Technical Guidelines for Terms of reference for diagnosis, feasibility studies and detailed sewage system designs

1 General aspects

1.1 Objective of the terms of reference

The Technical Guidelines for terms of reference presented in this document are intended to define the requirements and criteria that the contractor must meet in carrying out the studies concerning sewage systems.

1.2 Scope of the terms of reference

These terms of reference define the activities to be carried out in the different stages of the project from the diagnosis of the systems to the detailed design of the optimal alternative selected based on technical, social, environmental and financial criteria.

1.3 Document components

This document is divided into five sections, the first of which is introductory, the second presents the criteria for carrying out the diagnosis of sewage systems, the third is concerned with feasibility studies, and then section four stipulates the parameters that the contractor must follow in order to create the detailed designs.

Additionally, section five presents the general guidelines for presenting the project to the Ministry of Housing, City and Territory in order to obtain viability, in the case of requiring government resources for its construction.

2 System Diagnosis

2.1 Scope of diagnostic studies

Carrying out the diagnostic studies of the existing system has the objective of obtaining detailed knowledge of the existing system, in the impact zone of the project, in order to establish the behavior of the system under study with respect to present and future loads. The result of this diagnosis will permit the proposal of the activities of: rehabilitation, replacement, optimization or expansion of the sewage system networks in the study area.

In order to carry out the diagnosis, the contractor must collect and analyze secondary or primary information as required by the contracting entity, in accordance with the provisions of this document.

Within the feasibility study, the contractor must predimension each of the components of the project for each of the alternatives proposed for the project, in accordance with the provisions of this document.

2.2 Detailed diagnosis of the situation of the municipality

The contractor must make a diagnosis on the current conditions of the municipality regarding public health, the state of natural resources and social welfare from primary or secondary information which must be obtained in the relevant municipal, departmental or national entities.

The physical, economic and social conditions of the municipality and the area under intervention must be described. In the same way, a diagnosis should be presented on the general state of the provision of public services, identifying the areas with and without public services coverage, and their continuity, efficiency and quality.

2.3 Determining the affected population

As one of the products of the contract, the contractor must determine the population directly or indirectly affected, as well as the target or beneficiary population of the project; they must carry out the population projections based on the mathematical methods using the existing censuses, or based on the records of the domiciliary public services present in the project development area. From these calculations the contractor must define the design population for the project, which will serve as a basis for the execution of the design. For the execution of the population calculations, the contractor must establish a baseline, based on information from the relevant municipal, departmental or national entities.

In order to carry out the population and demand study, the contractor must perform the analysis and confrontation of all the information available on estimates of population growth and water consumption in the study area adjusted to the Territorial Land Use Plan. Based on this information, a socio-economic development scheme will be defined to allow the future population to be established with their respective current and future stratification, as well as their probable spatial territorial location in each analysis period.

In addition, the contractor must perform at least the following activities in order to complement the population analysis:

- Collect, revise and portray in drawings the information on the existent urban developments, the new and projected urban developments, the subnormal developments and in general, the different uses of soils present in these zones, in accordance with the municipal regulations in force on the physical order adopted.
- Perform a detailed assessment of the areas occupied based on recent airphotographies, plans and information from the IGAC and DANE, which should be supplemented and updated with field surveys.
- Carry out an estimation of the current population and its spatial distribution and make annual and five-year projections of the future population and its probable territorial distribution. With this information, the number of houses and homes in the study area must be projected.

2.4 Socio-cultural characteristics of the population and community participation

The contractor must include within the contract products information about the social and cultural conditions of the target population, based on primary or secondary information. This information must contain at least specific characteristics, such as special conditions of the population, spatial distribution, stratification, population density and expected population growth, periods of the year in which there are increases in the floating population, predominant income levels and economic activities, as well as growth and trends in industrial and commercial development. They must include the socioeconomic characterization of the population in aspects such as: NBI index, population in extreme poverty, land uses, social conditions, public health, educational aspects, civic organizations, income level, availability of human and material resources in the region, etc.

In the same way, they must also identify key aspects for deciding on the project approach, related to customs, beliefs, roots in the local area, and natural resources, among others.

The contractor must compile within the study area information on the population and the conditions and/or ethnic characteristics of the same (if applicable), number of dwellings, type of dwellings, and ownership of the land where the population is located (for example if it is located on land owned by the population, on vacant land, on collectively owned land, indigenous reserves, etc.), pre-consultations, existing water and sanitation infrastructure, water quality supplied for human consumption, and discharged by the sanitation infrastructure, protected areas, ethnic minority territories, identification of required environmental procedures, morbidity and mortality and other relevant aspects associated with water supply for human consumption and basic sanitation; in order to analyze the problems and identify viable technical and economic alternatives for solutions. If the previous information does not exist or is insufficient for the contractor, they must collect it as part of the population and demand study.

2.5 Quantification of demand and/or needs

The contractor must define the methodology for calculating the current and future demands of the system, in accordance with Colombian regulations in force at the time of creating the designs, and good engineering practices, considering that which is defined in the Territorial Land Use Plan, the Comprehensive Solid Waste Management Plan, and the other municipal planning tools, with the objective of estimating the necessary capacity of the systems in the established design horizon. In any case the analyses should make use of the historical information of the consumptions of the subscribers available in the companies providing the municipal service, or if this is not possible, then the information compiled in the single information system (SUI) of the Superintendency of domiciliary public services (SSPD).

2.6 Knowledge of existing infrastructure

2.6.1 Collecting information

The contractor must, at its own risk, collect, consult and analyse existing information directly or indirectly related to the development of the project in different official and non-official entities such as: the municipality, the different public or private service providers, the Regional Autonomous Corporation, the Ministry of Housing, City and Territory–MVCT or other ministries, the Geographical Institute Agustín Codazzi, the competent environmental entities, non-government organizations that make interventions or have a presence in the project area; as well as additional information available in other local, departmental, regional or national entities, in order to be used as a reference for the creation of the project.

