CHAPTER 10, APPENDIX D

HYDROLOGIC AND HYDRAULIC CHECKLISTS

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HYDROLOGY AND HYDRAULICS QUALITY ASSURANCE CHECKLIST SUMMARY

PROJECT DETAILS

Road: ______________________

Waterbody: ______________________

District: ______________________

Municipality: ______________________

County: ______________________

H&H Report Sealed by Licensed Engineer: ______________________

District or Company: ______________________

CHECKLISTS

Checklists Completed	Designer(s)	Reviewer(s)	Date(s)
☐ H&H Report			
☐ Abbreviated			
☐ Full			
☐ Hydrology			
☐ HEC-RAS			
☐ HY-8			
☐ Scour*			

*Not required with a Preliminary H&H Report submission

Instructions:

1. These checklists are intended to provide documentation that a quality assurance review was performed. All applicable checklists must be completed by an internal reviewer and included with H&H Report submission. If the report is submitted as a paper copy for review, the completed QA checklists must be attached to the transmittal letter. If the report is uploaded to the JPA_2 Expert System for review, these completed QA forms must be placed in the "PennDOT Files" section of JPA_2 Expert. These forms are not intended to be transmitted to PADEP with the permit submission. Information stored in the "PennDOT Files" section of JPA_2 Expert will not be transferred to PADEP with the permit application.

2. The check boxes on the right side of the H&H Report checklists are used to indicate whether an item has been included. If the item is not required or does not apply to the particular project, check N/A.

3. When filling out the forms electronically, the individual sheet headings are automatically updated based on information from the summary sheet input.

4. Additional space for comments is provided in the last tab; please indicate the applicable QA sheet and section.

5. **Printing Instructions**: When the applicable checklists have been completed, select those worksheets and select file - print. (To select multiple worksheets, Hold the shift key and select the worksheet tabs at the bottom of the page). The page numbers will automatically be updated to correspond to the total number of pages printed.

Notes:

The summary sheet should be printed and submitted with the applicable checklists. Depending on the project type, not all checklists will be required for an H&H Report submission. For example, a small culvert replacement project may include the H&H Report, Hydrology and HY-8 checklists (unless HEC-RAS was used). Whereas a bridge replacement project may require the H&H Report, Hydrology, HEC-RAS and Scour checklists.

ABBREVIATED HYDROLOGIC AND HYDRAULIC REPORT CHECKLIST

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION		ITEM PRESENT? YES	NO	N/A
B.1.a. LOCATION MAP				
Acceptable forms (one required):				
☐ USGS quadrangle map (or map of equal detail)	page ________			
☐ Aerial photographs	page ________			
B.1.b. ENVIRONMENTAL CONCERNS				
1. PA Code Chapter 93 stream classification (check all that apply)	page ________			
☐ WWF ☐ CWF ☐ MF				
☐ TSF ☐ HQ* ☐ EV*				
*Note if HQ or EV Stream, Antidegredation analysis may be required - see DM2, Chapter 13.7				
2. PA Fish and Boat Classification (check all that apply)				
☐ Approved Trout Stream (stocked) ☐ Class A Wild Trout	page ________			
☐ Verified Natural Reproduction ☐ None				
B.1.c. STREAM BED MATERIAL	page ________			
Type of material in stream bed from site inspection (i.e., sand, gravel, cobbles, etc.)				
B.1.d. PHOTOGRAPHS	page ________			
a. Existing structure (upstream and downstream face)				
b. Upstream / downstream channel and floodplain				
c. Past floods (if available)				
d. Roadway station ahead and station back (recommended)				
e. Photo location map (recommended)				
B.1.e. SITE INSPECTION RECORDS	page ________			
Dates and other information relative to site inspection(s) made by designer	date ________			
B.2. HYDROLOGIC ANALYSIS				
a. Show drainage area above proposed crossing (note method of determining area)	page ________			
b. Include design discharge(s) per Section 10.6.E	page ________			
B.3. HYDRAULIC ANALYSIS				
a. The project is located in a FEMA mapped area?	☐ yes ☐ no			
If Yes is it a Detailed or Approximate area? ____________________				
(1) Original FIS study and flood map(s) provided	page ________			
(2) Study is referenced in the text	page ________			
(3) Was FEMA model obtained or documentation provided if unavailable?				
(4) Proposed structure encroaches on (check one):	page ________			
☐ 100-year floodplain (floodway fringe)				
☐ 100-year floodway ☐ neither				
(5) Were existing flood elevations compared to FEMA's published?	page ________			
(6) Were any differences in flood elevations > 0.5 ft explained?	page ________			
b/c. Existing versus proposed conditions:				
(1) velocities*	page ________			
(2) backwater elevations*	page ________			
(3) bridge opening sizes (i.e., area of hydraulic openings)	page ________			
(4) Is there an increase in the proposed 100-year flood elevation?	☐ yes ☐ no			
* Recommend including a table to compare all cross sections for the PennDOT design event and the 100-year event				

