a Hole isn't available.
Used 2nd most often. Hardest method to estimate correctly
Too hard to estimate
If house pressure that crew got was acceptable. 2nd most common method
Use method used by crew.
Not considered accurate.
10% of houses
Inspector chooses. No guidelines.
Repeat test used by crew (unless crew is there)
Use what crew used

When do your auditors use quick ZPD measurements?

Bulkhead or cavity open to attic to check little zonal pressure difference. One spot tests used for tricky areas.
Pre/post used on every house to test attics, kneewalls, and crawl spaces.
Testing furnaces for duct leakage
When blower door is going and they see or feel something outside of the ordinary. Always test basements.
Depends on results of calculation tests
Attic zonal pressures are measured.
Every house to detect problems between zones.
Done on each house. Zone to attic at a minimum. Number of tests determined by complexity of house. (e.g. ranch house with attic and basement would only need 2 tests.
Each house: attic to house, attic to outside, crawlspace, porch roofs, attached garages, any zones where ducts are.
If the auditor has time and there is a problem with the house.
Attic to house; walls to zone, auditor decides when to run on a case by case basis
No calculated ZPDs. Use quick methods on every house.
Quick ZPDs are used during the "estimation" The contractor walks through with the auditor and then makes a bid.
Quick pressure measurements are used on several zones in all houses.
Quick ZPDs are used on every house after wx in attics, kneewalls, basements/crawlspaces, chases, attached porches, chases.
Between bedrooms and whole house to make sure there is proper air flow for furnace to operate.

What guidelines do your auditors use to make sense of quick ZPD measurements?

Know that lower leakage in house to attic zone is better. Acknowledge when there are weird results. (Auditors won't retest a house because of one screwy number).
Target is 45 -50.
2 pascals = pass; 3 needs work; above 3 = bad - need to find where the leaks are
Up to the auditor
Compare zone to zone. Note obvious problems when changes are large. State guidelines = 20 sq. in of leakage or less.
If the measurements show there is significant leakage the contractor will adjust his bid to allow for more air sealing/investigating.
Look for big pressure changes between zones
House specific
Rough 50=outside, 25=1/2 way in & out; 0=inside. Crews use their judgement and lots of other factors - blower door #, visual inspection etc. Attic to house + Attic to outside should = 50.
Nothing formal, 2 pascals or higher is suspect.
Rule of thumb is attic inside or outside 0 to 50
The ZPD results are recorded so the crews have something to compare post tests to.
State goal of +/- 3 pascals difference.

When do your crews/contractors use quick ZPD measurements?

Used on all houses pre/post for attics, kneewalls, crawlspaces.
Quick ZPD is used always unless there is no way to get to the attic. They record the attic pressure w/out the blower door to get a baseline. Then record attic pressure with blower door and get a pre post.
Almost always use quick measurements when there is a detached garage (about 50% of housing stock). Also do room to garage, room to outside; room to house.
The crew knows they don't need to test until after dense packing. They compare change in zone to attic and zone to crawlspace after wx.
Measures are taken two or three times during weatherization on all bathrooms, kitchens and any room that has a door.
Used if heat isn't distributed evenly in a house. If air leakage doesn't drop then the crews will go room to room and through zones to find the problem.
Used pre and post on ATZ, CAZ and all bathrooms and bedrooms.
On complex houses.
Attic zonal tests are required after bypasses are sealed.
Pre-all conditioned spaces. Post every house they can't get a good blower door reading on.
If crews find unusual blower door readings they will use a room-to-room or crawl space zone reading to find where problem is.
Quick ZPDs are used on every house after wx in attics, kneewalls, basements/crawlspaces, chases, attached porches, chases.

When do your crews/contractors use quick ZPD measurements (continued)?

After air sealing quick ZPD measurements are used on every house; house to attic; house to basement; 2nd story floors; sidewalls; slopes; attached porches.
Repeat tests used by auditor: attic to house, attic to outside, crawlspace, porch roofs, attached garages, any zones where ducts are.
Used in about 20% of the cases under the following circumstances: extremely tight houses; no return ducts in room; bedrooms where children or elderly sleep; bedrooms where doors are closed; bedrooms without windows.
Always used on attached garages and zone to outside. Only used room to room if a client says there is a particularly cold or hot room.
completely ineffective measurement tool without doing calculations
Used if called for by the auditor.
Used after weatherization only on houses that have blower door numbers that don't make sense.

What guidelines do your crews/contractors use to make sense of quick ZPD measurements?

Target for attic readings is 45 -50. Usually below 45 they use one of the methods.
If it's a big number it's a problem. If it's a small number it's not a problem. No written criteria. Different than most agencies. Pressure w/ respect
Get numbers and figure out which spaces are more connected. If they are not 0 or 50 then it indicates there is a problem.
House to attic 45 or below is not acceptable. Crawlspace and basements crews use judgement (below 20 pascals if basement is inside and higher if outside).
2-3 pascal difference
They look for positive and negative pressures between zones.
Compare to blower door numbers.
No specific guidelines.
Below 45 should be investigated.
No specific guidelines.
No guidelines
No set guidelines - depends on the house, crews use their judgement.

Rough 50=outside, 25=1/2 way in & out; 0=inside. Crews use their judgement and lots of other factors - blower door #, visual inspection etc.
House by house basis
Compared to pre numbers.
If pressure difference is over 2 pascals then the crew will get return air back in or tell the homeowners to leave doors open.
Rule of thumb, is attic truly outside?
The ZPD results are compared to the auditors pre tests to confirm that the numbers changed in the right direction.
Crews use their own judgement.
Compare pre to post make sure area is inside or outside 0 - 50.

When do your inspectors use quick ZPD measurements?

(1) Room to room; (2) worst case backdraft test combustion zone; (3) living area to outside.
When there is a problem with the post wx numbers then quick measures are used.
Inspectors probably use this method more than auditors do. Do this on every house with forced air heating system.
If there is a problem with the house.
Done on any room with a door; crawlspace, attic.
Crawlspace to zone, attic to zone, zone to outside.
Quick zone test for attic and combustion
Repeats post tests done by crews.
Used when blower door readings are unusual
Repeat tests that crew used, if crew isn't there to do tests.

Check to see if the hot/cold problems were fixed. Check ZTZ, HTZ, or ZTO if there seems to be problems with the post ZPD or blower door test.
On every house the inspector does a quick attic ZPD test and a combustion test.
Post test is done with the same method used by auditor. Contracts are present during the test.

What guidelines do your inspectors use to make sense of quick ZPD measurements?

Quick ZPD tests that the crews did are repeated. Sometimes crews are present at post-inspection.
Contractors are at inspections 95% of the time. House to attic, side attics, room to room. Contractor post numbers are verified.
State protocols, maximum room pressures used.
2=pass; 3=suspect; 4=bad except in a bathroom
Inspectors discretion.
Inspectors discretion.
State mandated 20 sq in leakage or less on post test.
Attic zone numbers above 45 are ok.
State guidelines listed on check off sheets.
Use targets that help determine if blower door reading is unusual.
Rules of thumb, compare to pre.
Document and compare to pre tests.
Post compared to pre. Make sure right areas are inside or outside.
0 -50 inside/outside
State guidelines +/- 3 pascal difference.

How does the ZPD information your auditors collect affect the way weatherization work is prioritized?

Gives us another feel of what's going on in the house. Just another tool.
Affects the amount of \$ given to a job for sealing bypasses.
It doesn't
Note on worksheets that they have high leakage. Stress contractors to dig around. Does not change job orders.
Determines where most wx time is spent.
Directs how much time is spent on wx.
Used to calculate the cost of a job. Auditors use it to determine wx priorities.
Tells the crews whether basement is inside or outside the house. Focus crews on what approach they should use for the house and where they should do post wx quick tests.
Gives auditor an idea of connections between zones. Gives crew extra time to seal bypasses.
Affects the contractor's estimation.
Used for bid specs. Tells contractors the condition of the house. Focuses work and helps them estimate a materials list.
Indicates where there are bypasses and where crews should spend the most time.
It helps auditors focus crew attention and tells auditor if more money is needed on the house.
ZPD tells crew where to start air sealing. Focuses on how they want to seal a house. Focuses on energy v. IAQ work (e.g. if crawlspace is really leaky and there are lots of cracks in the floors they will treat floors.)
Crews spend more time on leakier houses. If houses are tighter they'll add vents to make sure they don't over tighten homes after sealing bypasses.
Determines when the crews will use quick tests.
Pinpoints where the crews need to look.
Identifies infiltration trouble spots and saves on labor because it helps focus crew work.
Identifies problems and focuses crew work.
ZPD indicates where bypass work should be concentrated.
Doesn't affect what the contractors do.

How does the ZPD information your crews/contractors collect affect the way houses are weatherized?

Contractors are more prone to look for bypasses in the attic.
ZPDs are a big help in determining extent of bypasses and to find the harder bypasses.
Give them an idea of how big holes are and feedback on the success of sealing the holes.
Crews weatherize better, faster, and more efficiently. They can pin point the area where to focus weatherization efforts.
Doesn't affect them much. They do find out if crawlspaces are interconnected. Houses with high ZPD measurements indicate there are leaks but they are impossible to find.
Helps crew focus on problem areas
Crews know when to stop weatherizing. Also know which doors to cut off for better air flow from returns.
Find out if there are more leaks in the attic. Prevents them from going back and digging around in cellulose to find problems. It has reduced the number of crew call backs. Quick ZPDs also tell crews which doors have to be cut or where supply ducts need to be added.
If the contractors allotment of funding for bypasses is used up and they aren't getting cfm reduction or correct ZPD info they ask for more time in the house.
They base the air sealing in attics and basements by what they find in the pre tests. Don't spend a lot of time digging for problems after weatherization.
The pre readings help crews focus their work and saves them time.
Use ZPD to focus crew work.
Tells contractor if he has to do more investigating if attic zone measure is below 45.
Saves time, focuses work. Helps find bypasses.

There is not much affect on crews at all. They don't understand what they test. Some may check for bypasses and use it to focus their wx work.
Crew spend more time looking for leaks if post numbers are off compared to pre. They are especially used to determine if already insulated slopes need to be dense packed.
Tells them if they are heading in the right direction or are done.
Basically ZPDs tell crews when to stop sealing air leaks in the zones they are testing. Sometimes on difficult houses the crews use an infrared camera with ZPD measurements.
Where to add supply or return ducts. ZPD also used to determine where to dense pack.
Contractors do a better job of air sealing. Hopefully they realize that the test results are important. Sometimes they don't realize that the number looks good but it really isn't reliable.
Helps determine for small, hard to access attics whether bypasses have to be sealed.
Hopefully but not always. It tells the crews where to add returns.
Makes the job quicker. Identifies problems faster.

How does the ZPD information your crews/contractors collect affect the way houses are weatherized? (continued)

Makes vx faster for the crews. They have immediate feedback and know if they have accomplished their task. It helps them focus on target areas.

Helps focus their work.

If the contractors allotment of funding for bypasses is used up and they aren't getting cfm reduction or correct ZPD info they ask for more time in the house.

How does the ZPD information your inspectors collect help to assess if weatherization was done satisfactorily?

Depends on the situation. Duct through an unheated space. Less than 1 pascal on all duct openings. Attic bypasses or attached garage, less than 200 cfm50, goal is 0 cfm. High cfm may initiate a contractor call back.

Inspector sends crew back if air leakage in attic is greater than 500-600 cfm (goal is 200 cfm).

Inspectors identify problems and then send crews back if necessary.

Contractors are usually with the inspector during post ZPD. Inspectors and contractor look for leaks is leakage numbers don't make sense.

Inspector may send the contractor back to fix if pre/post ZPD measurements are "really off."

If the pressure numbers are off they might send a crew back (rare). For some houses the pressure measures are really hard to figure out.

Inspectors try to find the problem visually or use an infrared camera. Send crew back if they can't fix it on the spot.

We can easily tell that the crew has made a difference. ZPD gives us something to compare in pre/post.

Good to have crews at final inspection. Will tell them to keep working if necessary.

Sometimes send the crews back.

Sometimes send crews back to house especially if kneewalls aren't done right.

The inspector will sometimes send the crew back to find leaks.

Crew is there during the post test and they can investigate strange readings on the spot.

If the inspector determines there is no change in attic zonal pre/post then they try to analyze the problem.

Sometimes they will send the contractor back to finish work.

Inspectors may send the crew back to the house. Sometimes they will document that ZPD indicated a problem that the crew couldn't fix.

Rarely send the crew back to do more work. Rules of thumb, blower door #, type of house, visual inspection.

Send the contractors back if work isn't done well.

Send crew back if 200 cfm is not met in the attic.

Will send contractors back if something is wrong.

Sometimes crews are sent back

If house to attic numbers are not acceptable, then have them do further work.

What is the biggest barrier preventing your agency from using ZPD more effectively in the field?

Barrier	Solution
Sometimes the numbers just don't make sense	Check for a bug in the programming of hand held Sharps
Making a hole during post inspection	Come up with a way to have a hose in the attic without opening an attic door.
Lack of crew/contractor training	More training for crews. They don't use or understand ZPDs.
Interpreting what the measurements mean	More training for auditors and inspectors
Finding measurements that make sense.	In-field training
Interpreting what the results mean	Hands on training with specific house numbers and recording. (E.g. show Add-A-Hole method in the field.)
Don't have the right equipment:	3 point data logger with computer program
	\$ 2,000
Lack of crew training	More training
Worry about non-agency audits where absolute ZPD measurements are used.	Guidance that ZPDs should be considered qualitatively 1st and not quantitatively 2nd.
Windy days give false readings	Nothing
Houses are so leaky it is hard to do a proper test.	Nothing
Rules and regulations force them to use ZPD on every house.	Research into the effectiveness of rules and regulations.
Bad results on very leaky houses (e.g. house fires or remodeling projects).	Equipment upgrade to digital micromanometers
Lack of crew training on how to interpret results on anything besides combustion zone tests.	

What is the biggest barrier preventing your agency from using ZPD more effectively in the field? (continued)

Barrier	Solution
High cost of the equipment DG-3s & TI86's, infrareds	More funding requiring agency contracts for equipment
Time constraint to do a really thorough testing (takes 1.5 hours).	With more APTs they could test all the zones at one time.
Department culture does not make ZPDs a priority for crews.	Mandating that crews use ZPDs.
Lack of crew training	More crew training
Some contractors don't focus on doing ZPD because they are trying to get wx work done in a limited amount of time.	Consistency in how protocols are implemented. (Some contractors confuse wx protocols with protocols for different programs)
None (mentioned 7 times)	n/a

What is the 2nd biggest barrier preventing your agency from using ZPD more effectively in the field?

Barrier	Solution
When the house isn't tight enough to use ZPD for the pre blower door reading (above 5,0000 cfm)	Bigger blower door model to get pressure difference
Enforcing contractors to do the tests	Provide incentives for contractors.
Takes too much time.	More funding earmarked for training crews and contractors
Finding measurements that make sense	More training for auditors and inspectors
Too many windy days	n/a
Convincing the crew ZPDs are important	Hands on training that using ZPD makes a difference.
Not enough training opportunities	Increase the number of trainings available to crews
Tests take too much time	More training
Running tests adds a lot of time, especially when the results aren't telling you anything.	Research into the effectiveness of rules and regulations.
Don't have the right equipment (using magnahelic gauges)	Equipment upgrade to digital micromanometers
Lack of crew members that are capable of understanding tests. Most crew members are barely literate.	Begin training program on how to perform more than ZPD combustion zone tests.
Not having easy access to the zone.	More experience in accessing the zone
Weather: when its windy ZPDs aren't reliable; especially without an APT.	Give crews APTs.
High cost of training	More funding earmarked for training
Interpreting what the measurements mean.	Training for crews so they won't get wound around the numbers.
Lack of crew/contractor training	More training and a simple protocol.
None (mentioned 13 times)	n/a

Appendix G. Detailed Results of Repeated Tests

Table G1. Repeated Air Leakage Tests: 5 Second Averages, House 1

House/Outside			Blower Flow	Air Leakage (cfm50)
Baseline	Fan On	Adjusted		
-0.3	-49.9	-49.6	1,086	1,092
0.4	-51.0	-51.4	1,097	1,077
-0.3	-52.7	-52.4	1,138	1,104
0.0	-50.8	-50.8	1,109	1,098
0.4	-51.3	-51.7	1,119	1,095

Air Leakage (cfm50)				
Average	Minimum	Median	Maximum	Std Dev
1,093	1,077	1,095	1,104	9.8

Table G2. Repeated Air Leakage Tests: 30 Second Averages, House 1

House/Outside			Blower Flow	Air Leakage (cfm50)
Baseline	Fan On	Adjusted		
-0.1	-50.6	-50.5	1,113	1,106
0.3	-50.3	-50.6	1,099	1,091
-0.1	-49.9	-49.8	1,088	1,091
-0.2	-50.1	-49.9	1,095	1,096
0.7	-47.8	-48.5	1,082	1,104

Air Leakage (cfm50)				
Average	Minimum	Median	Maximum	Std Dev
1,097	1,091	1,096	1,106	7.1

Table G3. Repeated Air Leakage Tests: 30 Second Averages Using APT ZPD, House 1

House/Outside			Blower Flow	Air Leakage (cfm50)
Baseline	Fan On	Adjusted		
-0.7	-49.9	-49.23	1,095	1,106
0.1	-50.3	-50.44	1,088	1,082
-0.2	-50.3	-50.13	1,080	1,078
0.6	-50.4	-51.00	1,092	1,078
-0.3	-50.1	-49.80	1,081	1,084
-0.5	-50.4	-49.90	1,091	1,092
-0.1	-50.4	-50.24	1,089	1,086
-0.2	-50.4	-50.15	1,099	1,097
-0.1	-50.5	-50.43	1,099	1,093
-0.3	-50.4	-50.04	1,104	1,103

Air Leakage (cfm50)				
Average	Minimum	Median	Maximum	Std Dev
1,090	1,078	1,089	1,106	10.0

Table G4. Repeated Air Leakage Tests: 5 Second Averages, House 2

House/Outside			Blower Flow	Air Leakage (cfm50)
Baseline	Fan On	Adjusted		
-0.3	-50.0	-49.7	2,074	2,082
-0.5	-49.3	-48.8	2,027	2,059
0.6	-49.4	-50.0	2,011	2,011
-0.5	-50.3	-49.8	2,078	2,083
0.1	-50.2	-50.3	2,055	2,047
-0.3	-50.6	-50.3	2,074	2,066
-0.2	-50.1	-49.9	2,027	2,030
-0.1	-49.8	-49.7	2,074	2,082
-0.2	-50.2	-50.0	2,027	2,027

Air Leakage (cfm50)				
Average	Minimum	Median	Maximum	Std Dev
2,054	2,011	2,059	2,083	27.0

Table G5. Repeated Air Leakage Tests: 30 Second Averages, House 2

House/Outside			Blower Flow	Air Leakage (cfm50)
Baseline	Fan On	Adjusted		
-0.1	-50.6	-50.5	2,117	2,103
-0.5	-51.0	-50.5	2,107	2,093
0.2	-50.4	-50.6	2,104	2,088
-0.1	-50.0	-49.9	2,120	2,123
0.4	-50.1	-50.5	2,124	2,110
-0.2	-49.9	-49.7	2,107	2,115
-0.3	-50.6	-50.3	2,117	2,109

