THE 'REGIONAL FLOODPLAIN DATABASE' - AN INNOVATIVE FLOOD INVESTIGATION APPROACH

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Introduction

The Moreton Bay local government area is located immediately to the north of Brisbane, Queensland. Two years ago, Moreton Bay Regional Council commenced the preparation of a region wide flood investigation referred to as the Regional Floodplain Database (RFD). The RFD is possibly the single largest flood investigation project so far undertaken in Australia. The RFD incorporates a number of innovative features, each contributing to the project's overall success.

This paper provides further detail about the project including background and context of the project, an overview of the adopted approach, and examples of the innovations and value added products that form part of the project.

Background

Study Area

The Moreton Bay local government area covers a total area of 2070 km^2 extending between the northern suburbs of Brisbane to the southern edge of the Glass House Mountains. Floodplains represent one of the most common landforms in the region covering approximately 20% of the region or 400 km^2.

A total of 14 separate drainage catchments are located within the Moreton Bay region including those of the Pine and Caboolture Rivers, the headwaters of the Mary River, the Stanley River (a major tributary of the Brisbane River) and numerous large creek catchments. Some of these drainage catchments straddle the boundary of the Moreton Bay region. This means there is 630 km^2 of additional catchment area that is located outside the LGA but contributing to the floodplains located within the region. The study area therefore has a total footprint of 2700 km^2.

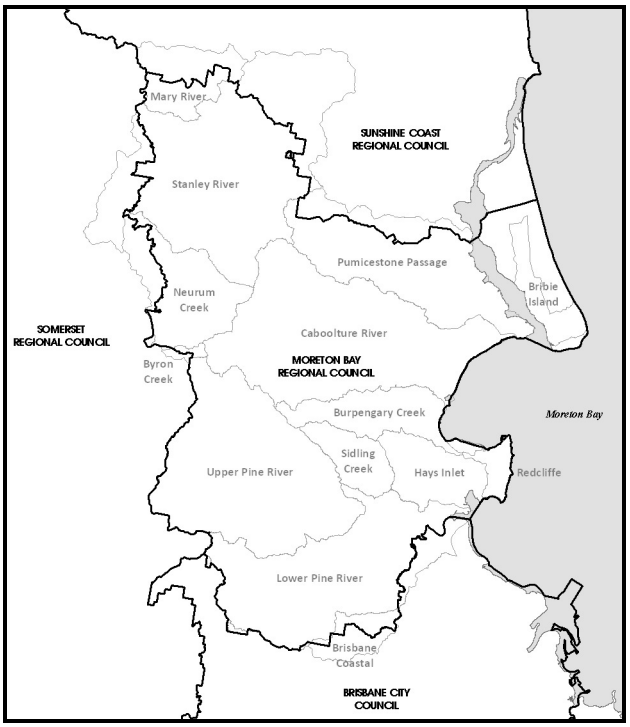

Figure 1: Study Area
(showing drainage catchment breakdown used for the Regional Floodplain Database)

The study area contains a diverse mix of landuses (e.g. rural, semi-rural, urban and forest) and provides a key urban growth corridor for South-East Queensland, expected to accommodate another 150,000 people over the next 20 years.

Historic Approach Towards Investigating Flood Behaviour

Moreton Bay Regional Council was formed in 2008 following the amalgamation of three former local government areas; Caboolture Shire Council, Pine Rivers Shire Council and Redcliffe City Council. A significant number of studies and investigations were undertaken by these former Councils to investigate various aspects of flood behaviour across their respective regions.

Approximately 65 smaller catchments formed the basis of the individual catchment investigations historically undertaken by the former Council authorities. These catchments are self-contained with minimal flooding interactions across their boundaries, making them a simple and logical basis for splitting up the overall floodplain analysis task. This catchment configuration also allowed the former Councils and their consultants to more easily manage each individual investigation by reducing the individual cost of each commission and reducing the scale of the required data collection and computer-based analysis.

However, as only a limited number of individual investigations could be resourced in any one year, the overall program of investigations would typically take between 5 and 15 years to complete. After this time, the program would normally re-commence to allow for revision and update of the initial studies.

Over such a long period, changes occur within the physical catchment and with the flood investigation techniques that are considered industry best practice. Change is also introduced through the advent of new improved flood modelling software and through introduction of different study teams with different competencies and approaches towards report documentation.