ABBREVIATED HYDROLOGIC AND HYDRAULIC REPORT CHECKLIST

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION		ITEM PRESENT? YES	NO	N/A
c. Acceptable hydraulic methods for the site (check the method used)				
☐ HEC-RAS (bridge and culvert design, water surface profiles)				
☐ HY-8 (culvert design)				
☐ Other List: ______				
d. Estimated scour depths (refer to DM-4, Chapter 7)	page ______			
e. Riprap sizing for bank, pier, abutment, and/or culvert protection	page ______			
f. Construction measures (temp. stream crossings, causeways, roads, etc.)	page ______			
Comments or computations included	page ______			
B.4. RISK ASSESSMENT OR ANALYSIS*				
Narrative description of factors related to the 100-year flood	page ______			
Narrative description of factors related to the 2-year flood (temporary conditions)	page ______			
* Refer to Section 10.7.C.4 for the definition and additional requirements of a risk analysis				
B.5. SUMMARY DATA SHEET				
Complete all information listed in the Summary Data Sheet (Figure 10.7.1) (available for download from http://www.dot.state.pa.us/hh/Summary-Data-Sheet.Zip)	page ______			
Summary data matches the report tables, output/calculations, and TS&L				
B.6. DRAWINGS AND FIGURES				
a. Roadway plans and profiles indicating the following information:				
1. Locations of existing and/or proposed structures, stream channels and wetlands	page ______			
- Structure or culvert plan showing plan and elevation view (Box culvert plans should show baffle layout)				
2. 100-year floodplain boundary	page ______			
3. Temporary stream crossing, access road, cofferdam, diversion facility, etc.	page ______			
4. The magnitude, frequency and pertinent water surface elevation for PennDOT design and 100-year flood	page ______			
b. Plan drawing showing the location and orientation of all cross sections used in the hydraulic model (with scale, contours, and all important hydraulic features)	page ______			
Cross-sections perpendicular to flood flow (minimum):	page ______			
☐ Upstream (500 ft)				
☐ Immediately upstream of proposed and/or existing crossings				
☐ Immediately downstream of proposed and/or existing crossings				
☐ Downstream (500 ft)				
Items 6.c and 6.d below do not require separate drawings provided that the information is available in the HEC-RAS model submitted with the report				
c. Profile of stream showing bed slope, normal water surface, and flood water surface elevations	page ______			
d. Cross section output of all cross sections used for backwater analysis	page ______			
e. Floodway maps and flood profiles from FEMA Flood Insurance Studies (when in a detailed FEMA study area)	page ______			
ELECTRONIC FILES				
Electronic files for the hydrologic and hydraulic models (as applicable)				

HYDROLOGIC AND HYDRAULIC REPORT CHECKLIST

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION	ITEM PRESENT? YES	NO	N/A
C.1.a. LOCATION MAP			
Acceptable forms (one required):			
☐ USGS quadrangle map (or map of equal detail) page ______			
☐ Aerial photographs page ______			
Required information:			
(1) Project location including proposed highway alignment			
(2) Drainage area			
(3) Label stream and direction, river reach studied			
C.1.b. EXISTING STRUCTURES (IF APPLICABLE) page ______			
1. Identify existing hydraulic structures (by map), including upstream and downstream of site			
2. Must describe:			
(1) Type of structure, span lengths, pier orientation			
(2) Cross section beneath structure - stream clearance and skew			
3. Compare stream and existing structure locations with the proposed crossing			
4. Indicate whether existing structures are to remain in place			
C.1.c. FLOOD INFORMATION page ______			
1. Elevations of available highwater marks along the stream w/ dates of occurrence			
2. Critical flood elevations of interest (possible damage)			
3. Local testimony of flooding (if available) or structure performance (non-flooding) per Section 10.7.C.1.i			
C.1.d. ENVIRONMENTAL CONCERNS			
- PA Code Chapter 93 stream classification (check all that apply) page ______			
☐ WWF ☐ CWF ☐ MF			
☐ TSF ☐ HQ* ☐ EV*			
*Note if HQ or EV Stream, Antidegredation analysis may be required - see DM2, Chapter 13.7			
PA Fish and Boat Classification (check all that apply)			
☐ Approved Trout Stream (stocked) ☐ Class A Wild Trout page ______			
☐ Verified Natural Reproduction ☐ None			
- Comments on other environmental concerns			
- Perennial, ephemeral, or intermittent stream? ______________			
C.1.e. HISTORY OF DRIFT, ICE AND STREAM BANK STABILITY page ______			
- Stability of stream banks (i.e., exposed soil, slumping, tilting trees, etc.)			
- Type of material in stream bed from site inspection (i.e., sand, gravel, cobbles, etc.)			
- History of ice accumulation or damage			
C.1.f. PHOTOGRAPHS page ______			
- Existing structure (upstream and downstream face)			
- Upstream / downstream channel and floodplain			
- Past floods (if available)			
- Roadway station ahead and station back (recommended)			
- Photo location map (recommended)			
- Upstream and downstream structures			
C.1.g. FACTORS AFFECTING WATER STAGES page ______			
1. High water from other streams			
2. Reservoirs (existing or proposed) and approximate date of construction			
3. Flood control projects and status (e.g., control structures, operator, operating policy)			
4. Other controls			

HYDROLOGIC AND HYDRAULIC REPORT CHECKLIST

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION		ITEM PRESENT? YES	NO	N/A
C.1.h. DEBRIS				
Indicate if debris can be a problem at the structure site	page ____			
C.1.i. SITE INSPECTION RECORDS	page ____			
- Dates and other information relative to site inspection(s) made by designer	date ____			
- If applicable, documentaion of local testimony is included				
C.1.j. LINE AND GRADE APPROVAL	page ____			
Indicate date of Line and Grade Approval or if pending	date ____			
C.2. HYDROLOGIC ANALYSIS				
a. Show drainage area above proposed crossing (note method of determining area)	page ____			
b. List flood records available	page ____			
c. Include design discharge(s) per Section 10.6.E	page ____			
d. Show flood-frequency curve for the site	page ____			
e. Show stage-discharge-frequency curves for the site (existing and proposed conditions)	page ____			
C.3. HYDRAULIC ANALYSIS				
a. The project is located in a FEMA mapped area?	☐ yes ☐ no			
If Yes is it a Detailed or Approximate area? ____________				
(1) Original FIS study and flood map(s) provided	page ____			
(2) Study is referenced in the text	page ____			
(3) Was FEMA model obtained or documentation provided if unavailable?				
(4) Proposed structure encroaches on (check one): ☐ 100-year floodplain (floodway fringe) ☐ 100-year floodway ☐ neither	page ____			
(5) Were existing flood elevations compared to FEMA's published?	page ____			
(6) Were any differences in flood elevations > 0.5 ft explained?	page ____			
b. Existing versus proposed conditions:				
(1) velocities*	page ____			
(2) backwater elevations*	page ____			
(3) bridge opening sizes (i.e., area of hydraulic openings)	page ____			
(4) Is there an increase in the proposed 100-year flood elevation?	☐ yes ☐ no			
* Recommend including a table to compare all cross sections for the PennDOT design event and the 100-year event				
c. Acceptable hydraulic methods for the site (check the method used)				
☐ HEC-RAS (bridge and culvert design, water surface profiles)				
☐ HY-8 (culvert design) ☐ HDS-5 (culvert design - equivalent to HY-8)				
☐ HEC-2 (water surface profiles) ☐ WSPRO (only if FEMA map revision necessary)				
☐ Visual Urban (HY-22 - mostly urban drainage applications)				
☐ Other List: ____________				
d. Was the HEC-RAS or HY-8 checklist completed?				
e. Model validation	page ____			
(1) Calibration with high water marks, storm events, and local testimony				
(2) Explanation of model warnings and errors				
f. Estimated scour depths (refer to DM-4, Chapter 7)	page ____			
g. Riprap sizing for bank, pier, abutment, and culvert protection	page ____			
h. Construction measures (temp. stream crossings, causeways, roads, etc.)	page ____			
Supporting model or calculations included	page ____			

