ADB

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# Mongolia: Darkhan Wastewater Management Project

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For the Ministry of Construction and Urban Development, Darkhan-uul *aimag* government, and Darkhan Us Suvag



Asian Development Bank

# Wastewater Management for Darkhan – Project Preparation

L2301-MON: Urban Sector Development Project (Additional Financing)
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**Ministry of Construction & Urban Development; Darkhan Us Suvag**

## Final Report

**September 2014**

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# Abbreviations

| | |
|---|---|
| ADB | Asian Development Bank |
| AIEC | Average Incremental Economic Cost |
| ASP | Activated Sludge Plants |
| BOD | Biochemical Oxygen Demand |
| CDIA | Cities Development Initiative for Asia |
| CDS | City Development Strategy |
| COD | Chemical Oxygen Demand |
| CPS | Country Partnership Strategy |
| CWWTP | Central Wastewater Treatment Plant |
| CWWTP | Central Wastewater Treatment Plant |
| D&B | Design and Build |
| DBOT | Design, Build, Operate, Transfer |
| DEIA | Detailed Environment Impact Assessment |
| DP | Displaced Person/People |
| DSCR | Debt Service Coverage Ratio |
| EIA | Environmental Impact Assessment |
| ENPV | Economic Net Present Value |
| EPA | Environmental Protection Agency |
| FCDI | Financial Charges During Implementation |
| FMA | Financial Management Assessment |
| FMAQ | Financial Management Assessment Questionnaire |
| GEIA | General Environmental Impact Assessment |
| GRM | Grievance Redress Mechanism |
| ICB | International Competitive Bidding |
| IEE | Initial Environmental Examination |
| LARP | Land Acquisition and Resettlement Plan |
| MCUD | Ministry for Construction and Urban Development |
| MDG | Millennium Development Goals |
| MEGD | Ministry of Environment and Green Development |
| MLSS | Mixed Liquor Suspended Solids |
| MNRM | Mongolia Resident Mission of ADB |
| MNT | Mongolian Tugric |
| MoED | Ministry for Economic Development |
| MoMo | Integrated Water Resource Management – Model Region Mongolia |
| NCB | National Competitive Bidding |
| NDS | National Development Strategy |
| NSO | National Statistic Office |
| O&M | Operation and Maintenance |
| OLA | On-lending Agreement |
| PC | Project Coordinator |
| PIU | Project Implementation Unit |
| PLC | Programmable Logic Controller |
| PMU | Project Management Unit |
| PPP | Public Private Partnership |
| PPTA | Project Preparation Technical Assistance |
| PUSO | Public Urban Services Organization |
| SBR | Sequencing Batch Reactor |
| SLA | Sub-loan Agreement |
| SS | Suspended Solids |
| TA | Technical Assistance |
| UDSP | Urban Development Sector Project |
| USD | United States Dollars |
| VAT | Value Added Tax |
| WACC | Weighted Average Cost of Capital |
| WWTP | Waste Water Treatment Plant |

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# EXECUTIVE SUMMARY

## Background and Rationale

Darkhan is the third largest urban area in Mongolia (after Ulaanbaatar and Erdenet). It was established as an industrial centre, and continues in this role with a thermal power plant, major metallurgical industries, cement and other construction materials manufacturing, and a host of smaller industrial units. However, despite this industrial heritage, there has been little new investment in either the manufacturing or processing industry in Darkhan in recent years. As a result, while the economic performance of the city has approximately matched that of the country as a whole, the city's population has stagnated. The registered population has remained much the same over the past decade, but has declined by almost three per cent between 2010 and 2013.

As part of its socio-economic development strategy, the Government of Mongolia is committed to promoting further investment in industrial development in Darkhan. Furthermore, Darkhan has been identified as a model city in Mongolia and the Government is supporting the preparation of a new Darkhan General Plan which will set out the development strategy and plan for Darkhan to year 2028 as both a "smart city" and a "green city". There is also the prospect of significant industrial investment in the short- to medium-term. A new oil refinery is proposed for Darkhan, to be developed through joint Mongolian and Japanese financing, and the aimag government is keen to encourage expansion of the existing metallurgical and construction materials industries.

While Darkhan has the same urban form as all other urban centres in Mongolia, with a distinct duality in the availability and quality of services between the central planned core on the one hand, and outlying ger areas on the other, the proportion of the population living in ger areas in Darkhan is smaller than most other urban areas in Mongolia, at only about 35-40% of the total urban population[1]. The city also has two distinct urban cores – Old Darkhan to the north and New Darkhan to the south, with the industrial estate a further 2 Km south of the southern edge of New Darkhan. This configuration means that much of the urban core is not surrounded by ger districts. This potentially facilitates the planning and delivery of expansion to the core areas for residential, commercial or industrial uses in a cost-efficient manner on green-field peri-urban sites, without the need to address the difficult issues associated with ger area redevelopment.

Conditions within the ger areas are poor – with water supply only obtainable from water kiosks, sanitation restricted to on-plot long-drop toilets, and no access to the centralised heating system. While conditions are significantly better within the core urban areas, with full household services provided to apartments and low-rise housing, both the water supply and sewer networks suffer from ageing and dilapidated infrastructure resulting in significant leakage from both systems, and frequent system failures. The three main wastewater pumping stations and central wastewater treatment plant function reasonably well most of the time, but are at, or beyond, the end of their economic life. The resulting occasional overloads and breakdowns cause pollution of the areas surrounding the pump stations and treatment plant with raw sewage. Taken together, these compromise the quality of the urban environment, and risk its progressive further deterioration.

A more significant issue is the age and degree of deterioration of the central wastewater treatment plant. Most elements of the system are now out of commission. Two out of three of the primary clarifiers and two out of three of the secondary clarifiers are no longer used and derelict, and many of the internal concrete walls of the aeration tanks are destroyed. Any mechanical equipment from the out-of-commission units has been cannibalised to keep the one remaining unit operational. Although planned for 50,000 cum/day, the plant is currently operating at a load of about 7,000 cum/day in summer with a peak flow of up to 13,000 cum/day in winter. The effluent has been measured to fail national effluent quality standards on 20 per cent of occasions, leading to elevated levels of nutrient in the Kharaa River.

[1] Accurate figures are not available, but based on analysis by the consultant a figure of 35% has been used as the current proportion of the Darkhan soum population living in ger areas.

**The Project**

The proposed project addresses these issues. The **rationale** for the project is threefold: (i) the existing wastewater management system is under strain, and performance in the sector is compromised by obsolete facilities and equipment; this puts the system at risk of failure; (ii) the city is identified by Government as a model industrial city and the target of future industrial investment, a lack of adequate wastewater treatment facilities could compromise this investment; and (iii) the Kharaa river presents a sensitive ecosystem and is a source for Lake Baikal; even when functioning well, the current treatment plant frequently does not satisfy discharge standards for nutrients, leading to elevated nutrient levels in the river:

The **goals** of the project are: (i) to make a significant and measurable contribution to improving the urban environment of Darkhan city, and (ii) to improve the water quality of the Kharaa River to meet international river quality standards.

The intended **outcomes** from the project are improved management and treatment of both industrial and domestic wastewaters delivered through more efficient and effective technology, processes and procedures.

The project **outputs** will be:

- A new and more efficient central wastewater treatment plant, constructed and operating at the location of the existing plant, delivering effluent in accordance with national and international standards, and providing optimal energy recovery and sludge handling capacity.
- Rehabilitation and equipment replacement at pump stations, and replacement of critical sections of the sewer network which have failed.
- Enhanced wastewater system management and operational skills developed in Us Suvag staff.
- Establishment of optimal arrangements for project procurement, execution, implementation and operation.

The proposed Investment Project is aligned with the priorities of the national and aimag governments, and is consistent with the current Darkhan Master Plan and with Government's intention to develop Darkhan as an industrial hub in the region, and as a model liveable city in Mongolia. The Government's Platform Action Plan for 2012 to 2016 includes the policy objective for the urban sector to "improve the centralized heating, water supply and wastewater systems for the people living in aimag centres in order to ensure that they live a comfortable life". The project is also in line with the impacts, outcomes and outputs supported by the ADB's CPS, and will contribute to the achievement of MDG targets in improved access to adequate sanitation in urban areas.

Generic lessons learned from prior assistance to the urban and water and wastewater sectors which have some relevance for the Investment Project include: (i) institutional weakness is a key constraint to timely and efficient execution of projects, and to long-term sustainability of the assets created; (ii) local capacity constraints are exacerbated by a highly centralized system of government. (iii) local-level infrastructure investments remain largely at the discretion of the central government, (iv) local officials lack the budgetary and human resources to maintain infrastructure; and (v) incentives and resources for local governments to strengthen services are limited. The project is being designed with these constraints in mind, but is also trying to address them both in the process of project preparation and through the design of project procedures and capacity development components.

**Wastewater Treatment Technology Selection**

The treatment technology proposed has been the subject of intensive analysis, based on both international and Mongolian experience of wastewater treatment under condition similar to those found in Darkhan. Wastewater treatment plants are complex systems which rely on a series of sensitive physical, biological and (sometimes) chemical processes to achieve optimal treatment results. While the evaluation has narrowed the technology choices to those which are most appropriate for Darkhan, the specific design of the treatment plant, and the way in which it is operated, will need to respond precisely to local conditions and the current and changing nature of the wastewater it will receive, as new generators connect to the wastewater network.

A three stage process was adopted for the evaluation of potential wastewater treatment solutions, and the selection of the optimal solution. During an initial evaluation, the full range of treatment options available was evaluated and those which are clearly impractical under Darkhan physical and socio-economic conditions were eliminated from further consideration. Under a second stage of evaluation, those systems which could have application in Darkhan were evaluated in greater detail, along with systems recommended for consideration by the MCUD Technical Committee on water and wastewater infrastructure[2]. From these, a shortlist of four options was selected: (i) rehabilitation of the existing WWTP as a modified activated sludge (integrated fixed-film activated sludge) process; (ii) construction of a new step-feed activated sludge system plant; (iii) construction of a new sequencing batch reactor plant; and (iv) construction of a new integrated fixed-film Activated Sludge (IFAS) system.

The evaluation concludes that the rehabilitation of the existing treatment plant as a modified activated sludge (IFAS) plant is the cheapest option in capital cost terms, but presents possible operation and lifetime risks in terms of: (i) dealing with the period of construction (further costs will need to be added to provide for treatment during the reconstruction): and (ii) the possible risks on project costs and operation associated with reuse of existing structures which cannot be fully evaluated without emptying the facility.

There is little between the three new systems in terms of cost and performance. The step-feed activated sludge process is slightly more expensive and has slightly higher operational cost than the other two systems. However, it comes close to the "tried and tested" conventional activated sludge process in terms of operation, and thus offers some security that it can be successfully operated under Mongolian conditions. Sequencing batch reactor technology offers high treatment efficiency and potentially the lowest operational costs, but demands high-levels of operational control, and is currently only used in small private plants in Mongolia, and nowhere in climates similar to that of Darkhan. The IFAS system has not been used previously in Mongolia but is commonly used elsewhere, including in Russia and China under climatic conditions similar to those in Darkhan. The table below summarises the outcome from the final stage of evaluation in terms of capital, operating and lifetime costs (best values highlighted).

| **Evaluation Criteria** | **Rehabilitation of existing activated sludge plant as IFAS** | **New modified step-feed process activated sludge plant** | **New sequencing batch reactor** | **New integrated fixed-film activated sludge (IFAS) system** |
|---|---|---|---|---|
| Estimated total capital cost (capital works, equipment and other costs) US$M | **12.25** | 19.30 | 16.35 | 16.70 |
| Estimated annual operating and maintenance costs (power, staff, chemicals and others) US$M | 0.592 | 0.631 | **0.541** | 0.567 |
| Estimated total economic lifetime cost over 25 years, MNT per m3 treated | 5,931 | 7,844 | 7,426 | 7,324 |
| Estimated total financial lifetime cost over 25 years, MNT per m3 treated | 2,087 | 2,329 | 2,168 | 2,372 |
| Economic Internal Rate of Return (EIRR) | **13.0%** | 4.8% | 6.2% | 6.5% |
| Financial Internal Rate of Return (FIRR) | **2.4%** | 1.0% | 1.8% | 0.7% |

Source: Consultant.

[2] Professional Committee of Water, Wastewater and Heating Engineering of the Urban Development, Building & Design Institute

The proposed technical options were considered by the MCUD Technical Committee on water and wastewater infrastructure which favoured the IFAS system – either using the rehabilitated existing structures or as a new plant. The MCUD Project Steering also considered the preferred options and concluded that the IFAS technology should be adopted, using those elements of the existing structures which are structurally sound and can be rehabilitated for reuse. The State Professional Inspection Agency carried out an audit of the existing structures and concluded that while the internal walls of the biological reactor were too degraded for rehabilitation, the external walls were structurally sound and could be rehabilitated for reuse as reactors to contain the IFAS treatment system. Consequently, the option selected is the rehabilitation of the existing plant using IFAS treatment technology.

**Project Execution and Implementation**

The processes of design, construction and operation of the plant are intimately linked. In structuring procurement for the design, construction and operational phases, the objective is to get best value for money for the client, while ensuring that risks to the client are minimised. The Government has elected to fund the detailed design for the plant using its own resources. In view of this, it is recommended that the ADB support a technical assistance to: (i) ensure that the detailed design adopts the optimal technological choice available under the IFAS treatment system, and (ii) determine what innovative but doable project packaging and procurement mechanisms can be used by the project to ensure that design, construction and operational phases are integrated in such a way as to optimise the prospect that the best and most efficient system will be selected and installed. Mongolia does not yet have in place the legislative and regulatory system, or standard contracting tools, to support a full Design, Build, Operate and Transfer contracting modality. However, the contract package for construction and installation of the plant should include operation assistance to Us Suvag over an extended period, during which staff will be fully trained in optimal operation.

The Ministry of Construction and Urban Development of the GOM will be the Executing Agency (EA) of the Project. It is proposed that the project is managed and supported by the existing Project Management Unit (PMU) of the Urban Sector Development Project for Mongolia (Loan 2301-MON) which will extend its existing responsibilities to include the new Project. The state-level Project Steering Committee (PSC) established for the Urban Sector Development Project will provide overall policy guidance on the project, and will have full powers to take decisions on matters relating to Project execution.

Implementation of the Urban Environmental Improvement Components (Parts A1 and A2) of the project will be by Us Suvag on behalf of the Darkhan-Uul aimag government with assistance from MCUD. MCUD will establish a Project Implementation Unit (PIU) in Darkhan–Uul aimag or Us Suvag, with responsibility for the day-to-day implementation of the physical works and equipment packages. Implementation of the institutional reform and capacity development, and project management and implementation support parts of the project (Parts B and C) will be managed by MCUD through the PMU for Loan 2301-MON.

**Environmental Due Diligence**

The project is Category B for environmental classification, and findings of the IEE show that the project does not have any predicted significant, long term or irreversible impacts on the physical, biological or socio-economic environment. The project will have short-term impacts during construction which can be mitigated to an acceptable level through mitigation measures which seek to reduce the potential for harm to the environment and human health. These measures relate primarily to implementing good construction practice as well as meeting the particular needs of the project area through consultation with affected people. Good practice through comprehensive training and appropriate technological design will also contribute significantly to reducing the operational impacts of the project.

The project will implement a robust Grievance Redress Mechanism and will engage an Environmental and Social Specialist to ensure that the GRM is well publicised and used effectively in order that that any negative or positive impacts from the project are captured and dealt with appropriately.

The stakeholder and consultation during the development of the IEE, particularly with Darkhan aimag and Us Suvag demonstrated that the project has local support as it will result in benefits in terms of the long term environmental and social sustainability of Darkhan's WWTP.

**Social Assessment and Due Diligence**

An assessment of the socio-economic conditions of the beneficiary community, and of the likely impacts of the project was carried out based on analysis of secondary data, and on primary data obtained through: (i) a household socio-economic survey of beneficiaries; (ii) extensive focus-group discussions with project stakeholders; and (iii) interviews with key informants. A Poverty Reduction and Social Strategy has been prepared which also includes: (i) a Social Action Development Plan (SADP): (ii) a Consultation and Participation Plan (CPP); and (iii) a Stakeholder Communication Plan (SCP). During the development of the PRSS, links were established to the national poverty reduction strategy and ADB's Country Partnership Strategy.

The project will provide social benefits in terms of: (i) an improved urban environment; (ii) health benefits resulting from reduced risk and occurrence of feacal-oral diseases; and (iii) reduced time and expense incurred by households in addressing wastewater management problems. Conclusions drawn from the results of the household surveys in respect of participation and empowerment issues include:

- Participation of residents in community activities is low, but there is strong support for greater involvement.
- Participation of entrepreneurs and business in the process of project planning and implementation is crucial.
- Willingness to pay for improved service can be enhanced if public awareness of wastewater issues is increased.
- There should be active and leading participation of the Apartment Owners Associations in the project planning and implementation process.
- There needs to be organizational or institutional reform and improved regulation among participants in the sanitation service.
- Residents worry about environmental issues, and especially pollution of the Kharaa River, and are prepared to help to solve this problem.
- Residents have very little knowledge and information about the water supply and sanitation services of Darkhan city, and have not realized that there are problems.

The Project is classified as having some gender elements (SGE). At the outset of project implementation, the following measures should be taken: (i) incorporate gender concerns into the planning, design, and implementation of improvements to wastewater management services; (ii) organize awareness campaigns among women of the impacted households on the importance of the project and provide training on the correct maintenance of sanitation facilities; and (iii) strengthen participation of women in project implementation.

**Economic and Financial Analysis**

For the financial analysis, the weighted average cost of capital (WACC) in real terms is estimated at 1.41% and the financial internal rate of return (FIRR) in the base case is 2.4%. The financial net present value (FNPV) is at MNT 4,920 million. The economic analysis indicates that the Project is economically viable with the economic internal rate of return (EIRR) exceeding the economic opportunity cost of capital (EOCC) in all sensitivity tests. The EOCC is assumed at 12% and the EIRR in the base case is at 13.0%, with the economic net present value (ENPV) at MNT 1,241 million. The resulting benefit–cost ratio for the Project is 1.3 denoting economic viability. Economic benefits were derived from analysis of willingness-to-pay survey conducted in Darkhan Uul. Sensitivity analysis conducted to test the robustness of the financial sustainability and economic viability when subject to adverse economic changes (i.e., 10% increase in capital cost, 10% increase in O&M cost, 10% reduction in benefits, combined 10% increase in costs and decrease in benefits, and 1-year delay in benefits) indicate that FIRRs (except in decrease in benefits, combined increase in costs and decrease in benefits, and delay in implementation) surpass the WACC, while only EIRRs for base case and increase in O&M cost exceed EOCC.

Assessment of the financial sustainability and economic viability suggests that the integrated benefits and impacts under base case conditions are expected to outweigh the costs. For higher financial the planned coverage needs to be achieved and a smooth transition undertaken from completion of works to operations. Analysis findings indicate that Project is financially viable required periodic tariff increases (starting with immediate adjustment in current year 2014 based on tariff application submitted to the National Water Regulatory Commission and the Aimag Tariff Committee, and followed by increases every five years from 2015 onward). For the measure to be relevant, this would be incorporated when PUSO and Darkhan Aimag budget their annual operational plans. These plans and related issues have been discussed and agreed with the executing agency, MUCD, for achieving financial sustainability of the overall investment. Us Suvag JSC has applied for water tariff adjustment (with sewerage tariff proposal to follow) to the National Water Regulatory Commission and awaiting approval, however, the budgeted tariffs are not based on full cost recovery. The analysis proposes tariffs cognizant of cost recovery principles and provides a realistic picture in terms of operational needs.

**Land Acquisition and LARP**

Only some portions of the sewerage pipelines right-of-way will involve land acquisition and resettlement; other portions will be constructed on either public land or land possessed by the Darkhan-Us Suvag company. A total of 8 affected entities including two small enterprises, three commercial entities and three state budget institutions will be affected by land acquisition and resettlement. Of the 8 affected entities, 5 affected entities were enumerated in the socioeconomic survey. 5 affected entities will lose a total of 2,711.1$m^2$ of land and all these losses are partial, all plots are possessed by the state institutions and private companies. No residential land or structures will be affected by the project. Fences and gates totaling 112m in length and belonging to 3 affected entities will need to be moved or replaced. Other affected structures include 2 entrance ways to a food shop and hair and beauty salon, speed bump and an advertisement board. Losses of land and structures, as well as transaction and relocation costs for each AP are covered. The budget for resettlement is expected to amount to MNT 78,116,172 or USD 45,315 for compensation, administration and contingency costs as well as for monitoring costs which will be funded from state government resources.

**Institutional Reform and Capacity Development**

The capacity of both the aimag government and Us Suvag to: (i) respond to citizen's demands; and (ii) initiate, plan, deliver and manage urban infrastructure development and improved service delivery is limited. Both agencies suffer from inadequate financial and technical resources, an absence of systems, few staff and insufficient capacity to effectively carry out these tasks. In the context of the Government's push towards increased fiscal decentralisation, including implementation of the Local Development Fund, the project needs to support the aimag government and Us Suvag in enhancing its capacity and capabilities in urban planning, and management and delivery of local infrastructure and services.

The Project presents an opportunity to introduce fundamental changes to the institutional framework for water supply and wastewater management service provision in Darkhan, and to build capacity to improve the efficiency and responsiveness of service delivery. This will be achieved through technical assistance support at the aimag government and Us Suvag service provider level which will support: (i) improved water supply and wastewater planning as an instrument to stimulate efficient, private-sector led development; (ii) institutional reform, including opportunities for divestiture of all or part of Us Suvag so as to decouple service providers from the aimag government administration and potentially attract private sector capital and expertise; (iii) development of a institutional reform road may; and (iv) introduction of an operating management contract that provides performance-based incentives for the service provider. It is proposed under part B of the project to use the project itself as a vehicle help bring about these changes.

**Project Risks and Risk Mitigation**

The major risks to timely and effective project implementation and/or realization of project outcomes, and associated mitigation measures are summarized in the table below.

**Summary of major Project Risks and Mitigating Measures**

| Risks | Mitigating Measures |
|---|---|
| Poor technology design or poor quality construction and equipment installation will | Optimisation of design, equipment specification and treatment operation under Darkhan conditions ensured through provision technical assistance for a wastewater management specialist to |

| Risks | Mitigating Measures |
| --- | --- |
| compromise treatment system performance | quality assure design of WWTP by Government and provide top management supervision and third party quality assurance through construction, commissioning and early stages of operation. |
| Delay in project implementation | The government will ensure that the PMU and PIU are staffed with experienced professionals. A procurement specialist will be recruited in advance to assist with the tendering process, and technical assistance will be provided to assist in procurement for the WWTP. |
| Unforseen changes in flow rates and composition of wastewater compromise treatment efficiency | Plant is designed to balance shock pollution loads (through the balancing tank) and the biological reactor is divided into three streams, each with a design loading of about 8,000 cum/day. Under higher loading conditions three stream can be operated, or under lower operating conditions two streams. Us Suvag will be strengthened to enforce national discharge standards for industries disposing of their effluent into the public sewer. |
| Darkhan Uul and Us Suvag implementation capacity is not sufficient for large and sophisticated works | Specific funding covers consulting services, support, and additional staff with experience and suitable skills. Darkhan Uul aimag and Us Suvag capacity and performance will be built during program implementation, particularly in the areas of project and contract management, financial management and project performance monitoring and reporting. |
| Inefficient procurement and corruption | Reviews will assess procurement to validate reported procurement capacity and address gaps that may impede program effectiveness. Relevant provisions of ADB's Anticorruption Policy (1998, as amended to date) are included in the investment program's loan regulations and bidding documents. The executing agency MCUD will disclose to the public and annually update the program's current status and how project proceeds are used. |

# 1 INTRODUCTION

## 1.1 Purpose and Scope of Report

1 This is the Final Report of the Additional Financing Technical Assistance (TA) for the Preparation of a Water Supply and Wastewater Management Project for Darkhan city under the Urban Sector Development Project for Mongolia (Loan 2301-MON). This Final Report provides the final technical output under the TA and presents the results from work carried out under the overall terms of reference (see Appendix A). It also incorporates further information obtained through the CDIA-supported Water Supply and Sanitation Infrastructure Improvement Project for Darkhan[3], and responds to comments provided during an extended period of review of the Draft Final Report by both Government and the ADB, encompassing loan fact-finding and including subsequent project adjustments. The Report focuses on the following areas:

i. An overview of Government policy and strategy in the sector, and review and assessment of Government's urban and sector development plans, and environmental policies;

ii. Analysis of sector performance with particular reference to water supply, sanitation, wastewater and sludge treatment and management, including an assessment of the existing wastewater treatment plant (WWTP) and its O&M, with respect to its suitability for rehabilitation and expansion or reconstruction;

iii. Review of existing urban development plans for Darkhan, likely industrial and population growth rates, likely shift between apartment and ger areas, and the development of projections for per capita and gross wastewater generation rates;

iv. Review of domestic and international best practices in wastewater and sludge treatment and management drawing on Asian Development Bank (ADB) projects, and other international experience in comparable environments;

v. Review and evaluation of the standards and targets for surface water quality and effluent discharge;

vi. Review of national experience in the improvement of water supply, sanitation and wastewater management in ger areas;

vii. Development of a framework and strategy for future wastewater management in Darkhan considering the existing urban, industrial and ger areas, and planned growth in existing and new areas;

viii. Development of outline concepts for water supply and wastewater management for the different urban typologies: (i) formalized urban areas including housing blocks and commercial and administrative districts, (ii) industrial and logistics zones, and (iii) informal Ger areas;

ix. Analysis of differing physical and socio-economic characteristics of ger areas in Darkhan and evaluation of options for service improvement to different types of ger area settlement;

x. Analysis of industrial effluents and pre-treatment requirements in assessing wastewater strength and assessment of separation or combination of WWTP operations;

xi. Review of alternative plant designs and technologies with possible application in Darkhan, and recommendation of an optimal approach for the WWTP in Darkhan;

[3] Pre- Feasibility Study on the Water Supply and Sanitation Infrastructure Improvement Project (WSSIIP) for the City of Darkhan, Mongolia, supported by the Cities Development Initiative for Asia, Manila February to July 2014.

xii. Identification of the location, scale and optimal technology for the new centralized WWTP and other critical system improvement requirements;

xiii. Development and optimization of a preliminary design for the WWTP as a new facility installed within the rehabilitated and reconfigured structures of the existing WWTP to optimize efficiency, provide a least cost solution, and minimise land acquisition and resettlement requirements and costs;

xiv. Development of preliminary design and costings for the proposed project package;

xv. Determination and quantification of the expected impact, outcomes, outputs, inputs, and activities of the project;

xvi. Development of an environmental baseline on wastewater management infrastructure and services provision, and environmental and social indicators (including health and other relevant data) for effective monitoring of project performance;

xvii. Carrying out of an environmental assessment of the project package and preparation of an initial environmental evaluation (IEE) and environmental management plan (EMP) for the project.

xviii. Conduct of household socio-economic surveys and preparation of a poverty reduction and social strategy, social action development plan, gender action plan, community action plan, and stakeholder communication plan;

xix. Investigation of any resettlement requirements under the preparation of a Land Acquisition and Resettlement Plan (LARP);

xx. Preparation of economic and financial justifications for the project and calculation of economic and financial internal rates of return;

xxi. Preparation of proposals for flow of funds and sub-lending arrangements;

xxii. Preparation of proposals for project execution and implementation arrangements, and assessment of capacity and capability of execution and implementation agencies;

xxiii. Development of policy and institutional reform proposals and capacity development arrangements;

xxiv. Proposals for contract packaging and for procurement arrangements and modalities; and

xxv. Assessment of risks related to project design and execution, and how those risks may be avoided or mitigated.

## 1.2 Purpose and Scope of the Technical Assistance

2 The objective of the assignment is to assist the Government of Mongolia and City of Darkhan with developing a solution to the city's wastewater management issues. The purpose of the assignment is to carry out a wastewater sector assessment, develop proposals for wastewater management improvements, and prepare a technical, financial and economic feasibility study to provide the basis for possible ADB support for the rehabilitation, reconstruction, or replacement of the Darkhan Wastewater Treatment Plant (WWTP) and associated wastewater infrastructure as appropriate.

3 This technical assistance helps Government consider wastewater treatment options, evaluate these options, determine the optimum solution, and provides a feasibility study report for this WWTP solution. The consultants have also prepared documentation necessary to support ADB processing and approval of the project. The outputs include reports on the technical, financial, economic, environmental, social and institutional feasibility of the project and associated environmental and social safeguards and due diligence.

4 The work is aligned with the Government's 2012–2016 Action Program, which includes objective of: (i) improving public utility services and networks in provincial centres; and (ii) supporting the significant expansion of industrial development in Darkhan city. The activity will further support the Government's policy objective of making Darkhan a national "model city for urban liveability".

5 In March of 2012, the Prime Minister made an announcement on plans for developing model cities in Mongolia, including the city of Darkan. A plan for Darkhan model city development was to be prepared during 2012, but this is now scheduled for completion during 2014. Appendix B provides a brief summary of the Prime Minister's statement on the model city programme for Darkhan.

# 2 RATIONALE: CONTEXT, BACKGROUND, SECTOR PERFORMANCE, CHALLENGES AND OPPORTUNITIES

6 This chapter provides an overview of urban, water and wastewater sectors in Mongolia and the framework within which the Darkhan Wastewater Management Project is being prepared. The project responds to both the ADB's strategic framework in the sector – as articulated through the country assistance strategy - and the Government of Mongolia's policy and strategy in the urban development and environmental sectors. The chapter also looks at the trends in urban development at both the national and city level, assesses current performance in the sector, and identifies sector constraints and opportunities. Finally, the chapter presents an assessment of the performance of other water supply and wastewater initiatives in Mongolia. It assesses lessons which can be taken from experience with: (i) water supply and wastewater improvements in urban core areas and ger areas; and (ii) wastewater treatment plants in regions with similar climatic and socio-economic challenges to Darkhan. It also takes lessons from prior donor and lender assistance to the urban, water and wastewater sectors in Mongolia.

## 2.1 Consistency with ADB's Country Partnership Strategy

7 Urban development was first included as a distinct sector in 1992 in the ADB Mongolia Country Strategy. However, the link between the urban sector and the overall country strategy was not strong. In an attempt to strengthen this strategic linkage, the 2004 country strategy and program sought to reorient the urban strategy toward the provision of those services fundamental to achieving MDG targets (which include potable water supply and adequate sanitation). The 2012-2016 Country Strategy continues on this trajectory, with a strong emphasis on infrastructure and access to basic services.

8 The second country operations strategy (although now outdated) also recognised the importance of the urban sector. However, the expected benefits from infrastructure-led development as a means of delivering economic growth and poverty reduction was not realised. This was partly attributed to the capital-intensive public investments failing to deliver inclusive growth outcomes. As a result, the operations strategy was reoriented towards placing an equivalent emphasis on wealth creation to that placed on poverty reduction, supported by good governance. At an operational level, this meant switching the main mechanism for growth generation from public sector investments in infrastructure to employment-generating investments aimed at engaging the private sector, while also providing support mechanisms to improve governance. The current country strategy and business plan continues to reflect this position.

9 The proposed Investment Project is included in the ADB Country Partnership Strategy (CPS) 2011-2015 as part of the on-going Urban Sector Development Project. It is in line with the impacts, outcomes and outputs supported by the CPS, and will contribute to the achievement of MDG targets in improved access to adequate water supply and sanitation in urban areas. The Investment Project is aligned with the priorities of the national and aimag governments, and is consistent with the current Darkhan Master Plan and with Government's intention to develop Darkhan as an industrial hub in the region, and as a model liveable city in Mongolia.

10 Finally, emphasis on the potential role of PPPs to support the sector strategy and achieve more inclusive growth is reflected within the ADBs strategy and plan, based on the lessons learned during the 90's and early 2000's. This emphasizes the need to explore a range of implementation and management models, including management contracts, leases, concessions, DBO and DBOT arrangements for design, construction and operation of the Project facilities. These approaches can consider the potential benefits around employment, knowledge transfer and increased institutional capacity while mitigating against potential operational and management risks. In assessing the options for project procurement and management, these sector objectives have been borne in mind.

## 2.2 Government Policy & Strategy in the Urban Environment, Water and Wastewater Sectors

### 2.2.1 Urban Sector Strategy

11 The Government of Mongolia has not articulated a specific strategy for the development of the urban sector. However, there are elements of existing Government policy, strategy and legislation which infer a trajectory for growth and development of the urban sector, and suggest where priority investment should be focused in the medium- to long-term. The most important of these are:

i. The National Development Strategy (NDS) which covers the period 2007 to 2021 and is structured around achievement of the Millennium Development Goals (MDGs);

ii. The Regional Development Concept and related Law on Regionalized Development Management and Coordination (of 2001 and 2003); and

iii. The Government Platform Action Plan 2012 to 2016.

12 The NDS targets economic growth rates of at least 14% per annum and a GDP per capita of US$5,000 equivalent by year 2015. It stresses both the need to “ensure rapid and sustainable development based on a market economy”, and to “actively develop regions and infrastructure to reduce urban-rural disparities”. The strategy also identifies as one of its key objectives to “allocate funds in accordance with (the) priority and needs of a sector, monitor spending and ensure its efficiency”.

13 The Regional Development Concept and related Law on Regionalized Development Management and Coordination; and Medium-term Strategy on Regional Development 2001-2010, called for better-balanced regional growth. This strategy sought to direct funds towards the development of “pillar” urban centres in each of the five regions. More recently, under the previous Government, the “soum centre development project” was intended to provide new administrative centres (school, hospital, government buildings) for a number of strategic and fast-growing soum centres. However, the continuing (and accelerating) primacy of Ulaanbaatar, stagnation in growth of most other major urban centres (including Darkhan) and focussing of non-Ulaanbaatar growth in towns impacted by major mining investment (e.g. Erdenet and the towns of the South Gobi) demonstrates the limited success of these strategies.

14 The Government Platform Action Plan 2012 to 2016 includes the following policy objectives for the urban sector:

i. Improve the centralized heating, water supply and wastewater systems for the people living in aimag centres in order to ensure that they live a comfortable life;

ii. Carry out re-planning of the urban areas with community involvement, and implement housing programs by providing centralized solutions to ger district electricity, drinking water and auto road-related issues, and other infrastructure elements, either making them independent or recoverable through instalments;

iii. Carry out technological renovations in water supply, drainage and sanitation facilities of towns;

iv. Take measures to enforce the Law on Water Supply and Sewer Use in towns and other settlements; and

v. Introduce technologies to treat and reuse industrial and household wastewater.

15 The project approach follows a number of these strategic directions, with its geographical focus on a secondary city, and in its addressing of sanitation, wastewater management and urban environmental issues. In addition it will support efforts to introduce technologies which will enable

the reuse of the outputs from the treatment process – treated wastewater effluent, mineralised sludge and methane gas.

### 2.2.2 Resolution of Darkhan-Uul Aimag Khural on Ger Area Development

16 The Darkhan Aimag Khural approved a resolution on ger areas development on 30th May 2013. The resolution commits the aimag government to improving the living conditions of ger area residents through a number of interventions. The objectives of the proposed programme are to:

i. Carry out research and create an urban database for ger districts;

ii. Develop designs for improving conditions of ger districts, and estimate the budgetary requirement;

iii. Upgrade the waste management systems in ger districts;

iv. Improve infrastructure conditions in ger districts; and

v. Improve the condition of the environment in ger districts.

17 It is anticipated that the resultant programme would: (i) connect ger districts to infrastructure networks; (ii) connect some ger areas to the sewer system and the central heating system; (iii) provide households with full use of cleaner stoves; (iv) support smokeless fuel manufacture; and (v) connect ger districts to the water supply system. It also proposes development of roadways, street lighting and public parks in ger districts, and the introduction of a street address system. Other components include holding competitions among baghs to improve the appearance of their surroundings; encouraging bagh leaders through rewards for their accomplishments and efforts made, and using public awareness programs to change public perceptions to support model ger area initiatives.

18 The budget allocated for this work is MNT 46 billion (or about US$ 35 million) but it is unclear as to where this money is to come from.

### 2.2.3 Water and Wastewater Sector Strategy

19 The laws of Mongolia which govern water use have been revised and consolidated, and new laws have been adopted over recent years. The Law of Mongolia on Water dated 22 April 2004 ("Old Water Law") has been replaced with a revised version of the Law of Mongolia on Water dated 17 May 2012 ("Water Law"). The Law of Mongolia on Fees for Use of Water and Minerals Water has been consolidated with other laws on the use of natural resources and is replaced with the Law of Mongolia on Natural Resources Use Fee dated 17 May 2012 ("Natural Resources Use Fee Law"). On 17 May 2012, the Law of Mongolia on Water Pollution Fees was newly adopted to introduce fees payable for pollution of water resources ("Water Pollution Fees Law")[4].

20 The overall effect of these changes is that under the Water Law, the Government has the authority to determine the intrinsic environmental value of water resources for each region or river basin. Currently, governmental resolution No. 302 dated 26 October 2011 sets out the intrinsic environmental value for each river basin in amounts ranging from MNT 800 to MNT 2651 per cubic metre for surface water, and MNT 1510 to MNT 9440 per cubic metre for sub-surface water (groundwater). The fee will be payable on a monthly basis and the user must also submit an annual report for water use fees.

21 In the wastewater sector, to implement the "polluter pays" principle in terms of water resources, the Water Pollution Fees Law introduces fees payable by entities and organizations that pollute water resources, and sets out the maximum and minimum amount of water pollution fees per polluting

[4] Based on: Revision of Environmental Laws in Mongolia and its impact on the mining sector, October 2012, Hogan Lovells, Ulaanbaatar

substance type[5]. The Government will set the specific fees payable in each water drainage basin taking into account the volume and quality of the water resources contained therein.

22 The Government is pursuing an ambitious reform agenda in the water and wastewater sector, assisted by the ADB. Based on the newly amended Law of Mongolia on Municipal Water Supply and Wastewater Treatment Operation (amendments) Article 9 (2011), a Water Regulatory Commission has been established and is operational. The head of the Commission and the members were appointed by Prime Ministerial Resolution No.56 of May 30, 2012, with duties to: (i) take control of water supply and sewerage system service tariff; (ii) set water supply and sewerage system service tariff; (iii) give approvals for system tariff; (iv) make resolutions on tariff and carry out analysis; (v) approve communication and regulation of water supply and sewerage entities (PUSOs); and (vi) approve any other such resolution as may be necessary.

23 The Commission has investigated the issue of water supply and sewerage tariffs and has proposed a system of tariff reform which would progressively increase tariffs, first to recover full operational and maintenance costs, and thereafter to also cover the costs of depreciation. The recommendations include: (i) a structure which provides for both fixed and variable tariffs; and (ii) that there be immediate substantial increase in tariff, and thereafter progressive increases in tariff to support the sustainable operation of water and wastewater management systems. However, at the time of writing (March 2014) there remain legal impediments to the recommended reforms of the Water Regulatory Commission being executed.

24 The proposed project will seek to operate within this sector framework. However, the level of investment anticipated under the project is significant, and the data from the household socio-economic survey indicates that it is hard to achieve direct recovery of more than the basic maintenance and operational costs of the new infrastructure and wastewater treatment plant from the system users, at least in the near term. This issue is addressed in detail in Chapter 5 of this Report.

### 2.2.4 Urban Environmental Policy and Strategy

25 There is no specific Government policy relating directly to urban environmental matters. The Government's overall policy for environmental protection, including the following of EIA procedures for public sector project proposals, provides the urban environmental protection framework. A summary of Mongolia's Environmental Policy and Integrated Water Resource Management Plan is provided at Appendix C.

26 The Government is promoting urban greening as part of the reforestation and green agenda of the Ministry for Environment and Green Development (MEGD). This builds on the statutory provisions within the urban planning laws of Mongolia which set out minimum requirements for public open space which are in turn reflected in the development tables accompanying each master plan (including the current Master plan for Darkhan). As with all ex-soviet countries, the guidelines for development set out very prescriptive requirements assigning areas in percentage terms – including those for green space. In this context, the Soum Government of Darkhan is proposing the establishment of an urban green zone between the built-up areas of Old and New Darkhan and the Kharaa River. There may be opportunities for use of treated wastewater as part of the development of this proposed green zone.

27 One of the specified requirements set out in the ToR for the new General Plan for Darkhan City which is currently under preparation[6] is that it should be a "green" city. It is to be expected that the plan would identify areas of particular ecological and environmental value which would be recommended for retention as open space or ecological zones, and on which development would be discouraged. This would likely include the flood plain of the Kharaa River.

[5] This sub-divides polluting load by: low density substance; organic substance; minerals; heavy metals; and toxic substances, but does not assign an acceptable value or fee rate for exceedence to each.

[6] The Darkhan General Plan is under preparation by the company Ark Construction and should be complete in draft by June 2014.

## 2.3 Urbanization and the Urban Form in Mongolia

### 2.3.1 Urban Form and Dynamics in Mongolia

28 In 2012, urbanization in Mongolia reached 68% (1.9 million out of a total population of 2.85 million). The urban economy grew by an estimated annual average of 11.2% during the 2006–2012 period, and now accounts for 65% of total gross domestic product. However, the urban sector is dominated by the capital city, Ulaanbaatar, which contains almost half the national population and two thirds of the urban population. Ulaanbaatar's population increased from 773,000 to 1.3 million between 2000 and 2012, due largely to in-migration, representing an annual average growth rate of almost 6%. Other areas which are showing significant population growth are those which are located adjacent to mining operations – such as Erdenet in Orkhon aimag and the urban areas of Omnogovi aimag. In stark contrast, many other urban areas – including Darkhan (see below), are showing stagnant or declining populations as people are drawn by the strong economic magnets of Ulaanbaatar and the booming mining towns.

