Crowder, D. W. and P. Diplas (2000). "Using two-dimensional hydrodynamic models at scales of ecological importance." Journal of Hydrology 230: 172-191.

Annotative Review:
This project evaluated the mesh grid size needed to accurately model ecosystem parameters in a stream at the meso-scale. This study determined the sensitivity of the 2D model to obstructions, boulders about 1 m in diameter. It determined that including these obstructions is very important to the results of the velocity profile. Velocity gradients were found and in cases the entire profile of the stream was changed by the inclusion. These changes in velocity are important habitat features. Inclusion of boulder/ obstruction topography was determined to be important during mesh analysis.

This paper detailed the sampling strategy very well. A 400 m reach was used, taking cross sections every 6-36 m with major changes detailed in between. A total station was used to collect XYZ points of the topography. 200 person hours were required to collect this data. RMA-2V model program was used for analysis this program is used by Army Corp. Model was not calibrated, roughness coefficients were used which reflected natural features- determined that they would better reflect actual conditions by not calibrating with unnaturally high roughness coefficients. 80% of accuracy of model determined by bathymetry, mesh design, and boundary conditions.

This is great because it shows that calibration using unnatural Manning's n values is not a necessary or even helpful part of the modeling process. It is really getting a detailed survey and modeling it well.

Emery, J. C., A. M. Gurnell, et al. (2003). "Classifying the Hydraulic Performance of Riffle-Pool Bedforms for Habitat Assessment and River Rehabilitation Design." River Research and Applications 19: 533-549.

Defines classification methodology for determining channel feature morphology by velocity cluster method as an assessment of hydraulic performance of bedforms. Channel bed, banks, and floodplain were surveyed at .5 m scale instream and 3 m on floodplain. Velocity was measured using a ECM (electromagnetic current meter) quite often- in a grid pattern, about every 2 m. Each of the two rivers studied were near a gauge.

Surfer 7, a contouring, gridding, surface mapping package was used to produce a 2D map of the 3D data. This package allows breaklines- which isolate areas in repect to velocity or depth. Then a agglomerative hierarchical cluster analysis was used to identify homogeneous groups of points using four different statistical methods, but used Wards analysis ultimately.

The model in this paper is statistical in nature, attempting to define habitat and stream classification using a cluster analysis to determine which parts of the stream are functioning as a specific hydraulic group. It was determined that a pool when reaching a certain smallness will hydraulically act as a riffle margin instead of possessing the attributes that define a pool. This system has proved reasonable for highlighting amplitude of channel bed oscillation which is important for habitat, but not necessarily defining habitat.

Ghanem, A., P. Steffler, et al. (1996). "Two-Dimensional Hydraulic Simulation of Physical Habitat Conditions in Flowing Streams." Regulated Rivers: Research and Management 12: 185-200.

Abstract from Article:

Instream flow needs (IFN) assessment studies are performed to provide guidelines for stream water management and to assess the impacts of different water projects such as weirs, dams and stream diversions on the available fish habitat. Many of the IFN assessment techniques require hydraulic parameters such as water depth, flow velocity, wetted perimeter or top width as input variables. The Physical Habitat Simulation System (PHABSIM), one of the most widely IFN assessment models used in North America, requires precise values of depth and velocity at numerous points within the study reach to produce relationships between streamflow and usable habitat area for different life stages of varying fish species. Numerical flow simulation is applied to obtain results for unmeasured flows. At present, the flow simulation techniques applied in most IFN assessment methods are rather simplistic. In PHABSIM, a one-dimensional approach, such as the application of HEC-2, is used to determine water surface elevations along the study reach. Then a technique based on a combination of Manning's equation and regression analysis is used to obtain the velocity distribution across the channel. As a typical length scale of physical habitat study sites is of the order of a few stream widths, the accuracy of the above approach is questionable, and a two-dimensional model may be more appropriate. The results of flow modelling of fish habitat based on one-dimensional and two-dimensional assumptions are compared. Firstly, the models are tested and compared for a hypothetical flow situation of flow over a side-bar, which shows a clear difference between the results of the one- and two-dimensional approaches. Then the two models are used to simulate the flow of water in a real fish habitat reach and the computed velocity results are compared with field velocity measurements. The results of the two-dimensional approach appear to be significantly better than the one dimensional approach.