HYDROLOGIC AND HYDRAULIC REPORT CHECKLIST

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION		ITEM PRESENT?		
		YES	NO	N/A
C.4. RISK ASSESSMENT OR ANALYSIS*				
Narrative description of factors related to:	page ______			
- 100-year flood				
- overtopping flood				
- 2-year flood for temporary conditions				
* Refer to Section 10.7.C.4 for the definition and additional requirements of a risk analysis				
C.5. SUMMARY DATA SHEET				
Complete all information listed in the Summary Data Sheet (Figure 10.7.1) (available for download from http://www.dot.state.pa.us/hh/Summary-Data-Sheet.Zip)	page ______			
Summary data matches the report tables, output/calculations, and TS&L				
C.6. DRAWINGS AND FIGURES				
a. Roadway plans and profiles indicating the following information:				
1. Locations of existing and proposed structures, stream channels and wetlands	page ______			
- Structure or culvert plan showing plan and elevation view (Box culvert plans should show baffle layout)				
2. Adjacent topographic features with key elevations or contours shown	page ______			
- Profile drawing showing proposed structure and ground line				
3. 100-year floodplain boundary	page ______			
4. Flood easement (if required)	page ______			
5. Temporary stream crossing, access road, cofferdam, diversion facility, etc.	page ______			
6. The magnitude, frequency and pertinent water surface elevation for specified floods	page ______			
b. Profile of stream showing bed slope, normal water surface, and flood water surface elevations	page ______			
c. Plan drawing showing the location and orientation of all cross sections used for backwater analysis (with scale, contours, and all important hydraulic features)	page ______			
Cross-sections perpendicular to flood flow (minimum):	page ______			
☐ Upstream (500 ft)				
☐ Immediately upstream of proposed and/or existing crossings				
☐ Immediately downstream of proposed and/or existing crossings				
☐ Downstream (500 ft)				
d. Floodway maps and flood profiles from FEMA Flood Insurance Studies (when in a detailed FEMA study area)	page ______			
ELECTRONIC FILES				
Electronic files provided for hydrologic & hydraulic models (as applicable)				

HYDROLOGY CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION	YES	NO	N/A
1. FEMA CONSIDERATIONS			
Is the proposed project in a detailed FEMA study area?			
If yes, are the following provided:			
- Published FIS flows page ________			
- Is FEMA hydrologic method acceptable per DM-2, Chapter 10? page ________			
- Are FEMA flows compared with calculated flows using PennDOT acceptable methods?			
- Is FEMA's published 100-year flow included in the analysis?			
Comments:			
2. ACT 167			
Is there a DEP approved Act 167 Stormwater Management Plan?			
How were the flows developed in the Act 167? ________			
Were there flows provided in the vicinity of the project site?			
Have the flows been included for comparison to calculated flows? page ________			
Comments:			
3. DESIGN FLOODS			
PennDOT roadway classification ________			
PennDOT design event (check one) ☐ 10-yr ☐ 25-yr ☐ 50-yr			
PADEP event (check one) ☐ 25-yr (rural) ☐ 50-yr (suburban) ☐ 100-yr (urban)			
Comments:			
4. HYDROLOGIC ANALYSIS			
Drainage area at site (DA) is correct ________ square miles			
Applicable hydrologic method used (check all that apply)			
☐ WRC method ☐ EFH2 (1 to 2000 ac)			
☐ Rational method (up to 200 acres)* ☐ TR-55* (10 ac to 3.1 sq mi)			
☐ PSU-IV (comparison only) ☐ WinTR-55 (1ac to 25 sq mi)			
☐ USGS WRIR 2000-4189* ☐ USGS SIR 2008-5102*			
☐ HEC-1/HEC-HMS* ☐ Other**			
* Methods may be used within the Watershed Modeling System (WMS) program			
** Project Engineer should ensure that the model is appropriate and that approvals are obtained from the Department			
Which method was chosen for the design flows? ________			
Was justification provided for the selection of the peak flow method? page ________			
Comments:			

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION	YES	NO	N/A
5. METHOD SELECTION DETAILS			
Fill out the appropriate section below based on the hydrologic method(s) used in Section 4.			
A. WRC Method (gage) page ______			
USGS gage # ______			
Gage location (i.e, town and stream/river name) ______			
Gage is on the same main stem as the project site			
Print out of gage record is included			
DA at gage ______ square miles			
DA_{site} is between 0.5 and 1.5 DA_{gage}			
Years of record ______			
Record is greater than 10 years			
Historic peaks (i.e., not recorded by gage) are excluded			
Record not partially influenced by regulation or diversion (e.g., reservoir, levee, etc.)			
Watershed characteristics consistent for entire record (e.g., landuse)			
Skew calculation method is appropriate (check one): ☐ Station ☐ Regional ☐ Weighted			
If gage is not at project site, were flows correctly translated to the site?			