29 All Mongolian cities present two very different and distinct patterns of residential development, each of which is highly correlated with the degree and incidence of both income- and quality-of-life-poverty. The first comprises planned areas based on Soviet-style urban design, encompassing medium-density multi-family apartment housing surrounding public open space. The second comprises the low-density *ger* areas: informal settlements that are characterized by long strips of large, (usually 700 square meters) un-serviced or under-serviced plots *(khashaas)* accessed along wide dirt roads. Each *khashaa* may contain a number of structures – often gers - but in better established ger areas also often houses of wood (widely used in Darkhan), masonry, or concrete construction. Most ger areas are served by water kiosks, supplied either from water mains or by water trucks. However, in general, the lack of services leads to harsh and insanitary living conditions in the *ger* areas.

30 The urban cores are characterized by groups of 5-storey walk-up or 9-storey apartment blocks, many of which were constructed in the latter years of the soviet period. These are frequently arranged around areas of public open space which include parks and playgrounds. The soviet-era housing stock is increasingly being supplemented, or replaced, by modern medium- and high-rise housing and commercial construction in Ulaanbaatar and other major urban centres, including Darkhan. These core areas are fully serviced with power, district heating, water supply, sewerage, and paved road access. Rights of way are often very wide, with ample space to allow services to be installed in soft shoulders and footpaths.

31 The migrant population to urban areas has created a unique urban phenomenon in the Ger areas, comprising large peri-urban and generally poorly-planned areas, characterized by unserviced plots, unpaved roads, and unsanitary conditions. In general, ger areas have the following characteristics: (i) disproportionate and tenacious: 30% of the country's population lives in ger areas, many have been there for generations; (ii) heterogeneous: households fall across the spectrum of low- to medium-income brackets; (iii) poorly planned: ger areas are formed with very little planning and urban regulation; (iv) un-serviced: limited access to basic urban services and lack of infrastructure; (v) secure land tenure: most residents have land entitlement and recognized property rights, and the eminent domain law is only applicable in Mongolia by the State to expel any tenant breaching the law, or for national security reasons; (vi) cold climate: the long winter with temperature dropping below -40°C, results in a short construction period and high cost of construction; (vii) low urban densities: estimated average of 40 persons per hectare, due to land parcels generally of 700 $m^2$ with no limitations on development and expansion of urban boundaries and the preponderance of development on steep terrain or into river flood plains; and (ix) predominately residential: commercial buildings, government offices, and public services occupy a very small footprint, while unpaved roads represent a significant percentage of the land area.

32 What is particularly striking about the ger areas is their resilience in the face of other major developments in urban areas in Mongolia – particularly over the past decade. The proportion of urban populations residing in ger areas remains almost unchanged over this period, and all urban centres have ger areas. Repeated attempts in the recent past to develop ger areas through approaches such as land pooling and land readjustment have generally met with failure. Past

plans to completely redevelop ger areas by extensive re-blocking and construction of medium or high rise housing have failed due to lack of willingness by *khashaa* owners to support the plans and sell their land.

### 2.3.2 Urban Form and Overall Development in Darkhan

33 The city of Darkhan (now Old Darkhan) was founded in 1961 with construction of New Darkhan commencing one year later. New Darkhan is located about 2 Km to the south of Old Darkhan, from which it is separated by a small range of hills. Figure 2.1 shows the location of the two urban centres, the neighbouring industrial estate, main ger areas, wastewater treatment plant and Kharaa River

### Population

34 About 85% of the population of Darkhan-Uul aimag lives in the city (Darkhan soum) but the population of both the aimag and each of the soums has shown only a very modest increase over the past few years. As table 2.1 shows, over the past decade, population remained little changed between 2003 and 2009, but following a significant increase in 2010, has shown a decline since then, with a particularly steep decline between 2011 and 2012, and only a slight recovery since then. This suggests that during the period 2003 to 2010 the slow out-migration from Darkhan was being compensated for by the natural population increase[7]. However, the figures indicate that over the past few years, there continues to be net out-migration from Darkhan, with the level of out-migration great enough to significantly reduce the increase which could be expected from natural growth (estimated at about 1.5% per annum)..

35 This increased rate of out-migration may be a function of the growing attraction of alternative economic drivers – particularly Ulaanbaatar and the mining operations in other parts of the country during the past two years of very rapid national economic growth. Oyu Tolgoi alone employed several thousand workers between 2010 and 2012 to work in its south gobi mine, and over 300 of these workers gave their place of permanent residence as Darkhan[8].

36 The city is characterised by two distinct urban cores on a north-south axis, with New Darkhan to the south and Old Darkhan to the north, and with ger areas concentrated to the west, north-west and north-east of Old Darkhan and to the east of New Darkhan (see Figure 2.1). Figures vary as to the proportion of the population of Darkhan soum who live in the centrally planned and serviced apartment areas of Old Darkhan and New Darkhan, and those who live in the peripheral ger areas. Estimates for the former vary from 60% to 69%[9] with the Aimag Land Administration office providing an estimate of 60%. The Aimag Land Administration office indicates that the target is to have 75% of the population living in the centrally planned and serviced areas by 2020.

37 There is a transient population in Darkhan which is not fully captured in the figures provided above, and for which accurate estimates are not available. This is primarily made up of:

i. Students: Darkhan is an educational centre with ten tertiary educational institutions in addition to 25 secondary schools and 14 kindergartens, and a number of other small vocational training centres. The transient student population during term-time is estimated to peak at about 5,000[10].

ii. Herders: The number of urban inhabitants rises during the winter months as some herder families relocate back to Darkhan after summers spent with their herds. Again, accurate numbers are unknown, but estimated at a few hundred[11].

[7] Mongolia Human Development Report 2011: From Vulnerability to Sustainability, UNDP, Ulaanbaatar, 2011
[8] Oyu Tolgoi Human Resources Department Employee Information, Oyu Tolgoi, Ulaanbaatar 2012.
[9] The figure of 69% is widely quoted in the MoMo reports and by the Darkhan Us Suvag, but is not verified by the aimag government which provides a figure of 60%. A figure of 65% is used for planning purposes.
[10] Estimate by the office of aimag chief of policy development.
[11] Office of the head of Administration; Darkhan Uul aimag.

**Figure 2.1 General Arrangement of Old Darkan, New Darkhan and the Industrial Estate**

**Table 2.1 Recent Population Trends in Darkhan-Uul[12]**

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Population:** | | | | | | | | | | | |
| **Darkhan uul aimag** | **90,178** | **90,428** | **90,656** | **89,427** | **90,224** | **91,093** | **91,358** | **95,043** | **93,137** | **92,735** | **93,554** |
| **Darkhan soum** | 73,692 | 74,277 | 74,663 | 73,457 | 74,526 | 75,104 | 74,454 | 77,547 | 75,494 | 75,644 | 76,428 |
| Khongor | 5,530 | 5,390 | 5,336 | 5,404 | 4,950 | 5,115 | 5,603 | 5,796 | 5,856 | 5,693 | 5,729 |
| Orkhon | 2,888 | 2,913 | 2,933 | 2,932 | 2,935 | 3,076 | 3,185 | 3,277 | 3,356 | 3,277 | 3,240 |
| Sahriin gol | 8,068 | 7,848 | 7,724 | 7,634 | 7,813 | 7,798 | 8,116 | 8,423 | 8,431 | 8,121 | 8,127 |
| **Annual Growth Rates:** | | | | | | | | | | | |
| **Darkhan uul aimag** | | **0.3%** | **0.3%** | **-1.4%** | **0.9%** | **1.0%** | **0.3%** | **4.0%** | **-2.0%** | **-0.4%** | **0.9%** |
| **Darkhan soum** | | 0.8% | 0.5% | -1.6% | 1.5% | 0.8% | -0.9% | 4.2% | -2.6% | 0.2% | 1.0% |
| Khongor | | -2.5% | -1.0% | 1.3% | -8.4% | 3.3% | 9.5% | 3.4% | 1.0% | -2.8% | 0.6% |
| Orkhon | | 0.9% | 0.7% | 0.0% | 0.1% | 4.8% | 3.5% | 2.9% | 2.4% | -2.4% | -1.1% |
| Sahriin gol | | -2.7% | -1.6% | -1.2% | 2.3% | -0.2% | 4.1% | 3.8% | 0.1% | -3.7% | 0.1% |

38 Based on these additional transient populations, the current population in Darkhan Uul can be estimated to peak at about 100,000 and for Darkhan soum about 82,000. In population equivalent terms, the transient and student population can be estimated to provide a population equivalent of between 4,000 and 5,000.

## Land Allocations

39 An indication of the vibrancy of the local economy in the recent past can be obtained by reviewing the number and type of land use applications made and approved in recent years. Figures obtained from the aimag Land Administration Office on the number of applications being received and approved for land use permits by year is provided in Table 2.2 below. This figure provides a reasonable proxy for economic growth in the city and shows no appreciable long-term trend in recent years in the number, or size, of land approvals being granted. However, the last two complete years of records (2011 and 2012) showed the largest number of successful applications for industrial commercial and institutional land. It is also noticeable that there are peaks in years 2004, 2008 and 2012 which correspond to the election cycle.

**Table 2.2 : Land Use Applications and Areas Approved – Darkhan Aimag**

| Year | Residential Approvals | Total Area ha | Industrial, commercial and institutional Approvals |
|---|---|---|---|
| 2003 | 98 | 8.5 | 31 |
| 2004 | 1201 | 13.1 | 39 |
| 2005 | 765 | 85.0 | 42 |
| 2006 | 440 | 42.1 | 41 |
| 2007 | 954 | 89.8 | 57 |
| 2008 | 1189 | 79.3 | 59 |
| 2009 | 774 | 67.3 | 33 |
| 2010 | 700 | 62.7 | 1 |
| 2011 | 665 | 59.5 | 78 |
| 2012 | 1138 | 92.4 | 123 |
| 2013 | 955 | 69.1 | 17 (partial record) |

40 The areas coved by industrial, commercial and institutional approvals are not shown, as approvals for land to be used for agricultural purposes distorts the figures, and it is not possible to distinguish between approvals by industrial, agricultural, commercial or institutional purpose.

41 However, figures from the Darkhan-uul planning office show that between 2011 and 2012, land allocated for urban development in Darkhan soum increased from 6,544 to 6,944 ha. (out of a total

[12] Source National Statistical Office of Mongolia, 2013

of 9,813 ha.) – an increase in one year of about seven per cent. Year on year increases for roads was from 443 to 453 ha. (2% increase); for industry was from 494 to 563 ha. (10% increase); for ger areas was from 698 to 725 ha (4% increase); and for the core urban area from 4,909 to 5,203ha (6% increase).

### Industry

42 Darkhan emerged as an industrial centre, partly because of its location on the trans-Siberian railway and road from the Russian federation, and partly as a result of its location at the centre of an area rich in construction materials. There remain pockets of small industry in a number of locations around Darkhan, but these are more of the cottage industry variety. Of the older medium-sized industrial units located around the city – particularly to the north of Old Darkhan – most have closed down, and only the timber processing facility in Old Darkhan remains. All the other major industrial units which are in operation are now located in the industrial estate which lies about 2 Km to the south of New Darkhan (see Figure 2.1) The estate currently has the following operational units:

i. Thermal power plant
ii. Metallurgical processing and production factory
iii. Cement production factory
iv. Brick production factory
v. Sheepskin tanning and dyeing facility
vi. Meat processing factory
vii. Flour mill
viii. Vodka production facility
ix. Grocery and edible oils production units

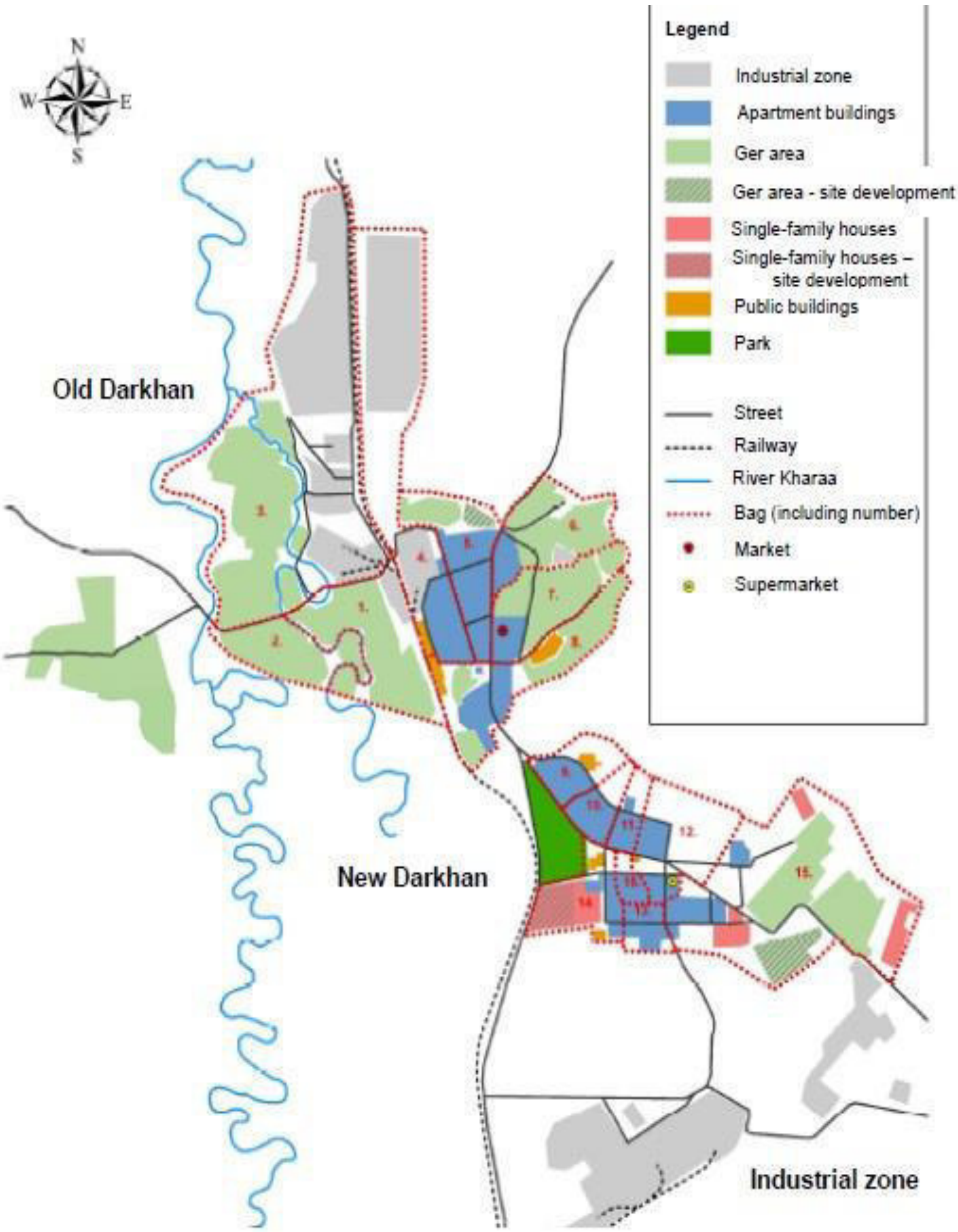
43 In addition, two new manufacturing undertakings were under development in 2013 and will go into production in 2014. These are: (i) a wool and felt processing factory; and (ii) an ore processing operation. These are not large, will employ less than 100 people between them, and will produce relatively minor amounts of wastewater.

44 The current picture in terms of the economic condition of Darkhan is then ambiguous, but it is reasonable to assume that following a recent decline there are now signs of growth in the local economy, which should in turn lead to a progressive increase in population. Clearly, the future growth of Darkhan is highly dependent on the economic performance at the national level, plus the degree to which the Government delivers on its commitment to develop Darkhan as an industrial centre. This is discussed more fully in sections 3.2 and 3.3 below.

45 Figure 2.2 below shows the existing land-use of Darkhan and bagh administrative boundaries[13]. This includes land allocated for these uses in year 2010, some of which are not fully built out.

[13] Sigel K. Environmental sanitation in peri-urban ger areas in the city of Darkhan (Mongolia): A description of current status, practices, and perceptions, Darkan, 2010

**Figure 2.2: Current Land Use in Darkan City**



### 2.3.3 Intensifying Environmental Challenges

46 Encouraging and supporting the development and delivery of urban services in Darkhan requires consideration of a range of issues. As with other urban areas in Mongolia, development planning and land markets are highly distorted and function poorly. Current development plans are based on a 'top-down' approach that does not take the changing and dynamic socio-economic conditions on the ground into account, nor does it respond well to the requirements of a market-led economy. This is evidenced by the fact that while the current Darkhan Master Plan is intended to provide the development framework for the city up to the year 2020, it is already considered out of date and is no longer used to guide growth and development. In the meantime, there is no planning framework guiding city development while a new plan is produced.

47 The legislative and regulatory functions governing the infrastructure requirements of the city are under the responsibility of a number of institutions responding to a wide range of laws and regulations. The integration and coordination of these remain poor, and infrastructure and development programming remain disjointed and are undertaken in the absence of any meaningful community engagement or participation. The service gap between the city core centres and outlying ger areas results in a poor integration of ger residents into the overall urban economy and can be expected to worsen, if ger areas continue to grow.

48 Furthermore, and **critically,** current policy forces ger area dwellers into areas which are difficult and very expensive to service, thus the poorest in society live in the locations that are most difficult and expensive to service, and are most vulnerable to flooding, erosion etc. This is in areas high on steep hillsides and in the flood plain of the Kharaa river characterised by a high water table, poor soil conditions and vulnerability to flooding. Large areas of many hundreds of hectares of good development land adjacent to the existing serviced areas lies vacant, while *khashaas* are issued for residential purposes on hillsides, in floodplains and very far from any central service networks.

49 Minimal long-term planning, inadequate infrastructure investment, and the absence of effective land-use regulation in ger areas have resulted in haphazard development, limited space availability for public facilities, poor access to socio-economic services, reduced livelihood opportunities, and unsafe neighbourhoods. Some ger districts lie in areas which should be kept fee from any development. Ger areas in the west and northwest quadrants of Old Darkhan between the urban core and the Kharaa River lie in areas of the Kharaa River flood plain which have a high water table, making the installation of piped services almost impossible, and certainly extremely expensive.

50 Within the core urban areas, conditions are better, but both the water supply and sewer networks suffer from ageing and dilapidated infrastructure resulting in significant leakage from both systems. Residents frequently report poor quality and discoloured domestic water supply, and there are frequent overflows from the sewerage network in residential districts. In the household socio-economic survey carried out under the project, residents frequently complained of raw wastewater flooding basements and the area around their apartment buildings. The wastewater pump stations and treatment plant function reasonably well, but occasional overloads and breakdowns cause pollution of the surrounding areas with raw sewage (discussed in greater detail below).

51 Taken together, these factors compromise the quality of the urban environment, and risk its progressive further deterioration. The poor choice of location for housing areas, lack of basic urban infrastructure in some areas, and poor condition of existing infrastructure in others, is preventing rational and dynamic urban development and raises the cost of doing business and of accessing services.

52 The Kharaa River has elevated nitrogen and phosphorous levels as the removal of these contaminants by the existing WWTP is inefficient. However, due to the dilution capacity and turnover processes in the river, the nutrient levels are only moderately elevated. This has led to limited detectable impact on the ecology of the river. It is possible that at times of low flow combined with a future increase in housing and industry, the impacts on the river arising from the current WWTP treatment shortcomings would become more significant and the environmental

sustainability could be compromised. This is increasingly likely as the existing outdated waste water treatment technology becomes progressively more unreliable with age.

### 2.3.4 Sector Performance in Darkhan

53 The existing situation with respect to the water and wastewater sectors in Darkhan can be described as problematic, but not critical. Water supply and wastewater management are the responsibility of the Public Urban Services Organisation (PUSO) for Darkhan – Darkhan Us Suvag (USAG) - which was established in 1965 and currently has 192 staff of which 40 have an engineering qualification. Darkhan Us Suvag functions as a service organisation and a limited liability joint stock company. The company is owned 40 per cent by the aimag government and 60 per cent by the aimag peoples Khural (on behalf of the people of the aimag). The water supply and wastewater assets of the aimag are vested in the Us Suvag LLC. The existing institutional set-up is set out in Appendix D.

### 2.3.5 The Water Supply System

54 The city is served through a system of wells located in the Kharaa river valley and about 5 Km upstream of Darkhan city. A total of 18 wells are available which could deliver a theoretical 70,000 cum/day of groundwater. However, current total residential and industrial demand (of about 18,000 cum/day but up to 23,000 cum/day) can be provided from just 5 or 6 production wells. This includes “technical water” of about 8,000 cum/day used by the thermal power plant, and which is drawn from their own wells. Us Suvag abstracts about 11,000 cum/day for domestic and other industrial use. During August 2013 abstraction rates varied from 8,800 to 12,100 cum/day, with an average of 11,000[14].

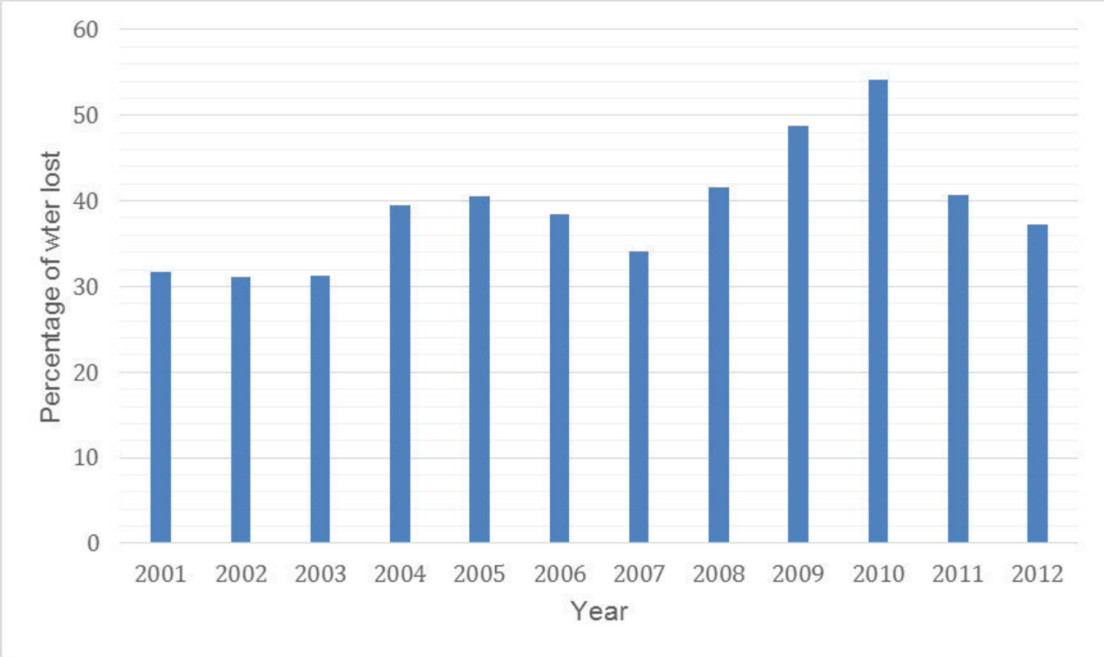
55 The raw water is generally of drinking quality at the point of extraction, and as such is not normally subject to treatment. However, chlorination facilities exist at raw water storage tanks and it is reported[15] that chlorination is occasionally carried out during the summer period when quality declines. Despite this, water quality problems are experienced at the point of delivery as a result of the poor condition of many sections of the 40 year-old pipe network, which suffers an overall leakage rate currently estimated at about 40%. Progressive replacement of key elements of the water supply network (which has been commenced) is likely to result in a progressive improvement in the leakage situation. However, there are still some sections which remain in urgent need of replacement[16].

56 In addition to the abstraction from Us Suvag’s own well network and those of the thermal power plant, some individual households and businesses extract groundwater from their own wells. However, over recent years, Us Suvag has attempted to stop this practice and now the vast majority of water supplied to residences is from the Us Suvag well fields via the distribution network, although there are still some private deep wells which provide water in the ger areas. Furthermore, the household socio-economic survey carried out under WSSIIP identified some households in baghs 1,2 and 3 (situated in the flood plain of the Kharaa river) which still use shallow wells for potable water supply, even though the groundwater is polluted.

57 Of the 11,000 cubic meters produced by Us Suvag per day, about 3,000 cum/day is consumed by industry and 8,000 cum/day by residential, institutional and commercial users. Of this amount most is consumed in the core serviced areas of old and new Darkhan, with only about 500 cum/d being consumed by the more than 25,000 who live in the ger areas, of which most is provided through the piped network to water kiosks, and about 90 cum/day by water trucks . There are a total of 35 water kiosks serving the ger areas, of which 18 are served from the water supply network and 17 by water tanker. The tankers mainly serve kiosks in areas near the Kharaa River (Baghs 1, 2 and 3) where water supply pipes cannot easily be installed due to the high water table.

[14] Us Suvag figures on raw water abstraction 2013.
[15] Reported by Us Suvag, Head of Laboratory Services.
[16] For instance in the area of Mangirt where the proportion of non-revenue water is estimated at 80%.

**Figure 2.3: Reported System Losses from Water Supply Network**




58 The centrally planned urban core areas are served by a reticulated water supply network which in places extends into the ger areas to provide water to water kiosks. The reticulated supply is provided through 223.2 Km of pipe varying in diameter between 100 mm and 1,000 mm. The age of the network by length is: installed in 1965: 59%; in 1990: 33%; in 2005: 5%; and in 2011: 3%. Appendix E shows the water supply network by length, diameter, materials and condition, and indicates the recent rehabilitations made.

59 Average water consumption within the central serviced core areas has been measured at 175 l/cap/day in warm weather conditions (when the hot water system is not in operation) and a further 40 l/cap/day, making a total of up to 215 litres/capita/day during cold weather conditions when the hot water system is operated. This includes the system leakage currently estimated at about 40 per cent. In the ger areas average per capita water consumption is estimated at around 10 to 20 l/cap/day[17]. Figure 2.4 below shows the estimated water balance for the city.

### 2.3.6 The Sewerage System

60 Darkhan has a separate sewer system – sanitary sewage and surface water are served by independent networks. The sewer system of Darkhan conveys wastewater from both old and new Darkhan and the industrial estate to the central WWTP, which lies just to the north (downstream) of old Darkhan and about 500 m from the Kharaa river. The WWTP is about 650 m from the nearest dwelling – which is a ger on a recently issued khashaa plot.

61 The sewer network has of total length of 223.5 Km made up of about 97 Km of trunk main, 2 Km of rising main, and the remainder in secondary sewers and connectors. The condition of the network is variable, as many of the pipes are almost 50 years old. The age of the network by length is: installed in 1965: 65%; in 1990: 30%; and in 2005: 5%. There is no detailed information on the retention period within the sewer system, although there are no reports of septicity problems. The generally sloping topography of the core urban areas of Darkhan help in generating self-cleansing velocities in the sewer network.

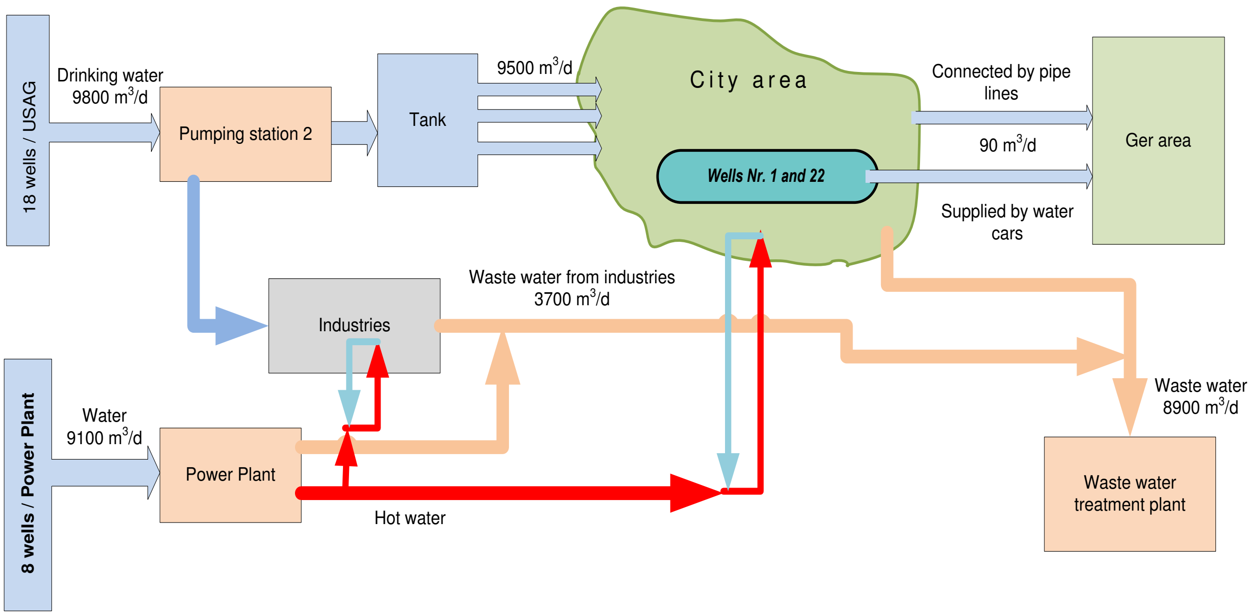
[17] Source: Milojevic, Nikola, Klaus-Jochen Sympher, Matthias Schütz, and Martin Wolf, MoMo Technical Report No 6 Integrated Wastewater Management in Central Asia – MoMo Model Region, 2011.

62 Since the two residential areas and the industrial estate are effectively in three separate valleys, the system requires two intermediate pumping stations to convey wastewater to the WWTP (one at the industrial estate and one in old Darkhan), with a further pump station at the plant to lift the wastewater to allow gravity flow through the treatment process. All pumps operate automatically according to pre-defined levels and there are both generators and emergency overflows at the pumping stations. Despite these provisions, due to periodic breakdown of equipment reaching the end of its economic life, there are occasions when there is overflow of raw sewage to the flood pain of the Kharaa River adjacent to the pump stations. In addition, the pump station serving the industrial area is an old plant running at capacity, and the far larger-capacity new pump station is currently not operational.

63 Us Suvag maintains that some 40% of the sewer network is in need of rehabilitation or replacement, and there is evidence of significant infiltration (and thus also exfiltration) from the sewer network. It is reported[18] that there is a significant increase in inflows to the WWTP during periods of intense rainfall, indicating significant ingress of storm water into the system. This suggests there is also significant ex-filtration under normal dry conditions, which has the potential to pollute groundwater resources. Based on the differential between water consumption and sewage flows, there are estimates that infiltration of ground water and surface water into the sewer system is of the order of 15 to 25%[19].

64 The sewer system only serves those residents that live within the service area, estimated at between 60% and 69% of total households which are connected to the public sewer system. Of the remaining percentage (most of whom live in ger areas), a significant majority use open long-drop pit latrines for sanitation, and soakage pits for sullage disposal. However, it is also reported that 14% of the wastewater generated in the city is directly discharged into surface waters – mainly from the ger settlements[20].

**Figure 2.4: Estimated Water Balance for Water Supply to Darkhan City**



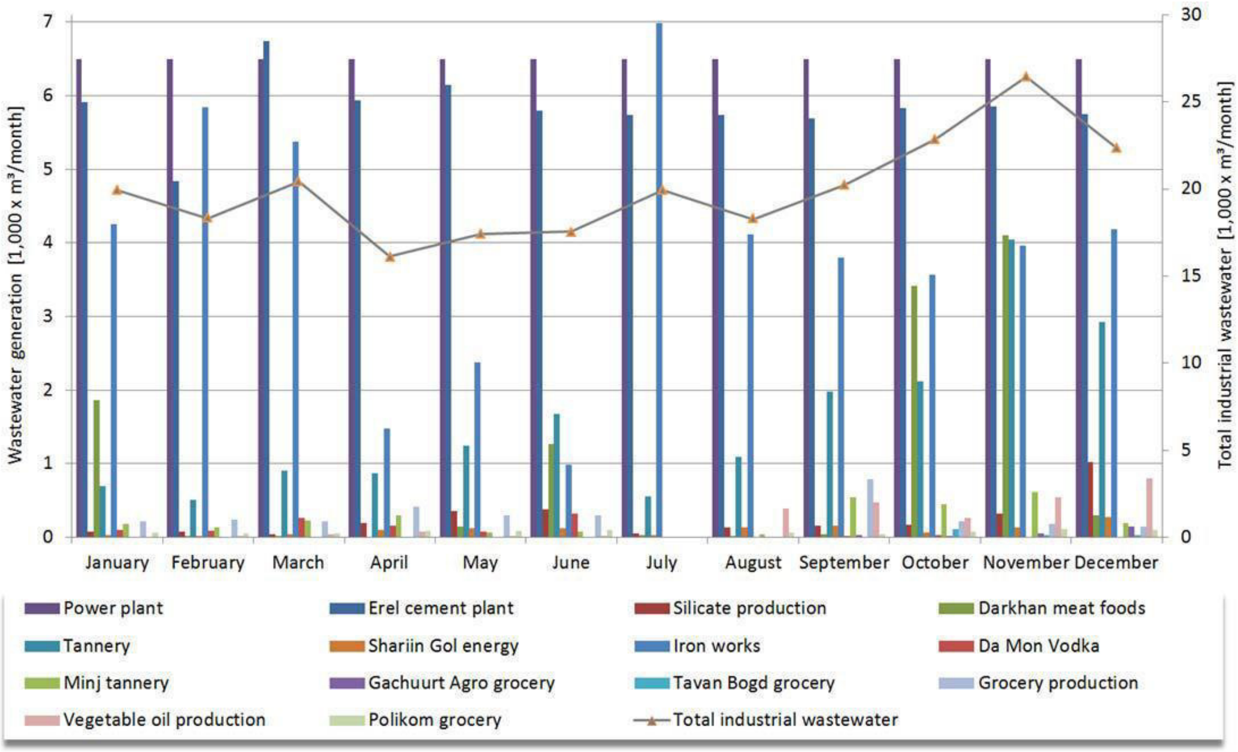

[18] Us Suvag flow records at CWWTP
[19] Source: Milojevic, Nikola, Klaus-Jochen Sympher, Matthias Schütz, and Martin Wolf, MoMo Technical Report No 6 Integrated Wastewater Management in Central Asia – MoMo Model Region, 2011.
[20] Source: p2mberlin GmbH Integrated Water Resouce Management (IWRM) Mongolia - MoMo Project: Proposal for a pilot SBR treatment system in Darkhan City, Berlin, 2010

### 2.3.7 Industrial Wastewater

65 The industrial estate generates up to an estimated maximum of 3,700 cum/day of wastewater, although the summer average is nearer 2,500 cum/day, which enters the public sewer network. Of this amount, approximately 2.5 cum/day generated by the sheepskin tanning and dying factory is subject to pre-treatment using a coagulation and precipitation reactor which precipitates out chromium and delivers an effluent which is acceptable for discharge into the public sewer. The meat processing factory also has a pre-treatment facility for its 40 to 60 cum/day effluent which is high in BOD and nutrients. However, this plant is currently not functioning so this effluent (which represents about 0.5% of total sewage flow) is discharged directly to the public sewer and thence to the treatment plant. Wastewater flows from other industries are not pre-treated. Us Suvag monitors the characteristics of industrial flows into the sewer network and believes that all industrial flows satisfy the conditions for discharge to a public sewer, except for the meat processing factory as long as its treatment plant is out of operation. These standards are provided at Appendix F.

66 Figure 2.5 below[21] shows a time series of industrial wastewater flows as reported by individual industries during 2011, although this is significantly less than the wastewater pumped as measured at pump station No 1. Us Suvag indicates that all industries discharge wastewater into the public sewer system. The left ordinate shows the monthly wastewater flow by industry, and the right ordinate depicts the monthly sum of industrial wastewater discharged. Industrial wastewater production in the winter months (October to March) is about 20% higher on average than in the summer months (April to September).

**Figure 2.5: Total and Average Industrial Wastewater Flows over 2011**




### 2.3.8 Wastewater Pumping Stations

67 There are three wastewater pumping stations currently used to deliver wastewater to the WWTP, including the station at the treatment plant itself which raises wastewater to the preliminary treatment works. There is a further pumping station at the industrial estate which is not currently operational, but which needs to be brought into service as the increasing wastewater volumes justify its use.

[21] Source: Heppeler, Jörn. Optimization of the operation of a sequencing batch reactor (SBR) – On the example of the pilot wastewater treatment plant in Darkhan, Mongolia, University of Stuttgart, Stuttgart, 2012

68 Wastewater from the industrial area is pumped to the WWTP in two stages, and that from Old Darkhan and New Darkhan in a single stage from the secondary pump station (See figure 2.4). The first stage pump station at the industrial estate is operating at its capacity (reported as 160 cum/hr), and under peak inflow conditions raw sewage surcharges in the wet well, sometimes to the point where it overtops the parapet. Consequently, the primary screens are ineffective, thus further adding to the risk of pump failure. It has single operating and standby pumps.

69 The unused primary pump station at the industrial estate has never been operated, despite being connected to the network and provided with pumps, power connections and a standby generator. It has a theoretical capacity of about 1,000 cum/hr, but pumps and electrical equipment have been removed and significant investment is required to make it operational.

70 The secondary pump station collects wastewater pumped from the industrial area, and flowing by gravity from New Darkhan and parts of Old Darkhan. The structure is in generally good condition, but again, the pumping equipment and power connections are in an advanced state of dilapidation. In addition, overflow pipework from the pump station is in need of replacement.

71 Figure 2.5 shows the pumping arrangement. The primary pumping station for the industrial area which is currently used is approximately 200 m south of the major primary pumping station which is currently unused but would need to be brought into service with increasing industrial wastewater flows.

### 2.3.9 The Central Wastewater Treatment Plant

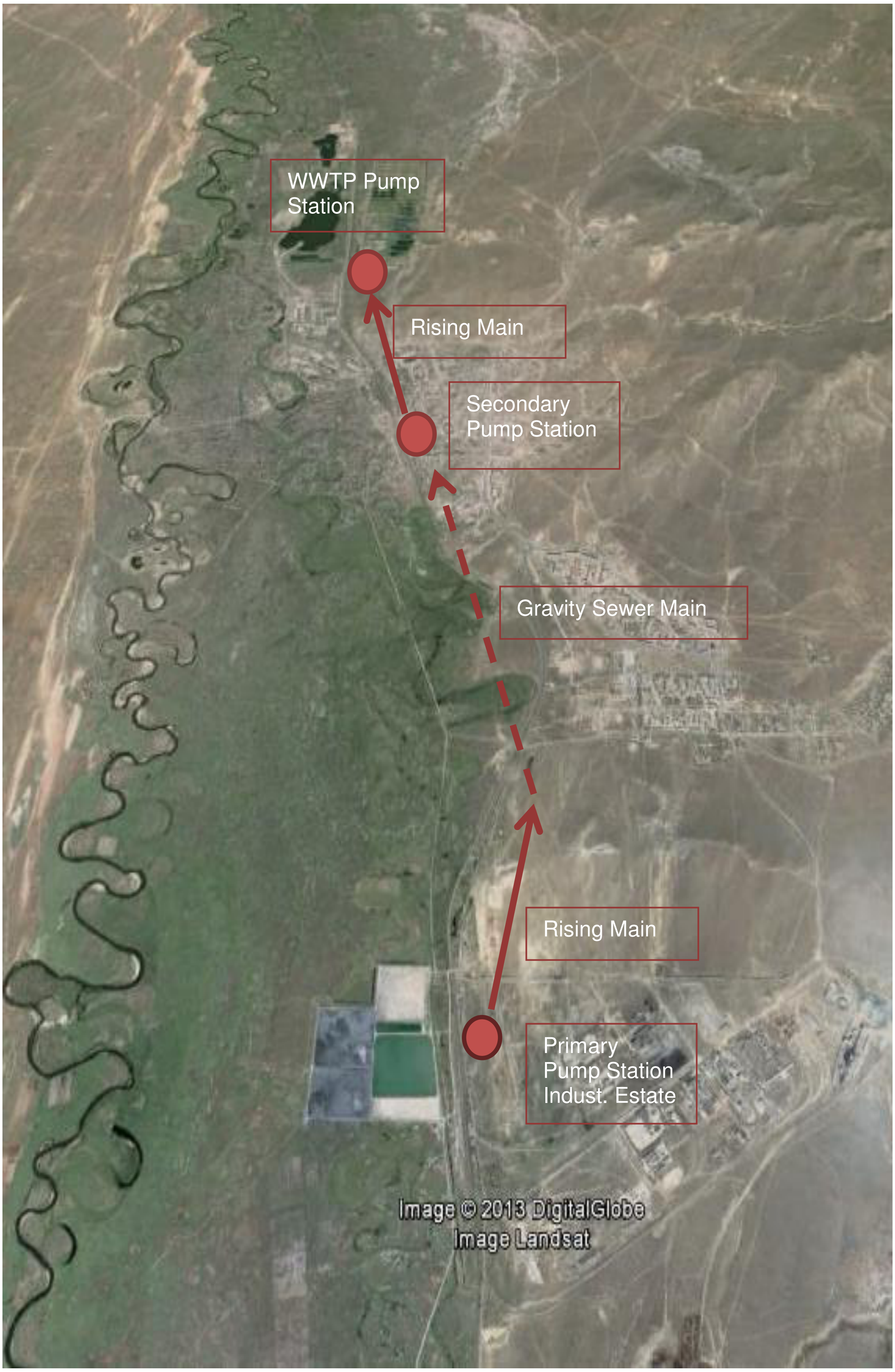
72 The first stage of the CWWTP was built during the construction phase of Darkhan in 1965, adopting Russian design and standards, and initially adopting a process of preliminary treatment followed by primary treatment in two primary clarifiers. From 1987 to 1990, a major upgrade and expansion of the facilities was completed, with the provision of: (i) new grit channels, (ii) three new primary clarifiers, (iii) secondary biological treatment based on the activated sludge process, (iv) three secondary clarifiers, and (v) effluent chlorination facilities. This mechanical and biological plant had a design capacity of 50,000 cum/day, and was complemented by a series of constructed ponds providing: (i) polishing in maturation ponds, (ii) sludge drying beds, and (iii) sand and grit disposal ponds. The original primary clarifiers were decommissioned once the new plant came on stream. It is unclear whether all three streams of the 1990 plant were ever operated since in recent years the flow has seldom exceeded 10,000 cum/day, which is one fifth of the design capacity.

