# River Restoration— A Study of River Musi and Analysis on Influence of Urbanisation

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***Abstract* - Water is a very essential element in formation of any livelihood. When we take a close look at the source of water in the present scenario, most of the rivers bear sewage water and thousands of water bodies have already extinguished. One such example is The River Musi, which is a tributary of Krishna River in the Deccan plateau of Telangana, India. It flows through the historical city, Hyderabad and divides old city from new city.**

**In 16th century (Kakatiya Dynasty) the city expanded along the banks of the river, but over a period of time due to urbanisation the city started expanding towards North because the land usage was restricted by the Cantonment area towards West and also found more potential when Hussain Sagar (Manmade Lake) was built as a perennial catchment area.**

**With the influence of the human habitat, the hydraulics of the river and the course of the bank responded differently at every part of the stream at various levels. When we look at the form of the channel and stream, it is quite evident how a 33 km stretch with in the city limits changes its dynamics at every stage. Human habitat and Urbanisation not only influenced the quality of the banks and water flow but also the geomorphology of the stream and surroundings. The disposal of industrial waste and sewage has a large impact on polluting the river. For example a coconut tree growing next to a healthy water body would yield a better quality of coconuts because of the good quality of water table. Whereas a coconut tree growing next to polluted water body would yield coconut water with high levels of Lead quantity because of an unhealthy water table.**

**The paper analyses the factors which influenced the healthy drinking river water transform into a carrier of sewage waste and how it could be restored with the help of strategical design techniques and proposal of policies to uplift the present condition of the river.**

**Keywords- Restoration, Geomorphology, Urbanisation, River banks, Hydraulics.**

## I. ABOUT THE RIVER MUSI

The River starts from Anantagiri hills (90 kms West of Hyderabad) which are known for its Herbal plants[9]. The city was founded by Md. Quli Qutub Shah, the fourth ruler of the Golconda kingdom. The river flows thru the city for 33km and joins the River Krishna at Wazirabad. The total length of the river is 256kms with a gradient of 2 metres per km within the city[10]. It is a perennial river which is narrow in form and harmless in flow though it witnessed few floods till the early years of 20th century[10]. In 1908 the river had devastating floods after which The Emperor Mir Osman Ali khan (VII Nizam) has constructed Reservoirs of Osmansagar & Himayatsagar [4].

There are lot of myths about the river and how these influenced the development of the surroundings and its usage but the most interesting one is how Hyderabad's Dum Biryani has got its fame and some scientific reasons behind it. Ananthagiri hills being a herbivorous mountain, When the water flows thru these medicinal herbal plants, it tends to carry the properties of these plants thus making it richer in taste, medicinal value and odour. It is said that one of the reasons for the flavoursome biryani is because of the herbal properties in it[4,9]. In spite of the existing reservoirs the city witnessed yet another flood in August 2000, this time the cause for the flood was not because of insufficient reservoirs but because of the reduction in the carrying capacity of the lakes in water shed area and the river channel itself[10].

## II. PRESENT CONDITION

In spite of all the conservation laws protecting the existing water bodies, today The River Musi is a mere carrier of the untreated/insufficiently treated domestic and industrial waste[1,3]. According to sewage treatment plant board [STP] it is estimated that nearly 350MLD (Million Litres a day) of polluted waste originating from the twin cities of Hyderabad and Secunderabad flows into the river[3]. Apart from having this drawback the river still shows a lot of potential on how it's working :

*A. Most of the Architectural monuments like Golconda fort, Osmania Hospital, Salarjung Museum (ones a Palace), High Court exist on the river edge which draw lot of tourism and functions as institutional hub.*

*B. The river also has a natural island which has been formed and it is very interesting to see how this island functions as an Interstate Bus Terminal inside the Musi.*

## III. FACTORS EFFECTING THE DEGRADATION

### *A. Settlement pattern of Urbanisation*

The River Musi has been a part of the city development since the city evolved. If you look at the development of the Road Network even during the Nizams rule and after the independence the river acted as a spine where initially the city started spreading along the banks of the river and later radiating from the central core being the river itself[9]. Progress in transportation network created the first of the shift in the development pattern which were the signs of the city spreading. The present decentralised mode of growth of the city with multiple nuclei being established, the general trend of growth is shifted from this once centre of activity but the already established road system majorly remains the same.

