# Beaufort County Stormwater Design

Explanation of Volume Control and its application on the Bluffton Gateway Development Plan


So what does the development like we saw in the last slide do?

It creates Impervious Surface that causes:

An increase in the rate of runoff

Generates Pollutants that are carried to receiving waters, and

Creates an increase in total volume of runoff


Our history of controls has been to address the causes that were creating the problem

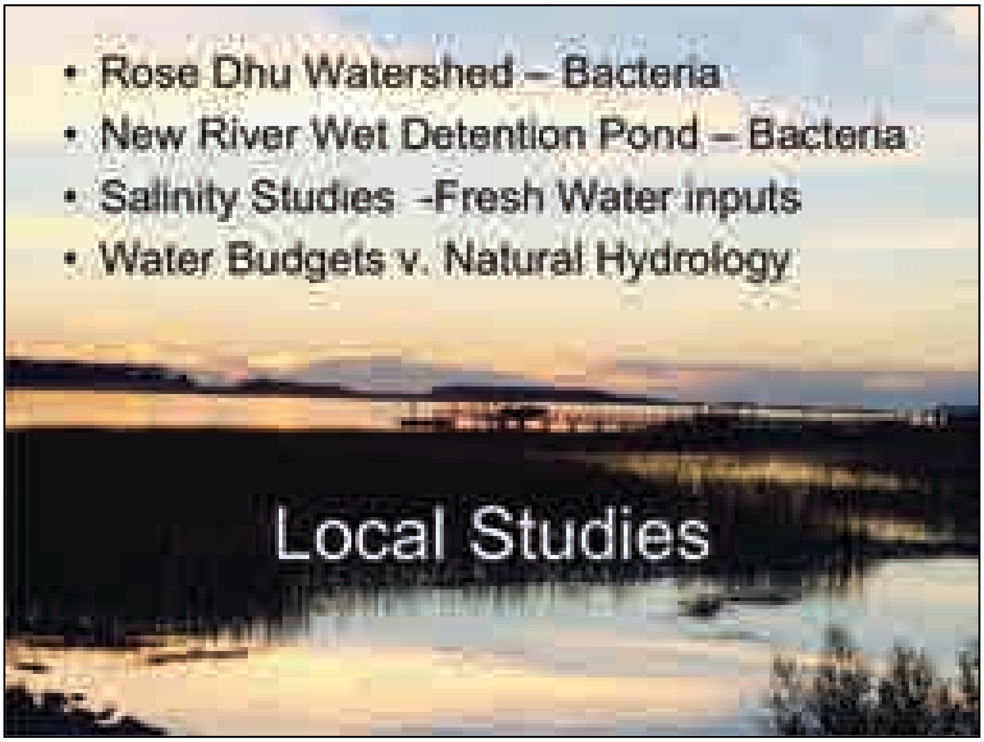
Our First controls were peak controls in response to flooding impacts

Then addressing pollutants became the primary focus after the closure of Shellfish harvesting in Broad Creek. We addressed various targeted pollutants like Phosphorous, Bacteria and Nitrogen between 1998 and 2009. These were tied to antidegradation goals that were based on 10 percent Equivalent Impervious Cover for phosphorus and nitrogen and 5% for Bacteria. Ill explain more about this later.

For a while we thought that was enough.

Volume controls were the outcome of impairments to Shellfish Harvesting that first occurred in May River in 2008 and the harvesting closures in 2009. Monitoring done to determine the cause of the impairment did not find the suspected sources of fecal coliform but indicated that the excess stormwater runoff volume being discharged by development was a factor. Low concentration stormwater discharges were causing large increase in concentration and loads of Fecal Coliform from natural area discharges – primarily freshwater wetlands.

This is what we found in many areas of the County.

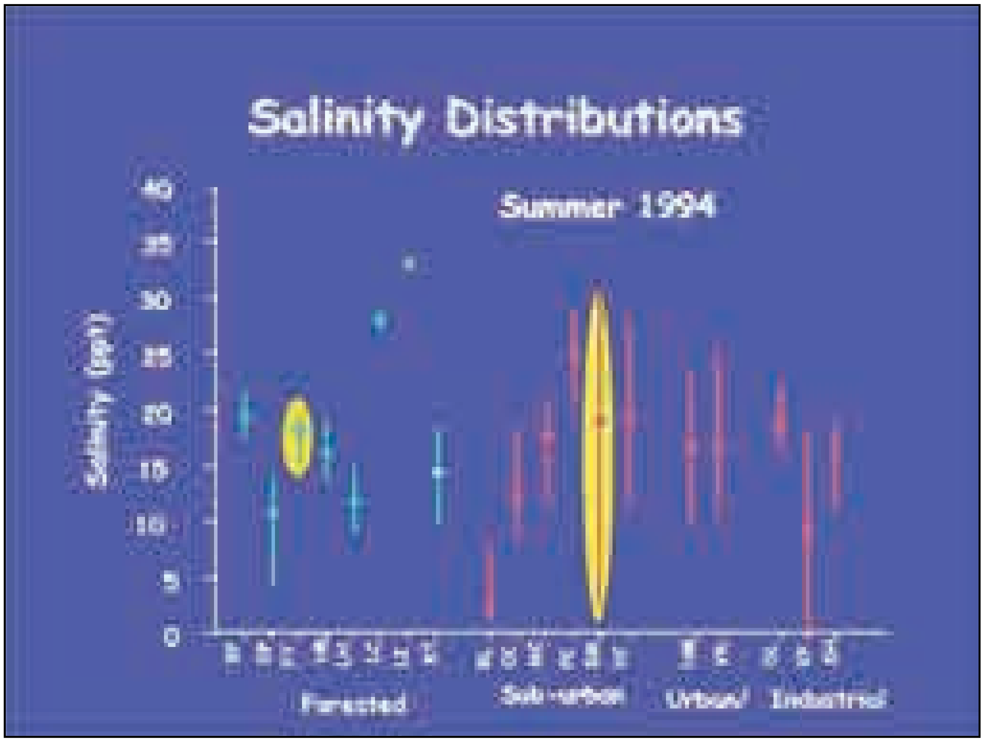



We've done quite a bit of studies to prove our concerns.

In the Rose Dhu and New River Watersheds, we found impairment is caused by a Fecal Coliform Load. You can either reduce it by reducing concentration or the Volume. What we are finding is that our watersheds have a high concentration of naturally occurring fecal, but we can successfully remove fecal coliform from the water through detention. However, after only traveling a short distance through the woodlands the fecal coliform levels are again high. This type of data lead to a decision to control the runoff volume since we could not get any further concentration reduction.

But what if we successfully cleaned the water before it entered the water body? Is fresh water a concern? As it turns out, in a salt water environment it is. Sea life depends on the saline waters for breeding and growth. We conducted a Salinity study to measure and model salinity levels in the headwaters of our tidally influenced streams. While we noted the daily flux in salinity due to tidal influence, we also noticed the dramatic changes in the salinity after a rain event. In the extreme headwaters, salinity drops to nearly zero. Due to the large tidal change during the day, tidal slosh, dilution and flushing of the headwaters can take days or even weeks. Literally, volume is the pollutant, not just a surrogate.

And finally, what happened when we unknowingly increase the influx of water into a watershed. Where does the excess water go? We wanted to find out.




So let's talk about how fresh water inputs into salt water estuaries can impact the environment.

We also learned, from our marine scientists, that excess runoff volume, even if it could be kept clean, could pose serious risks to our marine resources because our tidal headwaters are fishery spawning grounds and low salinity can be toxic in their spawning cycle.

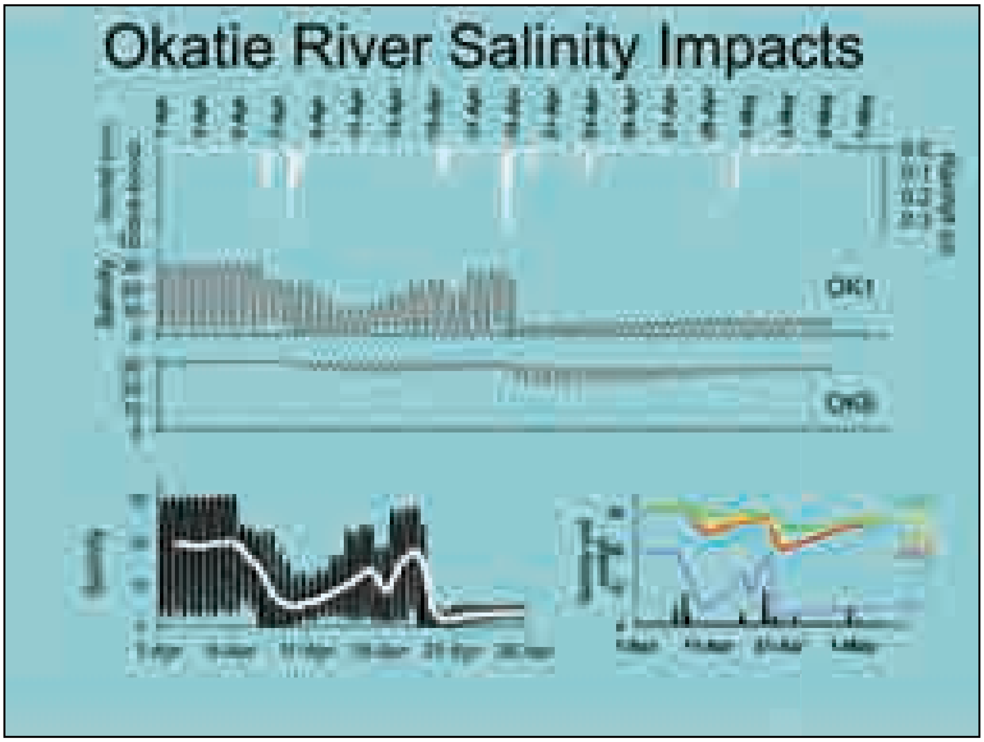
The next series of slides will show you the problem with this.

This chart is from research by NOAA.  It shows salinity variations that occur in volume uncontrolled developed watersheds.

These variations have occurred naturally in larger rain events, but are occurring with greater frequency and amplitude with development.

This chart compares salinity ranges of forested to developed watersheds in the Charleston SC area.  Some of the creeks in the developed areas go nearly fresh. Notice the two highlighted creeks.  Same average but much larger change.

This increased change of salinity is being called salinity “flashiness” by scientists




This chart is a sample of the data collected at Okatie #1 and comparing it to the other stations. Note the daily flux in salinity due to tidal influence. Then notice the dramatic changes in the salinity after a rain event. In the extreme headwaters, salinity drops to nearly zero. Further downstream, the effect is less. Normalizing the average daily salinity levels (in the bottom left chart) you can see the trend as it relates to storm events. In the bottom right, we have plotted the average daily levels for all 6 stations on the same graph. Again, as you move away from the headwaters, the sensitivity of salinity levels changes due to runoff is less.

Thinking back to one of the first slides, you will recall the large tidal amplitude we experience daily. As a result, fresh water is trapped in the headwaters for day, sloshing back and forth. A large salinity drop, combined with a heavy pollutant loading, is detrimental to aquatic life.


So now that I've provided a little background on why we created our stormwater standards, let's get back to our regulations and how they work.

Here is a quote from our Code of Ordinances.

The bar is set pretty high. no development or redevelopment shall cause post-development stormwater rates, quality or volume to increase above predevelopment (not existing conditions if a redevelopment) levels.

