Criteria Assessment Protocols Workgroup

August 9th, 2016

USGS Baltimore Water Science Center
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Minutes

10:00 AM Welcome (Peter Tango USGS@CBPO, Chair - Criteria Assessment Protocol Workgroup)

INTRODUCTION TO THE MEETING:

10:10AM Review of our charge and overview of our process. (Peter Tango).

We are charged with providing recommendations on any adjustments to the existing CHLA criteria assessment protocols that provide decision rules for measuring water quality standards attainment in the tidal waters of Chesapeake Bay.

- The Chesapeake Bay Program (CBP) has recently charged the CBP Scientific Technical Assessment and Reporting Team (STAR) for reconvening the CAP WG with the short-term task of 1) critically reviewing the existing tidal waters chlorophyll *a* assessment procedures and 2) providing consensus recommendations on any alternatives to consider in revision of the existing procedures by **mid-September 2016**.
- The charge references the urgent need as: "*These recommended procedures would need to be presented to Virginia DEQ's James River Chlorophyll Criteria Re-evaluation Regulatory Advisory Panel (RAP) at their September meeting. Virginia is following regulatory promulgation process which has strict deadlines within a clearly defined overall schedule. In order for Virginia DEQ to make needed decisions by the December timeframe, there is a need for their RAP membership to hear the CAP Workgroup's recommendations in September*."
- We need to develop statements of support on the following issues:
    i. The sampling protocols supporting chla assessments.
    ii. The averaging period for the data collections in the assessment,
    iii. The interpolator operations
    iv. The application of the CFD for supporting attainment decisions
    v. Decision rule(s) on impairment status

SEE PRESENTATION.

Peter reviewed the charge that has been given to the CAP Workgroup regarding the development of recommendations for any changes to water quality standards attainment assessment of chlorophyll *a*. These recommendations are scheduled to be presented to VA DEQ's James River Chlorophyll Criteria Re-evaluation Regulatory Advisory Panel (RAP) around the time of their September 2016 meeting.

The resulting recommendations for a protocol method will not only be used in the field, but also for modeling scenarios that determine how our actions are meeting TMDL expectations. Decisions on updating the protocol for chlorophyll a standards attainment assessment in Virginia are anticipated to

serve as a model for other tidal water states and Washington DC for adoption into their protocols for assessment, indicating that there are wide-ranging implications for the outputs of the CAP WG here.

It is important that the updated protocol improves accuracy of the assessment results. A revised protocol is envisioned to have fewer untested/untestable assumptions than the current framework, does not require a monitoring design that is especially burdensome in resources required for making the assessment yet is compatible with EPA's "all existing and readily available water quality data" mandate, and can be used to process model output for TMDL/attainability analyses.

10:30AM Alternatives for CHLA Assessment – Presentation by Tish Robertson, VADEQ.

Reference documents attached:

1. SEE Presentation on Alternatives for CHLA Assessment
2. Critical Review of the CHLA Protocol Assessment.

Tish reviewed VA's current chlorophyll *a* standards with its criteria and assessment protocol. The current standard is bounded in its application by the main stem of the James River for spring and summer seasons. The James River shows few issues with hypoxia and numeric chlorophyll criteria were adopted into state standards to stand in for severe hypoxia levels. Tish also reviewed the James River Chlorophyll study. She provided a brief overview of how they assess chlorophyll *a* criteria for the Bay. VADEQ samples on a monthly basis with their fixed stations. VADEQ also have Dataflow (i.e., water quality mapping) data on a weekly basis, on a portion of the James River mainstem.

Tish also reviewed the Bay Interpolator and the interpolation technique that estimates data for regions where no data are collected. The collection of data layers resulting from interpolating each monitoring cruise of information is used to generate a seasonal mean in each grid cell for a segment of the James River. The seasonal mean layer allows for a calculation of the spatial exceedance rate of the applicable criterion. This is done for a three year assessment window, the results from each season are used to create an assessment curve that is compared with a reference curve. At this point in time, the reference curve is a hyperbolic 10% reference curve that was previously agreed upon and published in EPA guidance. The curve is part of the assessment methods that are adopted into VA water quality standards.