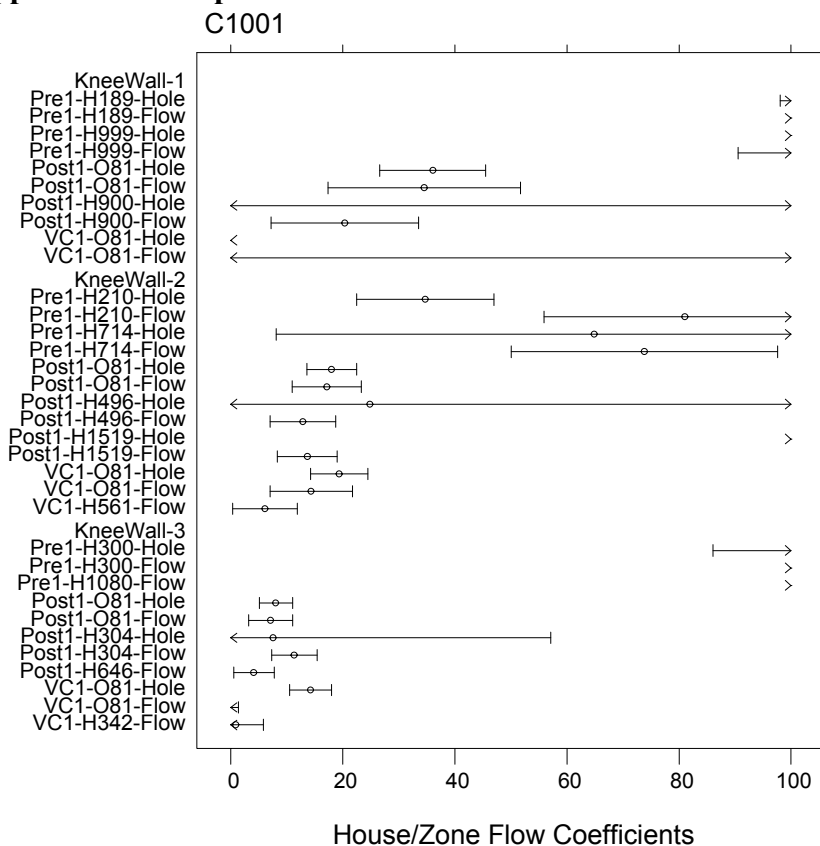
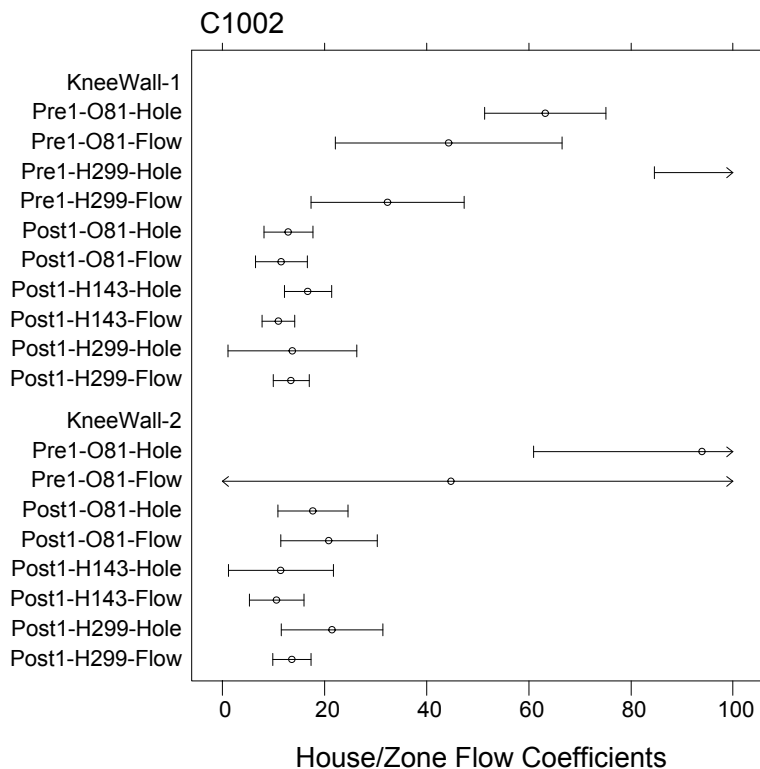
Air Leakage (cfm50)				
Average	Minimum	Median	Maximum	Std Dev
2,106	2,088	2,109	2,123	12.2

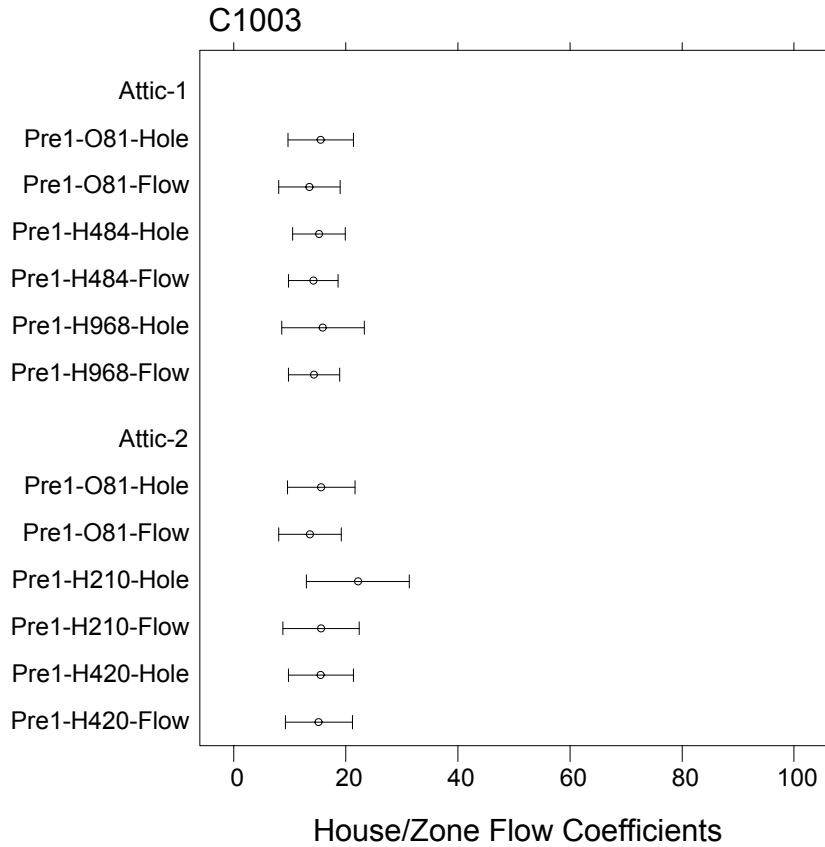
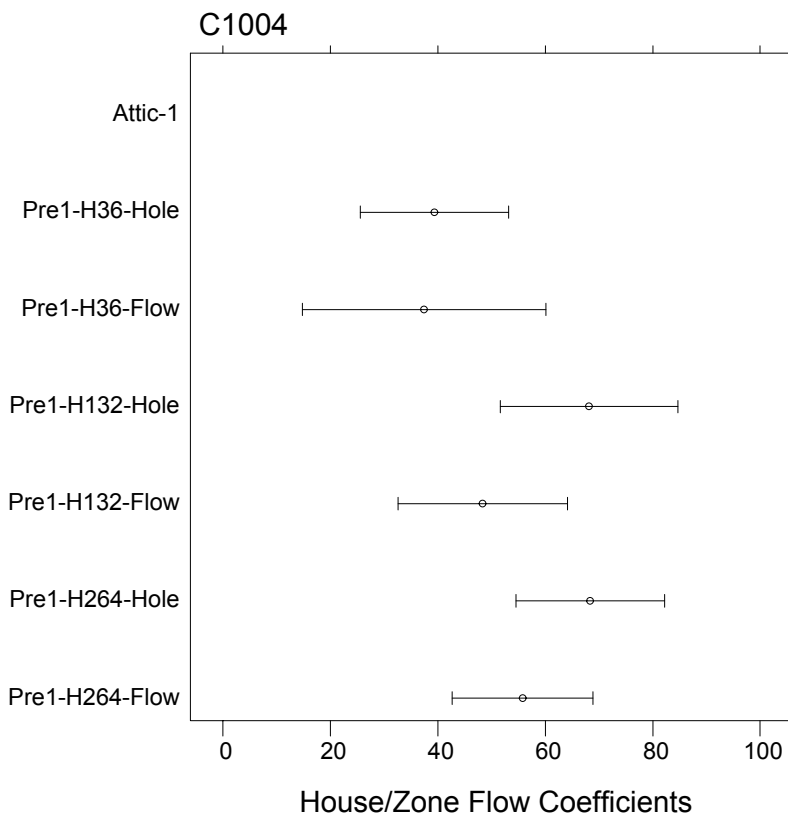
Table G6. Repeated Air Leakage Tests: 30 Second Averages Using APT ZPD, House 2

House/Outside			Blower Flow	Air Leakage (cfm50)
Baseline	Fan On	Adjusted		
-0.2	-50.2	-50.0	2,054	2,055
-0.6	-50.1	-49.5	2,022	2,036
-1.1	-49.4	-48.3	2,019	2,065

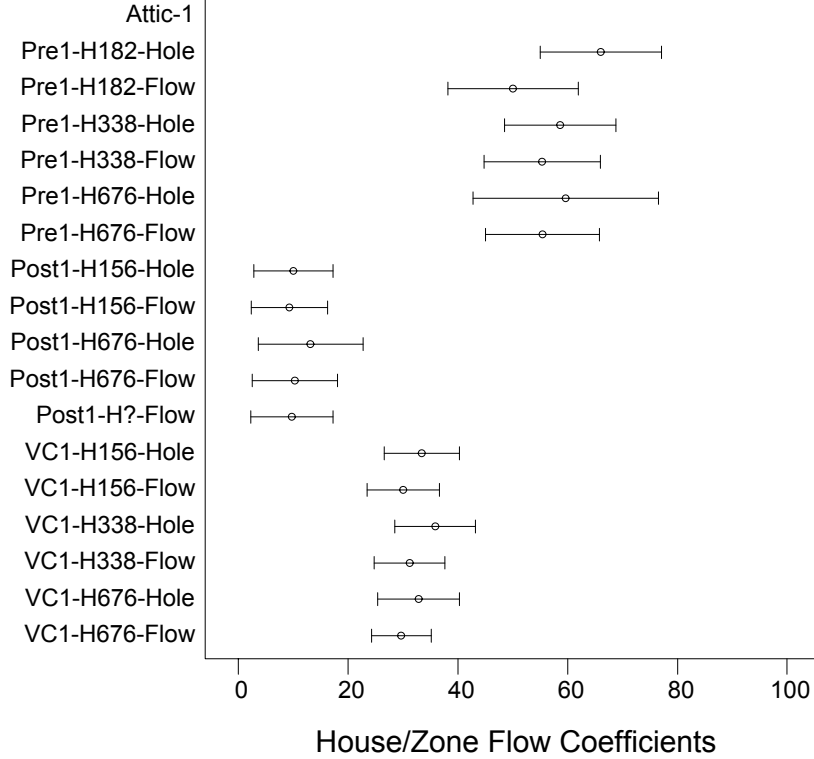
Air Leakage (cfm50)				
Average	Minimum	Median	Maximum	Std Dev
2,052	2,036	2,055	2,065	14.9

Appendix H. Graphs of House to Zone Coefficient For Each ZPD Test

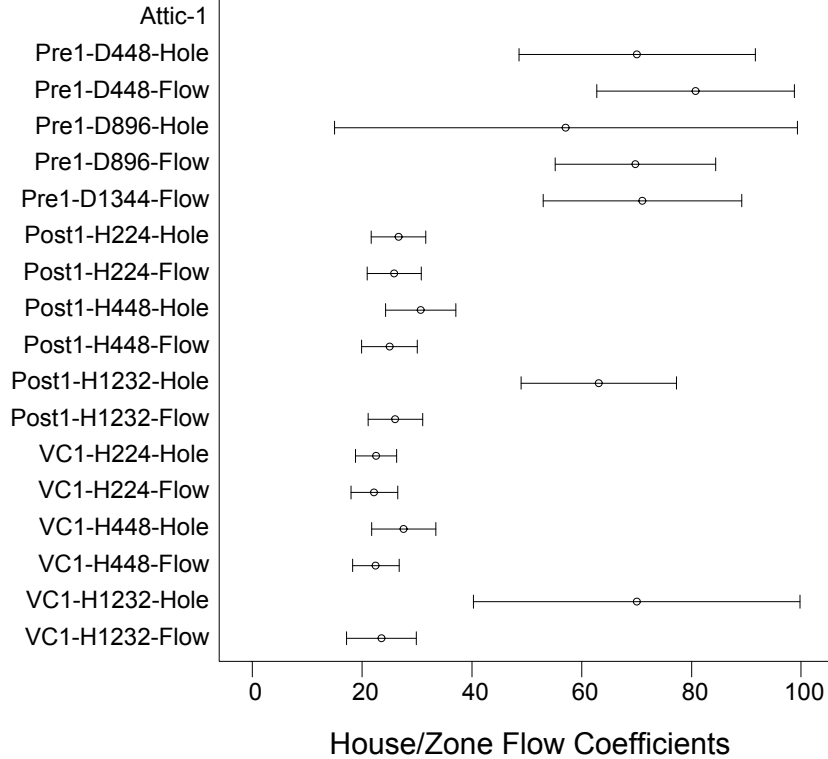


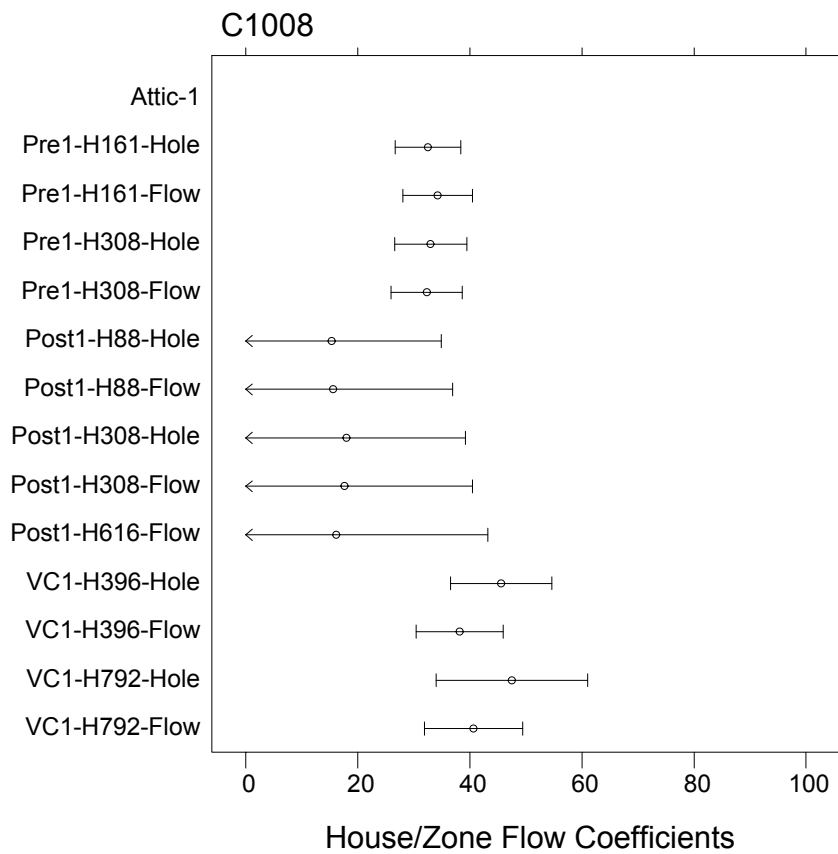
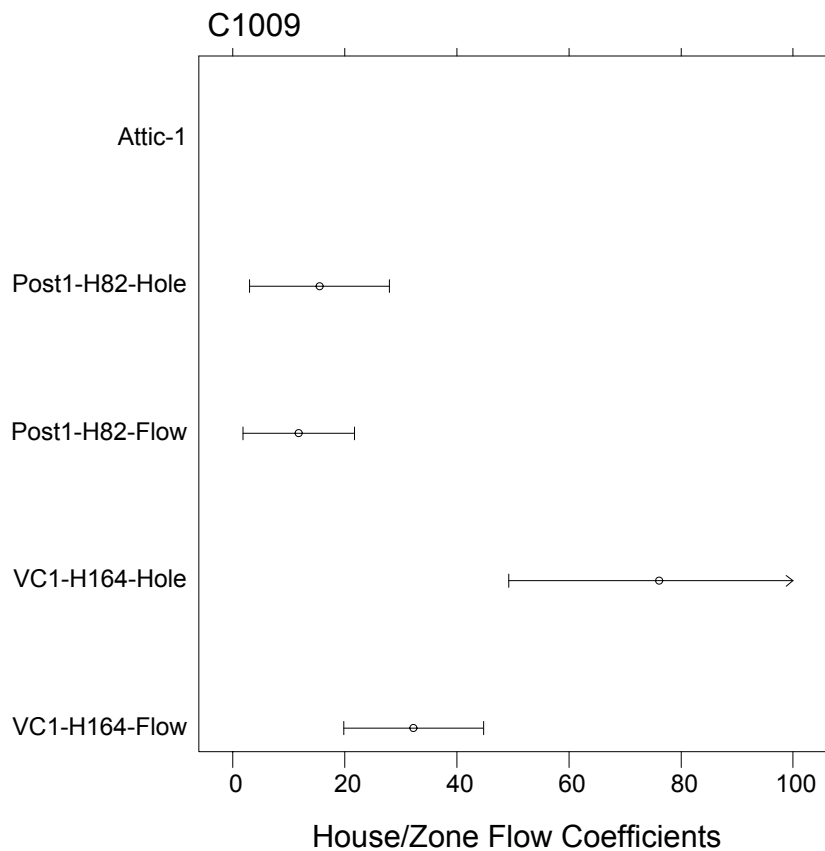


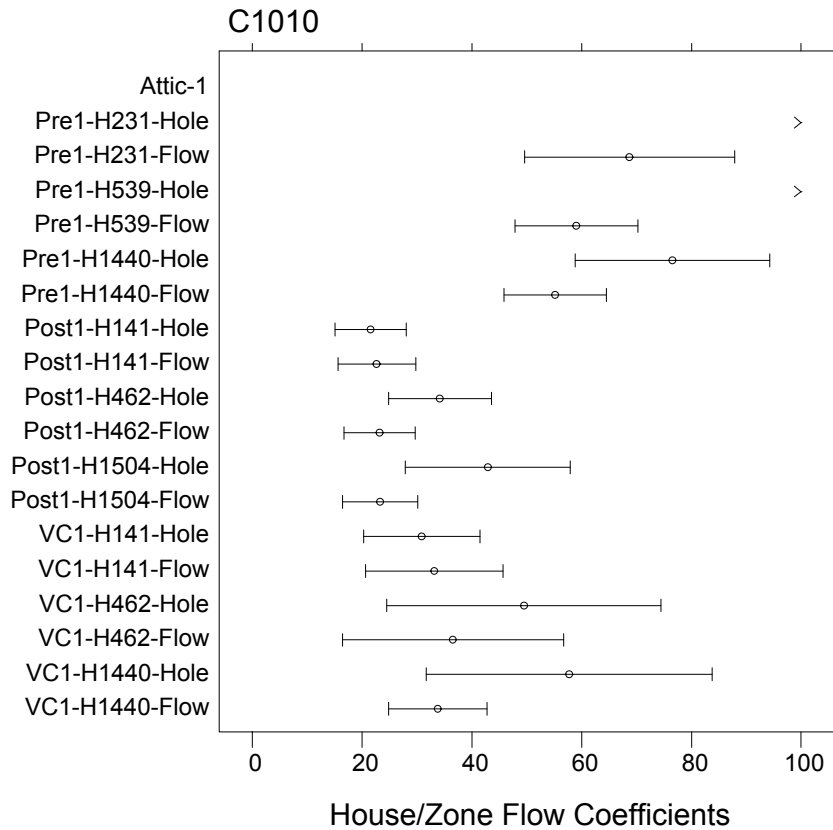
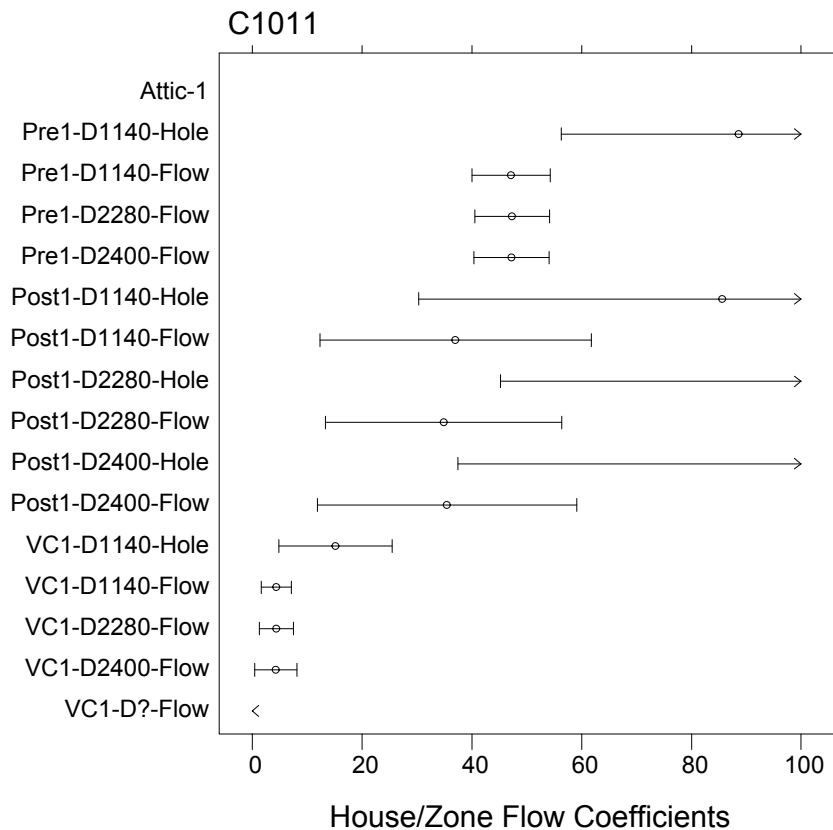
C1005