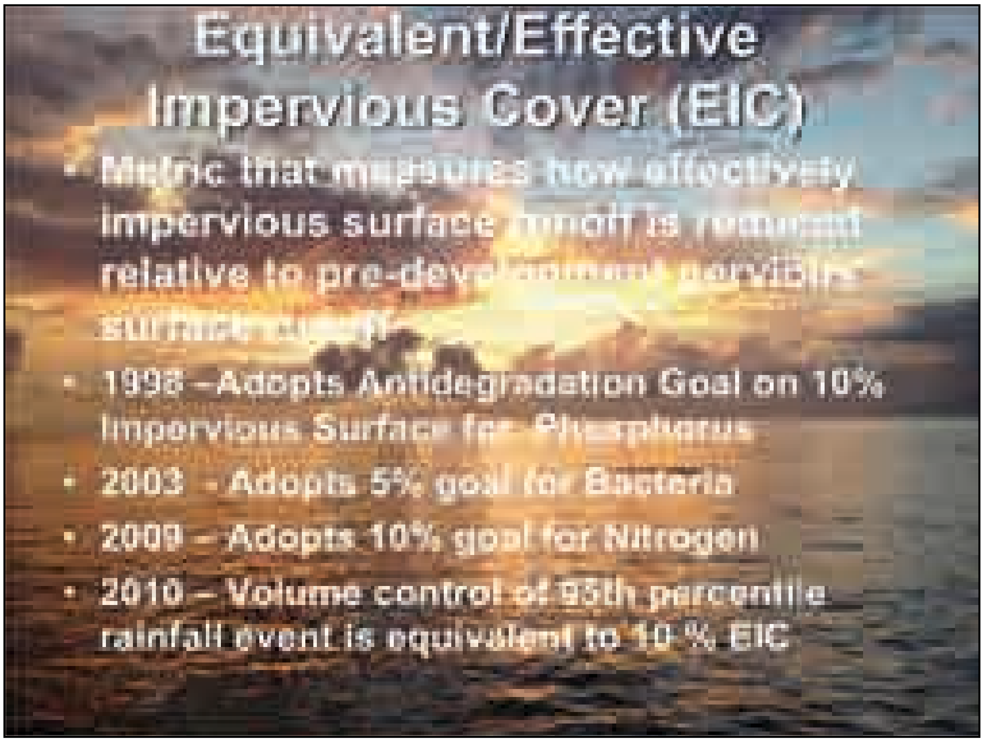
As with most policy statements, the devil is in the details. Our standards are found in a technical guide, the BMP manual.


The Regulation, cont.
and integrate Stormwater BMPs which are
location and environment, and
overall character of a proposal.
implemented at the development scale
to the maximum extent
BMPs may
part of various
BMPs in series to achieve the
pollution load, and peak runoff
control


This flow chart shows the basic concept of our design criteria.  Peak and Water Quality Controls are pretty straight forward.  We design Peak for the 25 year storm and check the 100 yr storm on critical facilities, such as evacuation routes.

Water Quality Control and Runoff Volume Control are also very prescriptive in the BMP Manual.  We provide worksheets for water quality and provide assumed pollutant removal efficiencies for various BMPs.  With a simple Pre=Post rule, volume reduction can also be calculated and proven through some type of volume retention practice.

However, it is the fourth control that is offered that really is the basis of the Water Quality and Quantity Integration we are discussing today.  As I'll explain over the next few minutes, controlling the amount of impervious cover can achieve all the goals of the other three controls combined.




Equivalent Impervious Cover is critical to how we plan to protect our waters.

Previous studies by the Center for Watershed Protection have told us that when the impervious surface goes above 10 % we see impacts in our receiving waters. That has been accepted as fact, but not the idea that we can create an equivalent impervious surface below 10 % to prevent these impacts.

So, Equivalent Impervious Area is a Metric that measures how effectively impervious surface runoff is reduced relative to pre-development pervious surface runoff.

As I stated before, the County adopted antidegradation Goals in percent of effective impervious surface.

This slide describes this evolution.

Volume controls turned out to address both the volume and quality issues. With this linkage we have integrated the quantity and quality issues as I will explain in a minute.


Our Volume controls were adopted in two steps.

In October 2009 we adopted from Section 438 of 2007 EISA (Energy Independence and Security Act) the control event of the 95$^{th}$ percentile (1.95 inch)

At the same time, an inventory of current approved developments revealed that we had over 22,000 vacant lots in the county that could be built on. 15,000 of these lots were in previously approved developments without volume controls. This is significant since there is only 39,000 single family homes in the unincorporated county at the time. Therefore, in June 2010, the county then required individual lot controls at the same 95th percentile standard if the development could not meet volume controls on a regional basis. This is extremely unique in that it is one of the only regulations I've ever seen that does not grandfather existing development and actually enforces new regulations retroactively.

This had an added benefit in that several development came forward with plans to retrofit their stormwater system so that each lot was not required to go through the time and expense of Step 2 when applying for zoning and building permits.


This is a key slide in integrating volume controls for a 95th percentile event to water quality on an annual average rainfall.

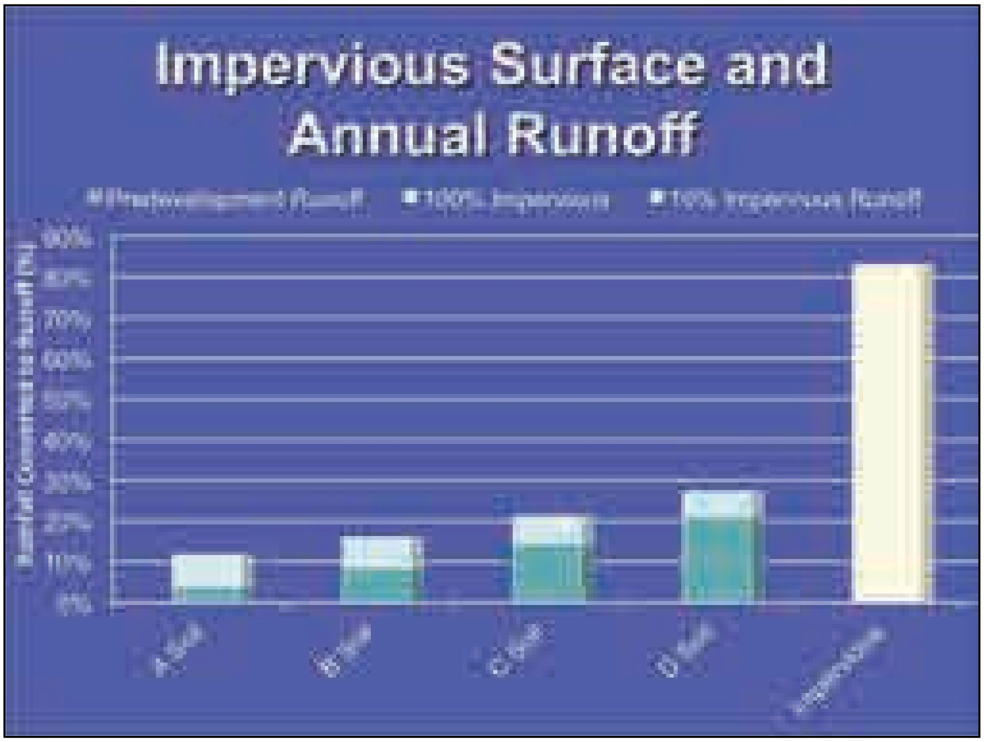
Our calculations found that best management practice sizes necessary to control the 95th percentile volume were similar to controlling annual average runoff volume that was expected from a site with 10% EIC, in addition to reducing the pollutant concentration.

To translate controls of a storm event to an EIC we must consider two factors. The volume reduction from the BMP is compared to what would be expected from runoff an existing site, which could vary depending on the existing soils. Depending on the volume reduction needed, the BMP size will be determined. A BMP of a certain size can have 4 different EICs for each of the 4 soil types shown in the BMP manual. The EIC will also vary with the best management practice used.

After generating a EIC, this value can be included in the water quality control sizing. In other words, if a volume reduction practice reduces impervious cover from say 50% to 20 % EIC, then 20% EIC can be used in computing required water quality and quantity controls.

Another way to look at it is this…

A 10% impervious watershed produces X volume annually. Volume can be calculated based on our approx. 48” per year. Loading of a developed watershed with 10% impervious can be calculated as well using typical concentrations. The 95th percentile volume for a developed watershed can be calculated as Y by using LID type BMPs to reduce runoff volume. Smaller storms will have 0% runoff while larger storms will have a released volume on an annual average that is Y < or = to X. At the same time, the BMPs are reducing concentrations in runoff so that lesser volumes released would mean loading would be reduced too.




This chart shows two things:
1. Why we will sometimes have 4 different EICs for the same size practice and
2. How antidegratation goals allow some increase over natural runoff.

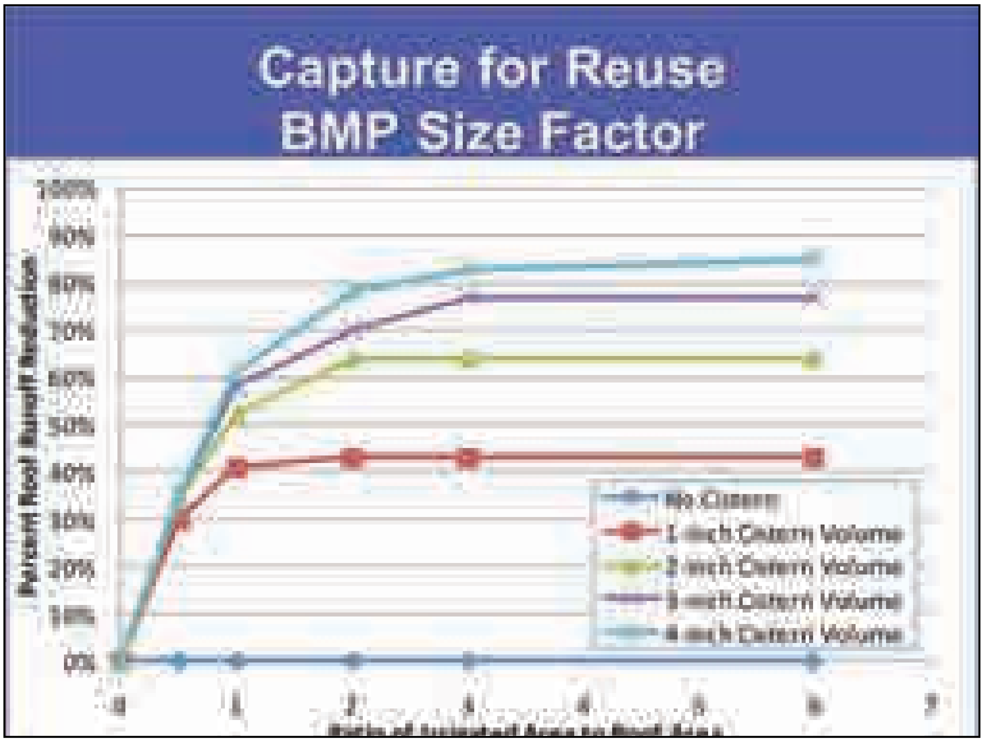
This chart shows pervious runoff by soil type and impervious runoff. As I mentioned, controlling the volume for the storm event less than or equal to the 95th percentile storm (events below 1.95 inch in Beaufort) is equivalent to controlling runoff to what is expected from areas with 10 percent impervious surface on an annual basis.