The influence of such change has led to a high degree of inconsistency across the flood data holdings available in the Moreton Bay region.

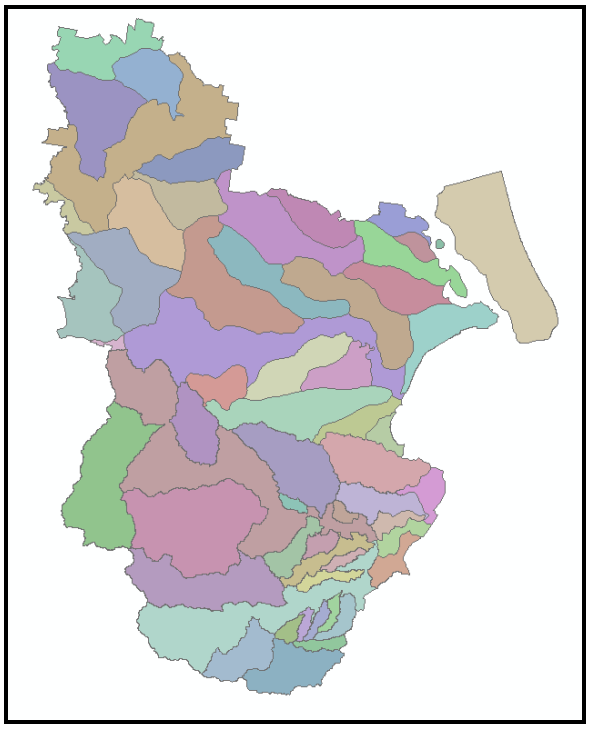

Figure 2: Historic Investigation Catchments
(historically used as the basis for separate flood investigations)

This inconsistent and 'piecemeal' understanding of the floodplains in the region restricts the amount of flood information able to be effectively extracted from these data holdings by Council or others. This is compounded by the presence of multiple electronic storage formats and diverse report standards.

Whilst those staff immediately involved with a particular study may have had a strong understanding of that particular study's methodology, limitations and outcomes, it is found that many subtleties are lost to new staff investigating many years later.

All these characteristics when combined, seriously impair the ability of Council and the community to make use of the historic flood studies for timely and strategic planning decisions. This is the current challenge faced by Moreton Bay Regional Council.

Project Inception

Immediately following amalgamation, Council staff made an assessment of Council's inventory of flood information and resolved to commence with preparation of revised flood mapping to ensure the available information was both current and regionally

consistent. Recognising the problems identified and described above, Council staff sought a more modern approach.

An alternative investigation methodology was devised and a 'proof of concept' undertaken to ensure it was indeed feasible. This proof of concept was successful and formed the basis for a business case for a substantial budget allocation to undertake the project. The organisation's leadership recognized the need for quality flood information and the potential for overall cost-savings from this approach. The business case was therefore supported.

In parallel to the development of the above business case, an application for co-funding was made to Emergency Management Queensland and Emergency Management Australia under the Natural Disaster Mitigation Program (subsequently replaced by the Natural Disaster Resilience Program). This application was also successful.

Accordingly a three year project commenced in July 2009. The project was branded the 'Regional Floodplain Database' in order to reflect two core principles of the adopted approach, those being:

- a whole of region investigation (i.e. not catchment by catchment)
- a focus on using 'best of breed' data collection, management and storage through the use of latest technology including the use of a single spatial database as the ultimate repository for the information obtained from the investigation.

Project Delivery

The RFD is being co-ordinated and managed by Council's Drainage Waterways and Coastal Planning Unit (DWCP) under the guidance of a Study Advisory Group comprising of:

- Floodplain analysis expert (Dr John McIntosh)
- Floodplain management expert (Mr Steven Molino)
- Spatial sciences and information management expert (Mr Ross Carew)
- Two community representatives (Councillors Mick Gillam and Chris Whiting)

The project is being delivered with the assistance of several experienced floodplain consultant teams from Sydney and Brisbane. To assist with this delivery, the project was split into three stages, with each stage comprising of multiple discrete work packages referred to as 'sub-projects'.

The delivery of such a large and complex project is a considerable challenge, requiring careful consideration of the overall sub-project breakdown and sequencing. Council has also needed to work closely alongside the consultant teams and pair them with sub-projects that most strongly reflect their skills and interests.