73 Most elements of the system are now out of commission. Two out of three of the primary clarifiers and two out of three of the secondary clarifiers are no longer used and derelict. Any mechanical equipment from the out-of-commission units has been cannibalised to keep the one remaining unit operational. Despite this, the plant is fully operational, with the exception of the chlorination facility. However, although planned for 50,000 cum per day, the plant is currently operating at a load of about 7,000 cum/day in summer and an average of 10,000 cum/day in winter, with a reported peak flow of significantly less than 20,000 cum/day. Consequently, only one stream (out of three) of both primary and secondary clarifiers is necessary. However, all three streams of the activated sludge biological reactor are operated, resulting in excessively long aeration periods. During the month of August 2013, daily flow rates into the plant varied between 5,100 and 10,900, and averaged 7,100 cum/day[22]. The inflow rates are somewhat higher in winter due to the extensive use of hot water in apartments and institutions.

74 Figure 2.7 below shows the layout of the WWTP and indicates the units which are currently operating highlighted in blue.

[22] Us Suvag inflow records for CWWTP.

**Figure 2.6 Arrangement of Sewage Pumping Stations**



75 Despite being operational most of the time, the plant is in an advanced state of disrepair. Some of the original pumps are decommissioned and have been cannibalised to provide parts for remaining serviceable pumps. Most of the control equipment in no longer operational, which means that the plant is operating sub-optimally contributing to excessive operational costs and compromising effluent quality. Although most pumps are out of order, the pumping stages in the plant are kept operational by repaired pumps and new pumps brought in to replace those no longer operable. Occasional breakdown and insufficient duty and standby pump capacity causes occasional raw sewage overflow and pollution of the immediately surrounding area.

76 The operation of the mechanical treatment processes is severely compromised by the failure of the screens which allow bulky debris to enter the system and provide a potential risk to pipes and pumps. The efficiency of the sand and grease trap is doubtful as the intermittent operation of the inlet pumps results in high temporary loads on the sand and grease trap and the primary sedimentation tank – exceeding the capacity of both to do an adequate job.

77 The primary sedimentation process is sometimes overloaded as only one out of three tanks is operational, and the sedimentation process in the primary sedimentation tank appears insufficient as faeces, paper and other floating debris leave the tank. The biological treatment aeration tank is in a very poor structural condition, with parts of the concrete walls having been eroded away, resulting in very uneven spill-over at the overflow weir. Aeration is very intensive, and visual inspections suggest the aeration rate is far too high, negatively impacting on treatment and wasting energy.

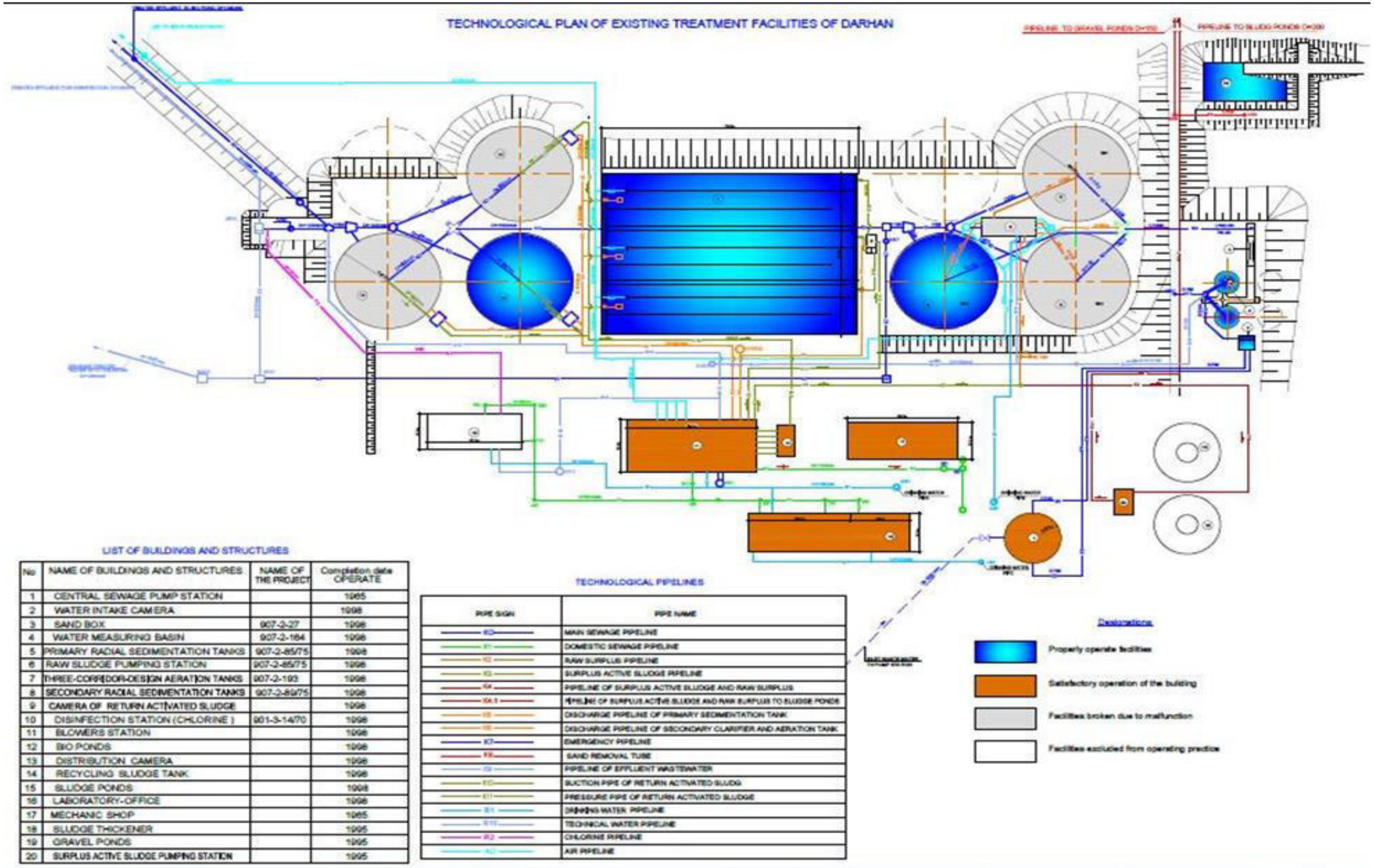
78 The performance of the secondary sedimentation tank is compromised by the ineffective operation of the sludge bleed system, resulting in sludge rising and being carried over with the supernatant. If the effluent from the plant is conveyed to the maturation ponds this should result in further effluent polishing, but is in unclear as to whether this is done on a regular basis.

79 In sum, the plant is struggling to keep going, and suffers frequent breakdowns which compromise the treatment efficiency and risk pollution events. In summer and autumn of 2012 regular aeration failures were observed due to the breakdown of the blowers, which on occasion, lasted for more than one week. The repeated blackouts led to a loss of activated sludge and negatively impacted on the treatment efficiency[23].

80 Despite these problems, the plant shows reasonably good treatment efficiency in terms of BOD and SS removal, less so in the case of COD and nutrient removal. Table 2.3 shows the performance of the plant measured by Us Suvag during 2012 and the first half of 2013. This measures parameters at the outlet from the secondary clarifier, and further treatment can be anticipated in the polishing ponds prior to discharge to the Kharaa River. It should be noted that this data is based on filtered samples of effluent, which is the standard practice adopted by Us Suvag in measuring wastewater parameters. It is noticeable that $BOD_5$ removal is consistently high at around 90% apart from in April 2013 when it dropped significantly. This could be due to the sudden warming of the weather causing a dramatic increase in anaerobic activity in trapped sludge deposits releasing BOD into the supernatant and increasing sludge carry-over.

[23] Pm2berlin, Terms of Reference Main Trunk Sewer and Central Wastewater Treatment Plant for Darkhan, Mongolia Draft, Berlin March 2013

**Figure 2.7: Existing Wastewater Treatment Plant** (Units shown in blue are currently operational)




LIST OF BUILDINGS AND STRUCTURES

| No | NAME OF BUILDINGS AND STRUCTURES | NAME OF THE PROJECT | Completion date OPERATE |
|---|---|---|---|
| 1 | CENTRAL SEWAGE PUMP STATION | | 1965 |
| 2 | WATER INTAKE CAMERA | | 1998 |
| 3 | SAND BOX | 907-2-27 | 1998 |
| 4 | WATER MEASURING BASIN | 907-2-164 | 1998 |
| 5 | PRIMARY RADIAL SEDIMENTATION TANKS | 907-2-85/75 | 1998 |
| 6 | RAW SLUDGE PUMPING STATION | 907-2-85/75 | 1998 |
| 7 | THREE-CORRIDOR-DESIGN AERATION TANKS | 907-2-193 | 1998 |
| 8 | SECONDARY RADIAL SEDIMENTATION TANKS | 907-2-89/75 | 1998 |
| 9 | CAMERA OF RETURN ACTIVATED SLUDGE | | 1998 |
| 10 | DISINFECTION STATION (CHLORINE) | 901-3-14/70 | 1998 |
| 11 | BLOWERS STATION | | 1998 |
| 12 | BIO PONDS | | 1998 |
| 13 | DISTRIBUTION CAMERA | | 1998 |
| 14 | RECYCLING SLUDGE TANK | | 1998 |
| 15 | SLUDGE PONDS | | 1998 |
| 16 | LABORATORY-OFFICE | | 1998 |
| 17 | MECHANIC SHOP | | 1965 |
| 18 | SLUDGE THICKENER | | 1995 |
| 19 | GRAVEL PONDS | | 1995 |
| 20 | SURPLUS ACTIVE SLUDGE PUMPING STATION | | 1995 |

**Table 2.3: Darkhan WWTP performance in 2012 and H1 of 2013**

| Existing WWTP performance 2012 & January to July 2013 - Us Suvag figures | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | $BOD_5$ | | | COD | | | SS | | | $NH_4$ | | |
| | Inlet | Outlet | Removal | Inlet | Outlet | Removal | Inlet | Outlet | Removal | Inlet | Outlet | Removal |
| 2012 | 91.00 | 9.00 | 90% | 103.00 | 45.00 | 56% | 150.00 | 28.00 | 81% | 2.28 | 0.65 | 71% |
| Jan-13 | 66.60 | 5.60 | 92% | 182.40 | 42.00 | 77% | 130.00 | 36.60 | 72% | 1.40 | 0.37 | 74% |
| Feb-13 | 100.00 | 8.00 | 92% | 96.00 | 48.00 | 50% | 95.00 | 27.30 | 71% | 1.62 | 0.69 | 57% |
| Mar-13 | 87.00 | 8.90 | 90% | 86.50 | 44.80 | 48% | 91.00 | 23.00 | 75% | 1.40 | 0.78 | 44% |
| Apr-13 | 62.00 | 24.20 | 61% | 124.80 | 44.60 | 64% | 87.70 | 25.70 | 71% | 1.39 | 0.43 | 69% |
| May-13 | 80.00 | 6.30 | 92% | 93.00 | 42.00 | 55% | 86.00 | 25.00 | 71% | 1.19 | 0.42 | 65% |
| Jun-13 | 81.00 | 7.30 | 91% | 141.00 | 25.00 | 82% | 134.00 | 33.00 | 75% | 1.24 | 0.37 | 70% |
| Jul-13 | 96.50 | 9.80 | 90% | 76.80 | 75.00 | 2% | 109.30 | 28.00 | 74% | 0.87 | 0.53 | 39% |
| **Average** | | | **87%** | | | **54%** | | | **74%** | | | **61%** |

81 Additional data were collected by the MoMo project in the summer of 2012 on the treatment efficiency achieved by the WWTP, in this case using unfiltered samples. The average results are shown in Table 2.4 below. These also show a poor performance in terms of nutrient removal, although improved performance in removing COD.

**Table 2.4 Darkhan WWTP performance in 2012 and H1 of 2013**

| Existing WWTP Performance MoMo figures | | | | |
|---|---|---|---|---|
| Measured over period May to August 2012 | | | | |
| **Parameter** | **Minimum mg/l** | **Mean mg/l** | **Maximum mg/l** | **Average removal rate %** |
| COD | 164 | 385 | 634 | 72 |
| Total N | 39 | 59 | 74 | 40 |
| $NH_4$-N | 28 | 41 | 57 | 49 |
| Total P | 3.4 | 5.9 | 7.5 | 61 |

82 The Meteorological Office[24] of Darkhan-Uul aimag is responsible for monitoring the performance of treatment plants in the aimag, and the Darkhan CWWTP is one of four plants operating within the aimag which are monitored for compliance with national effluent discharge standards (see Appendix F). The results from sampling at the points of discharge from the treatment plants to the Kharaa River carried out in the summer of 2013 are shown in Table 2.5. This reveals that despite its operational problems, the Darkhan WWTP delivers an effluent which satisfies the effluent discharge standards on 80% of occasions. In doing so, it performs better than the other wastewater treatment plants in the aimag.

**Table 2.5 Darkhan-Uul Aimag WWTP Discharges against Quality Standards.**

| Wastewater Treatment Plant Location | Approximate Distance from Darkhan city (km) | % of effluent samples meeting Mongolian National Standard MNS4586:1998 |
|---|---|---|
| Darkhan WWTP | - | 80.0 |
| Khongor Soum WWTP | 25 km | 36.9 |
| Salkhit WWTP | 35 km | 42.9 |
| Sharin Gol WWTP | 47 km | 70.4 |

[24] Source: Darkhan Meteorological Office Data available on http://www.icc.mn/aimag/Darkhan/

## 2.4 Wastewater Discharge Standards

83 The standard for wastewater discharges to water bodies (MNS 4943: 2011) has been recently revised (2011) and now aligns quite closely with European Standards. It appears to be both consistent with international standards and appropriate for Mongolian conditions. (See Appendix F).

84 The standard for wastewater discharges to a public sewer (Regulation number No a/11/05/A/18: Allowed Limits of Industrial Wastewater Composition Before Letting Effluents into the Central Wastewater Treatment Systems) are older (1997) and appear to be based on Russian standards. Some parameter limits look high, and problems could be experienced with treatment plant operations where heavily polluted industrial flows comprised a high proportion of wastewater flow into the plant, even though satisfying these discharge standards.

## 2.5 Government Initiatives in New Wastewater Treatment Plants

85 The Government, either through its own funding or with the assistance of donors and lending agencies, is embarked upon an ambitious program for the construction of new or expanded wastewater treatment plants in the major cities, and in rapidly growing smaller urban centres, of Mongolia. Those which are of a similar size to the treatment plant proposed for Darkhan, and as such are of greatest relevance in informing the approach to the Darkhan WWTP, are the new plant proposed at Nisekh, on the edge of Ulaanbaatar; and the extension to the existing WWTP for Erdenet in Orkhon aimag. However, all major current proposals are considered here so that any lessons relevant to the design of the WWTP for Darkhan can be drawn out.

86 In Ulaanbaatar, a new plant is proposed at Nisekh ultimately treating 20,000 cum per day, with a first stage of 10,000 cum/day, for which a tender has been issued and a preferred bidder selected. The Nisekh plant has been the subject of full feasibility analysis and, although initially proposed for funding by KfW, is now being funded using the government's own financial resources. In addition, preliminary plans and a feasibility study have been prepared for the upgrading and extension of the existing Central WWTP in Ulaanbaatar. The proposal is to increase the current capacity of 120,000 cum/day (upgradable to 180,000 cum/day) by progressive increments of 63,000 cum/day by 2020, a further 84,000 cum/day by 2028 and a further 63,000 cum/day by 2035.

87 In Orkhon aimag, the existing plant is being extended to enable it to treat a further 20,000 cum per day using a combination of Government funds and a loan from the Government of France. In addition, a new wastewater treatment plant is being designed for Zamyn uud soum in Dornogovi to be funded under the Chinese infrastructure loan, and with a first phase design population of 20,000 which is equivalent to a capacity of about 3,000 cum/day.

88 Finally, government has commissioned the construction of a new plant to replace the poorly functioning existing plant at the airport at Nisekh in Ulaanbaatar. This has a design capacity of 2,000 cum/day and it has been constructed adopting a modified activated sludge treatment process. The plant is ready for commissioning, but is not yet operational.

89 These initiatives, and the lessons they provide in consideration of the options for wastewater treatment for Darkhan, are briefly discussed below.

### 2.5.1 The Proposed WWTP at Nisekh

90 Feasibility studies and plans were developed for the Nisekh plant with funding from KfW over a period of more than one year and through three development phases[25]. The reports together: (i) carry out a detailed investigation of possible wastewater treatment alternatives at Nisekh; (ii) provide a more thorough evaluation of the preferred two options (sequencing batch reactor and modified activated sludge process); and (iii) provide detailed costs and operational requirements for the preferred option of a step-feed process activated sludge process. The work also develops a

[25] Environmentally Sound City Development in Ulaanbaatar, Feasibility Study Report, Final Version, Gitec and Mongol Erdem, Ulaanbaatar August 2011.

project planning matrix that discusses potential risks to project implementation, and possible remedial measures to mitigate those risks.

91 The first stage evaluation considered six systems against a range of criteria including cost and operability under Mongolian conditions etc. These were:

i. Trickling Filter technology
ii. Activated Sludge technology
iii. Extended Aeration technology
iv. Sequencing Batch Reactor technology
v. Membrane Bioreactor technology
vi. Biofilm technology

92 Although there was no detailed evaluation of each of these options, from preliminary assessments of suitability for Nisekh, a shortlist of three processes emerged which were subject to further scrutiny: (i) a modified activated sludge system - adopting a step feed activated sludge process and including anaerobic sludge digestion; (ii) a sequencing batch reactor system, including anaerobic sludge digestion; and (iii) an extended aeration system (in this case using an oxidation ditch or Carrousel approach). The Oxidation Ditch (Carrousel) process used as an extended aeration system was further considered only as this was understood to be the preferred option of the Municipality of Ulaanbaatar. However, on detailed evaluation of these three systems, the extended aeration option was rejected for the following reasons:

i. Sludge treatment and disposal issues – sludge less well mineralised than in other options
   a. Greater sludge volumes generated
   b. No energy recovery option from sludge digestion
   c. Poor handling characteristics of sludge
ii. Volume of aeration tanks: Extended aeration tanks are three times the size of activated sludge tanks, incurring higher capital costs and risking reduced temperatures inducing freezing problems unless enclosed
iii. Energy demand for oxygen is 30% greater than for the other options
iv. Energy recovery not possible whereas from the activated sludge and SBR plants energy recovery could be as great as 2,500 MWh/annum

93 The preferred process identified through this selection procedure was the Activated Sludge Step Feed Process. This is a relatively new process but now successfully demonstrated elsewhere and increasingly used. It was evaluated as preferable to either the SBR process, or to other modified activated sludge process systems for the following reasons:

i. It achieves a high rate of denitrification and of Phosphorous removal (good for discharge to water courses)
ii. It enables a compact design, reducing aeration tank size by between 33% and 70%
iii. It is energy efficient: no sludge recirculation is required and it exerts a lower oxygen demand that is comparable to conventional ASP systems
iv. Average mixed liquor suspended solids (MLSS) is higher without an increased load on clarifiers
v. There is a reduced risk of sludge bulking
vi. It is relatively easy to operate (compared to an SBR) with greater flexibility of operation
vii. It offered least combined capital and operation and maintenance (O&M) cost
viii. The capital cost was about 10% less than for the SBR option

### 2.5.2 The Extension to Ulaanbaatar CWWTP

94 A study on strategic planning for the water supply and sewerage sectors in Ulaanbaatar was carried out during 2012 and the first half of 2013 with assistance from JICA[26]. The study provided analysis and recommendations for the future development of the water and wastewater systems in Ulaanbaatar, including for the rehabilitation and expansion of the existing central wastewater treatment plant of Ulaanbaatar. The existing facility is an activated sludge process plant, the original design of which dates back to the soviet period. For the extension of the plant's capacity to accommodate increasing wastewater flows over the 20 year design period, seven potential treatment processes were evaluated against a range of criteria which were focussed mainly on treatment efficiency, management and operational requirements and cost. The evaluation was conducted on the following systems:

i. Conventional activated sludge (AS) system;
ii. The anaerobic anoxic oxic ($A_2O$) process – a modification of the AS process for targeted nitrogen and phosphorous removal;
iii. The step-feed biological nitrogen removal process – another modified AS process;
iv. Sequencing batch reactor process;
v. Membrane Bioreactor technology;
vi. Waste stabilisation ponds; and
vii. Reverse Osmosis technology

95 This evaluation concluded that: (i) stabilisation ponds and conventional activated sludge should be removed from further consideration due to poor Nitrogen and Phosphorous removal; (ii) the $A_2O$ and SBR processes present operational complexities in removing both Nitrogen and Phosphorous; and (iii) the reverse osmosis process is prohibitively expensive to construct and operate. The three remaining options: the oxidation ditch (or Carrousel) process, activated sludge step-feed process, and membrane bioreactor process are each judged suitable process for the plant extension, and are recommended for further evaluation during a future full feasibility study.

96 However, it is understood that Ulaanbaatar city has expressed a preference for the oxidation ditch (Carrousel) technology and the development plans for CWWTP presented in the report assume that this is the technology which will be adopted.

### 2.5.3 The Proposed WWTP Extension for Erdenet in Orkhon Aimag

97 Erdenet is the second largest city in Mongolia, and was constructed to serve the adjacent copper mine. The city continues to grow at about 3% per annum[27], and as a result, the existing activated sludge wastewater treatment plant has reached its capacity. A feasibility study to prepare an extension for the plant, increasing its treatment capacity by 20,000 cum/day, was conducted with assistance from the Government of France in 2010. The project preparation study did not consider a wide range of options. Rather, the approach taken was to build upon the existing treatment technology which has been successfully operated by the Erdenet PUSO.

98 Consequently, the extension plant uses the same basic process as the existing facility, with some evolution in activated sludge configuration, and the addition of mechanical sludge drying using a centrifugal process. The wastewater treatment process follows a conventional activated sludge process configuration: (i) screening; (ii) grit and grease removal; (iii) primary settling; (iv) a modified activated sludge process; (iv) secondary settling; and finally (v) transfer of effluent to the existing tertiary treatment system (sand filtration) for polishing. The excess sludge treatment process is thickening and centrifugation prior to disposal into sludge drying beds.

99 The rationale for this approach is primarily the adoption of a treatment process which is already well-understood in Erdenet, with the system adaptation enabling the process to be optimised based on a better understanding of how the activated sludge process can be made more effective through

[26] Study on the Strategic Planning for Water Supply and Sewerage Sector in Ulaanbaatar City in Mongolia, Draft Final Report, JICA, NJS consultants, Tokyo Metropolitan Sewerage Service Corporation, Ulaanbaatar, May 2013.
[27] Based on NSO figures for inter-censul period between 2001 and 2011.

revised configuration and sludge return arrangements. This option offers security both in terms of process efficiency, and in maximising the prospect of successful operation by the current plant management team due to its similarity to the existing system.

100 One interesting feature of the execution of this project is the separation of the contracts for equipment and civil works. The process equipment (paid for through a credit from the Government of France) was procured two years ago and has been on-site since 2011. The civil works to create the plinths, tanks and aeration basins has only just commenced (in August 2013), and will not be completed until 2014. It is to be hoped that the equipment will not have deteriorated during the time of its on-site storage. In any event, this would appear not to provide an optimal procurement arrangement, as it also risks problems when attempts are made to install the equipment into the structures. If problems occur at this stage in the fit between equipment and structures, the owners could find themselves assuming responsibility for any additional costs occurring as a result of extra work required to ensure smooth installation. Problems could occur again if operation problems are encountered and it is unclear whether these are the fault of the equipment supplier or the civil works contractor.

### 2.5.4 The Proposed WWTP at Zamyn uud

101 The proposed WWTP for Zamyn uud appears to have been developed without evaluation of alternative treatment process options, but to exceed the national standards for wastewater discharge which will enable the effluent to be used for watering green areas and dust suppression on gravel or earth roads. The plant is designed to replace an existing waste stabilisation pond WWTP at Zamyn uud which is not functioning well.

102 The proposed WWTP adopts a standard activated sludge technology with additional tertiary treatment stages as follows:

i. Preliminary treatment: screening, grit and grease removal
ii. Primary sedimentation and balancing tank
iii. Activated sludge biological treatment, using diffused air aeration
iv. Secondary sedimentation and sludge return
v. Sand filtration
vi. Carbon filtration; and
vii. Sludge treatment through sludge press, dewatering and disposal into sludge drying ponds

103 This project is at an early stage of development, and the arrangements proposed for management and operation are not known at this stage. However, the tertiary treatment processes in particular are complex, and will require a high level of operational skills.

### 2.5.5 The New WWTP at Chinggis International Airport

104 The new WWTP for the Chinggis International Airport appears to have been developed without consideration and evaluation of alternative treatment process options. It is unclear what led to the selection of the process, but it is understood that the plant is based on a modified activated sludge process (ASP) technology. Construction of the plant is complete and it is shortly to be made operational.

### 2.5.6 Other small wastewater treatment plants used in Mongolia

105 It is worth drawing on experience from the operation of other small wastewater treatment plants in Mongolia, as this can further inform the selection process for optimising the system adopted for Darkhan. Most of the small treatment systems currently operational fall under three basic categories, which cover a wide range of operational sophistication. These are:

i. Waste stabilisation ponds: Used in a number of aimag centres, and previously constructed under ADB and other donor and lender-supported urban development projects. The experience of these systems[28] is that while they are both cheap and easy to operate: (i) they tend to be neglected, resulting in poor performance and nuisance problems; (ii) they provide little treatment in winter, storing the influent wastewater, which can cause operational problems in the spring thaw; and (iii) even when functioning well, they provide only poor removal of nutrients (N and P).

ii. Activated Sludge Plants: A number of urban communities which have sewerage systems are served by small activated sludge plants, many of which were constructed during the soviet period. Experience is variable, but those plants which have been well maintained function reasonably well, and those which have not (often due to high power consumption costs and equipment breakdown) are either completely out of operation or provide little or no treatment. Even when working well, nutrient removal is generally poor. There were recent rehabilitations of the activated sludge systems in at Tuv and Selenge aimags (Zunmod and Sukhbaatar respectively). These introduced system modifications, automatic control systems, sludge dewatering devices, and in the case of Tuv, uniting the buildings and structures to reduce the number of pipelines underground and thus frequency of freezing in winter. Training was also provided, but while the Zunmod system is working well, that in Sukhbaatar is not being operated according to the prescribed operational system, and as a result, treatment is largely ineffective[29].

iii. Sequencing Batch Reactors: SBRs have been installed to serve a number of communities in Mongolia – particularly mining camps[30]. In general, these plants have been operated by the equipment supplier and consequently operation has been continuous and performance has invariably achieved design discharge standards. The SBR is considered an appropriate choice for this type of situation, where the necessary high-level of management and operational supervision is available. Also the use of SBR systems in similar cold weather situations is well proven[31].

## 2.6 Prior Water and Wastewater Sector Initiatives in Darkhan

106 There are a number of other organisations supporting, or planning to support, the development of urban utilities, including wastewater management, in Darkhan. Work under the current TA builds on the work previously carried out, and, where possible augments it. Key past, on-going and proposed investments in the water and wastewater sectors are presented in table 2.6 below.

107 The past and on-going projects to replace critical sections of the water supply network should ensure that system losses continue to fall from the peak of over 50% observed in 2010 (see section 2.3.4). However, there is currently no investment in the rehabilitation of the sewerage system, and Us Suvag has insufficient funds to address the immediate priorities for system repair and rehabilitation to reduce infiltration to, and exfiltration from, the system.

108 Under the MoMo project, a pilot scale Sequencing Batch Reactor (SBR) was operated at the existing central wastewater treatment plant in Darkhan for a period of two years. The SBR pilot plant was commissioned in August 2011, and consists of a 6m³ aeration and sedimentation tank with an excess sludge thickener, and process for water reception from sludge treatment. It is fully automated and controlled by a programmable logic controller (PLC). The SBR is fed with raw wastewater coming directly from the distribution chamber of the primary clarifiers at the Central WWTP, and as such should, to some extent, mimic real wastewater treatment conditions.

[28] Project Completion Report; Mongolia: Integrated Development of Basic Urban Services in Provincial Towns; ADB, Manila, June 2010
[29] Observations based on visits to Tuv and Selenge but study team members
[30] Review of Wastewater Treatment Plants in South Gobi, SMEC, Ulaanbaatar, 2012
[31] Morling, S., SBR Technology – Use and potential Applications for Treatment of Cold Wastewater, 2009, TRITA-LWR PhD Thesis 1050, ISBN 978-91-7415-341-5

**Table 2.6: Recent Support to the Darkhan Water and Wastewater Management Sector**

| Funding Agency | Activity | Implementation Period | Allocation |
|---|---|---|---|
| Government | Replacement of old and leaking water supply transmission and distribution pipes in PVC | 2010-2013 (on-going) | US$0.8 million |
| JICA | Water Supply Improvement Project: Rehabilitation of Water Supply wells, replacement of pumps, construction of water kiosks and 8 km of pipeline replaced | 2005 to 2011 | US$ 4.5 million |
| German Ministry for Education and Research | MoMo 1: 12 water kiosks constructed<br>MoMo 2: Pilot SBR installed and pilot sludge collection and digestion facility installed | 2007 to 2010 | US$ 100,000<br>US$ 400,000 |
| Czech Republic | Support to the development of a pre-treatment WWTP for Sheepskin factory in Darkhan | 2006-2010 | US$1.4 million |
| ADB | Replacement of 1.2 Km water supply distribution mains in Bagh 7 | 2010 | US$0.2 million |
| CDIA | Proposed preparation of a water supply and sanitation infrastructure improvement project for Darkan | 2014 | US$0.3 million |

109 The objective of the two-year operation period of the pilot plant is the adaptation of this flexible technology to the varying sewage loads and extreme climatic conditions experienced in Darkhan. It was anticipated that the plant would achieve better treatment results than the existing activated sludge process adopted at the WWTP, although full results of the pilot are currently not available. The treatment process was optimised, focusing on low concentrations of suspended solids in the treated effluent in preparation of the future disinfection and reuse of the effluent.

110 Preliminary conclusions have been drawn from the first two years of operation of the pilot, which could have implications for the design of a full scale plant, but only limited information has been made available on the operation of this plant. It is understood that some operational problems have been experienced with freezing in winter, although this may be a function of the small scale of the pilot plant. However, a recent MoMo publication concludes that "*the (SBR) process and the implemented control strategy have been found to be suitable for Mongolian conditions, and the majority of technical problems could be solved*"[32]. It is also worthy of note that (as indicated above in section 2.4.5) SBR plants have been working successfully for a number of years serving mining communities of up to 10,000 in the South Gobi region.

111 Under the Cities Development Initiative in Asia (CDIA)-funded Water Supply and Sanitation Infrastructure Improvement Project (WSSIIP) for Darkhan, assistance is being provided to the aimag with development planning, including preparation of a water supply and sanitation infrastructure improvement strategy and program for the city of Darkhan. This work is focussed on the ger areas, and also addresses some of the sector issues which are currently not being addressed by other donors or lenders, and are not a part of this current technical assistance. This includes a more thorough assessment of the existing water supply and wastewater networks, and system constraints, and in particular addresses issues relating to ger area water supply and sanitation, particularly in those areas close to the river where the water table is high (Baghs 1, 2 and 3).

## 2.7 External Assistance in the Water and Wastewater Sectors and Lessons Learned

112 There has not been much external assistance directed specifically to the wastewater sector in Mongolia in recent years, but wastewater improvements have been included in: (i) urban

[32] Integrated Water resources Management – Model Region Mongolia: Experiences and Results in Integrated Urban Water Management; Fraunhofer IOSB; 2013

development and housing projects and programmes; and (ii) water and wastewater sector investment projects. The details of recent investments in these sectors is set out below, along with an analysis of this assistance and some lessons that have been drawn from those projects which have been implemented and for which project completion or project evaluation reports are available.

113 There is much greater experience in the implementation of water supply, sanitation and wastewater management projects in ger areas in Mongolia. In addition, the MoMo project has piloted sanitation approaches in its work in Darkhan. The lessons drawn from this work are also summarised below.

### 2.7.1 Lessons from Assistance in Urban, Water and Wastewater Sectors

114 Generic lessons learned from prior assistance to the urban and water and wastewater sectors which have some relevance for Darkhan Wastewater Management Project include:

i. Institutional weakness is a key constraint to timely and efficient execution of projects, and to long-term sustainability of the assets created.

ii. Local capacity constraints are exacerbated by a highly centralized system of government. Related to this is the delineation of functions and inter-governmental fiscal relations which constrain the ability of local government to plan and manage public sector investments, and also to manage the recovery of investment costs.

iii. Local-level infrastructure investments remain largely at the discretion of the central government, and local officials lack the budgetary and human resources to maintain infrastructure properly and effectively respond to constituents' needs.

iv. Incentives and resources for local governments to strengthen services are limited. These weaknesses may have been reinforced by interventions which have been executed centrally and maintained and operated locally.

v. There is a need for externally-supported projects to take the opportunity to support greater local involvement in project planning, design and implementation, and address issues of capacity constraints and poor incentives for quality service provision at the local level.

vi. In considering the possible adoption of a design and build (D&B) procurement modality the project might be able to eliminate problems experienced in prior ADB loans where there is difficulty in assigning responsibility for deficiencies when infrastructure is turned over to local authorities.

vii. Projects have had limited and variable success in raising tariffs, resulting in under-funding of operation and maintenance. The support of ADB and other donors has focused on rebuilding assets in a variety of urban sub-sectors, but has placed relatively less emphasis on building the institutions and systems required to ensure these assets are maintained and operated efficiently. Given the acute needs in urban areas in the 1990s, the emphasis on building and rehabilitating assets was probably justified. Today, it is clear that Mongolia lags behind other former socialist countries in institutional reform and strengthening, and risks wasting resources on infrastructure that is not well maintained and managed.

115 As there has been little direct support to wastewater treatment, there are few specific lessons from donor assisted projects supporting WWTP construction. However, in addition to the generic lessons drawn from urban and water sector projects outlined above, experience has been gained from attempts to extend water and wastewater infrastructure to provide household connections in ger areas, and from attempts to introduce decentralised wastewater treatment plants into ger areas. These findings are instructive in developing a wastewater typology for different forms of urban development in Darkhan (which is provided in section 3.4 below), and in determining what the most effective and sustainable solutions to the improvement of sanitation services in ger areas is likely to be.

### 2.7.2 Lessons from Assistance in Ger Area Development

116 Many attempts have been made over the past 20 years to improve conditions and access to services for ger dwellers on a sustainable basis. The Government of Mongolia has worked with a wide range of bilateral and multilateral development agencies in numerous attempts to design and introduce service improvements that are technically feasible, socially acceptable and financially affordable. Some of these interventions have succeeded, but many have failed. It is important that this project learns from this experience and only adopts approaches which have a proven good chance of success.

117 Experience from a number of projects[33,34] which have attempted to introduce water and wastewater networks into ger areas is that:

i. Due to the large plots, connection to the water main and sewer main is expensive – even where communities have been surveyed to establish interest in making connections, when it comes to signing up, many back away from their prior commitments. Even where commitments are signed in advance of construction, experience is that households renege on these agreements once payments have to be made to join the network.

ii. Due to the high cost of keeping the water and sewer pipes above freezing at the point of entry to the dwelling (which requires 24 hour heating), few people connect.

iii. Due to the low community water demand and thus low pipe flow velocities resulting from the limited number of connections, water supply pipes freeze.

iv. Due to the low sewage flows, self-cleaning velocities cannot be achieved and pipes block and then freeze.

v. The problems of freezing highlighted above result in the loss of water supply and sewerage services for those connected, for months during winter.

118 Under the WB-funded Second Ulaanbaatar Services Improvement Project, a decentralised wastewater treatment plant was constructed at Dambadarjaa – a ger area in Ulaanbaatar to which water supply and sewerage services were also provided to institutions and households. An evaluation report on the project[35] found that the sub-component for households in Dambadarjaa to be connected to the main water supply system and be provided with individual sewerage connections with a stand- alone WWTP (septic tank and pond) to treat the collected wastewaters was not successful. This was partly due to freezing of water supply and sewerage pipes, and partly failure of the decentralised treatment plant which was found not to represent the most cost-effective solution for wastewater disposal. The conclusions drawn were that:

i. On-site (i.e. on-plot) sanitation approaches are recommended for ger area development since they present the most cost-effective approach. The recommended detailed approach depends on the water supply situation. If the supply is by water kiosks (in which case, water use is at around 10-20 l/cap/d) lined pit latrines, holding tanks or Eco Sanitation is recommended which are assumed to produce effectively zero operating costs for the beneficiary.

ii. Should it be decided to go for individual water supply connections, then only a septic tank approach will be able to cost-effectively cope with the increased wastewater production. If septic tanks are to be provided, a geological test should be carried out to determine soil absorption and percolation capacity.

iii. In this case, a sanitation concept based on household sewer connections and a small independent WWTP is definitely not the least-cost sanitation concept. Such a concept is

[33] Project Completion Report: Mongolia: Integrated Development of Basic Urban Services in Provincial Towns, ADB, Manila, June 2010.

[34] Implementation Completion and Results Report (IDA 38900; TF 53820) on a credit in the amount of SDR 12.1 million to Mongolia for the Second Ulaanbaatar Services Improvement Project, October. 2012

[35] Options Study to Improve Dambadarjaa Pilot Project, E Kaschka, World Bank, Washington DC, December 2012

expensive and technically risky. Costs per household of more than US$ 4,500 equivalent have to be considered – not an easy sell for a sanitation system.

iv. A small independent sewer system in ger areas is a major challenge – from both the technical and financial perspectives. This approach requires a density of population that can generate constant and sufficient flow of wastewater. Such systems should only be developed: (i) if sufficient density and connections can be achieved; and (ii) if the system can be connected to the central sewer system. If an independent sewer system is unavoidable, the design should ensure that as far as possible institutions producing continuously large quantities of wastewater will be connected (e.g. bath houses, schools, restaurants, and other commercial and institutional establishments).

v. For large areas with only private single houses on large plots (most ger areas), a sewer system should be avoided. In this case on-site sanitation facilities are the only workable option.

vi. For shallow sewer sections in ger areas, heating cables must be provided, and a realistic hydraulic load must be considered in the design (around 50l/cap/day). In case a small WWTP is unavoidable, simple, robust, processes should be applied such as rotating biological discs, trickling filters, or aerated ponds (all housed).

vii. A WWTP or a stand-alone sewer system can only be considered if receiving water for discharge is available which has sufficient dilution capacity for the received wastewaters. Infiltration to the ground is definitely not suitable as a final recipient under the climatic conditions of Mongolia.

viii. If water supply and sewerage systems are introduced to ger areas, steps must be taken to minimise the risk of freezing. Services (particularly heating and water supply) need to be installed in common trenches, and heating of both water supply and sewer pipes is necessary. This is expensive. In the Dambadarjaa pilot area in the winter months, the average cost of water supply to households was US$ 2 per month, while the average cost of heating the water supply pipes was US$25 per month – more than 10 times the cost of the water consumed.

119 There is a lot to be learnt from past projects and programmes in developing proposals for the improvement of water supply, sanitation and wastewater management services in the ger areas in Darkhan. However, it is also the case that the socio-economic environment in Mongolia is changing rapidly – particularly in urban areas. It maybe that approaches which have failed in the past, would not fail today. Consequently, a balanced view must be taken between tried and tested approaches and those which offer new and innovative solutions. Recent innovations in making service provision to ger areas include:

i. The “New District’’ project at Khilchin in Ulaanbaatar which adopts "Soft line" technology involving heated cable insulated with a vacuum-layer around pipes laid at a depth of less than 1 m. The development is not yet fully operational, but the development costs are high. Household connection costs for heating, hot and cold water and sewerage averages 15.0 million MNT per household – unaffordable for most ger areas residents;

ii. The iPIT system, piloted under the MoMo project and similar on-plot Ecosan toilets can have a role in sanitation solutions for ger areas, and could be particularly useful where a high water table makes pit latrines ineffective and piped solutions very expensive. However, a number of operational issues would need to be resolved before a technology of this type would be likely to be sustainable under conditions in Darkhan: (i) how to deal with frozen excreta in winter; (ii) how to deal with the high costs of transportation equipment and operation; (iii) how to solve the problem of faeces digestion not working in winter; and (iv) how to encourage a market for the organic fertilizer produced as a result of digestion.