Available information on existing studies, operation and maintenance logs, construction reports, flow records, information of the years of installation, and deterioration rates of existing networks should be collected, as well as geotechnical, topographical and hydrological information, and any relevant information in order to establish the current state of sewage networks and critical areas in the project area. Likewise, the contractor must compile the existing information, in the aforementioned entities, related to existing or projected networks of all public or private service systems that may interfere with the development of the project or that, by the judgment of the contractor or the auditor, should be considered regarding the development of the project.

The contractor must evaluate in the field if there are sufficient works corridors to trace the alignments of the pipes, always trying to follow areas of public space or public roads; if this is not possible, they must identify and diagnose the number of properties or easements to be acquired.

In the event that the sewage network register required to design the sewers subject to the scope of this project is not available, the contractor must create it. No additional cost will be recognised for this activity, so the contractor should investigate this situation in the elaboration phase of his offer, in order to bear this in mind when calculating costs.

Documents such as: geological and geomorphologic maps and geotechnical exploration carried out by others in a strip of up to 10m on each side of the pipe lines.

As part of the review of existing information, specialists in geology, hydrology and geotechnics should make a field visit to the sector. It is recommended that this visit be done once the contractor has reviewed at least 50% of the existing information. This visit is part of the field work to be carried out by the contractor.

The diagnostic report should present the preliminary geological and geomorphologic characterization and identify potential stability problems that could lead to changes in the direction of the pipeline networks.

The geotechnical component must present a generalized geotechnical characterization or sectorization along the networks. This should be based on the geotechnical information collected and its analysis. The contractor must present in his report the bibliography of all the sources of information used for the design diagnosis.

The contractor must request from the different service companies, obtaining networks of services plans such as gas, electricity, aqueduct, sewage and fiber optics. This information should be used to determine the final location of each exploration point and thus mitigate potential network damage and accidents for the exploration staff.

2.6.2 Information analysis

The information compiled by the contractor in accordance with the previous paragraph must be classified and organized following the guidelines established by the good practices of document management in such a way as to guarantee their availability and easy consultation from appropriate inventories, listings, registries and formats, which must be expressed in the information collection and analysis document which the contractor must create. All existing information that is collected will be analyzed with the purpose of evaluating its relevance and possible use.

The contractor must carry out a detailed analysis of all the information collected for the purpose of verifying it with respect to the current reality, and to generate the description of the area affected or benefited by the project, at least in terms of the following aspects: geographical location, limits, communication routes, hydrology, climatology, soil types, topography, cartography, geology, building materials, pavements, urban development, potential risk areas, among others. For this they must collect relevant information such as plot plans and urban plans of the study areas, plan records of existing networks, studies and designs of projected networks, Territorial Land Use Plans, and any other information that the contractor, the auditor or the municipality consider relevant in order to be able to determine the drainage areas, runoff coefficients, affected areas, and other technical data necessary for carrying out the project. In the same way, based on this information, the contractor must assess whether the sectors envisaged for the design are located

in areas of high, medium or low threat or risk as defined by the competent body; it should also be assessed whether the sectors to be designed are in patrol areas, or areas of environmental management and preservation of water bodies, forest reserve zones, or national park areas.

The contractor should analyse the compatibility and relevance of the municipality's development Plan, the Territorial Land Use Plan, as well as previous studies of sewage systems, environmental risk, flood plains and, in general, all municipal, regional and national studies related to the impact area of the project.

The contractor must also make an assessment of the urban and sanitary perimeter in order to determine the area to be covered by the project (considering the surrounding rural sectors, if this is the case); areas will be identified which are suitable for urban development due to their topography, soil quality, the possibility of receiving public services, the continuity of the urban infrastructure, and spontaneous and directed urban growth trends.

The contractor must validate in the field, in the influence area of the project, the information contained in the plans of the sewage system and other public services on designs previously developed, to identify and verify the networks, other existing projects and those projected for construction in the study area, where the development of this project could cause interference.

Based on the information collected, the contractor must define the cartography to be used as a basis for the development of the project, and on the basis of this shall be defined, in conjunction with the auditor or the contracting entity, the scope of the topographic surveys to be carried out, and the methodology and technology to be used, along with due justification of their selection.

2.7 Systems Analysis

The comprehensive diagnosis should recognize and contain local information on the uses, customs and traditions regarding the basic forms of sanitation of the population, the existence of infrastructure and historical schemes in the provision of the service; also it should include studies of capacity and payment availability of the population.

From the review and analysis of the information collected, the contractor must carry out the analysis of the current state of the sewage system in the study area, in order to identify in detail the areas with problems, and carry out the projection of inspection works of the networks so as to determine with precision the faulty sections and the types of failures or damages that they present. Based on the results of this study the contractor must carry out the diagnosis of the existing infrastructure, in order to propose the rehabilitation, replacement, optimization or expansion of the existing networks or sewage infrastructure.

In the same way, from the review and analysis of the information collected, the contractor must carry out the diagnosis of the behavior of the existing sewage systems (rainwater, sanitary, or combined) in the study area, identifying and quantifying the sewers, interceptors and final emissaries constructed; describing and indicating in plans the quantities, lengths, capacities and hydraulic and structural characteristics of the components of the system and the basic characteristics of the currents, structures, sections or receiving water bodies. A diagnosis will be made of each and every one of the elements that make up the sewage systems in the influence area of the project. For this purpose, a technical identification and description of these components, their dimensions, their functioning, their condition, and their problems must be carried out. All the diagnosis must be carried out taking into account the technical, economic, financial, institutional, social and environmental approaches.

In order to carry out the diagnosis, the contractor must present and determine, based on the information collected, the design parameters of the sewage systems (combined or separate), including population and demand analyses, selection of complexity level, period and flow design for each component, and the other design guidelines and parameters established in the current RAS; as well as the criteria related to the quality of the sources or receptors of the discharges for the effluent of the wastewater treatment plants.

Similarly, the contractor should present and determine, based on the information collected, the hydrological parameters used for the design of the rainwater sewers. Additionally, based on the information collected, the contractor must identify the areas susceptible to flooding and evaluate the possible effects on the different structures of the system that can be affected by flooding, calculating the periods of return permitted by the system, those required, and those indicated by the regulations; and the necessary protection measures must be established and designed to mitigate these impacts.