Annotative Review:

This article focuses on the determination of IFN (instream flow needs). These are a means of assessing the effects of hydraulic alterations on fish habitat. Comparison of 1D and 2D hydraulic models. This is the first article to introduce the use of River-2D, it is by the makers of the program and basically introduces it as an alternative to determining IFN instead of PHABSIM, which this article also focuses on. It points out that PHABSIM assumes that any changes in fish habitat cam be described using depth, velocity, substrate, and cover. This article is very technical and goes into the equations, simulation theory, and numerical processes the programs use to solve the hydraulic equations. Generally this would be very difficult to wade through if not familiar with modeling.

Two tests were analyzed in this article. A simulated sand bar in a straight channel was modeled, resulting in the 2D model being much closer to expected values although without analytical data it was impossible to make conclusive determinations. Real data was used for a second trial only 12 cross-sections were surveyed for 245 m of stream and this same data was used for each model. Both sub and super critical conditions were tested and found to be accurate. Also the 2D model was found to not be sensitive to the roughness factor.

The 2D model shows good representation of flows in fish habitat. The 1D model needs lots of velocity measures at different flows. The 2D model only needs a few velocity measures. The office work for the 2D model is easier due to automatic mesh simulation. 2D model more flexible to input data- can survey in interesting parts of streams and not just the cross-sections. 1D not capable of modeling eddies or recirculated flow.

Horritt, M. S. and P. D. Bates (2002). "Evaluation of 1D and 2D numerical models for predicting river flood inundation." Journal of Hydrology 268: 87-99.

This study compared the use of three models to accurately predict floodplain inundation during large storms. HEC-RAS, a 1D model inputting cross-sections and a LiDAR based DEM to approximate the floodplain, and TELEMAC-2D a 2D, both based on St. Venant formulas were both used. LISFLOOD-FP, another 2D model uses the Newton-Raphson method to solve raster-based high resolution topographic data sets. The LISFLOOD-FP data was taken from the LiDAR DEM, with the river digitized from 1:25000 maps. These three models were used to model one section of the River Severn in the UK for two storm events.

RADARSET satellite imagery was used to provide a reference for extent of flooding on the floodplain for each of the storms. This was used for validation- by determining the amount of cells overlapping divided by the number of cells in both areas, F-value. Using this validation all models preformed on par. Another source of validation information is the time the floodwave took to reach the downstream stage, which is historical, and calculated by the model. The LISFLOOD-FP model is less sensitive to floodplain friction, throwing the timing off from the measured. The HEC-RAS and TELEMAC-2D, because both based on the same equations gave similar results for this calibration technique.

These results on models show that for this specific application, HEC-RAS is the easiest and most effective model to use. It requires less data input and has the same output as the 2D model in both calibration techniques. This is very specific to the flood modeling because of the floodplain friction component.

Lacey, R. W. J. and R. G. Millar (2004). "Reach scale hydraulic assessment of instream salmonid habitat restoration." Journal of the American Water Resources Association: 1631-1644.

ABSTRACT: from paper

ABSTRACT: This study investigates the use of a two-dimensional hydrodynamic model (River2D) for an assessment of the effects of instream large woody debris and rock groyne habitat structures. The bathymetry of a study reach (a side channel of the Chilliwack River located in southwestern British Columbia) was surveyed after the installation of 11 instream restoration structures. A digital elevation model was developed and used with a hydrodynamic model to predict local velocity, depth, scour, and habitat characteristics. The channel was resurveyed after the fall high-flow season during which a bankfull event occurred. Pre-flood and post-flood bathymetry pool distributions were compared. Measured scour was compared to predicted shear and pre-flood and post-flood fish habitat indices for coho salmon (*Oncorhynchus kisutc*h) and steelhead trout (*O. mykiss*) were compared. Two-dimensional flow model velocity and depth predictions compare favorably to measured field values with mean standard errors of 24 percent and 6 percent, respectively, while areas of predicted high shear coincide with the newly formed pool locations. At high flows, the fish habitat index

used (weighted usable area) increased by 150 percent to 210 percent. The application of the hydrodynamic model indicated a net habitat benefit from the restoration activities and provides a means of assessing and optimizing planned works.

Annotative Review:

This study used 2D hydrodynamic model, River2D to determine if modeling could predict location of scour, local velocity, depth, and habitat characteristics after habitat structures are added to a stream. A goal was to provide good habitat for salmon in the river during high flow events.