Tish then identified some issues with the current assessment protocol. One issue was the high uncertainty when fixed station datasets are used. There is higher variability of chlorophyll concentrations than what the Bay interpolator can process. Utilizing work done by Elgin Perry with con mon and DataFlow, it was found that assessments which are based on fixed station datasets tend to be highly biased towards non-compliance and bear little resemblance to the "true" picture of attainment.

Tish confirmed that this analysis was done with three seasonal means, (as opposed to monthly or instantaneous values), in accordance with their water quality standards assessment program.

Another issue that Tish reviewed included the defensibility of the 10% reference curve. There are questions raised here about the 10% attainment curve and whether it's an accurate depiction of conditions that yield an appropriate picture of standards attainment. DEQ contracted with Claire

Buchanan (ICPRB) to generate bioreference curves based on exceedances of the James River chlorophyll criteria when nutrients are low and light availability is high (i.e., reference conditions). The assumption is that when nutrients are low and light availability is high, reference-like phytoplankton communities will be found. Because the data for the James River was limited, Claire looked at all Bay habitats. She reviewed the Chesapeake Bay database for data going back into the 1980s to evaluate chlorophyll levels with respect to the appropriate James River criterion. She would count how many monitoring events exceeded James Polyhaline criterion and then divided by all monitoring events that met all of the criteria. The assumption is that this would be a spatially balanced data set to make the inference that it would translate to a spatial exceedance rate for that particular event.

Tish suggested that most of the bioreference curves that were created by Claire Buchannan do not conform to the 10% curve. Most of the bioreference curves look to be more lenient than the 10% reference curve. However, we cannot determine the true reference curves at this time, since her analysis was instantaneous and the criteria is a seasonal measurement.

There is a capacity beyond the criteria that is still okay, an allowable exceedance, which pertains to error and uncertainty. It was originally meant to hedge against false positives to equipment and human error.

Tish then reviewed **possible alternatives for assessment protocols.**

USING DATAFLOW and FIXED STATIONS

- How accuracy may be increased by sampling differently.
    - Currently surface measurements are within 1 m from the surface. An alternative can be sampling with a depth integrated assessment approach.
        - Con- Data Flow is a surface mapping approach, not depth integrated. However, there are other technologies that could accommodate this alternative such as vertical profilers, Autonomous underwater vehicles or Acrobat towed behind a boat.

- How can we evaluate the data in a more defensible manner? **Using Dataflow+ Fixed Stations**
    - Option 1: Assess a segment-wide seasonal mean against the criterion. Consider rule for out of attainment as more than one seasonal violation (if 3-year) or two (if 6-year) exceedences allowed.
        - Con- Hot spots can be masked when using a segment-wide mean approach.
    - Option 2: Continue to assess spatial exceedance rates
        - Use a bioreferenced CFD with 95% confidence
            - Con- What would be the reference population? We have not agreed upon this yet.
        - Impairment is defined as cumulative exceedence rate greater than X%
            - Con- A decision is needed for what X% should be used and what would be the rationale?
        - Impairment is defined as any single exceedence rate greater than X%
            - Con- What X% should be used and what would be the rationale?
        - Impairment is defined as average exceedence rate greater than X%
            - Con- What X% should be used and what would be the rationale?

USING FIXED STATION ONLY

- How accuracy can be increased by sampling differently.
    - Increase accuracy by changing assessment period? 3year or 6year
        - Con- Presently, we see there is high uncertainty with a small assessment window
    - Use depth integrated samples?
        - Con- What is the value added for changing our approach to require depth integrated measures of chlorophyll *a* over just a surface value?

- How can we evaluate the data in a more defensible manner? **Using Fixed Stations ONLY**
    - Option 1: Assess station seasonal means. Impairment is defined as an average spatial exceedence rate greater than X%.
        - Con- Many additional fixed stations are needed.
        - Con- What threshold would we use?
    - Option 2: Assess station seasonal means. Impairment is defined as any single spatial exceedence rate greater than X%.
        - Con- Many additional stations are needed.
        - Con- What threshold would we use
    - Option 3: Assess **segment** seasonal means (aggregated station data). One (if 3-year) or two (if 6-year) exceedences allowed.
        - Con- Some additional fixed stations are needed.
        - Con- Hotspots can be masked.