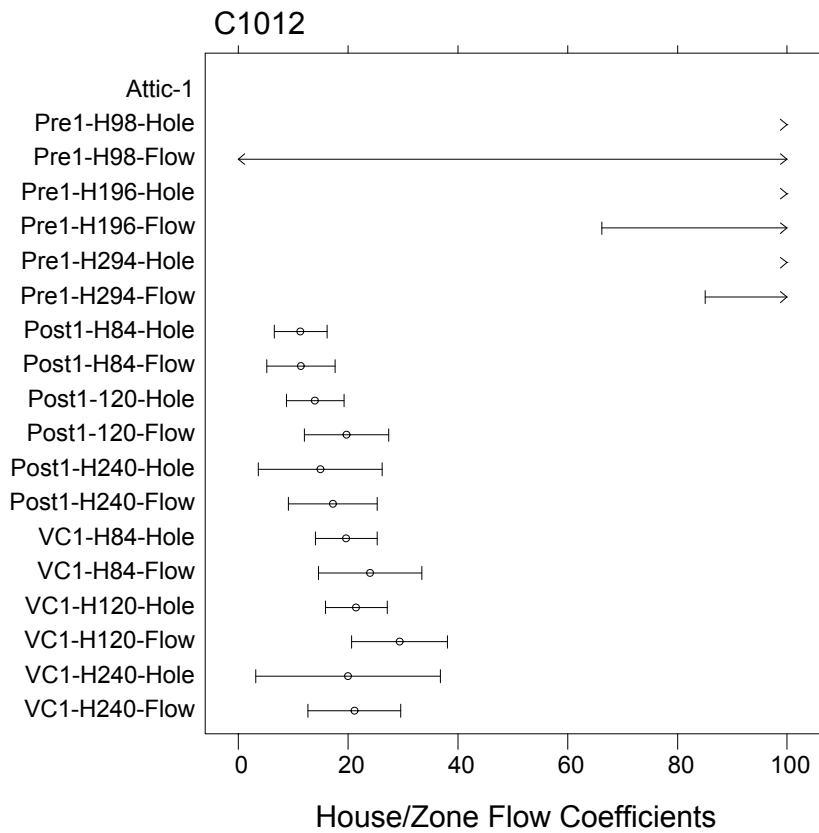
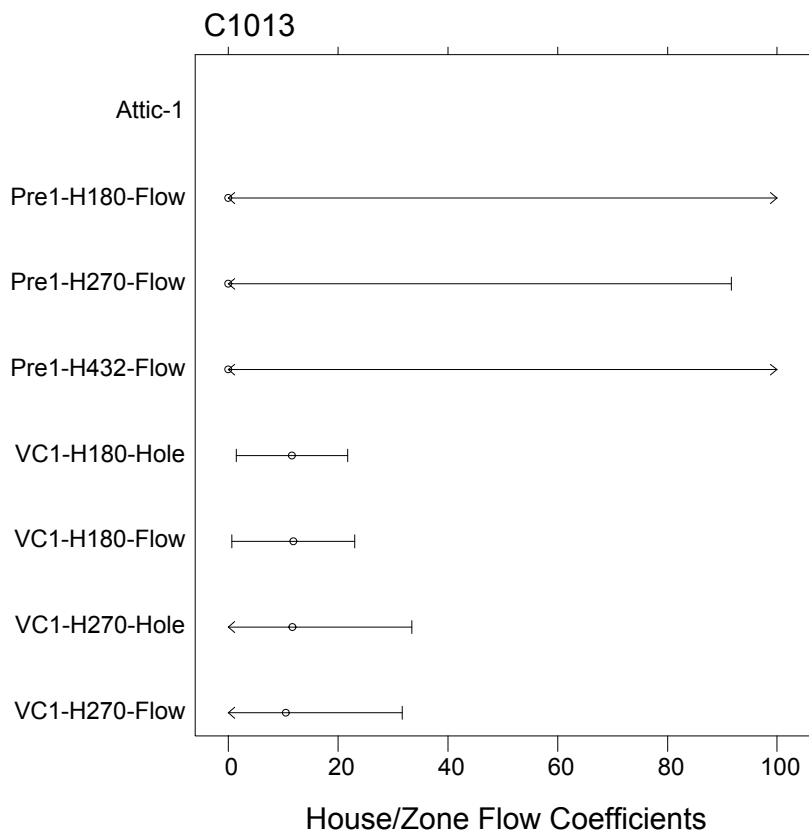


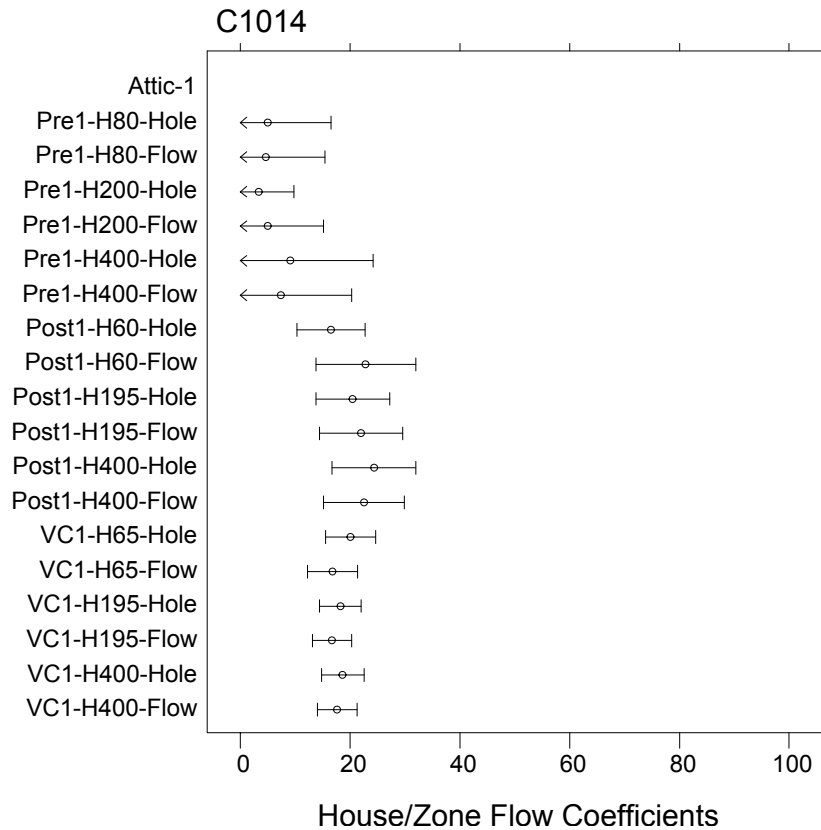
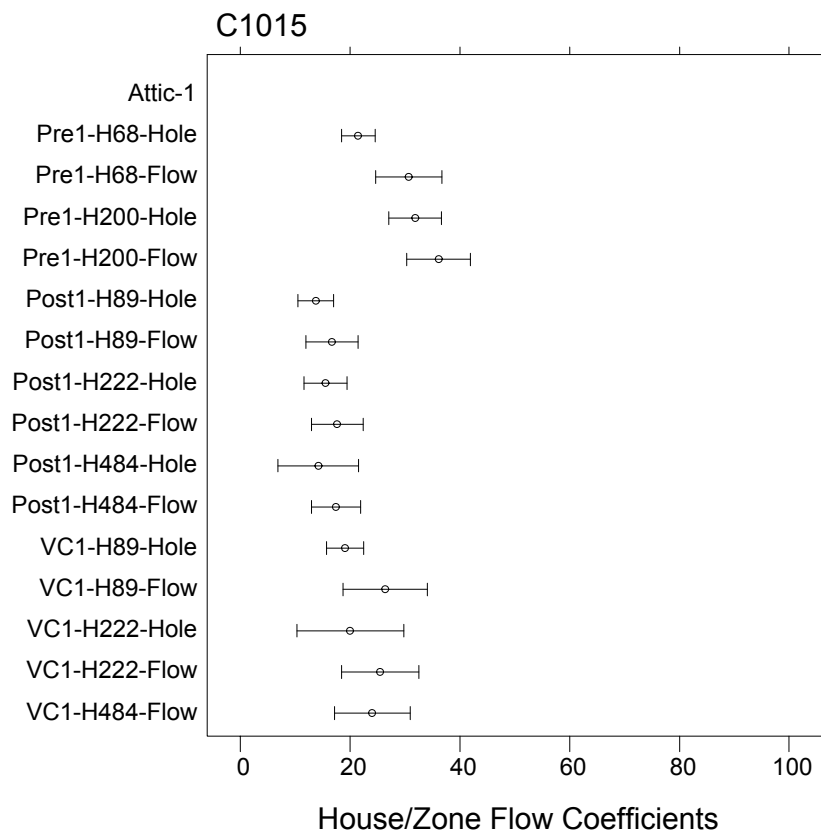
C1006

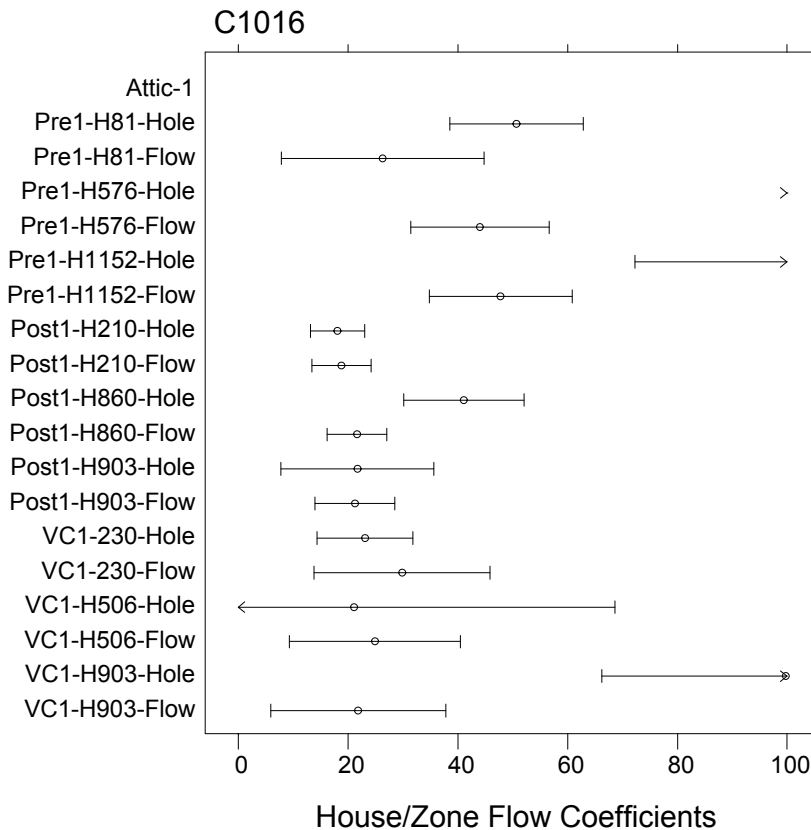
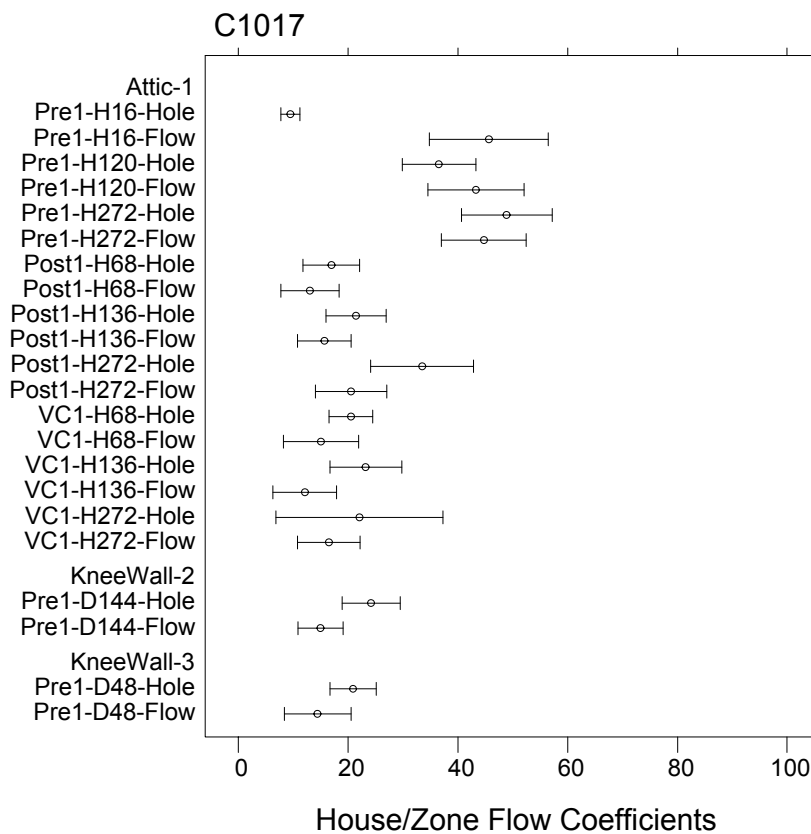


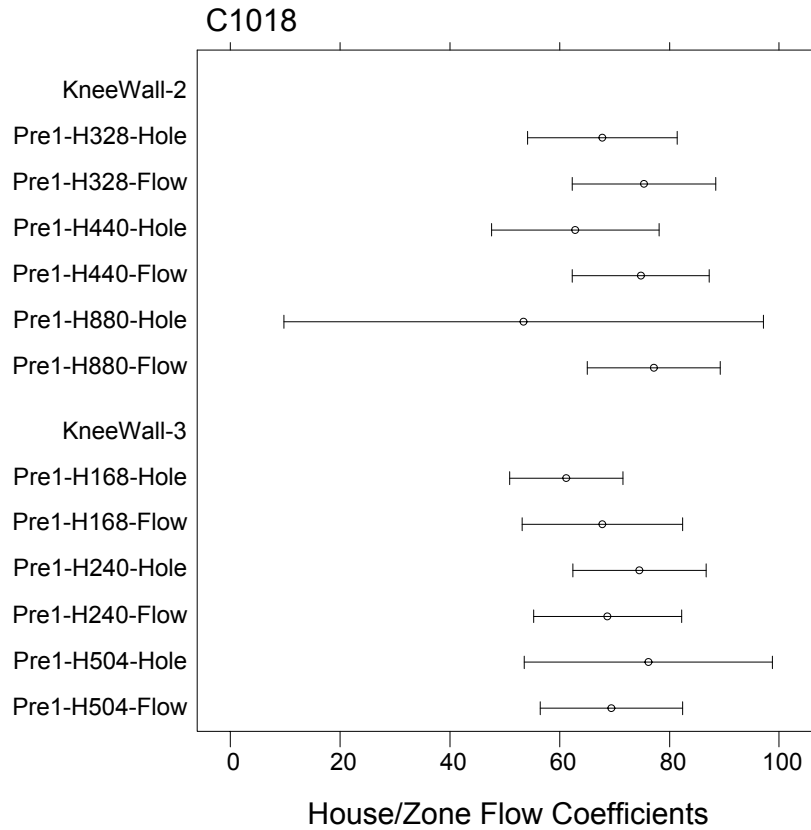
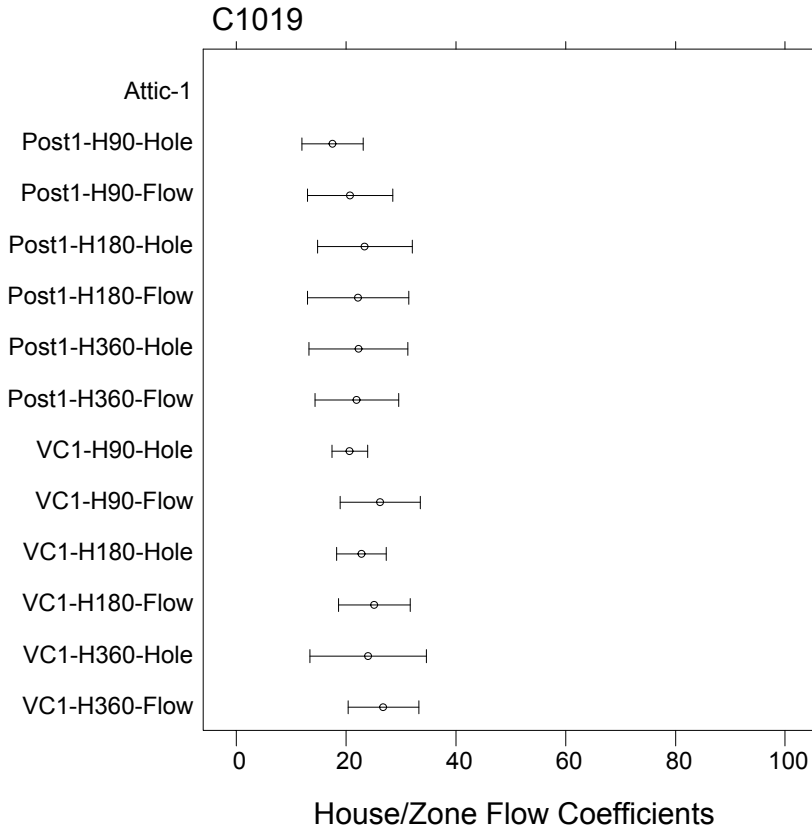