Therefore the BMP manual presents a series of credits (based on size) for various practices and that can be chosen to reduce the runoff from impervious surface down to the goal existing runoff volume based on the soil type on the site.

By given credits for varying practices, the actual impervious surface is reduced to an "Equivalent/Effective" percentage meeting the antidegradation goals. In other words, we can make development that looks like the Impervious Column act as if it is one of the four columns for the four soil types.

D soils naturally have more runoff. Developing a site then creates the same runoff, but the change (or delta) in runoff volume in less. The same volume control BMP can achieve more reduction in poor soils. (you get more bang for your buck). This artificially encourages development on poor soils and preserves the areas with good soils.

We have to be careful though. While this concept of 10% Effective Impervious Cover is designed to create a developed watershed that mimics a more natural state, engineers can use the other Stormwater Control standards I previously mentioned and meet volume reduction and antidegradation goals and still be above the 10% EIC. The important thing to remember is that this is a goal to shape how development occurs and sometimes common sense has to overrule all the math.




Our  BMP manual lists credits and EICs for six practices on various soils.

Rooftop Practices

Pervious Pavement

Runoff Capture and Reuse

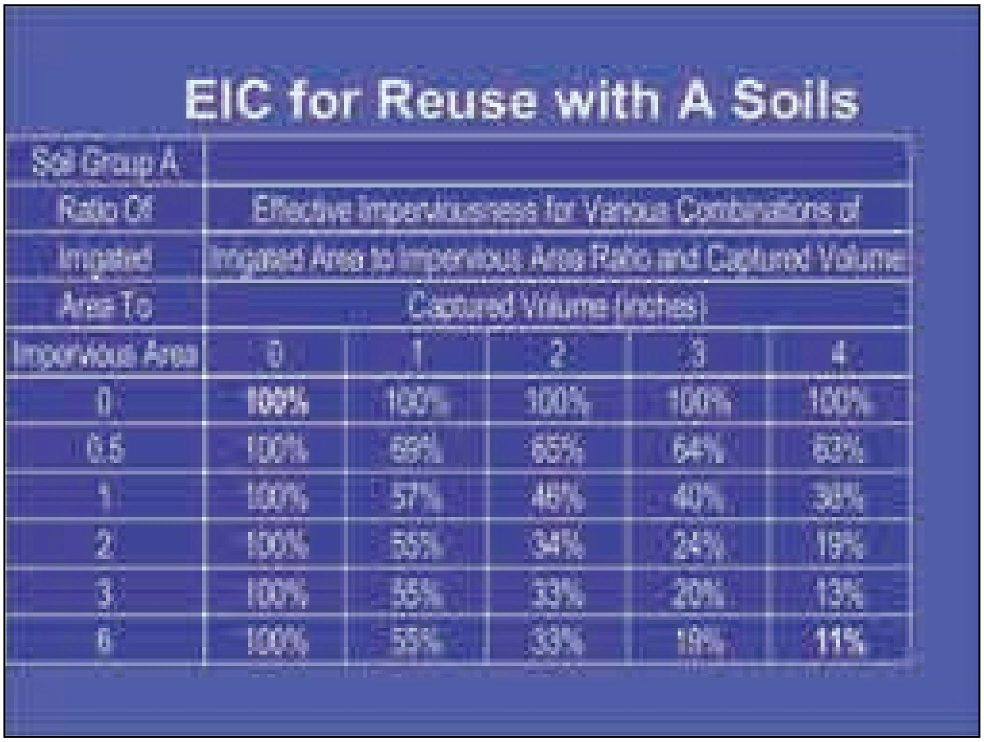
Disconnection of Impervious Surfaces

Bioretention/Raingardens

Swales

So Lets take one and see how this integration works.

I have picked one of the practices, a cistern used to capture  rooftop runoff for irrigation.    As can be seen on the chart, depending on size of cistern and area to be irrigated, we get a runoff reduction.   Part of the application of this practice is to determine the optimal irrigation rate.  Typical values are 1-2 inches per week, however certain plant types and soil type may allow the designer to increase the rate.  As you can also see, if you can increase the amount of pervious area to be irrigated, you can increase cistern volume and increase runoff reduction.



# EIC for Reuse with A Soils

| Soil Group A | | | | | |
|---|---|---|---|---|---|
| Ratio Of | Effective Imperviousness for Various Combinations of | | | | |
| Irrigated | Irrigated Area to Impervious Area Ratio and Captured Volume | | | | |
| Area To | Captured Volume (inches) | | | | |
| Impervious Area | 0 | 1 | 2 | 3 | 4 |
| 0 | **100%** | 100% | 100% | 100% | 100% |
| 0.5 | 100% | 69% | 65% | 64% | 63% |
| 1 | 100% | 57% | 46% | 40% | 38% |
| 2 | 100% | 55% | 34% | 24% | 19% |
| 3 | 100% | 55% | 33% | 20% | 13% |
| 6 | 100% | 55% | 33% | 19% | **11%** |

Now with the size of the BMP determined, we then use the second factor, Soil type, to determine EIC. We have done the math for you. The BMP manual has charts for four soil types. In this chart for A soils, the first column shows would happen if runoff was not captured and there would be no decrease in EIC. By increasing capture volume and ratio of rooftop to irrigated area, we can reduce EIC to lowest value of 11%.

Some additional practice deployed in a treatment train would be needed to bring to below 10% EIC

## EIC of Reuse with D Soils

| Soil Group D | | | | | |
|---|---|---|---|---|---|
| Ratio Of Irrigated Area To Impervious Area | Effective Imperviousness for Various Combinations of Irrigated Area to Impervious Area Ratio and Captured Volume | | | | |
| | Captured Volume (inches) | | | | |
| | 0 | 1 | 2 | 3 | 4 |
| 0 | 100% | 100% | 100% | 100% | 100% |
| 0.5 | 100% | 62% | 57% | 56% | 56% |
| 1 | 100% | 48% | 34% | 27% | 23% |
| 2 | 100% | 46% | 19% | 8% | 1% |
| 3 | 100% | 46% | 18% | 2% | -6% |
| 6 | 100% | 46% | 18% | 2% | -8% |

This is for D Soils – remember from the chart a few slides ago that we have 20% of annual rainfall running off D soils compared to 4% for A Soils.

Because D soils produce more runoff, the same size BMP can actually achieve a negative EIC (less water runoff than in a undisturbed situation) and could be used to offset other impervious cover within the development. This is since we are comparing reduction to the runoff amount in the existing, predeveloped condition.

Engineers will mix and match practices based on soils. Reuse may be a better practice in D soils and infiltration may be a better practice in A soils.

# Bluffton Gateway Development Plan

Application of Volume Control on a large scale commercial site


Site Plan

# BMP Manual Guidelines

- Peak Controls
  - BMP Manual Section 2.6.1 - The design storm criteria to be used in calculations for the sizing of peak attenuation and volume control BMPs is to limit the post-development runoff for multiple storm events including the 2-, 10-, 25-, 50 and 100-year/24-hour storms to the predevelopment rates.


Peak Control

# Bluffton Gateway - Peak Control

- Ordinance requires the 2-, 10-, 25-, 50 and 100-year/24-hour events to be considered

| Storm Event | Pre-Development Discharge (cfs) | Post Development Discharge (cfs) |
|---|---|---|
| 2 Year, 24-Hour | 18.45 | 18.04 |
| 10 Year, 24-Hour | 42.59 | 41.98 |
| 25 Year, 24-Hour | 66.91 | 61.12 |
| 50 Year, 24-Hour | 92.04 | 93.10 |
| 100 Year, 24-Hour | 122.02 | 118.04 |

## BMP Manual Guidelines

- Water Quality Controls
  - BMP Manual Section 5.4 (paraphrased) – "Antidegradation" **goal** for total phosphorus and total nitrogen is based on annual average loads expected to be generated by land uses with an overall imperviousness of approximately 10%. The load **target** for fecal coliform bacteria should be based on an overall imperviousness of 5%. BMPs are selected based on removal efficiencies.

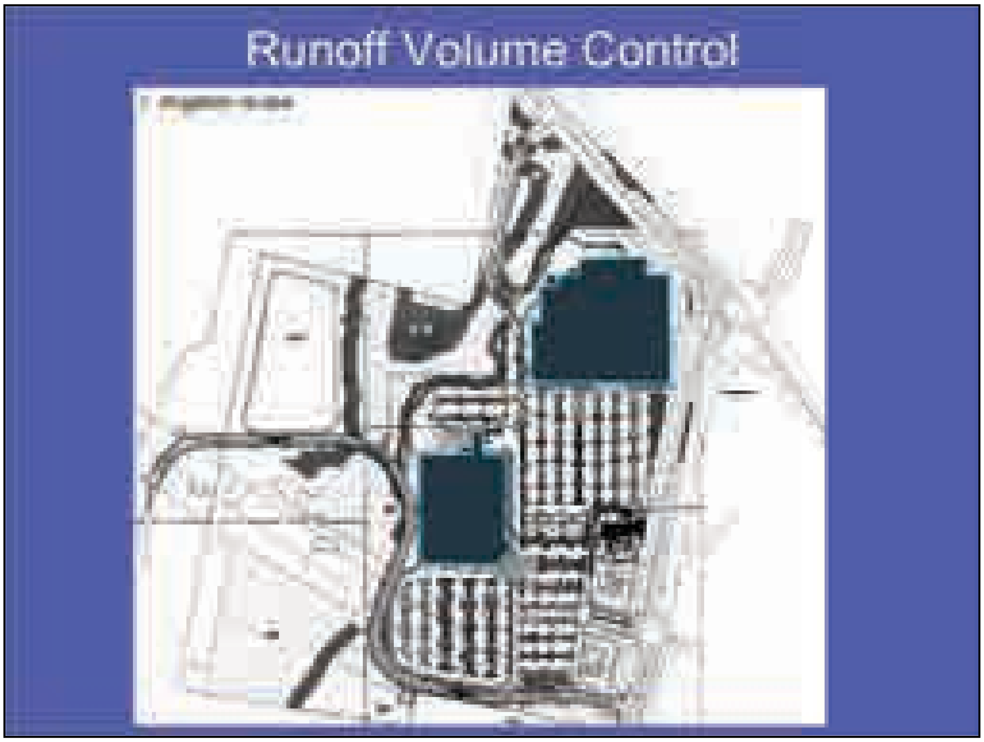

Water Quality Control

## Bluffton Gateway - Water Quality Control

- Design utilizes a Wet Detention Pond as primary BMP for nutrient and bacteria removal
- This analysis considers % impervious cover
- Engineer submitted analyses for 10%, 14.4%, 15.2%, 19.8%, 24.5% effective impervious area
- Any level of effective impervious at or below 19.8% meet this criterion

# BMP Manual Guidelines

- Runoff Volume Controls:
  - BMP Manual Section 5 – All development will control and retain total volume by retention and other methods to the maximum extent technically feasible (METF) so that stormwater runoff levels will not exceed predevelopment levels for storm events up to the 95th percentile event.


Runoff Volume Control

# Bluffton Gateway - Runoff Volume Control

- Based on the 95th percentile design storm event, the engineer determined:
  - Pre-Development Volume = 24,189 CF
  - Post-Development Volume = 67,631 CF
  - Increase = 43,442 CF
- Irrigation capture and reuse BMP provides 156,233 CF storage
- Therefore, 100% of site runoff volume is captured

## BMP Manual Guidelines

- Impervious Cover Controls
  - BMP Manual Section 5.1 (paraphrased) – Volume control **target** is a threshold of 10% effective impervious area. It is consistent with the overall framework of the BMP reviews for water quality, which allow for anti-degradation loads of total phosphorus (total P), total nitrogen (total N), and fecal coliform from proposed development up to the uncontrolled load expected from a 10 percent impervious development.