The contractor must carry out the studies and analyses for the collection and evacuation system of sewage or rainwater in the study area, which must include at least:

- General description of the current system and operating conditions, structural state of the same and costs of operation and maintenance of the system, reliability and vulnerability. All of the above taking into account also the projects that are in execution at the time of carrying out this contract.
- Integrality of the urban drainage.
- It shall determine whether there is a plan for ordering and managing the supply basin, the water quality of the effluent from the wastewater treatment plant or the existing discharge points must be determined, and a description given of the collection systems of wastewater, and flows captured in each structure.
- The capacity, operating status and operation of each component of the systems must be determined, the existing sewage system types, flow designs and years of projection, and the installed capacity of the wastewater treatment plant if present; the hydraulic characteristics of the collection and transport networks identifying the matrix networks and the coverage index of the sewage service, wastewater discharge points and environmental impacts.

Based on the results obtained in the aforementioned analyses, the contractor must create the plans for the rehabilitation, replacement, optimization or expansion of the networks or sewage infrastructure, for which they should consider at least the following aspects:

- The deterioration of infrastructure and equipment with age and use, for which infrastructure aging models should be implemented, in order to support decisions based on a system of asset management and risk management.
- Frequent causes of repair, determined by signals such as: customer complaints, infiltration-exfiltration problems in the sewage systems, alerts in monitoring and follow-up systems if they exist, and any other relevant information to identify failures in the sewage networks.
- The hydraulic performance of all the elements of the system for which the hydraulic simulation of the networks must be implemented, which preferably must be carried out in specialized software, or in the absence of this, with properly designed spreadsheets; these simulations must be accepted by the auditor.
- Decision-making on the expansion and capacity-building of systems, leading to proactive rehabilitation.

- The incidence of external factors affecting the rehabilitation strategy, such as decisions by the regulatory agent, competent environmental entities or related ministries.

The contractor shall carry out the analysis and assessment of the current operating conditions of each of the components of the sewage or rainwater collection system in the intervention area, such as: sewers, interceptors, manholes, spillways, pumps, treatment systems and discharge structures to water bodies. As a result of the analyses, the contractor must clearly define whether the system properly performs its normal operation function, considering the operation and status of each of its components.

The contractor will have to evaluate and present alternatives to rehabilitate, optimize or expand the operation of the existing infrastructure, and propose realistic actions to obtain improvements in efficiency and productivity in the management and operation of the sewage services, calculating the potential for generating internal resource savings. The contractor must identify the actions necessary to increase operational efficiency, achievable goals, the necessary resources to achieve these goals, and indicators for controlling and monitoring compliance.

The contractor must include in the diagnosis, the respective conclusions of the state of each component of the sewage system, identifying whether the sewage systems are separated, or if it is a combined sewage system.

In the development sites of the project where there is sewage infrastructure that has an impact on the execution of the studies and designs, and of which there is no reliable network register, or in the sites where the contracting entity requires, the contractor must create a register of sewage networks in the sections which have a direct impact on the project, or in those defined by the contracting entity. This register must be carried out following the guidelines established in paragraph **¡Error! No se encuentra el origen de la referencia.** of this document, and these systems must be properly referenced for consultation and operational use.

Also the contractor should carry out an investigation of all the properties affected by the project, defining basically fences or walls, identifying the owner, the state of the deeds, easements and other relevant information.

The results of the diagnosis of the system should be included in the geographic information system of the municipality, or if this system does not exist, the municipality will define the way in which the results must be delivered.

3 Feasibility studies

3.1 Scope of feasibility studies

In the feasibility study the alternatives for solutions to the problems identified in the diagnosis of the system should be presented in order to define the optimal technical, environmental, operational, social and financial alternative for the municipality. The contractor shall undertake the collection of the relevant primary information for proposing the alternatives subject to analysis based on the following paragraphs.

3.2 Proposal of alternatives

The contractor should undertake the proposal and comparison of necessary alternatives where different methodologies, types of construction, technologies and other aspects are evaluated,

enabling the selection of the optimal technical, environmental, and social, operational and financial alternative for the municipality.

The alternatives proposed by the contractor must be articulated in accordance with the Territorial Land Use Plan or scheme, and with the environmental and sectorial plans such as: Plan for the Management and Handling of Water basins (POMCA), Plan for the Sanitation and Management of Discharges (PSMV), Comprehensive Solid Waste Management Plan (PGIRS), in order to establish the implications that the system, or any of the components of the project, would have within urban development, or the basin, and so that its execution is aligned with municipal and regional goals in the sector.

3.3 Alternatives Analysis

Based on the assessment and diagnosis of existing sewage systems, the contractor must identify, propose and predimension at least three solution alternatives for the identified problems and for each element to be adapted, rehabilitated, optimized, or replaced, and the reasons and justifications for the inclusion of new elements.

Thus, the contractor should consider, predimension, evaluate, and select the most favorable alternative for the municipality or contracting entity based on the provisions of this document.

The feasible alternatives proposed for each component should be to ensure the proper functioning of the sewage system and its components, incorporating its technical, institutional, financial, economic, social and environmental dimensions, in accordance with the current regulations of the Technical Regulations of the Drinking Water and Basic Sanitation Sector – RAS, represented in resolution MVCT 330 of 2017.

Each of the feasible alternatives proposed by the contractor must have a financial model that reflects the estimation of investment costs, administration, operation and maintenance, and should determine in an approximate way the fee and subsidy levels that are demanded, in order to conclude that the existing business scheme or the new proposed one, and in general the alternative proposed for the provision of the services, is feasible.

The solution alternatives proposed should be in accordance with the diagnostic phase in relation to the prioritization of the problem, for which the alternatives will be proposed in response to the different stages, in terms of short, medium, and long term. For each of the alternatives proposed, it will be necessary to create the corresponding hydraulic model in accordance with the provisions of this document.

3.4 Field work

The contractor must carry out the field trips necessary for the recognition of the area in order to visualize directly and without the possibility of error the situation of the area, the real possibilities for handling the solutions to the problems formulated, the need for the acquisition of properties, the requirement of special studies, as well as the definition and scope of the topographic works necessary in order to carry out the detailed designs of the project.