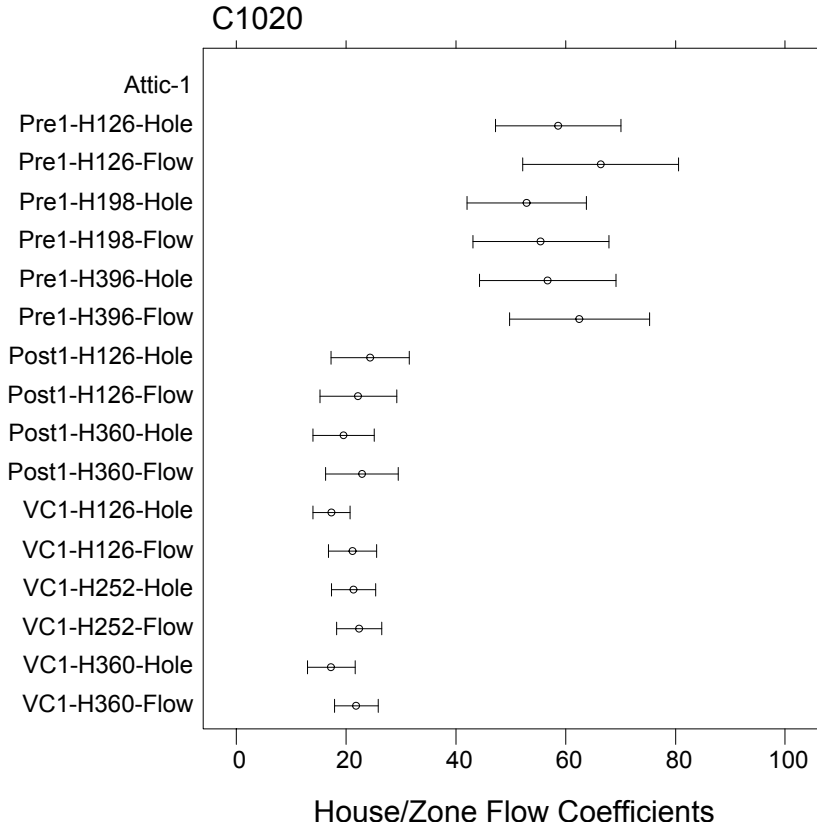
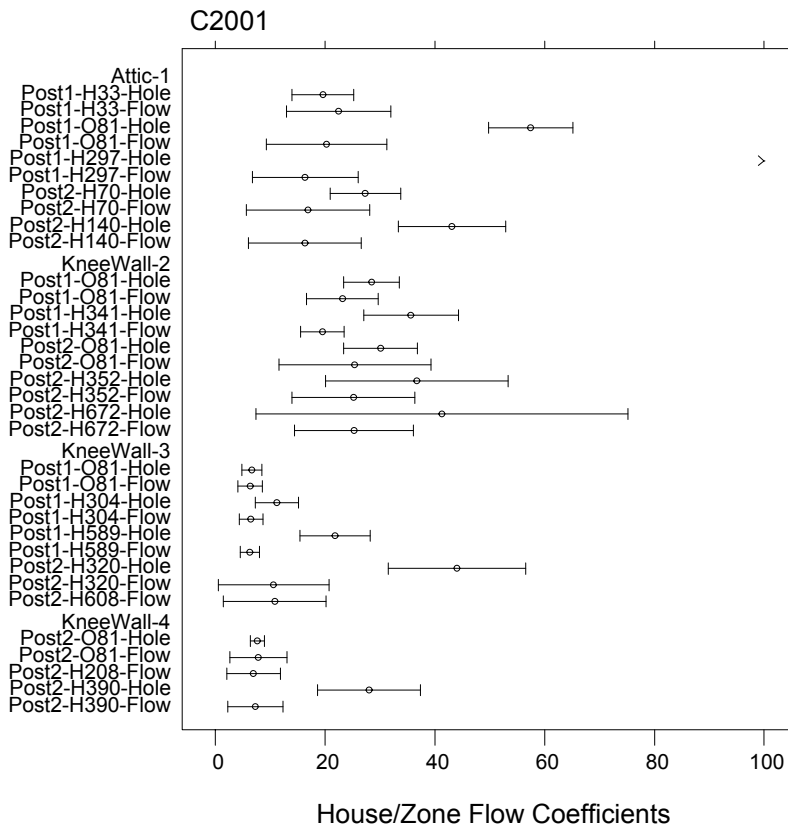


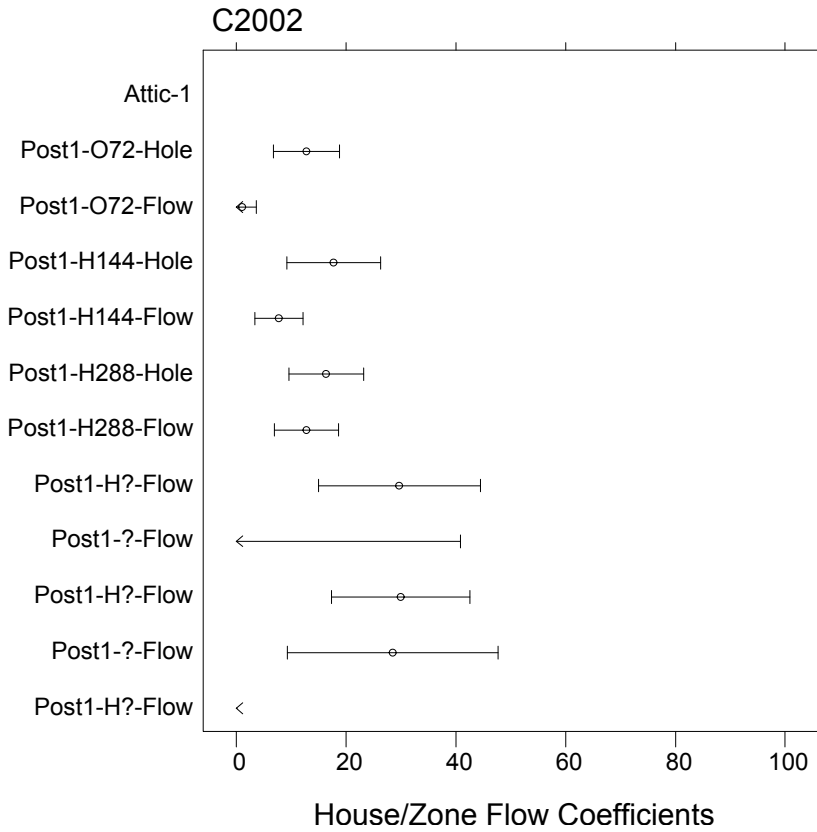
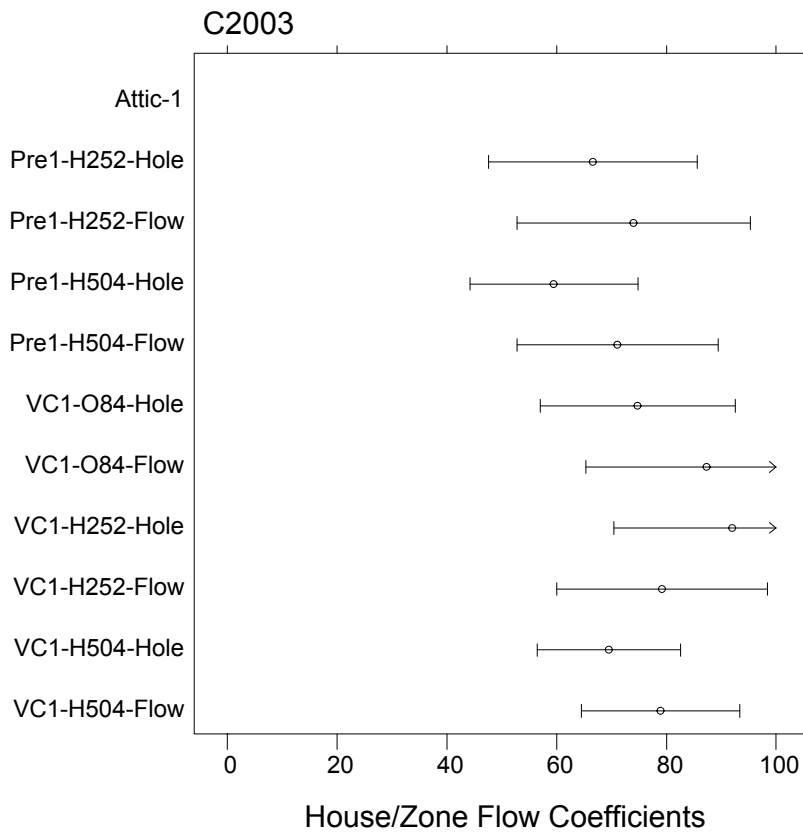


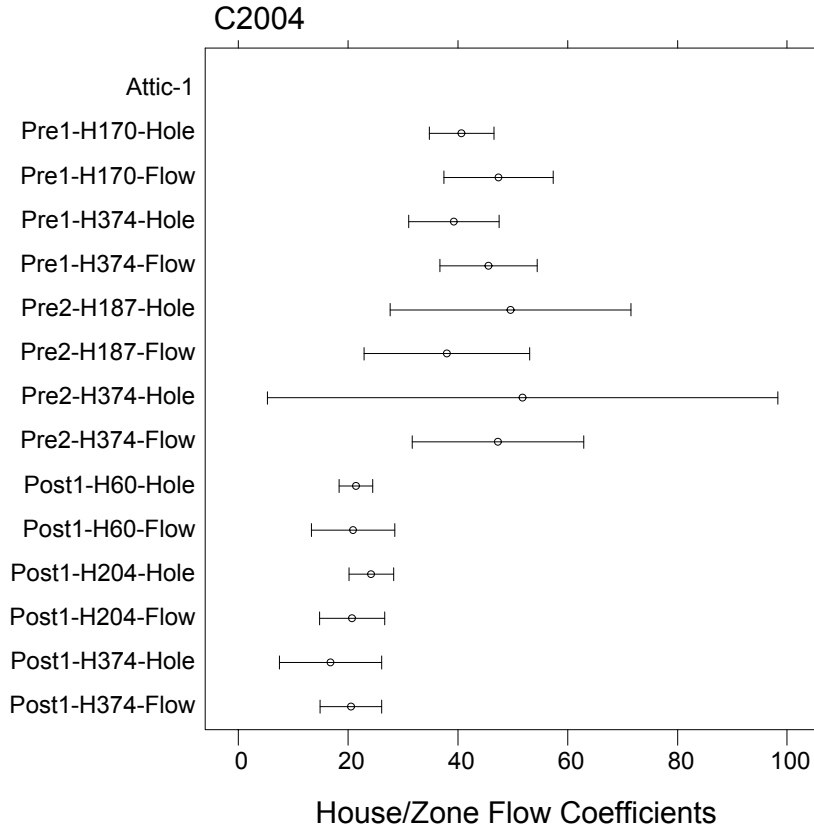
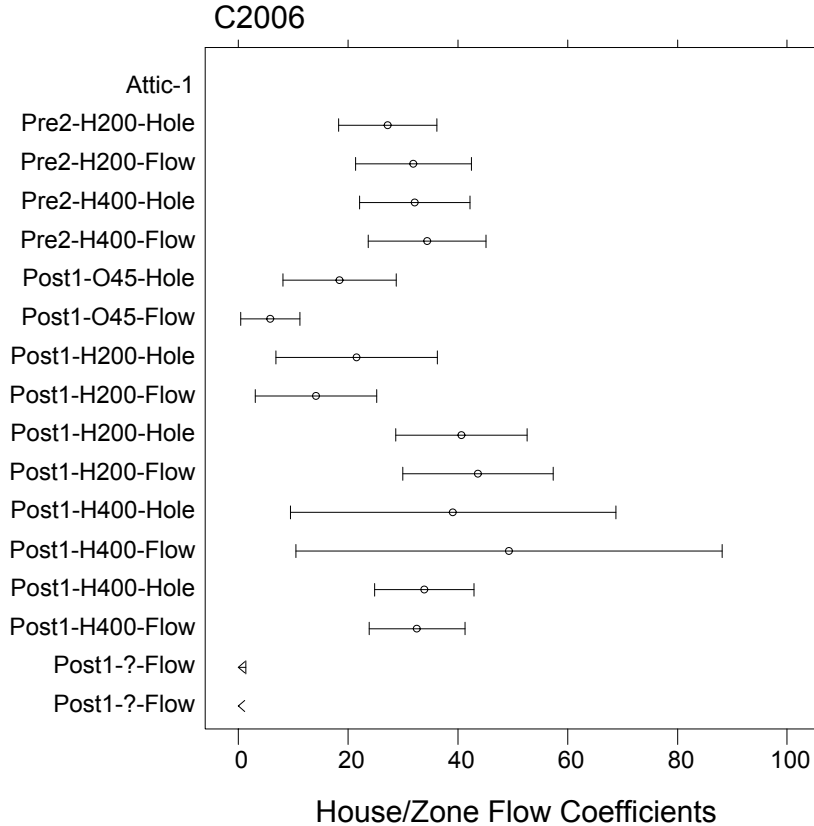




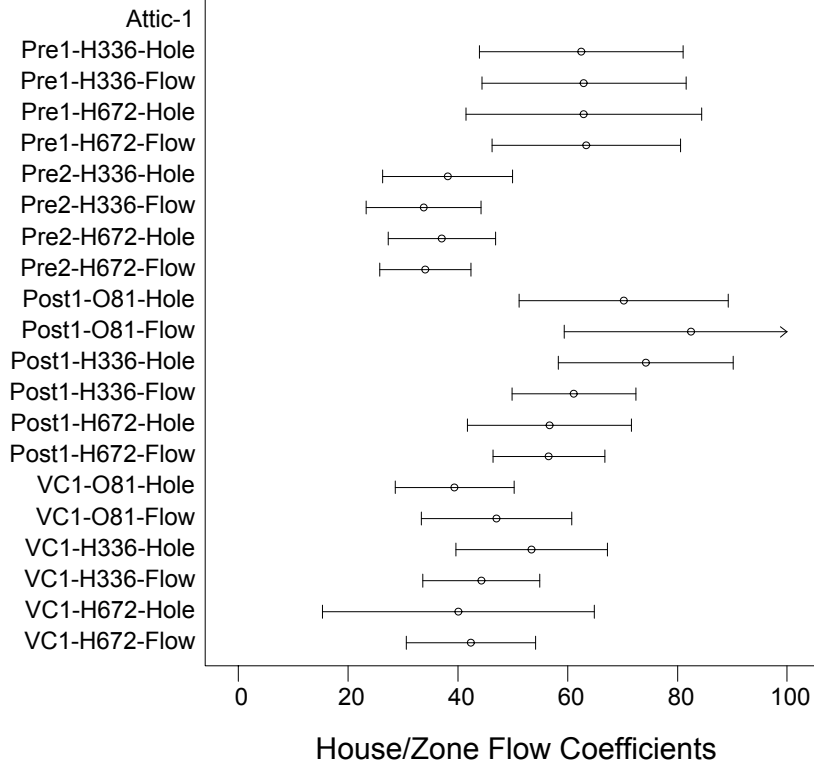




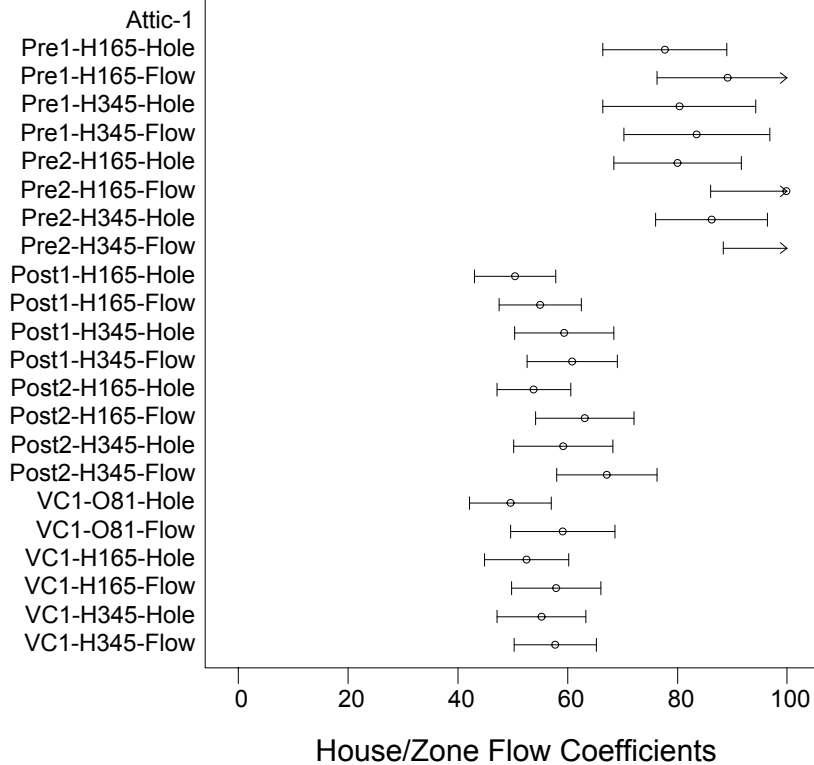


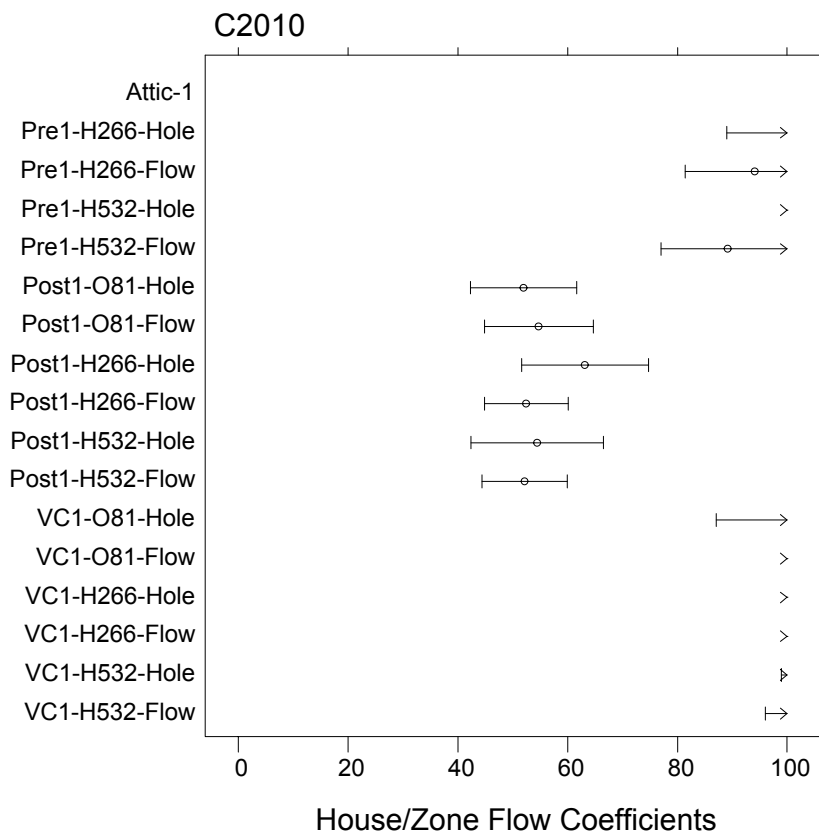
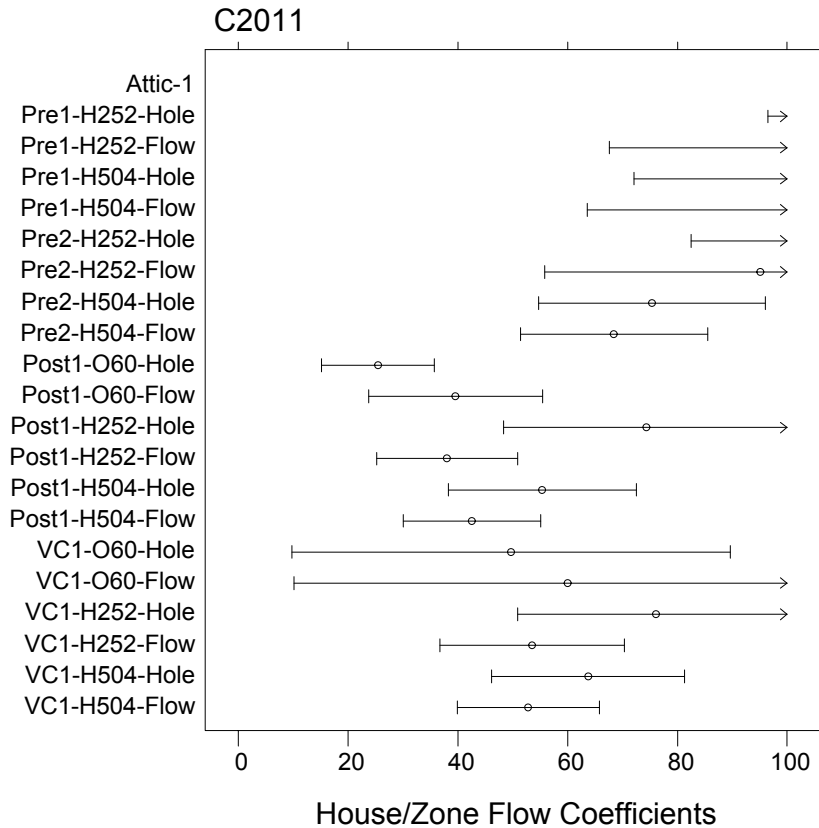