Impervious Cover Control

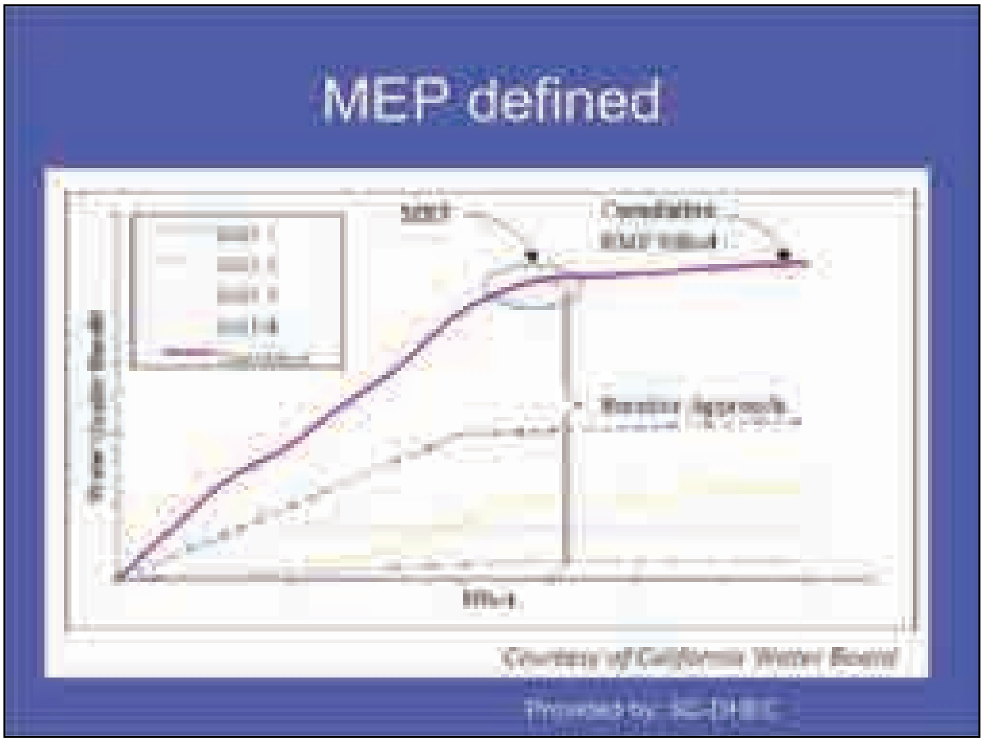
## Bluffton Gateway - Impervious Cover Control

- Engineer submitted analyses for 10%, 14.4%, 15.2%, 19.8%, 24.5% effective impervious area
- Design utilizes these BMPs:
  - Wet Detention Pond
  - Bio-swales / Rain Gardens
  - Runoff capture and reuse for irrigation
  - Porous Pavement
- The range of values was intended to demonstrate Maximum Extent Practicable (MEP)

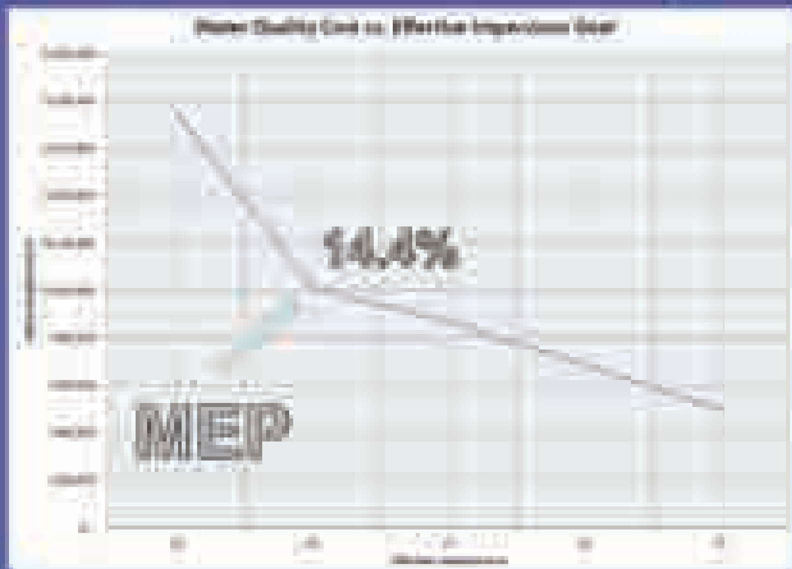
## The Logic of the "10% Rule"

- ...runoff volume controls (are) a different way to handle stormwater runoff and **not an additional set of controls**.
- ...by utilizing volume controls, most water quality and some of the peak shaving requirements are also addressed.
- ...in addressing a runoff volume requirement, volume quantity and quality **requirements can be integrated by utilization** of Equivalent (effective) Impervious Cover (method).

\- D. Ahern, R. Wagner, R. Klee (2012)


MEP defined
Courtesy of California Water Board
Provided by: SC-DHEC

# MEP on Bluffton Gateway site



# Conclusion

- 4 separate analyses, but
- Impervious Cover Control review has basis as an alternate approach to review the other three main components and applies a performance standard in those three components.
- The BMP Manual allows compliance with the three main components yet not meet the Impervious Cover Control approach.
- Section 5.1 Volume Control – "if post – development impervious surface runoff is equal or less than pre-development pervious surface runoff, then the effective impervious area is 0%.

## Conclusion cont.

- The BMP Manual **does not** mandate the use of specific BMPs. Instead, it offers a variety of BMP alternatives that can be used on a project that have found to be effective in reducing volume and pollutants.
- All BMPs are engineered solutions that require maintenance to remain effective in reducing volume and pollutants.
- The BMP Manual **does not** prohibit the use of "engineered solutions" for BMPs.

# Conclusion cont.

- Politics "trump" engineering standards


Our BMP Manual, studies, and other papers are posted on the County's web site. The website is www.bcgov.net but the best way to get there is to google "Beaufort County Stormwater"

Thank you for the opportunity to share our program today.

Are there any questions?

# Contact Information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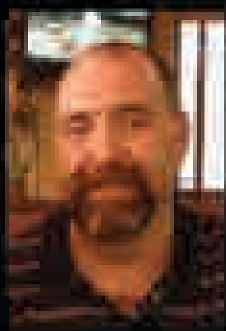

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As I mentioned earlier, these Equivalent Impervious Cover volume controls addressed new and redevelopment but the question of the impact of previously approved - but not built out - developments still remains. This situation exists in the Rose Dhu watershed example I mentioned.  This lead to ordinance for Step 2 on-lot volume control.

The ordinance changes were fairly simple – less than a page –  and used the same criteria as for new development.  The 1.95 inch storm event is the 95th percentile rain event. There was considerable pressure to not make this something that a homebuilder would have to get engineering support to satisfy. This was also a goal of the stormwater and engineering staff that did not want to have to review up to 22,000 control proposals. On-lot controls were the vehicle to use since the county requires zoning approval before getting a building permit and these controls are applied at that time.  Therefore considerable effort was invested in developing a worksheet that could help a builder/homeowner develop an approvable set of practices to meet the ordinance.

It was hoped that some developments would opt to meet Volume controls on a development basis or combination and eliminate the need for on-lot controls. We even did some pilot projects to see if some developments could retrofit to meet volume stds. easier than via on-lot controls, and we were successful.


The On-lot volume worksheet was developed as an option for the Homeowner who did not want to have a professional developed plan.

It leads to an output that can be field verified in the existing building inspection program.

The worksheet is the official document that is included in the county's BMP manual.

Unfortunately it requires a number of calculations and it was suggested that a web-based program be developed that would take input and generate the output for the user.


Here is the information to be added to web based program.

Later on the homeowner has to add some additional BMP implementation data and this might be the most difficult item, Such as the input related to the disconnected impervious practice that credits runoff removal for sheet flow over the surface of the lot.

The next slide shows one of the two figures utilized to assist homeowners to estimate the impervious surface and pervious surface that it flow over.

The worksheet allows only two cases – runoff the lot in one direction or two directions.

This is the two direction example and has a pervious driveway.

A homeowner would need to estimate the Impervious surface and the pervious surface that the runoff sheet flows over

Here is a printout for one possible set of selected practices for the lot shown in the help figure. Storage and reuse could be increased and eliminate the need for raingardens or storage could be reduced and have larger raingardens.

It should be noted that there are other practices that could control runoff volume but the homeowner would have to utilize the BMP manual and develop a separate report. That might require an engineer to get involved because you get into storage volume needs, infiltration rates, and grading or piping.

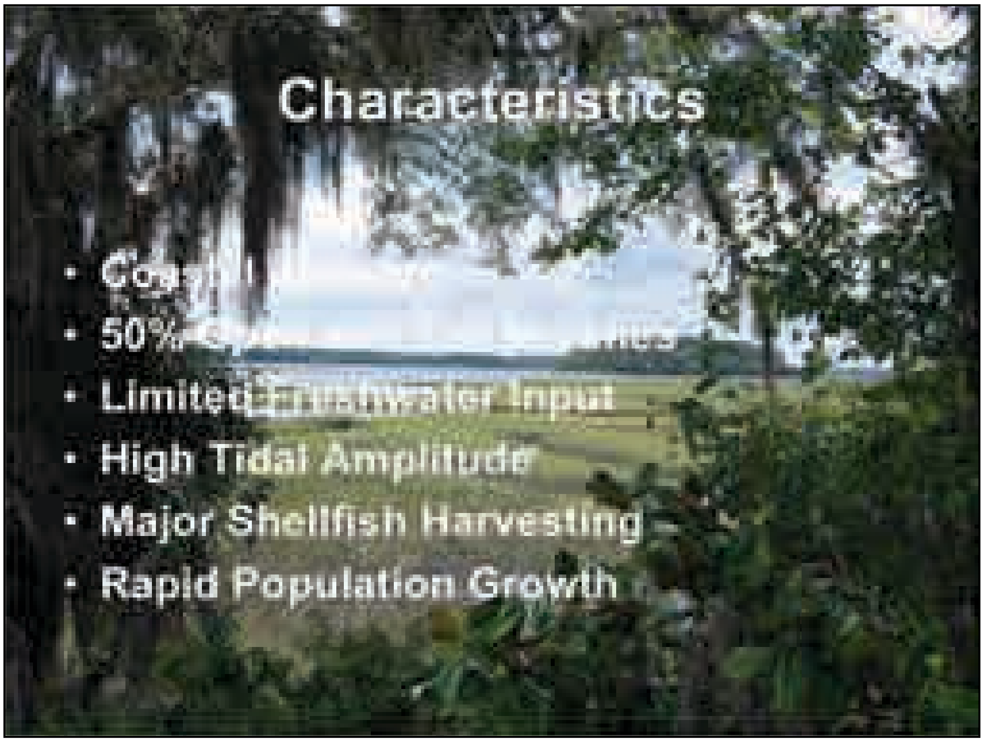
This is the form that would be attached to the Building permit and would be field verified by the building inspector.

Our current version of the tool has lengthened the printout only to provide more clarity to the reviewer.


Here is the location of Beaufort County SC.

We are  between Savannah Ga and Charleston SC on southeast coast.

The county includes Hilton Head Island, the Town of Bluffton, one of the fastest growing Towns in the state, the City of Beaufort, one of the oldest Cities in the nation, and for any Marines in the audience – Parris Island Recruit Depot and the Marine Corp Air Station.