The contractor must carry out the necessary studies to acquire the basic knowledge of the sector, in order to evaluate the alternatives proposed. These should be agreed with the auditor and the municipality before execution, and must be carried out in accordance with the guidelines set forth in this document and in the regulations in force at the time of carrying out the aforementioned works.

3.4.1 Topographic survey

The contractor should carry out the planimetric and altimetric topographic surveys enabling the description of the terrain where the works are projected and the surrounding areas, these works should be carried out based on precise topographic surveys such as total stations with an angular precision of no more than three seconds, or by using global GPS positioning systems.

Topographic surveys should comply with the guidelines of the Colombian Technical Standard NTC 6271 "Geographic information. Topographic studies" or with the national or international standards which the contracting entity stipulates and considers relevant. The topographic studies must comply at least with the following aspects:

The field portfolios must be filled out with the relevant information about the person in charge of carrying out the work and must follow the guidelines stipulated in La NTC 6271.

The by-product will be the report in magnetic and physical form of the topographic studies for the defined projects. It must be endorsed by the signature and professional registration number of an engineer surveyor or surveyor with professional registration.

3.4.2 Bathymetry

If a rainwater sewer is required to be discharged to a surface water body, topo-bathymetry surveys must be carried out on the channel; the number and extent of the sections to be surveyed will depend on the conditions and characteristics of the receiving body and the flow to be discharged. The contractor should build the models and give details of the factors that make up the study area by establishing the topographic conditions of the space and the terrain surrounding the section of interest, together with the bathymetric measures present in the axis of the receiver body at the time of the study. All this with the intention of knowing its morphological characteristics both on the surface (length, width, shape, and those it considers decisive within the study), and under water (depth, thickness of the sediments, topography of the bottom, among others).

For this purpose, the technological tools to process information such as longitudinal profiles, cross sections, level curves, among others, should be put at the service of the studies.

3.4.3 Analysis of properties and easements

The contractor must carry out the property research for each of the alternatives proposed, by identifying the affected areas, the area of affectation, and other aspects which enable the identification of the processes of acquisition of properties, or the recognition of easements.

The contractor must analyze the costs derived from the affectation of properties, in the case of each one of the alternatives, so as to enable the comparison of each one of the alternatives.

3.4.4 Geotechnical investigation works

The depths of geotechnical exploration, type of exploration and frequency shall be at least that required by the Colombian Regulations for Seism Resistant Construction NSR-10 and in resolution No. 0330 of June 8th, 2017 of the Ministry of Housing, City and Territory of the Republic of Colombia. By which the Technical Regulations of the Drinking Water and Basic Sanitation Sector is adopted – RAS and the resolutions 1096 of 200, 0424 of 2001, 0668 of 2003, 1459 of 2005, 1447 of 2005 and 2320 of 2009 are repealed.

All geotechnical exploration must be supervised by a field engineer who controls the minimum requirements for quality and execution of the different perforations, shafts, trenches, sampling,

execution of field tests, description of the samples, storage and transport of samples to the soil laboratory in which they should be stored in a humid room. The soil laboratory must have the certification of equipment calibration and the certification of training of laboratory personnel.

The geotechnical exploration and the methodology of work for the feasibility stage should be given as a report to the auditor, who will or will not give their approval of the exploration. The contractor must indicate in the report whether or not permission is required from properties to carry out the exploration.

The geotechnical exploration carried out at the feasibility stage should be used in the detailed design stage.

3.5 Technical assessment of alternatives

3.5.1 Hydraulic assessment

3.5.1.1 Defining sewage flows

For calculating the flow of sanitary sewers, the contractor should identify, analyse and define parameters such as areas to be drained, return coefficient to sewer system, socioeconomic stratum, water consumption, current and future population density according to the projections made, capacity factor, infiltrations, erroneous connections, among others. In addition, to define the contributions of commercial, industrial, and institutional type, to be adopted, according to the user register already existing, or created.

Likewise, in rainwater and combined sewers (if applicable), for rainwater contributions, the following parameters are determined, among others: area to be drained, intensity-frequency-duration curves of the nearest pluviographic or pluviometric season, return period, concentration times, runoff coefficients, etc.

In addition, the hydraulic parameters that foster the proper functioning of sewage systems, defined in RAS 2017, will be followed.

3.5.1.2 Hydraulic analysis of alternatives

From the information of the field studies, the current and future population, the calculation of the flows and other aspects collected, the contractor should carry out the predimensioning of the networks and other components of the project, and carry out the assessment of the hydraulic behavior of projected networks and existing ones that are affected by the realization of the project.

For the predimensioning and assessment of the networks, and other components, the contractor must carry out the hydraulic simulation of the networks in a specialized software for this purpose, which may be of free use or of private firms previously approved by the auditor and the contracting entity. The contractor may make use of electronic spreadsheets for the hydraulic assessment of the systems, with prior approval from the auditor and the contracting entity.

3.5.2 Geological, geomorphological and geotechnical assessment

The contractor must carry out the geological and geomorphological characterization of the study area as well as the preliminary geotechnical investigations which provide the knowledge of the soil where the construction, renovation or rehabilitation of the sewage system is projected.

In raising the alternatives the contractor should contemplate the different scenarios and/or geological, geomorphological and geotechnical variations that may favor or disadvantage the

alternatives proposed. For this the geotechnical component must be included within the assessment matrix of the alternatives proposed by the contractor.

In this stage of selection of alternatives, the contractor will be able to execute a geotechnical exploration campaign at feasibility level. This exploration of the subsoil should be justified and its approach should contemplate existing explorations as complementary information for the analyses at this stage.

3.5.3 Structural assessment

The contractor must perform the structural assessment of all the components of the system located in the study area, which can be used as part of the proposed solution. Likewise, they must carry out the conceptual or basic structural designs of each one of the alternatives in order to be able to estimate the costs, affectations and other aspects that allow the comparison of the different alternatives.

The designs created must follow the guidelines established in the Colombian seism resistant standard NSR-10 or those laws or decrees that modify it, and the contracting entity may require the fulfillment of additional regulations if considered relevant.