The Regional Floodplain Database Approach

Key Steps

The Regional Floodplain Database approach follows several key steps:

1) Regional Data Capture: Collect and collate each of the data 'layers' necessary for floodplain analysis using the most efficient tools available. Data layers gathered must cover the entire region and must be at sufficient resolution to support detailed floodplain analysis (i.e. regional footprint does not justify capture of data layers at a coarse resolution). The data layers are stored in generic spatial data formats compatible with the organisation's Geographic Information System (GIS) in a well structured spatial database repository that can be easily accessed by stakeholders.

2) Establish Standard Flood Estimation Technique: Establish a standardised and efficient flood estimation technique that is aligned as closely as possible to industry best practice. This includes the selection and adoption of 'best of breed' computer software, modelling procedures and model parametisation necessary for rigorous floodplain analysis. The adopted techniques may involve some compromise between simplicity and technical precision in order to achieve strict consistency of approach. The computer software selected should efficiently deal with spatial information, which should either be in a format aligning with the corporate standard, or support open file formats that lend themselves to rapid data translation. For the RFD Council has initially adopted the hydrologic modelling software package WBNM and the hydraulic modelling software package TUFLOW.

3) Conduct Floodplain Analysis: Using the outcomes of Step 1 and Step 2, conduct a floodplain analysis for all catchments and floodplains in the region and produce detailed information about flood behaviour. The data is stored in generic spatial data formats compatible with the organisation's Geographic Information System (GIS) in a well structured spatial data repository (i.e. database) that can be easily accessed by stakeholders.

4) Prepare 'Value-added' Products: Using the detailed information about flood behaviour generated at Step 3, prepare 'value-added' products and services such as maps and reports that support floodplain management decisions and encourage uptake and dissemination of the information obtained.

Key Benefits

The Regional Floodplain Database addresses the typical problems associated with the historic 'catchment by catchment' approach to floodplain investigations by focusing on the integrity of the underlying information capture and leveraging modern spatial analysis techniques to improve overall efficiency and reduce costs. This allows the initial version of the database to be populated faster and to be subsequently updated on a more frequent basis, providing for more responsive floodplain management.

The adopted approach provides:

1) Strong information consistency across the region, enabling the floodplain manager to more confidently identify areas of greatest flood risk. In an environment of uncertainty, whole of region management decisions are enhanced by the consistency introduced through this approach including improved prioritisation and targeting of resources (which are often limited).

2) Economies of scale that result in an overall reduction in project investigation timeframe and cost. Because the data is to be captured regionally, the investigator is forced to consider efficient data capture techniques and make better use of technology. The traditional 'catchment by catchment' approach can instead encourage inefficient data capture by presenting the flood investigator with a smaller investigation footprint where cumbersome and inefficient data capture methods may be tolerable.

3) Future flexibility to re-deploy the flood models to incorporate any physical changes to the floodplain, incorporate change in flood modelling practice or undertake regional scenario analysis. Whilst an internal skill base is important to support these activities, the methodology does not rely on this entirely. Instead typical outsourcing arrangements would involve a regional data collection activity and/or model redeployment by a consultant team. Council should however have at all times a strong understanding of its data, its limitations and how it is being used.

4) A centralised information repository that can be made available to a wider group of stakeholders. Corporate ownership of the data will assure ongoing data capture and maintenance will be supported through an ongoing business process. As the data is stored in a corporate database, using fixed conventions, integration with other corporate systems is possible, enabling the development of automated data delivery systems for the community.

5) Reduced training for Council staff who are required to maintain Council's flood model library. By having consistent approaches, Council staff are able to more quickly understand and familiarise themselves with the data and models and gain a stronger appreciation of the suite of model parameters suitable for the region. Changes are only made to parameters if they can be justified regionally forcing more careful consideration of such changes.

Key Challenges

Whilst the Regional Floodplain Database approach has a number of strong benefits, it also brings a number of challenges. These include:

1) Significant 'up-front' expenditure The total project outlay for initial setup of the Regional Floodplain Database is approximately $2.4 million over three financial years for consultants and contractors delivering the project. This has been shared with the State and Federal Governments who have each contributed one third of this amount. Each funding partner will therefore contribute approximately $270,000 each year for three years.

