Plan

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- Use USGS Records to develop REGIONAL RELATIONSHIPS
- Average Annual Flow Output (QAA) Related to Basin Average Annual Input (P, A)
- Average Daily Flood (Q1F2), Average Low Flow (Q7L2) and Annual Maximum (QAMax) and Minimum (QAMin) Flows Related to QAA

Modeling Matrix Defined

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OUTPUTS

(3) CC	3:1	3:2	3:3
(2) QC	2:1	2:2	2:3
(1) BC	1:1	(NR)	(NR)
Origin	**(1) BC**	**(2) QC**	**(3) CC**

INPUTS

- CC = Channel Characteristics
- QC = Flow Characteristics
- BC = Basin Characteristics
- NR = no relationship

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Matrix Operation

OUTPUTS

(3) CC	3:1	3:2	3:3
(2) QC	2:1	2:2	2:3
(1) BC	1:1	(NR)	(NR)
Origin	(1) BC	(2) QC	(3) CC

INPUTS

- Read up from the origin and then to the right
- All models are Power Equations $\mathbf{Y = C\,(X)^E}$
- Dependent **Outputs** are a function of the Independent **Inputs**

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Examples of Models

Flow is the link between the basin and the channel

CHANNEL	Chan. W related to Basin Area	Hydraulic Geom. W = f(Q)	Width to Depth Ratio W = f(D)
FLOW	**Ave. Flow QAA = f(P,A)**	**Ave. Floods & Low Flows = $C(QAA)^E$**	Continuity Equation Q = AV
BASIN	Stream Length = f(Basin Area)	(NR)	(NR)
Origin	BASIN	FLOW	CHANNEL

Examples: QC = QC (Two Types)

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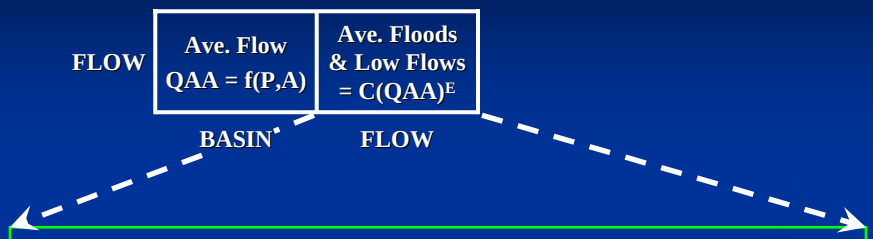

- Type 1: Relate to QAA
  - Q1F2 = C1(QAA)^{E1}
  - Q7L2 = C2(QAA)^{E2}
  - QAMax = C3(QAA)^{E3}
  - QAMin = C4(QAA)^{E4}
  - Monthly Flows
  - Q10% Fishpass Flows
- Type 2: Relate Statistical Flows
  - RI Analysis from Gages
  - QPF2 = C1(Q1F2)^{E1}
  - QPF50 = C2(Q1F2)^{E2}
  - QPF100 = C3(Q1F2)^{E3}
  - Daily Floods

Examples of Flow Nomenclature

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FLOW (cfs)	No. Days (Averaged)	Type of Flow	Recurrence Interval (RI)
Q	1	F	2
Q	P	F	100
Q	7	L	10
Q	60	L	2

- Q1F2 = Average 1-day Flood Flow, 2-year RI
- QPF100 = 100-year Peak Flood- Road Safety
- Q7L10 = Water Quality Flow
- Q60L2 = WDFW Habitat Flow

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CHARACTERISTIC FLOWS

- QAA = Average Annual Flow
- Q1F2 = 1-Day Ave. Daily Flood with a 2-year Recurrence Interval (RI)
- Q7L2 = 7-Day Ave. Low Flow with a 2-year RI

- **SIGNATURE FLOWS**

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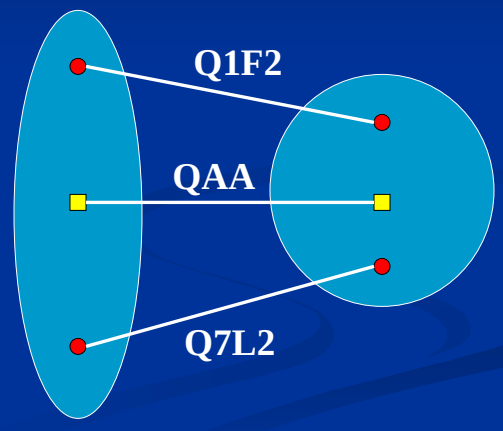
Balance Between Characteristic Flows

- Two Basins with the same P, A and QAA but Q1F2 and Q7L2 are different.
- Why?