### *B. Urbanisation of the City and loss of Water bodies*

Urbanisation is associated with loss of natural wetlands, forest habitat, farmlands and increase of impervious surface. As the Urbanisation increases catering for drinking water is also becoming complex. Most of the Water bodies which come under water shed area are either dried up or encroached by land developers or very few lakes which exist, bear toxic Industrial effluents.

The other sources of drinking water like rivers and groundwater also suffer from the similar problem. About 18 water bodies of over 10 hectare size and 80 tanks of below 10-hectare size were lost over a period of time[2, 10].

As the River flows through the city, there is a change in Land use with respect to Urbanisation.

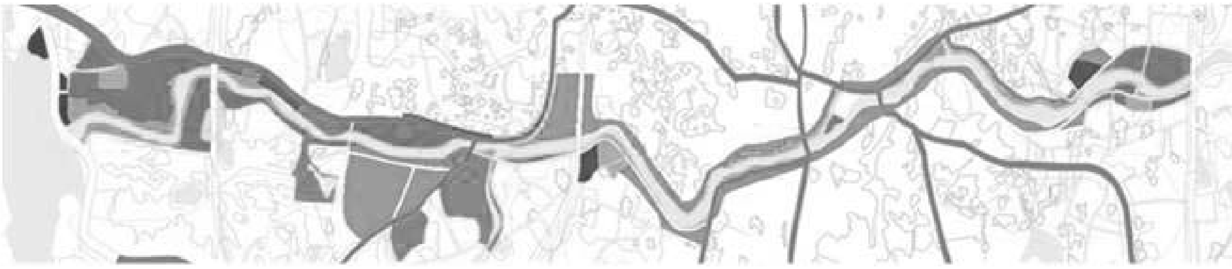


Fig 1: Land Use plan from Osman Sagar to Uppal Ring Road


Fig 2: Zone of Influence

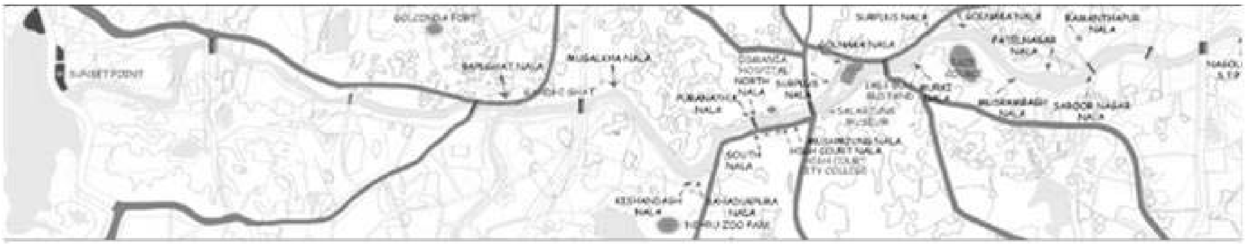



Fig 3: Sewage Inlet points entering into the Musi

*C. Pollution of Water Bodies*

Most of the industries are located on the upstream and in spite of strict laws (Environment Protection Act, 1986, the Water Act, 1974 and the Air Act, 1981) which have been enforced stating that the toxic industrial effluents have to be treated first before releasing into the river, it is not being followed [1]. Many industries dig up underground pipe lines reaching the river bed and release the waste [7]. This not only impacts the stream quality but also the underground water table of the surrounding area is being polluted. The city Hyderabad produces 850 MLD of sewage waste but whereas only 133 MLD gets treated in the STP n the rest is discharged in its actual form or by diluting it with further waste water [6]. This is due to insufficient STP's in the city and as well as improper location of the STP's. Previously there were six Industrial areas in the corporation limits (Azamabad, Musheerabad, Sanathnagar, Kavadiguda, New Bhoiguda, and Lalaguda) but in recent years there were eleven more industries which came up [6].