In terms of internal resources, the Council has made available a staff member for full-time project management over the project duration, along with other internal resources for technical direction, ground survey and data management as needed. Council has also invested in additional computing hardware and software to support the project.

This represents a substantial investment by the Council on behalf of the community. However, the business case still 'stacks up'. If the total cost of the investigation is put into the context of what a traditional 'catchment by catchment' flood study approach would have cost for a region of the same size, then the RFD project represents exceptional value for money.

2) Co-ordination and Project Management A complex technical project of this scale requires a number of specialist teams contributing to its delivery. The project has had up to eight (8) consultant teams working concurrently on various data collection and modelling tasks at any one time. Many of these tasks are inter-dependent and therefore must be completed in careful sequence and in a timely manner. A project team with appropriate project management and delivery skills is necessary in order to provide for a successful outcome under these conditions.

3) Model Calibration A flood model incorporates a number of assumed model parameters that are utilised to represent the physical processes occurring in the catchment and floodplain. The parameter values are typically selected on the basis of a 'model calibration' whereby standard values are adjusted to achieve good comparison between the model predictions and a number of historic events for which observed flood records are available.

   The traditional flood study approach used by the former Councils in the Moreton Bay region resulted in a range of model parameter values in order to achieve adequate calibration for each catchment. These parameter values often vary even where the input data and analysis procedures are very similar.

   The RFD approach requires strict model parameter consistency across the region. Accordingly the flood modeller has limited freedom to adjust parameters locally in order to achieve 'best fit' of the modelled versus observed flood data. The trade-off between ideal fit and acceptable region-wide calibration is a challenge, but was found to be manageable.

   Arguably the restricted calibration freedom of the RFD approach is not a compromise but simply allows Council to better understand the inherent accuracy limitations of its flood data holdings.

4) Data Management and Intensity of Numerical Processing The study area is quite large and has complex features. The volume of data that must be collected in order to support the floodplain analysis is significant and results in the need to store, transfer, open, manipulate and analyse electronic data files that at times exceed the capacity of normal 32 bit desktop-based computer hardware and software.

To address this challenge, Council has invested in high specification computer hardware and paid careful attention to methodologies used for data collection and analysis to ensure efficient processes were used where possible.

A specific sub-project has also been initiated that will specifically investigate and recommend an optimal information management framework for the project to assist with this challenge.

Examples of Project Innovations

The following section provides a brief overview of some of the innovations that have contributed to this project.

Terrain Tool

The RFD flood models primarily use aerial survey (LiDAR) information, supplemented by ground survey and bathymetry (under water survey) to define the surface terrain over which floodwaters pass. Intensive processing tasks are normally required to convert the raw survey data into a format suitable for the flood modelling software.

There is no prescriptive industry standard approach to this processing task. This can result in inconsistency in the modelled terrain which then passes to the flood model results and subsequent mapping.

As part of the Regional Floodplain Database project, one of Council's consultant teams were tasked with deriving a standardised procedure to undertake terrain processing. An innovative software tool was developed that optimises the calculation process to provide a model terrain having the highest possible degree of accuracy compared to the source survey. The algorithm achieves this by dynamically selecting either a TIN or point averaging terrain calculation method depending on the density of the survey at a particular location. Where the density of source point data is low, the model terrain is assigned a valued using a TIN, whereas if there is a high density of source point data the model terrain is assigned a valued based on an average of all points within an appropriately selected search distance.

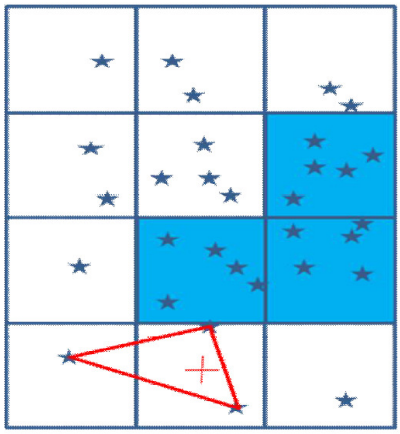

Figure 3: Example of Approaches used by the Terrain Tool for Assigning Hydraulic Model Cell Elevations (WorleyParsons, 2010)

This concept is further described in Figure 3 above. In this example those cells that have been shaded blue have been selected to have sufficient density of source point data to permit a point averaging technique to be used whereas the remaining cells will be assigned their value using a TIN. This pattern of shading would be dynamically adjusted should an alternate smaller or larger cell size be chosen.