C2007

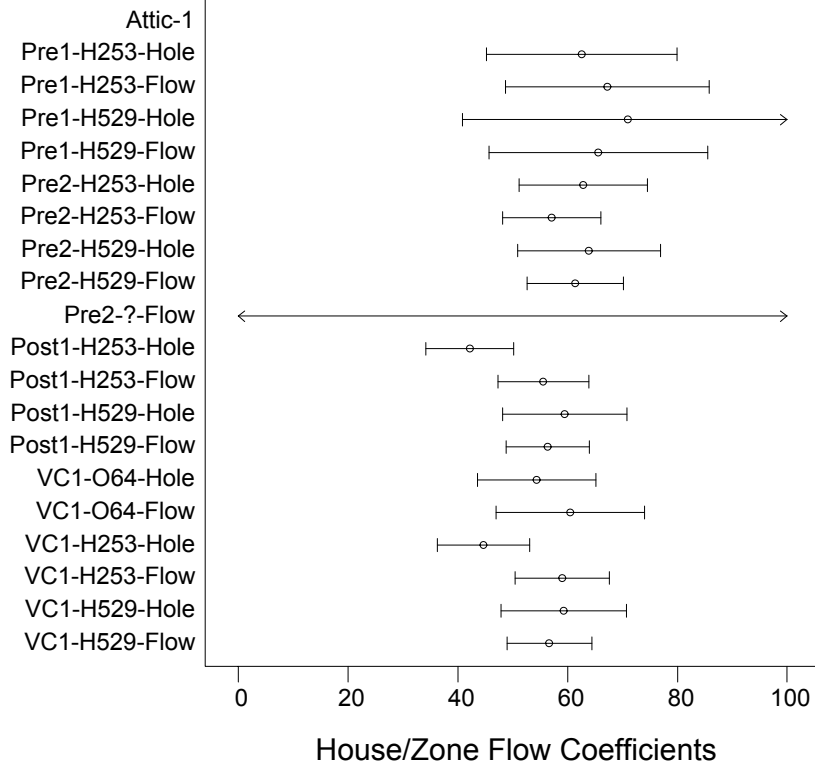


C2008

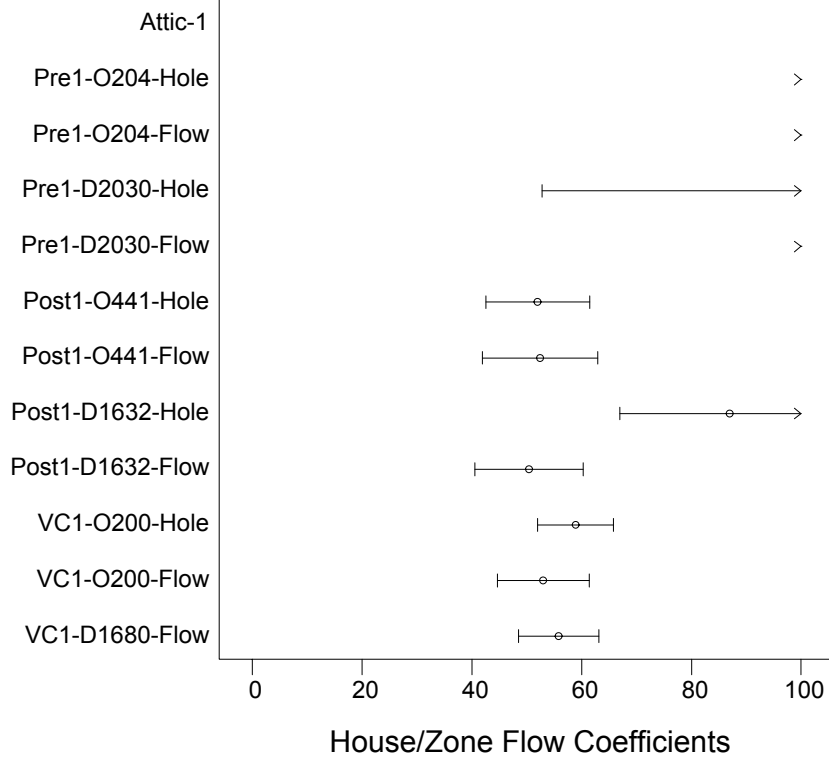


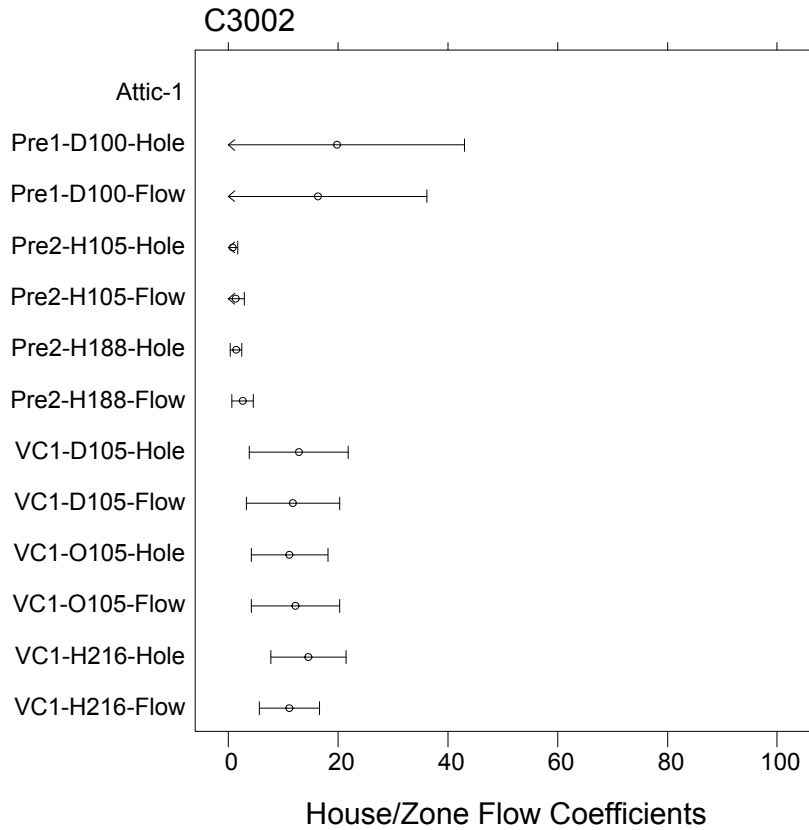
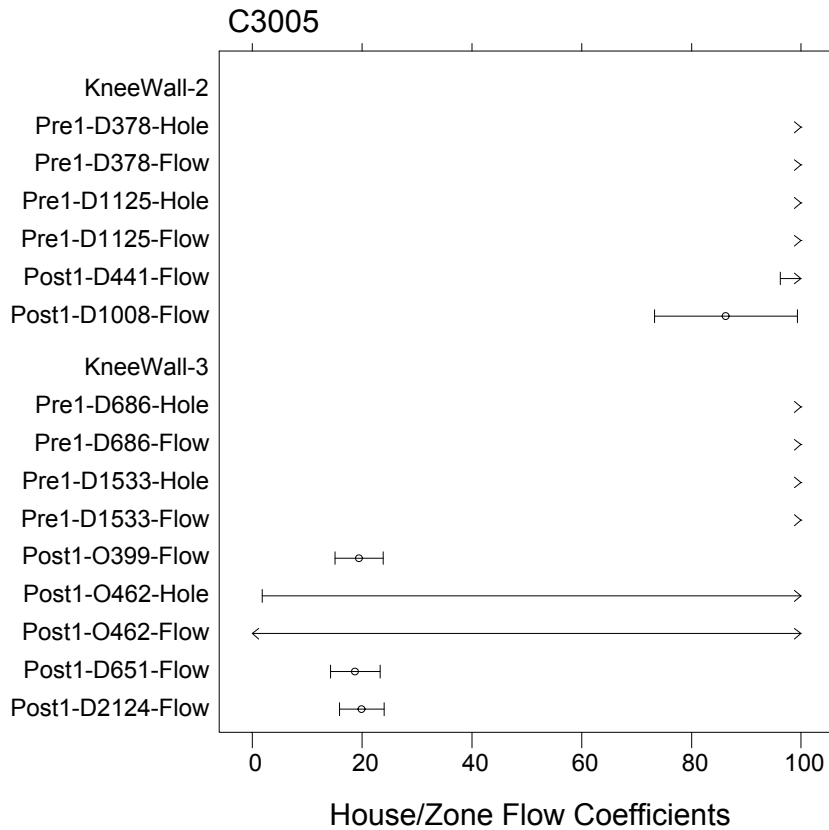


C2012

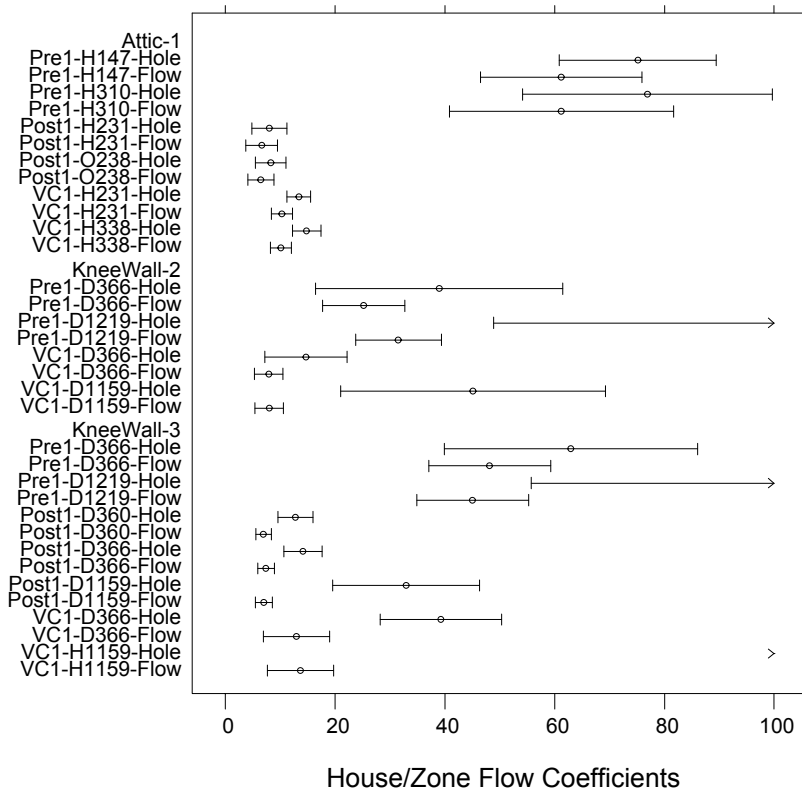


C3001

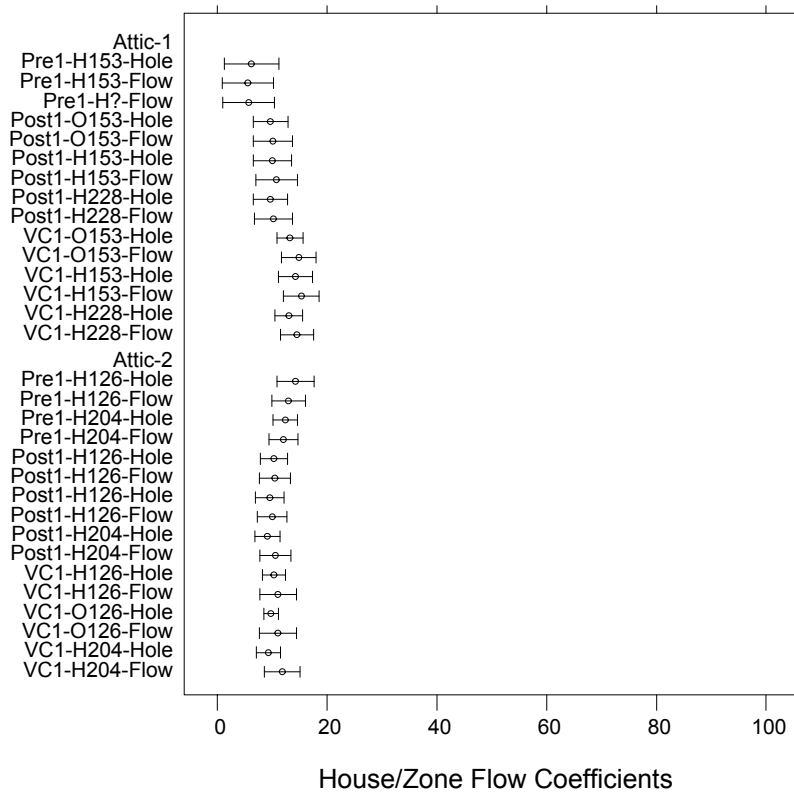


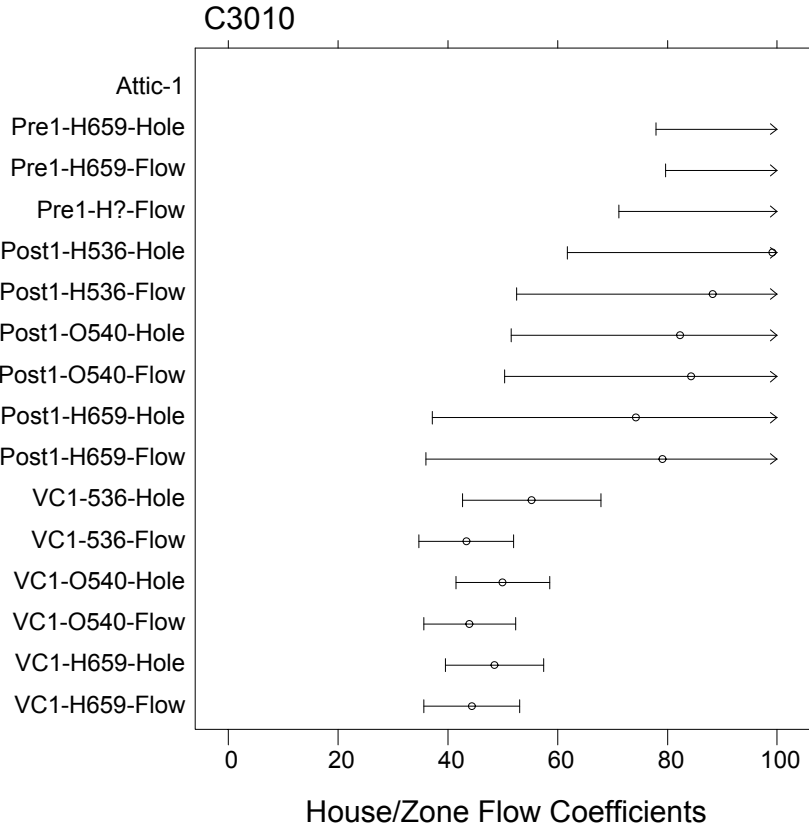
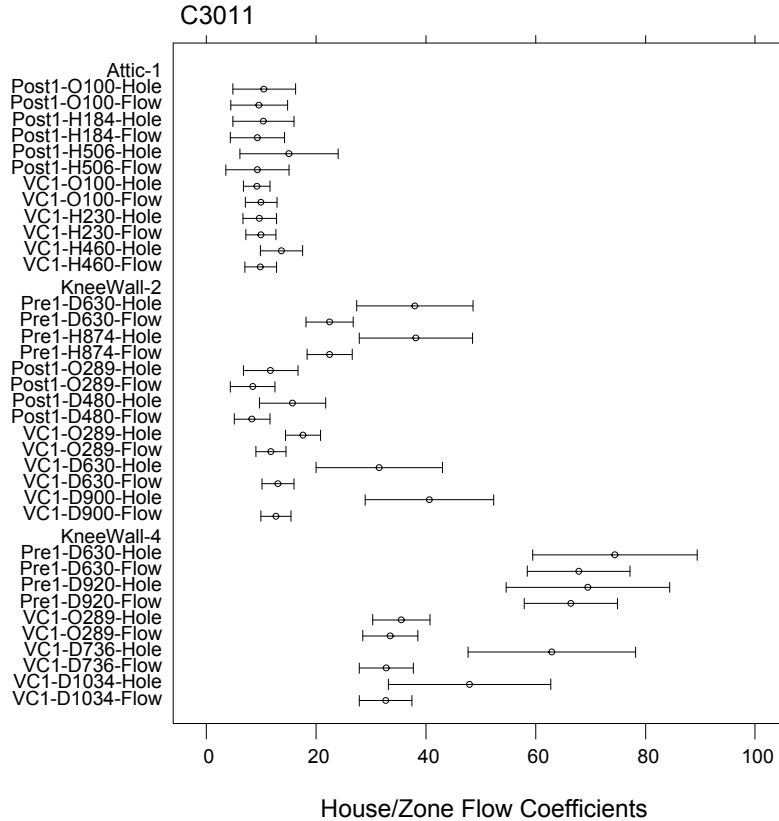