*1) Sewage Treatment Plants (STP)*

The city does not have sufficient treatment plants for the amount of effluent it produces (as mentioned previously). Most of the primary treatment happens at Amberpet STP and the rest is let into Nallacheruvu, a tank downstream, through irrigation canals to Edulabad Cheruvu and finally River Musi [6]. There are in total of 5 STP's in the city and they are as follows: Jiyaguda – 21MLD, Amberpet – 339 MLD, Nalla cheruvu – 30 MLD, Nandi Musalaiguda – 172MLD, Nagole – 172 MLD. The total capacity of all the above STP's are 592 MLD [6]. There were plans for 2 more STP's at Jiyaguda & Nandi Musalaiguda, but because of the land acquisition problems they are tentatively on hold. There are plans of few more STP's in upstream Attapur and surrounding to river Musi which are in planning process [6].

*2) S.T.P and Water quality*

Nagole S.T.P [6]:
Capacity – 150 to 172 MLD
B.O.D – 250 to 300
Eco- friendly Sewage treatment plant, Sludge – 1%

Amberpet S.T.P [6]:
Capacity – 339 MLD
Inlet – 250 to 300 MLD
Nallacheruvu S.T.P [6]:
Capacity – 32 to 38 MLD
Per Day – 10 to 11 MLD

*3) Common Effluent Treatment Plants (CETP)*

The CETP's evolved due to insufficient STP's present in the city out of necessity. These are non-Government bodies and are owned and operated by group of private industries. There are total 2 CETP's in and around the city, out of which one, falls in the catchment area of Musi [10]. It regulates as regular Industry where a membership has to be taken by the private Industries to use its facilities for the treatment generated by their company (trade effluents).

*D. Encroachment of Land*

In 2000 August there was a rainfall of 24cm in 24hrs which was unpredicted in the aired region of Deccan Plateau and led to sever flooding. It was then which came into notice of everyone that how land encroachment has reduced/narrowed the flood plains and water courses, thus leading to flooding of the river.

According to Newspaper – Vaartha (Telugu Daily), Hyderabad edition, 11 June 2002:
Some localities of Hyderabad experienced worst flooding where water reached up to first floor level (Shankarmutt-Nallakunta) and navy boats had to be used to traverse in the flood water. Thus Protection of water bodies and watercourses become even more important after experiences of August 2000 *in Hyderabad.*

*E. Green fodder- paragrass (Gramineae Panicum purpuras cens )*

Till the beginning of the 1960s, agriculture like growing paddy, sorghum, millet and vegetables, both for household and market consumption was happening along the Musi River [11]. These crops were grown with the help of irrigation water from River Musi, but later as the inflow of untreated wastewater in the River Musi increased, the water was no more suitable for growing these crops. Thus cultivation was Paragrass came into the picture.

Green fodder is the cultivation of a type of feed for the cattle, in this case green fodder production is happening for Dairy production where small n big companies are involved. These are majorly located in 2 places Uppal to Ghatkesar (2529.6 acres) and Attapur (172.75 acres) all along the Musi River [11]. In order to cultivate this grass land owners draw waste water from the river [11]. Among the above mentioned areas, Uppal comes under city limits and it caters to the industries mostly situated in the Old city [7]. This weed needs to be planted ones and annual re – seeding is not required, as a result it requires very less maintenance except for pesticide which is used to avoid mosquitoes.

*F. Vegetable farming*

As the Green Fodder picked up in the sub urban regions of the city, at the same time there was increase in growing leafy vegetables, coconut plantations happening in the surrounding area of Purana Phool, Old city [7]. The area under leafy vegetable production along the Musi River has increased from 13.59 acres in 2002 to 39.53 acres in 2006[11]. Most of this land is part of the encroached settlement of the flood plain of the River. The water is drawn from the River in order to cultivate these vegetables and these are sold in the nearby markets.

*G. Slums*

Due to lack of land availability and over population encroachment of the flood plains for the slums have been a major concern because these areas would be prime sufferers in case of situation of flooding [10]

*H. Dhobi Ghat*

Until early 20th century there were several Dhobi Ghats situated along the banks of the river and most of these Dhobi Ghats catered for the nearby Hospitals located in old city. But with the Government law enforcement presently all the Ghats have been evacuated.

## IV. METHODOLOGY

Secondary data has been collected to create a base for the study; further physical study has been done by visiting the site. The 33km river course has been divided into 6 segments based on urbanization, change in landform, historical settlements, stream pattern, etc. Land use maps, Zone of Influence maps, and visual analysis maps, have been generated by site study. Further research has been done by interviewing people to collect data on para farming, land encroachment, farming on flood plains. Data for Pollution levels of water has been collected from STP's and water board. With the help of manpower from localities, study has been conducted to understand the geomorphology of the stream, its banks and the flood plain which was further used in analyzing the steam stability by Rosen's flow chart method [5].