Hydrography Dataset

The hydrography dataset is a detailed representation of the catchments and streams within the study area. This dataset is used as a basis for the hydrologic estimates that are used in the floodplain analysis.

Derivation of this dataset involved a semi-automated procedure that first delineated the stream network and then subsequently the catchments contributing to each of these streams.

The hydrography dataset is a highly detailed and structured dataset comprising of multiple data layers that each contribute towards a comprehensive description of the region's catchment and streams. The foundation data layers that contribute to the overall dataset are: 'stream reaches', 'minor catchments' and 'junctions'. These are nested inside larger groups such as 'streams' (groupings of connected 'stream reaches') and 'minor basins' (groupings of connected 'minor catchments').

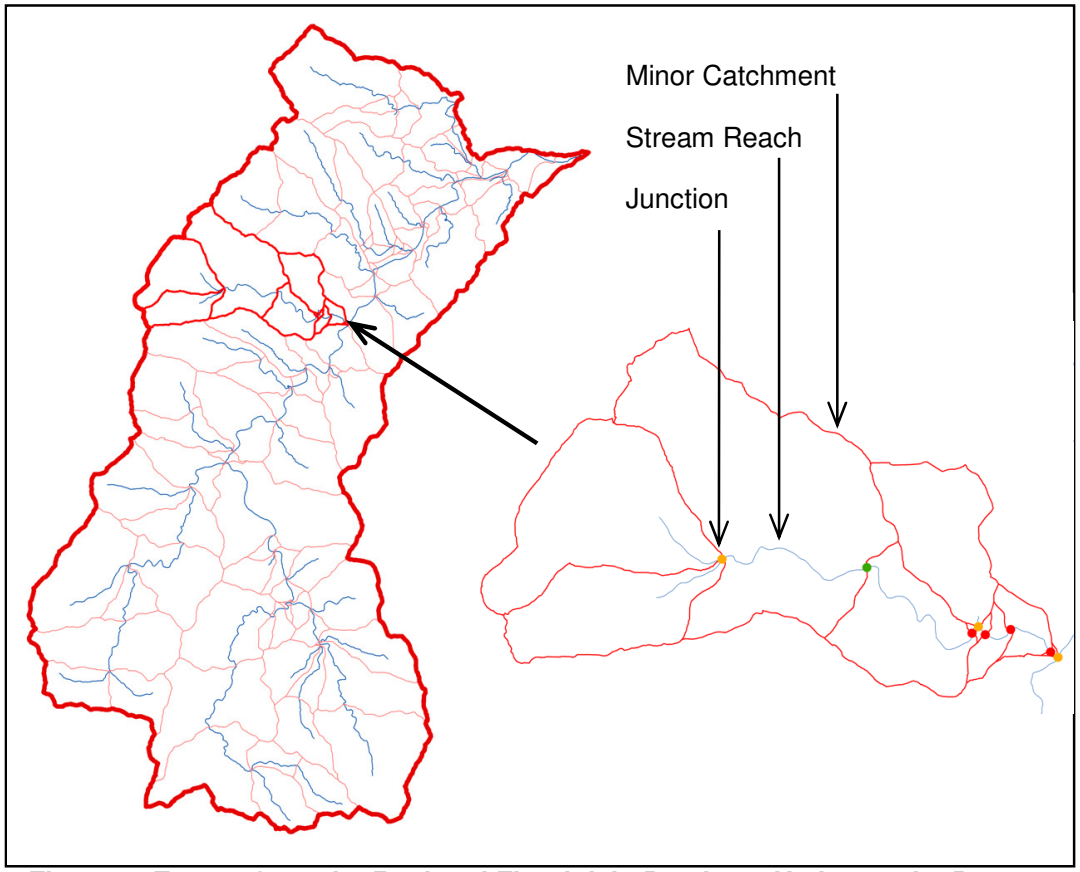

Figure 4: Extract from the Regional Floodplain Database Hydrography Dataset

The innovative aspects of this dataset include; the adopted nested structure, a unique chainage based identification system that permits insertion of a more detailed stream and catchment breakdown as required over time, and feature attributes that store both input and output values from the adopted hydrologic model software.