120 In adopting any of these or other approaches, the risk of failure must be minimised or mitigated. To reduce or mitigate risks, important findings from past ger area improvement projects and programmes, particularly in the water supply and wastewater sectors, are as follows:

i. When implementing projects to improve water supply and sanitation in ger districts, it is important that they are aligned with city development planning and trends;

ii. Household water supply and sanitation improvements are expensive - it is important to select technologies which provide the most cost-effective and optimal solution according to local physical, social and affordability characteristics;

iii. Technical solutions should only be proposed if there is a strong and realistic indication of success – pilot approaches must be avoided;

iv. Excreta removal systems can work, but face problems in winter, and with the cost of the excreta removal service; and

v. Where household connections are made in ger areas, the project beneficiaries need to assume some responsibility for maintenance of household connections if pipe freezing is to be avoided.

### 2.7.3 Lessons Learned from MoMo Decentralised WWTP Pilot

121 A pilot decentralised WWTP using bio film technology has been installed under the MoMo project at a kindergarten in Orkhon soum of Darkhan-Uul aimag, with a load of 50 population equivalents (PE), and replacing an existing septic tank. The objective of the two-year pilot operational period is to test adaptation of this technology to the varying sewage loads and extreme climatic conditions experienced in Mongolia. The treatment process is optimized for low energy consumption and thus minimal operating cost (although more than for the septic tank). The plant appears to be functioning well so far, but has not been observed under deep winter conditions.

122 It is anticipated that the trial results could have application in the basic design of a standardized system for groups of houses or gers serving from 5 to 5,000 PE. Specific process benefits are claimed to be: (i) media is self-cleansing and does not need replacing; (ii) a robust system able to handle shock loading and long periods of low loading; (iii) low sludge generation; (iv) low consumption of energy and minimal operating costs; (v) nitrification at temperatures below 12°C.; and (vi). Simultaneous nitrification and de-nitrification of at least 30 to 50%.

123 However, as noted above, even if a wastewater treatment system of this type is installed in a ger area, the challenge will be to avoid problems with freezing of the sewer network. Decentralised wastewater treatment plants of this nature are considered to have wider application is serving a cluster of public or private buildings with relatively high wastewater flows – such as might be found in a soum centre.

## 2.8 Lessons Learned from International Best Practice in Wastewater Treatment in Extreme Climates

124 In addition to the review of other wastewater treatment systems operating and planned in Mongolia, investigations were made of wastewater management systems used in climatic and socio-economic conditions similar to those experienced in Darkhan This focussed on: (i) experience in Northern and Central China (and particularly ADB-funded wastewater treatment plants); (ii) experience in Russia – particularly those regions of Russia which are relatively close to Mongolia; and (ii) experience from other parts of the world, and particularly the far North of North America and Europe.

125 The ADB has supported construction of a number of wastewater treatment plants in northern and central China, and Table 2.7 below shows the size of the facility, technology used in each case, and other special features such as sludge handling. Information on the performance of these systems is not readily available, but where project completion reports have been completed, no adverse performance of the plants has been noted.

**Table 2.7: ADB-supported Wastewater Treatment Plant Construction in China**

| Location | Capacity cum/day | Treatment System | Sludge Treatment and Other Features |
|---|---|---|---|
| Hebei- Baoding | 240,000 | Activated Sludge (Anaerobic/Oxic (A/O) process) similar to IFAS | Fertilizer pellet production |
| Hebei - Chengde | 80,000 | Extended Aeration (Oxidation Ditch) | Composting and fertilizer |
| Hebei- Tangshan | 80,000 | Activated Sludge (Anaerobic/Oxic (A/O) process) similar to IFAS | Composting and fertilizer |
| Hebei-Xuanhua | 120,000 | Extended Aeration (Oxidation Ditch) | |
| Hebei- Zangjiakou | 100,000 | Extended Aeration (Oxidation Ditch) | |
| Shandong- Binzhou | 40,000 | Activated Sludge (Anaerobic/Oxic (A/O) process) similar to IFAS | Sludge landfilled |
| Shandong- Gaotang | 40,000 | Activated Sludge (Anaerobic/Oxic (A/O) process) similar to IFAS | Composting and fertilizer |
| Shandong-Shanghe | 40,000 | Activated Sludge (Anaerobic/Oxic (A/O) process) similar to IFAS | Composting and fertilizer |
| Shandong- Linquing | 100,000 | Submerged biofilm (plastic media) | Sludge landfilled |
| Tianjin-Beicang | 100,000 | Activated Sludge (Anaerobic/Oxic (A/O) process) similar to IFAS | Centrifugal sludge dewatering |

126 The experience of wastewater treatment systems in cold continental climates in Russia is again based largely on variations on the activated sludge process. Recent innovation has introduced a modification to the traditional activated sludge system which takes elements of both the sequencing batch reactor and step-feed activated sludge processes. This hybrid system is known as the Integrated Fixed-film Activated Sludge (IFAS) system and has been used successfully in a number of locations in the region. Table 2.8 provides summary information on some of the systems recently constructed in Russia.

**Table 2.8: Wastewater Treatment Plant Operations in Cold Adjacent Regions of Russia**

| Location | Capacity cum/day | Treatment System | Sludge Treatment and Other Features |
|---|---|---|---|
| International airport at Irkutsk, Russia | 1,000 | Single module system of the IFAS hybrid process | Mechanical dewatering using filter press |
| Yakutsk city , Russia | 100,000 | IFAS process | Mechanical dewatering using filter press |
| Tyumen city, Russia | 150,000 | IFAS process | Dewatering using centrifuge |
| International airport at Vladivostok, Russia | 2,000 | IFAS process | Mechanical dewatering using filter press |

127 For comparative climatic conditions in other parts of the world, the WWTPs for the main cities in Alaska and the Canadian city of Winnipeg are of interest. Table 2.9 below provides a summary of treatment capacities and technologies adopted. In the case if Winnipeg there is on-going work valued at hundreds of millions of dollars to bring its existing treatment plants in line with nutrient discharge requirements. While the treatment technologies are of interest the relevance to the

situation in Darkhan is limited as the cultural and socio-economic conditions in North America are quite different from those of Darkhan.

**Table 2.9: Wastewater Treatment Plant Operations in Cold North American Locations**

| Location | Capacity cum/day | Treatment System | Sludge Treatment and Other Features |
|---|---|---|---|
| **Alaska: Anchorage (three plants)** | 200,000 | Activated Sludge Process and Sequencing Batch Reactors (indoors) | Sludge press and incineration |
| **Alaska: Fairbanks** | 30,000 | Modified Activated Sludge Process (indoors) | Sludge digestion and composting for fertilizer |
| **Alaska: Juneau – Mendenhall Plant** | 40,000 | Modified Activated Sludge Process (indoors) | Sludge digester and filter press |
| **Canada: Winnipeg (three plants)** | 400.000 | Activated Sludge Process and Modified Activated Sludge – further modifications on-going to reduce N&P | Sludge treatment consolidated at one facility – sludge trucked from others |

128 Preliminary investigation of WWTPs constructed for cities in similar environments (Northern China, USSR, North America and Northern Europe)[36] provides the following guidance in the design process for the WWTP at Darkhan:

i. The use of relatively large quantities of hot water during winter months in cold climates (particularly where district heating is provided) ensures that relatively high temperatures are maintained in urban sewage, ameliorating potential problems related to low treatment efficiencies and freezing at low sewage temperatures. However, systems involving non-submerged media should be avoided as should reactors with large surface areas, since these lose heat quickly. Surface areas in open reactors should be minimised, and in extreme cold environments, systems are fully housed. This is expensive and should be avoided, or if found necessary, reactor surface areas should be minimised. Minimising inter-connecting pipework will also reduce operational problems due to freezing in conditions of extreme cold.

ii. Where cities have large industrial wastewater flows, these can become an issue adversely affecting wastewater treatment efficiency, and/or contaminating sludges, unless pre-treatment is provided. There are clear guidelines for discharges to the public sewer system in Mongolia and provided that these are complied with, and volumes of industrial wastewater remain modest in comparison to domestic flows, problems of this nature should be avoided. Where necessary, heavily polluting industries (such as tanneries) should provide their own pre-treatment in individual or collective treatment facilities.

iii. Wastewater treatment technologies adopted for both large and medium-sized cities of similar climatic and socio-economic conditions to Darkhan are most commonly a variation on the Activated Sludge Process, with only limited experience in other technologies, except in the case of industrial wastewater treatment. SBR systems are used more widely in countries (such as North America and Northern Europe) where there is greater familiarity with more sophisticated operating systems. There is little or no experience with the operation of full-scale SBR systems for the treatment of wastewaters in very cold continental climates. The most northerly example found are in Wyoming in the USA and in Sweden, where average temperatures dip below freezing in the winter, but are not comparable with those experienced during the Darkhan winter.

iv. Sludge handling can become more of an issue in colder conditions. There are considerable benefits to including sludge digestion in the process (production of more stable and better mineralised sludge and energy recovery) where sludge volumes are adequate. However, the anaerobic digestion process requires relatively high temperatures, and maintaining such temperatures is a challenge during the coldest winter months. In addition, $BOD_5$ concentrations in Mongolia are relatively low by international standards (see table 2.3), resulting in relatively low sludge volumes, and making digestion a marginal proposition. There have been claims[37] that the technology proposed for Nisekh was changed from a step-feed process to traditional activated sludge in order to generate sufficient sludge to justify sludge digestion. If this is the case, it does not represent a sound rationale for making such a change.

[37] Personal communication with MCUD.

# 3 WASTEWATER SECTOR FRAMEWORK FOR DARKHAN

129 Plans for future development of water supply and wastewater management services, and the sequencing of such development, depend upon the creation, approval by competent authorities and execution of viable structure plans and spatial development plans for Darkhan. While there is an existing master plan for Darkhan (see section 3.1.1 below), as it stands this plan does not offer a realistic blue-print for the future development of the city. Indeed, the head of land administration and chief architect for Darkhan-Uul aimag have both indicated that the existing plan is inadequate as a guide for development, and that the land-use plan is no longer being followed in providing land-use and construction permits.

130 Based on the current Master Plan 2005-2020, and on other spatial development plans of the aimag Government, there are proposals for the development of new residential and industrial areas at some distance from the existing serviced areas (see Figure 3.2 below). This does not represent the most efficient form of development as there are suitable plots both within and adjacent to the existing (serviced) residential and industrial areas which remain vacant. As is indicated below, the existing plan does not present a realistic long-term outcome for the development of Darkhan, either to year 2020 or within any other planning horizon. However, Darkhan is included as one of a number of key aimag and soum centres which are to receive Government assistance through MCUD for preparation of a new General Plan for the city which could improve the planning framework and plan execution, in order to maximise development effectiveness. The ToRs for the proposed General Plan preparation are discussed below.

131 The current situation is that development is still being encouraged in areas of the city that are unsuitable for residential housing and/or are very expensive to provide with infrastructure, either because they are high above the core city, on flood plains, or remote from the core area. This is poor planning, and does not represent the most efficient form of development as: (i) any servicing or redevelopment of ger areas comes at a very high social and investment cost; and (ii) there are a number of suitable plots both within and adjacent to the existing (serviced) residential and industrial areas which remain vacant, and would thus be ideal for further medium- and high-rise development, without the need to relocate ger area dwellers, or encourage them to settle in hard-to-service locations.

132 A note of caution. The economy of Darkhan has been, and is likely to continue to be, based on manufacturing, and to a much lesser extent on mining and agriculture. The economic impacts on national economies of a resource boom, such as that in which Mongolia now finds itself, are well documented. In the medium-term, the appreciation of the Tugric is likely to bring about the so-called “Dutch disease”, in which manufacturers relying on export markets will find it hard to maintain prices in real terms, thus suffering reduced demand for their products. It is notable that even over the past 10 years, while the population growth of Ulaanbaatar and of mining areas such as Erdenet and the South Gobi has been in the range of 3 to 5% per annum, Darkhan’s population has remained flat, or even declined slightly. Without significant Government investment in Darkhan, it is unlikely that the city will see anything other than very sluggish growth.

133 The TA team is working with the information currently available on Government’s plans for the city, to enable likely future wastewater flows to be calculated and thus the wastewater treatment facility to be sized. A strategic framework for future wastewater management in the city has been devised based on this information, and on what the consultant believes are realistic projections for development of the city. However, the proposals are designed to be robust in the face of the changing pace and nature of future development as refined through subsequent master-planning, and the realities of the pace and magnitude of future investment in Darkhan. The practicalities of this are that future facilities should make provision for incremental modular expansion which can be implemented if more optimistic projections of economic and population growth are realised.

## 3.1 Darkhan Master Plan and Strategic Plan

### 3.1.1 Existing Master plan: 2005 to 2020

134 Darkhan was one of the cities designated as a “pillar centre” under the Government’s Regional Development Concept (2001) and Mid-Term Strategy on Regional Development (2003). As such, the previous Master Plan was updated in 2004 to reflect the new status of Darkhan as a growth node of the north central region. The Master Plan 2005-2020 for Darkhan was then prepared adopting a Soviet-style, centralized planning methodology. The plan provides illustrated site plans, targeting uses for each specific land parcel, and using this to develop what amounts to an investment plan for the central government. The Plans are based on the assumption that the state, as the unique owner of urban real estate, will finance the development of the plan in its entirety.

135 The Plan is also a symptom of national fiscal policy at the time of its preparation, in that it restricts local governments’ ability to be financially self-sufficient. Because local government resources and thus ability to invest in capital improvements are severely constrained, the Master Plan comprises a set of centrally-driven urban investments dependent on the central government for financing. The plan does not make room for investment by either local government or the private sector. In today’s context, the Master Plan’s restrictions for individual parcels hinders the exercise of market-driven choices by individuals and businesses which could put the city’s land and infrastructure to its most productive uses.

136 In addition, the existing Master Plan was developed without public participation, being prepared by non-resident consultants with very little input even from the local government, let alone the city’s residents and businesses. This process did not give the city the opportunity to set its own development priorities and make those known to the central government, donors or private investors. Critically, the 2005-2020 Master Plans disregards the ger areas altogether, designating other uses, such as parks or recreation areas on land occupied by ger communities, and where about 35 percent of the population currently lives.

137 For these reasons, the aimag now considers the 2005-2020 Master Plan an inappropriate tool to guide future development of the city. Figure 3.1 shows the areas targeted for development between 2005 and 2020 under the plan, and Figure 3.2 shows specific areas proposed for the development of 17,300 new dwellings (high-rise and low-rise) in New Darkhan under the plan.

### 3.1.2 City Development strategy (CDS)

138 A City Development strategy (CDS) was carried out for the city of Darkan in 2005 with financing from the World Bank and the support of international and national consultants. This was a participatory planning exercise involving city officials and administrators, local businesses and community representatives which sought to address some of the shortcomings of the Master Planning process. The CDS prioritized selected investments outlined in the Master Plan and provided an action plan for implementation of these priority projects. It also sought to bring in new development ideas based on local knowledge and input to the planning process. The strategic initiatives identified were as follows, although there is no evidence that these initiatives where ever introduced into the development plans of the aimag government:

i. Improve the business environment to encourage the development of small and medium-size enterprises;

ii. Improve living conditions of the ger communities through infrastructure investment;

iii. Develop human resources capable of meeting the requirements of both the existing and future job market;

iv. Adopt appropriate urban development and land management systems to encourage socio-economic growth;

v. Protect the urban and local environment; and

vi. Improve local human development and social welfare policies.

139 It is unclear where the ownership of this exercise lay at the local level, and as a result it appears to have had no impact on the development trajectory of Darkhan. There was no institutional or financial framework developed as part of the CDS framework, and consequently no one to take responsibility for the delivery of these strategic initiatives.

**Figure 3.1 Existing Built up Areas and Area Proposed for Development under the 2020 Master Plan**

Key: Blocked areas: already developed; Hatched areas: to be developed by 2020. 1 – Old Darkan; 2 – New Darkan; 3 – Industrial Area

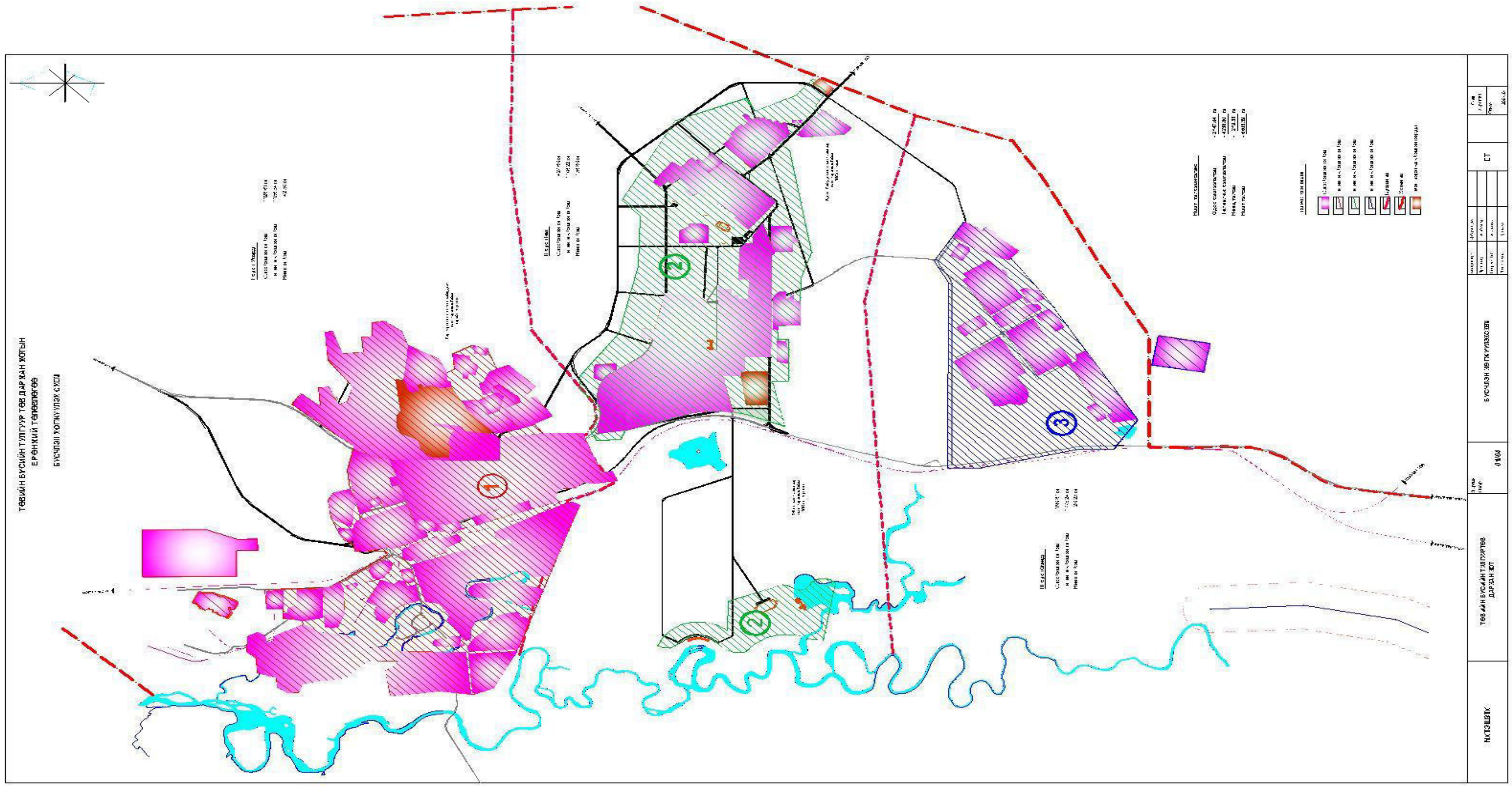
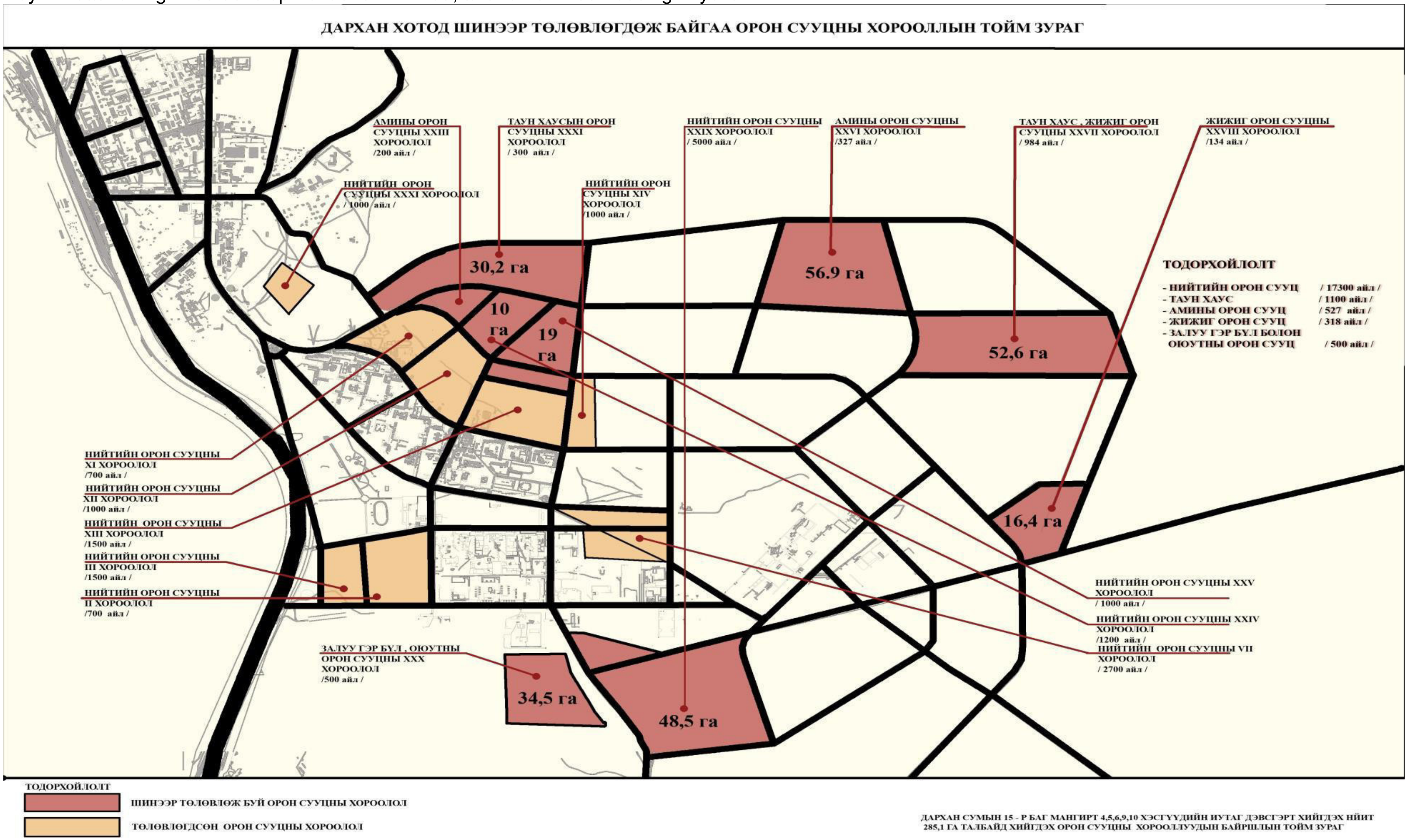


**Figure 3.2: Expansion Areas for New Darkhan Proposed for Development under Master Plan to 2020 – 17,300 new homes**

Key: Areas for high rise development shown in red; and for low rise housing in yellow.



### 3.1.3 Darkan-uul aimag Development Policy and Strategic Plan: 2009 to 2020

140 The Darkan-uul Development Policy and Strategic Plan 2009 to 2030 articulates the aimag Government's development objectives for the plan period. Although the plan is quite generic, lacks detail, and is not accompanied by any spatial plans, it does provide some guidance as to what are seen as key development constraints and opportunities, and sets out strategic priorities in the main economic sectors for Darkhan-uul. It recognises that: (i) a key constraint to growth is out-migration of both skilled and unskilled workers to find jobs in Ulaanbaatar or other growth areas of the economy; and (ii) that the key to reversing this decline is to create more jobs in Darkhan through attracting investment in manufacturing, agriculture and service industries.

141 It sets as its development target for the plan period that the economic growth of Darkhan-Uul aimag should match than of the country as a whole. At the time of plan preparation in 2009 this provided target economic growth rates of between 10 and 13 per cent per annum over the plan period. This translates into a doubling of the GDP per capita, from US$ 3,800 in 2009 to US$ 7,600 by 2021.

142 The sectoral split in the local economy in 2009 was: 43.3 per cent in the industrial and construction sector; 23.7 per cent in the agricultural sector and 33.0 per cent in the service sector. The strategy proposes a slight shift away from industry and agriculture to the service sector with the proportions respectively 43.2 per cent, 22.9 per cent and 34 per cent by year 2021. Growth in the industrial sector is anticipated to come from:

i. The further development of industrial areas in Darkhan, through introduction of additional industrial units in the existing industrial estate to the south of New Darkhan, the existing industrial area to the north of Old Darkhan (around the WWTP site) and at a new industrial zone to be created to the north east of New Darkhan;

ii. The development of a Free Economic Zone for industry and trade in Darkhan (location unspecified);

iii. Additional investment in the following industries: (i) mining and ore processing factories based on locally-mined minerals (including cement, metallurgy and brickworks); (ii) development of dairy industry based around local animal husbandry; (iii) sustainable environmental products in transport, energy and infrastructure sectors; and (iv) processing of local products – sheepskins, cotton and felt; and

iv. Establishment of an aimag development fund to support private sector investment in industry and commerce, particularly around manufacture of high quality products for export and in the IT sector.

143 The importance of infrastructure and urban development investment is also recognised with a focus on road transport (grade separation for critical junctions in Darkhan), land development for housing and redevelopment of ger areas. Water supply and wastewater infrastructure is mentioned, but the focus is on rehabilitation and extension of existing networks, and not on improving wastewater treatment.

### 3.1.4 General Plan to Make Darkhan a National Model City: 2015 to 2028

144 The Government of Mongolia, through MCUD, has issued Terms of Reference for planning consultancies to prepare General Plans for a number of major towns in the country as "Model Cities". Darkhan has been designated as one of these model cities, and the Terms of Reference (ToR) for the work are provided at Appendix H. MCUD has selected consultants[38] to carry out this work which has now been in implementation since February of 2014. The first stage of the work to collect and analyse data has been completed. The General Plan covers the period 2013 to 2028 in two phases: a first phase from 2013 to 2018, and a "Long-term Strategic Plan" for the period 2018 to 2028. Development and investment plans will be prepared for these two phases, with a draft report complete by June 2014.

[38] Ark Construction

145 The ToR set out the requirements, based on existing national planning documents which cover some of the plan period (up to 2016). The objective is to provide a plan for Darkhan as both a "smart city" and a "green city". Key features of the General Plan will be:

i. A comprehensive review of the development opportunities in Darkhan (completed but not yet issued).

ii. A focus on industrial development, and particularly on the development of an oil refinery, metallurgical industry, construction materials industry, light industries and food industries.

iii. A comprehensive plan for land use and for the development of areas for housing and commercial activity.

iv. Development of detailed sector-by-sector plans for infrastructure and services, and for the development of green areas within the city.

v. A process of consultation to obtain the views of government and civil society on the planning proposals and as inputs to the plan development.

146 While the ToR cover the physical aspects well, and make frequent mention of using innovative approaches to ensure efficient and environmentally sustainable approaches are used, there is no requirement to address the issue of how the proposals will be paid for and implemented. This raises the prospect that the resultant plan will again provide a model for the future without addressing the key issues of how this end-state will be brought about: how the proposals will be paid for, and who will do it. In this regard, the plan is set up adopting a traditional master planning approach, and assuming that Government has control over all the resources required to bring about realisation of the plan – which it doesn't. There is no mention of the potential role for the private sector in realising the plan objectives.

147 Some discussions have been held between the planning consultant and the TA team to try to ensure there is some consistency in the planning approaches being adopted in both projects. However, there is no certainty that the General Plan will follow the growth and development assumptions adopted in this report.

### 3.1.5 Planning Issues to be addressed in Darkhan

148 It is to be hoped that the consultants hired to prepare the proposed General Plan for the period 2013 to 2028 will adopt an approach which introduces the idea of a more flexible planning framework designed to attract private sector investment to help achieve the desired development outcomes. One critical issue is improving connectivity between the ger areas and the city core centres – this is critical for inclusiveness and important to ease of movement of people and goods, develop urban corridors, and introduce the possibility of creating sub-centers in the ger areas. Another is to develop a planning hierarchy: There is neither a hierarchy of plans nor an understanding of contemporary planning practice and the role of plan making. Preparing appropriate development plans needs to be based on the acknowledgement that land use planning provides a policy mechanism that enables diverse and often conflicting objectives to be integrated and addressed in a development or spatial framework which:

i. Identifies appropriate area(s) and location(s) for specific land uses;

ii. Determines what risks are associated with specific land uses in specific locations;

iii. Determines and identifies sensitive or important societal or environmental features; and

iv. Details minimum requirements and/or expectations of particular land use types.

149 Put simply, this determines what development is required and where it should go. Developing this further in the preparation of the General Plan and development framework should involve the consideration of a number of important questions. Some of these are asked as part of the General

Plan ToR in an oblique manner, but it is far from certain as to whether the General plan prepared for Darkhan will be able to answer these questions:

i. What is the development objective?

ii. What environmental assets are present?

iii. What development constraints exist?

iv. What and where is major infrastructure located or does it exist?

v. What type of development is appropriate in this area?

vi. What opportunities and inducements exist to encourage multifunction or mixed use areas?

vii. What types of changes are likely to occur over time e.g. pressure for urban land, informal development areas and climate change impacts?

viii. What types of management controls are necessary (based on preceding outcomes to questions above)?

150 Relating this to the development of Darkhan, the General Plan will need to identify a typology of areas with specific constraints and opportunities within the context of inherent planning complexities. This complexity is apparent in topography, climatic conditions, areas of specific environmental sensitivity (e.g. along the river), absent or dilapidated infrastructure, degraded environment, high levels of vulnerability and risk, and a current centrally-led planning framework prepared in isolation without the input and/or support of the community, and in the absence of capacity within the local authorities to implement and enforce it. It is to be hope that some of these issues will be addressed in the General Plan preparation,

## 3.2 Population Growth Projections

151 The only “official” population projections available in published documents for Darkhan are those contained within the 2005 to 2020 Master Plan, and are for Darkhan-uul aimag rather than for the soum. However, it is interesting to compare the projections made at the time of plan preparation in 2005 and the actual population as measured by NSO in the same years. This data is presented in Table 3.1 below:

**Table 3.1: Comparison of planned and actual population projections**

| Year | 2000 (base) | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|
| Darkan Master Plan 2005 to 2020 | 84,200 | 93,600 | 103,600 | 113,500 | 122,800 |
| Actual as measured by NSO | 84,200 | 90,600 | 95,000 | | |
| Over-estimation in Plan | 0 | 3,000 | 8,600 | | |

152 Population projections have been generated based on: (i) the recent history of population change in Darkan-Uul aimag and Darkhan soum; (ii) UN projections for the current period[39]; and (iii)

[39] UNSTATS. "United Nations Statistics Division." Vers. 30. Department of Economic and Social Affairs. 2012. http://unstats.un.org/unsd/pocketbook/

discussions with the Darkan-Uul Government and aimag statistics office on likely future population trends. Based on these sources, the assumption that have been made are as follows:

i. There is sufficient evidence from: (i) the growing number of development approvals and land-use parcel permissions issued; (ii) current levels of residential construction (at least eight apartment blocks currently under construction in New Darkan); and (iii) new occupations of khashaas on the edge of existing get areas (see figure 3.4), to suggest that the recent trend of declining population in Darkhan has been reversed. Thus the growth rate for the period from 2013 to 2015 has been assumed at 1.5% per annum – this approximately matches natural growth.

**Figure 3.3: New Gers at the edge of an established Ger Area in Old Darkhan**

ii. In recent years the urban population growth rate in Mongolia has been running at 1.9 percent per annum, and there is little to suggest that this will change in the short-term. Based on Government's commitment to invest in the city, It is assumed that Darkhan will grow at slightly above this urban growth rate average (at 2% per annum) over the period 2015 to 2020 (moderated by the continuing more rapid growth of Ulaanbaatar and urban areas close to mining operations).

iii. In the medium-term, there could be a significant impact on population from the development of additional industries as currently proposed for Darkhan by the Government of Mongolia. It is assumed that over time, at least some of the industrial development currently planned will be established in Darkhan. However, in the absence of either confirmed funding or firm proposals at present, it is unlikely than any impact would be felt on the population for at least the next few years. In addition, the pull factors of Ulaanbaatar and mining towns will continue to exert out-migration pressure on Darkhan's workforce.

iv. Despite these pressures, population increase through natural growth and some in-migration could be expected during both the construction and operational phases for these new industrial facilities. Indications are that once operational, the additional work force would be of the order of 2,000 to 3,000, resulting in an overall population increase of perhaps 10,000 to 12,000. This would occur over several years, but it is assumed that this would mean the growth rate in Darkhan continuing at a rate slightly above the current average urban growth rate of 1.9%. An annual rate at 2% per annum has been assumed between 2020 and 2030, adding a population of about 20,000 to the city over that period. After this period of sustained high growth, it is assumed that the rate would decline, but remain relatively high at 1.5% for 2030 to 2035 and the same from 2035 to 2040.

153 The proportion of the total population living in apartments has remained at somewhere between 60% and 70% over the past couple of decades. In the short term there is little to suggest that this would change, although in the medium-term, it is anticipated that there would be a slow but progressive move from ger areas to centrally planned areas – either through people moving from ger areas into apartments, or through services being progressively introduced into ger areas. In line with the target of the aimag Government, it is assumed that over the next 20 years the proportion living in ger areas would decrease from about 35% to 20%. Experience over the past few years when there has been significant economic growth without a commensurate shift in population between the ger and central core areas, suggests that a more aggressive target for this transition would be overly optimistic.

154 Over the past 15 years there has been a five-fold increase in GDP per capita in Mongolia – but this has had little impact on the proportion of the urban population living in ger areas in any of the cities and towns in the country. The proportion remains much the same, and the numbers have increased. Consequently it is considered unlikely that any such change in the future would be rapid, but it is assumed that with increasing wealth, there would be a progressive reduction in the number of people living in the ger areas, and commensurate increase in those living in apartment areas. Experience also suggests that some of those moving to apartments will keep their ger area residences for summer occupation.

155 Based on these assumptions, the projected population growth for Darkhan city is shown at Table 3.2. This does assume a turnaround in the trajectory of the local economy and population dynamic over the next few years. From an average annual increase in population of 0.4 percent over the past 10 years, to an average annual increase of 1.8 percent over the next 27 years.

**Table 3.2 Population Projections for Darkan City – Core and Ger areas.**

| Year | | 2005 | 2010 | 2011 | 2012 | 2013 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Darkhan soum** | | **74,663** | **77,547** | **75,494** | **75,644** | **76,428** | **75,063** | **82,876** | **91,501** | **101,025** | **108,832** | **117,244** |
| **Core Area** | | 48,531 | 50,406 | 49,071 | 49,169 | 49,678 | 52,544 | 60,085 | 68,626 | 78,294 | 87,066 | 96,726 |
| **Ger Area** | | 26,132 | 27,141 | 26,423 | 26,475 | 26,750 | 22,519 | 22,791 | 22,875 | 22,731 | 21,766 | 20,518 |
| | | | | | | | | | | | | |
| **% in core assumed** | 65% | 65% | 65% | 65% | 65% | 65% | 70% | 73% | 75% | 78% | 80% | 83% |
| **Growth actual/assumed** | 1.1% | 0.5% | 4.2% | -2.6% | 0.2% | 1.0% | 1.5% | 2.0% | 2.0% | 2.0% | 1.5% | 1.5% |
| | | | | Ave: | 0.4% | | | | | | Ave: | 1.8% |

## 3.3 Economic and Industrial Growth Projections

156 There are proposals to increase the industrial economic base of Darkhan. The Government of Mongolia has committed to reinforcing the role Darkhan as an industrial centre through supporting investment in industrial growth in Darkhan. Government has also committed to moving some industries (e.g. leather processors, tanneries and sheepskin factories) from areas around Ulaanbaatar to a single location in Darkhan. However, these proposals are as yet at a low level of detail, and it is unclear as to the timeframe within which the developments would take place.

157 In the short–term there are small industries establishing and planning to establish within the existing industrial areas around the city – and particularly within the existing Industrial Estate. As mentioned in section 2.3.2 above, two new enterprises are expected to go into production in 2014: a wool and felt processing factory; and an ore processing operation, although both are relatively small.

158 One major investment which is committed is the construction of the Darkhan Petroleum refinery, which will be funded by loans from Japanese Banks and other financial institutions, and through a Government equity stake of 51 per cent (see Appendix I). There are still issues as to the financial

structuring and guarantees for the investment, but a site has been identified to the north of Old Darkan (and north of the existing WWTP) which would be used for the facility. The refinery has an estimated development cost of US$ 600 million, and once operational is expected to have the capacity to process two million metric tons of oil per year. It would employ several hundred people during the construction phase and in operation would employ about 200.

159 While the aimag Government's medium-term strategy and plan predicts further investments in metallurgy and other ore-based industries there are as yet no firm proposals for investments in these areas. For the metallurgical industries, government has estimated a further 5 to 6 units will become established in the medium-term (say, up to 2020) each with the capacity to hire between 300 and 800 employees. However, there is no detail as to any specific proposals of this nature, and no information on any potential investors.

160 The same is the case for proposal for the relocation of skeepskin, leather processing and tanneries out of Ulaanbaatar and into an estate established for the purpose in Darkhan. While this is stated as a proposal of government, the timing of any such move is unknown, and incentives would need to be provided to the existing industries to get them to move to Darkhan. No site has been identified for the relocation of these industries, although a detailed plan was prepared in 2011 for a dedicated industrial estate of this nature, located about 10 km. to the west of Ulaanbaatar[40]. This site of about 200 ha, was fully serviced and included a collective wastewater management facility.

161 Likely additions to the existing Industrial Estate, or to the other areas currently intended for industrial use (the area north of Old Darkan and to the east of New Darkan) are difficult to predict accurately. However, based on the information available, a modest growth in industrial activity can be predicted in the short-term, with the possibility of major investments in the medium- to long-term. The implications for the wastewater management strategy and approach are to: (i) plan for this modest growth; (ii) assume polluting industries would be grouped together to facilitate collective pre-treatment; and (iii) provide a solution at the CWWTP that would facilitate options for modular expansion should this become necessary.

## 3.4 Wastewater Management Typology

162 This section briefly describes the categorisation of the city into sanitation catchments which exhibit one of three differing characteristics. For this purpose the areas of Darkhan can be grouped into:

i. Central, planned and serviced medium-density, largely residential, commercial and institutional areas of both Old Darkan and New Darkhan;

ii. The existing industrial estate area to the south of New Darkhan, and the old industrial area to the north of Old Darkhan (a typology which would also apply to any new industrial areas or zones);

iii. The ger areas, which include dachas, and which lie outside the centrally serviced urban core, in well-defined but semi-planned or un-planned low-density communities.

### 3.4.1 Central Planned Areas

163 The centrally planned and serviced areas of both New Darkhan and Old Darkhan present the same basic characteristics in terms of wastewater management. The majority of the core is made up of apartment blocks and commercial and institutional buildings, which are fully serviced with water supply, wastewater and district heating connections. The new housing areas of New Darkhan (to the west of the centre) which have condominium-style apartment blocks, duplex or detached houses on small (200 sqm) plots on the edge of the apartment block areas, are connected to the sewer network and are thus included in this category.

164 In these areas, wastewater is discharged directly to the sewer network and thence conveyed to the treatment plant via a pumping station in Old Darkhan. This would continue to be the arrangement

[40] New Industrial and Residential Technology Zone, Feasibility Report, IDEA Group LLC, Ulaanbaatar, 2011

in the future. There are areas of the existing network which require rehabilitation, and these repair needs would be progressively addressed through a rolling program of upgrading and replacement using Us Suvag's own financial resources.

165 As new core serviced areas for residential or mixed residential, commercial and institutional development are opened up, the sewerage network would be extended to serve these areas. Almost all the current development of apartment blocks and mixed residential and commercial buildings is taking place within the serviced core, or immediately contiguous with it.

### 3.4.2 Industrial Areas

166 The current Industrial areas to the south of New Darkhan and to the north of Old Darkhan also discharge wastewater directly to the sewer network and thence to the wastewater treatment plant. The one exception to this is the sheepskin factory in the industrial estate which pre-treats wastewater for the removal of Chromium prior to discharge to the public sewer network. Information available suggests that all other industries are

167 For the existing and future industrial areas, all those industries which produce wastewater which contain one or more pollutants which exceed the discharge standards to a public sewer should provide pre-treatment sufficient to deliver an effluent which achieves the standard for discharge to a public sewer. Future planning for industrial estates should ensure that industries of a similar nature, or which produce wastewaters of similar characteristics, are grouped together so as to provide the opportunity for them to develop and make use of common pre-treatment facilities. This approach is being followed by the Darkhan-uul planning department, and it is anticipated will be incorporated into the new General Plan to be prepared in the near future (see section 3.1.4 above).

168 New industrial areas planned, either contiguously with the existing industrial area, or in new parts of the city, will follow the same pattern.