These are the six characteristics that factored into our stormwater control actions in Beaufort County.

We are 923 square miles of Coastal County with over 50% being tidal rivers and salt marsh, with no land over 40 ft of elevation.

Our local scientists tell us we have half of the SC’s salt marsh.

In addition, we have Limited Freshwater Input, a High Tidal Amplitude, we are a Major Shellfish Harvesting source, and we have experienced Rapid Population Growth.

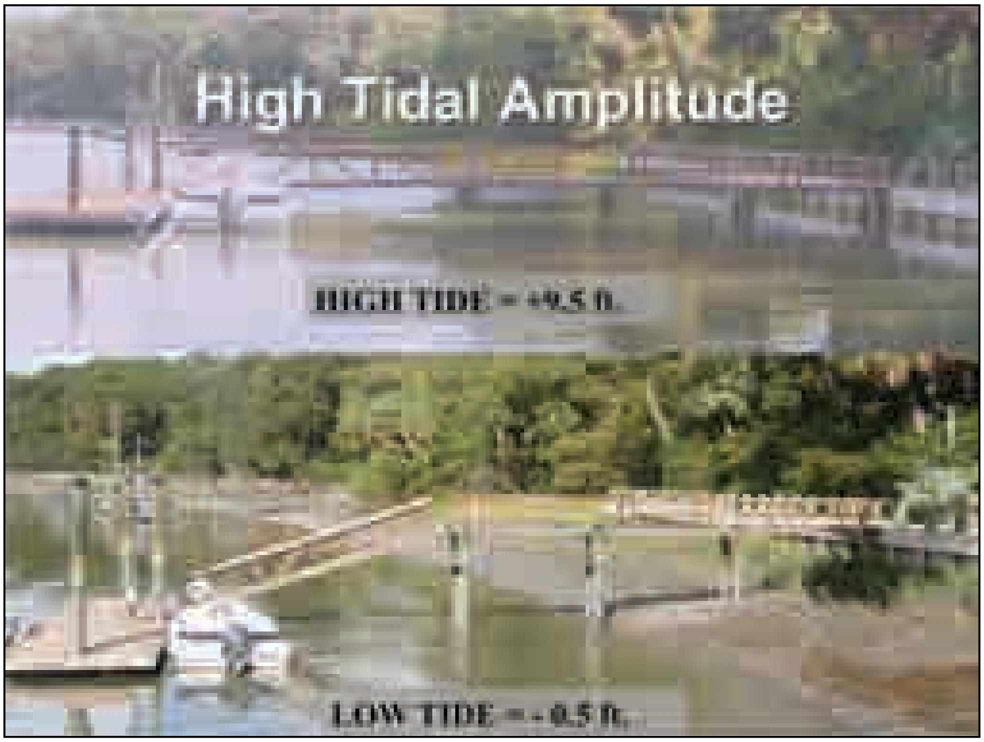
I will go over each of these briefly.


Our tidal rivers and estuaries are saline and brackish. They are more like fingers of the ocean.

Reason for this is that there is little upstream watershed for the Port Royal Sound

It is unusual to have an estuary that does not inherit water quality/quantity issues from upstream areas.

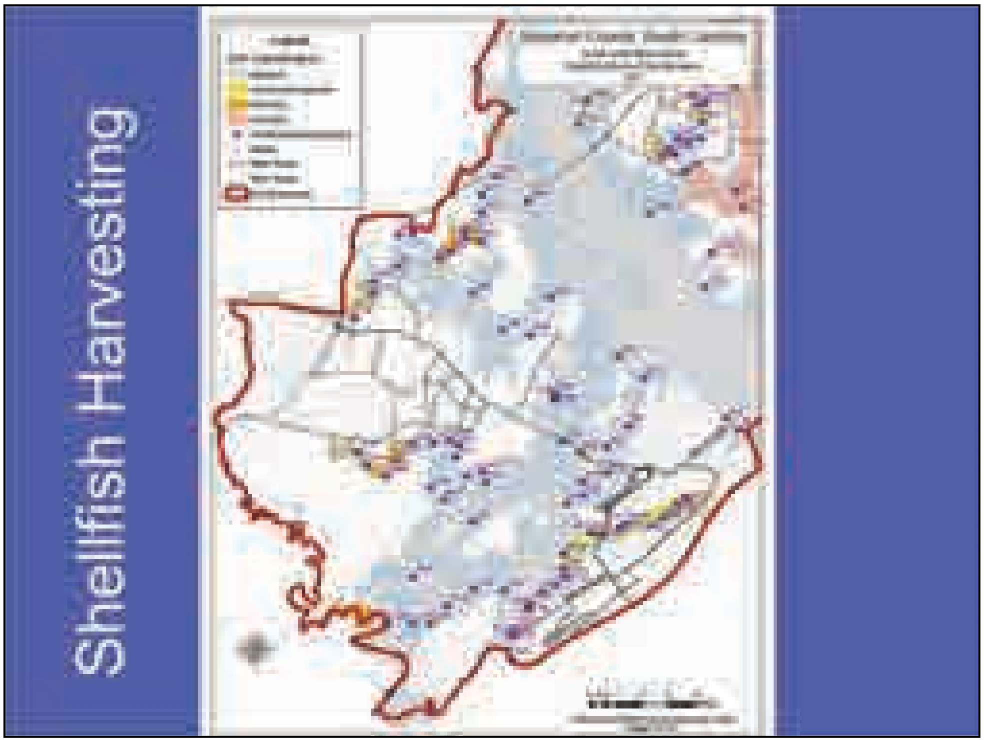
This is why so many of our residents realize they are in control of their own water quality.




The Port Royal Sound has the highest tides along the East Coast below Maine.

This slide gives you a visual of a 10 ft tidal change.

This becomes important when we start discussing the influence of stormwater runoff volume in the salt water estuaries.




In 2007, Beaufort County harvested 2/3rds of the Oysters in SC.

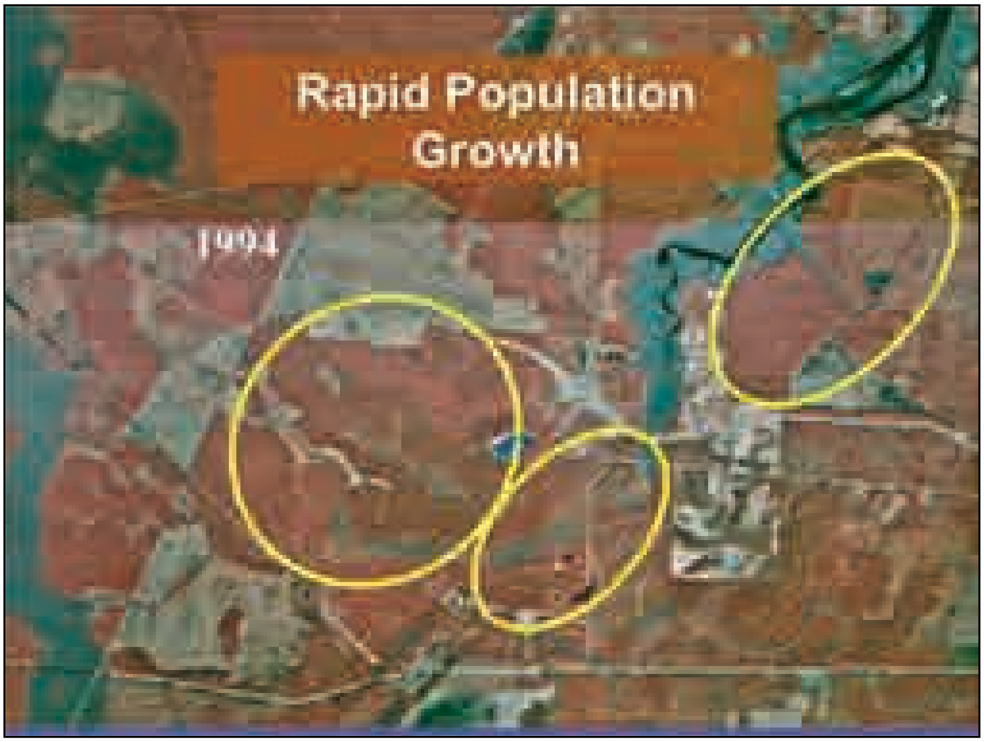
Most communities have gone to a e. coli or enterococcus standard, we still focus on fecal coliform levels. Shellfish harvesting water quality standard is regulated by the FDA, not SC-DHEC, hence the concern over Fecal. Fecal Coliform levels for human consumption is one of the most restrictive standards with a geo-mean of 14 Fecal Coliform colonies per 100 ml - compared to a swimming/recreation standard of 200 colonies per 100 ml.

Beaufort County is split into two section, north and south of the Broad River, which is part of the Port Royal Sound. This is a 2011 shellfish map of southern Beaufort County that shows three of the areas that drove much of the County's Stormwater Controls. They are:

<u>Broad Creek on Hilton Head Island - </u>The 2014 303d list from DHEC removed Broad Creek form impairment and designating it has Approved for shellfish harvesting. This is a tribute to the effort the Town of Hilton Head Island has made with water quality over the past few years.

<u>Upper reaches of the May River is an outstanding state resource water that had a closure in 2009. </u>- One of the monitoring Stations on the May River was also upgraded in 2014 by DHEC - a small victory in efforts the Town of Bluffton is making to reduce fecal coliform levels, but only to be re-classifed as restricted in 2015.

<u>The Okatie River, which also has areas restricted from harvesting</u>. - The Okatie River has a TMDL for bacteria and continues to be a focus of the County's planning efforts on future projects, as I will demonstrate with the next slide on population growth.




So, the Last characteristic of our County is our rapid growth.  Since 1970 Beaufort County's population growth has been above the state and national averages.

This aerial map is of the headwaters of the Okatie River.

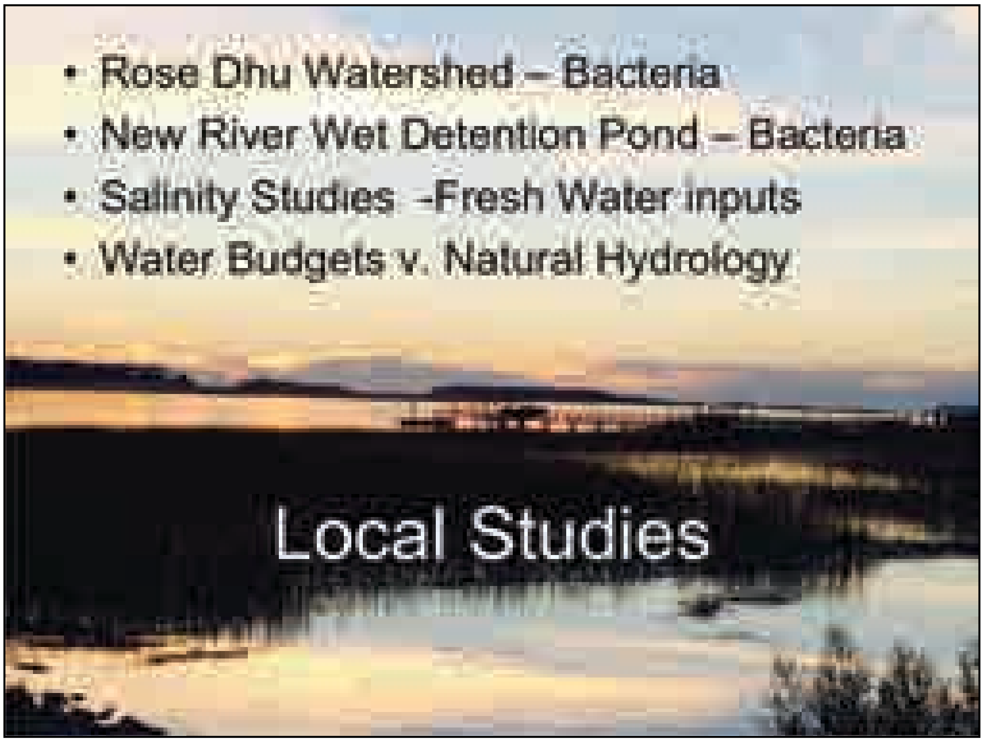
In 1994 are large part of county was managed timber lands.