DISCUSSION

Peter asked how fixed stations and Data Flow data were combined in an assessment. Tish responded that they interpolate each monitoring run separately. If a run falls on a different date, they get two different interpolations according to the date the data were collected. When they create seasonal composites, they average all interpolations to produce the seasonal mean layer.

Claire asked about a scenario in which a 9% exceedance every year actually results in degradation. Would you consider a rule other than 10% every year? Tish replied that she only discusses uncertainty. That question would need to be decided at another time.

Claire asked if it would be better to use monthly samples instead of seasonal mean? Tish answered that the duration of criteria (averaging period) might be changed to improve certainty, but she does not think it would be best practice to do that at this time. However, instantaneous criteria or annual mean criteria could be used to increase sample size, but that shouldn't be the reason to adopt criteria with those durations. The durations should be set to the particular endpoint meant to be protected. Claire reiterated that if you went to instantaneous criteria, or monthly average, the ideas presented would still hold. Tish confirmed this by saying the 10% rule could be used with that instantaneous data. All of the options presented could be used with the criteria, but the issue of criteria duration is a separate discussion and not a protocol specific discussion.

Clifton Bell served on the James River Science Advisory Panel (SAP) and discussed the effects-based approach for deriving criteria and how it would seem to support the "pooled approach" for data

assessment. The SAP report analyses looked at the correlation between seasonal mean chlorophyll *a* and various effects, indicators that might correlate with potential impairments- DO, pH, etc. The analyses looked at the relation between chlorophyll *a* and the probability of the effect, but then integrated that over a season based on what was seen in the instantaneous relationships. The SAP reviewed the question of what the implications were for the overall space-time occurrence rate of that effect. This is important because it was related back to an effect in space-time.

Peter asked if Elgin's simulation work, and the grid that is currently being used, makes sense with the data density to accurately capture the variability of the appropriate scale? Tish thought that it was, at least for the James PH. The interpolator cells used in the lower James are 1kmx1km, which she felt was fine because the spatial correlations were consistent with at the scale of about 1 km.

Tish added that from day to day there is a lot of variability in time as well as space, creating a very different picture from day to day. Will confirmed that this leads to the idea that a lot of conditions are being missed. Peter added that the ability to extrapolate through time may or may not capture the reality.

Mark Trice mentioned a comparison study with continuous monitoring fixed station sampling and other sampling methods which resulted in a lot of variability in the results. A three-day study was done with the remote sensing and its difference with *in situ* monitoring, and there was a lot of variability there as well.

Mark Trice added that for the James, satellite data could potentially supplement the current data collections.

Will added his thought that Data Flow should be used to improve the averaging, since even with con mon and Data Flow, the entire picture may still not be captured.

Mark also mentioned the resource of aerial runs by Harding and current data from the Chesapeake Bay Remote Sensing Program: www.Cbrsp.org. This website contains 25 years of data.

12:30-3PM Afternoon. Lightning round. 30 minutes per issue. 5 issues. First thoughts toward consensus statements.

> I.   **The sampling protocols supporting chla assessments.**

Surface vs. depth integrated.

Will Hunley discussed surface vs. depth integration data collection. VA DEQ started off taking vertical profiles that showed vertical heterogeneity during the sampling cruises. Typically there is more chlorophyll near the surface, decreasing as depth increased. However, these sampling cruises occurred during the morning however, when the dinoflagellates exhibited a vertical migration pattern. During an extensive bloom, they tend to be aggregated at the surface during morning hours. This could lead to a bias towards higher estimates of chlorophyll. Conversely, the migration pattern could lead to a concentration of chlorophyll at night, possibly biasing towards lower estimates of chlorophyll in measurements. ODU helped to conduct studies on this at a fixed site. However, at a fixed site, the bloom can move. A surface and bottom con mon was installed that showed a chlorophyll signal that showed diurnal behavior with vertical migration. ODU is trying to relate these patterns to tidal currents,

salinity, and a number of different parameters. The vertical component could potentially affect the pass/fail of attainment, but this study is not complete to definitely claim this yet. Will Hunley's recommendation: the best available information says we should use surface data, but this should be put on a long term research track to possibly revise this recommendation after ODU finishes their study. A status report could be given to show the state of the research.

Mark Trice added that similar effects have been observed with ConMon sites in part because these are 1 m below the surface and portions of the plankton community such as the dinoflagellate community migrates. If you used satellite data, there is still vertical integration with the satellite sensors but that effect varies based on turbidity and other factors.