### 3.4.3 Ger Areas

169 The ger areas are currently characterised by a lack of household-level water supply, district heating or hot water supply. Domestic water supply is obtained from water kiosks operated by Us Suvag and which are supplied either from the reticulated water supply network, or by water tankers. Consequently, water consumption is very low (usually restricted to between 10 and 20 litres/cap/day), and as a result of this low water consumption, wastewater generation is equally low – probably of the order of 5 to 10 litres/cap/day. Sewer connections are not possible since the sewerage system does not extend into these peri-urban areas. Consequently wastewater is disposed of on-plot. This method of disposal is not a problem in spring, summer and autumn, when simple on-plot soakaways can be used for sullage disposal. This situation does become more problematic in the winter, when sullage freezes before it percolates or evaporates. However, even then, wastewater volumes are so low and plots so large, that no public health or environmental problems result from this practice. Dry pit latrines are invariably used for excreta disposal, although some commercial or institutional water users in the ger areas are connected to individual septic tanks, which are generally in a poor state of repair.

170 The development of improved wastewater management in ger areas is entirely dependent on the introduction of improved water supplies. Without sufficient water to drive a sewerage network, sewers won't work, and without sewers, options are effectively restricted to dry on-plot systems – improved pit latrines or possibly compost toilets (although these have repeatedly failed to find favour in ger areas in Mongolia). A recent World Bank[41] report on ger areas in Ulaanbaatar notes: *"While various donors offer programs to improve latrines, none of these programs seem to have made any large-scale impact in ger areas, and some donors have withdrawn support for improved latrines. It does not appear that there is much incentive for ger area residents to invest in improving latrines".*

171 The alternative, which is provision of full services to individual houses in ger areas (whether through a centralised sewer system or community-level system), is prohibitively expensive, as

[41] Enhancing Policies and Practices for Ger Area Development in Ulaanbaatar; World Bank, Washington DC, 2010.

noted in Section 2.6 above. Another World Bank report[42] notes: "*Because of the minimal amount of water consumption in the ger areas and the extreme climate of the country, sewer collection would face almost unsolvable technical challenges unless the ger residential areas are converted to fully-served apartment dwellings. For ger areas, the existing system of public kiosks seems to be the most practical way to provide water. It would be exorbitantly expensive to connect detached houses in established ger areas to the central water supply (and wastewater) systems; estimated connection costs range from Tg 5.6 million–Tg 16.1 million (US$4,000–US$11,500) per household, depending on topography, proximity to existing networks, and requirements for wastewater treatment*".

172 In addition, experience in Mongolia is that pipes in ger areas freeze, if not in the supply pipes, at the point of meeting of pipe with ground and/or structure. Provision of such services to ger areas should thus only be contemplated if a heated utilities room is provided. Also, the design of the manholes for the necessary co-locating of water and heating networks in the road should include a manifold system as a means of: (i) providing a more efficient and cost-effective supply; and (ii) allowing take off points underground to then be directed to consumer sites. For the sewer system, sufficient water for self-cleansing is required, and in winter, sufficient hot water to prevent sewers from freezing – which means connection to the hot water supply. Again, this points to a prohibitive level of expense.

173 Numerous studies and evaluations[43] have shown that for significant behavioural change to take place that full services (water, heating, hot water and wastewater) need to be provided, that the cost of doing this in ger areas is extremely high, and that previous attempts have failed. For centralised (or community-level) piped services to be introduced to ger areas requires that: (i) densification takes place to generate sufficient demand to drive networks; and, related to this (ii) that there are enough paying users to defray the high costs of provision. A new approach is proposed under the ADB-supported ger-area sub-centre project in Ulaanbaatar which supports processes to achieve greater densification built around existing sub-centre "cores" within the ger areas[44]. This approach relies on infrastructure provision as just one in a number of strategies to encourage development and a move to higher-value uses for land (others being better planning, direct trading or pooling of land, and attracting private sector development investment).

174 While this approach might have some application in Darkhan, it is unlikely that this will happen in the short- to medium-term. Consequently, it is not anticipated that the ger areas will contribute significant volumes of wastewater to the centralised sewer system or wastewater treatment plant. It is assumed that there will be a slow migration of ger residents to the core serviced areas of the city over time, and this is reflected in the population projections provided at section 3.2.

175 A further consideration is that Darkhan does not have the same land pressures as Ulaanbaatar, which is surrounded by ger areas to west, north and east, and a national park to the south. Darkhan has a wealth of undeveloped areas adjacent to the existing fully-serviced urban core - areas which would be significantly cheaper to develop with full services for new build, rather than the ger areas with their complexities of unplanned access, large plots and variable land tenure arrangements. This again suggests that extension of networks into ger areas is unlikely to represent an efficient use of scare investment funding for system expansion.

176 However, it is understood that future work in Darkhan might include further efforts to find a solution to the problems posed by the high cost and difficulty of connecting ger areas to the central water and wastewater system, so some provision is made for this eventuality. However, in such cases, wastewater generation is likely to be low (recorded as 50 litres/cap/day in Ulaanbaatar[45]) and systems need to be flexible enough to respond to varying demand. This again supports an approach which ensures that the selected WWTP system provides the opportunity for relatively simple and cost-efficient modular expansion.

[42] Managing Urban Expansion in Mongolia, World Bank, Washington DC, 2010.
[43] See footnotes 26, 27 and 28
[44] TA 7970 Mongolia: Ulaanbaatar Urban Services and Ger Areas Development Investment Program; ADB, Ulaanbaatar, September 2013.
[45] Options Study to Improve Dambadarjaa Pilot Project, E Kaschka, World Bank, Washington DC, December 2012

## 3.5 Water Demand and Supply Projections

177 The most recent work on water consumption in Darkhan[46] indicates that water consumption per capita among those with a household connection, based on raw water actually supplied, is of the order of 175 litres/capita/day. This is quite a high figure, but includes the approximately 40 per cent which is lost through system leakage. Figures for actual household consumption, which would dictate wastewater flows, are more modest, at an average daily cold water consumption of about 125 l/cap, which, with the addition in winter of the average daily warm water consumption of 40 l/cap provides a winter total of 165 litres/cap/day (Gross of about of 215 litres/cap/day). One important feature of the water supply system which impacts on the wastewater volumes arriving for treatment at the WWTP, is that the source of the heated water consumed in apartments is not the Us Suvag supply system, it is the technical water extracted by the thermal power plant.

178 The 125 litres/capita/day is an average consumption figure based on analysis of both domestic and commercial users. Based on 2013 billing figures, the 11,000 household connections use an average of about 6.5 cum/month – equivalent to about 60 litres/capita/day. In addition, the 2,000 commercial users consume an average of about 50 cum/month, equivalent in per capita terms to about 70 litres per day. These combined provide the actual cold water per capita consumption estimate of 125 litres per day.

179 Water consumption to the industrial area is currently measured at about 3,000 cum/day[47], with the majority of this consumed in industrial processes rather than for domestic use. There are some contradictions in the figures for industrial wastewater volumes generated, with figures provided by each industry failing to match with the much higher volumes pumped from Pump Station No. 1. In addition, future industrial demand for water is difficult to predict in the absence of clear indications of industrial development in the short-medium or long-term. However, recent trends in water supply requirements have been used to generate future projections.

180 For the ger areas, water supply requirements are only a fraction of the total, and this is unlikely to change dramatically for the reasons outlined in section 3.4 above. However additional projections have been made to show the likely impact on demand if mains water supply were to be progressively introduced to households in the ger areas, as is currently proposed.

181 Water supply projections presented in Table 3.3 are based on the above assumptions and on the population growth projections provided at section 3.2 above. Further assumptions made are:

i. Through improvements to the water supply distribution network currently being made, and through likely future management and network improvements, there will be a progressive reduction in the currently high rate of system losses. Over the next 27 years to 2040, losses are predicted to fall from the current 40% to 28%. This appears a reasonable assumption based on the experience of Ulaanbaatar in particular, which has benefitted from a number of years of system management and technical support[48].

ii. There will be a modest increase in the actual water consumption per capita by consumers served with household supplies from about 125 l/c/d in 2012 to 150 l/c/d by year 2040. This reflects a progressive increase in wealth and thus use of more water-consuming appliances, moderated by the downward pressure on consumption introduced through a continued progressive increase in tariff. This would mean that the per capita consumption in Darkhan would remain below current levels of consumption in Ulaanbaatar.

iii. In ger areas there will be a moderate increase in per capita consumption only. This reflects the continuation of water supply via kiosks in view of the impracticality of the introduction of mains water supply to get households.

[46] Source: Milojevic, Nikola, Klaus-Jochen Sympher, Matthias Schütz, and Martin Wolf, MoMo Technical Report No 6 Integrated Wastewater Management in Central Asia – MoMo Model Region, 2011.

[47] This excludes an estimated 8,000 cum/day of technical and make-up water used by the thermal power plant which is drawn from its own wells and does not enter the wastewater system.

[48] Personal communications with USUG staff and Vitens Evides International staff

iv. There will continue to be a progressive rise in the "floating population" of Darkhan which is currently considered to contribute about 5,000 population equivalents (PE) of demand.

182 Table 3.3 below shows projected water consumption and demand for Darkhan city based on the assumptions outlined above. This shows water demand more than doubling between 2012 and 2040. However, it should be noted that the capacity of the existing well fields supplying raw water to Darkhan are estimated at 70,000 cum/day – more than double this projected demand. It can be assumed that the 70,000 cum/day represents a sustainable yield from the well field since this is the Water Authority-approved reserve estimation for the source.

**Table 3.3: Water Demand Projections for Darkhan City for period 2015 to 2040**

| Year | 2012 | 2013 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| **Darkhan soum** | **80,418** | **81,345** | **82,995** | **91,258** | **100,370** | **110,418** | **118,690** | **127,594** |
| **Core Area** | 52,272 | 52,874 | 54,777 | 63,881 | 73,270 | 83,918 | 93,765 | 104,627 |
| **Ger Area** | 28,146 | 28,471 | 28,218 | 27,377 | 27,100 | 26,500 | 24,925 | 22,967 |
| | | | | | | | | |
| **Water Supply Projections** | | | | | | | | |
| **Core Residential Area** | | | | | | | | |
| Net Per capita consumption l/c/d | 125 | 125 | 128 | 134 | 141 | 148 | 150 | 150 |
| Losses % of extracted | 0.40 | 0.40 | 0.38 | 0.36 | 0.34 | 0.32 | 0.30 | 0.28 |
| Total Per capita consumption l/c/d | 175 | 175 | 176 | 182 | 188 | 195 | 195 | 192 |
| Total Demand (cum/day) | 9,148 | 9,253 | 9,638 | 11,631 | 13,801 | 16,350 | 18,284 | 20,088 |
| **Industrial Area** | | | | | | | | |
| Total Demand (cum/day) | 3,000 | 3,000 | 3,300 | 3,960 | 4,752 | 5,702 | 6,843 | 8,211 |
| **Ger Areas** | | | | | | | | |
| Per capita consumption l/c/d | 15 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| Total Demand cum/day | 422 | 427 | 444 | 474 | 493 | 506 | 500 | 484 |
| | | | | | | | | |
| **Grand total demand (cum/day)** | **12,570** | **12,680** | **13,382** | **16,065** | **19,046** | **22,558** | **25,627** | **28,783** |

183 To determine the impact on demand of mains water supply and household connections being progressively introduced to the ger areas, the projections were run with a progressive increase in numbers of ger area households connected so that by 2040 ger area residents are consuming about the same volumes of water as apartment residents. This exercise is undertaken to show the likely impact of this assumption on water demand. As shown in table 3.4, the impact on overall demand would be relatively minor, with the demand in 2040 about 10 per cent higher than it would be with all ger residents continuing to use water kiosk supplies. .

**Table 3.4: Water Demand Projections Where Ger Residents Obtain Household Connections**

| Year | 2012 | 2013 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| **Darkhan soum** | **80,418** | **81,345** | **82,995** | **91,258** | **100,370** | **110,418** | **118,690** | **127,594** |
| **Core Area** | 52,272 | 52,874 | 54,777 | 63,881 | 73,270 | 83,918 | 93,765 | 104,627 |
| **Ger Area** | 28,146 | 28,471 | 28,218 | 27,377 | 27,100 | 26,500 | 24,925 | 22,967 |
| | | | | | | | | |
| **Water Supply Projections** | | | | | | | | |
| **Core Residential Area** | | | | | | | | |
| Net Per capita consumption | 125 | 125 | 128 | 134 | 141 | 148 | 150 | 150 |
| Losses | 0.40 | 0.40 | 0.38 | 0.36 | 0.34 | 0.32 | 0.30 | 0.28 |
| Total Per capita consumption | 175 | 175 | 176 | 182 | 188 | 195 | 195 | 192 |
| Total Demand (Cum/day) | 9,148 | 9,253 | 9,638 | 11,631 | 13,801 | 16,350 | 18,284 | 20,088 |
| **Industrial Area** | | | | | | | | |
| Total Demand (Cum/day) | 3,000 | 3,000 | 3,300 | 3,960 | 4,752 | 5,702 | 6,843 | 8,211 |
| **Ger Areas** | | | | | | | | |
| Per capita consumption l/c/d | 15 | 15 | 28 | 41 | 56 | 72 | 99 | 125 |
| Total Demand cum/day | 422 | 427 | 779 | 1127 | 1,513 | 1,898 | 2,468 | 2,866 |
| | | | | | | | | |
| **Grand total demand (cum/day)** | **12,570** | **12,680** | **13,717** | **16,718** | **20,066** | **23,950** | **27,595** | **31,166** |

## 3.6 Wastewater Flow Projections

184 The current wastewater flow is made up of contributions from the core residential areas of New Darkhan and Old Darkhan, the industrial areas around the treatment plant to the north of Old Darkhan, and the Industrial Estate to the south. There is no wastewater flow contribution from the ger areas. Wastewater inflow to the plant varies considerably by day and by season, due to variable flows from industry and increases once the hot water system is made operational. However, projections have been made based on the water supply projections presented above and on the following assumptions:

i. The proportion of water delivered by Us Suvag and consumed in apartments and homes within the serviced core area which enters the sewerage system is 80%, and will remain at this level in the future. This is consistent with international comparators for communities in similar socio-economic conditions to those observed in Darkhan;

ii. The hot water provided from the thermal power plant during winter and used in apartments and homes in the serviced area will remain at the current levels of 40 l/c/d actually consumed, and the proportion of this hot water delivered to the sewer network is assumed at 75% of that consumed. This will remain the same over the projection period;

iii. Industrial wastewater flows are assumed to increase at an average rate of about 3% per annum over the period 2013 to 2040. This is the area for which it is most difficult to make reliable projections, and the 2.7 fold increase over this period is somewhat higher than that projected by the MoMo project which predicts a doubling of industrial water demand and wastewater flows for the Darkhan region over the same period[49];

iv. The current level of exfiltration losses from the sewer network are assumed at 15%. This is in accordance with the figures observed under the MoMo project[50] at the lower end of the scale. It is assumed that the amount of exfiltration will reduce over time as those sections of the sewer network which are most in need of rehabilitation or replacement are repaired or replaced. This will result in a progressive reduction in exfiltration from an average of 15% in 2015 to 10% in 2040.

185 Based on the foregoing assumptions, the projected wastewater flows for winter conditions in Darkhan (when the hot water system is on) is as follows in Table 3.5. Summer flows will be reduced by about 10% to account for the absence of the hot water contribution, although this is partially compensated for by additional cold water use.

**Table 3.5 Wastewater Flow Projections for Darkhan City**

| Year | 2012 | 2013 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| **Wasewater Projections cum/day** | | | | | | | | |
| From core residential area | 5,227 | 5,287 | 5,587 | 6,842 | 8,240 | 9,909 | 11,252 | 12,555 |
| Additional from hot water | 1,464 | 1,480 | 1,534 | 1,789 | 2,052 | 2,350 | 2,625 | 2,930 |
| From Industrial Area | 3,105 | 3,105 | 3,416 | 4,099 | 4,918 | 5,902 | 7,082 | 8,499 |
| Exfiltration | - 1,469 | - 1,481 | - 1,580 | - 1,782 | - 1,977 | - 2,179 | - 2,306 | - 2,398 |
| **Total Wastewater Flow cum/day** | **8,326** | **8,392** | **8,956** | **10,947** | **13,232** | **15,981** | **18,654** | **21,585** |

186 While arrived at using a quite different methodology, the 2040 projected wastewater flow figure of about 21,500 cum/day agrees quite closely with the design figure provided by the MoMo project for Darkhan. Using a design year of 2042 and a predicted effective population equivalent (PE) of 80,000 at an average contribution rate of just over 250 litres/capita per day, their average design flow is 21,200 cum/day. The MoMo report makes the point – which should be reiterated here – that

[49] MoMo Integrated Water Resource Management for Central Asia Model Region for Mongolia, Final Project Report, Ulaanbaatar September 2009,

[50] Source: Milojevic, Nikola, Klaus-Jochen Sympher, Matthias Schütz, and Martin Wolf, MoMo Technical Report No 6 Integrated Wastewater Management in Central Asia – MoMo Model Region, 2011.

these projections are the best possible with the information available, but that system flexibility is important as there is a high degree of uncertainty in the projections.

187 It is considered highly improbable that the ger areas will ever be fully connected to the sewerage network, for the reasons set out above in section 3.4.3. However to provide an indication of the possible impact on wastewater flows of sewer connections being extended into the ger areas, projections have been made on the basis that there would be a progressive and accelerating rate of connections – in sequence with the increase in water use as a result of the introduction of mains water supply connections as presented in table 3.4 above. The resulting projections are shown in table 3.6 below. As in the case of water supply projections, the impact is minimal in the short- to medium-term, but by 2040 when the ger areas would be fully sewered, the increase in wastewater flows would be of the order of 10% of total.

**Table 3.6: Wastewater Projections Where Ger Residents Obtain Household Sewer Connections**

| Year | 2012 | 2013 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 |
|---|---|---|---|---|---|---|---|---|
| **Wasewater Projections cum/day** | | | | | | | | |
| From core residential area | 5,227 | 5,287 | 5,587 | 6,842 | 8,240 | 9,909 | 11,252 | 12,555 |
| Additional from hot water | 1,464 | 1,480 | 1,534 | 1,789 | 2,052 | 2,350 | 2,625 | 2,930 |
| From Ger Areas | - | - | 234 | 451 | 756 | 1,139 | 1,727 | 2,293 |
| From Industrial Area | 3,105 | 3,105 | 3,416 | 4,099 | 4,918 | 5,902 | 7,082 | 8,499 |
| Exfiltration | - 1,469 | - 1,481 | - 1,580 | - 1,782 | - 1,977 | - 2,179 | - 2,306 | - 2,398 |
| **Total Wastewater Flow cum/day** | **8,326** | **8,392** | **9,190** | **11,398** | **13,989** | **17,120** | **20,381** | **23,878** |

# 4 WASTEWATER TREATMENT PLANT OPTIONS ANALYSIS

## 4.1 Framework for Technology Evaluation and Selection

188 A three-stage process has been adopted for the evaluation of potential wastewater treatment options for Darkhan, and selection of the preferred approach. In the first stage, a broad range of treatment options is considered against a set of criteria covering the operational characteristics and likely costs (capital and operational) of systems of the required treatment capacity operating under Darkhan environmental and socio-economic conditions. During the first stage evaluation, most options have been eliminated from further consideration as a result of: (i) their unsuitability for operation under Darkhan conditions; (ii) high levels of operational risk; and/or (iii) high capital or operational cost.

189 In the second-stage evaluation, those technologies which appear to provide the most cost effective solution to wastewater treatment were subjected to further scrutiny with a view to identifying an optimal treatment solution for Darkhan conditions. To this shortlist were added two technologies recommended for further consideration by the MCUD Technical Committee for Water and Wastewater Infrastructure.

190 In the third-stage evaluation, two possible approaches (using some of the existing structures, or constructing an entirely new facility), and three technologies (step-feed activated sludge, sequencing batch reactor and intehrated fixed-film activated sludge) were evaluated and a preferred option was selected.

## 4.2 First-stage Options Evaluation

191 Based on broad international practice in wastewater treatment technologies in cold and temperate climates, a long-list of possible treatment technologies was drawn up for first-stage evaluation. This list excluded a number of technologies which are in use in more temperate climates but which would not function in the extreme cold experienced during the long and deep winters in Darkhan, or are excluded for other operational reasons, such as only being suitable for low wastewater volumes. The systems excluded from further consideration at this stage are:

i. The trickling filter variety of biofilm systems: Such systems are better suited to lower flow rates and would likely become inoperable due to freezing during the deep winter unless covered,

ii. Extended aeration systems involving long retention times in aeration basins (such as Aerated Lagoons): Operational problems are likely due to freezing in quiescent parts of the lagoons during deep winter conditions unless units are covered, which would become prohibitively expensive for the large reactor areas involved (and necessitated by surface aeration).

iii. Upflow Anaerobic Sludge Blanket Process: Insufficient experience at full scale operation and not suitable for use in cold climates due to sensitivity of anaerobic process to low temperature (obligate anaerobic methane-forming bacteria which are necessary to avoid odour associated with the intermediate products of anaerobic treatment cease to function at about 15 deg C).

192 The systems which are considered in the first stage evaluation are those which could have application under operating conditions experienced in Darkhan. These are:

i. Waste Stablisation Ponds (facultative and maturation ponds in series)

ii. Constructed or Managed Wetlands

iii. Extended aeration oxidation ditch (or Carrousel) extended aeration systems

iv. Conventional or modified (e.g. Anoxic/Oxic) activated sludge process systems

v. Sequencing Batch Reactor systems

vi. Membrane bioreactor and reverse osmosis technologies

vii. Biofilm systems – submerged and part-submerged (such as rotating biological contactors)

193 These systems are evaluated against a range of criteria to determine which are likely to offer the best solution under Darkhan conditions in terms of costs and operating efficiency. The criteria used in the evaluation are:

i. Experience of operation of similar wastewater treatment technologies elsewhere in Mongolia, both positive and negative; and also whether featuring in consideration as a potential process for adoption by other urban communities in Mongolia;

ii. Experience of operation elsewhere in the region, or under similar climatic, economic and technical environments as Darkhan, and at similar flow rates

iii. Likely biological treatment performance in removal of $BOD_5$, COD and SS.

iv. Likely nutrient removal efficiency – particularly nitrogen and phosphorous removal

v. Likely treatment efficiency in removal of bacterial indicator organisms

vi. Shock-loading resilience: ability to handle fluctuation in influent volume and composition - particularly to chemical agents likely to be present in (pre-treated) industrial wastewaters.

vii. Approximate land requirement and ability to be accommodated within the footprint of the existing plant (thus avoiding land acquisition and resettlement issues);

viii. Approximate capital costs for civil works equipment and related plant costs;

ix. Likely energy requirements for operation;

x. Possible energy recovery opportunities – such as through bio-gas from sludge digestion;

xi. Likely operational and maintenance costs;

xii. Sludge volume and handling characteristics;

xiii. Operational complexity: need for sophisticated real-time IT-based management systems, number and complexity of moving parts and exposure of appurtenances;

xiv. Potential for odour or noise nuisance, or provision of a favourable environment for insect or disease vector breeding;

xv. Aesthetic considerations: ability of plant to fit well with surroundings;

xvi. Resilience to harsh winter operating conditions;

xvii. Expansion potential: ability of plant capacity to be increased on a modular basis as flow rates increase; and

xviii. General observations and result of evaluation: overall summary of evaluation and assessment of suitability for further consideration.

194 The evaluation is summarised at Table 4.1. Based on this evaluation, other outliers can be eliminated:

i. Waste stabilisation ponds systems and constructed wetlands offer simple, cheap, robust and resilient processes for wastewater treatment but: (i) use large areas of land; (ii) would function poorly in winter and early spring; (iii) risk odour and insect vector breeding; and (iv) offer only poor nutrient removal performance.

ii. At the other end of the spectrum, membrane bio-rectors and reverse osmosis plants: (i) are expensive to construct and very expensive to operate and maintain; (ii) involve complex operational systems; (iii) do not have a history of successful use in environments similar to that of Darkhan; and (iv) offer very high quality effluents – but unnecessarily higher quality than is required for discharge to the Kharaa River.

iii. Biofilm technologies vary widely and are eliminated from further consideration as stand-alone systems because: (i) there is not an established biofilm technology which has been used in Mongolia or is widely used elsewhere in the region; and (ii) the ability of biofilm systems to operate under cold winter conditions or respond to shock loadings is not well established. However, they continue to be considered in combination with activated sludge technologies.

## Table 4.1: Comparative Treatment Data for Treatment Processes[51]

| Item | Waste Stabilization (Oxidation) Ponds | Constructed Wetlands | Extended Aeration: Oxidation Ditch (Carrousel) | Conventional or Modified A/O Activated Sludge | Sequencing Batch Reactor | Membrane Bioreactor & Reverse Osmosis | Biofilm Technology (submerged or exposed) |
|---|---|---|---|---|---|---|---|
| **Use elsewhere in Mongolia** | Extensive (small systems) | Few (small systems) | No | Yes | Several (small systems for private companies) | No | No |
| **Use in cold climates** | Extensive | Some (small systems) | Some (but not in very cold climates) | Extensive | Several (developed environments) | Few (small systems) | Some (small systems) |
| **$BOD_5$, COD & SS Removal (%)** | 75-85 | 75-90 | 75-85 | 90-95 | 90-95 | 95-98 | 75-90 |
| **$NH_4$, P Nutrient Removal (%)** | Small | Small | Moderate | Moderate to High | High | High | Moderate |
| **Faecal Coliforms Removal (orders)** | Log 2-4 | Log 2-4 | Log 2-3 | Log 1-3 | Log 1-3 | Log >4 | Log 1-3 |
| **Handling hydraulic and organic load fluctuations** | Good | Good | Fair | Fair to Good | Good | Good | Fair to Good |
| **Land Requirement (approx.$m^2$/cum/day)** | 40.0 | 25.0 | 2.0 | 1.0 | 0.75 | 0.25 | 0.75 |
| **Total Capital Cost (US$/cum/day)** | 150 | 300 | 900 | 800 | 800 | 1,200 | 700 |
| **Power Requirement (kWh/cum treated)** | Minimal | Minimal | 1.3 | 1.0 | 0.9 | 1.5 | 0.5 |
| **Opportunities for energy recovery** | Low | Moderate | Moderate | High | High | Moderate | Moderate |
| **Total O&M Cost (US$/ cum)** | 0.05 | 0.05 | 0.4 | 0.35 | 0.4 | 0.8 | 0.4 |
| **Sludge production and handling.** | Low/Easy | Low/Easy | Moderate/ Easy | Moderate/ Hard | Moderate/ Hard | Moderate/ Hard | Moderate/ Hard |
| **Operational Complexity Characteristics** | Simple | Simple | Moderate Skill/Complexity | Moderate/Skilled/Complex | Highly Skilled/Complex | Highly Skilled/Complex | Moderate Skill/Complexity |
| **Potential odour, insect and vector Nuisance.** | Yes: | Yes | Moderate | Minor | Least | Least | Moderate |
| **Aesthetics with surroundings** | No | No | No | Fair | Best suited | Best suited | Best suited |
| **Winter operational resilience** | OK but poor performance | OK but poor performance | Moderate | Good | Good | Good | Moderate |
| **Potential for modular expansion** | Possible | Difficult | Difficult | Moderate | Simple | Simple | Moderate |
| **General observation and evaluation result** | Area required very large to accommodate cold periods & nuisance during spring thaw – not a practical solution for Darkhan | Area required very large to accommodate cold periods. More widely used for smaller communities – not a practical solution for Darkhan | Possible option but no Mongolian experience, susceptibility to very cold conditions and poorer nutrient removal than other options | Already used in Mongolia and in region, performance good except nutrient removal in conventional plants. Modifications can improve nutrient removal | Already used in Mongolia (at a small scale) and in region. Good performance and adaptable, but requires relatively sophisticated operating system | High capital and operating costs and requires complex operational controls. High level of treatment performance not necessary in Darkhan | May have application but little experience in region or in cold climates. RBC can be effective but better suited to smaller plants. |

[51] This data is taken from a wide range of sources and as such is approximate, particularly the cost information which is purely indicative, and based on an assumed medium-sized facility (say 10,000 cm/day capacity). The purpose is to help narrow the options down to those two or three treatment technologies most appropriate for the situation in Darkhan

## 4.3 Second-stage Options Evaluation

195 This first stage process leaves three basic technologies which are considered to offer the best options for application in Darkhan: (i) the activated sludge process in its various forms – modified in accordance with the specific treatment requirements; (iii) the sequencing batch reactor system; and (iii) the oxidation ditch or Carrousel extended aeration system. In addition, the Membrane Bio-rector (MBR) and Moving-bed Bio-reactor (MBBR) were further considered at the request of the MCUD Technical Committee on Water and Wastewater Infrastructure, which evaluated the consultant's preliminary recommendations. The Committee requested that the consultant look again at these options. Each of the systems is described in terms of its operational parameters, and an evaluation is carried using a combination of quantitative and qualitative criteria. The detailed analysis is presented in Appendix K, and a summary of findings is presented below.

196 The oxidation ditch is included at this stage, largely because it is understood to be the preferred technology for the CWWTP extension in Ulaanbaatar, and as a result has also been considered for the new treatment plant and Nisekh. However, it is considered that this system does not represent as good an alternative for Darkhan as either the modified activated sludge or SBR technologies, or other systems which use elements of these two. While from a technical point of view, the system would be able to achieve the required treated effluent quality standards, there are process disadvantages when compared to the modified ASP, SBR and related systems, under the operating conditions experienced in Darkhan. As an extended aeration system, the oxidation ditch aerobically stabilises the activated sludge. This has the advantage that no additional and separated sludge stabilization is required, but has the disadvantages that; (i) the extended aeration systems means that about 25% more energy is used than in either conventional activated sludge or SBR systems; and (ii) the aeration tank volumes required are about 4- 5 times those required by either the modified activated sludge or SBR systems.

197 A further disadvantage of the oxidation ditch system when operating in cold climates is that since the aeration takes place at the surface, the aeration tank depth cannot exceed approximately 3.50m. This combination of large volume requirement and restriction on depth means a very large footprint and thus equally large exposed liquid surface area, leading to rapid cooling of the liquor in winter and thus the risk of freezing. The only way to maintain the required temperature in these circumstances is to enclose the reactor – at a very high capital cost.

198 A further consideration is the option for some energy recovery through anaerobic sludge digestion – an option which is not open in the case of an extended aeration system – and the benefits from dewatering an anaerobically digested (as opposed to aerobically digested) sludge. Under optimal conditions, provided that anaerobic sludge stabilization follows the activated sludge process, about 60% of the total energy required for the operation of the entire WWTP can potentially be recovered and utilized to defray energy costs[52]. Furthermore, during the anaerobic digestion process the sludge quantity is reduced by about 30% which in turn reduces the cost for dewatering and final disposal. Additionally, anaerobically digested sludge can be much more efficiently dewatered than aerobic sludge, which consequently reduces the final disposal cost still further.

199 Further detailed analysis of the potential for use of the MBR system reinforced the original conclusion. The analysis indicated that while the degree of treatment achieved can be very high, the system suffers from the following disadvantages under Mongolian conditions:

i. Where there are occasional system failures - for instance due to power cuts - the micro filters become clogged and require constant cleaning resulting in high maintenance costs.

ii. The membrane cartridges need to be changed often, are imported, and are consequently very expensive.

iii. To operate micro filters, vacuum pumps are required and these are considerably more expensive to operate than using secondary sedimentation tanks for clarification.

[52] This is a theoretical figure, and there is some doubt as to whether the low levels of BOD found in Darkhan wastewater will support an anaerobic digestion and bio-gas recovery investment – this will be investigated further during the TA.

200 The MBBR system is similar to the IFAS, except in that floatable media are used rather than fixed media. A disadvantage of the use of floatable media is that the ability of biomass to cling to the media is reduced, thus in turn reducing the intensity of biomass activity. Thus the IFAS is considered preferable to the similar MBBR system, and the MBBR system is excluded from further consideration.

201 These factors combine to eliminate the oxidation ditch (or Carrousel) option, MBR and MMBR systems from further consideration. Consequently, the treatment systems which are evaluated in greater detail in stage three of the evaluation are:

i. Option 1: The rehabilitation of (parts of) the existing activated sludge system to provide enhanced operation and treatment using a modified activated sludge technology (IFAS);

ii. Option 2: A new modified activated sludge system adopting the step-feed activated sludge process to promote nutrient reduction;

iii. Option 3: A new sequencing batch reactor system; and

iv. Option 4: A new modified activated sludge treatment plant adopting IFAS technology.

202 In general, activated sludge systems do not provide a high level of nutrient removal, but the step-feed ASP, IFAS and SBR processes are designed to improve the nutrient removal performance of the system, so this should not constitute a problem in achieving the required discharge standards.

203 Each of these systems produces a well mineralised sludge which can be readily dewatered, or offers the possibility for anaerobic digestion and thus energy recovery. However, in view of the low sludge volumes and problems encountered in maintaining temperatures sufficient for sludge digestion in winter, this approach is not recommended at this stage. Also, while the addition of anaerobic digestion to generate bio-gas as a resource to reduce energy should be beneficial, there is doubt as to the applicability and efficiency of biogas digesters under Mongolian conditions where relatively high water consumption (150 l/c/d) and low organic loads (27 g/c/d) lead to low $BOD_5$ and SS concentrations in raw sewage ($BOD_5$ 90-95mg/l, SS ~150mg/l).

## 4.4 Third-stage Options Evaluation

204 Based on the second stage evaluation, four options emerged as those most suitable for application in the city. These are discussed and evaluated below, and summarised in Table 4.2 below. In addition, Appendix S provides a lifetime cost analysis comparing each of the preferred treatment options.

### 4.4.1 Option 1: Rehabilitation of Existing Activated Sludge Plant

205 The existing WWTP is generally in a poor state of repair. Virtually all mechanical units are beyond their economic life and many of the structures are beyond economic repair. Investigations were conducted on the main structural units which showed that while some elements are structurally sound, and can be rehabilitated, others are not capable of economic rehabilitation. This information is presented in Appendix L, which also provides unit cost estimates for the rehabilitation of structurally sound elements, and reconstruction of those which are beyond rehabilitation.

206 However, some of the units are still structurally sound, and the significant over-design of the existing plant (50,000 cum/day as against actual flows averaging < 10,000 cum/day) means that the more sound units could be rehabilitated and used as part of a renewed modified activated sludge treatment plant using IFAS technology. A suggested design has been made for this renewal and conversion, and this is set out in Appendix K. This would require surface treatments to the clarifier units and a major reconstruction of the aeration tank, plus complete replacement of mechanical and electrical equipment. This approach would generate savings in capital works over a brand new plant.

207 There would be some complications in adopting the rehabilitation approach. The first would be the arrangements which would need to be made during the re-construction of those units which would be used as part of the new operating system. An advantage of the construction of a new plant would be that operation of the old plant would continue while the new plant was constructed. In the case of rehabilitation, additional costs would be incurrent in redirecting wastewater to a temporary treatment facility (probably other elements of the existing plant which are currently unused) to be used during the re-construction. A further disadvantage would be that because of its configuration, the rehabilitated plant would not lend itself to modular expansion as easily and cost-effectively as a new plant. However, again, use can be made of existing structures which would be surplus to requirements in the first stage of development.

### 4.4.2 Option 2: New Modified Activated Sludge Plant (Step-feed activated sludge)

208 The design of a proposed new activated sludge step-feed process WWTP for Darkhan has largely followed the adopted for the Nisekh WWTP in Ulaanbaatar[53]. The advantages of the step-feed ASP technology are that it provides a high level of treatment without the same level of operational complexities inherent in SBR system. Furthermore, raw sludge and excess activated sludge can be used to produce energy through sludge digestion which is both environmentally-friendly and can provide energy through the bio-gas produced which offsets some of the energy costs of operation

209 The potential disadvantages of the system are that when extending the capacity of the WWTP there will be a need for additional primary and secondary sedimentation tanks, aeration tanks and other basins, which will add to the cost of modular capacity enhancement. It will also require increases to the number of sewage pipelines and other interconnecting pipework and appurtenances. The existing plant does not lend itself to conversion to a step-feed activated sludge process as well as it does to the IFAS system

### 4.4.3 Option 3: New Sequencing Batch Reactor Plant

210 The SBR effectively carries out the series of treatment processes involved in the activated sludge process in a single reactor. Its primary benefits are: (i) the amount of excess sludge is reduced, which in turn reduce sludge-handing problems; (ii) because all of the operations are carried out in a single tank, the reactor footprint can be minimized; and (iii) the operation of the system is fully-automated. This means that the aeration device has a timing unit which varies aeration intensity and duration in accordance with the characteristics of the incoming wastewater. This means that there is no need to plan for peak capacity loadings and operation is flexible and operates with optimal efficiency at any inflow level and concentration within the maximum design flow.

211 However, there are also a number of disadvantages with the SBR system. A higher level of sophistication is required because the timed phases in the bioreactor are controlled with an automatic timing unit. Consistent with the automated nature of the process, there is a higher level of maintenance associated with more automated switches, valves and shut offs. Under Mongolian (and certainly Darkhan) conditions there is the potential of higher cost of operation and maintenance of automated facilities, higher risk of sub-optimal operation, and a higher risk of breakdown. The system is not robust to long operational interruptions and with a power-cut induced break in flow rate for, say 6-8 hours during anaerobic conditions and with low water temperatures (say 10°C) there may be long-term damage to the microbiological population which can seriously damage operation performance and take a long time to correct. There is also increased risk of freezing during the quiescent phase of operation.

212 There are also issues of constructability. The SBR requires good quality heat-insulation and extensive use of polypropylene which may add to material cost, to lead times for construction materials, and to the period for construction required under Mongolian conditions.

[53] Environmentally Sound City Development in Ulaanbaatar, Feasibility Study Report, Final Version, Gitec and Mongol Erdem, Ulaanbaatar August 2011.

#### 4.4.4 Option 4: The Hybrid: Modified Bioreactor & Activated Sludge Plant – the Integrated Fixed-film Activated Sludge (IFAS) system

213 The IFAS system is widely used in Russia and in other locations in China and Europe, but is not as well known internationally as either the modified step-feed ASP or SBR. Its advantages are that it both reduces the volume of sludge and improves the final purification result as a result of the progression of microbiological processes (the IFAS). The system can be adapted to more or less automated control, and the reactors can be united into a single construction block, thus reducing the total reactor volume and area, thus in turn reducing operational complexities and costs. It can also operate on more of a modular step-feed arrangement to provide additional operational flexibility.

214 The main disadvantages of the IFAS system are that since all treatment functions are in separate tanks, it occupies more space than the SBR system, although has a similar footprint to the step-feed ASP. In addition, while the operation is partially automated, the absence of a fully automated system for managing aeration time means that operational costs are marginally higher than for the SBR system at the flow rates anticipated in Darkhan. However, it offers a more robust treatment system which does not rely so heavily on automated controls as do the SBR and step feed ASP systems.

## 4.5 Evaluation Results – the Optimal Technical Solution

215 The options analysis does not present a clear "winner" in terms of the qualitative and quantitative evaluations. The rehabilitation of the existing treatment plants as a modified ASP using IFAS technology is the cheapest option in capital cost terms, but potentially presents more challenges in terms of: (i) dealing with the period of construction (further costs will need to be added to provide for treatment during reconstruction); and (ii) providing a system which is suitable for straightforward and cost-effective modular expansion. A further consideration is that the reduced construction requirements in terms of concrete and other materials will reduce the carbon footprint in the short term (i.e. of the construction), but additional energy requirements over the new SBR plant optimally operated offsets this saving in the longer-term. A further advantage of reusing elements of the existing WWTP is that the new plant can be constructed within the footprint of the existing plant.

216 Based on this analysis, there is little between the other three new systems in terms of cost and performance. The step-feed activated sludge is slightly more expensive and has slightly higher operational cost than the other two systems. However, it comes closest to the "tried and tested" conventional activated sludge process in terms of operation, and thus offers some security that it can be successfully operated under Mongolian conditions.

217 The other two systems provide solutions which emerge as the most cost effective, (assuming that the rehabilitation of the existing plant is disregarded) with little to choose between them. The SBR technology is finding increasing application in many parts of the world – but was considered and rejected under the extensive studies looking at systems for: (i) Nisekh in Ulaanbaatar; (ii) the extension of the Ulaanbaatar CWWTP, and (iii) the Orkhon WWTP extension. It works well when the automated systems work well and the level of supervision is high. But is it reasonable to assume this is likely in the Darkhan situation? This presents an addition level of operational risk over options which have more in common with the more familiar conventional ASP system.

218 The version of the IFAS system knows as the "3-sludge" system which is proposed, has emerged from Russian experience, is widely used in Russia, and variations are adopted in China, and in Europe, Japan and Saudi Arabia. This option was not considered at all in the evaluations of potential treatment plants for Ulaanbaatar and Orkhon mentioned in the previous paragraph. There is limited experience of the system outside Russia, and although some elements of the system have been successfully introduced to a small plant in Mongolia (at Zunmod) it is relatively untried in Mongolia and elsewhere. Consequently, its adoption could pose a high risk. However, ultimately it is a variation on the activated sludge process with some benefits over the step-feed ASP process in terms of the amount of interconnecting pipework, valves and number of inspection chambers, and provides simpler operation than the SBR. The basic principles of the IFAS and related MBBR technology are widely applied elsewhere globally.