Structures were added to the stream, and after a flood event the stream was surveyed again- XYZ coordinates with total station- distributed points about .5-1 m apart. In modeling found there to be nodal restrictions in the River2D model and had to narrow the study site to accommodate. This caused strange interpolated values along the stream which caused aggradations and scouring along the channel edge.

Shear stresses were calculated for the bed surface to determine areas of scour. Found that River2D was less determined by roughness coefficients than 1D models- therefore extrapolation to flows other than the calibrated flow can be more reliable. According to these researchers after data has been collected in the field- little effort is needed to perform the 2D analysis with River2D. This study shows that channel diversity and scour are accurately predicted for post flood channels, without the need of post-surveying.

Lamouroux, N. and H. Capra (2002). "Simple predictions of instream habitat model outputs for target fish populations." Freshwater Biology 47: 1543-1556.

Annotative Review:
58 small streams in southern France- riffle, pool configuration with reaches 14 times longer than width, were modeled using EVHA which is similar to PHABSIM. 34 reaches were where only brown trout were found, 24 were trout and other species. The trout only reaches were used to determine a numerical model, which was tested for the brown trout predictions for the other 24 streams. The model predicted velocity and depth for different discharges- which were compared to the preference curves known for the species for those perameters and then multiplied by surface area to get Weighted Usable Area- WUA.

This study was trying to determine what easily measured parameter was most correlated to the WUA in order to simplify the process of habitat determination for streams. Being able to skip the detailed surveys would be key to saving money and more widespread use of the habitat estimation model. The computer model currently requires detailed topography, velocity, depth, particle size distribution for many cross sections.

Numerical analysis was preformed to determine which parameters were the best indicators of the WUA. Froude number (low in pools and higher in riffles) and Reynolds number were both calculated in each case. D/H (relative roughness) indicates the number of hydraulic shelters in the water. W/H (width to depth ratio) show shape of wetted cross section. Gudgeon and minnow

HV values depended directly on Reynolds number. Other species were influenced by Froude50 (at mean natural flow as determined by regional discharge curves). This showed that average reach characteristics provided a good estimation of HV for all except sculpin (66%), others showed 84+% variance depended on these average values. Therefore, regional curves can be used to get a general idea of the habitat values for streams- without the detailed surveys. Although this may over or underestimate the values.

Loranger, J. and S. Kenner (2004). <u>Comparison of One- and Two-Dimensional Hydraulic Habitat Models for Simulation of Trout Stream Habitat</u>. World Water and Environmental Resources Congress 2004, Salt Lake City, Utah, USA, ASCE.

Annotative Review:

This paper compares the use of 1D and 2D models for simulation of trout habitat, using PHABSIM and River2D. The authors note that both of these programs use WUA (weighted usable area) in determining habitat suitability, not a measure of area of habitat. This means that the program is quite good at determine relative habitat at differing flows, but not the actual measure of habitat area. The project focuses on whether the increased data and computation in the 2D model are really necessary compared to the 1D model. An urban stream, Rapid Creek, in Rapid City, South Dakota is modeled to determine trout fisheries.

The flows in the stream are regulated by a reservoir upstream of Rapid City and the stream geometry has been altered by canalization and straightening. Adult brown trout habitat was quantified with depth and velocity suitability index curves, because these curves are on a scale less than 1, they can be multiplied to form a composite suitability number. WUA calculations were determined for 5 100m stream reaches using both PHABSIM and River2D. There were compared, showing that PHABSIM produced very low WUA in comparison to River2D results. This may be due to extrapolation of pool geometry in PHABSIM, as compared to the greater accuracy of interpolation in the mesh by River2D. Using the same input data for both programs, PHABSIM is using a cell size of 9.75 m2 and River2D cell size is 1 m2. If spatial analysis is going to be done on the data, PHABSIM does not create as much useful data.

This article notes that a 2D model is more costly and takes more time. This is in contrast to other article's determinations. This article does not detail why it considers the 2D more costly and time consuming. This article is obviously not peer reviewed- I (the worst speller ever) found two spelling errors that should not have been here. Obviously conference proceedings are not of the same caliber as some of the journals I have been reading. This is a reasonable article for getting a feel for the differences in WUA as output from the two types of models and will be useful for me in my research. It would have been nice to have had more on the topic of how this was pertinent- this is an urban, regulated river and it needs to be managed in some way- how is this study going to help at all? It was basically just about which model to use- and didn't address what it seemed like it should as stated in the beginning.