Return Period (yrs)	Q_{gage} (cfs)	Q_{site} (cfs)

Comments:

______
______
______
______

HYDROLOGY CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION	YES	NO	N/A
B. Rational Method page ______			
DA is less than 200 acres			
Weighted C value is correct C = ______			
Time of concentration (T_c) is correct T_c = ______			
Storm duration equals the T_c for intensity determination			
Rainfall intensity from PDT-IDF curves			

Return Period (yrs)	Intensity (in)	Q (cfs)

Comments:

______

______

______

DESCRIPTION	YES	NO	N/A
C. USGS WRIR 2000-4189 Method page ______			
DA at site between 1.5 and 2,000 square miles			
Region is correct (check one) ☐ A ☐ B			
% Forest is reasonable ______ %			
% Urban is reasonable ______ %			
In Region B, urban % does not exceed 5%			
% Carbonate is reasonable ______ %			
% Controlled is reasonable ______ %			

Return Period (yrs)	Q (cfs)

Comments:

______

______

______

HYDROLOGY CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION		YES	NO	N/A
D. USGS SIR 2008-5102 Method	page ________			
DA at site between 1.0 and 2,000 square miles				
Region is correct (check one)	☐ 1 ☐ 2 ☐ 3 ☐ 4			
% Forest is reasonable	________ %			
% Urban is reasonable	________ %			
% Carbonate is reasonable	________ %			
% Storage is reasonable*	________ %			
*surface area of lakes, ponds, wetlands, etc.				
Mean basin elevation is is correct (Region 3)				

Return Period (yrs)	Q (cfs)

Comments:

____

____

____

HYDROLOGY CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:

Municipality: County:

Reviewer(s): Date:

DESCRIPTION		YES	NO	N/A
E. PSU IV (Comparison Method Only)	page ________			
DA at site between 1.5 and 150 square miles				
Region is correct (check one)	☐ 1 ☐ 2 ☐ 3 ☐ 4			
Standard Deviation is correct	________			
Skew Coefficient is correct	________			
Divide Elevation is correct	________ feet			
% Forest is reasonable	________ %			
Adjustment for carbonate area applied				
Indicate other adjustments applied	________________			

Return Period (yrs)	Q (cfs)

Comments:

____

____

HYDROLOGY CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION		YES	NO	N/A
F. TR-55 Method / WinTr-55	page ______			
DA at site is between 10 and 2,000 acres (< 3.1 square miles) for TR-55				
DA at site is between 1 acre and 25 square miles for WinTR-55				
Note if multiple drainage areas are used, attach additional sheets for CN, etc.				
CN calculated correctly	CN = ______			
Time of concentration (T_c) calculated correctly	______ hrs ($0.1<T_c<10$ hr)			
Sheet flow length no greater than 100'	______ feet			
Shallow concentrated flow length appropriate	______ feet			
Channel flow length appropriate	______ feet			
Rainfall from PDT-IDF curves (24-hour duration)				
PDT-IDF Curve or SCS Type II 24-hr rainfall distribution used				

Return Period (yrs)	Rainfall (in)	Q (cfs)

Comments:

HYDROLOGY CHECKLIST
QUALITY ASSURANCE REVIEW

Project:	District:
Municipality:	County:
Reviewer(s):	Date:

DESCRIPTION		YES	NO	N/A
G. EFH2 Method	page ________			
DA at site between 1 and 2,000 acres (< 3.1 square miles)				
CN calculated correctly	CN = ________			
Urban % does not exceed 10%	________ %			
Hydraulic length is between 200 and 26,000 feet	________ feet			
Average watershed slope, Y	________ %			
Y is the average overland slope between drainage divide and stream channel				
Rainfall from PDT-IDF curves (24-hour duration)				
PDT-IDF Curve or SCS Type II 24-hr rainfall distribution used				

Return Period (yrs)	Rainfall (in)	Q (cfs)

Comments:

____

____

HYDROLOGY CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION	YES	NO	N/A
H. HEC-1 / HEC-HMS Method page ________			
DA subareas ≤ 3.1 square miles or justification provided for larger subareas			
Note if multiple drainage areas are used, attach additional sheets for CN, etc.			
CN calculated correctly CN = ____________			
Lag time, t_L ____________ hours			
Lag time calculated with SCS method			
If subdivided, routing was performed			
Rainfall from PDT-IDF curves (24-hour duration)			
PDT-IDF Curve or SCS Type II 24-hr rainfall distribution used			

Return Period (yrs)	Rainfall (in)	Q (cfs)

Comments:

____

____

HYDROLOGY CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION	YES	NO	N/A
I. Other Method ____________ page ______			
Calculations included			
Method appropriate for location			
Rationale / justification provided			

Return Period (yrs)	Rainfall (in)	Q (cfs)

Comments:

HEC-RAS MODEL CHECKLIST
QUALITY ASSURANCE REVIEW

Project:	District:
Municipality:	County:
Reviewer(s):	Date:

1. File Management**

HEC-RAS program version ______________________
Project file name (*.prj) ______________________
Plan name for existing conditions ______________________
  Plan Short ID ______________________
  Geometry file name (*.gxx) ______________________
  Steady flow file name (*.fxx) ______________________
  Final date of run file (*.rxx) ______________________
Plan name for proposed conditions ______________________
  Plan Short ID ______________________
  Geometry file name (*.gxx) ______________________
  Steady flow file name (*.fxx) ______________________
  Final date of run file (*.rxx) ______________________
Plan name for temp conditions (if applicable) ______________________
  Plan Short ID ______________________
  Geometry file name (*.gxx) ______________________
  Steady flow file name (*.fxx) ______________________
  Final date of run file (*.rxx) ______________________

**The following HEC-RAS files must be submitted for review: project (*.prj), geometry (*.gxx), steady flow (*.fxx), plan (*.pxx), run (*.rxx), and output (*.oxx). The run file and output file extensions will correspond to the appropriate plan file extension.