C3006

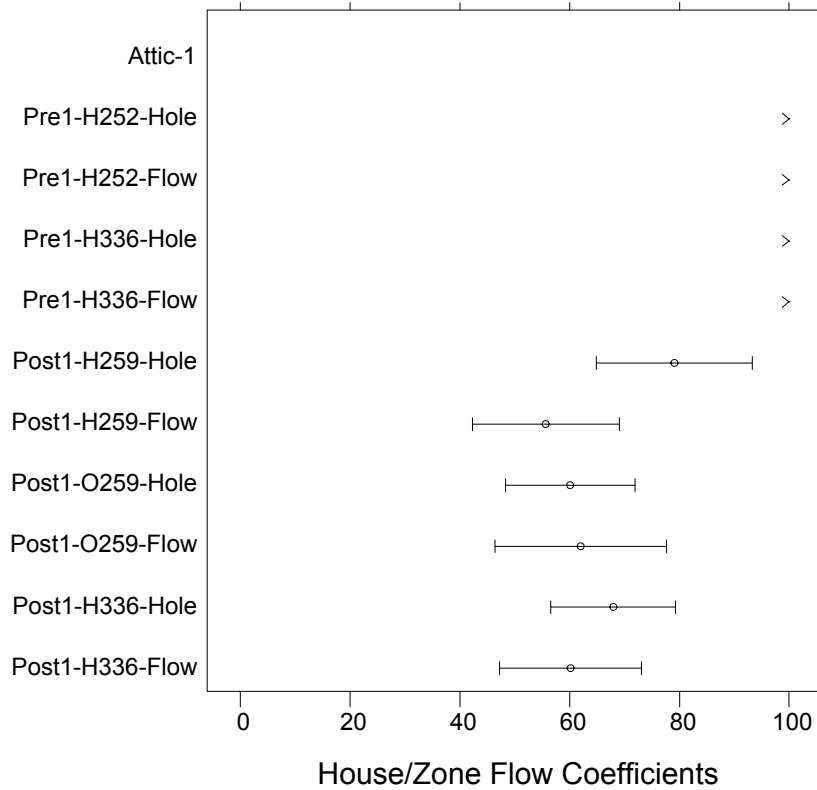


C3008

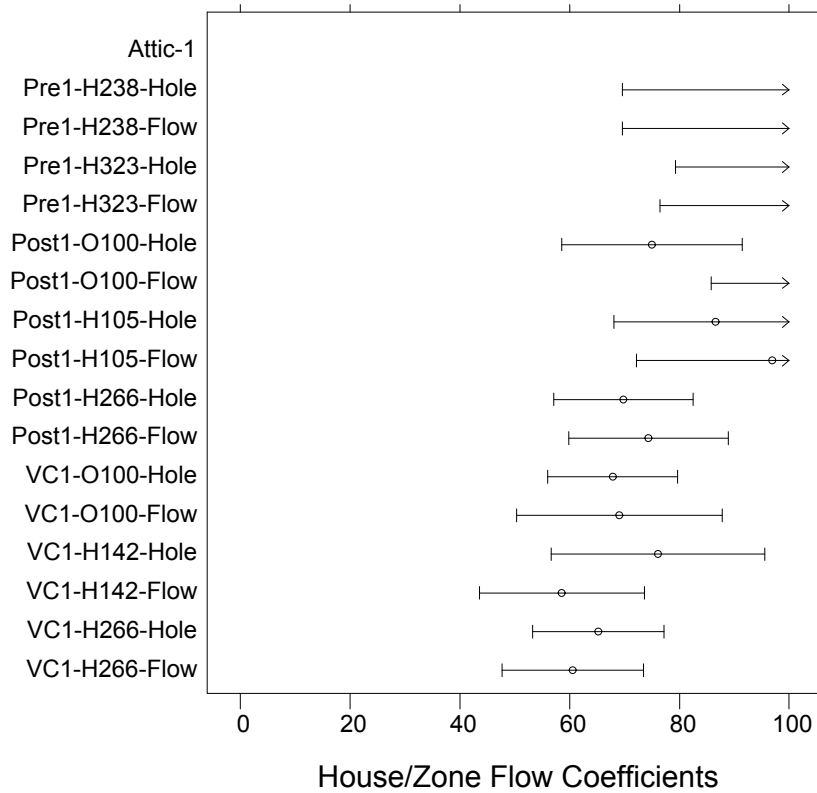


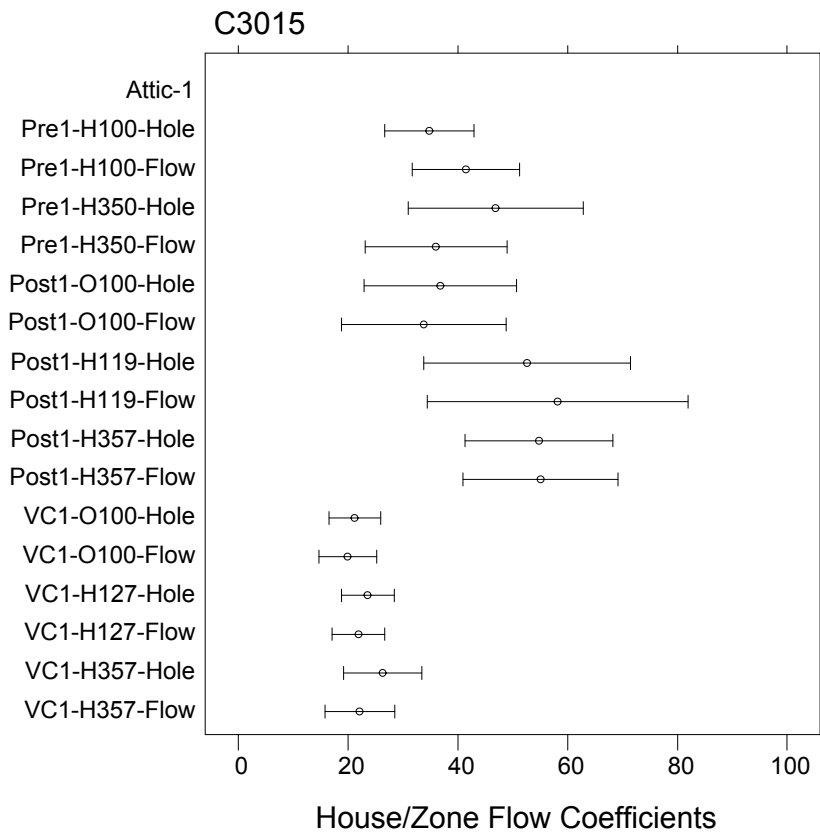
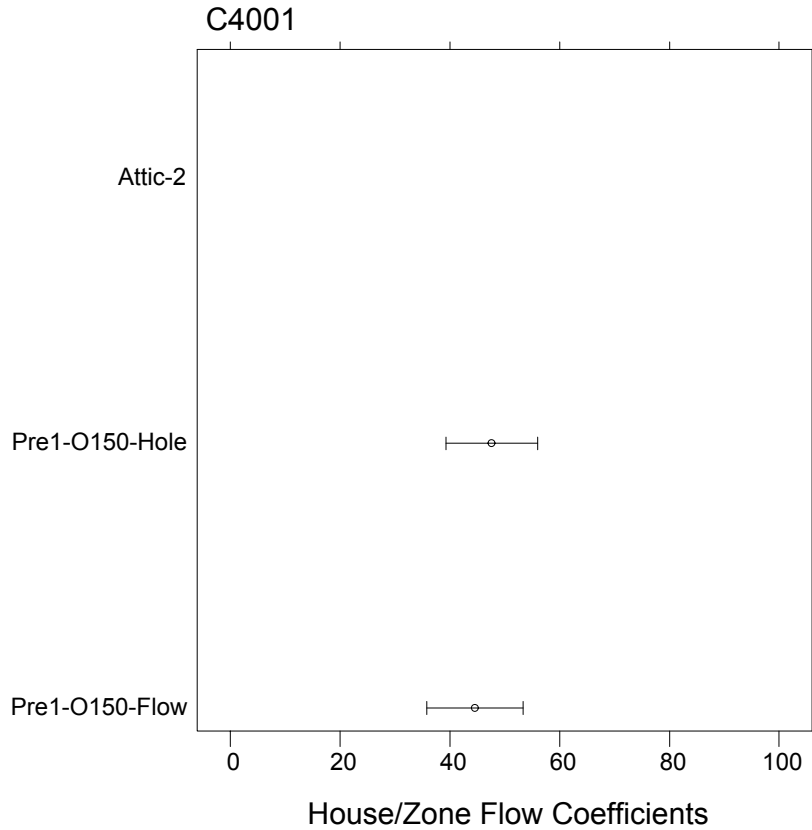


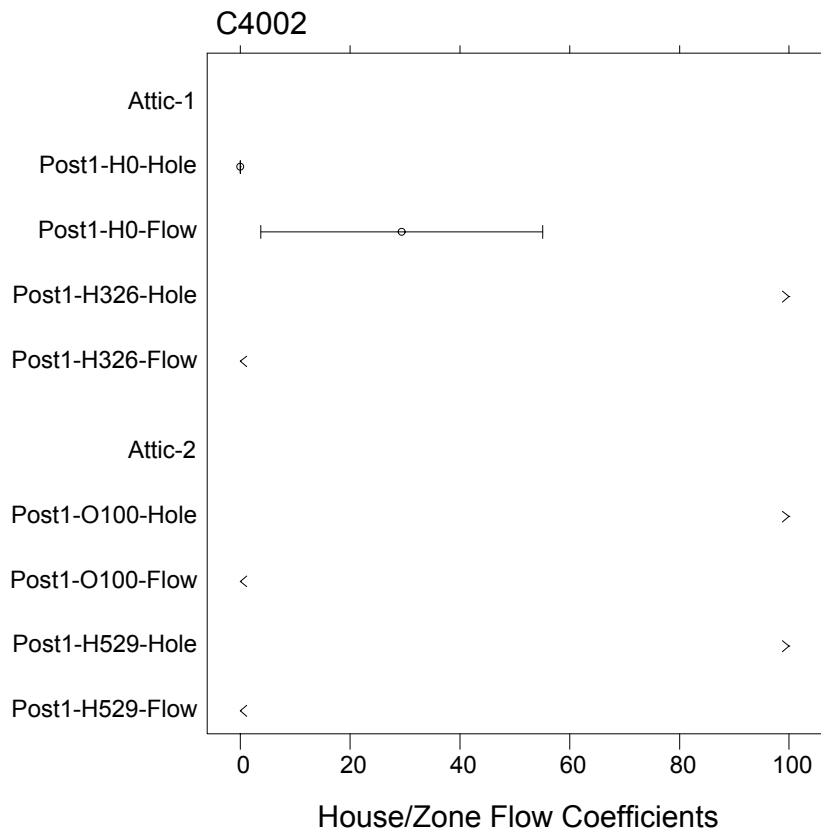
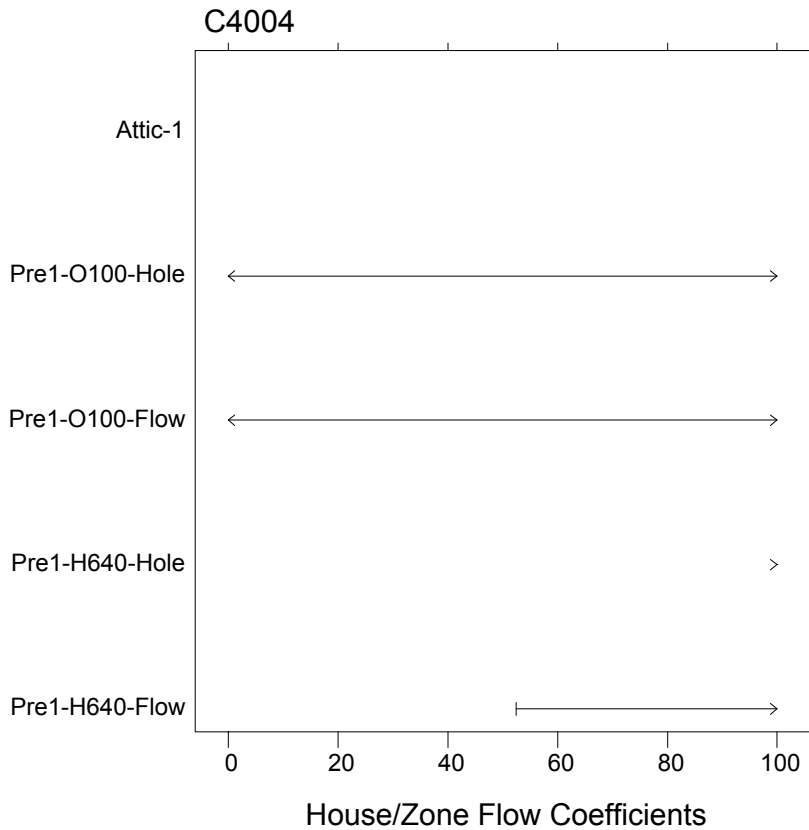
C3012

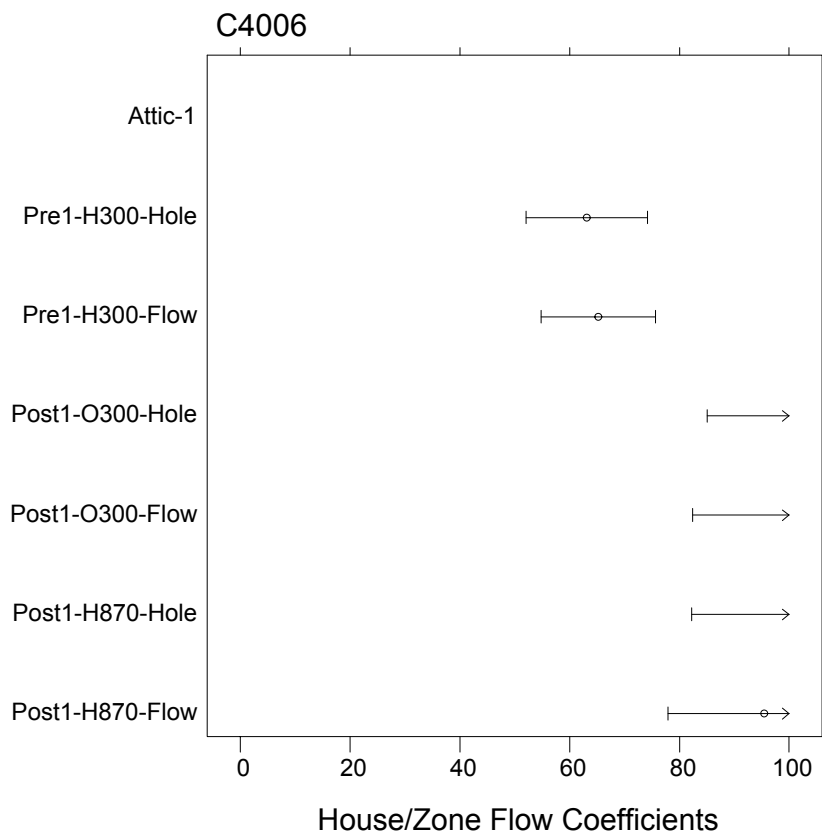
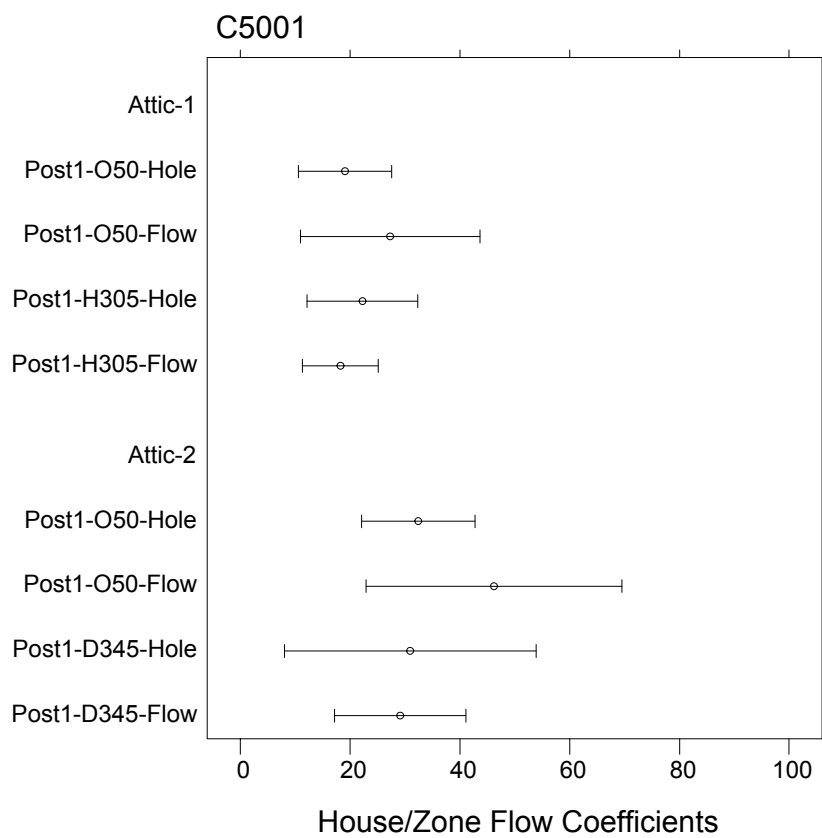


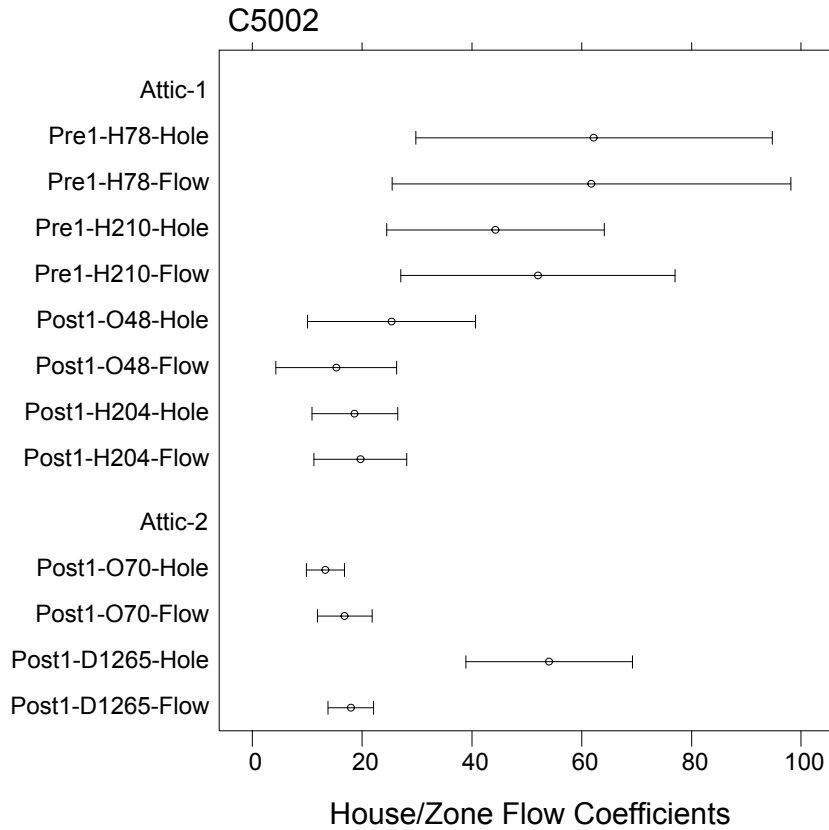
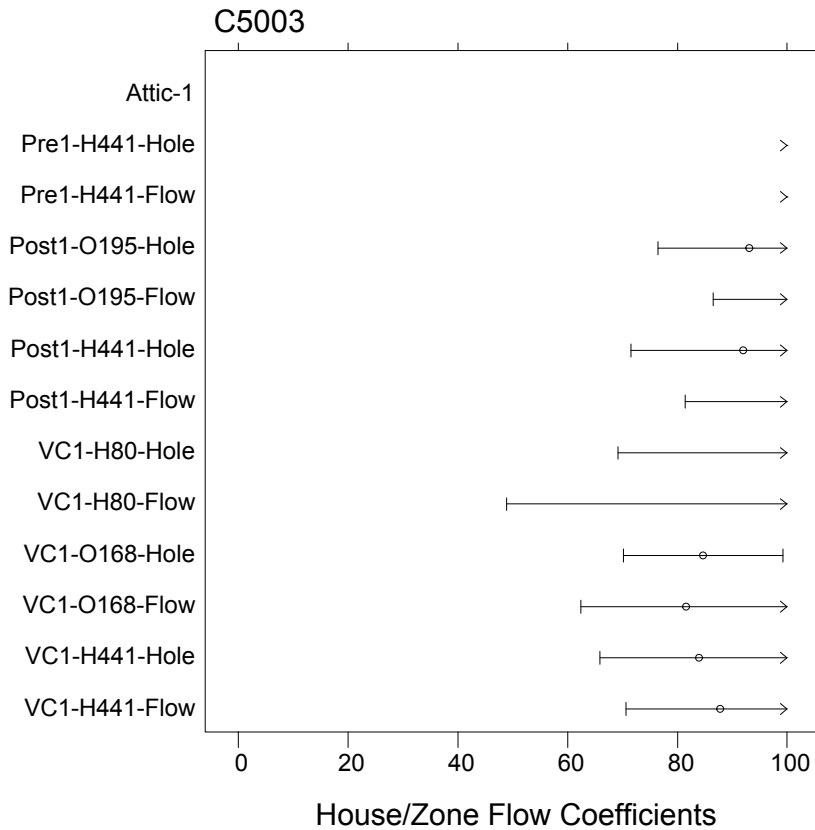
C3013