Waddle, T., K. Bovee, et al. (1997). Two-dimensional Habitat Modeling in the Yellowstone/Upper Missouri River System. North American Lake Management Society. Houston, TX.

One dimensional models are not considered to be accurate enough for water resources managers in government agencies to make informed decisions for management. Previously flow has been managed in order to provide the necessary conditions for a few species. There is a feeling at this point that this practice must shift to consider ecosystem functions and how they are related to the flow regimes. This study was done in conjunction with a program to inform reservoir managers in the upper Missouri and lower Yellowstone Rivers as to the proper hold/release patterns for the reservoir water. At this point it is not conclusive as to if it is the daily release schedule of water from reservoirs or the overall structure of the stream, or both, which is more important for habitat. Therefore this study is trying to determine if it is variability over space or time which is more important.

PHABSIM is a traditional one-dimensional model which needs extensive field data collection and modeling requirements. It is found that the 1D model is not accurate when the channel is split into 2 or more channels, and the 2D model is able to model the variable backwater produced. Backwater habitats- in tributaries and on the floodplain are thought to be valuable habitat and very important to model.

FRAGSTATs used in order to determine geo-statistical analysis of the river when modeled in 2D. 1D would only produce one velocity measure per cross-section with 2D we can determine patches of like-velocities in order to determine how these patches are effected with differing flows. It is important how well-connected areas of like-velocity are- for fish movement, as well as how often they exist- as they will change with varying flows. This provides the opportunity to examine temporal and special habitat metrics at the same time.

Under water- detailed bathymetric surveys, floodplain- digitized aerial photos and surveying??? This produces less than great quality of data- so eco-sounding was also used to determine the elevation map.

Time for calibration of the two models is the same.

Wagner, C. R. and D. S. Mueller (2002). Use of velocity data to calibrate and validate two-dimensional hydrodynamic models. Second Federal Interagency Hydrologic Modeling Conference, Las Vegas, NV.

This is an interesting study- and may come into play with my research. This was discussing the use of and Acoustic Dopler Current Profiler to collect 3D? velocity data in the RIVER and use it to validate a sediment transport model. They found that using just water surface depths to calibrate the model, the steady state results did not match the velocity fields measured for those flows in the field. The rivers in this study are both big- The Ohio River – the lower part. ‘Low Flow’ has a discharge of 300,000 ft^3/s.

Collected data- water surface elevations and cross-sections of bathymetry data – measured at 30 cross sections- about 1.5 miles apart. This is a very different scale than my project is working at. The ADCP was used from a moving boat- and its scale does not even allow measurement of the velocity fields within 3 ft from the top. They used RMA-2 for modeling. They needed to change the Manning's n to .035 at the banks from .024 in the middle to accommodate for a no-slip condition that they noticed when examining the field data in correspondence to the modeled data.

Wang, L., J. Lyons, et al. (2001). "Impacts of Urbanization on Stream Habitat and Fish Across Multiple Spatial Scales." Environmental Management 28(2): 255-266.

This study linked the impacts of urbanization to instream habitat. They found that the amount of connected impervious surface in the watershed was best measure to predict fish density, species richness, diversity, and index of biotic integrity. The interesting thing was that imperviousness was not correlated with habitat quality for fish. This study identified a 'threshold' value for impervious surfaces, where between 8 and 12 % connected impervious surfaces there were a larger response in stream condition to minor changes in urbanization. The position in the watershed of the impervious surfaces was also important, within 50 m of stream or 1.6 km radius to sampling point was more critical.
Correlated land use variables with stream variables using simple linear regression. Developed predictive models to relate stream attributes to urban land use in watershed. They repeated this regression at different scales in order to determine if there were thresholds. There were 90% quartile regressions to determine linear models.

Imperviousness does predict the amount of bank erosion in the stream, and is the best indicator of fish communities and base flow. Although, not good indicator of habitat quality. This article is great- in that it really talks about the statistical techniques used to develop the models- and the threshold values. It seems like there is enough information given to really understand the process- and the variable transformations undertaken.