**Table 4.2 Detailed Evaluation of Shortlisted Treatment Methods**

| Item | Evaluation Criteria | Modification and Rehabilitation of existing Activated Sludge Plant as IFAS system | New modified Step-feed process Activated Sludge Plant | Standard Sequencing Batch Reactor System (as recommended by MoMo) | Integrated Fixed-film Activated Sludge Process (IFAS) |
|---|---|---|---|---|---|
| 1 | **Estimated total capital costs (Capital works, equipment and other costs) for a plant treating 20,000 cum/day in US$ million** | 12.25 | 19.30 | 16.35 | 16.70 |
| 2 | **Estimated annual operational cost (Power, staff, chemicals and other) in US$ million per annum** | 0.592 | 0.631 | 0.541 | 0.567 |
| 3 | **Estimated total economic lifetime costs over 25 years in MNT per $M^3$ treated** | 5,931 | 7,844 | 7,426 | 7,324 |
| 4 | **Financial lifetime cost in MNT per $M^3$ treated** | 2,087 | 2,329 | 2,168 | 2,372 |
| 5 | **Economic Internal Rate of Return (EIRR)** | 13.0% | 4.8% | 6.2% | 6.5% |
| 6 | **Financial Internal Rate of Return (FIRR)** | 2.4% | 1.0% | 1.8% | 0.7% |
| 7 | **Operational simplicity or complexity, e.g. need for PC-based SCADA control system, number of moving parts and complexity and exposure of appurtenances** | Operation would be streamlined to use only one stream of primary and secondary clarifiers which would be converted to bio-reactors in accordance with the IFAS system. Other elements would remain unused. There would still be an assortment of external reactor connections etc. which would be exposed and thus present continued | The opportunity exists to minimise the need for external pipework by planning the configuration of reactors to minimise number of structures. The process is complex and requires a degree of automated control, although treatment is reasonably robust in cases where control is not as finely managed (is sub- | The system is reasonably compact and so does not involve a great deal of external pipework. The system works in an automatic mode and is controlled by a relatively complex PC-based SCADA system. There is a risk of automatic system failure, in which case the effluent quality is likely to be significantly adversely | The system is modification of conventional ASP with additional steps and can be configured so as to minimise external pipework. The system can operate in either an automated or a manual mode. Since the timing of phases is not as critical as in other options, treatment efficiency can be maintained in cases where |

| Item | Evaluation Criteria | Modification and Rehabilitation of existing Activated Sludge Plant as IFAS system | New modified Step-feed process Activated Sludge Plant | Standard Sequencing Batch Reactor System (as recommended by MoMo) | Integrated Fixed-film Activated Sludge Process (IFAS) |
|---|---|---|---|---|---|
| | | operational risk. | optimal). | affected. Backup systems are needed | operational controls are not so carefully managed |
| 8 | **Successful operation proven elsewhere in Mongolia, or at least in the region, and in similar climatic, economic and technical environments, and similar flow rates** | The existing plant works reasonably well, and is based on a technology used elsewhere in Mongolia (e.g. Erdenet and Ulaanbaatar) which has provided a reasonable level of treatment when operated well, although low levels of nutrient removal. It is considered that the plant could be adapted to operate under a modified activated sludge process – the IFAS process – well, but this may present an operational risk in its reuse of structures. | No step-feed ASPs working on Mongolia, but there are a number of modified activated sludge processes operating with significant variation in treatment efficiency. Team visited WWTPs at Sukhbaatar in Selenge and Zunmod in Tov where a modified activated sludge systems were operating: the first not well, but the second providing a high level of treatment. Thus due to variability in operation and not design issues. | The SBR pilot plant at the Darkhan treatment plant was said to be working well, but the performance results are not available with Us Suvag. Some operational problems with the pilot were experienced during winter. While widely used in more economically advanced and warmer environments, SBRs have yet to find widespread use in the region, or in Mongolia (except for relatively small private plants) | The IFAS system is widely used in Russia in its "3-sludge" form, but is not well known in this form elsewhere. It is a modification of an activated sludge-type process which is widely adopted elsewhere and has been adopted in Mongolia for smaller plants. Some elements included in plants at Sukhbataar and Zunmod. |
| 9 | **Probable treatment efficiency (BOD, COD, SS & $NH_4$ removal) in climatic extremes likely to be experienced in Darkhan** | BOD=10.0mg/l<br>COD=20mg/l<br>SS=10.0mg/l<br>NH4=0.4mg/l | BOD=20.0mg/l<br>COD=50mg/l<br>SS=50.0mg/l<br>NH4=6.0mg/l | BOD=20mg/l<br>COD=50mg/l<br>SS=50mg/l<br>NH4=6.0mg/l | BOD=6.0mg/l<br>COD=15mg/l<br>SS=6.0mg/l<br>NH4=0.4mg/l |
| 10 | **Sludge handling characteristics – minimisation of sludge problems** | If operated as a IFAS system the dry sludge produced is about one half of that produced from the activated sludge process. | Sludge volumes produced from this process are less than for conventional ASP but relatively high. | The volume of dry sludge produced from the system is about two thirds of that produced from the conventional ASP. | The volume of dry sludge produced from the system is about one half of that produced from the conventional ASP. |
| 11 | **Shock-loading resilience – particularly to chemical agents likely to be present in (pre-treated) industrial wastewaters** | The system is robust in treating wastewaters with variable characteristics provided they meet with the | The system is robust in treating wastewaters with variable characteristics provided they meet with the | The system has the benefit that it can adjust the intensity of treatment to deal with variability in | The system is robust in treating wastewaters with variable characteristics provided they meet with the |

| Item | Evaluation Criteria | Modification and Rehabilitation of existing Activated Sludge Plant as IFAS system | New modified Step-feed process Activated Sludge Plant | Standard Sequencing Batch Reactor System (as recommended by MoMo) | Integrated Fixed-film Activated Sludge Process (IFAS) |
|---|---|---|---|---|---|
| | | standards for discharge to public sewers | standards for discharge to public sewers | inflow characteristics. | standards for discharge to public sewers |
| 12 | **Energy efficiency, (construction and operational phases and opportunities for energy recovery (e.g. methane biogas recovery)** | Energy saving on construction. Annual electricity consumption amounts to about US$ 0.123 mil. | Annual electricity consumption amounts to about US$ 0.127 mil. | Annual electricity consumption amounts to about US$ 0.122 mil. | Annual electricity consumption amounts to about US$ 0.123 mil. |
| 13 | **Suitability for incremental expansion** | Would be more difficult to extend than a new plant as the configuration is dictated by the existing structures, but could just use additional disused elements of existing plant on rehabilitation. | Relatively easily extended by the construction of additional parallel treatment streams if designed for modular expansion, although pipework complexity. | Relatively easily extended by the construction of additional parallel treatment streams if designed for modular expansion. | Relatively easily extended by the construction of additional parallel treatment streams if designed for modular expansion. |
| 14 | **Operational resilience in extreme winter climate** | The existence of significant underground pipeline networks increases the risk of freezing and interruption to treatment in extreme conditions, but OK in past. | There is a moderate amount of underground pipework which risks operational problems in winter, but not if well located. | Minimal interconnecting pipework but pilot plant at Darkhan suffered freezing problems in the winter, but these may have been due to small size | System minimises the need for interconnecting pipework. |
| 15 | **Likely creation of odour or other nuisance** | No odour if working properly. | No odour if working properly. | No odour if working properly. | No odour if working properly. |
| 16 | **Constructability** | Complicated by the need to rehabilitate existing structures | Relatively straightforward, although more complex than IFAS | Straightforward for structural elements, less so for mechanical equipment and controls | Relatively straightforward |
| 17 | **Suitability for risk reduction through D&B or DBOT modality** | Nature of works required would not lend it to DBOT modality easily due to rehab of structures. | Would be suitable for DBOT-type modality (although design now separate) | Would be suitable for DBOT-type modality (although design now separate) | Would be suitable for DBOT-type modality (although design now separate) |
| 18 | **Major Risks associated with each** | • Extensive use of existing | • Susceptible to | • Operational complexity | • Relatively untried |

| Item | Evaluation Criteria | Modification and Rehabilitation of existing Activated Sludge Plant as IFAS system | New modified Step-feed process Activated Sludge Plant | Standard Sequencing Batch Reactor System (as recommended by MoMo) | Integrated Fixed-film Activated Sludge Process (IFAS) |
|---|---|---|---|---|---|
| | **option:** | structures increases risk of structural failure of basins & reactors<br>• Use of existing configuration of structures means that new WWTP cannot adopt optimal layout<br>• Inter-connecting pipework increases risk of winter freezing<br>• Incremental development relatively difficult but inexpensive if using existing structures<br>• Need for interim treatment arrangements during construction (use of other existing plant structures)<br>• Contractors or suppliers my limit warranty period based on use of existing structures | reductions in treatment efficiency under high or low loading rates.<br>• Configuration of structures and interconnecting pipework means that new WWTP cannot readily be extended.<br>• Extensive inter-connecting pipework increases risk of winter freezing<br>• Step-feed process adds to complexity and cost | increases risks of operational failure or treatment problems<br>• Treatment efficiency susceptible to wide variations in flow unless large balancing tank in front of reactor<br>• External experts required for the maintenance of sophisticated technical equipment<br>• Flexibility in arranging phases requires sophisticated computer-based control system, demanding extensive external support and training of the operating staff on commissioning: high cost & risk of failure | technology increases operational risks, although based on well-tried principles<br>• Need for optimal treatment conditions requires the use of relatively sophisticated computer-based control system. |
| 19 | **Risks associated with contracting out works** | Contractors may be reluctant to undertake works, or to guarantee works, because of doubts on viability of structures | Well known system and should attract wide interest from contractors | Well known system and should attract wide interest from contractors | Relatively less well known process could restrict international contractor interest and responsiveness |
| 20 | **View of Expert Technical Committee on Water and Wastewater Treatment and Steering Committee** | Existing structures should be used where possible if certified by competent | This process is well understood but could be developed further based on | This system may face operational problems as not used before at this | This system is preferred as it is relatively simple modification of ASP and |

| Item | Evaluation Criteria | Modification and Rehabilitation of existing Activated Sludge Plant as IFAS system | New modified Step-feed process Activated Sludge Plant | Standard Sequencing Batch Reactor System (as recommended by MoMo) | Integrated Fixed-film Activated Sludge Process (IFAS) |
|---|---|---|---|---|---|
| | | authorities | Mongolian experience and conditions. | scale in Mongolia | thus the most suitable for Mongolian conditions |
| 21 | **View of experts from ADB's RSDD** | There is value to reusing existing structure and providing new plant within existing plant footprint.<br>Full extent of damage to structures can only be fully assessed once the whole facility is emptied.<br>In-situ partial demolition and reconstruction on same footprint an option but adds risks, complexity and potentially costs. | Step-feed arrangement relatively costly in terms of both capital and operating costs.<br>New facility optimises new technology and minimizes risk, but creates potentiall more negative impacts due to footprint and need to deal with decommissioned existing structures | Concern that operational complexity could compromise performance<br>New facility optimises new technology and minimizes risk, but creates potentiall more negative impacts due to footprint and need to deal with decommissioned existing structures | Not well known but technology appears sound as based on ASP technology.<br>New facility optimises new technology and minimizes risk, but creates potentiall more negative impacts due to footprint and need to deal with decommissioned existing structures |

## 4.6 Cost Estimates for Options

219 Base capital and operating costs for the options considered are provided in Tables 4.3 and 4.4 below. These base capital and operational costs were used to calculate the total costs (including all add-on costs) used in Table 4.2 above.

**Table 4.3: Treatment Plant Base Capital Costs in US$ million**

| Item | Capital Cost Item | Modification and Rehabilitation of existing Activated Sludge Plant as "three sludges" system | New modified Step-feed process Activated Sludge Plant | Standard Sequencing Batch Reactor System (as recommended by MoMo) | Modified Batch Reactor Activated Sludge Process (three sludges system) |
|---|---|---|---|---|---|
| 1 | Site Preparation | 0.015 | 0.015 | 0.015 | 0.015 |
| 2 | Earthworks | 0.050 | 0.470 | 0.470 | 0.470 |
| 3 | Main pump station rehabiliation -works | 0.050 | 0.050 | 0.050 | 0.050 |
| 4 | Main pump station rehabiliation -equipment | 0.370 | 0.370 | 0.370 | 0.370 |
| 5 | Civil works construction | 1.200 | 6.640 | 4.000 | 4.320 |
| 6 | Treatment Mechanical Equipment | 6.200 | 5.744 | 6.245 | 6.200 |
| 7 | Electrical equipment & control panels | 0.280 | 0.350 | 0.280 | 0.280 |
| 8 | automatic control of sewage disposal system | 0.172 | 0.172 | 0.172 | 0.172 |
| 9 | Interconnecting pipe works | 0.100 | 0.500 | 0.250 | 0.250 |
| 10 | Commissioning & adjustment works | 0.150 | 0.150 | 0.150 | 0.150 |
| 11 | Project management and supervision costs | 0.040 | 0.040 | 0.040 | 0.040 |
| 12 | Miscellaneous items | 0.600 | 0.600 | 0.600 | 0.600 |
| **Sub-total** | | **9.227** | **15.101** | **12.642** | **12.917** |
| 13 | Contingencies | 1.384 | 2.265 | 1.896 | 1.938 |
| **Grand Total** | | **10.611** | **17.366** | **14.538** | **14.855** |

**Table 4.4: Annual Operational Costs for Treatment System Options**

| Item | Operating Cost Item | Modification and Rehabilitation of existing Activated Sludge Plant as "three sludges" system | New modified Step-feed process Activated Sludge Plant | Standard Sequencing Batch Reactor System (as recommended by MoMo) | Modified Batch Reactor Activated Sludge Process (three sludges system) |
|---|---|---|---|---|---|
| 1 | Staff costs | 0.185 | 0.200 | 0.180 | 0.185 |
| 2 | Energy (power) costs | 0.123 | 0.127 | 0.122 | 0.123 |
| 3 | Chemical dosing costs | 0.054 | 0.054 | 0.054 | 0.054 |
| 4 | Heating and other services | 0.150 | 0.170 | 0.110 | 0.130 |
| 5 | Laboratory and monitoring costs | 0.030 | 0.030 | 0.030 | 0.030 |
| 6 | Other operational costs | 0.050 | 0.050 | 0.045 | 0.045 |
| **Total Annual Operating Cost** | | **0.592** | **0.631** | **0.541** | **0.567** |

## 4.7 Process Evaluation: Conclusions and Recommendation

### 4.7.1 Evaluation Conclusions

220 All treatment options would potentially provide a level of treatment of Darkhan wastewater adequate to satisfy Mongolian wastewater discharge standards.

221 There is a strong rationale for reusing elements of the existing WWTP and upgrading the system technology and equipment within these reactors, if it can be proven that the existing structures can be rehabilitated to guarantee at least 30 years of service life. The Mongolian Government's expertise agency[54] and a private sector company specialising in structural rehabilitation[55] have both advised that rehabilitation is possible. However, the true condition of the structure cannot be known until the facility is completely emptied. Whichever option is selected, the reactor should be covered to avoid freezing.

[54] See appendix xx
[55] See Appendix I

222 **Costs:** the overall costs (and lifetime costs) do not differ widely, although reuse of elements of the existing plant does provide significant cost saving on capital works (approximately US$ 4 million), and makes little difference on operational cost.

i. In economic and financial lifetime cost terms, the rehabilitation of the existing plant as an IFAS system is the cheapest.

ii. The reuse of the existing structures for the IFAS system generates the highest EIRR (13%) and the new IFAS systems the second highest EIRR (6.5%).

iii. The reuse of the existing structures for the IFAS also generates the highest FIRR (2.4%) while the new SBR system generates the second best FIRR (1.8%).

223 Despite some advantages in operational costs, the adoption of the new SBR is considered risky since an SBR at this scale has not been operated under similar conditions in Asia, or elsewhere in the world, and the operation is complex.

224 The step-feed activated sludge process has the advantage of being a modification of systems already operational in Mongolia, but is relatively expensive to construct and operate.

225 The IFAS system is also a modification of the Activated Sludge Process already operating in Mongolia with configuration and operational adjustments to improve nitrification/de-nitrification and reduce excess sludge volumes.

226 There is some benefit to constructing a new system in that the existing system can operate until the new system is ready to be brought on-stream, but this is offset by: (i) the fact that the existing system can be rehabilitated while other currently unused stream of the existing plant are used to continue treatment; and (ii) the reconstruction of the new facility within the existing WWTP footprint.

### 4.7.2 Evaluation Recommendations

227 The recommendation is that of the consultants based on: (i) the technical review summarised above; (ii) the views of the Technical Committee; and (iii) the views of other experts in the field:

i. Based on the fact that the existing structures have been certified by the Mongolian Expert Agency to be sound, and with rehabilitation to be capable of giving at least 30 years of life, the new WWTP should use the existing structures, redeveloped and strengthened where necessary, and modified to provide an IFAS system approach.

ii. If for any reason there is a requirement to adopt a completely new plant on a new site, then the recommended technical solution is a new treatment plant adjacent and to the south of the administration buildings of the existing plant, and adopting the IFAS system.

iii. In view of the fact that the IFAS system is effectively a stepped modification of the activated sludge process which combines activated sludge and fixed film technology, and offers a flexible solution, it is further recommended that the ToR for the detailed design consultants specify that the consultants should provide a design based on the IFAS approach, and optimised for conditions in Darkhan. The ToR should also require that the design consultants provide designs and specifications which would attract broad international interest in tendering for the construction, supply, installation, commissioning and operational advice for the plant.

iv. Specific assurances should be included in the contract documentation to ensure that the works are guaranteed by the contractor, despite them involving the rehabilitation of existing structures. It will be the responsibility of the contractor to ensure that the rehabilitated structures provide the specified design life.

v. The contractor (or consortium) carrying out the construction and installation works should provide operational assistance over an extended period (at least 3 years) in order to train Us Suvag operators or their plant operation contractors.

## 4.8 Government Consideration of Recommendations

228 The client group has reviewed the evaluation prepared by the consultants, and has been informed of the arguments set out above on a number of occasions. In addition the consultants have made presentations to both the Darkan Uul aimag Government and Us Suvag on the treatment system evaluation and the options under consideration. The conclusions and recommendation of this group have been as set out below:

i. In its meeting held in December of 2013, the MCUD Project Steering Committee concluded that a separate meeting involving MCUD, academia, technical experts and specialists, and Us Suvag should be convened on 27th January 2014 to select the preferred technology for the WWTP.

ii. The expert group met and a presentation was made by the consultant team. However, the group recommended that the MCUD Technical Committee on Water and Wastewater Infrastructure should consider the options and make a recommendation.

iii. On 20th February 2014 a meeting of the MCUD Technical Committee on Water and Wastewater Infrastructure recommended: (i) that the consultants look again at the MBBR and MBR options for treatment; (ii) that the existing structures of the WWTP should be rehabilitated if proved to be feasible; and (iii) that a modified ASP technology – such as the IFAS system - should be adopted which is proven suitable for Mongolian conditions.

iv. At the MCUD Steering Committee meeting held on Wednesday April 2nd 2014 it was concluded that: (i) the proposed design capacity of 20,000 cum/day should be reviewed and confirmed by the consultants based on projections of future wastewater generation rates; (ii) that the most appropriate and up-to-date technology should be used for the plant; (iii) that the committee supported the adoption of the modified activated sludge process (the three sludge or Integrated Fixed-film Activated Sludge (IFAS) process) for the Darkhan WWTP, and that the existing structures should be used where feasible, and where consistent with the treatment plant adopting the most modern treatment approaches.

# 5 THE INVESTMENT PROJECT

229 The work carried out during the preparation of this Draft Final Report has enabled the team time to identify the preferred approach to the investment project, and confirm project components. The proposed project has been reviewed by: (i) the Project Steering Committee of MCUD; (ii) the MCUD Technical Committee on Water and Wastewater Infrastructure; and (iii) the Darkhan Uul Government. All have supported and endorsed the approach adopted and selection of treatment technology and project components.

## 5.1 Project Rationale

230 The rationale for the project is threefold:

i. firstly, the existing wastewater management system is under strain, and performance in the sector is compromised by obsolete facilities and equipment; this puts the system at risk of failure;

ii. secondly, the city is identified by Government as a model industrial city and the target of future industrial investment. Industries are often heavy users of water and thus producers of large volumes of wastewater; lack of adequate wastewater facilities could compromise this investment, and thus the city's role as a modern industrial centre;

iii. thirdly, the Kharaa river presents a sensitive ecosystem and is a source of replenishment for Lake Baikal – a UNESCO world heritage site. Even when functioning well, the current treatment plant does not satisfy discharge standards for nutrients, leading to elevated nutrient levels in the river and consequent algal blooms.

## 5.2 Project Impact and Outcome

231 The Design and Monitoring Framework (DMF) presented at Appendix J sets out the project impact, outcome, outputs and inputs, and specifies the performance indicators and means of verification, and the key risks and assumptions.

### 5.2.1 Project Goals

232 The goals of the project are: (i) to make a significant and measurable contribution to improving the urban environment of Darkhan city; and (ii) to improve the water quality of the Kharaa River to meet international river quality standards.

### 5.2.2 Project Outcomes

233 The intended outcomes from the project will be improved management and treatment of both industrial and domestic wastewaters delivered through more efficient and effective technology, processes and procedures.

### 5.2.3 Project Outputs

234 The project outputs will be:

i. A new and more efficient wastewater treatment plant constructed and operating at the location of the existing plant, and providing optimal energy recovery and sludge handling capacity.

ii. Rehabilitation and equipment replacement at pump stations, and replacement of critical sections of the sewer network which have failed.

iii. Enhanced wastewater management and treatment capacities developed in Us Suvag staff.

iv. Optimal and sustainable operational arrangements for the wastewater management and treatment system established.

v. Efficient and effective project execution and implementation.

### 5.2.4 Project Inputs

235 Investment funding from the Asian Development Bank in the amount of US$ 18.5 million equivalent, with balance of funds required from Government of Mongolia, to fund: (i) a new wastewater treatment plant, rehabilitating and re-utilising some of the structures of the existing plant; (ii) replacement of pumps and critical repairs to the pump stations and sewerage network; (iii) support to institutional reform and capacity development for Us Suvag; and (iv) support to project management and operation.

### 5.2.5 Special Features

236 Wastewater treatment plants are complex systems which rely on a series of sensitive physical, biological and (sometimes) chemical processes to achieve optimal treatment results. While this technical assistance has evaluated the possible treatment options and selected the most appropriate systems for Darkhan, the specific design of the treatment plant, and the way in which it is operated, will need to respond precisely to the conditions in Darkhan and the nature of the wastewater, and the way in which this will change over time with the addition of new generators of effluent.

237 The processes of design, construction and operation of the plant are intimately linked, and equally, there are a large number of ways to achieve the optimal result. The design and procurement process for the treatment facility needs to recognise this fact, and innovative mechanism need to be developed to ensure that design, construction and operational phases are integrated is such a way as to optimise the opportunities for the best and most efficient system to be selected.

238 This also relates to risk. The traditional procurement modality which involves tender-design-tender-construct-operate exposes the owner (in this case the aimag government and Us Suvag) to all the project risk. If there are contract overruns as a result of design issues exposed during construction, the aimag Government or Us Suvag will have to bear all the additional costs. Equally, if there are system problems exposed during operation beyond the normal contract liability period, the aimag Government or Us Suvag will bear the additional costs. The project needs to seek an improved basis under which to procure required design, construction and operational support services, and should examine alternative options for management of the assets created under the project.

239 There needs to be a mechanism which can allow the designers and constructers of the plant to take a measure of responsibility for its performance. Equally the operational and maintenance arrangements need to be capable of operating the plant optimally – as specified in the design and allowed for by faithful construction and equipment fabrication, and installation according to the design and specifications.

## 5.3 The Proposed Project

### 5.3.1 Project Description

240 To achieve the objectives outlined above, and in accordance with the options evaluation, the Project will comprise three parts: (i) Part A: priority wastewater management improvements; (ii) Part B: institutional reform and capacity development; and (iii) Part C: project management support. The project parts are as described below:

241 **Part A**: Environmental improvements through new and upgraded wastewater infrastructure and improved and more efficient treatment capacity in Darkhan. This will include two components: Component A1 is the construction of a new wastewater treatment plant at the same site as the existing WWTP in northern Old Darkan. Component A2 involves the replacement of three elements

of the sewerage system and the rehabilitation of the intermediate sewage pumping stations at the industrial estate and in Old Darkhan.

242 **Component (A1): Wastewater Treatment Plant.** A new central wastewater treatment plant (CWWTP) for Darkhan adopting IFAS technology, will treat all wastewater from residential areas in New and Old Darkhan and all wastewater (un-treated, and where necessary, pre-treated) from the Darkhan industrial area. The new WWTP will be constructed within the same footprint of the existing WWTP (see Figure 5.1) except that it will occupy a smaller area, reusing only some of the structural elements of the existing plant. The new WWTP will have the following characteristics:

i. First Phase treatment capacity: 16,000 cum per day (in two streams of bioreactors with one standby stream) with capability to extend to 20,000 cum per day (approximately 150,000 population equivalent at Darkhan flow rates). Modular design to allow ready addition of further treatment streams as wastewater flows increase (a cost efficient approach). The new modules may utilise additional elements of the existing plant as increasing flow rates justify their reconstruction or replacement.

ii. The wastewater treatment system improvement and reconstruction will comprise:

- renovation of the existing inlet works and pump station, and replacement of screening equipment (2 streams) and duty (2 no.) and standby (1 no.) pumping sets;
- complete reconstruction of preliminary treatment works (replacement of sand and grit settling and grease removal structures, and installation of new sand elevators and venturi flume flow measurement equipment);
- complete rehabilitation and reconstruction of the existing northern-most primary clarifier including removal of all redundant equipment and structural elements, and reconstruction (as necessary) and lining of the structure and equipping with mixers to function as an equalisation basin;
- demolition and complete reconstruction on the same site of the existing northernmost two sections of the ASP biological treatment reactor to make way for reactors to provide an integrated fixed film activated sludge process which will combine the features of activated sludge and fixed biofilm technologies in a series of reactor tanks. The tanks will be arranged in three parallel streams to facilitate operational flexibility, with two operational and one standby stream;
- complete rehabilitation and reconstruction of the existing northern-most secondary clarifier including removal of all redundant equipment and structural elements and reconstruction (as necessary) and lining of the structure and equipping with mixers to function as a sludge settling and thickening tank, and installation of new sludge pumps;
- installation of new blowers in the existing blower building and addition of sludge coagulation equipment and a sludge filter press, and necessary ventilation equipment; and,
- rehabilitation of pipework and structural elements of the existing sludge drying beds and oxidation ponds to provide tertiary treatment, provision of ultraviolet disinfection equipment and rehabilitation of the exiting outfall sewer to the Kharaa river.

iii. In view of doubts about the viability of waste sludge from the system being digested to produce bio-gas to offset energy costs, it is proposed that the filter press be introduced to reduce sludge volume prior to discharge to sludge drying beds. The biological process will produce a well-mineralised sludge which will be dewatered using the filter press from which it will be conveyed to the sludge drying beds. The dried sludge can ultimately be reused as organic fertilizer. In addition, the maturation ponds have the potential to be used for fish farming, and the final effluent produced will exceed the Mongolian standard for discharge to waterways.

243 A layout for the proposed treatment configuration is provided at Figure 5.2 which highlights in blue those elements which will be rehabilitated and used as an IFAS system. The arrangements for maintaining treatment capacity during rehabilitation and reconstruction of the new plant will involve temporary use of the other treatment units which are currently not utilised. The process and sequencing for this is provided at Appendix C.

244 **Component (A2): Infrastructure Replacement/Rehabilitation**. Replacement and/or rehabilitation of critical elements of the existing sewer network, pumps and ancillary facilities which are currently broken or beyond their useful economic life, located at various points within the city network. All works will follow existing pipeline alignments, or be located at existing facilities (e.g. pump stations). The priority sub-projects comprise:

i. Tertiary sewers at primary “new” south pumping station: 1,400m x 1 m dia.;

ii. Tertiary sewers at old Darkhan hospital No. 2: 300m x 0.3 m dia.;

iii. Bypass main at secondary pumping station: 100m x 0.8 m dia.; and

iv. Repair works, now duty and standby pumps, and 6Kw power distribution networks at both primary “new” and secondary pumping stations. (details of pump station rehabilitation works and equipment replacements are provided at Appendix M)

245 **Component B: Institutional reform and capacity development of Darkhan Us Suvag** The project will provide support to Us Suvag to assist in improving the efficiency and effectiveness of the organisation and its ability to manage the wastewater treatment plant. Components will include:

i. Strengthening the institutional structure

ii. Management and technical training in systems operation, facilities management etc.

iii. Development of job descriptions and career development guidelines

iv. Reform to the tariff structure

v. Support to management on contracting out as a way to improve efficiency.

246 **Component C: Project management support** to the project executing and implementing agencies (MCUD and Darkhan-Uul aimag/Us Suvag)

i. Support in establishment of Project Implementation Unit

ii. Project design and pre-construction support in detailed design/employers requirements

iii. Project management support in procurement, tender evaluation and contract management

### 5.3.2 Project Base Costs

247 Base capital costs are as follows in Tables 5.1 5.2 and 5.3 below. Table 1 shows the base cost for the IFAS system using some rehabilitated units of the existing facility. For comparison, the capital costs for all four treatment options are provided in Table 5.3 below, although since Option 1 has now been selected as the preferred option, this option is highlighted.

**Table 5.1: Treatment Plant Base Capital Costs in US$ million**

| Costs for Three Streams of IFAS Design Flow 20,000 cum/day | |
|---|---|
| **Capital Cost Item** | **Base Cost US$** |
| Site Preparation | 0.018 |
| Earthworks | 0.016 |
| Civil Works - Concreting and Lining | 1.492 |
| Blowers, Pumps and Media | 6.487 |
| Electrical equipment & control panels | 0.340 |
| Automatic Control System | 0.200 |
| Interconnecting pipe works | 0.120 |
| Centralized heat supply of sewage treatment plants, (1500 m) | 0.674 |
| Rehabilitation of Sludge Drying Beds and Oxidation Ponds | 0.600 |
| Start-up and Adjustment Works | 0.150 |
| Other Ancillary Items | 0.600 |
| **Total** | **10.697** |

**Table 5.2: Capital Cost for Critical Sewer System Improvements**

| Item | Capital Cost Item | Expenditure category | Cost in US$ million |
|---|---|---|---|
| 1 | Re-development of the primary sewage pumping station at the south industrial zone (pumping station № 1) | Civil Works | 0.100 |
| | | Pumps and electrical control equipment | 0.320 |
| 2 | Reconstruction of secondary pump station in Old Darkhan (pumping station № 2) | Civil Works | 0.020 |
| | | Pumps and electrical control equipment | 0.400 |
| 3 | Trunk sewer to Primary sewage pumping station D = 800 mm, L=1400m | Civil Works | 0.548 |
| 4 | Secondary sewer near the Second Hospital D=250mm, L=600m | Civil works | 0.035 |
| 5 | Overflow Input pipe to secondary sewage pumping station No. 2, D= 1m; L=100.0m | Civil works | 0.044 |
| 6 | Miscellaneous Items | Gates, valves etc. equipment | 0.020 |
| **Sub-total** | | | 1.907 |
| 7 | Contingencies | | 0.286 |
| **Total Estmated Costs** | | | **2.193** |

**Table 5.3: Project Base Capital Costs in US$ Million**

| Components | Option 1 | Option 2 | Option 3 | Option 4 |
|---|---|---|---|---|
| A.1. WWTP Construction | 10.679 | 18.262 | 15.924 | 15.225 |
| A.2. Rehabilitation and Renovation of Existing Facilitie | 1.349 | 1.349 | 1.349 | 1.349 |
| B. Institutional development & capacity building | 1.566 | 1.566 | 1.566 | 1.566 |
| C. Start-up, Project Management & Supervision | 0.992 | 0.992 | 0.992 | 0.992 |
| **Total A, B & C** | **14.584** | **22.168** | **19.830** | **19.131** |
| Physical Contingency | 1.154 | 1.761 | 1.574 | 1.518 |
| Price Contingency | 1.562 | 3.869 | 3.069 | 2.865 |
| **Contingencies** | **2.716** | **5.630** | **4.643** | **4.383** |
| **Project Cost** | **17.300** | **27.798** | **24.473** | **23.513** |
| **Project Cost, MNT million** | **29,237** | **46,978** | **41,359** | **39,738** |

### 5.3.3 Project Operation and Maintenance

248 The operation and maintenance arrangements for the proposed new treatment plant will be determined following: (i) the detailed assessment of the structure, skills and capability of Us Suvag wastewater management staff and systems; (ii) determination of the treatment system to be constructed in Darkhan, and its operational and maintenance characteristics and requirements; and (iii) the modality for project procurement and possible opportunities for outsourcing.

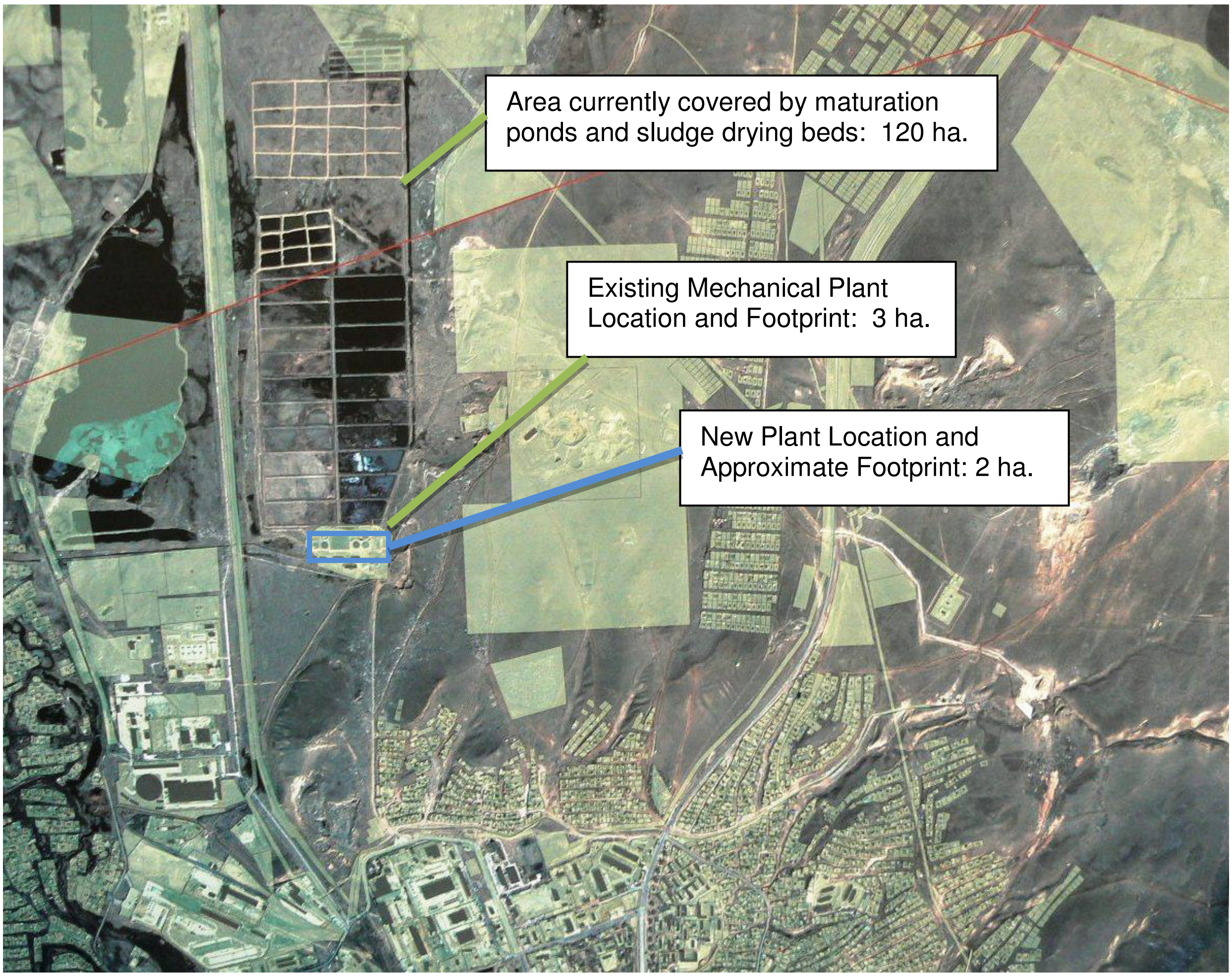
249 The estimated operational and maintenance costs for the four treatment system options under consideration are shown in Table 4.5 below.

**Table 5.4: Annual Operational Costs for Treatment System**

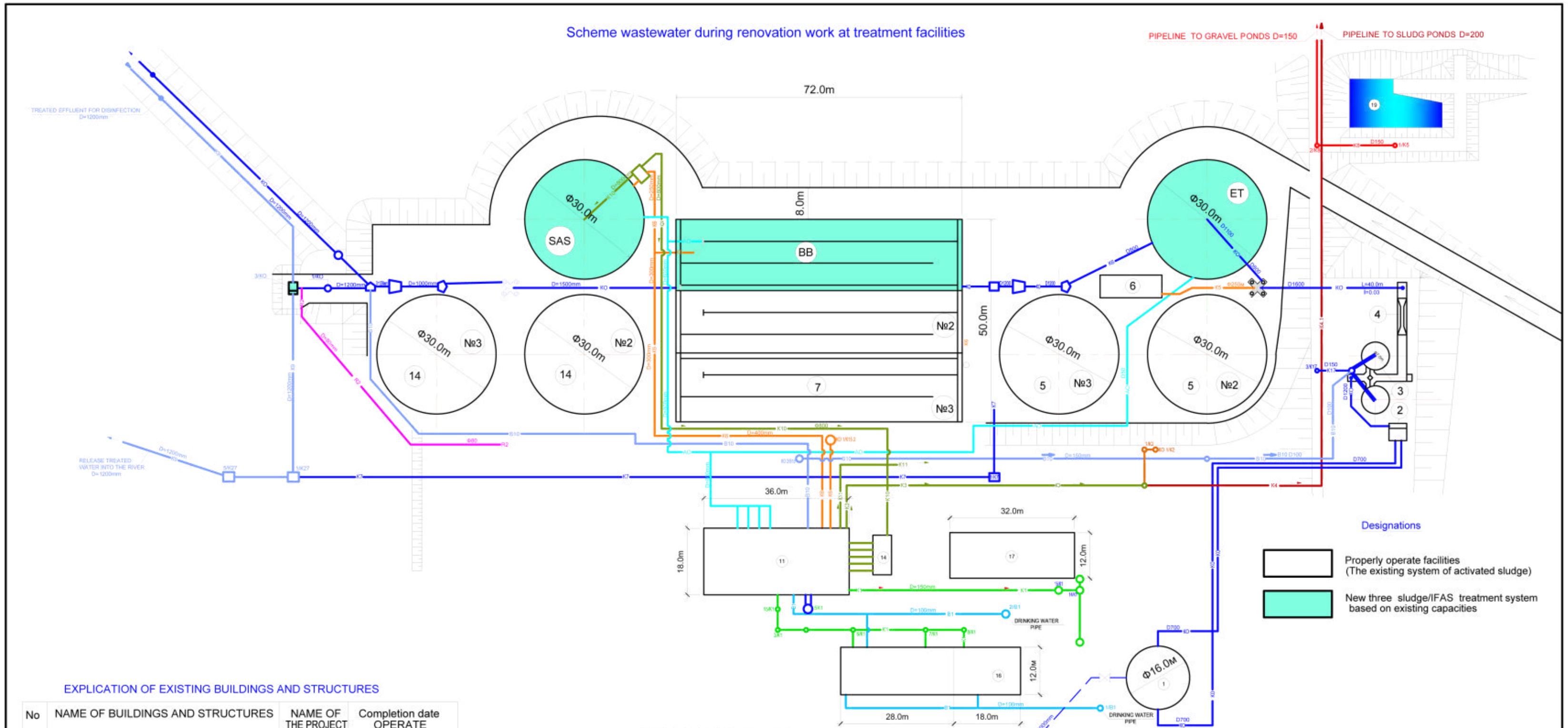
| Cost Items | Option 1 | Option 2 | Option 3 | Option 4 | Average | %T Average |
|---|---|---|---|---|---|---|
| Staff Salaries | 200 | 200 | 200 | 200 | 200 | 24% |
| Power | 208 | 215 | 206 | 208 | 209 | 26% |
| Chemical dosing | 91 | 91 | 91 | 91 | 91 | 11% |
| Heating services | 441 | 39 | 25 | 245 | 188 | 23% |
| Labotatory and monitoring | 51 | 51 | 51 | 51 | 51 | 6% |
| Maintenance materials, others | 85 | 85 | 76 | 76 | 80 | 10% |
| **Total O&M Cost** | **1,076** | **680** | **650** | **871** | **819** | **100%** |
| **Total O&M Cost, $ million** | **0.64** | **0.40** | **0.38** | **0.52** | **0.48** | |

250 Although the pump station at the treatment plant itself will fall under the operational arrangements to be adopted for the treatment plant, the sewer network, and associated primary and secondary pump stations, will remain under the direct operational responsibility of Us Suvag.