Claire Buchannan discussed her research in the upper Potomac River regarding vertical migration of zooplankton. Her research showed that the tidal exchange produced hydrodynamic forcing that would not allow for sustained vertical stratification leaving the water column well mixed. If one were to extrapolate to phytoplankton, phytoplankton are probably very well mixed in the tidal fresh environment, and is a very different situation from the polyhaline.

Joe concurred that it seems premature to change the depth of sampling given the amount of time until the recommendations are required. He agreed with Will's recommendation of continuing research to help update information at a later date.

ODU has been using hand deployed sensors hourly of vertical profiles over 24 hours to collect data that will help evaluate this question.

Tish asked if, when Mark Brush conducted Acrobat monitoring, if they had fluorescence sensor, beyond dissolved oxygen. We think it was just dissolved oxygen. Tish continued if you could compare the chlorophyll profiler with the shallow water con mon, would they get similar results.

Peter revisited for clarification that the criteria only applies for the open water mainstem of the James River. Tributaries do not have this criteria in Virginia- only oxygen. Tish added that the standard does not specify "where, but simply states "open water," which extends shoreline to shoreline. In that way, it is not limited to the shallow water use, but rather complete open water.

Will added that this vertical component is just an issue that will not be resolved at this moment. Both Tish and Will agreed a depth component would create complications.

Claire added that if a chlorophyll probe is used that isn't protected, bleaching occurs giving an artificially low, incorrect reading.

Peter asked, when utilizing fixed sites data and Data flow, if there is a minimum sampling density per segment that the chlorophyll procedure should be applied to? Would this be a limitation? Joe from CBF added that when you look at fixed stations and Dataflow, you get different answers. Dataflow is a higher quality. So is it even worthwhile to do single station sampling if it's too far off from the higher quality Data Flow? Therefore, how many fixed stations would you need to somewhat equal that quality? Tish did an analysis looking at the ability to estimate spatial exceedance accurately. For example, if you have x number of stations, how close would the results compare to the Data flow results? And the results showed that it's not very close. Tish added that she does not believe however, that monitoring chlorophyll requires Data flow, since the main goal is to find evidence to detect problems. This is an

aquatic life use and should be handled accordingly. Peter added that some info is better than no info. He added that we may continue to use the data but with the awareness that there are limitations to the fixed stations.

Tish added that an option for fixed station collection could include sampling more in a single season when an issue has been indicated. This would be breaking away from the usual protocol of listing and delisting water bodies by using the same data. Joe commented that this would lead to two different ways to evaluate data- requiring two different values. Logistically this would be challenging. Tish agreed. If DEQ listed a station based on its stations as impaired, and then citizen science indicates that it's fully supporting, how would we integrate this data?

Decision of the group:

Continue surface monitoring as before. The incorporate depth measurements is an unresolved decision that needs more research and follow up. Even though continuing surface monitoring *may* introduce a positive bias in the data. The gap has been identified here.

ii.   The averaging period for the data collections in the assessment.

Should this assessment periods change from a 3 year assessment?

Tish added that the longer averaging period allows for a greater sampling size. This also helps with the extreme annual variability. In the lower James River, there are some years that are really bad years, and shorter assessment periods exacerbate the "flashy" quality of this data.

Claire suggested that in addition to lengthening the assessment period, we should do away with seasonal averages. She recommends monthly averages or greater. Algae blooms don't last an entire season, therefore they would be easy to miss with this assessment period. To focus on a seasonal average would probably be very limiting. Monthly averages would help to even out the data.

Mark confirmed that, by comparison and similarity, water clarity assessments look at the individual cruises. However, these assessments are over a three year period with a yearly average of those results. The decision rule regarding attainment is based on the single best year of the three year time period.

Will added that this is a criteria duration issue. We need to decide what the criteria will be first and then assess to that. We need a recognition that we can't change the criteria but need to figure out how to work with the seasonal data, and a way to do this would be over a longer assessment time of 6 years. Peter added that if our recommendations recognize that we are not in the business of working with the criteria, then we can possibly take it on in the future in further depth if they request it.

Tish added that if you had a longer duration, using annual means, you could have more samples to create that mean and therefore have more confidence in the results. But you would need to move away from the CFD to do this.