DATA SET 1 EQUALS DATA SET 2

WHY ?

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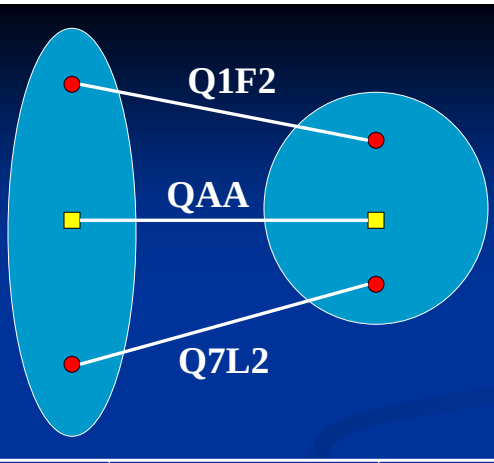

Tight; Clay	**SOILS**	Porous; Moraine
Shallow	**BEDROCK**	At Depth
Small	**AQUIFER**	Large
Higher	**FLOODS**	Lower
Poor	**LOW FLOW**	Good

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Relating QAA to Basin Characteristics

- Locate Project Site
- Determine drainage basin area (A)
- Determine average annual precipitation (P)
- Locate gages (USGS and others) in "Region"
- Relate Average Annual Flow (QAA) at gages to Basin Area (A) and Precipitation (P)
- **$QAA = C(P)^{E}A$ or $QAA = C(PA)$**

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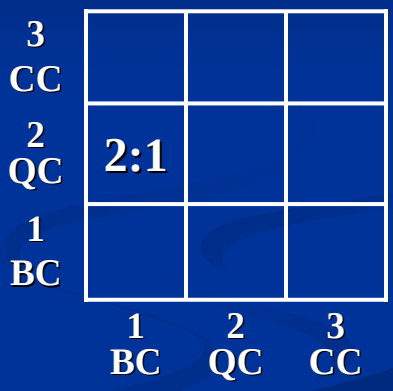
Regional Model for QAA

- Regional Model 2:1
  QAA = f(Basin Char.)
- Start With
  QAA = function of Area
- For Olympic
  Peninsula… EXAMPLE



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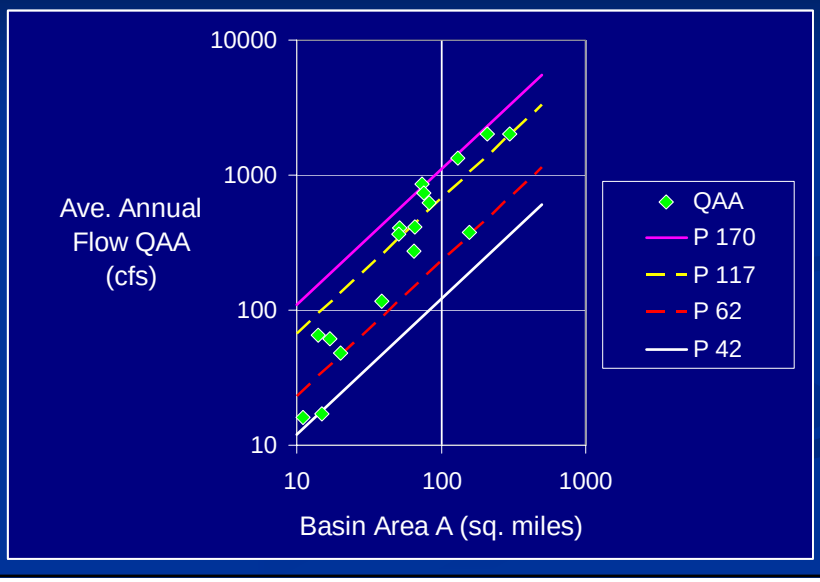
Regional Model for QAA
Olympic Peninsula



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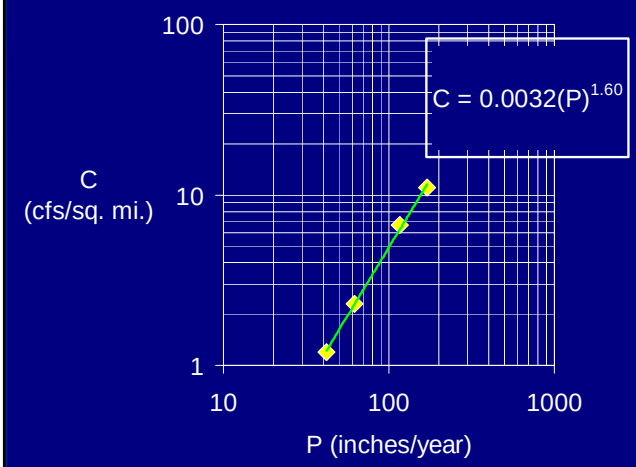
Solving for C Related to P