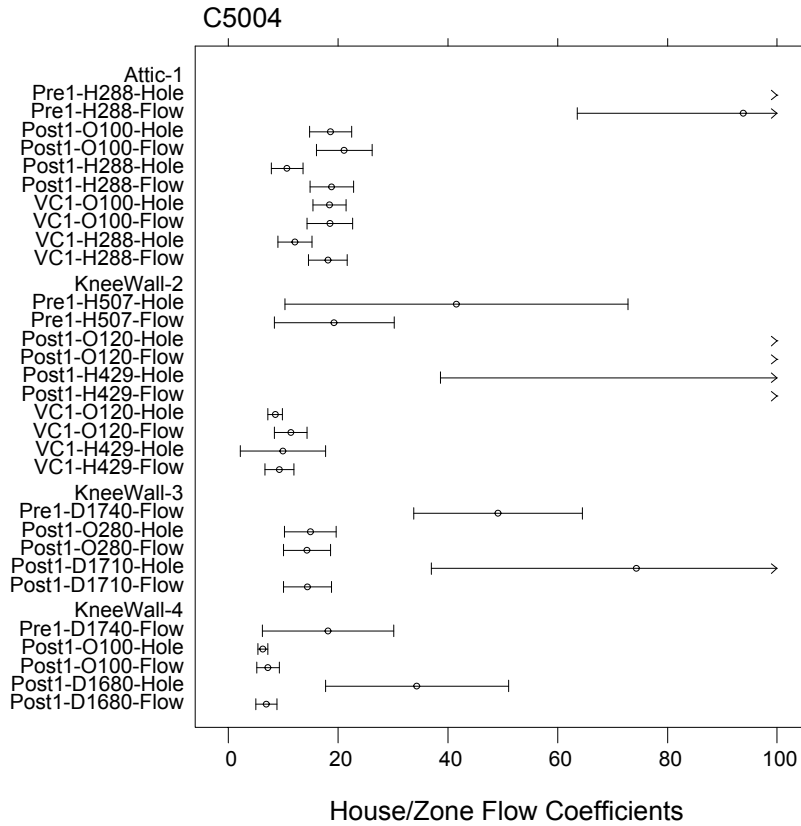
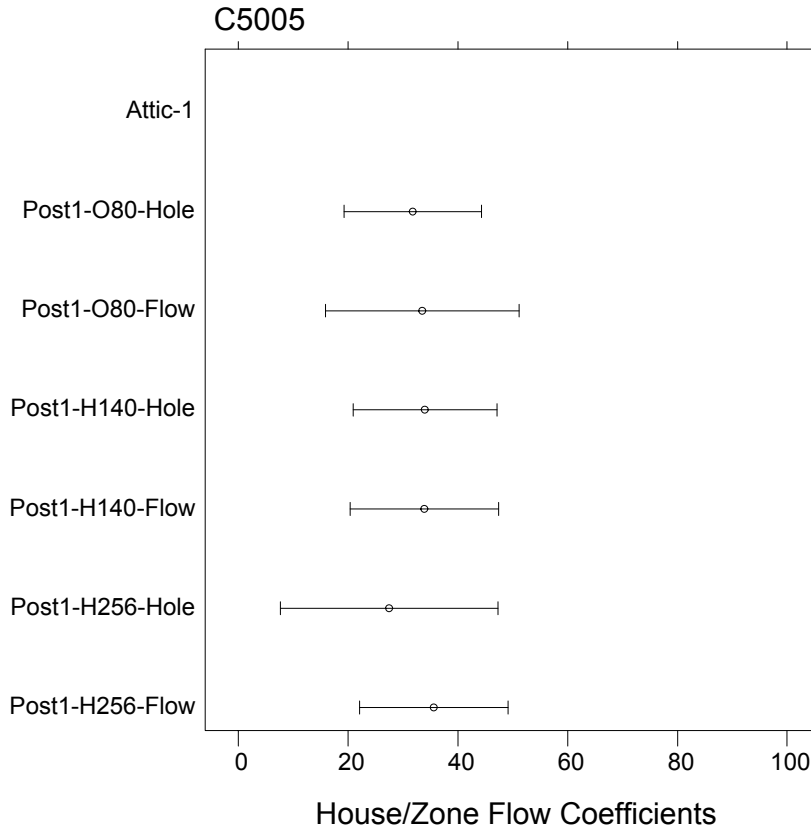


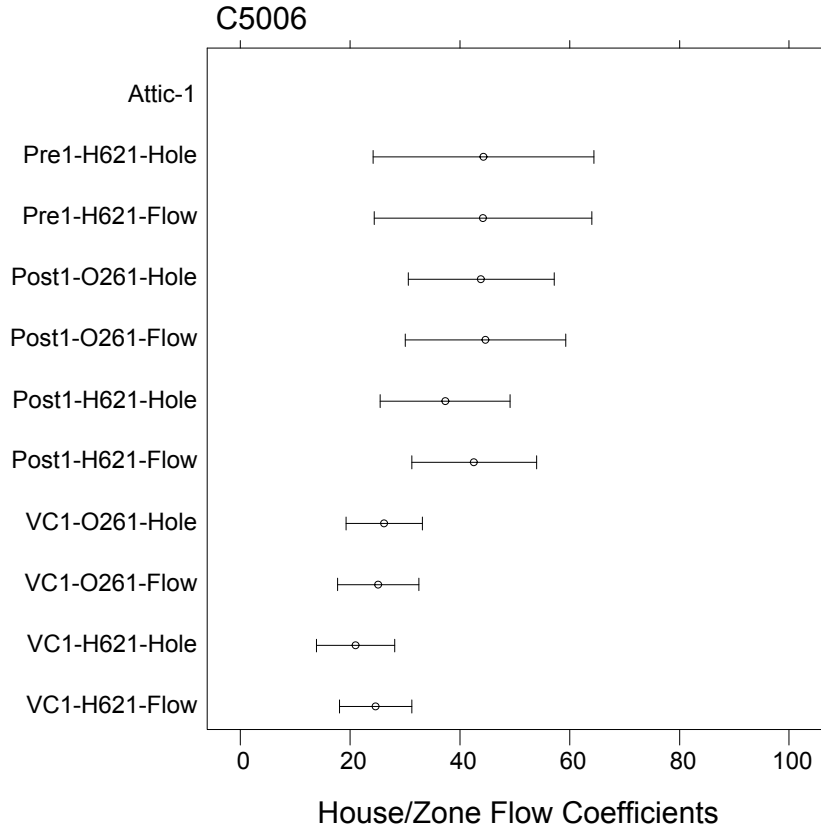
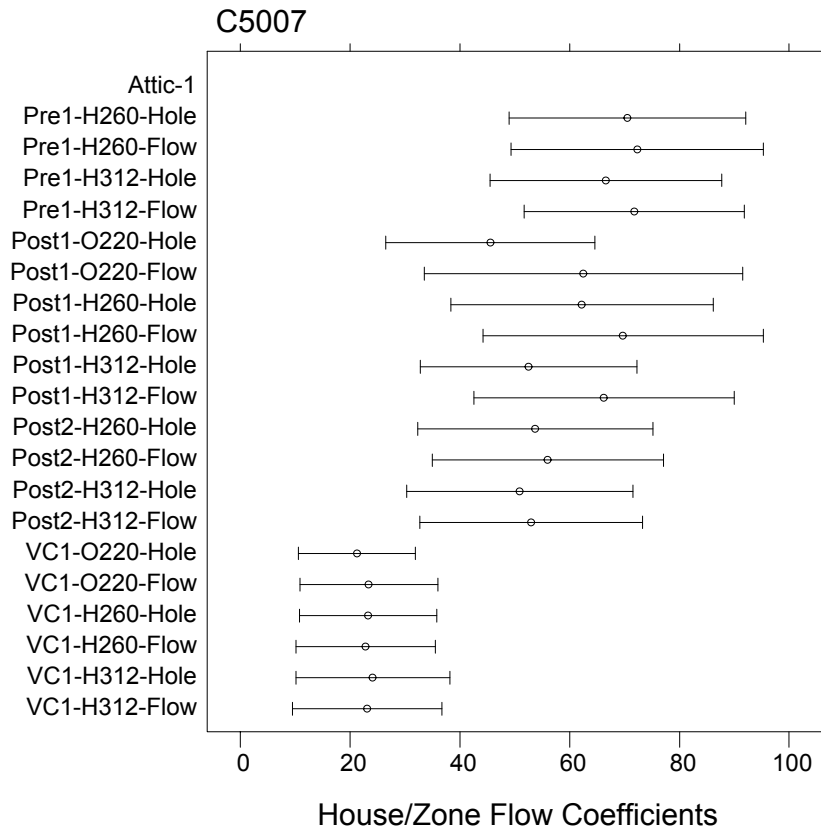


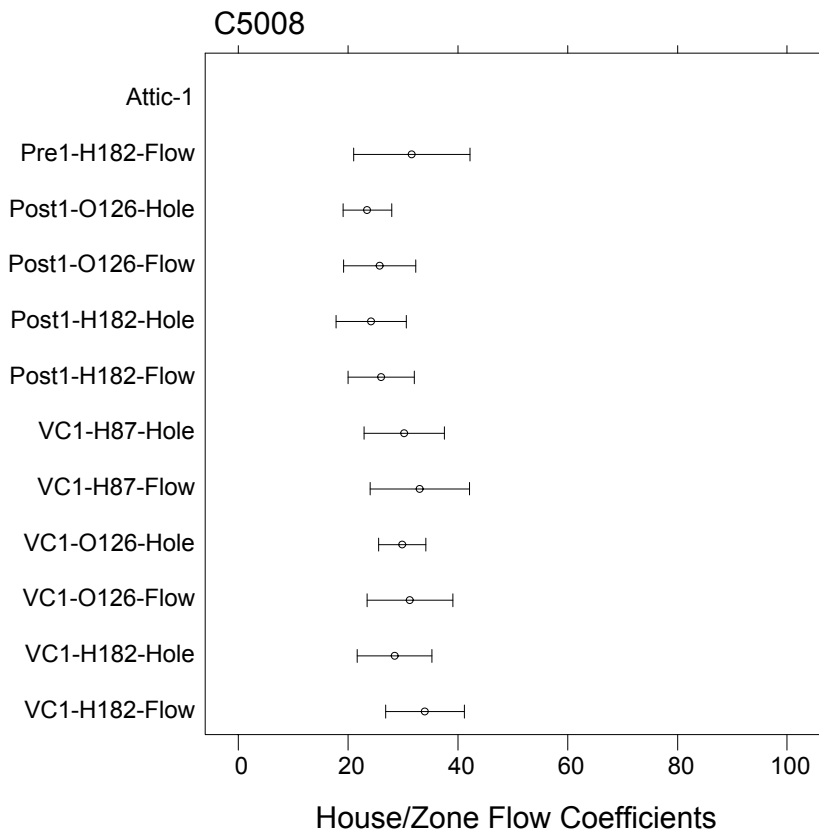
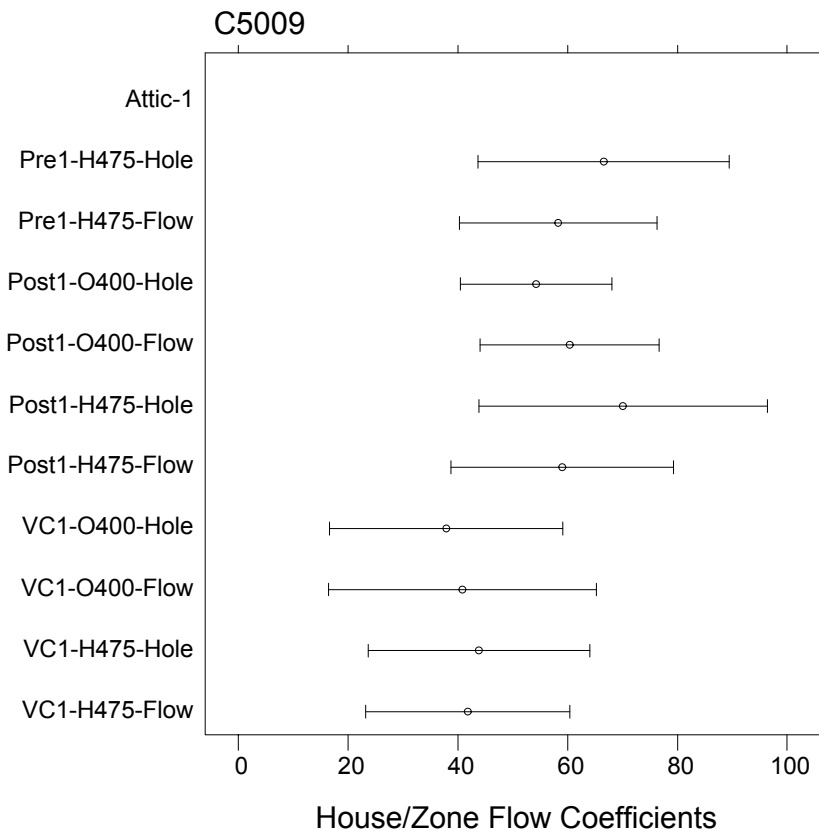




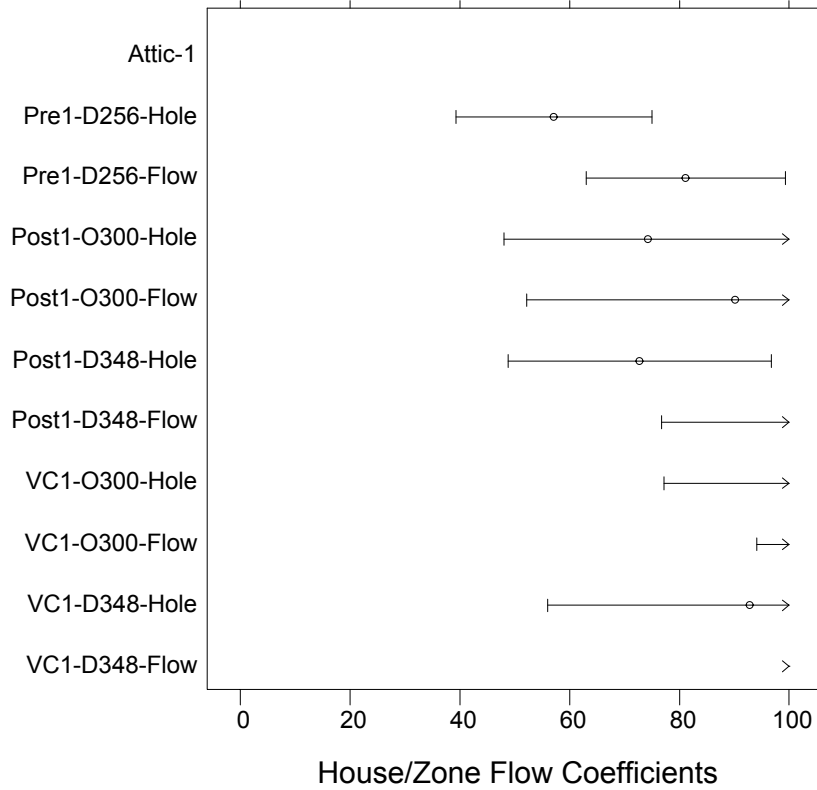




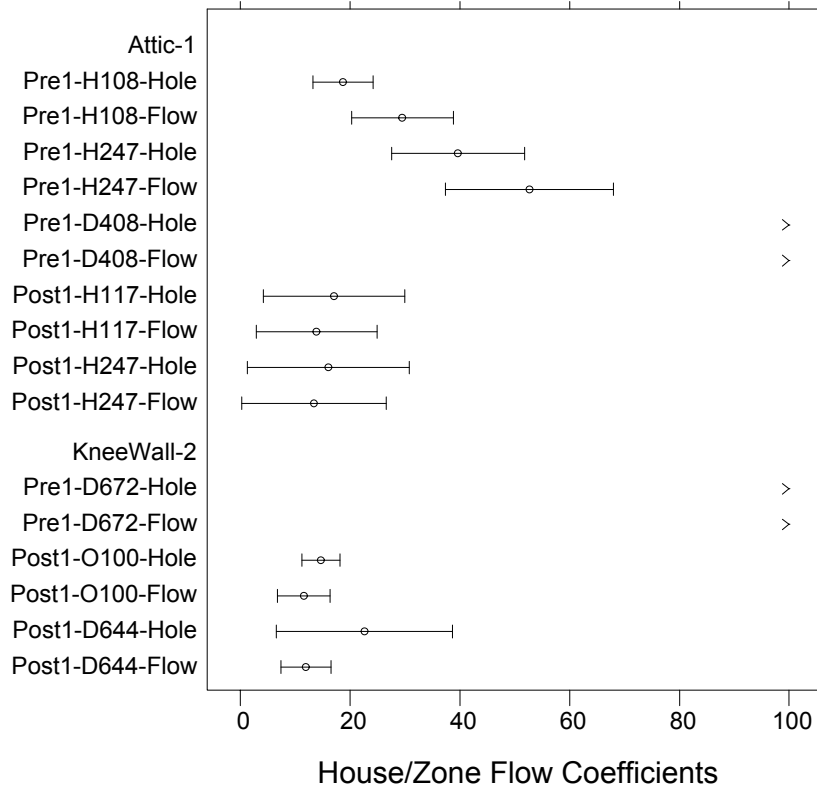


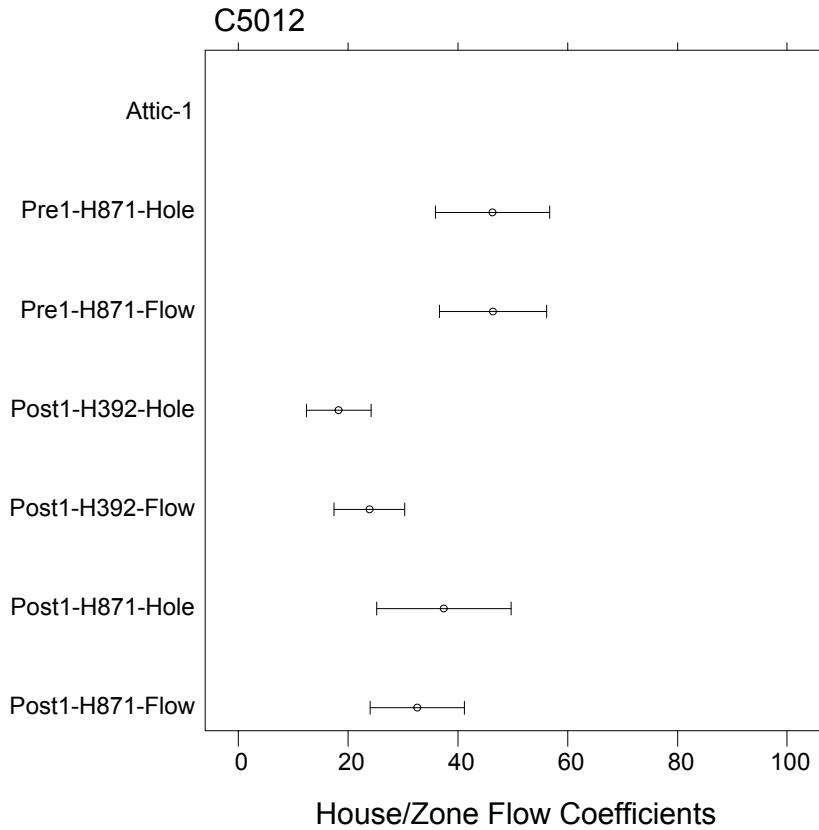
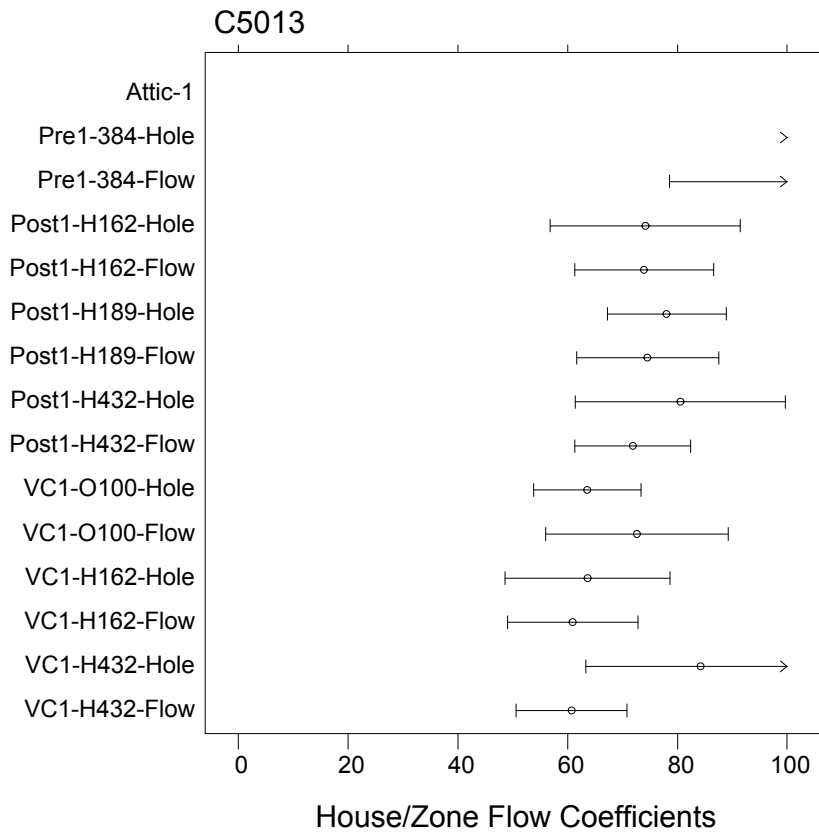