Matt added that modeling should be considered in this, because the models are poor at predicting individual chlorophyll a values, but can be decent at predicting seasonal means and annual means.

Tish added about the gray area in data analysis of fixed stations. One option would be to evaluate the past six years to resolve the issues. Three year data currently used, six year data could be used to extend

the data window when there isn't enough data to be had. Tish believes there is a precedent for this from the SAV/Water Clarity work. If there's not a lot of confidence in an assessment period, you could expand the evaluation period to include the previous three years, to see the long term picture to help make decisions. Matt Stover added MD uses this type of protocol for bacteria and beach data.

Peter reminded group members that we can return to these thoughts in the next meeting.

iii.   The interpolator operations.

Knowing that the Bay Interpolator may not provide the clearest picture for segments with only 2 data points, and may not take into account data points' location in space, what alternative options should we consider?

Tish added that using the fixed stations most often causes accuracy issues in the Bay Interpolator.

Claire asked Tish about instead of restricting everything to the segment, what if looking up and down stream segments to the stations would help provide more accurate interpolation? Tish added that the program would need to be reworked to do this, since the search window is by segments.

Claire asked about connecting the 1km segments, by stretching the river out, for kriging purposes.

Mark added that for a handful of fixed station sites, interpolation is hard because it would make more sense to define the aerial extent that the site represents, more like a triangulation type of interpolation instead. Will agreed. Will added however, that the dataflow cruise track requires interpolation to make that data representative.

Tish added that we need a lot more confidence when it comes to regulation like 303d lists, which is why we need to find methods with more defensibility.

Mark added that within ArcGIS, and the geostatistical analysis, you can use kriging to do a confidence interval, based on sample path, similar to a rate of change of your parameter. It results in a confidence interval map, showing which region might be under-sampled, which could be a very useful tool.

Tish added that this is basically like accounting for what they're doing. Stakeholders have questions, and we need to account for what we're doing. It's possible that the interpolation might be part of the issue. We need to start using science that does justice to our monitoring data. Matt added that data flow is the only answer then. Tish said that it would be so if we stay with our current assessment framework.

Claire asked about using satellite image as the interpolator, and then using fixed point data to calibrate individual cells, then using the pixels in the image. Mark followed up that there have been workshops on this and it was not useable data. But Mark will look into this option to be sure.

Tish added that we it would be great to have con mon data incorporated with the 10% CFD.

Will added that to limit the interpolation on the cruise track is probably a good idea because it would give flexibility and would not require interpolation too far out. Some of his cruise tracks will actually be adapted to hit more cells. Tish added that she has confidence if we did data flow in mid channel, it

would be a good job in capturing the chlorophyll. Because to interpolate across would only add unnecessary error.

There is concern about getting the consistent funding for infrastructure and maintenance costs for this. $174k for Dataflow start up on a boat. $60k for annual maintenance for the program. This may also extend runs that are currently being done, to two days or more.

Peter summarized that we need to continue to understand the interpolator, the search window, can we get three points, kriging, the value of ArcMap, and the search barriers. There was a reference to the representativeness of the site, as well as the policy dimension of confidence and defensibility. We need to remember these concerns as we continue future discussion on this topic. If we are interpolating beyond our capacity to effectively describe the characteristic of what's actually happening, does that move us more towards an alternative?

iv.   The application of the CFD for supporting CHLA standards attainment decisions.

Tish added that the only pro to the current CFD approach is that it's the one that's been used for so long. The cons to switching will include defending it. While having a lot of Data Flow would be ideal, chlorophyll does not warrant a highly expensive monitoring program and there remains discussion on the issue of defensibility with reference curves.

Claire added that the criteria is a seasonal mean, and the mean is central tendency, so half the time the data is above or below it. It is not a threshold criteria. The original 10% curve (CFD curve process) seems to be best for the upper threshold. Claire says that the assessment curve should match the metric you're using to evaluate the data. Tish agreed that everything has to be consistent with how that reference curve was derived. The 10% curve in Claire's work is based on instantaneous threshold, it is not average data. Claire added that by imposing the 10% hyperbolic curve on the seasonal mean, it makes attainment very hard to achieve.