At the time of this picture the county was just over 100,000 population


Here is the same area in 2006 When the population was estimated to be about 140,000.  2013 estimates have our population at 171,000.

We are now finding out that these tidal headwaters are our most sensitive areas to development.

This tidal headwater is now impaired for Shellfish Harvesting.




We've done quite a bit of studies to prove our concerns.

In the Rose Dhu and New River Watersheds, we found impairment is caused by a Fecal Coliform Load. You can either reduce it by reducing concentration or the Volume. What we are finding is that our watersheds have a high concentration of naturally occurring fecal, but we can successfully remove fecal coliform from the water through detention. However, after only traveling a short distance through the woodlands the fecal coliform levels are again high. This type of data lead to a decision to control the runoff volume since we could not get any further concentration reduction.

But what if we successfully cleaned the water before it entered the water body? Is fresh water a concern? As it turns out, in a salt water environment it is. Sea life depends on the saline waters for breeding and growth. We conducted a Salinity study to measure and model salinity levels in the headwaters of our tidally influenced streams. While we noted the daily flux in salinity due to tidal influence, we also noticed the dramatic changes in the salinity after a rain event. In the extreme headwaters, salinity drops to nearly zero. Due to the large tidal change during the day, tidal slosh, dilution and flushing of the headwaters can take days or even weeks. Literally, volume is the pollutant, not just a surrogate.

And finally, what happened when we unknowingly increase the influx of water into a watershed. Where does the excess water go? We wanted to find out.

Here is an example of what we were finding.

This is Rose Dhu Subbasin of the May River. This subbasin, of about 3,700 acres in the May River watershed, has major interconnected drainage infrastructure, yet development is only partially complete.

The drainage system takes stormwater runoff from developed areas and runs it through a series of ponds and most of it discharges from the developed area at two areas, HH2 and HH3. (Hampton Hall). There is a natural wetland drainage system that is sampled at HH4 and HH5 upstream of the developed area discharges. There are also a number of other sampling points.

I will draw your attention to HH 6 right below the HH2 and HH3 discharges and MRR6 which is the tidal portion of the Creek. The State monitoring station that lead to closure of the Shellfish Beds in the May River is shown as 19-19

Next I'lll show you the some data from these stations

## Sampling Station Fecal Data

| Station Date | January 6, 2011 | January 12, 2011 | January 19, 2011 | January 26, 2011 |
|---|---|---|---|---|
| HH4 | N/A | N/A | N/A | 770 |
| HH5 | N/A | N/A | N/A | 866 |
| HH2 | 6 | 11 | 3 | 14 |
| HH3 | 7 | 5 | 4 | 6 |
| HH6 | 4,082 | 1,072 | 1,245 | 582 |
| MRR6 | 41 | 1,226 | 25 | 1,120 |

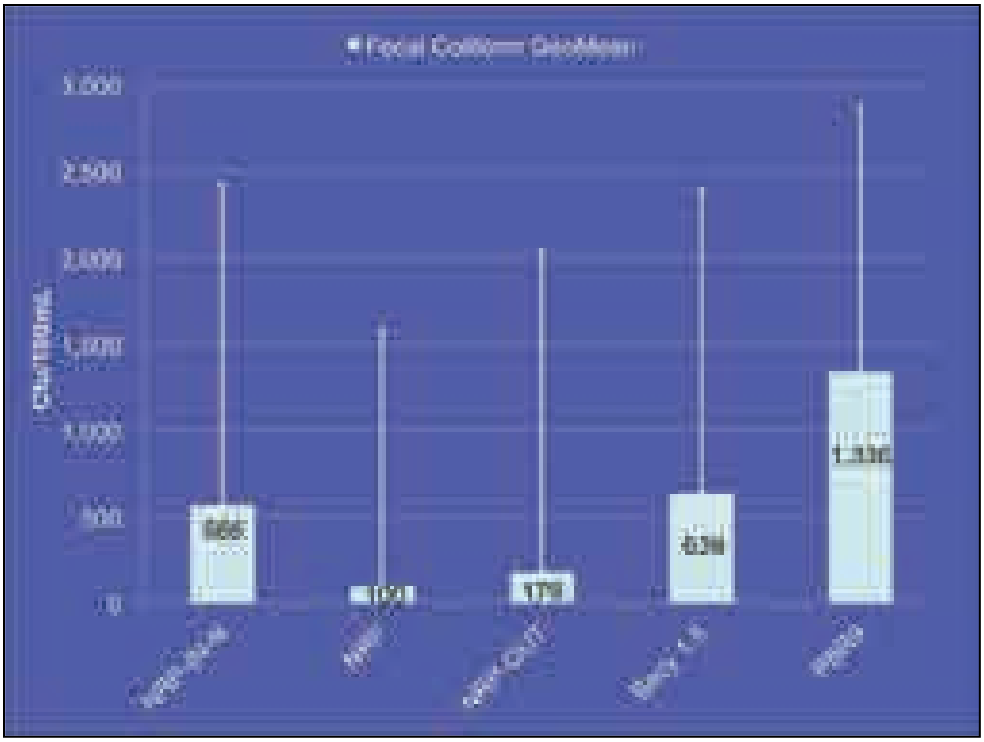
This data indicates no flow in the upstream wetlands (HH4&5) for three weeks in the month of January since December had little rainfall. We now add discharges of low Fecal coliform level fresh water from the pond system (HH2&3) and we do not get good results immediately downstream.

The tidally influenced sampling point further downstream has varying results based on the tidal cycle. During high tide, salt water pushes inland and drops concentration. At low tide, the heavily loaded Fresh water flows out.

Impairment is caused by a Fecal Coliform Load. You can either reduce it by reducing concentration or the Volume.

This type of data lead to a decision to control the runoff volume since we could not get any further concentration reduction.

Here is a more recent study example, and one created by the construction of a stormwater wet detention facility to prove the volume reduction theory.  This subwatershed of the New River watershed is sparely developed.  However, fecal coliform levels were high.  The pond has inflow at two locations, NRP IN North and South, and one outlet, NRP Out.   NRP is located at the outflow pipe, once the water has traveled through the basin.   Downstream is one of our routine monitoring stations, BECY 1.5, and yet further downstream is station PBR9 (unfortunately not representing a 9 pack of beer. Ha ha!), which is located at the headwater of the May River marsh.

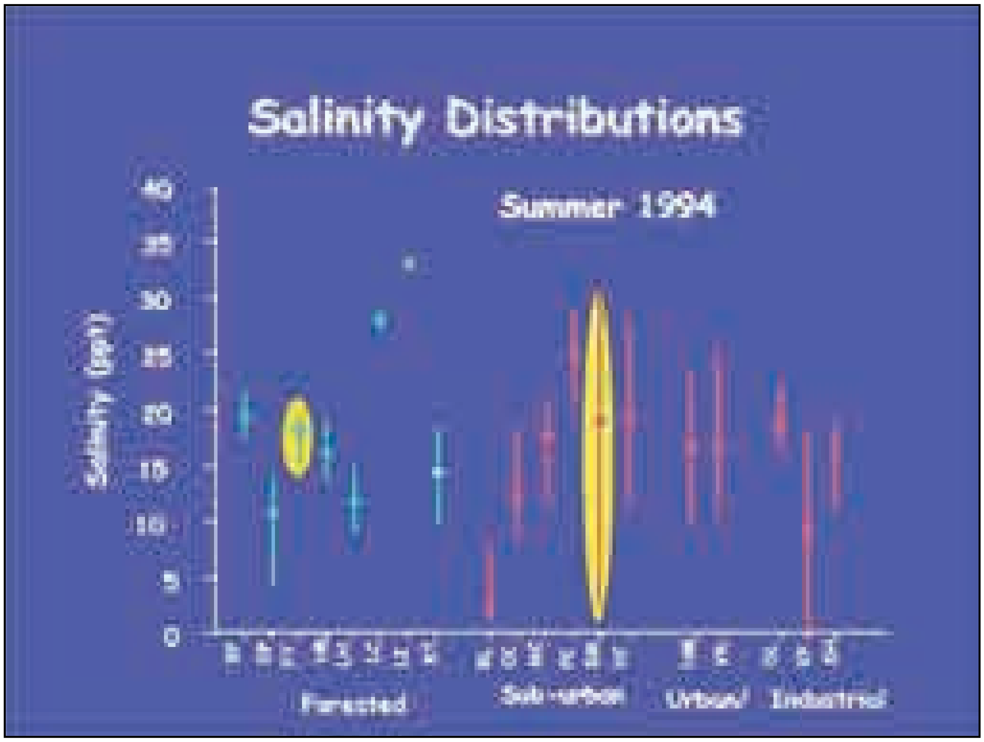



What we are finding is that our watersheds have a high concentration of naturally occurring fecal, but we can successfully remove fecal coliform from the water through detention. However, after only traveling a short distance through the woodlands the fecal coliform levels are again high – similar to our findings in Rose Dhu Creek.

*The data shown is cumulative since construction was complete and we began sampling (July 2013 – January 2015). (The Error Bars on the graph represent the Standard Deviations for that sampling site. )*

*On the map there is a sampling site, NRP-IN-S, that is not listed on the graph. We only pull that site when it is flowing and I believe in 2014 we pulled this location only twice. Both times FC was extremely low.*

What we hope to do in the future is see if we've mitigated the Fecal Coliform at BECY 1.5 and PBR9. Although FC concentration begins to pick back up at these sites, did we reduce the load going into the May River through wet basin treatment and volume reduction? That question is yet to be answered.




So let's talk about how fresh water inputs into salt water estuaries can impact the environment.

We also learned, from our marine scientists, that excess runoff volume, even if it could be kept clean, could pose serious risks to our marine resources because our tidal headwaters are fishery spawning grounds and low salinity can be toxic in their spawning cycle.