3.5.4 Electro–mechanical assessment

In cases where the use of pumping equipment or any other element requiring the use of mechanical equipment is needed, the contractor must carry out the predimensioning of the equipment in order to compare the proposed alternatives.

In all cases where electrical power supply is required, the contractor must determine the availability and reliability of electricity in the influence area of the project. In the same way they must determine the characteristics of voltage, power and frequency of the service, and the contractor must include in the analysis of alternatives the energy cost.

In the same way, if necessary, the contractor should analyze the possibility of generating electricity through alternative energies, including the possibility of using renewable energies.

3.5.5 Environmental assessment

The contractor must carry out the preliminary environmental assessment of each of the alternatives subject to analysis, identifying the most significant impacts, and enabling a comparison regarding the environmental aspect of each of the alternatives proposed.

3.5.6 Vulnerability and risk assessment

The contractor should identify and characterize the threats present in the area, as well as identifying the weaknesses of the infrastructure, and determining the physical vulnerability of its components, of the financial capacities, such as suspension of payments, expenses in repair of the systems, increase of production and distribution costs, and of the operative costs, observing the technical resources and the prepared personnel, in the systems and services.

In considering the works to be carried out for the best provision of the water supply and management service, measures and works of protection must be included to ensure the sustainability of the systems against the environmental risks.

In the assessment process it is important to consider and take advantage of the knowledge that the local population has regarding the environment. It should always be kept in mind that local

risk management should involve the community itself and gather its knowledge of the main natural threats, the places at greatest risk and the magnitude in which they have occurred, and combine this with the available technological options so that the components are located in the lower-risk areas, or the necessary preventive measures are included.

The contractor must identify, evaluate and quantify the risks associated with the proposed alternatives. For each type of risk the contractor should propose efficient mechanisms of allocation and mitigation. The responsibility of each risk must be assigned to the party that is best able to control it. The financial implications of the risks and required mitigation mechanisms will be quantified so that the financial viability and the reliability of the proposed mechanisms can be established.

3.6 Other studies ahead

3.6.1 Socioeconomic studies

The socio-economic assessment of projects should be carried out in order to measure the net contribution of projects to the well-being of the population. For aqueduct, sewage and/or sanitation projects, minimum socioeconomic studies such as cost-efficiency analysis and/or minimum cost analysis and capacity expansion, are required (see Social Management and Gender Equity Plan).

3.6.2 Labor availability

The availability of qualified and unskilled labor for the development of the project and of technical personnel for operation and maintenance work, as well as the salaries in force in the locality, must be analysed. In the same way, the availability and capacity of local, regional and national production of materials and equipment required for the construction of works, and resources for operation and maintenance must be established, precisely defining the availability of quarries and their distance to the work area, as well as the availability of disposal sites for surplus materials.

Depending on the type of engineering work that is expected to be carried out within the project, a greater depth and detail in the study of sources of stone materials and their specific environmental requirements will be necessary, and the detail of this analysis will be defined in conjunction with the auditor and the contracting entity.

3.6.3 Access roads

An inventory must be made of the roads, paths, railways, as well as of the routes of air, sea, river and lake access to the locality, establishing the distances to the nearest urban areas. This will make it possible to establish the accessibility for the required transport of materials and equipment for the execution of the works, and their subsequent maintenance.

3.7 Selection of the most favorable alternative

The contractor should select the best alternative based on sustainability criteria, from the assessment of the economic, technical, environmental and social aspects; for this they must use methodologies that imply minimum valuation subjectivity, and the lowest cost of investment, operation and maintenance. The definition of variables and the weighting values in the selection of the most favorable alternative should be assessed by the use of multi-criteria selection matrices.

4 Detailed Designs

4.1 Scope of detailed designs

In the detailed design stage all designs must be carried out that enable the construction of the selected alternative in the feasibility study. The contractor must dimension and design all the components of the project to ensure the proper operation of the sewage system, and its interaction with the non-intervened or existing system.

The contractor must execute the detailed designs of the selected alternative in accordance with the provisions of the Colombian regulations applicable, especially with the Technical Regulations for Drinking Water and Basic Sanitation Sector RAS represented in the resolution 330 of 2017 and any decree or resolution amending it.

In the same way, the contractor must accept the recommendations of good engineering practices of the aforementioned regulation, as long as they do not differ from the legislation in force at the time of the development of the works, and from what is stipulated in the present document.

4.2 Design criteria

In conjunction with the auditor the contractor must define the design criteria for the sewage systems of this project, which must be within the framework of the requirements of the Colombian regulations in force. The auditor or the contracting entity may require compliance with additional national or international standards which must be considered within the definition of the design parameters or criteria.

The contractor must submit a document summarizing the criteria to be used in the project which must be approved by the auditor and the contracting entity.

4.3 Minimal aspects of the detailed designs

The detailed designs must contemplate at least the aspects summarized below which must be developed within the framework of the Colombian laws and the national or international regulations that have been defined as the basis for carrying out the designs.

4.3.1 Additional field work

4.3.1.1 Topographic surveys

During the detailed design stage, the contractor should carry out the topographic surveys of detail necessary to complement the work carried out in the feasibility stage, in order to get to know the study area in detail, the interference with other systems such as roads, networks of other public or private systems, and all those present along the route of the networks or in the location of the structures. If required, the register of existing sewer networks that are involved in the detailed design of the new infrastructure must be completed.

4.3.1.2 Geotechnical exploration

An appropriate geotechnical exploration will have to be carried out to provide a detailed geotechnical characterization. In the Colombian regulations there are guidelines regarding the depth, frequency and minimum amount of exploration according to the type of work proposed; however it is the specialist geotechnics engineer who will define if this minimum number is sufficient or not to cover the level of detail that each structure requires. For no reason shall a quantity or depth be lower than that required by the current regulations.

The contractor must implement direct methods (mechanical perforations, trenches, shafts) and indirect methods such as geophysical exploration (seismic refraction lines, Down hole and Cross Hole), electrical tomography and vertical electrical soundings. Any interpretation of stratigraphic profiles of indirect methods should be confirmed with the laboratory results carried out on soil samples obtained by the methods of direct exploration.