## V. ANALYSIS

The analysis is structured into four levels [5]:

*A. Level I:*

It is based on geomorphic characterization of stream types; it incorporates watershed assessment of valley morphology in order to understand probable stream types. The classification also deals with pattern, profile, and slope analysis for the valley type assessment.

Classifying stream type: (Meandering Stream);
Classifying channel type: Alluvial and Bedrock.

*1) Interpretation of channel with respect to sediments and transport response*

The River has flatter channels (braided, regime, riffle-pool) experiencing morphological adjustment with respect to increased sediment load.

*2) Fluvial Geomorphological Analysis*

In this stage data such as watershed area, channel discharge, and channel geometry data is used to analyze how fluvial geomorphological characteristics influence the stream.

*3) Degradation of Water Shed area*

There are many reasons for the degradation of the water shed area like, the catchment area of the upstream river at Vikharabad is in poor stage or it could be influence of the catchment area at Himayatsagar and Osmansagar reservoirs.

As the city gets urbanized, most of the ground area becomes impermeable, there for leading to change in drainage pattern and degradation of catchment areas. It is also due to the lack of conservation of lakes as part of the large drainage pattern.

*4) Catchment area calculation[10]*

Sources of water would be Rain water through storm water drain.

Catchments of rain water:

Area – A

Area of catchments = 321.6 HA (321,6070 sq.m ) Average annual rainfall = 803 mm (0.803 M )

Runoff coefficient = 0.50

Annual water harvesting potential for 321,6070 sq.m 321,6070 x 0.803 x 0.50 = 1291,252 CU. M. (129,12,52,000 L ) = 1290 Mill. Lt

Area – B

Area of catchments = 364.5 HA (364,5933 sq.m ) Average annual rainfall = 803mm (0.803 m )

Runoff coefficient = 0.50

Annual water harvesting potential for 364,5933 sq.m 364,5933 x 0.803 x 0.50 = 1463,842 CU. M. (146,38,42,000 L ) = 1460 Mill. Lt

Net water:

1290 Mill. Lt + 1460 Mill Lt = 2750 Mill Lt

Capacity of reservoir to catch 275,50,94,000 L. of water for a dry season of 245 days

Fig.4: Water shed area of Old city (10)

*B. Level II*

In this classification it includes geomorphological information on channel entrenchment ratio, width to depth ratio, sinuosity, channel slope, and channel materials to more precisely categorize stream types and substrate.

*1) Classification by Bed Material*

When you take a cross section it reveals how the various substrate materials, along the channel reach type, tend to influence the cross section shape. Some substrates create more angular shapes, while other substrates allow for more curvilinear features.

*C. Level III*

It is based on stream state or condition of the stream. A stable channel will maintain its morphologic pattern, profile, and dimension, with erosion and deposition at levels below excessive aggradation and degradation. Channel stability is influenced by channel and watershed factors of hydrologic, biological, ecological and human nature. When a channel is self-maintaining its stability, and has a good ecologic condition, it is considered to be operating at its full potential.

Flood analysis is directly linked to channel stability. This analysis helps in understanding the important field indicators of channel stability and provides with exposure to methods for quantifying such indicators.

Parameters for assessment of stream stability include riparian vegetation, channel flow regime, channel debris, channel order, channel depositional pattern, channel meander pattern, and Streambank erosion potential.

*1) Riparian vegetation*

Forbs, Annual grass, Perennial grass, Rhizomatous grasses (sedges, rushes), Low brush, High brush, Deciduous with brush or grass, Perennial over story, Wetland vegetation community.

*2) Debris & Channel Obstruction Influences*

Debris directly influences channel stability and pattern, profile and dimension evolution. Debris blockages happen mainly because of the Human Intervention. Area which fall under commercial spaces like market yards, retail shops or places like slums, bridges and Bus Terminals tend to produce lot of waste which goes into the river and reflects in blockage due to Debris.