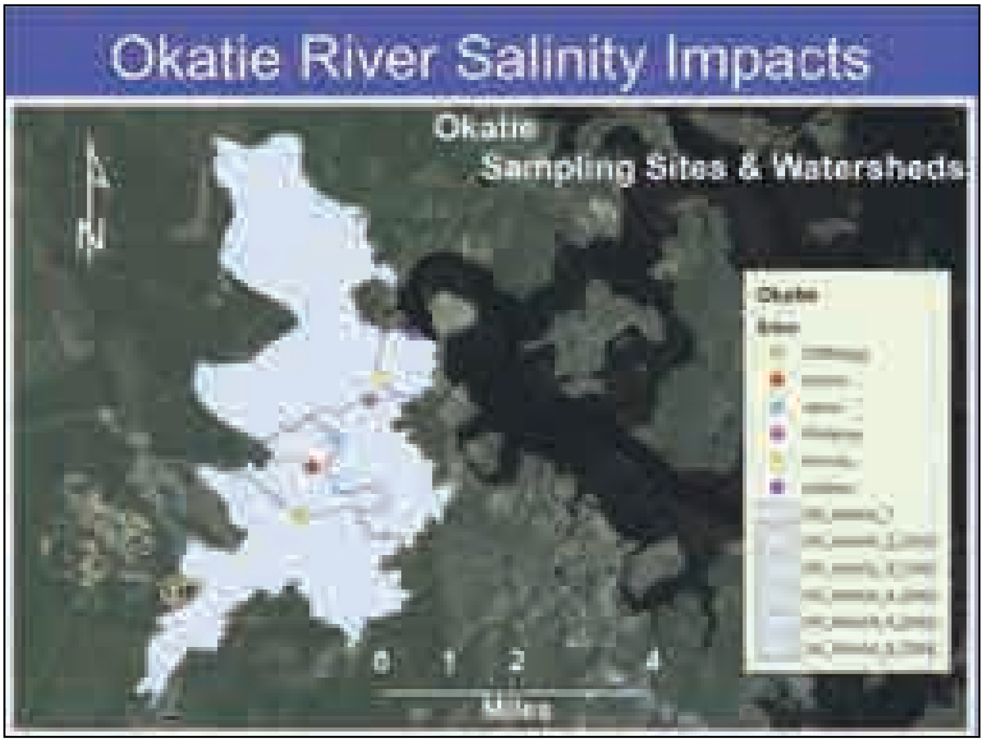
The next series of slides will show you the problem with this.

This chart is from research by NOAA.  It shows salinity variations that occur in volume uncontrolled developed watersheds.

These variations have occurred naturally in larger rain events, but are occurring with greater frequency and amplitude with development.

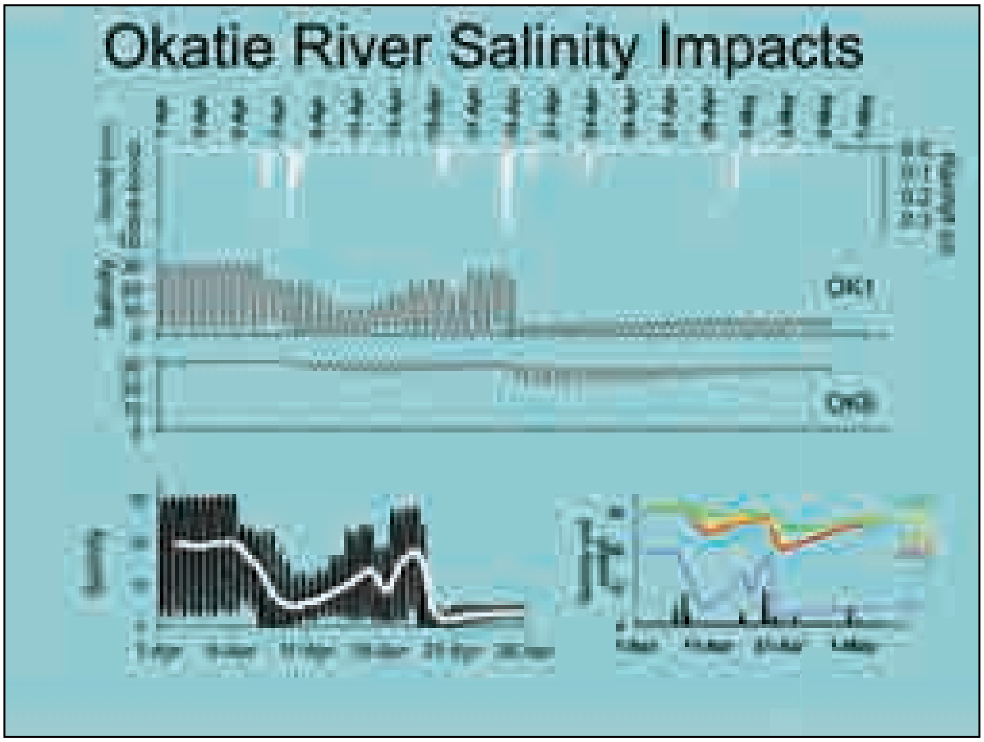
This chart compares salinity ranges of forested to developed watersheds in the Charleston SC area.  Some of the creeks in the developed areas go nearly fresh. Notice the two highlighted creeks.  Same average but much larger change.

This increased change of salinity is being called salinity “flashiness” by scientists



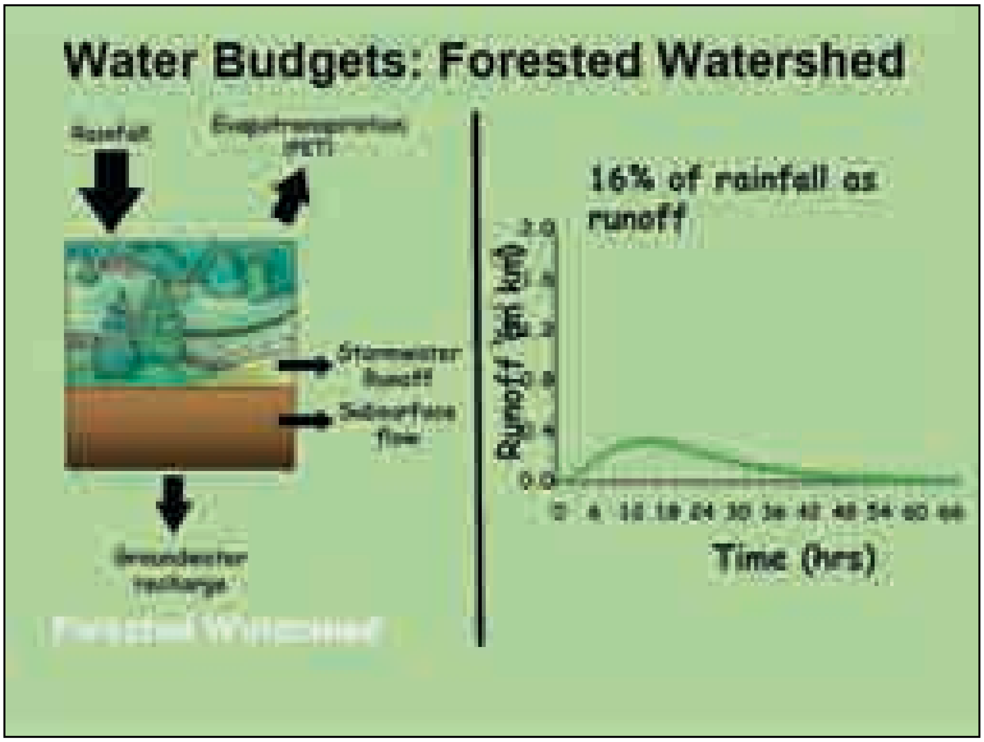

This is a most recent study. The South Carolina Department of Natural Resources Marine Resources Division and the Univ. of SC Beaufort head a collaborative team including SC Sea Grant Consortium, the ACE Basin National Estuarine Research System Science Collaborative, NOAA, and the County to study the impact of urban runoff on Salinity. Not only are we collecting empirical data, we are developing a model that can predict sensitivity of salinity change by urban runoff based on land use, soil type, etc.

This is one of the watershed being studied. Here is the Okatie River watershed map again. Okatie River happens to be impaired by bacteria and has an approved TMDL. Like the Rose Dhu watershed, this watershed has been heavily developed in the last decade, which directly contributed to the problem. The upper most reach of the watershed, where most of the development has occurred, has the first monitoring station, OK1. The stations continue downstream.




This chart is a sample of the data collected at Okatie #1 and comparing it to the other stations. Note the daily flux in salinity due to tidal influence. Then notice the dramatic changes in the salinity after a rain event. In the extreme headwaters, salinity drops to nearly zero. Further downstream, the effect is less. Normalizing the average daily salinity levels (in the bottom left chart) you can see the trend as it relates to storm events. In the bottom right, we have plotted the average daily levels for all 6 stations on the same graph. Again, as you move away from the headwaters, the sensitivity of salinity levels changes due to runoff is less.

Thinking back to one of the first slides, you will recall the large tidal amplitude we experience daily. As a result, fresh water is trapped in the headwaters for day, sloshing back and forth. A large salinity drop, combined with a heavy pollutant loading, is detrimental to aquatic life.

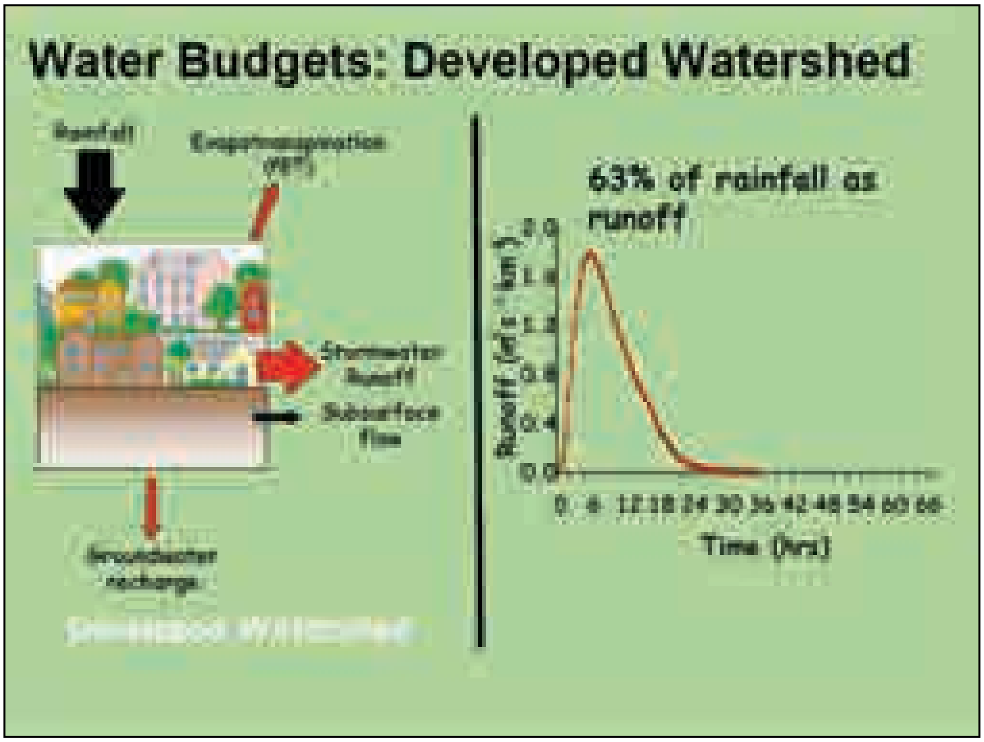



I want to take the next few minutes to discuss an important concept in volume control, the Water Budget, and how it relates to the integration of water quantity and water quality.

I am going to use a couple slides from a Tidal Creek Habitat publication and a couple we developed to illustrate how volume controls evolved.

This shows the undeveloped situation – Pre development

Note the high evapotranspiration and low percentage of SW surface runoff. The 2004 South Carolina Water Plan said that in Beaufort County the average annual precipitation – subtracting evaporation - is less than 10 inches. This means more that 38 of our 48 inch rainfall goes back up in the atmosphere.