Comments:

____
____

DESCRIPTION	YES	NO	N/A
2. FEMA Study (this section required if the project is in a detailed FEMA study area)			
- Hydraulic model used in the FEMA study ____________ page ______			
- Was the original FEMA model obtained? (check all that apply)			
☐ Paper copy of model input page ______			
☐ Paper copy of model output page ______			
☐ Electronic files			
- If FEMA modeling data was unavailable, letter from FEMA stating such is provided?			
- Datum: FEMA ________ Project ________			
- Datum Conversion (FEMA to project): ________ ft			
- List the FEMA cross sections used as-is in existing conditions model ______________________ ______________________			
- List the FEMA cross sections modified with current survey in existing conditions model ______________________			
- List the new survey cross sections in existing conditions model ______________________ ______________________			
- Does the hydraulic cross section plan show all FEMA sections and surveyed sections used in the existing conditions model? page ______			

Comments:

____
____
____
____

HEC-RAS MODEL CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION	YES	NO	N/A
3. Steady Flow Data			
Boundary Conditions — Upstream / Downstream			
☐ Normal depth — S= ______ S= ______			
☐ Known WS — WS Elev= ______ WS Elev= ______			
☐ Critical depth			
☐ Rating curve — source= ______ source= ______			
- Are the boundary conditions appropriate?			
- Are the same boundary conditions used in the existing and proposed models?			
- If applicable, was a known WS used for the FEMA published flow?			
Discharge Information (see also Hydrology checklist)			
- 100-year, DEP and PennDOT design events were modeled			
- Temporary conditions event modeled ______ year			
- Flows for the modeled events match peak flows in the H&H Report			
- Flow change(s) reflects tributary location(s)			
Comments:			
4. Geometric Data			
Plan Information / River System Schematic			
- Plan showing the location and orientation of all cross sections provided (with scale, contours, and all important hydraulic features) page ______			
- Number of reaches ______			
- Number of junctions ______			
- Cross section numbers increase from downstream to upstream			
Cross Section Geometry			
- Cross sections extend across 100-year floodplain			
- Cross sections are perpendicular to flow direction (except at bounding structure sections)			
- Cross sections do not overlap			
- Cross section data is entered from left to right (looking downstream)			
- Left and right bank stations: - are reasonable			
- have consistent elevations			
- Reach lengths are correct			
- Manning's n values are reasonable (Table 3.1 in Reference 1)			
- Contraction/expansion coefficients are reasonable (contr = 0.3, exp = 0.5 bounding structure sections)			
- Ineffective flow areas reflect contraction / expansion reach near hydraulic structure (Reference 2)			
- Ineffective flow areas in overbanks are used where appropriate			
- Levees are used where appropriate			
- Blocked obstructions are used where appropriate			
Comments:			

HEC-RAS MODEL CHECKLIST
QUALITY ASSURANCE REVIEW

Project:	District:
Municipality:	County:
Reviewer(s):	Date:

DESCRIPTION	YES	NO	N/A
Geometric Data continued			
4a. Bridge Geometry*			
- Plan with high/low chord elevations included page ________			
- Bridge cross section ________ (E) ________ (P)			
- Bounding bridge sections are at or beyond the embankment toe and parallel to each other			
- High chord (max.) ________ (E) ________ (P)			
- Low chord (min.) ________ (E) ________ (P)			
- High/low chords match the report/drawings			
- Bridge width ________ (E) ________ (P)			
- Bridge widths match the report/drawings			
- Distance to US section ________ (E) ________ (P)			
- US distances match the hydraulic section plan			
- Number of spans ________ (E) ________ (P)			
- Normal clear span length(s) ________ (E) ________ (P)			
- Bridge normal clear span lengths match the report/drawings			
- Number of piers ________ (E) ________ (P)			
- Existing pier centerline(s), width(s) and elevation(s) are correct			
- Proposed pier centerline(s), width(s) and elevation(s) are correct			
- Ineffective areas "turn off" when weir flow passes over bridge			
- Minimum weir flow elevation is reasonable			
- Bridge modeling methods Existing Proposed			
Low flow ________ ________			
High flow ________ ________			
- Methods are appropriate per Reference 1			

* Check for existing (E) and proposed (P) structure; low chord elevations and normal clear span lengths are not applicable to arch structures.

Comments:

HEC-RAS MODEL CHECKLIST
QUALITY ASSURANCE REVIEW

Project:	District:
Municipality:	County:
Reviewer(s):	Date:

	DESCRIPTION			YES	NO	N/A
	Geometric Data continued					
4b.	*Culvert Geometry					
	- Plan with inverts elevations included		page ________			
	- Structure cross section	________ (E)	________ (P)			
	- Bounding culvert cross sections are at or beyond the embankment toe					
	- Ineffective areas "turn off" when weir flow passes over road					
	- Minimum weir flow elevation is reasonable					
		Existing	Proposed			
	- Number of barrels	________	________			
	- Shape	________	________			
	☐ Diameter	________	________			
	☐ Span x Rise	________	________			
	- Spans/diameters are correct					
	- Chart #	________	________			
	- Scale #	________	________			
	- Chart and Scale match the culvert type and entrance conditions					
	- Distance to US section	________ ft	________ ft			
	- US distances match the hydraulic section plan					
	- Culvert length	________ ft	________ ft			
	- Culvert lengths match the hydraulic section and structure plans					
	- Entrance loss coeff	________	________			
	- Exit loss coeff	________	________			
	- Loss coefficients are appropriate for entrance/exit conditions					
	- Manning's n for top	________	________			
	- Manning's n for bottom	________	________			
	- Manning's n for top and bottom are appropriate					
	- Depth to use bottom n	________	________			
	- Depth blocked	________	________			
	- Blocked depth reflects the depressed depth for fish passage					
	- US invert elevation	________ ft	________ ft			
	- DS invert elevation	________ ft	________ ft			
	- Invert elevations match the report/drawings					
	- High chord (max.)	________ ft	________ ft			
	- High chords match structure drawings					