The Depositional Features also influence the stream in different ways. Excessive sediment deposition is associated with increases in width to depth ratios and decreases in channel slope. The placement of the channel material will influence in the channel hydraulics, subsequent deposition, and the next sequence of channel type that forms.

*D. Level IV*

It is described as a validation level for stream types earlier characterized in Level II and III.

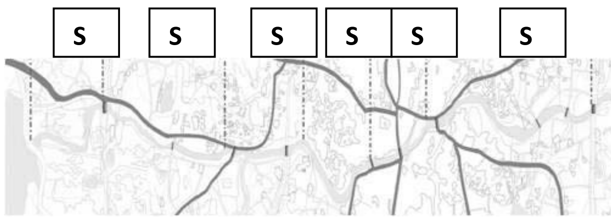
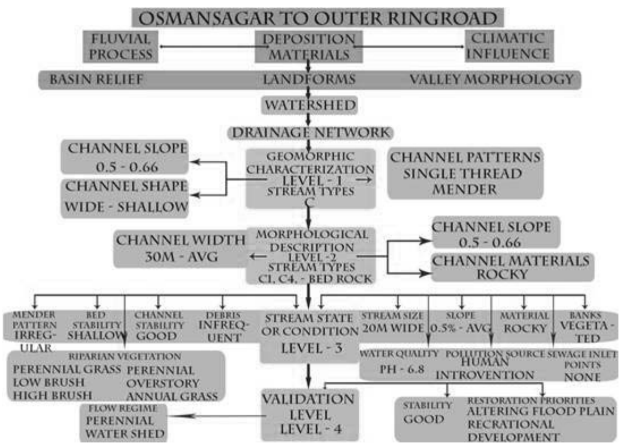



Fig. 5: Division of the stream in to 6 segments

## VI. SEGMENT 1



*A. Level I analysis*

Stream Type C

The characteristics of Segment-1 Stream type are - it has very gentle slope, with gentle relief and multiple terraces, the stream Meanders, it has Riffle/pool sequence, it has a broad flood plain and flows on Alluvial channel.

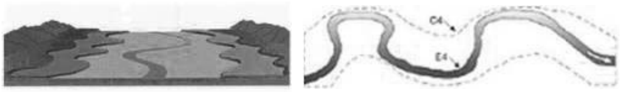



Fig.6: Broad Terraced Floodplain, [5]. C4 channel Analysis by Pattern, Profile and Dimension

*B. Level II analysis*

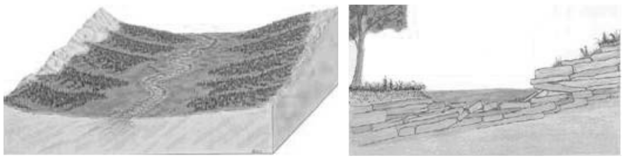
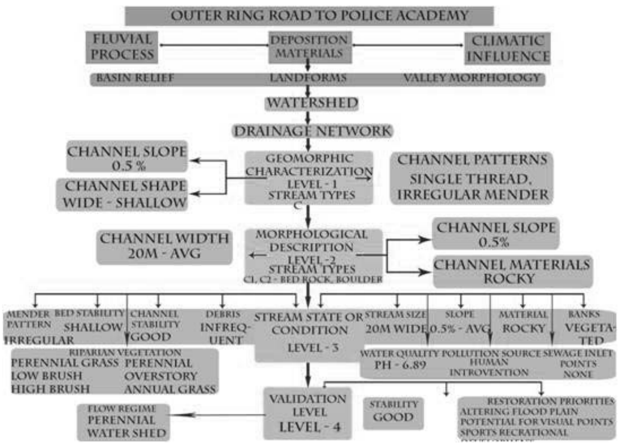


Fig.7: Stream Type C1 [5]

## VII. SEGMENT 2




*A. Level I analysis*

The stream type of Segment 2 is the same as segment 1 (Osman Sagar to Outer Ring road) in level 1 analysis. In Level 2 Analysis along with the stream type C1 (Rocky Bed), it also comprises of C2 which is a rocky bed with boulders and earth.