The programming of laboratory tests must comply with the frequency required in the Colombian regulations. These tests, in addition to focusing on the geotechnical design of foundations, piping networks and slope stability, should also focus on the identification of special geotechnical conditions such as the presence of expansive soils, dispersive soils or erodible, collapsible soils.

The required tests must be carried out to complement those carried out in the feasibility stage, in order to identify the physical-mechanical characteristics and chemical characteristics that identify the potential of corrosion and its reaction with metallic and non-metallic elements which are to be located in the subsoil; geotechnical study which determines: the bearing capacity, conditions of threat and vulnerability and the geotechnical stability of the soil and of the works that require it. Recommendations for the design and construction of foundation elements, containment structures, protection and drainage; the geometry and safety factor of slopes. The need to undertake more detailed studies of geology, hydrogeology, and/or soils must be established, justifying the reasons for the recommendation, as well as the additional field research plan to be carried out at the design stage.

4.3.2 Hydraulic design

4.3.2.1 Geometric design and interference analysis

According to the topographic surveys carried out and based on the requirements of the project, the geometric design of the alignments of the sewage system networks will be carried out, including the chambers, manholes and all the structures the system requires for proper operation.

Each of the elements that make up the system must be located in the plant and in profile, incorporating all the interferences that can be found at the time of executing the works. As part of the detailed design the handling of visible and non-visible interference with other public or private service networks must be determined. This aspect must be described in detail, and should include the authorizations necessary, and the budget for the solution proposed for handling the interferences in the construction.

The contractor must submit a detailed design report, which includes the records of calculation, plans, specifications, work quantities, budget, work schedule, environmental management plan, and other documents necessary for the construction of the project.

4.3.2.2 Hydraulic dimensioning

The contractor must perform the detailed hydraulic design or dimensioning of all components which are part of the system such as networks, chambers or manholes, landfills, spillways, channels and any other structure necessary for the proper hydraulic operation of the system.

The contractor must define the type and class of pipe to be used in the construction of the sewage systems, considering the type of soil, the loads to which the network will be subjected, the type of installation and foundation and other relevant aspects.

The hydraulic dimensioning of the networks can be carried out by means of the use of any of the different methodologies established in the RAS, taking special care of the application restrictions of each one of these methodologies.

If it is necessary to use mechanical equipment for the operation of the sewage system, the contractor must dimension and describe the suitable equipment, as well as the necessary structures to house them.

The design of the sewage system must be carried out using the mathematical formula that define the diameters, slopes and the minimum hydraulic parameters of the systems' pipelines, which must be verified by the use of a hydraulic modeling of sewage networks, through the use of a program to simulate among others things the existing system, which should be based on fluid resistance equations, in order to obtain results in such a way that the mathematical model largely represents the physical model or prototype of the sewage system. The hydraulic analysis program must have the ability to simulate uniform flow conditions, as well as non-permanent flow conditions by solving the Saint-Venant equations, with their corresponding border conditions.

Additionally, the analysis program should be able to simulate the effect of the lower energy losses caused by the presence of connection and/or inspection structures. In any case, the parameters used in the design and the modeling must be justified, and in the calculations the actual internal diameter should be used. The contractor shall deliver the calculation records within which the raw data of the hydraulic models and their results must be included, and the procedure followed for the creation of the models so that they may be verified, and the files must be delivered in digital and physical form. In the same way, the reports must include the parameters and assumptions used for the design of each of the components of the sewage system.

In the same way the contractor must deliver the hydraulic plans to a suitable scale, which must contain the location of each of the components of the system, their hydraulic dimensions and sufficient details for their understanding.

4.3.2.3 Hydrological study

If the project includes hydraulic dimensioning of rainwater or combined sewage networks, the contractor must estimate the temporal distribution of rainfall (duration of rainfall) in the area to obtain design flows based on the design return periods stipulated by Colombian regulations according to the scale of the project. This activity should be carried out based on rainfall records, and on hydro-climatological variables of seasons located in the area of the hydrological study as precipitation (maximum monthly average, maximum precipitation in 24 hours, etc.), evapotranspiration and evaporation (monthly average). Based on this information the contractor must define rainwater flows into the sewage system.

In order to obtain the flows, the contractor will be able to use any of the methodologies present in the Colombian regulations or in the good engineering practices, taking special care of the application restrictions of each one of the methodologies. The auditor will have to approve the calculation methodology finally selected.

The designer must present the calculation records of the hydrological component indicating the procedures carried out and the results obtained in order to acquire the flows.

4.3.3 Structural Design

The structures that compose the system must be designed to withstand the loads to which they will be subjected, in accordance with the provisions of the Colombian Regulations for Seism Resistant Construction NSR-010, law 400 Of 1997 and Decrees numbers 33 of 1998, 926 of 2010, 2525 of 2010, 92 2011 and 340 of 2012, or those that modify, add or replace them.

Likewise for the hydraulic structures such as, culverts (of different sections), boxes interconnecting networks that due to their location are subjected to vehicle load regime, the design regulations to be applied will be the "CCP-14 Colombian Regulations for seismic bridge design" and the American Association of State Road and Transport Officers AASHTO.

The contractor must present the calculation records, which must be consistent with the structural design requirements ("Aci 350/350R Code Requirements for environmental engineering concrete structures and commentary"), Colombian Regulations of seism resistant design and construction-NSR-10," CCDSP-95 Colombian code for seismic bridge design", and other regulations quoted. They should include information from all the analyses carried out, if the structural design is done with the Help of specialized computer programs, they must include the specific name of the software and version; accompanied by a description of the program, the input data and the results obtained.

The contractor must deliver the structural plans which should contain the location of the structural elements, their dimensions, reinforcement on an adequate scale, and sufficient details for the correct construction. They can also refer to the dimensions indicated in the hydraulic or sanitary plans when appropriate. Elevations and cuts must be carried out with appropriate scale, quantity and scope to indicate interdependence and connections between the different elements. Special care should be taken to ensure that those details included and qualified as typical are applicable to the conditions of the project.