Tish added that when they did the attainability analysis, the James River Chlorophyll criteria when the Bay TMDL was done in 2010, they found that the criteria are not attainable across the board. We still have nonattainment in certain segments, possibly holding these segments to reference conditions they may never achieve.

Will added points in favor of evaluating the data relative to a seasonal mean. The pros include the ability to look back in the past, allowing for assessment of good and bad years, showing what attainment and nonattainment looks like. It will be easier to explain to the public. But when using something like the CFD, it creates a different assessment and derivation system, there then is a disconnect about what the number means and the reference curve. Claire added that this shouldn't preclude using a CFD approach to evaluate the data. Tish added that we probably won't ever fully abandon the CFD approach. There are just a lot of unknowns when it comes to using it to assess chlorophyll. Tish cannot fully defend the CFD. Will added that there are issues with the CFD, but not sure if entirely pulling it would help.

Joe added that the inadequacy comes from lack of sampling really, not the CFD.

Tish added that our expectations need to match the prioritization of chlorophyll in public perception. This is not a human health concern.

v.   Decision rule(s) on impairment status.
Claire reiterated that in her analysis, she found that 9 or 10 data points should be the minimum vs 3 points for tracking the 10% curve.

Tish said there is no regulatory decision rule for insufficient information.

Claire added that as far as bioreference curves, the 10% curve does a good job of describing where the bioreference curve is IF the bioreference curve is within the 90-95 percentiles of reference communities. They track the 10% hyperbolic curve. It's justification for that curve being considered.

Peter asked about OPTIONS outside of the CFD.

Claire mentioned the 2004-2005 Virginia CHLA criteria setting document, and its use of different numbers that look like upper limits. She added that she never saw clear explanation for why. Tish added that the numbers decided on in the document were different from the numbers promulgated. Part of this was due to the attainability analysis. It makes it harder to say there is a scientific basis for the criteria.

Tish wanted to point out that there are constraints and assumptions with the options she put forth in her presentation. She believes that we are in charge of interpreting what the water quality standard says. Peter reiterated that we should be focused on the protocol side.

3:00 PM Summary

Peter asked for group members to really start thinking about the options put forth in Tish's presentation.

Next meeting date: Late August. Last weekend Aug, First week Sept.

Additional notes: Issues within each topic for consideration during our discussions over the next 6 weeks include but may not be limited to the following:

      i.   The sampling protocols supporting chla assessments.
         1.   Long term fixed site only?
         2.   DATAFLOW?
         3.   modified DATAFLOW?
         4.   use of fixed-station ConMon?
         5.   Citizen Monitoring support?
         6.   Surface vs. Depth integrated?
      ii.   The averaging period for the data collections in the assessment,
         1.   3 year assessments versus some other assessment period?
         2.   Stay with seasonal average, move to monthly average, or instantaneous basis for the assessments?
      iii. The interpolator operations
         1.   IDW has default settings.

a. Interpolations with only 2 stations in a segment do not appear to average anything but assign one value or the other to an interpolation cell. Problem?
b. Alternatively, with DATAFLOW/modified DATAFLOW, there appears to be is a decision-rule to use the 4 closest data points, apparently it is no matter their distribution in space. Is this the kind of weighting that best represents the values for an unmeasured location?

2. IDW has an octant option to distribute the search for data points limiting the influence of all data coming from one tangent. Is this a more appropriate option for interpolations?
3. Is there another alternative interpolation approach to consider?

iv. **The application of the CFD for supporting attainment decisions**
1. CFD application pending the sampling protocol.
   a. Pros and cons of CFD with fixed station long term.
   b. Pros and cons of CFD with higher spatial resolution sampling.
   c. Discuss
      Any progress on confidence intervals for the CFD assessment?
      Any option to bias correct for small sample size effects?
      Do we consider any flow-adjusted method of assessment?
      Do we consider the effect of different averaging periods or instantaneous level assessment?

v. **Decision rule(s) on impairment status**
1. Is there a CFD breakdown point used with seasonal means creating only a 3-sample assessment?
   a. Does a waterway have a status associated with insufficient information if we have to depend on the long term fixed station network for CHLA assessment?
2. CFD has the 10% allowable exceedance
   a. Bioreference curve developments versus the 10% curve for assessment?
3. If we recommend an option other than the CFD, what is the decision-rule for attainment associated with that option?

PARTICIPANTS

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