This dataset has been used extensively in the organisation beyond the immediate need for the Regional Floodplain Database including environmental assessments, water quality monitoring, general display and a basis for the unique identification of waterway related assets.

Landuse Dataset

Landuse information is used in a floodplain analysis to calculate: 1) impervious surface cover proportion within a catchment, and 2) to define the 'roughness' of the floodplain. These factors influence the amount and speed of flow through the catchment and floodplain.

Deriving accurate landuse information for a region of this size is a considerable challenge. For the RFD, Council's consultant team undertook a comparison of multiple options and established that the optimal method for deriving the landuse dataset was to manually digitise different types of landuse from high quality aerial photography.

Whilst the process of manual digitization is not highly innovative in its own right, the recommendation was coupled with a carefully considered standard landuse classification that optimised the accuracy of the flood models and kept data capture costs as low as possible. The adopted process also made best use of Council's pre-existing data holdings and was the most flexible option for future upgrade and improvement.

Structure Data standards

A series of sub-projects were undertaken to standardise the approach towards defining hard infrastructure within the floodplain including buildings, culverts, bridges, detention basins and large trunk stormwater systems.

A suite of carefully considered spatial data standards were established by the consultant incorporating the specific variables required for the flood model. The data standards give a high degree of consistency to the way in which this infrastructure is defined and therefore impacts on modelled flood behaviour across the study area. The data standards were developed in a way that allows the storage of the input data on Council's corporate GIS rather than in native model formats allowing multiple users across the organisation to benefit from the data gathered by the project.

Information Management Framework

The information management aspects of flood investigations are often neglected and can contribute to the poor utilisation and dissemination of the flood information obtained.

In conjunction with the gathering of datasets and flood modelling activities associated with the RFD project, Council has sought to establish an 'Information Management Framework' to support Council in the future management of the large volumes of valuable information that will be generated by the RFD project.

The Information Management Framework will identify and characterise the information entities created by the project and identify inter-dependencies and workflows required to support their storage, dissemination and maintenance.

'Value-Added' Products

In conjunction with this project a number of flood information systems and products are being established including:

- datasets to support flood warning and evacuation activities
- a publicly accessible 'Floodplain Summary' document
- a geoprocessor tool for the integration of property and flood data
- an automated system for the delivery of property-based flood certificates

- a web-based 'Flood Mapping Portal' for public dissemination of flood information

The previously described Information Management Framework will investigate the inter-dependencies between the information entities derived from flood models and these value-added products to ensure the highest possible efficiency and quality control can be achieved during their initial establishment and future ongoing maintenance.

Considerations for Others Interested in the RFD Approach

The Regional Floodplain Database approach is generic and lends itself to application wherever an authority has a need for detailed flood information across a number of catchments. The approach is scaleable and could be used across an area smaller or larger than the Moreton Bay Regional Council local government area.

However, prior to initiating a project of this nature, other parties that may be interested in adopting a similar approach will need to carefully consider:

- Likelihood of ongoing multi-year funding support for the project during the development phase, including the ability of the organisation to absorb significant up-front expenditure
- Availability of suitable internal staff to manage and guide the project during the development phase
- Need for up-front agreement from management to the resourcing of an ongoing business process to maintain the information over the long-term
- Availability of suitable computing technology for information storage and data processing along with internal staff with the necessary skills to support this technology
- Availability of an adequate number of consultant teams with appropriate skills to support an intensive period of investigation activity during the development phase
- Acceptability of the approach to approvals agencies and funding partners

Conclusion

At the present time the Regional Floodplain Database project is well advanced with the regional data collection activities essentially complete and the majority of the flood models established. Calibration and validation has occurred which has allowed the commencement of design event simulation. Whilst the original project envisaged a 3 year timeframe this will be extended for a further 6 months due in large part to the 11 January 2011 flood event which introduced additional data collection and calibration requirements.

With this project Council is successfully challenging the historic 'catchment by catchment' flood investigation paradigm and delivering flood information in a more efficient and effective manner. While the adopted approach is not without its challenges, Council can strongly suggest to other local governments and interested parties that consideration be given to this innovative approach when developing their forward flood investigation program.

Acknowledgements

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