4.3.4 Geological and geomorphological Study

The design should establish regional and local geological and geomorphological characteristics, which allow the identification of fault zones, mass movements, seismicity conditions, and define geologic and geomorphological sectorization areas associated with the area of interest, and its surroundings or immediate affectation area.

The contractor's geology and geotechnics professionals must perform a detailed field survey to identify critical areas for the project, and to propose possible solution alternatives. It should be noted that the geology and geomorphology component should encompass the water basin of the bodies of water and identify any stability problems in it.

The contractor must present a geological and geomorphological sectorization map in the project area.

4.3.5 Detailed Geotechnical Design

All new structures, modifications to existing constructions, excavations, permanent slopes, land containment structures, pipe foundations and drainage works must have a geotechnical design, and must comply with the minimum requirements demanded by the Colombian regulations.

The contractor must present the geotechnical sectorization in the area of pipeline networks. In the sectorization, the average geotechnical characterization must be presented for each geotechnical sector.

The average geotechnical characterization should be based on the analysis of index, granulometric, geomechanical and deformability properties. All the geotechnical exploration and execution of laboratory tests on soil and rock samples must be carried out following section 100 – Soils of the Regulations Manual for testing road materials of the National Roads Institute (Invias). Manual based on international regulations developed by the ASTM.

The programming of laboratory tests must comply with the frequency required in the Colombian regulations. These tests, in addition to focusing on geotechnical design of foundations and slope stability, should focus on the identification of special geotechnical conditions such as the presence of expansive soils, dispersive soils, or erodible, collapsible soils.

The contractor must oversee the quality of the exploration work. The laboratory tests to be carried out must have quality certification, and the calibration of the equipment, and the qualification of the personnel that execute it.

4.3.5.1 Pipeline Foundations

The foundation must be designed for pipe networks in accordance with the methods of last resistance or limit states of service. This design must comply with the purpose of safety, durability, resistance, integrity of the elements, and the economy of the project.

All pipeline designs must withstand seismic design events. The design of the pipe foundation must take into account the type of material of the pipe, rigidity, installation conditions, load conditions, load factors depending on the depth of the pipe, digging depth, width of the excavation, and deformations such as deflection, buckling, breakage and resistance of the pipe. As well as the indices properties, of resistance and deformability of the subsurface.

The safety and stability of all unsupported excavations will be evaluated taking into account the depth of the excavation, the inclination of the slopes and the conditions of water pressure in the subsoil, according to code NSR-10-chapter H. 5.

When the excavation cuts are not stable, the temporary or permanent use of a system of excavation brackets will be designed to limit the amount of soil to be removed, as well as to protect the new adjacent structures. The stability of all slopes with timbering must be analyzed and determined from the assessment of the thrusts induced by the subsoil and the groundwater level upon the different components of the timbering (supports, anchors, props, struts, etc.).

All slope stability analyses shall be carried out in compliance with the minimum safety factors indicated in table H. 2.4-1 of code NSR-10 – Chapter H. 2 – Definitions.

4.3.6 Property aspects

Once the definitive areas have been defined for the different components of the project, the contractor should make an assessment of the property rights of these areas and establish the need to buy some of them and define their cost, or failing this, to establish the actions of legalization of the rights and easements necessary for the construction and operation of the project. The respective project plan must be attached, with an enclosed database identifying the properties to be intervened, which must contain at least (if this information exists):

- Name of the property
- Register identification number
- Real Estate Registration number

- Georeferencing of each one of the properties to be intervened
- Owner's name and copy of the owner's national ID card or NIT card
- Rural area and/or neighborhood
- Simple copy of the public deed.
- Certificate of Tradition and freedom of the property with validity of two (2) months
- Property information contained in the land register.
- The contractor will present a topographical report for the affected areas that includes polygonal and border strip or plot used in the project, with field portfolios, polygonal diagrams, calculation records, list of adjusted coordinates and photographic record of the materialized points, affected areas and free areas, and land register and owner information obtained.

The contractor must deliver the respective property cards for each property affected on appropriate scales, such as: 1:200, 1:500 or 1:1000, which will be approved by the auditor. These cards should have table with the data mentioned above, as well as the length of the boundaries, the plot area, and areas to be intervened according to topographic survey.

The contractor must submit a legal report of the affected property where the situation of ownership of the property is specified, if there is an owner, and their legal situation, on the basis of which the contractor shall make the relevant recommendations to the contracting entity on the necessary formalities before the public entities for the acquisition of the properties or easement rights as necessary. The legal report must include at least the following information:

- Situation of the property to be intervened.
- Copy of the individual topographic register.
- Photographs of the property.
- Copy of the owner's national ID card.
- Certificate of Tradition and Freedom.
- Simple copy of public deeds.
- Property information contained in the cadastre registers.
- Magnetic file of the photographs.

If it is necessary for the municipality to purchase some land or easement rights of passage, the cost must be included in the project's investment plan or budget.

In addition to the property study described, the contract should make the necessary steps to ensure the acquisition of the properties or easement rights necessary for the development of each project, including the approaches between municipal authorities and owners, and supporting the municipality in obtaining the necessary documents to carry out the required procedures before the respective entities for the declaration of public utility of the required properties, negotiation and formalization and legalization of the purchase of the required properties or easement permits.

The contractor must submit a property management report that includes the aforementioned.

4.4 Environmental assessment

The environmental assessment should be carried out on the basis of the "General methodology for the presentation of environmental Studies" of the Ministry of Environment, Housing and Territorial Development (2010).

A methodology for identifying and evaluating impacts for non-project and project-based situations should be employed, using matrices of cause and effect, which use qualitative and quantitative indicators to assess environmental impacts and enable the assessment to be presented in terms of relative values of environmental quality.

The contractor should follow the recommendations made by the Regional Autonomous Corporation or the competent municipal environmental authority, with respect to the works and actions formulated to mitigate the negative impacts generated by the project, or to the environmental management measures defined for the development of the project, both in its construction phase and in the operation phase.

The contractor will establish for each of the components of the project the positive and negative impacts generated by the execution of the project and its corresponding measures of prevention, mitigation or compensation with regard to the resources of water, air, fauna, flora and population, determining the degrees of affectation of each one, whose costs and priorities will be determined in the budget.