*B. Level II analysis*

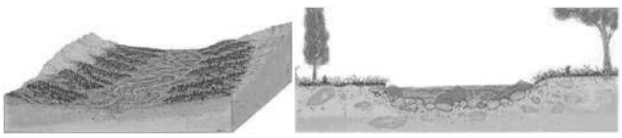
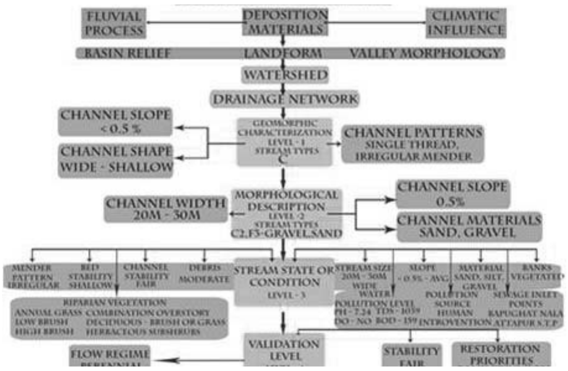


Fig.8: Stream Type C2 [5]

## VIII. SEGMENT 3




*A. Level I analysis*

The stream type of Segment 3 is the same as segment 1 (Osman Sagar to Outer Ring road) in level 1 analysis. In Level 2 Analysis along with the stream type C2 (Rocky Bed with boulders), it also comprises of F3 which is a Gravel and Sand bed.

*B. Level II analysis*

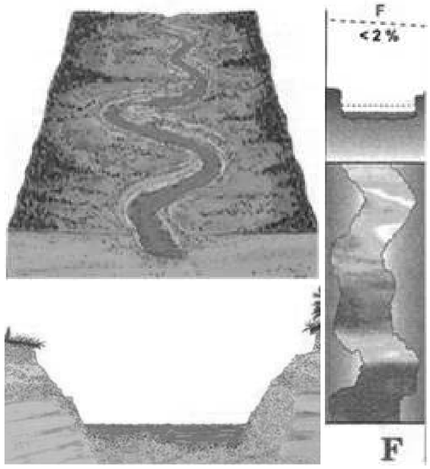
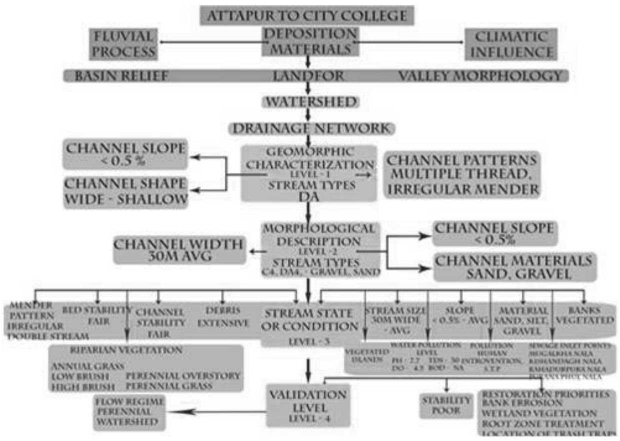



Fig.9: Stream Type F3, F [5]



## X. SEGMENT 5

### *A. Level I analysis*

The characteristics of Segment-5 Stream type are - it has low gradient with low width / Depth ratio. The stream has a very high Meandering channel with Riffle / pool sequences. We can see a little deposition happening on the banks and on the edges of the meanders but still it possesses characteristics of stable and efficient banks.

### *B. Level II analysis*

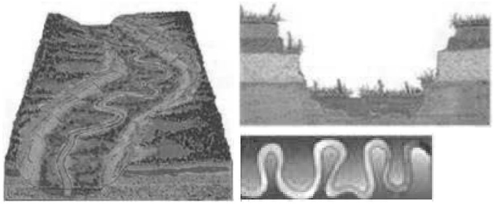
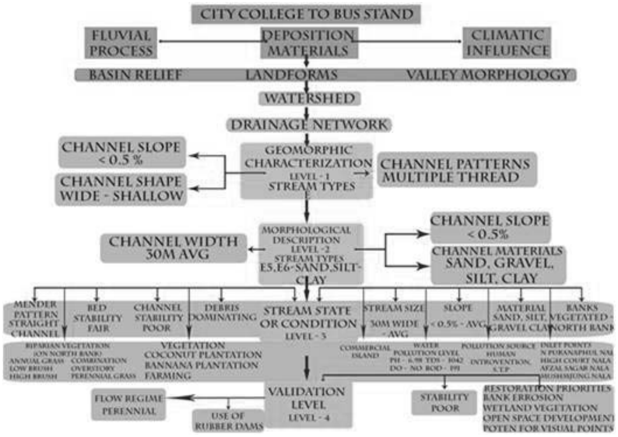