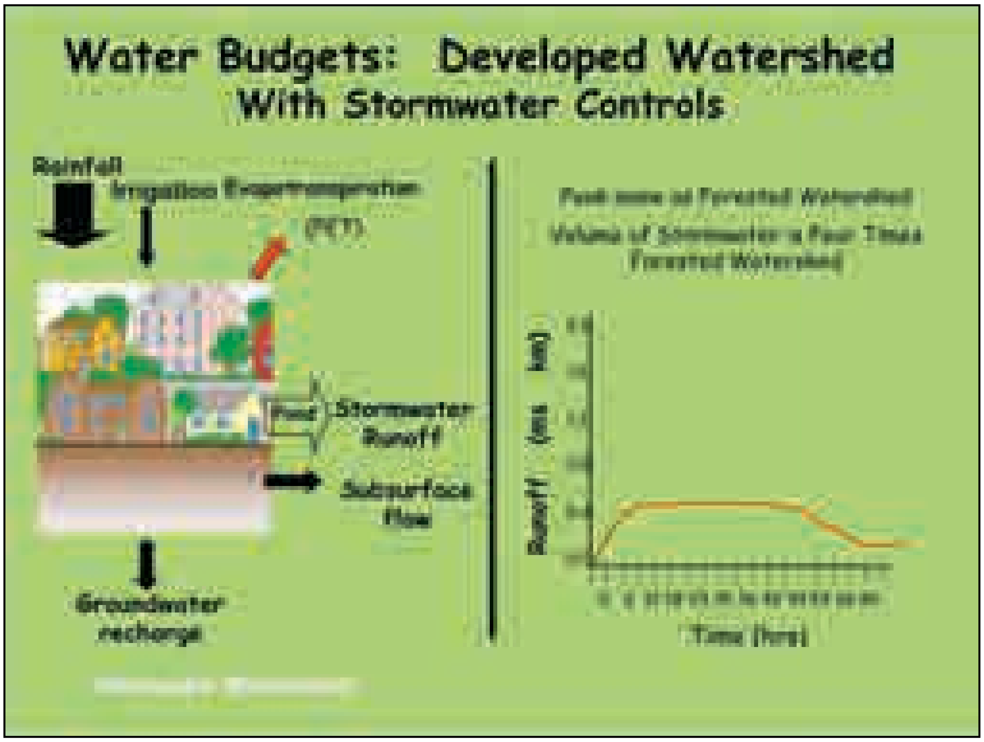



This is the developed watershed example without volume controls.

Note the lower amount of Evapotranspiration and the increase in SW runoff.

This would indicate that four times the volume of SW runs off the site at a very fast rate. The peak is indicated to be over 4 times the pre development rate and it is picking up pollutants.

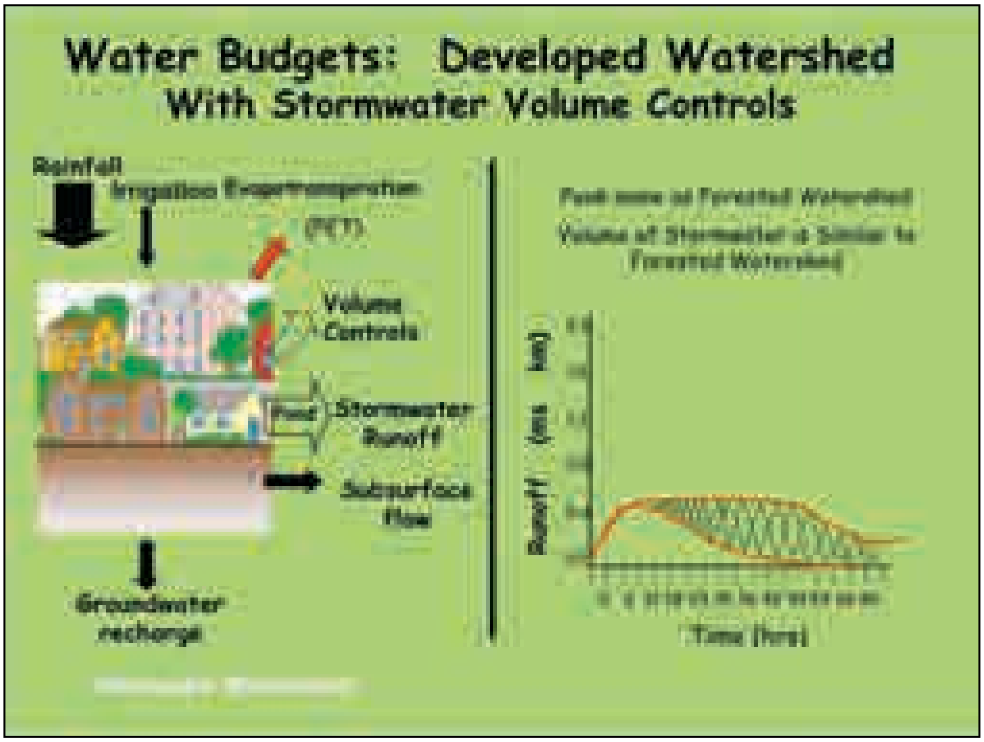
We will now go to our next slide which depicts Beaufort County’s pre volume controls coming to the rescue.




This slide shows what happens when we address only the first two causes of impervious surface increase. (Peak flows and water quality) Generally that has been by ponds in Beaufort County and they did a good job addressing the first two causes as you saw in the Rose Dhu data.

Unfortunately they didn't reduce the runoff volume just slowed it down and cleaned it up.

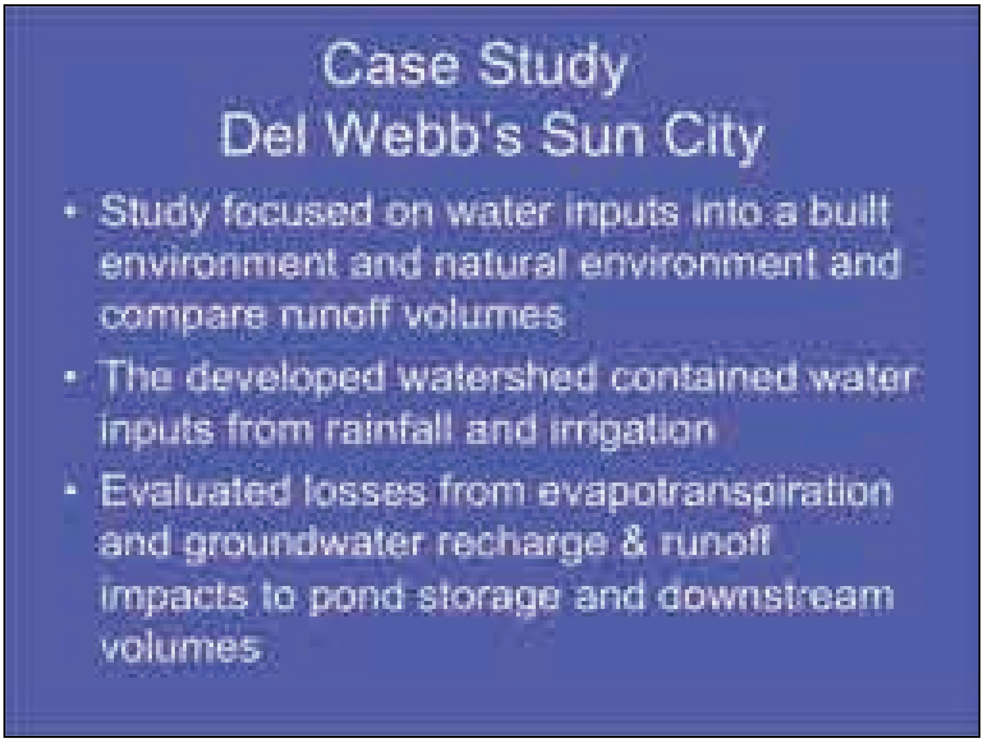
This slide shows that the total volume could still be 4X predevelopment.




This slide shows what happens when we add volume controls to the picture.

The new volume controls require volume above that would be expected at a 10% equivalent impervious area (EIC) (handle small 95% percentile storms) to be either infiltrated, evaporated or reused.

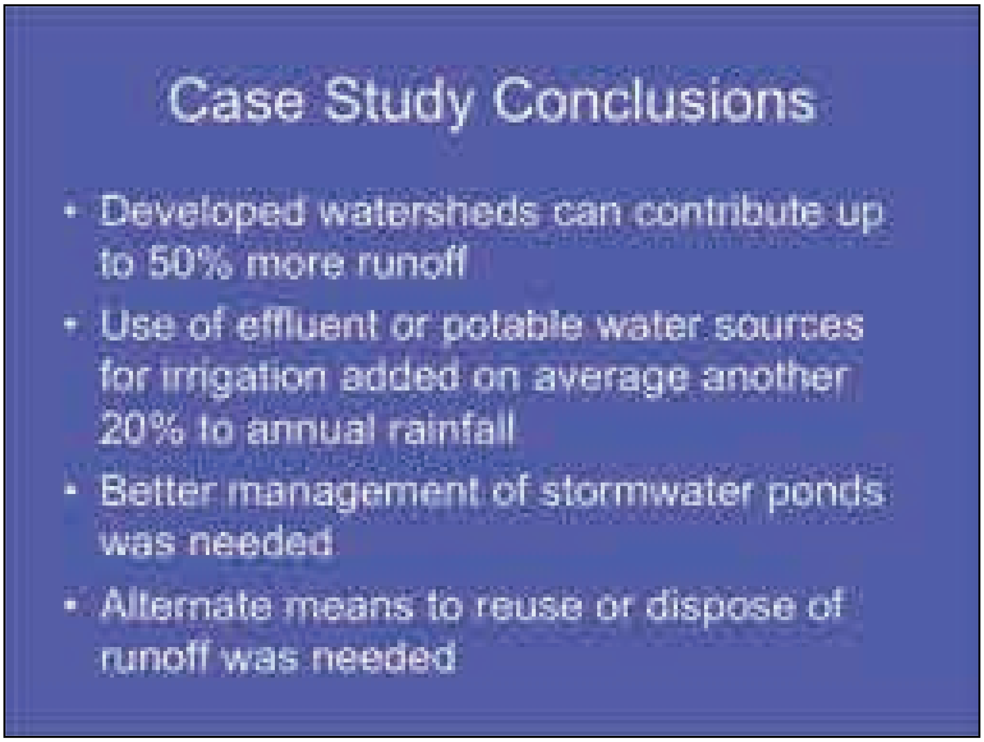
What we are seeing is that New developments seem to be going to retention and reuse for irrigation as a solution for larger developments. On-lot solutions are using disconnected impervious surfaces and bioretention.




Here in Beaufort County, we commissioned a study to demonstrate the concept of the Water Budget. The study focused on water inputs into a built environment and in to a natural environment and then compared runoff volumes. The developed watershed we studied is the Del Webb Community, Sun City, located in the Okatie River watershed.

As you would expect, the developed watershed contained water inputs from rainfall and irrigation sources such as effluent water supply from the waste water treatment plan or potable water. The study then calculated losses from evapotranspiration and groundwater recharge & evaluated runoff impacts to pond storage and downstream volumes.

While this study did not specifically model water quality and pollutant removal, it builds on the concept that less water downstream means less loading, even if at the same concentration.




So what did we learn?

Developed watersheds can contribute up to 50% more runoff

Use of effluent or potable water sources for irrigation added on average another 20% to annual rainfall

Better management of stormwater ponds was needed.  Ponds need to be drawn down after rain events to prepare for the next event.  Use of potable water, reclaimed effluent water, or groundwater to fill ponds for aesthetic value needs to be minimized.

Alternate means to reuse or dispose of runoff was needed.  Aquifer storage and recovery is a viable option for stormwater disposal.