The contractor must create the respective impact matrices and formulate the management plan with actions of preservation, compensation, mitigation and control of the impacts, during the phases of the project, in the construction, operation and maintenance. It will analyse the effects of environmental impacts and control measures: soils, geology, water quality, hydrography, climate, fauna, flora, urban development and health. In the case of the receiving sources, the contractor must create a current and future base, in which the environmental state is identified before and after the implementation of the works. The environmental management plan for the implementation of the intervention will be presented to the auditor who will approve and monitor it.

For the above, the contractor must recognise the regional and geographical context in which the works will be carried out, in order to define the programs that apply according to the scope of these and the conditions of their influence area. The purpose of this assessment is to ensure sustainable development with the social and environmental surroundings, according to applicable Colombian regulations.

The contractor must observe and enforce laws and regulations concerning occupational health and industrial safety, considering scenarios to take all necessary precautions aimed at preventing and preventing accidents or conditions that derive from occupational diseases in the work areas and temporary installations.

Once the Environmental Management Plan has been structured and approved, the contractor must convert it into a field manual, written in a clear language that facilitates its understanding, to be taught to the operative staff, prior to and during the execution of the work, in such a way as to ensure its fulfillment. In this case, the contractor will be able to review the Handbook of Good Environmental Practices published by the Ministry of Housing.

Additionally, the contractor will provide the necessary information for the procedure before the environmental authority to acquire the permissions required for the project; which may be:

permission to grant water, occupation of watercourses, forestry use, permits for the extraction of materials from quarries, permit for discharges, permit for environmental license, permit for the environmental diagnosis of alternatives, permit for atmospheric emissions, and debris disposal in the study area.

4.5 Technical construction specifications

The design must specify the technical specifications of each of the elements of the project, including the details of materials, conditions, quantities and measures to be applied to the project. In addition, the design should include the constructive procedures recommended for the construction of the works.

The contractor will prepare the volume of technical construction specifications required for the quality control of the work and measurement and payment of the same, and following the format established for this purpose, which must be previously concerted with the auditor, and designated for that purpose.

For the creation of the technical specifications for the execution of the work which is the product of this contract, the following recommendations must be taken into account:

- These must contemplate and establish the minimum technical quality of materials and equipment to be used, in addition to the labor and services necessary for the construction of the project.
- These must establish the essential characteristics of the product that will be acquired.
- It should be avoided to establish an excess of specifications, in this way establishing unnecessary characteristics which can result in too restrictive specifications that may impede free competition and increase the cost of the product.
- The specifications must be reasonable and contain the necessary precision, otherwise they could possibly be expensive and may limit the competition.
- The text of the specifications should be clear, use common language, and without the use of terms susceptible to various interpretations.
- The use of abbreviations must be restricted to those which are of common use, and in respect of which it is not possible to cause misunderstandings.

4.6 Unit Price Analysis (APU)

The contractor must prepare the codification of the items of the budget, the APU's and the specifications that provide a clear traceable route to the value of each of the items on the work quantities form. Therefore it will be necessary to use a format, in order to break down each one of its components, equipment and tools, building materials, external and internal transport, labor and other parameters required for calculating the budget.

For purposes of calculating the APU, administration, contingencies and utilities a format must be used to enter in an organized way the different indirect costs of the project, including among others: administrative personnel, mobilization and facilities, general expenses, legal and tax expenses, and in addition a percentage for the contingencies and a percentage for the profits must be expressed.

4.7 Budget and work schedule

The contractor must include as part of the detailed design, the estimated work budget of the works to be executed, specifying the work quantities and the respective unit price analyses.

In addition, the design should include a tentative schedule proposal for the execution of the works, involving the stages of recruitment and execution of the works of the different components of the project, identifying the critical route and defining the constructive sequence most appropriate for the proposed scheme.

Based on the above, the contractor will create the schedule and the funds and investments flow for the execution of the project in order to determine the optimal sequence for carrying it out. A bar diagram will be made that indicates the duration of each activity, the interrelation between each one of them and in a clear way the critical route of the project; preferably in specialized software intended for this purpose.

To satisfactorily advance with the execution of the project, they will recommend and dimension the technical and human resources that are necessary for the proper functioning of the required organizational scheme.

The contractor will also need to estimate the cost of the required service of the project's auditor, which will be part of the financial plan, and the ideal personnel for monitoring the detailed design.

4.8 Other studies

The contractor must perform all the studies and designs with sufficient and necessary detail, including all the technical components described and others that the project may require, in order to materialize and construct the selected alternative.

5 Presentation of the project to the Ministry of Housing, City and Territory (MVCT)

The contractor must provide the contracting entity all the products necessary so that the municipality can formulate and present the project viability application to the Ministry of Housing, City and Territory. Also they should accompany the municipality in the procedures and activities that are the exclusive competence of the territorial entity (acquisition of land, formal establishment of easements, environmental procedures and special permits for crossing roads), which are necessary to obtain the viability of the project in accordance with the provisions of resolution 1063 of 2016, referring to: technically acceptable project.

Additionally, the contractor must know all the requirements of the project viability mechanism of the Ministry of Housing City and Territory, as it is their responsibility to carry out all the studies and designs required by this entity. The contractor may be required by the auditor or the contracting entity to make the appropriate adjustments and corrections to the projects, or solve doubts and concerns arising from the project, so as to clarify them in a timely manner.

5.1 Design documents

As a result of the design, a consolidated document containing each and every one of the documents produced in carrying out the steps here described should be provided, including design records, detailed drawings for construction, the definitive technical construction specifications, budget, unit price analysis and other relevant documents in original and two (2)

copies, as well as in magnetic form (CDS) compatible with the software applications available in the municipality where the project will be executed.

5.2 Plans

The contractor will provide the study plans in magnetic and original physical form, and two (2) copies, of 0,70 m x 1.00 M of the general plans and one reduced as a plan, and another in profile to an adequate scale in order to appreciate the whole of the project.

The plans delivered must be constructive plans, duly bound, and to appropriate scales, and must be signed by the contractor, the auditoror, and by the specialist professional of the respective area responsible for the design.