Fig.11: Stream Type E5, E [5]




## XI. SEGMENT 6

### *A. Level I analysis*

The stream type of Segment 6 is the same as segment 5 (city college to bus stand) in level 1 analysis. In Level 2 Analysis along with the stream type E5, it also comprises of E4 which is also a meandering channel with riffle / pool sequences but possesses high meander width ratio.

### *B. Level II analysis*

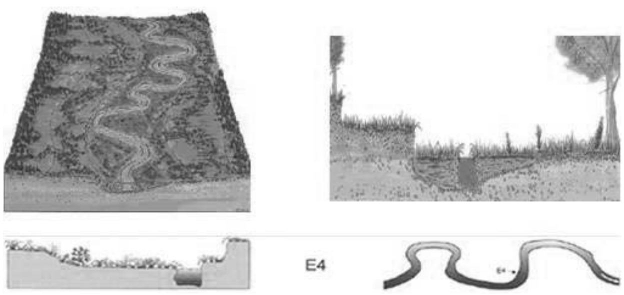
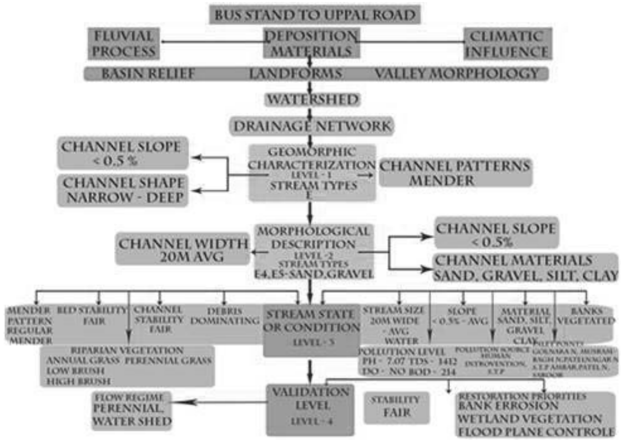



Fig.12: Stream Type E4, E5 [5]. Analysis by Pattern, Profile and Dimension




## XII. RATING SYSTEM ACCORDING TO ROSGEN'S THEORY

After the four level analyses, according to Rosgen's theory the data is further transformed into rating system. In order to arrive at the rating for every segment to understand the condition of the stream if it falls under Excellent / Good /Fair / Poor, The analysis is broken down to three categories:

*A. Upper Bank: land Form slope, Mass wasting, Debris Jam potential, Vegetative bank protection.*
*B. Lower Banks: Channel Capacity, Bank Material, Obstructions to flow, cutting of Bank, Deposition.*
*C. Bottom: Rock Angularity, Brightness, consolidation of the particles, scoring and Deposition, Aquatic vegetation.*

The Rating for all the Segments based on Rosgen's Theory is as follows

| | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| | 1 Landform Slope | 4 | 4 | 6 | 6 | 8 | 6 |
| | 2 Mass Wasting | 6 | 6 | 9 | 9 | 6 | 9 |
| | 3 Debris Jam Potential | 4 | 4 | 6 | 6 | 6 | 6 |
| Upper Banks | 4 Vegetative Bank Protection | 6 | 6 | 9 | 9 | 12 | 9 |
| | 1 Channel Capacity | 2 | 2 | 3 | 2 | 3 | 3 |
| | 2 Bank Rock Content | 4 | 4 | 6 | 6 | 8 | 6 |
| | 3 Obstructions to Flow | 4 | 4 | 6 | 6 | 8 | 8 |
| | 4 Cutting | 12 | 12 | 12 | 12 | 12 | 12 |
| Lower banks | 5 Deposition | 4 | 4 | 12 | 12 | 4 | 4 |
| | 1 Rock Angularity | 2 | 2 | 3 | 3 | 3 | 3 |
| | 2 Brightness | 2 | 2 | 2 | 1 | 1 | 1 |
| | 3 Consolidation of Particles | 4 | 4 | 6 | 2 | 2 | 2 |
| | 4 Bottom Size Distribution | 12 | 12 | 12 | 8 | 16 | 8 |
| | 5 Scouring and Deposition | 12 | 12 | 12 | 12 | 12 | 12 |
| Bottom | 6 Aquatic Vegetation | 2 | 2 | 3 | 3 | 3 | 3 |
| | | 80 | 80 | 107 | 97 | 104 | 92 |