**Figure 5.1 Location and Approximate Footprint of Proposed New WWTP**




# Figure 5.2 Treatment Plant Layout as new Integrated Fixed-film Activated Sludge Plant




EXPLICATION OF EXISTING BUILDINGS AND STRUCTURES

| No | NAME OF BUILDINGS AND STRUCTURES | NAME OF THE PROJECT | Completion date OPERATE |
|---|---|---|---|
| 1 | CENTRAL SEWAGE PUMP STATION | | 1965 |
| 2 | WATER INTAKE CAMERA | | 1998 |
| 3 | SAND BOX | 907-2-27 | 1998 |
| 4 | WATER MEASURING BASIN | 907-2-164 | 1998 |
| 5 | PRIMARY RADIAL SEDIMENTATION TANKS | 907-2-85/75 | 1998 |
| 6 | RAW SLUDGE PUMPING STATION | 907-2-85/75 | 1998 |
| 7 | THREE-CORRIDOR-DESIGN AERATION TANKS | 907-2-193 | 1998 |
| 8 | SECONDARY RADIAL SEDIMENTATION TANKS | 907-2-89/75 | 1998 |
| 9 | CAMERA OF RETURN ACTIVATED SLUDGE | | 1998 |
| 10 | DISINFECTION STATION (CHLORINE ) | 901-3-14/70 | 1998 |
| 11 | BLOWERS STATION | | 1998 |
| 12 | BIO PONDS | | 1998 |
| 13 | DISTRIBUTION CAMERA | | 1998 |
| 14 | RECYCLING SLUDGE TANK | | 1998 |
| 15 | SLUDGE PONDS | | 1998 |
| 16 | LABORATORY-OFFICE | | 1998 |
| 17 | MECHANIC SHOP | | 1965 |
| 18 | SLUDGE THICKENER | | 1995 |
| 19 | GRAVEL PONDS | | 1995 |
| 20 | SURPLUS ACTIVE SLUDGE PUMPING STATION | | 1995 |

TECHNOLOGICAL PIPELINES

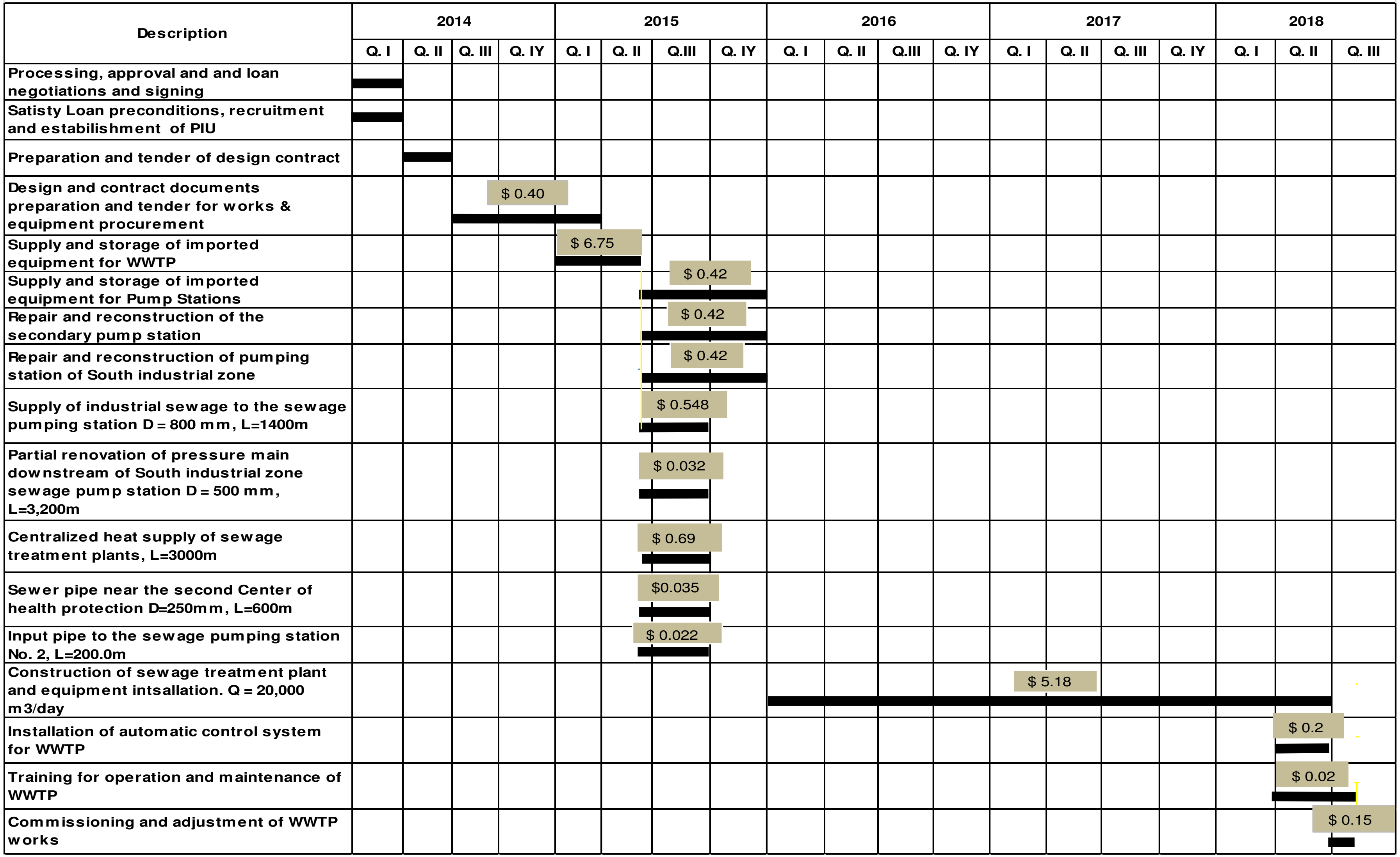
| PIPE SIGN | PIPE NAME |
|---|---|
| KO | MAIN SEWAGE PIPELINE |
| K1 | DOMESTIC SEWAGE PIPELINE |
| K2 | RAW SURPLUS PIPELINE |
| K3 | SURPLUS ACTIVE SLUDGE PIPELINE |
| K4 | PIPELINE OF SURPLUS ACTIVE SLUDGE AND RAW SURPLUS |
| K4.1 | PIPELINE OF SURPLUS ACTIVE SLUDGE AND RAW SURPLUS TO SLUDGE PONDS |
| K5 | DISCHARGE PIPELINE OF PRIMARY SEDIMENTATION TANK |
| K6 | DISCHARGE PIPELINE OF SECONDARY CLARIFIER AND AERATION TANK |
| K7 | EMERGENCY PIPELINE |
| K8 | SAND REMOVAL TUBE |
| K9 | PIPELINE OF EFFLUENT WASTEWATER |
| K10 | SUCTION PIPE OF RETURN ACTIVATED SLUDG |
| K11 | PRESSURE PIPE OF RETURN ACTIVATED SLUDGE |
| B1 | DRINKING WATER PIPELINE |
| B10 | TECHNICAL WATER PIPELINE |
| R2 | CHLORINE PIPELINE |
| AO | AIR PIPELINE |

EXPLICATION NEW STRUCTURES

| Position | Name of new structures | Notes |
|---|---|---|
| 1 | CENTRAL SEWAGE PUMP STATION | Make a major overhaul with the reconstruction of the equipment |
| 2 | WATER INTAKE CAMERA | Repair of concrete products |
| 3 | SAND BOX | Repair of concrete products and replacement of the pumping system of the pulp |
| 4 | WATER MEASURING BASIN | Repair of concrete products and replacement of water meter |
| ET | EQUALIZATION TANK | On the basis of the radial averager arrange the settler effluent. Repair of concrete products, dismantling of existing equipments installation mixers and submersible pumps. |
| BB | BLOCK BIOREACTORS (THREE BLOCKS) | Based on one section of the existing aeration arrange block bioreactors for three sludge system / IFAS wastewater treatment. Repair of concrete products, units needed additional partitions |
| SAS | SLUGDE AEROBIC STABILIZER | Based on the existing secondary clarifier radial stabilizer arrange aerobic activated sludge. Repair of concrete products dismantling equipment and machinery aeration systems |

### 5.3.4 Implementation Schedule

**Figure 4.2: Implementation Schedule for Modified Bioreactor/Activated Sludge process (3 sludges system) - Base Costs US$M**



# 6 PROJECT ECONOMIC AND FINANCIAL FEASIBILITY ASSESSMENT

## 6.1 Economic Analysis

### 6.1.1 Introduction

251 The project will support improvement of the city's wastewater management, its central wastewater treatment plant (WWTP), sewer system, and pumping stations. The city's WWTP, and the sanitary sewer system and pumping stations, were built in 1965, and partially updated and expanded in 1987. They are in urgent need of structural rehabilitation and technological retrofitting. Breakdowns of the current system cause untreated water to discharge into the groundwater and the Kharaa River. Without the project, the existing WWTP would further rapidly deteriorate and fail, as the remaining life of the facility has been estimated at just 2 years. Moreover, anticipated urban and industrial growth could not be served by wastewater management services. The project will directly benefit more than 53,700 residents (66% of the urban population) and with the expanded sewer system the beneficiary population will further increase to 62,400 residents (70%) by 2030. Indirectly, more than 68,900 residents (75%) will benefit from the project by 2040. The expected project benefits include savings from improved plumbing and services, reduced health and medical costs, addressed environmental concerns, and savings from costs of mitigating overflows polluting the Kharaa River. The project will also support institutional development, training, project management, and policy dialogue to ensure economic and financial sustainability.

252 The project economic analysis follows Asian Development Bank guidelines[56] and assesses economic viability of the least cost alternative using standard cost-benefit analysis. The main viability parameters applied are the economic internal rate of return (EIRR) and economic net present value. The project is economically feasible when EIRR exceeds the economic opportunity cost of capital (EOCC) at 12%. The project is also tested for robustness under adverse economic conditions including cost overruns, decrease in benefits, and delay in implementation. The analysis has been undertaken at constant mid-2013 price levels, and assesses the project effects over a 20-year period. Details of project economic analysis are provided in **Appendix T.**

### 6.1.2 Project Economic Rationale, Goals, and Strategies

253 Government intervention for project financing is required to ensure that urban and industrial development in Darkhan is not hindered by deteriorating wastewater management facilities. The water and wastewater utility company, Darkhan Us Suvag (DUS), has experienced operational losses for the past several years. Main causes for losses are dilapidated facilities and networks, operational and management inefficiencies, and tariffs below cost recovery. Without external support, DUS cannot respond to need for improved and expanded system which in turn will affect the economy. Users are willing to pay higher tariffs for the benefits of improved services and approval for tariffs increases is pending.[57].

254 The project is designed to (i) increase efficiency and effectiveness of the WWTP, (ii) enhance cost recovery through increased efficiency and expanded demand-based services delivery, (iii) ensure economic sustainability through cost-based and affordable tariffs, (iv) safeguard public health by reducing incidence of water- and vector-borne diseases, and (v) stimulate economic activity. The project is considered high priority, timely, and well-integrated with other investment activities in the city and in the region, e.g., Cities Development Initiative for Asia initiatives. Improved efforts at cost recovery and operation and maintenance (O&M) positively impact on willingness to pay (WTP) of existing and potential customers.

[56] ADB, 1999, Handbook for the Economic Analysis of Water Supply Projects; ADB, 1998, *Guidelines for the Economic Analysis of Water Supply Projects*. Manila.

[57] The tariff application submitted in 2013 is expected to be implemented in 2014 upon approval by the National Water Supply Regulatory Commission and the Competition and Consumer Rights Agency.

255 To ensure sustainability of the project and overall operation of DUS, in addition to tariff increases, there is a need for the Darkhan-Uul Aimag government (DAG) to provide counterpart funding for capital investment needs during construction, and subsidize unforeseen O&M costs that may result in net losses during operation.[58] These subsidies will need to be assured by DAG to DUS. The DAG will need to source additional transfers from higher government (provincial and/or national level) through its annual budget for infrastructure support.

### 6.1.3 Project Alternatives and Least Cost Analysis

256 A range of technical alternatives has been developed, compared, and evaluated. Four options emerged as most technically and financially feasible and most suitable for Darkhan: (i) Option 1: Rehabilitation of existing activated sludge plant (ASP) with integrated fixed-film activated sludge technology; (ii) Option 2: New step-feed ASP; (iii) Option 3: New sequencing batch reactor plant; and (iv) Option 4: Hybrid, modified bioreactor and ASP, integrated fixed film activated sludge system.

257 Based on an engineering assessment, no clear “best option” in terms of qualitative and quantitative advantages was identified. All options potentially provide a level of wastewater treatment adequate to satisfy Mongolian wastewater discharge standards. The lifetime costs of the four options do not differ widely, and O&M costs only differ marginally. However, the reuse of structural elements of the existing plant did provide savings in capital cost.

258 In determining the least cost alternative among the technical options, the average incremental economic cost (AIEC) approach is adopted. In the analysis, AIEC calculates the present value of incremental investment and O&M costs against the present value of incremental wastewater production (output) to arrive at the cost per cubic meter (MNT/m3) of the project alternative. Costs and output are based on with- and without-project scenarios, and discounted using the economic discount rate at 12%. The least cost alternative is Option 1, the selected solution with combined capital and operating costs (lifetime cost) at MNT 35,664 million and the resulting AIEC at MNT 5,931/m3. Table 6.1 presents the least cost analysis results.

**Table 6.1. Least Cost Analysis of Technical Options[1]**

| Item | Unit | Option1 | Option2 | Option3 | Option4 |
|---|---|---|---|---|---|
| Capital and O&M Costs | MNT mill | 35,664 | 47,165 | 44,650 | 44,037 |
| Demand | $m^3$ million | 6.013 | 6.013 | 6.013 | 6.013 |
| AIEC | MNT/$m^3$ | 5,931 | 7,844 | 7,426 | 7,324 |

AIEC = average incremental economic cost, $m^3$ = cubic meter, MNT/$m^3$ = cost per cubic meter, O&M = operation and maintenance.

[1/] Calculated in equivalent net present value (NPV).

Source: Consultant estimates.

### 6.1.4 Cost and Benefit Analysis

259 **Economic costs**. Project demand and cost are based on with- and without-project scenarios, assessed over a 25-year period. Economic costs are in constant December 2013 prices, converted from financial costs using domestic price numeraire. The financial investment cost is converted into economic cost by excluding taxes and duties, as well as price contingencies, and using conversion factors where appropriate. The financial O&M cost of the proposed physical works, including staff salaries and other recurrent costs, are converted to economic costs by excluding effects of inflation, taxes and duties, and other transfer payments using shadow pricing. Capital and O&M costs are distributed into traded and non-traded components, and skilled and unskilled labor. The shadow wage rate factor assumed in the analysis is 0.8 for unskilled labor and 1.0 for skilled labor, and 1.03 shadow exchange rate factor for traded goods. Unskilled labor comprises 30% of total labor requirement.

[58] The Linked Document on Financial Analysis discusses the fiscal impact analysis and finds that the project fund requirements (O&M costs and project debt service) to be between 0.4% and 3.3% of the total revenue. Fiscal risk is considered to be moderate.

260 **Economic benefits.** Project economic benefits arise from non-incremental and incremental wastewater generation estimated at 80% of water consumption. Non-incremental wastewater consists of wastewater from the existing collection system. As DUS implements programmed improvements and additions to the existing water supply system, supplies to existing consumers are augmented and excess volume made available to new consumers. In the without-project scenario, the existing WWTP will not have the capacity to handle augmented supplies from the planned expansion of the water supply system. These additional supplies comprise incremental water, later processed through the sewerage system to be collected as incremental wastewater.

261 Currently, DUS reports average domestic water consumption comprising residential, institutional, and commercial entities at 120 liters per capita per day (lcd). Industrial consumption is at 12 cubic meters per day per establishment. Based on engineering estimates on non-connected population, domestic consumption averages 80 lcd. Wastewater generation is at 80% of these volumes, which for purposes of the analysis is assumed in the without-project situation. In establishing non-incremental and incremental wastewater, the with- and without-project situation is compared and analyzed. Table 6.2 presents the per capita wastewater projection for connected and non-connected users under the with- and without-project situation.

**Table 6.2. Incremental and Non-incremental Demand**

| Particulars | Unit | 2012 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 |
|---|---|---|---|---|---|---|---|---|
| **Without project** | | | | | | | | |
| Connected Population | no. | 38,077 | 39,371 | 39,371 | 39,371 | 39,371 | 39,371 | 39,371 |
| Domestic | lcd | 89 | 96 | 96 | 96 | 96 | 96 | 96 |
| Industrial | $m^3d$ | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Non-connected population | no. | 11,207 | 14,365 | 17,106 | 19,987 | 23,015 | 26,197 | 29,542 |
| Consump per cap/unit | lcd | 60 | 64 | 64 | 64 | 64 | 64 | 64 |
| Industrial | $m^3d$ | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| **With project** | | | | | | | | |
| Connected population | no. | 38,077 | 39,371 | 39,371 | 39,371 | 39,371 | 39,371 | 39,371 |
| Domestic | Lcd | 89 | 102 | 107 | 112 | 118 | 120 | 120 |
| Industrial | $m^3d$ | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| New consumers | no. | | 14,365 | 17,106 | 19,987 | 23,015 | 26,197 | 29,542 |
| Domestic | lcd | 60 | 102 | 107 | 112 | 118 | 120 | 120 |
| Industrial | $m^3d$ | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| **Non-incremental** | | | | | | | | |
| Connected population | | | | | | | | |
| Domestic | lcd | 89 | 96 | 96 | 96 | 96 | 96 | 96 |
| Industrial | $m^3d$ | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| **Incremental** | | | | | | | | |
| Connected population | | | | | | | | |
| Domestic | lcd | | 6 | 11 | 17 | 22 | 24 | 24 |
| Industrial | $m^3d$ | | | | | | | |
| New consumers (from Non-connected population) | | | | | | | | |
| Domestic | lcd | 60 | 102 | 107 | 112 | 118 | 120 | 120 |
| Industrial | $m^3d$ | 9 | 9 | 9 | 9 | 9 | 9 | 9 |

lcd = liters per capital per day; $m^3d$ = cubic meters per day.
Source: Consultant estimates.

262 The analysis assumes that non-connected population will eventually connect to the system once improvements are in place. Wastewater from these new connections are treated in the analysis as incremental volume. Non-incremental demand derives from existing connected population. Additional or incremental wastewater is generated from existing connections as a result of augmented supplies and general economic development and improved well-being.

263 Economic benefits are estimated using the WTP approach. A survey was conducted in Darkhan to determine consumer WTP for expected project benefits including savings from improved plumbing and services, reduced health and medical costs, addressed environmental concerns, and savings from costs of mitigating overflows polluting the Kharaa River. The survey reveals that 80% of respondents are satisfied with current sewerage service, however they are largely unaware of

sanitation issues in their communities. The mean WTP, from the household survey, for wastewater treatment services is calculated at MNT1,076 per cubic meter[59].

264 The non-incremental benefits are valued using the economic supply price. The value of incremental benefits is obtained by multiplying incremental volume by the WTP or demand price.

265 **EIRR and Sensitivity Analysis**. The cost and benefit streams are established using the assumptions described above, discounted at EOCC at 12%. The proposed project is economically viable with EIRR at 13.0%, exceeding the EOCC. The economic net present value is calculated to be MNT 1,241 million.

266 The survey also explored potential benefits of improved environment of the Kharaa River and wastewater reuse. Of the residents, 83% are concerned about environmental degradation of the Kharaa River and 64% support reuse of grey water, with 41% willing to reuse grey water to flush toilets. About 68% indicated that they are willing to pay an average of MNT 15,100 for improvements that would allow bathing and other recreational activities in the river. There was also an average WTP of MNT 10,000 for reuse of water for industries and households. The levels of WTP for potential benefits indicate that net economic benefits, and thus EIRR, are higher.

267 The resulting EIRR is tested for sensitivity to adverse economic conditions, including (i) increase in economic capital cost by 10%, (ii) increase in economic O&M cost by 10%, (iii) decrease in benefits by 10%, (iv) ) combined increase in costs and decrease in benefits by 10%, and (v) one-year delay in project implementation. The results show that the project remains robust despite 10% cost overruns, but falling below the EOCC with a decrease in benefits and delay in implementation. Combined cost overruns and decrease in benefits result in 7.5% EIRR, with ENPV at minus MNT 6,738 million. Switching values measure the changes in costs and benefits under the same scenarios with EIRR set at 12% and ENPV at zero. The sensitivity indicators reflect the changes in EIRR and ENPV relative to the changes in the variables. The high value of an indicator represents high sensitivity to the variable. Table 6.3 presents the discounted cash flow analysis.

[59] The WTP value was estimated using maximum, mean and median averages. The mean average at MNT 1,076 per cubic meter was used in the analysis. The specific question asked of sample households is: *Assume that the improvement of WTTP of Darkhan city would require your household to pay following amount of additional tax per year (during five years), assuming that other households also pay their fair share: Set 1 Respondents: 10.0 thousand MNT; Set 2 Respondents: 15.0 thousand MNT; Set 3 Respondents: 20.0 thousand MNT; Set 4 Respondents: 25.0 thousand MNT; Set 5 Respondents: 30.0 thousand MNT.*

**Table 6.3: Economic Internal Rate of Return and Sensitivity Analysis (MNT million, in constant 2014 prices)**

| Year | Total | Incrementl Value | Non-incrmtal Value | Total | Capital | O&M | Base Case | Cap Cost+ 10% | O&M Cost+ 10% | Benefit- 10% | Costs+, Bene- 10% | Delay by 1-year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | 4,130 | 2,629 | 1,501 | 4,785 | 3,036 | 1,749 | (655) | ( 959) | (830) | (1,068) | (1,547) | (4,785) |
| 2016 | 4,202 | 2,701 | 1,501 | 12,529 | 10,728 | 1,801 | (8,327) | (9,400) | (8,507) | (8,747) | (10,000) | (8,400) |
| 2017 | 4,276 | 2,774 | 1,502 | 10,951 | 9,096 | 1,855 | (6,675) | (7,584) | (6,860) | (7,102) | (8,197) | (6,749) |
| 2018 | 4,352 | 2,848 | 1,503 | 8,633 | 6,723 | 1,910 | (4,281) | (4,953) | (4,472) | (4,716) | (5,580) | (4,357) |
| 2019 | 4,429 | 2,924 | 1,504 | 3,463 | 1,496 | 1,967 | 965 | 816 | 769 | 522 | 176 | 888 |
| 2020 | 5,157 | 3,502 | 1,656 | 2,026 | - | 2,026 | 3,132 | 3,132 | 2,929 | 2,616 | 2,413 | 2,403 |
| 2021 | 5,249 | 3,594 | 1,655 | 2,080 | - | 2,080 | 3,169 | 3,169 | 2,960 | 2,644 | 2,436 | 3,077 |
| 2022 | 5,342 | 3,688 | 1,654 | 2,137 | - | 2,137 | 3,206 | 3,206 | 2,992 | 2,671 | 2,458 | 3,112 |
| 2023 | 5,438 | 3,784 | 1,654 | 2,195 | - | 2,195 | 3,243 | 3,243 | 3,024 | 2,699 | 2,480 | 3,148 |
| 2024 | 5,535 | 3,882 | 1,653 | 2,254 | - | 2,254 | 3,281 | 3,281 | 3,055 | 2,727 | 2,502 | 3,184 |
| 2025 | 5,800 | 3,982 | 1,817 | 2,316 | - | 2,316 | 3,484 | 3,484 | 3,253 | 2,904 | 2,673 | 3,220 |
| 2026 | 5,902 | 4,084 | 1,818 | 2,384 | - | 2,384 | 3,517 | 3,517 | 3,279 | 2,927 | 2,689 | 3,415 |
| 2027 | 6,006 | 4,189 | 1,818 | 2,455 | - | 2,455 | 3,551 | 3,551 | 3,305 | 2,950 | 2,705 | 3,447 |
| 2028 | 6,113 | 4,295 | 1,818 | 2,529 | - | 2,529 | 3,584 | 3,584 | 3,331 | 2,973 | 2,720 | 3,478 |
| 2029 | 6,222 | 4,404 | 1,818 | 2,604 | - | 2,604 | 3,618 | 3,618 | 3,357 | 2,995 | 2,735 | 3,509 |
| 2030 | 7,077 | 5,169 | 1,909 | 2,682 | - | 2,682 | 4,396 | 4,396 | 4,128 | 3,688 | 3,420 | 3,540 |
| 2031 | 7,177 | 5,267 | 1,910 | 2,759 | - | 2,759 | 4,418 | 4,418 | 4,142 | 3,701 | 3,425 | 4,319 |
| 2032 | 7,278 | 5,367 | 1,911 | 2,838 | - | 2,838 | 4,440 | 4,440 | 4,157 | 3,713 | 3,429 | 4,339 |
| 2033 | 7,381 | 5,469 | 1,912 | 2,919 | - | 2,919 | 4,462 | 4,462 | 4,170 | 3,724 | 3,432 | 4,359 |
| 2034 | 7,485 | 5,572 | 1,913 | 3,002 | - | 3,002 | 4,483 | 4,483 | 4,183 | 3,735 | 3,434 | 4,379 |
| 2035 | 7,591 | 5,677 | 1,914 | 3,088 | - | 3,088 | 4,504 | 4,504 | 4,195 | 3,745 | 3,436 | 4,397 |
| 2036 | 7,681 | 5,767 | 1,914 | 3,173 | - | 3,173 | 4,508 | 4,508 | 4,191 | 3,740 | 3,422 | 4,418 |
| 2037 | 7,773 | 5,859 | 1,914 | 3,261 | - | 3,261 | 4,511 | 4,511 | 4,185 | 3,734 | 3,408 | 4,420 |
| 2038 | 7,866 | 5,952 | 1,914 | 3,352 | - | 3,352 | 4,514 | 4,514 | 4,179 | 3,727 | 3,392 | 4,421 |
| 2039 | 7,960 | 6,046 | 1,914 | 3,444 | - | 3,444 | 4,516 | 4,516 | 4,171 | 3,720 | 3,375 | 4,421 |
| 2040 | 8,055 | 6,141 | 1,914 | 3,539 | - | 3,539 | 4,516 | 4,516 | 4,162 | 3,710 | 3,357 | 4,420 |
| EIRR | | | | | | | 13.0% | 11.4% | 11.7% | 10.0% | 7.5% | 9.9% |
| ENPV | 36,868 | 25,277 | 11,592 | 35,664 | 20,409 | 15,255 | 1,204 | (836) | (321) | (2,482) | (6,775) | (3,083) |
| Sensitivity Indicator EIRR | | | | | | | | 16.27 | 12.64 | 30.38 | 55.23 | 95.42 |
| Sensitivity Indicator ENPV | | | | | | | | 16.94 | 12.67 | 30.61 | 66.25 | 108.96 |
| Switching Value EIRR | | | | | | | | 0.06 | 0.08 | 0.03 | 0.02 | 0.10 |
| Switching Value ENPV | | | | | | | | 0.06 | 0.08 | 0.03 | 0.02 | 0.01 |

## 6.2 Financial Analysis

### 6.2.1 Introduction

268 Financial analysis was conducted for the Darkhan Wastewater Management Project following ADB guidelines[60] including: (i) project financial viability analysis; (ii) assessment of affordability and willingness to pay; (iii) assessment of operational and financial strength of the operator, Darkhan Us Suvag (DUS), the city's utility company; and (iv) fiscal impact assessment of Darkhan Uul-Aimag government (DAG), the implementing agency and end-borrower of the loan, to ensure capacity for timely provision of counterpart funds, debt servicing and operating and maintenance (O&M) costs. Details of the analysis are provided in **Appendix T**.

### 6.2.2 Financial Viability Analysis

269 **Assumptions.** Financial projection covers 25 years to compute the required annual revenues to ensure the cumulative cash flow would meet cash operating costs, depreciation, and debt service. Cost streams to calculate FIRR comprise capital investment and O&M costs. Capital costs include the project costs for the wastewater treatment plant (WWTP), pump stations and sewer pipe rehabilitation. O&M costs include personnel salaries, cost of chemicals and agents, utilities, maintenance, administration and overheads. Revenues come from wastewater treatment fees. Demand projections are based on growth of population connected to the sewer network, estimated at 45,000 in 2013 growing at an average of 1.04% annually. Daily per capita water use is estimated at 125-150 liters and Industrial water consumption was assessed based on actual and projected use. Wastewater generation is assumed at 80% of water consumption. Income tax is assumed at 10%. Foreign exchange rate used in the analysis is MNT 1,690 to $1.00. Inflation rates applied are: for foreign, -1.6% in 2013, 2.3% in 2014, 2.4% in 2015, and 1.4% in 2016 onwards; for local, 9.5% in 2013, 10% in 2014, and 8% in 2015 onwards.

270 **Weighted Average Cost of Capital (WACC)**. If the financial internal rate of return (FIRR) exceeds the WACC, the project is deemed financially viable. The nominal interest rates applied are: (i) ADB-ADF loan 2.0% per annum, (ii) ADB-OCR[61] loan 3.18% per annum, and (iii) Government contribution 15% based on prevailing commercial bank rates, representing the opportunity cost of capital. Foreign inflation is at 1.4% for ADB loan, and local inflation at 9% for the government contribution. The interest rates are computed on after-tax basis, resulting in a WACC in real terms of 1.41%. The project capital investment amounts to MNT 34,957, of which MNT 31,268 million will be financed by ADB, and MNT 3,689 by the government. Table 6.4 presents the WACC calculation.

**Table 6.4. Weighted Average Cost of Capital**

| | Unit | Total Cost | ADF Loan | OCR Loan | Government |
|---|---|---|---|---|---|
| Amount | MNT million | 34,957 | 15,333 | 15,935 | 3,689 |
| Weighting | %Total | 100.0% | 43.8% | 45.6% | 10.6% |
| Nominal cost | | | 2.0% | 3.18% | 15.0% |
| Tax rate | | | 10% | 10% | 0% |
| Tax-adjusted nominal cost | | | 1.8% | 2.9% | 15.0% |
| Inflation rate | | | 1.4% | 1.4% | 9.0% |
| Real cost | | 7.3% | 0.4% | 1.4% | 5.5% |
| Real WACC | | 1.41% | 0.17% | 0.66% | 0.58% |

ADF = Asian Development Fund; OCR = Ordinary Capital Resources; MOF = Ministry of Finance.
Source: Consultant estimates

271 **Cost recovery**. DUS has been operating at a loss in three of the past four years, incurring a net loss of MNT 717 million ($0.42 million) at the end of 2012 and at the end of 2013 the deficit was expected to reach MNT 374 million. DAG provides budget support for cost recovery, in part from

60 ADB 1999, Handbook for the Economic Analysis of Water Supply Projects. ADB. 2005, Financial Management and Analysis of Projects. ADB 2009, Financial Due Diligence: A Methodology Note.

61 LIBOR-based, using US dollar fixed-swap rate at 2.58% p.a., plus ADB spread at 0.50% and premium at 0.10% .

national government transfers. It is estimated that DAG will need to provide an estimated MNT 374 million to cover losses expected at end-2013. With timely and appropriately set tariffs starting 2015 there will be no further operational subsidy required from DAG.

272 **Tariffs**. Current water and wastewater tariffs differentiate between domestic and non-domestic customers. In 2013, over 90% of connections in Darkhan were metered and it is expected to be 100% in 2014. At full operation of the project in 2017, all current tariffs will be volumetric, in line with national policy. Current tariffs are categorized based on domestic and non-domestic type connections and uniformly applied across Darkhan City. Since October 2010 water and wastewater tariffs remained at the same levels. The proposed WWTP project will entail increases in O&M costs due to larger treatment volume and debt service obligations. To recover costs, tariffs need to be adjusted and an application to approve tariff increases was submitted to the various agencies including MOF, National Water Source Regulatory Committee (NWSRC) for final approval by the Competition and Consumer Rights Agency (CCRA). The tariff adjustment is anticipated to be approved in 2014. Approval is needed to cover losses from previous years. To attain financial self-sufficiency for the project in the coming years, it is necessary to increase domestic and non-domestic wastewater tariffs by 20% in 2015, 10% in 2020 and 2025, and 5% in 2030 and 2035. To ensure profitability for overall operations, water supply tariffs should likewise be adjusted by 30% every three years starting 2015. Table 6.5 presents the tariff schedule.

**Table 6.5. Schedule of Anticipated Tariff Increases, MNT per $m^3$**

| Wastewater | 2011-14 | 2015-19 | 2020-24 | 2025-29 | 2030-34 | 2035 |
|---|---|---|---|---|---|---|
| Domestic | 700 | 840 | 924 | 1,016 | 1,067 | 1,121 |
| Non-domestic | 1,179 | 1,414 | 1,556 | 1,711 | 1,797 | 1,887 |
| Average Effective | 880 | 1,061 | 1,179 | 1,311 | 1,392 | 1,484 |
| % Increase | | 20 | 10 | 10 | 5 | 5 |
| **Water** | **2011-14** | **2015-17** | **2018-20** | **2021-23** | **2024-26** | **2027-29** |
| Domestic | 650 | 845 | 1,098 | 1,428 | 1,856 | 2,413 |
| Non-domestic | 1,200 | 1,560 | 2,028 | 2,636 | 3,427 | 4,456 |
| Average Effective | 788 | 1,029 | 1,349 | 1,768 | 2,318 | 3,038 |
| % Increase | | 30 | 30 | 30 | 30 | 30 |

Source: Consultant estimates, based on DUS projections.

273 **FIRR and Sensitivity Analysis**. Based on the discounted cash flow analysis, the FIRR for the proposed WWTP project is 2.4% exceeding the WACC (at 1.41%) with a financial net present value of MNT 4,920 million over the period. Hence the project is financially viable. Sensitivity tests are performed to determine the effects on project viability under adverse conditions. Project remains robust even with a 10% capital cost increase. However, the project becomes infeasible under other sensitivity scenarios, including a one-year delay in implementation. Table 6.6 shows the FIRR and sensitivity analysis results. Details of analysis is presented in Table 6.7.

**Table 6.6. FIRR and Sensitivity Analysis Results**

| | Base Case | Cap Cost +20% | O&M Cost +20% | Revenue -20% | Rev +, Costs- 20% | Delay by 1-year |
|---|---|---|---|---|---|---|
| FIRR | 2.4% | 1.8% | 1.7% | 1.0% | (0.3%) | 1.3% |
| FNPV, in MNT million | 4,920 | 1,869 | 1,478 | (2,065) | (8,678) | (802) |

Source: Consultant estimates.

**Table 6.7. Details of FIRR and Sensitivity Analysis**

| Year | Revenue | Costs | | Net Inflow (Outflow) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Capital | O&M | Base Case | Cap Cost + 10% | O&M Cost + 10% | Revenue - 10% | Costs+, Benefits- 10% | Delay by 1-year |
| 2015 | 660 | 3,216 | 536 | (3,091) | (3,413) | (3,145) | (3,157) | (3,532) | (3,752) |
| 2016 | 769 | 11,189 | 645 | (11,065) | (12,184) | (11,129) | (11,142) | (12,325) | (11,173) |
| 2017 | 881 | 9,381 | 750 | (9,250) | (10,188) | (9,325) | (9,338) | (10,351) | (9,362) |
| 2018 | 996 | 6,860 | 851 | (6,716) | (7,402) | (6,801) | (6,815) | (7,586) | (6,831) |
| 2019 | 1,115 | 1,509 | 950 | (1,344) | (1,494) | (1,439) | (1,455) | (1,701) | (1,463) |
| 2020 | 1,636 | 0 | 1,047 | 589 | 589 | 484 | 426 | 321 | 69 |
| 2021 | 1,763 | 0 | 1,136 | 627 | 627 | 513 | 451 | 337 | 500 |
| 2022 | 1,895 | 0 | 1,224 | 671 | 671 | 549 | 482 | 359 | 540 |
| 2023 | 2,031 | 0 | 1,310 | 721 | 721 | 590 | 518 | 387 | 585 |
| 2024 | 2,171 | 0 | 1,394 | 777 | 777 | 637 | 560 | 420 | 637 |
| 2025 | 2,820 | 0 | 1,477 | 1,342 | 1,342 | 1,195 | 1,060 | 913 | 693 |
| 2026 | 2,997 | 0 | 1,564 | 1,433 | 1,433 | 1,277 | 1,133 | 977 | 1,256 |
| 2027 | 3,181 | 0 | 1,650 | 1,530 | 1,530 | 1,365 | 1,212 | 1,047 | 1,347 |
| 2028 | 3,370 | 0 | 1,736 | 1,634 | 1,634 | 1,460 | 1,297 | 1,123 | 1,444 |
| 2029 | 3,565 | 0 | 1,822 | 1,743 | 1,743 | 1,561 | 1,387 | 1,205 | 1,548 |
| 2030 | 4,092 | 0 | 1,908 | 2,184 | 2,184 | 1,993 | 1,775 | 1,584 | 1,657 |
| 2031 | 4,309 | 0 | 1,992 | 2,318 | 2,318 | 2,119 | 1,887 | 1,688 | 2,101 |
| 2032 | 4,533 | 0 | 2,075 | 2,457 | 2,457 | 2,250 | 2,004 | 1,797 | 2,234 |
| 2033 | 4,763 | 0 | 2,160 | 2,604 | 2,604 | 2,388 | 2,127 | 1,911 | 2,373 |
| 2034 | 5,000 | 0 | 2,244 | 2,756 | 2,756 | 2,532 | 2,256 | 2,032 | 2,519 |
| 2035 | 5,644 | 0 | 2,329 | 3,314 | 3,314 | 3,081 | 2,750 | 2,517 | 2,671 |
| 2036 | 5,905 | 0 | 2,413 | 3,492 | 3,492 | 3,251 | 2,901 | 2,660 | 3,230 |
| 2037 | 6,175 | 0 | 2,498 | 3,677 | 3,677 | 3,427 | 3,059 | 2,809 | 3,407 |
| 2038 | 6,453 | 0 | 2,584 | 3,868 | 3,868 | 3,610 | 3,223 | 2,965 | 3,591 |
| 2039 | 6,738 | 0 | 2,671 | 4,067 | 4,067 | 3,800 | 3,393 | 3,126 | 3,781 |
| 2040 | 7,033 | 0 | 2,759 | 4,274 | 4,274 | 3,998 | 3,570 | 3,294 | 3,979 |
| FIRR | | | | 2.4% | 1.8% | 1.7% | 1.0% | -0.3% | 1.3% |
| FNPV | 69,848 | 30,508 | 34,420 | 4,920 | 1,869 | 1,478 | (2,065) | (8,678) | (802) |
| Sensitivity Indicator | | | | | | | | | |
| FIRR | | | | | 6.41 | 6.93 | 14.49 | 28.10 | 16.53 |
| FNPV | | | | | 6.20 | 7.00 | 14.20 | 27.64 | 16.51 |
| Switching Value | | | | | | | | | |
| FIRR | | | | | 0.16 | 0.14 | 0.07 | 0.04 | 0.06 |
| FNPV | | | | | 0.16 | 0.14 | 0.07 | 0.04 | 0.06 |

### 6.2.3 Affordability and Willingness to Pay

274 The affordability analysis examined the levels of water and wastewater expenditures against total average household incomes. A field survey conducted in January 2014 and DUS statistics provided the average household size as 4 persons, household water consumption, and household incomes. Table 6.8 shows the summary affordability analysis for both average- and low-income households for the periods following the proposed adjustments of wastewater and water tariffs.

**Table 6.8. Affordability Analysis**

| | Unit | 2015 | 2018 | 2020 | 2021 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **Average Household** | | | | | | | |
| Average HH income [a] | MNT | 732,335 | 790,922 | 854,196 | 854,196 | 854,196 | 913,990 |
| Average HH sewerage bill | MNT/mo | 10,125 | 10,5230 | 11,874 | 11,992 | 12,353 | 13,723 |
| Income spent for sewerage | | 1.4% | 1.3% | 1.4% | 1.4% | 1.4% | 1.5% |
| Average HH water bill | MNT/m | 8,956 | 14,147 | 15,615 | 21,162 | 30,613 | 31,568 |
| Income spent for water | rate | 1.2% | 1.8% | 1.8% | 2.5% | 3.6% | 3.5% |
| **Combined spending** | **rate** | **2.6%** | **3.1%** | **3.2%** | **3.9%** | **5.0%** | **5.0%** |
| **Low-income Household [b]** | | | | | | | |
| Average HH income | MNT | 322,904 | 348,737 | 376,636 | 376,636 | 376,636 | 403,000 |
| Average HH sewerage bill | MNT/m | 6,750 | 7,015 | 7,916 | 7,995 | 8,235 | 9,148 |
| Income spent for sewerage | MNT/m | 2.1% | 2.0% | 2.1% | 2.1% | 2.2% | 2.3% |
| Average HH water bill | MNT/m | 5,970 | 9,431 | 10,410 | 14,108 | 20,408 | 21,046 |
| Income spent for water | | 1.8% | 2.7% | 2.8% | 3.7% | 5.4% | 5.2% |
| **Combined spending** | **rate** | **3.9%** | **4.7%** | **4.9%** | **5.9%** | **7.6%** | **7.5%** |

Source: Consultant estimates.

275 The average household spends between 1.3% and 1.5% of total household income on average for wastewater services over the period and between 1.2% and 3.6% for water and wastewater combined. An internationally accepted rule for wastewater tariff affordability is around or below 2-3% of household average income. Accepted affordability levels for combined water and wastewater tariff are 6-8% of household income. Hence the proposed tariffs are deemed affordable for average households.

276 Low-income households with 44% of average income will spend between 2.0% and 2.3% for wastewater and between 3.9% and 7.6% for combined water and wastewater of the average income. Hence the proposed tariffs are deemed affordable for low-income households.

277 Based on survey results, the mean willingness to pay (WTP) for a wastewater service fee of apartment dwellers in Darkhan is MNT 1,076/m3 ($0.64/m3). If WTP amount were an estimate of actual tariff requirements for cost recovery, then the proposed tariffs shown in Table 2 matches consumer expectations for benefits of improved service.