P (in/yr)	C (cfs/sq mi)
170	11.0
117	6.7
62	2.3
42	1.2

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Relating Other Regional Flows to QAA

- Other Regional Flows include:
  - Average Maximum Annual Flow (**QAMax**)
  - Average Minimum Annual Flow (**QAMin**)
  - Average Daily Flood Flow (**Q1F2**)
  - 7-Day Average Low Flow (**Q7L2**)
  - Monthly Maximum, Mean and Minimum Flows
  - Q10 High Fish Passage Flow (Monthly Migration Flows)

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Relating Regional Flows to RI Models

- Relationships are Flow to Flow Models:
  - Q1F2 to daily floods of other recurrence intervals
  - Peak flood flows related to Q1F2
  - Q7L2 related to low flows of other RI

    (e.g. Q7L10, Q7L20, Q30L2, Q60L2)

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Relating Monthly Flows to QAA

- QM#(10-9) as a **function of QAA**
  - 10 = October … 9 = September in Water Year
  - QMmax = **f**(QAA)
  - QMmean= **f**(QAA)
  - QMmin= **f**(QAA)
- 10% Exceedance fish passage flow each month
  - Q10% = **f**(QMmean) for Any Month

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Maximum and Minimum Annual Flows

- Geographic Regions and Equations

REGIONS	QAMax (cfs)	QAMin (cfs)
Olympic Pen.	$1.3(QAA)^{1.00}$	$0.54(QAA)^{1.00}$
SE Puget Sound	$1.4(QAA)^{1.00}$	$0.63(QAA)^{1.00}$
SW WA	$1.4(QAA)^{1.00}$	$0.60(QAA)^{1.00}$
E. Puget Sound	$1.4(QAA)^{1.00}$	$0.64(QAA)^{1.00}$
NE Puget Sound	$1.3(QAA)^{1.00}$	$0.66(QAA)^{1.00}$
Okan.-Methow	$1.7(QAA)^{1.00}$	$0.54(QAA)^{1.00}$

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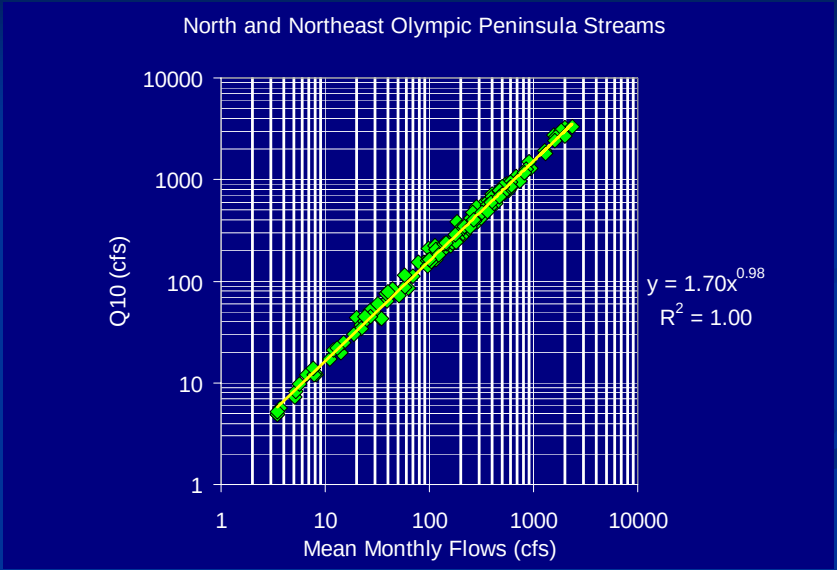
10% High Fishpass Flow



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Summary

- The Average Annual Flow (QAA) is used to model extreme average flows (Q1F2, Q7L2)
- These three characteristic flows are inversely related hydrologically and geologically
- Floods that occur less frequently are estimated using Q1F2 and Recurrence Interval (RI)
- Low flows of longer RI as well as those of longer duration are estimated using Q7L2

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Summary (continued)

- The variability in maximum and minimum annual flows are related to QAA
- Maximum, mean and minimum average monthly flows are related to QAA
- The maximum fish passage flow for barrier design (Q10) is related to the mean monthly flow in each month: $Q10FP = 1.7(QMM)^{0.98}$


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HIGH
WATER