By using the conversion of stability chart the ratings which are derived above are matched in this chart based on the typology of the stream which is already been analyzed in the flowchart.

| Conversion of Stability Rating to Reach Condition by Stream Type | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream Type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 |
| Good | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 |
| Fair | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 69-88 |
| Poor | 48+ | 48+ | 130+ | 133 | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 89+ |
| Stream Type | C1 | C2 | C3 | C4 | C5 | C6 | | | D3 | D4 | D5 | D6 |
| Good | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | | | 85-107 | 85-107 | 85-107 | 67-98 |
| Fair | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | | | 108-132 | 108-132 | 108-132 | 99-125 |
| Poor | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | | | 133+ | 133+ | 133+ | 126+ |
| Stream Type | | | DA3 | DA4 | DA5 | DA6 | | | E3 | E4 | E5 | E6 |
| Good | | | 40-63 | 40-63 | 40-63 | 40-63 | | | 50-75 | 50-75 | 50-75 | 40-63 |
| Fair | | | 64-86 | 64-86 | 64-86 | 64-86 | | | 64-86 | 76-96 | 76-96 | 64-86 |
| Poor | | | 87+ | 87+ | 87+ | 87+ | | | 87+ | 97+ | 97+ | 87+ |
| Stream Type | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
| Good | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| Fair | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| Poor | 106+ | 106+ | 125+ | 125+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

Fig.13: Conversion of Stability Rating,
Note: The values considered for the analysis is approximate.

## XIII. CONCLUSIONS

When we look at segment 1, it comes under cantonment area due to which there is less intervention by humans, when we follow a land use plan it shows the existence of flood plain and the buffer zone as well. Due to nonexistence of any sewage inlet points in this zone, in spite of lack of water due to the concerns discussed earlier, the research says that the stream condition is 'Good'.

Where as in the segment 2 and 3 parts of the southern bank falls under cantonment but at the same time the rest of the south bank is exposed to commercial unit. The North bank fairly has some amount of buffer zone but the entry of 2 sewage points from the STP's makes the situation worse and the analysis is predicted as 'poor' condition of the stream

In the segment 4 and 5 due to rapid urbanization seen in terms of development of commercial spaces and 6 sewage inlet points from the STP's and private industries, a noticeable change is seen in the pattern of the stream flow. The stream here becomes braided with lot of debris and the flood plain is encroached completely by the vegetable and coconut farming. Thus all this impacts on the bank erosion and there for these two segments are also categorized into 'poor' condition.

In the segment 6 as the river exits the suburbs of the city we see a little amount of flood plain on the North bank and few patches of buffer zone protecting the banks of the river. There are 7 sewage inlet points in this segment including an STP which is located on the North bank. Uppal region which comes under the catchment area for this zone is known for its 'Green Fodder – Para grass'. Though the process of Green fodder farming in this area is not being conducted in the right manner, the existence of framing lands substituted by the concrete ground retains the natural drainage system to a large extent and thus it result in the analysis which is categorized under 'Fair' condition.

## REFERENCES


[1] Manual of A.P. Municipal Laws; 2nd edition.
[2] Data collected from HMWSSB
[3] Hyderabad Metropolitan Water Supply & Sewerage Act, 1989; 1997; 1st edition.
[4] Wikipedia – Ananthagiri hills, River Musi
[5] Rosgen's stream classification - https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=1189
[6] Data collected from Amberpet STP
[7] Data from Mr. Guru Swamy - Paragrass
[8] Physical survey Data
[9] Data from Mr. Srinivas Rao Thota – Musi H
[10] Natural Resource Management for Sustainable Hyderabad (NRMSH) –Pilot project
[11] URBAN AND PERI URBAN AGRICULTURE: G V Krishnagopal and R. W. Simmons
[12] Site work coordinator – Mr. Divyaj Reddy T