* Check for existing (E) and proposed (P) structure

Comments:

HEC-RAS MODEL CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:
Reviewer(s): Date:

	DESCRIPTION	YES	NO	N/A
	Geometric Data continued			
4c.	*Roadway Profile			
	- Roadway profile plan provided page ________			
	- Roadway stations are entered from left to right (looking downstream)			
	- Roadway (high chord) stations and elevations match drawings (exist and prop)			
	- Highest roadway elevation is coded as the US side so that weir flow is correctly calculated.			
	* Check for existing (E) and proposed (P) structure			
	Comments:			
4d.	Temporary Conditions			
	- Temporary fill and/or structure(s) proposed in the channel? (check all that apply)			
	☐ Cofferdam (e.g., sheet piling, Jersey barrier, sand bags)			
	☐ Causeway			
	☐ Temporary road			
	☐ Other ________________			
	- Dimension and locations match report and E&S Plan page ________			
	- Geometry reflects worst-case construction scenario (i.e., generally the most obstructed area)			
	Comments:			
5.	**Plan File**			
	Flow Regime			
	☐ Subcritical			
	☐ Supercritical			
	☐ Mixed			
	- If subcritical only, is the Froude number < 1.0 at every section?			
	- If supercritical only, is the Froude number > 1.0 at every section?			
	Comments:			

HEC-RAS MODEL CHECKLIST QUALITY ASSURANCE REVIEW			
Project: District:			
Municipality: County:			
Reviewer(s): Date:			
DESCRIPTION	**YES**	**NO**	**N/A**
6. Output			
Existing versus Proposed Output			
- Water surface profiles are in the correct order in the cross section output			
- Is the existing low chord elevation equal to or below the proposed?			
- Hydraulic opening area stated ________ (sf) Exist. ________ (sf) Prop.			
- Is the proposed opening area equal to or larger than the existing?			
- Errors, warnings, and notes reviewed and discussed page ______			
- Are there increases at any cross section for the proposed 100-year event?			
- Existing and proposed HEC-RAS cross section plot output are included page ______			
- Existing and proposed HEC-RAS profile output are included (table & plot) page ______			
- Output shows 100-year, DEP and PennDOT design events			
Comments:			
Temporary Conditions Output			
- The H&H report states that the________ year event does not overtop the temporary measures			
- The magnitude and extent of temporary increases are quantified page ______			
- Are the temporary increases contained within the channel? page ______			
- Do the temporary wsels tie in to existing wsels within the study limits? page ______			
Comments:			

References

[1] Hydrologic Engineering Center. 2002. HEC-RAS, River Analysis System Hydraulic Reference Manual. U.S. Army Corps of Engineers, Davis, CA.
[2] Hydrologic Engineering Center. 1995. RD-42, Flow Transitions in Bridge Backwater Analysis, U.S. Army Corps of Engineers, Davis, CA.

HY-8 MODEL CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION	YES	NO
1. File Management		
HY-8 Version ______________		
Project file name ______________		
Is HY-8 Run (input/output) attached?		
Comments: ______________		
2. Discharge Data (Crossing Properties)		
Flows Input:		
Minimum ________ cfs		
Design ________ cfs		
Maximum ________ cfs		
Discharge Information		
100-year and DEP's & PennDOT's design events were modeled		
Flows for the modeled events are correct		
Comments: ______________		
3. Tailwater Data (Crossing Properties)		
Channel Type (check one)		
☐ Rectangular ☐ Irregular		
☐ Trapezoidal ☐ Rating Curve		
☐ Triangular ☐ Constant Tailwater Elevation		
Channel type selection is reasonable		
Channel input dimensions are consistent with plans		
Comments: ______________		
4. Roadway Data (Crossing Properties)		
Roadway Profile Shape (check one)		
☐ Constant		
☐ Irregular		
Roadway profile dimensions are consistent with plans		
Comments: ______________		

HY-8 MODEL CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION	YES	NO
5a. Existing Culvert Data (Culvert Properties)		
Culvert Name ____________		
Shape (check one) ☐ Circular ☐ Arch-Open Bottom ☐ Concrete Box ☐ Low Profile Arch ☐ Elliptical ☐ High Profile Arch ☐ Pipe Arch ☐ Metal Box ☐ User Defined ☐ Arch-Box-Concrete		
Culvert material and size: ____________		
Culvert specifications are consistent with plans and/or site survey data		
Comments:		
5b. Proposed Culvert Data (Culvert Properties)		
Culvert Name ____________		
Shape (check one) ☐ Circular ☐ Arch-Open Bottom ☐ Concrete Box ☐ Low Profile Arch ☐ Elliptical ☐ High Profile Arch ☐ Pipe Arch ☐ Metal Box ☐ User Defined ☐ Arch-Box-Concrete		
Culvert material and size: ____________		
Culvert specifications are consistent with plans		
Comments:		
6. Site Data (Culvert Properties)		
Site Data Input Option (check one) ☐ Culvert Invert Data ☐ Embankment Toe Data		
Site data is consistent with plans		
Comments:		

HY-8 MODEL CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION	YES	NO
7. Results		
Overtopping?		
If yes, overtopping discharge:		
Existing ________ cfs		
Proposed ________ cfs		
Upstream 100-year water surface elevation		
Existing ________ ft		
Proposed ________ ft		
Is the proposed 100-year flood elevation greater than existing?		
Velocities		
Design storm velocity		
Existing ________ ft/s		
Proposed ________ ft/s		
100-year flood velocity		
Existing ________ ft/s		
Proposed ________ ft/s		
Results are acceptable for HY-8 use		
Entrance velocities < 5 fps		
Comments:		
____		
____		