C5010

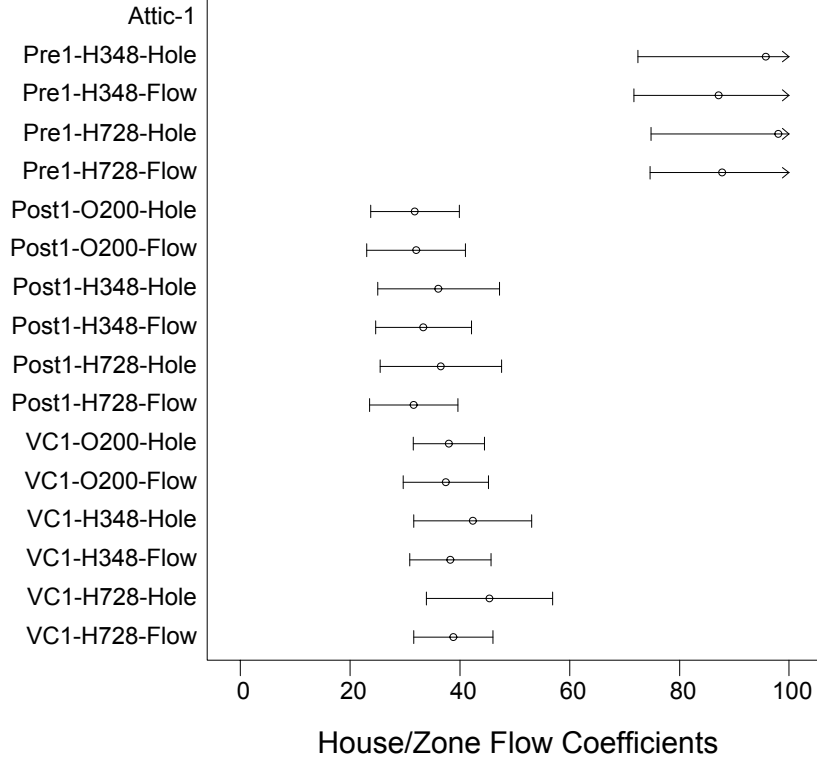


C5011

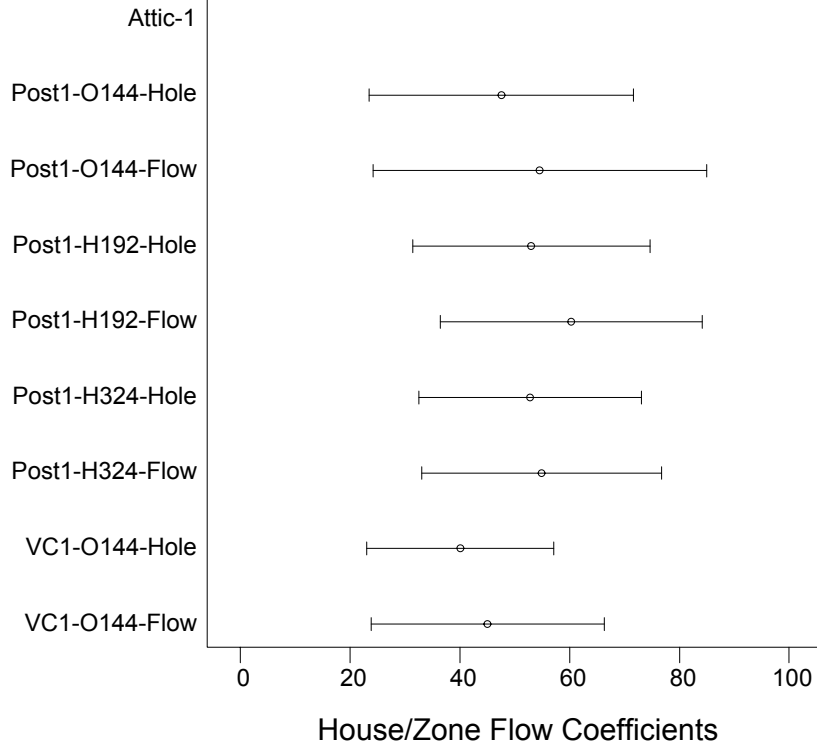


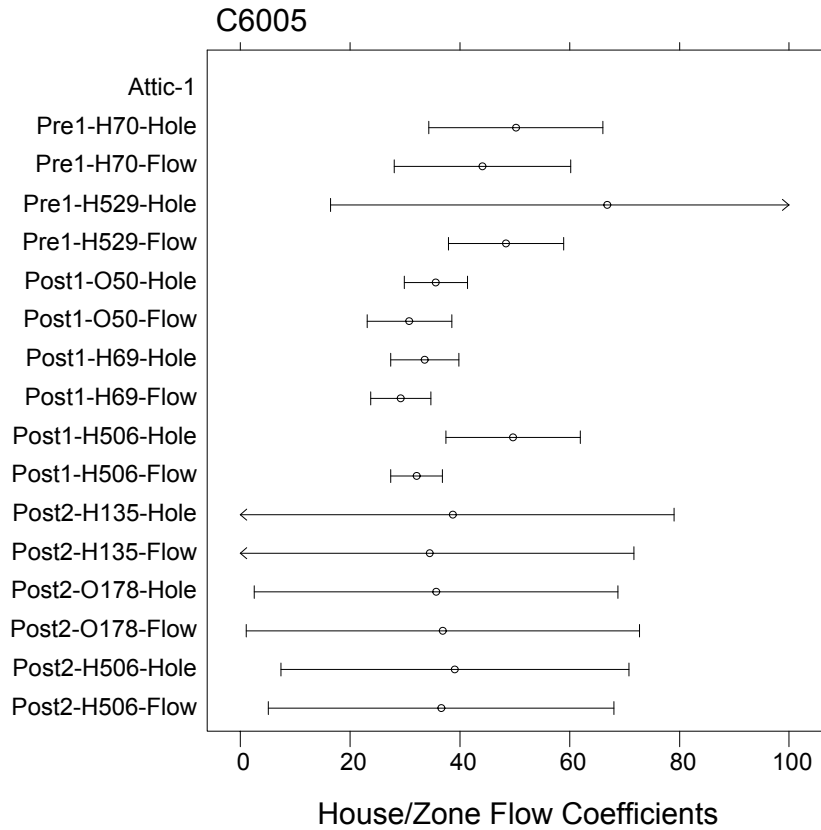
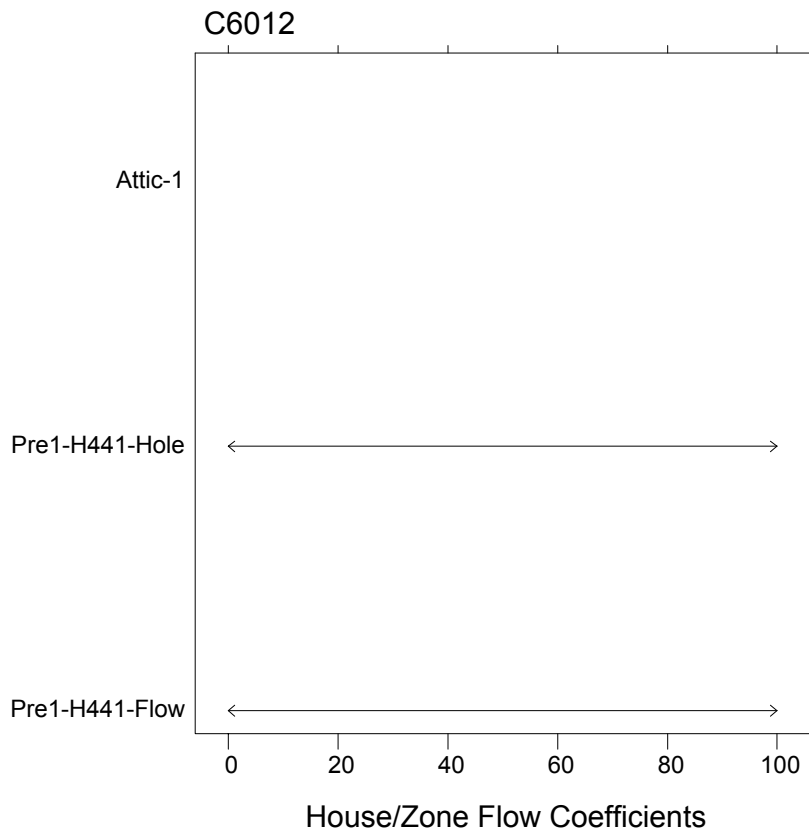


C5014



C6003





Appendix I. Proposed Crew Protocol Instructions and Field Data Forms

In order to apply this protocol, agencies will need to develop criteria for (1) Building Tightness Limit below which ZPD measurements are not required, (2) characteristics used to identify a zone as having an IAQ concern – i.e. all attached garages and accessible crawlspaces, (3) characteristics used to identify attic zones for which there may be durability issues, (4) pre-weatherization zone tightness category below which further zone pressure measurements are not required, (5) basement exterior leakage that indicates further air sealing would be beneficial, and (6) post-weatherization zone tightness category below which further visual inspection or Hybrid Method tests are required.

Step by Step Instructions

1. Complete first ½ page of Field Data Form (weather conditions/house characteristics).
2. Perform house air leakage test. Follow agency's protocol.
 - Can't reach 50 Pa & large, obvious leaks: Fix big leaks before doing any tests. After leaks sealed, repeat air leakage test and record results (first page of form).
 - No initial air sealing: Record results on first page of form.
3. Compare house CFM50 to agency Building Tightness Limit.
 - If CFM50 is less than Limit: Only perform ZPD measurements in zones where there is an IAQ or durability issue. For those zones measure zone pressure before weatherization (WX) and perform a ZPD "Hybrid" test (i.e. add-a-hole or open door) after WX.
4. Identify zone type. ZPDs are to be conducted on all key primary zones including attics, crawlspaces, basements, and attached garages. They will also be conducted on some secondary zones such as porch roofs and cantilevers where sealing off from the house is anticipated. Use the following list to determine the type of ZPDs required for the zone.
 - IAQ Concern: Perform Hybrid Method test before work and, if work is performed in zone, after work (before work – **Hybrid**, after work – **Hybrid**). Each state must designate the zones where there is an IAQ concern and it is necessary to document air leakage accomplishments. Preliminary recommendation: include both an **attached garage** and **crawlspace** in this category. Note - if the crawlspace is vented, only measure the zone pressure before work and perform Hybrid Method test after work.
 - Attic With Durability Concern: Perform Hybrid Method test before work and, if work is performed in zone, after work (before work – **Hybrid**, after work – **Hybrid**). An attic is considered to have a durability concern (i.e. potential structural damage) if any of the following conditions are true (each state may want to customize this list):
 - ✓ attic has known moisture problems
 - ✓ house has signs of high winter RH (condensation on windows, mold problems) or high moisture sources are evident

-
- ✓ ice dams are a concern
 - ✓ house is, or is expected to be, tighter than 2,000 CFM50
- Other Attics: Measure zone pressure before work (before work – **Pressure Only**). Use the attached pressure interpretation table to estimate the leakage class and compare the result to program targets for that zone type. If a zone already meets the target leakage class or is in the “unknown” category, then don’t use any further ZPD tests to assess progress in that zone (after work – **None**). Otherwise, use zone pressure to track progress (after work – **Pressure Only**).
 - Basement: Perform Hybrid Method test before work and, if work is performed in zone, after work (before work – **Hybrid**, after work – **Hybrid**). Conduct test by closing door between basement and rest of house. Preliminary recommendation: an exterior leakage greater than 100 square inches indicates an opportunity for large, quick leakage reduction.
 - Secondary – No Access: Measure zone pressure before work (before work – **Pressure Only**). If house/zone pressure is greater than 35 Pa (indicates significant connection to outside), do not measure any further (after work – **None**). If house/zone is less than 35 Pa, continue to measure zone pressure to track air sealing progress (after work – **Pressure Only**). Secondary zones include building cavities that do not have any direct access to the living space or outside and weatherization work is planned to change it’s leakage characteristics. However, because venting is usually unknown in these zones, the initial zone pressure should not be interpreted as meaning that no connection exists or that work is not needed.
5. Complete zone information section of Field Data Form for each zone. Enter one of the five different types of zones – the first letter is also entered in the hybrid calculator. Use the results from step (4) to determine the Zone Type. If there are vents in the zone enter in the table the number of roof vents, gable vent area (physical size), length of ridge vent, and number of turbine vents. Multiply or divide the values in the second row by the default values in the third row and enter the result in the third row. Add all the values in the third row to get the Total Vent Area.
6. Use a digital manometer to measure the zone to house pressure (Z/H: zone – input, house – reference) for each zone. Note – it is not necessary to measure the baseline pressure. Enter the Z/H value in the Field Data Form. Determine whether further measurements are required:
- IAQ Concern & Attic/Durability: If house CFM50 < agency limit, no further measurements before work. Otherwise, perform Hybrid Method test before work.
 - Attic/Other: Use Z/H and Vent Method to find leakage class in lookup table. Compare to target class set by agency. If measured class is tighter than or same as target, no measurements during or after work are required.

- Basement: Perform Hybrid Method test before work. Close door and adjust house pressure to -50 Pa. Measure flow and Z/H pressure. Note – enter these measurements with the basement door closed in the “No Hole Added” section of the spreadsheet and the first set of measurements with the door open in the “Hole Added” section.
 - Secondary – No Access: No further measurements before work.
7. If hybrid method is required. Complete first five steps of Hybrid Method calculator data entry. Use recommendations to determine: baseline required, Z/H or Z/O, and opening location. A recommendation window will also inform you whether the Hybrid Method is likely to provide useful information. Do not perform test if the recommendation states that the results will not be accurate. Otherwise, conduct add-hole/open door type test for all zones that require quantification. Note – added hole should be large enough to produce a 25 to 35 Pa change in the zone pressure. Complete remaining steps of the Hybrid Method calculator. Enter data and results (if desired) in the Field Data Form. Enter CFM50 and pressure goal in zone section of Field Data Form.
 8. Perform work – take intermediate zone pressure measurements and compare to targets (as helpful).
 9. After work is complete, perform required post work measurements. Review zone information sections to determine required measurements (None/Pressure Only/Hybrid). If not Pressure Only measure Z/H and use value along with vent area to find leak class from table. If leak class is not the same or tighter than target, either inspect for additional air sealing opportunities (and repeat Z/H measurement) or use Hybrid Method to better determine remaining leakage. If Hybrid Method is required, repeat step (7).

Figure I1. Pressure Interpretation Table

		Estimated Venting (and outside leakage)																								
		1 vent			2 vents			3 vents			4 vents			5 vents			6 vents			7 vents			8 vents+			
Inside/Outside	Pzh	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	Pzh
Completely Inside	0																									0
	1																									1
Almost All Inside	2																									2
	3																									3
	4																									4
Mostly Inside	5																									5
	6																									6
	7																									7
	8																									8
	9																									9
	10																									10
	11																									11
	12																									12
More In than Out	13																									13
	14																									14
	15																									15
	16																									16
	17																									17
	18																									18
	19																									19
	20																									20
	21																									21
	22																									22
	23																									23
	24																									24
In the Middle	25																									25
	26																									26
	27																									27
	28																									28
	29																									29
	30																									30
	31																									31
	32																									32
	33																									33
	34																									34
	35																									35
	36																									36
More Out than In	37																									37
	38																									38
	39																									39
	40																									40
	41																									41
	42																									42
	43																									43
Mostly Outside	44																									44
	45																									45
	46																									46
	47																									47
Almost All Outside	48																									48
	49																									49
Completely Outside	50																									50

Crew Production Field Data Form

Agency: _____ Agency house identifier: _____

Street

City

Technician Name: _____ Start Date: _____ Complete Date: _____

Weather Conditions

Air temperature. (F), outside: _____ Inside: _____

Wind Speed Class: **1** – (0-3mph), **2** (4-12mph), **3** (13-24mph), **4** (>24mph)

House Characteristics

House height (above ground): _____ (ft)

Stories: **Ranch** **1 ½ story** **2 story** **2 ½ story** **Split** **Other** _____

Floor area (sq ft): Lower _____ First _____ Second _____ Third _____

Will house sidewalls be insulated? **No** **Already complete** **During Work** **After Work**

House comments or notes

Note – some states may require the sections with a gray background to be completed to assist them in refining zone target values. These sections are not required for the ZPD calculations.

Air Leakage Test (Before Work)

House/out (Pa), Base: _____ Blower On: _____ Adjusted: _____

Flow (cfm) _____ Adjusted CFM50: _____ Ring **Open** **A** **B** **C**

Air Leakage Test (After Work)

House/out (Pa), Base: _____ Blower On: _____ Adjusted: _____

Flow (cfm) _____ Adjusted CFM50: _____ Ring **Open** **A** **B** **C**

Zone Information

(1) Identifier: _____ Type: **attic** **garage** **crawlspace** **basement** **other**

Zone type: **IAQ** **Attic/Durability** **Attic/Other** **Basement** **No Access**

Attic-type: **(Kneewall attic)** **(Peak attic w/vents)** **(Full attic, open floors)** **(Pk over 1 ¾ story)**
(Porch attic) **(Peak attic no vents)** **(Full, floored attic)**

Approx. Floor area: _____ (sq ft)

If Zone Has Vents To Outside				
Roof Vents	Gable Area	Ridge Length	Turbine	
(#)	(sq in)	(ft)	(#)	TOTAL VENT AREA
x25	÷4	x8	x120	=

Leakage Class (from table): _____ Target Class: _____

Zone/House pressure (Pa): Initial _____ Final _____

Intermediate _____

Hybrid Results - CFM50 Goal: _____ Pressure Goal: _____

ZPD - Before work: **Pressure Only** **Hybrid** After Work: **None** **Pressure Only** **Hybrid**

(2) Identifier: _____ Type: **attic** **garage** **crawlspace** **basement** **other**

Zone type: **IAQ** **Attic/Durability** **Attic/Other** **Basement** **No Access**

Attic-type: **(Kneewall attic)** **(Peak attic w/vents)** **(Full attic, open floors)** **(Pk over 1 ¾ story)**
(Porch attic) **(Peak attic no vents)** **(Full, floored attic)**

Approx. Floor area: _____ (sq ft)

If Zone Has Vents To Outside				
Roof Vents	Gable Area	Ridge Length	Turbine	
(#)	(sq in)	(ft)	(#)	TOTAL VENT AREA
x25	÷4	x8	x120	=

Leakage Class (from table): _____ Target Class: _____

Zone/House pressure (Pa): Initial _____ Final _____

Intermediate _____

Hybrid Results - CFM50 Goal: _____ Pressure Goal: _____

ZPD - Before work: **Pressure Only** **Hybrid** After Work: **None** **Pressure Only** **Hybrid**