Federal Highway Administration (FHWA) HY-8 Version 7.0, March 16, 2007
Software developed by: Environmental Modeling Systems, Inc.
Based on HDS-5 Documentation

SCOUR ANALYSIS & RIPRAP SIZING CHECKLIST
QUALITY ASSURANCE REVIEW

Project:	District:
Municipality:	County:
Reviewer(s):	Date:

DESCRIPTION	YES	NO	N/A

1. Streambed Particle Size

- D_{50} __________ in = __________ ft

Typical D_{50} Values:

Clay and silt	0.00024 - 0.062 mm	
Sand	0.062 - 2.00 mm	0.002 - 0.08 in
Gravel	2 - 64 mm	0.08 - 2.5 in
Cobbles	64 - 250 mm	2.5 - 10 in

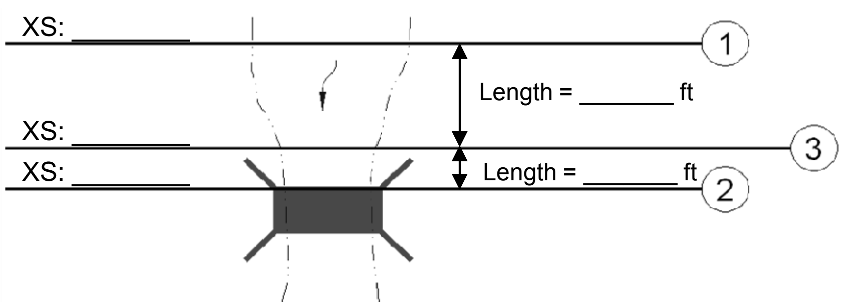
- Method used to determine D_{50}
  - ☐ visual inspection ☐ sieve analysis
  - ☐ pebble count ☐ core boring* (see notes on applicability below)
- Location of streambed sample __________
- Streambed material description __________ page __________
- Is bedrock visible?
- Is D_{50} appropriate for studied reach?
- Evidence of long-term streambed elevation change (aggradation or degradation)?

* For limitations on core borings use see requirements in DM-4, Chapter 7. Also for most PA streams core borings may underestimate the size of the streambed material. If the approximate D_{100} particle size is less than the core diameter and the sample is taken in the stream channel, the core borings may provide a reasonable D_{50} for the armor layer.

Comments: __________

2. Contraction Scour

HEC-RAS Sections - fill in the appropriate information from the proposed HEC-RAS model



Key
1. Upstream uncontracted cross section (XS output)
2. Internal bridge cross section (BR U or BR D in HEC-RAS output)
3. Upstream bounding cross section (XS output)

Comments: __________

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION	YES	NO	N/A
2. Contraction Scour (continued)			
Critical Velocity			
- Was HEC-18, Equation 5.1 used?	☐	☐	
- K_u coefficient is correct (6.19 - SI units / 11.17 - English units)	☐	☐	
- y is channel hydraulic depth variable from XS (1)	☐	☐	
- V is channel velocity from XS (1)	☐	☐	
- 100-year scour type (check one) ☐ Clear ☐ Live			
- 500-year scour type (check one) ☐ Clear ☐ Live			
- HEC-RAS output tables are included with input parameters labeled page ______	☐	☐	
Comments:			
Live-Bed Scour - calculate for the event(s) determined to be live-bed*	☐		☐
*Where coarse sediments are present, it is recommended that scour depths be calculated for live-bed scour conditions using the clear-water and live-bed equations, and the smaller scour depth be used.			
- Were HEC-18, Equations 5.2-5.3 used?	☐	☐	
- y_1 is channel hydraulic depth variable from XS (1)	☐	☐	
- y_o is hydraulic depth variable from XS (2)	☐	☐	
- W_1 (check one) ______ ft ☐ Top ☐ Bottom			
- W_1 is the estimated bottom or top channel width from XS (1)	☐	☐	
- W_2 (check one) ______ ft ☐ Top ☐ Bottom			
- W_2 is the estimated bottom or top channel width from XS (2)	☐	☐	
- W_1 and W_2 are consistent (both top or both bottom)	☐	☐	
- Q_1 is the channel flow from XS (1)	☐	☐	
- Q_2 is the flow in the contracted channel** from XS (2)	☐	☐	
- k_1 coefficient correct (0.59 - mostly contact, 0.64 - some suspended, 0.69 - mostly suspended)	☐	☐	
- y_s (100-yr event) ______ ft			
- y_s (500-yr event) ______ ft			
- HEC-RAS output tables are included with input parameters labeled page ______	☐	☐	
**If the proposed bridge abutments are located in the channel (HEC-18, Case 1a) or at the channel banks (HEC-18, Case 1b), Q_2 should be the flow through the bridge opening.			
Comments:			

SCOUR ANALYSIS & RIPRAP SIZING CHECKLIST
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:
Reviewer(s): Date:

DESCRIPTION	YES	NO	N/A
Clear-Water Scour - calculate for the event(s) determined to be clear-water			
- Were HEC-18, Equations 5.4-5.5 used?			
- K_u coefficient is correct (0.025 - SI units / 0.0077 - English units)			
- y_o is hydraulic depth variable from XS (2)			
W (check one) ________ ft ☐ Top ☐ Bottom			
- W is the bottom or top channel width from XS (2)			
- Q is the flow through the bridge opening or on the set-back over bank area at the bridge associated with the width, W, from XS (2)			
- HEC-RAS output tables are included with input parameters labeled page ________			
Comments:			
3. Local Pier Scour (if applicable)			
Local Pier Scour for Simple Piers			
- Was HEC-18, Equation 6.3 used?			
- Pier nose shape ________			
- K_1 pier nose coefficient is correct (HEC-18, Table 6.1)			
- Angle of attack of flow, θ ________			
(θ is 0 when the pier is aligned with the flow direction)			
- K_2 angle of attack coefficient is correct (HEC-18, Table 6.2)			
- K_3 bed condition coefficient is correct (HEC-18, Table 6.3)			
- K_4 armoring factor coefficient is correct (values less than 1 require a sieve analysis)			
- y_1 is hydraulic depth directly upstream of the pier from XS (3) flow distribution table			
- V_1 is velocity directly upstream of the pier from XS (3) flow distribution table			
- g, acceleration of gravity (check one) ☐ 9.81 m/s^2 ☐ 32.2 ft/s^2			
- Fr_1 is the Froude number directly upstream of the pier from XS (3) $Fr_1 = V_1 / (gy_1)^{0.5}$			
- a, pier width ________ ft			
- a is the pier width perpendicular to the flow direction (i.e., projected pier width)			
- K_w calculated with Eqn. 6.9 or 6.10 if y/a < 0.8, a/D_{50} > 50, and Fr < 1			
- y_s (100-yr event) ________ ft			
- y_s (500-yr event) ________ ft			
- HEC-RAS output tables are included with input parameters labeled page ________			
Comments:			

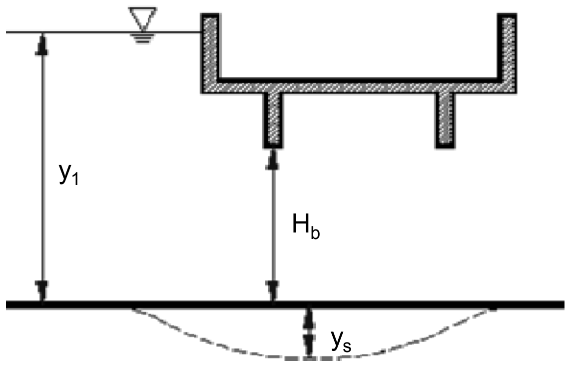
SCOUR ANALYSIS & RIPRAP SIZING CHECKLIST QUALITY ASSURANCE REVIEW	
Project:	District:
Municipality:	County:
Reviewer(s):	Date:

DESCRIPTION	YES	NO	N/A

3. Local Pier Scour (continued)

Pressure Flow Scour (Vertical Contraction Scour)

*Pressure flow scour should be calculated for all events that submerge the low chord



- H_b, distance from average streambed elevation to low chord of bridge ________ ft
- H_b dimension calculations provided/appropriate? [YES] [NO]
- y_1 is hydraulic depth variable from XS (3) [YES] [NO]
- y_1 is greater than H_b for what events?* ________
- V_a is the average velocity <u>inside</u> the bridge from XS (2) BR U [YES] [NO]
- Was HEC-18, Equation 6.21 used? [YES] [NO]
- y_s (100-yr event) ________ ft
- y_s (500-yr event) ________ ft
- HEC-RAS output tables are included with input parameters labeled page ________ [YES] [NO]

Comments:

____

____

____

____

SCOUR ANALYSIS & RIPRAP SIZING CHECKLIST QUALITY ASSURANCE REVIEW			
Project: District:			
Municipality: County:			
Reviewer(s): Date:			
DESCRIPTION	**YES**	**NO**	**N/A**
4. Total Scour			
- If live-bed contraction scour depths are limited by streambed armoring, was the lesser of the clear-water and live-bed contraction scour depths used?			
- If multi-layered riprap protection is proposed for the piers, was the local pier scour depth reduced by 50%?			
- If the structure has piers, was the total pier scour depth calculated as the sum of the contraction scour, pressure scour, and adjusted local pier scour depths?			
- Scour envelope is illustrated on the HEC-RAS bridge section page ______			
- Total scour depths are included in the H&H Report page ______			
- If any aggradation or degradation was indicated in bridge inspection reports was it included with total scour?			
- Scour depths were calculated for the temporary bridge (25-year event) per DM-4, Chap 5.			
*Note: Per DM-4, Chapter 7 local abutment scour calculations are not required when the substructure is protected with multi-layered riprap protection.			
Comments: ______________________________			
5. Riprap Sizing			
- Unfactored velocities Abutment: V_{100} ______ ft/s; V_{500} ______ ft/s Piers: V_{100} ______ ft/s; V_{500} ______ ft/s			
- For abutments, V is the BR Open Vel variable for the velocity <u>inside</u> the bridge			
- For piers, V is the avg upstream velocity in the section upstream of the piers - XS (3)			
- HEC-RAS bridge output table shows inside bridge velocity page ______			
- What event has the highest velocity inside the bridge? ______			
- Was the highest velocity used?**			
Abutments			
- Was the 1.8 safety factor applied to the velocity <u>before</u> sizing the riprap?			
- Riprap size meets DM-4 Chapter 7 requirements R - ______			
Piers			
- Was the 1.5 safety factor applied to the velocity <u>before</u> sizing the riprap?			
- Riprap size meets DM-4 Chapter 7 requirements R - ______			
Temporary Bridge			
- Was the 1.8 safety factor applied to the 25-year velocity per DM-4, Chapter 5?			
- Riprap size meets DM-4 Chapter 7 requirements R - ______			
**Note: Per DM-4 Chapter 7, riprap has to be designed to withstand the 500-year velocity only when the 500-year scour depth is below the bottom of footing elevation. If a lower event has the highest velocity inside the bridge, it should be used for riprap sizing.			
Comments: ______________________________			

US Department of Transportation, FHWA. Hydraulic Engineering Circular No. 18 (HEC-18), Evaluating Scour at Bridges, 4th Edition. May 2001.

ADDITIONAL COMMENTS
QUALITY ASSURANCE REVIEW

Project: District:
Municipality: County:

Checklist ___________ **Section** ___________

Checklist ___________ **Section** ___________

Checklist ___________ **Section** ___________

Checklist ___________ **Section** ___________

Checklist ___________ **Section** ___________

Checklist ___________ **Section** ___________

Checklist ___________ **Section** ___________