### 6.2.4 Operational and Financial Strength of Darkhan Us Suvag

278 **Past Financial Performance**. The past financial management of the operator of the project facilities DUS was assessed to determine its performance in terms of services delivery, profitability and financial strength for the period of 2009 to 2012. DUS uses the accounting system required by the government which is based on the accrual method, following international accounting standards. DUS systems are almost completely computerized.

279 **Profit and Loss.** Wastewater service revenues grew at a compounded average growth rate (CAGR) of 4.1%, and water supply revenues grew at 11.5%. In 2012 the O&M cost for water supply increased without the benefit of a tariff increase, and DAG provided a subsidy to cover. The 2012 increase in other revenue reflected the infusion as mainly interest income. However, the subsidy was insufficient to cover the debt burden, which increased by 352% from MNT 183 million in 2011 to MNT 827 million in 2012 which resulted in a net loss of MNT 717 million. In 2013, O&M cost for water and wastewater increased by 15%, and the 32% increase in revenue failed to cover the deficit and the DAG subsidy provided was less than in 2012. DUS applied for tariff increase in 2013 and approval remains pending.

280 Balance Sheets. DUS fixed assets reflected the magnitude of system expansion of 270% between 2010 and 2011. The improvements were funded by capital infusion from several short-term commercial loans amounting to MNT 1,540 million with interest rates of between 1.0 to 1.8% per month, payable in 3-12 months. The current ratio (current assets to current liabilities) averages 2.0. Current assets comprise 73% receivables, 3% cash, and 24% inventories and other current assets. Current liabilities comprise 47% short-term loans, 31% payables and 22% other current payables.

281 **Financial Projections**. Detailed financial projections are prepared to assess the impact of the proposed WWTP project on DUS overall operations. Pro-forma statements are utilized to reflect financial profitability, funds availability and financial position. The projections are in nominal terms, covering a 25-year period, and follow ADB guidelines.

282 The main financial viability parameters include (i) operating ratio, which should be less than or equal to unity when the project becomes fully operational, (ii) debt service coverage ratio (DSCR), at minimum 1.5 average during the loan period, and (iii) tariff affordability, generally acceptable at maximum 6-8% for water and wastewater. Cost recovery is analysed at different levels: the projections determine the tariff levels needed to cover O&M costs and debt servicing from the project and if feasible, depreciation and re-investment margins.

283 Generally, the indicators show a satisfactory forecast for operations starting 2015, with annual net profits resulting from appropriate tariffs based on cost recovery. The tariff increases during the period are limited to ensure affordability for the low-income households, and are deemed sufficient, if implemented as planned. Cash will have accumulated to MNT 889 million by 2025 and all expenditures will be fully covered. Return on net fixed assets at 8% average compares with industry average which is 8% for most utilities. The proposed tariffs are structured to fully recover O&M cost plus debt servicing and depreciation, while ensuring affordability. The operating ratio for combined O&M for water and wastewater reflects satisfactory compliance of the conditions. Minimum debt coverage is attained during the loan period, averaging 1.6, higher than the acceptable industry level at 1.5. Debt to equity and to assets is within acceptable levels at 30% on average.

### 6.2.5 Fiscal Impact Assessment of the Project on Darkhan Uul-Aimag Government

284 **Historic Revenue and Expenditure**. The performance of DAG as end-borrower was analysed to determine its financial capacity to provide counterpart funds during implementation, and O&M and debt service during operation. Revenue and expenditure statements in the period of 2009 to 2012 and financial projections until 2030 were carried out to assess financial performance including capital structure, internal funds generation to support current operations, debt service capacity, and ability to finance O&M of the project after completion. Central government transfers comprised 88% of total revenues, and non-tax revenue comprised 12%. 78% of revenues were allocated for the operations budget, Fiscal expenditures include employee salaries (32%), goods and services (31%), programs and events (17%), fixed asset utilization (18%), and transfers to Soums, social welfare, rent and other expenses (2%). The average growth rate for revenue during the period was 33%, and 32 % for expenditures.

285 **Results of Fiscal Impact Assessment**. Financial projections were prepared based on DAG historic revenue and expenditure growth patterns of between 20% and 25% annually between 2009 and 2013. Table 6.9 summarizes the effects of project cash requirements on DAG operations.

**Table 6.9. Project Fund Requirements as Percentage of Revenue, in MNT million**

| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|
| Total Revenues | 16,009 | 20,811 | 27,055 | 35,171 | 45,723 | 61,726 | 192,892 | 565,114 |
| Total Expenditures | 15,123 | 18,148 | 22,140 | 27,675 | 35,147 | 48,503 | 178,240 | 548,014 |
| Project Counterpart | 360 | 1,306 | 1,079 | 780 | 164 | - | - | - |
| % Total expenditures | 2.4 | 7.2 | 4.9 | 2.8 | 0.5 | - | - | - |
| % Total Revenues | 2.3 | 6.3 | 4.0 | 2.2 | 0.4 | - | - | - |
| Project O&M Cost | - | - | - | - | - | 293 | 2,269 | 5,694 |
| % Total Revenues | - | - | - | - | - | 0.5 | 1.2 | 1.0 |

| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|
| Project Debt Service | - | - | - | - | - | 2,021 | 2,021 | 2,021 |
| % Total Revenues | - | - | - | - | - | 3.3 | 1.0 | 0.4 |
| Total Funds required | 360 | 1,306 | 1,079 | 780 | 164 | 2,314 | 4,290 | 7,715 |
| % Total Revenues | 2.3 | 6.3 | 4.0 | 2.2 | 0.4 | 3.7 | 2.2 | 1.4 |

Source: Consultant estimates.

286 As a percentage of annual revenues during the loan grace period from 2015 to 2019, the annual DAG counterpart funds are estimated at between 0.5% and 7.2% of total annual fiscal expenditures, and slightly lower at between 0.4% and 6.3% of total annual fiscal revenue. After project construction, wastewater O&M cost is projected to be between 0.5% and 1.2% of total fiscal revenue. Project debt service is forecasted to be between 0.4% and 3.3% of total revenue, averaging 0.8% over the debt payment period. Combining all project fund requirements, the percentage to total annual fiscal revenue comprises between 0.4% and 6.3%[62]. These findings indicate that the fiscal risk is moderate as fiscal revenue is expected to continue to grow with the country's and the local economic and industrial development estimated at 20% annually, as promoted and supported by the central government.

### 6.2.6 Conclusions

287 The project is financially viable and sustainable. The DAG assures to provide the subsidies required to cover O&M costs and debt service, when necessity arises, as well as to cover past losses. Based on the fiscal impact analysis, the DAG has the financial capacity to provide these subsidies. The anticipated tariff increases will further ensure the project's financial sustainability. However, the financial action plan needs to be implemented, by the DAG, including: (i) implementing tariff increases as suggested, and (ii) assuring sufficient budget allocation to provide timely counterpart funding, (iii) allocating and disbursing from the budget the O&M subsidies needed to recover net losses and ensure O&M sustainability, and (iv) ensuring affordability assessments and social mitigation measures, including public awareness campaigns, consultation and participation plan and subsidies programs for the poor and vulnerable are carried out prior to increasing tariffs for water and wastewater services.

[62] Based on generally accepted criteria employed by the World Bank, the counterpart contributions are considered affordable to the municipality if the required annual amount does not exceed 15–20% of projected annual construction budget. As this is difficult to assess with available municipal construction budget data, the annual contribution is compared with overall annual municipal expenditure and also as a share of special infrastructure projects funded by the government. In the case of debt service, the acceptable standard is that debt service payments associated with the project should not exceed an average 2.5% of municipal revenues.

## 6.3 Financial Management and Procurement Assessments

### 6.3.1 Financial Management Assessment

288 The purpose of the FMA is to analyse the financial management capacity of the executing agency (EA) and the implementing agency (IA) or unit that will be directly involved in handling and coordinating project finances. For the proposed WWTP development project for the Darkahn-Uul PUSO (Us Suvag), the MCUD, which is the same EA managing the existing Urban Development Sector Project (UDSP), will continue in its role as EA for the new Investment Project which falls within the overall scope of L2301-MON. The same PMU at MCUD is seen as continuing as the project manager and overseer of all project-related activities, including major procurement and funds management. As discussed in the section on project implementation arrangements, the PMU will establish a project implementing unit (PIU) at the project site in Darkhan Uul at the Aimag with involvement at the PUSO (Us Suvag) level.

289 Following on from the implementation experience under Loan 2301-MON at Erdenet (mainly in water and basic urban services at ger areas), the PUSO entered into a sub-loan agreement (SLA) and on-lending agreement (OLA) with Erdenet Aimag. The Aimag has shown sufficient capability to manage project funds. Initial institutional assessment of Us Suvag reveals that the PUSO has the capacity to implement the WWTP project, with some assistance from MCUD and technical assistance under the loan. As such, FMA was administered to Us Suvag management, particularly the Accounting Department, to further assess PUSO financial management systems and practices.

290 FMA was previously administered to MCUD as part of the original Urban Development Sector Project (UDSP) preparation. The results of the assessment rated MCUD as low risk and experienced at project financial management of foreign-assisted projects. ADB experience under UDSP has enhanced the organization's capability in project management and in providing direction to attain project objectives. FMAQ has been re-administered to MCUD to update previous findings and information. The results of the assessment are given in **Table 6.10.** The accomplished FMAQ is presented in **Appendix U.**

**Table 6.10: MCUD FMA Summary Results**

| Particulars | Risk Rating | Conclusions |
|---|---|---|
| A. Implementing Unit | Low | MCUD is a line ministry and has five main departments including the Department of Finance, Investment and Cooperation. Its experience as current EA for UDSP makes it the natural choice to continue as EA for the UDSP Additional Financing. |
| B. Fund Flow Arrangements | Low | MCUD is knowledgeable and experienced as EA in managing ADB loan and grant projects. MCUD coordinates with MOF and designated commercial banks for all local and foreign project transactions supported by external assistance. |
| C. Staffing | Low | MCUD is sufficiently staffed with experienced personnel. Any required new PMU accountants and finance staff will be selected in accordance with the ADB Guidelines and trained accordingly. |
| D. Accounting Policies and Procedures | Low | MCUD accounting policy is based on the Accounting Standard of Mongolia (ASM). A manual for the accounting procedures is available to the staff of PMU and MCUD accounting department. The PMU financial management manual is updated annually and satisfies the requirements of the MOF and ADB. |
| E. Internal Audit | Moderate | MCUD does not have an internal audit unit. |

| Particulars | Risk Rating | Conclusions |
|---|---|---|
| F. External Audit | Low | MCUD and its PMU are audited on an annual basis by independent external auditors, the Government Audit Commission under the Ministry of Finance and the State Audit Office at Aimag on an annual basis. The audit is done in accordance with international standards of auditing (ISA) and complies with the requirements of ADB and MOF. |
| G. Reporting and Monitoring | Low | MCUD and its PMU reporting complies with MOF requirements. PMU progress reports, including financial reports, conform to and are regularly submitted to ADB |
| H. Information Systems | Low to Moderate | MCUD uses the MAKS accounting software for internal and project operations, as well as financial reporting, but the systems are not linked in a joint information network. Linking the MCUD, the PMU, and the PIUs in one information network will improve effectiveness of the information exchange. |

291 **FMA of Darkhan Uul Aimag:** The Darkhan Uul Aimag has project implementation experience and is guided by accounting, budget and financing laws in project transactions. Aimag follows IAS and ISA and state accounting standards and has capability to satisfactorily record all transactions and balances, support the preparation of regular and reliable financial statements and financial monitoring reports, safeguard the assets, and subject these to auditing arrangements acceptable to ADB. The FMA finds Aimag to comply with the minimum financial management requirements of ADB as potential IA, with a rating of **low to average** risk. The summary FMA results are given in **Table 6.11.** The accomplished FMAQ is provided in **Appendix U.**

**Table 6.11: Darkhan Uul Aimag FMA Summary Results**

| Particulars | Risk Rating | Conclusions |
|---|---|---|
| A. Implementing Unit | Low | The Aimag Government has experience as IA during implementation of ADB Loan project on renovation of engineering network of the 2$^{nd}$ Micro District. |
| B. Fund Flow Arrangements | Low to Average | The Aimag has knowledge of and working experience in ADB funding arrangement and closely coordinated with MOF in project transactions. No problems were reported regarding counterpart fund transfers through existing budget processes. Aimag does not currently have capacity to manage forex risk. Existing reporting system needs upgrading to enable Aimag to track project proceeds from sources and contributors to final beneficiaries. |
| C. Staffing | Averagee to High | The Aimag needs additional staff to fill in vacant accounting positions. Existing staff complement requires training on ADB procedures to ensure smooth workflow. |
| D. Accounting Policies and Procedures | Low | Aimag follows ASM based on international accounting standards. Accounting follows the accrual basis and uses the accounting policy and procedures of budget organizations. Accounting and budget manuals are updated regularly. There are existing controls for collections, timely deposits and recording these. Regional and national offices participated in project implementation and controls and procedures were in place for funds use and project reporting and monitoring. |
| E. Internal Audit | Average | There is no internal audit unit. |

| Particulars | Risk Rating | Conclusions |
|---|---|---|
| F. External Audit | Low | Aimag is audited annually by independent external auditors, the General Auditor of Aimag and the State Audit Office. The audit is in accordance with international standards for auditing (ISA) and complies with the requirements of MOF. Auditor recommendations are implemented. |
| G. Reporting and Monitoring | Low | Aimag follows international accounting standards and prepares necessary financial statements and other financial reports on quarterly basis. Reporting complies with the MOF requirements and used regularly by management. |
| H. Information Systems | Low to Average | Accounting and financial management systems are computerized. Aimag uses automated accounting software, Acqulous, which may be adapted to include local project operations and reporting requirements. |

292 **FMA of Us Suvag PUSO:** Following from the implementation experience under Loan 2301-MON at Erdenet (mainly in water and basic urban services at ger areas), the PUSO entered into a sub-loan agreement (SLA) and on-lending agreement (OLA) with Erdenet Aimag. Erdenet Aimag has shown sufficient capability to manage project funds. Initial institutional assessment of Us Suvag reveals that the PUSO has the capacity to implement the WWTP project, with some assistance under the loan. As such, FMA was administered to Us Suvag management, particularly the Accounting Department, to further assess PUSO financial management systems and practices. Us Suvag financial staff are found to have sufficient work experience backed by appropriate education and training in accountancy, and with commensurable training in ADB financial management procedures, will be able to efficiently and satisfactorily handle project funds management tasks. FMA rates PUSO as **low to average** risk as IA. The results of the Us Suvag FMA, including a risk assessment are reflected in **Table 6.12.** The accomplished FMAQ is provided in **Appendix U.**

**Table 6.12: Us Suvag FMA Summary Results**

| Particulars | Risk Rating | Conclusions |
|---|---|---|
| A. Implementing Unit | Low to Moderate | Us Suvag is a locally-owned joint stock company that has recent experience in implementing JICA funded projects. |
| B. Fund Flow Arrangements | Low to Moderate | The company has knowledge of and working experience in JICA funds flow arrangements. For the project, Us Suvag coordinates with MOF and designated commercial bank for all project transactions. The company did not experience any problems regarding project fund transfers. |
| C. Staffing | Moderate | Us Suvag is staffed with experienced technical personnel of appropriate educational background to undertake assigned tasks. The accounting department is insufficiently staffed with only the company accountant as head, assisted by a budget and project engineer. Positions for required accounting staff have not been filled. For the project, accountants will be selected in accordance with the ADB Guidelines and trained accordingly. |
| D. Accounting Policies and Procedures | Low | The company accounting policies and procedures are based on the Accounting Standard of Mongolia (ASM) that follows international accounting standards (IAS). Accounting follows the accrual basis. A manual for the accounting procedures is available to the accounting staff. The financial management manual is updated annually and satisfies the requirements of the Ministry of Finance (MOF). |

| Particulars | Risk Rating | Conclusions |
|---|---|---|
| E. Internal Audit | Moderate | The company does not have an internal audit unit. |
| F. External Audit | Low | Us Suvag is audited annually by independent external auditors, the Government Audit Commission under the Ministry of Finance and the State Audit Office. The audit is in accordance with international standards for auditing (ISA) and complies with the requirements of MOF. Auditor recommendations are implemented. |
| G. Reporting and Monitoring | Low | Us Suvag reporting complies with the reporting requirements of the MOF and the State Tax Department. Financial statements are prepared quarterly, and used by management in decision-making. |
| H. Information Systems | Low to Moderate | The company uses accounting software for local project operations, and for financial reporting, but the systems are not linked in a joint information network. |

### 6.3.2 Procurement Capacity Assessment

293 **Procurement Capacity Assessment of MCUD:** PCA has been conducted to determine EA capacity to manage project procurement activities. MCUD-PMU has been involved in procurement contracts under L2301, making it ideal implementing unit to manage the same for the loan project. The PCA rates the EA procurement capacity as **low to average**. **Table 6.13** summarizes the findings of the assessment. Standard PCA questionnaire used as assessment tool is given in **Appendix U.**

**Table 6.13: MCUD PCA Summary Results**

| Particulars | Risk Rating | Conclusions |
|---|---|---|
| A. Agency Resources | Low to Average | By law, MCUD can enter into contracts. PMU is sufficiently staffed for the project. Staff are hired full-time. Senior and professional staff have average experience in project procurement, with support staff needing some training in complex procurement tasks. Staff have high educational background with IT-literacy high among management and technical staff; fair among support staff. PMU office is adequately equipped and secure; computers, back-up power, storage and consumables are in good order. There is no procurement training program within EA; where and when available, staff are sent to enhance specific skills. |
| B. Procurement Processes | Low | PMU has 3-year experience in procurement using ADB guidelines. For goods and works, MCUD and ADB identify requirements; for consulting, including drafting and managing bids documentation, MCUD. Bid opening is public; late bids not accepted; and no bids rejected at opening. Minutes are taken during pre-negotiations and bid openings, and distributed to bidders free of charge. Bid evaluation is by ad-hoc committee, whose final evaluation is not subject to further approvals. EOI is advertised for works over MNT 10 B, and goods over MNT 100 M. Selection criteria include experience, financial capacity and personnel qualification. Selected firm has 7-14 days to negotiate. MCUD does not have specific unit for, nor the capacity to provide on-site contract management. MCUD has processes for cargo collection, clearance and receiving at entry ports. For ICB contracts, MCUD appoints counterpart to undertake day-to-day contract administration. |
| C. Records Keeping | Average | Centralized database is missing; procurement and contract filing is outdated (kept in metal cabinet) although secure from theft, tampering and fire. All bid proposals including advertisements and contractual correspondence are stored in individual files but corresponding invoices are kept separately. Although records are cross-referenced, having them |

| Particulars | Risk Rating | Conclusions |
|---|---|---|
| | | together cuts time searching. Records are kept a maximum of five years only to avoid taking too much storage space. |

294 PCA finds MCUD-PMU as low to average risk as implementing unit to accommodate all procurement activities under the proposed Additional Financing project to develop Darkhan WWTP. The agency has sufficient resources, experience and processes in place to undertake the procurement TOR. Some elements need enhancement, such as (i) improving support staff knowledge at specific procurement tasks, (ii) developing IT central database to enhance data transfer and security, and (iii) establishing contracts management and monitoring unit both at PMU and field levels.

# 7 ENVIRONMENTAL SAFEGUARDS AND DUE DILIGENCE

## 7.1 ADB and Domestic Environmental Due Diligence

295 **Environmental categorization:** Based on ADB's Rapid Environmental Assessment checklists the project is classified as environmental category "B", requiring an IEE. The IEE report provided at Appendix N is prepared in accordance with ADB's Safeguard Policy Statement (2009).

296 The Mongolian EIA process is set out in local law. The domestic EIA requirements will be met for this project. A request for a General EIA was issued to the Ministry of Environment and Green Development (MEGD) in September 2013. A detailed EIA was undertaken by a Mongolian company in February and March 2014.

## 7.2 IEE Key Findings

297 **Environmental Policies**. Mongolia has a comprehensive policy and legal framework for environmental assessment and management. It has policies, legislation and strategies in place to manage the protected areas such as national parks, to satisfy its international obligations, and to protect the quality of the environment for the health and well-being of its citizens[63.]

298 The EIA requirements of Mongolia are regulated by the Law on EIA (1998, amended 2002[64] and amended 2012). The terms of the law apply to all new projects, as well as rehabilitation and expansion of existing industrial, service or construction activities and projects that use natural resources.

299 The purpose of the EIA law is environmental protection, the prevention of ecological imbalance, the regulation of natural resource use, the assessment of environmental impacts of projects and procedures for decision-making regarding the implementation of projects. Under this law, the project was subject to a Detailed EIA.

300 **Baseline Environmental Conditions:** The physical, biological, socioeconomic, and cultural resources in the project area have been examined and the baseline environmental conditions determined. This allows assessment of the direct, indirect, cumulative and induced environmental impacts on and risks to these resources. In order to develop an environmental baseline, site visits were undertaken which identified potential receptors in the project area which may be impacted on by the project. The receptors are given in **Table 7.1: Potentially Affected Receptors and Resources in Component Sites**.

**Table 7.1: Potentially Affected Receptors and Resources in Component Sites**

| Component Site | Affected Receptor/Resources and Distance (meters) |
|---|---|
| Component A1 - Central WWTP | Soil / Ground - contamination and erosion<br>Water - Kharaa River from effluent<br>WWTP operators/staff - noise and dust<br>Air - dust<br>Waste disposal site<br>Resource use - materials and energy |
| Component (A2): Infrastructure Replacement/Rehabilitation | **Sewer Replacement at old Darkhan hospital**<br>Socio-Economic- Street sellers outside hospital / market and two businesses in apartment blocks (3 m and 20 m)<br>Residents - apartment blocks (20 m) |

[63] UNDP. 2008. Institutional Structures for Environmental Management in Mongolia. Ulaanbaatar and Wellington.
[64] Law of Mongolia on Environmental Impact Assessments (1998, amended in 2002). Unofficial translation available from http://cdm-mongolia.com.

| Component Site | Affected Receptor/Resources and Distance (meters) |
|---|---|
| | Social services - School (5 m), Hospital (15 m)<br>Cultural Resources - Temple (100 m<br>Soil / Ground - contamination and erosion<br>Health and Safety - community<br>Waste disposal site<br>Resource use - materials and energy |
| | **Sewer Replacement & Power Distribution at Secondary Pumping Station**<br>Soil / Ground - contamination and erosion<br>Water - Kharaa River from effluent<br>Air - dust<br>Residents - gers (130 m from pipe, 30 m from pumping station)<br>Socio-Economic - pastureland<br>Health and Safety - community<br>Waste disposal site<br>Resource use - materials and energy |
| | **New south pumping station**<br>Soil / Ground - contamination and erosion<br>Socio-Economic - pastureland<br>Air - dust<br>Residents - ger (50 m)<br>Health and Safety - pumping station caretaker<br>Waste disposal site<br>Resource use - materials and energy |

Source: ADB Study Team

301 **Climate:** The Kharaa river basin climate is characterized as a dry winter continental climate. Mean annual temperatures are around 0 °C with long cold winters; mean monthly temperatures in January range from -20 to -25 °C with minimum temperatures reaching - 40 °C). The summer season is short and warm, with average temperatures for July exceeding 15 °C[65]. The Kharaa river is continuously covered with ice between November and March.

302 **Soil:** Soils in the project area to be dominated by (i) fluvisols - typically found on flat land associated with flood plains, (ii) Kastanozems - are humus-rich soils that were originally covered with early-maturing native grassland vegetation, which produces a characteristic brown surface layer, found in relatively dry climatic zones[66]. Around the city, where the ground is not covered with vegetation or paved such as in unpaved ger areas, dry friable soils are visible, with gulleying caused by stormwater flow on slopes. A Detailed EIA undertaken for the project included soil sampling at six locations in the project area. The analysis confirmed that two samples are of alluvial soil, three are of sandy dark brown soil and one is a dark brown soil. The Detailed EIA also concludes that all the samples tested for chemical contamination meet the relevant Mongolian National Standard.

303 **Precipitation:** Specific rainfall data for Darkhan Uul, showing that the project area receives about 320 mm of precipitation annually, of which over 90% occurs in summer months67. However, precipitation patterns in Mongolia are showing evidence of change. Between 1940 and 2008, evidence shows an increasing trend of winter precipitation and a decreasing incidence of summer rainfall.[68] Although for Mongolia, over the longer term, climate models predict that summer rain will increase.

304 **Water Resources:** Surface water resources in the project area are dominated by the Kharaa river. The existing WWTP is approximately 1.5 km from the river. In between the river and the WWTP is

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65 MoMo (2009). Integrated Water Resources Management for Central Asia: Model Region Mongolia (MoMo) Case Study in the Kharaa River Basin Final Project Report

66 United Nations Food and Agriculture Organization

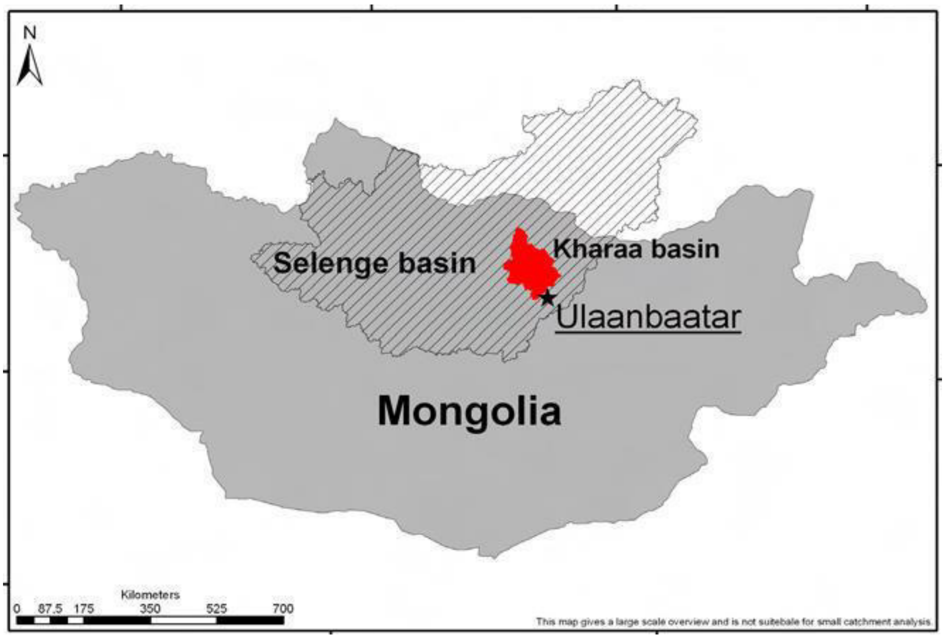
67 Environ LLC (2014) A Detailed Environmental Impact Assessment Report for Expansion Project of Central Treatment Plant in Darkhan-Uul Province [*sic*].

68 Mongolia 2nd National Communication for UN Framework Convention on Climate Change

a water body which is a flooded borrow pit, currently used for sand extraction, according to maps held by the *aimag* Land Administration.

305 The Kharaa River Basin is part of the larger Selenge river catchment, shown in **Error! Reference source not found.**7.1.

**Figure 7. 1: Selenge River Basin**




Source: MoMo[69]

306 The Kharaa river is 362 km long and has a mean long-term annual discharge (1990-2008) of 12.1 $m^3 s^{-1}$, measured at the Buren Tolgoi, 23 km from Darkhan city. In the lower end of the drainage basin, in which the project is based, the river flows naturally and is channelized in only a limited number of locations and therefore the river meanders and the floodplain meadow still serves its natural function.

307 **Groundwater:** Groundwater resources are abstracted and monitored by Us Suvag. Groundwater is located primarily along the river channel and flood plain. The depth to groundwater fluctuates with the season and averages at 3 m. There are 18 groundwater abstraction boreholes in the *aimag* along the Kharaa river valley and about 5 km upstream of Darkhan city, of which currently around five are used for meeting the water use requirements[70]; the current total residential and industrial demand (of about 18,000 cum/day but up to 23,000 cum/day) can be provided from just 5 or 6 production wells. The remainder of the boreholes can be bought into operation by Us Suvag if needed. The wells are located along the Kharaa river and are approximately 70 m deep

308 The Detailed EIA undertaken for the project presents water quality data for the Kharaa river. The data and a comparison with the Mongolian National Standard are presented in Table 7.2**: Kharaa River Water Quality** The table shows that for the data given, the parameters of ammonia (NH4) and the Biological Oxygen Demand did not meet the standard.

[69] MoMo (2009). Integrated Water Resources Management for Central Asia: Model Region Mongolia (MoMo) Case Study in the Kharaa River Basin Final Project Report
[70] Meeting Ms Sarangerel, Us Suvag Laboratory 26. 09. 2013

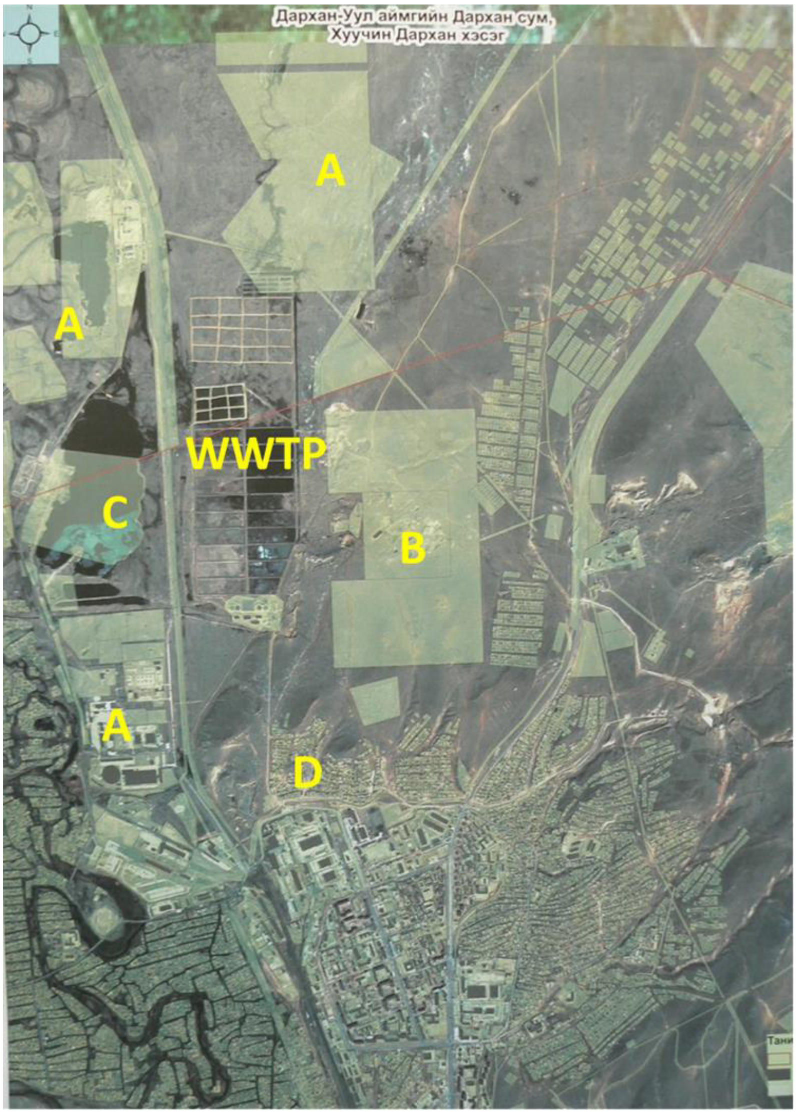
**Table 7.2: Kharaa River Water Quality**

| Parameter | Kharaa bridge (mg/l) | Kharaa- Darkhan Meteorological Office (mg/l) | Mongolian National Standard (mg/l) | Standard is Met |
|---|---|---|---|---|
| PH | 8.12 | 8.14 | **6.5-8.5** | ✓ |
| Solute O2 | 9.63 | 9.67 | **6.00** | ✓ |
| NH4 | 0.2 | 1.02 | **0.50** | × |
| NO2 | 0.009 | 0.019 | **0.02** | ✓ |
| NO3 | 0.029 | 1.22 | **9.00** | ✓ |
| P | 0.043 | 0.061 | **0.100** | ✓ |
| BOD5 | 2.39 | 3.02 | **3.00** | × |

Source: Environ LLC. Detailed EIA

309 **Land use:** The WWTP is shown to be in a clear industrial area according to maps provided by the *aimag* Land Administration. The maps show that the nearest ger housing, or hashaa (plot of land) is approximately 650 m from the WWTP.

**Figure 7.2: *Aimag* Land Administration Maps, Darkhan City**




Key: A -Industrial areas. B - Brick Factory. C: Aggregate extraction. D: Hashaa area
Source: *aimag* Land Administration: Land Allocation

310 **Flooding:** The Kharaa river does not regularly flood. The most significant flood in recent years was in 1973 when flows of 722 $m^3$/second in Kharaa river. Also in January 2006 high rainfall led to the Kharaa river flooding and flowing at 65.9 $m^3$/sec[71]. However, during intense rainfall events, specific areas of the city are subject to temporary flooding, primarily caused by blocked stormwater channels. The channels are blocked with sediment and solid waste. Flooding is exacerbated by the lack of connections to the storm water drainage system; most areas of the city, apart from main roads, have no stormwater flow management72. Areas liable to this flooding include old Darkhan's market area, the micro-district in between old and new Darkhan and ger areas built on the flood plain of the Kharaa river, to the west of the railway. The flooding generally lasts for one to two days after a prolonged intense rainfall event.

311 **Air Quality:** An environmental assessment undertaken by the Meteorological Office for the National Committee on Reducing Air Pollution[73] concludes that the main cause of air pollution in Darkhan is the power station. This is leading to higher than expected outputs of pollutants such as $NO_x$ and $SO_x$. The 2011 Human Development Report for Mongolia noted that air quality issues are significant in urban areas. The report made a policy recommendation specifically to reduced the vulnerability of urban residents to urban air pollution in a number of urban areas including Darkhan by improving energy use industries. Annual average $SO_2$ & $NO_x$ data for Darkhan *soum* against the National Standard MNS 5919:2008 show that air quality parameters do not meet national standards on average.

312 **Physical Cultural Resources:** The only observed cultural site in the project area is the Old Darkhan Buddhist temple. The temple is not a heritage site and has multiple entrances, the closest being approximately 100 m from component A2, sewer pipeline replacement at Darkhan hospital.

313 **Flora and Fauna:** The Detailed EIA[74] for the project confirmed that although approximately 20 species of bird are indicated as using the area around the project site, none of the species are on the IUCN red list and those that are present, such as crows and sparrows, are familiar with habitats which have been degraded by human activities. The Detailed EIA also includes information on a number of rodents which are common in Mongolia, such as the house mouse (*Mus musculus*) and Mongolian gerbil (*Meriones unguiculatus*) however the study also concludes that the presence of these mammals cannot be confirmed but the habitat is already greatly disturbed by human activities therefore any species which are present are likely to be those which tolerate disturbance and do not need a habitat with a high ecological value.

314 **WWTP Technology Alternatives:** The treatment technologies proposed have been the subject of intensive analysis, based on both international and Mongolian experience of wastewater treatment under condition similar to those found in Darkhan. Wastewater treatment plants are complex systems which rely on a series of sensitive physical, biological and (sometimes) chemical processes to achieve optimal treatment results. Given the context of the Darkhan WWTP, the technology alternatives evaluated as part of the Technical Assistance are narrowed to:

i. Option 1. rehabilitation of the existing WWTP as a modified activated sludge process;

ii. Option 2: construction of a step-feed activated sludge system;

iii. Option 3: construction of a sequencing batch reactor; and

iv. Option 4: construction of an Integrated Fixed-film Activated Sludge (IFAS) Plant

315 In terms of environmental risks, there is little between the options considered as all, if operated correctly, will offer adequate performance. In terms of costs, the step-feed activated sludge is slightly more expensive and has slightly higher operational cost than the other two systems.

[71] http://air.president.mn/en/

[72] MoMo (2009). Integrated Water Resources Management for Central Asia: Model Region Mongolia (MoMo) Case Study in the Kharaa River Basin Final Project Report

[73] http://air.president.mn/en/

[74] Environ LLC (2014) A Detailed Environmental Impact Assessment Report for Expansion Project of Central Treatment Plant in Darkhan-Uul Province [*sic*]

Following a series of discussions and workshops, the final technology choice is IFAS which where possible, will be housed within the existing structures.

## 7.3 Environmental Impacts and Mitigation

316 A screening process is undertaken which identifies the residual impact i.e. the impact on a receptor after mitigation. This is key to the assessment of impacts and demonstrates the importance of the implementation of EMP mitigation measures. **Error! Reference source not found.**7.3 shows the matrix used during the screening process to anticipate the Potential and Residual Impact Significance.

**Table 7.3: Potential Impact Significance**

| | | Magnitude of Impact | | |
|---|---|---|---|---|
| | | LOW | MEDIUM | HIGH |
| Receptor Sensitivity & Importance | LOW | Low | Low | Medium |
| | MEDIUM | Low | Medium | High |
| | HIGH | Medium | High | High |

317 The screening process showed that following mitigation, related to project design (design phase), the most significant impacts are the temporary economic displacement of around 5 street vendors and the need for ensuring continuity of relocation sewage treatment. The majority of impacts will arise during the construction phase. The most significant impacts may arise from hazardous waste arisings and noise and dust arising from excavations which at one project site, is outside a school and a hospital. In the operation phase, with mitigation, including comprehensive training for the WWTP operators, it is anticipated that the environmental benefits of the project will be significant.

318 The project will have a number of positive environmental benefits:

i. **Environmental Sustainability & Energy:** It is possible that at times of low flow and with an increase in housing and industry, the impacts on the river arising from the current WWTP would become more significant with time and the environmental sustainability will be compromised. This is increasingly likely as the outdated waste water treatment technology becomes progressively more unreliable with age. Therefore the project will seek to improve the environmental sustainability of the WWTP. Environmental sustainability will also be improved through the use of more energy efficient technologies. The current WWTP is inefficient, wasting valuable energy resources. The introduction of efficient modern technology, such as improved sewage pumps, will mean significant energy savings, associated with which are savings in carbon emissions and resource use.

ii. **Industrial Development:** Darkhan is considered an industrial city in Mongolia, and the potential attraction of additional industries to the city, will increase the likelihood that industrial wastewater volumes will increase. Current and future industries will benefit from the WWTP as their effluent will be able to be treated centrally in the WWTP, following pre-treatment if needed.

iii. **Community Health and Safety:** The project will help to ensure that the safety of the community is not impacted upon by the potential health impacts associated with leaking sewer pipes, particularly when they are above ground, such as the emergency sewer pipe near the Secondary Pumping Station (Component A2). Component A2 will also include the installation of a cover on the inspection chamber which is currently covered only partially and temporarily, yet is outside a school entrance.

319 **Mitigation Measures:** Before construction starts, the contractor is required to develop a number of documents which will guide the construction process in order to reduce the likelihood of adverse environmental impacts:

i. Water Protection Management Plan
ii. Soil Erosion Management Plan
iii. Aggregate, Borrow Pits and Spoil Management Plan.
iv. Spill Management Plan
v. Hazardous and Non-Hazardous Waste Management Plan
vi. Health and Safety Management Plan (HSMP).

320 **Mitigation of impacts on soil:** The impacts on soil will be mitigated through a number of measures which will control the impacts in relation to (a) soil erosion, through managing slopes, cut faces and re-vegetation; (b) soil contamination through managing use and storage of potentially polluting materials; (c) borrow pits through appropriate siting and restoration.

321 **Mitigation of impacts on air quality:** Humans are the receptor most sensitive to dust. The mitigation measures to protect sensitive receptors from air quality issues include (a) management of stockpiles to reduce dust (b) good construction site practices to suppress dust (c) covering materials during transport (d) siting plant for production of concrete or pavement surfaces away from receptors.

322 **Mitigation of impacts on surface and groundwater:** In general the project will improve the quality of the surface. Potential impacts may occur through accidental release of pollutants therefore mitigation measures include (a) Adequate WWTP capacity to be maintained at all times (b) controlled storage and management of all chemicals and wastes (c) spill management plan to be developed.

323 **Mitigation of impacts from solid and liquid waste and resource use:** The potential impacts arising from solid and liquid waste production and disposal will be mitigated through a number of activities including (a) application of the waste hierarchy at all times (b) appropriate storage and containment of wastes including potential PCB wastes and PCB containing equipment which may be present in old transformers in the pumping stations; this will require a specific PCB assessment and management plan.

324 **Mitigation of impacts from construction noise:** Although noise can never be entirely eliminated, the potential noise impacts will be mitigated through measures which include (a) Source control: Maintaining all equipment in good working order (b) siting noise generating activities such as concrete mixing away from receptors (c) operating within reasonable times and in consultation with affected people.

325 **Mitigation of impacts on Community Health and Safety:** Potential impacts may arise at any construction sites, therefore the focus will be on clear signage, using machinery only in day light and where possible keeping members of the public out of construction areas.

326 **Mitigation of impacts on Occupational Health and Safety:** The civil works contractors will implement adequate precautions to protect the health and safety of construction workers and will appoint an Environment Health and Safety Officer (EHSO) to develop, implement and supervise a Health and Safety Management Plan (HSMP), as well as ensure that the requirements of the EMP are implemented.

327 **Potential indirect impacts - Traffic during Construction:** When the WWTP and related infrastructure is constructed, indirect impacts will result in potential longer journey times around the important market area in Old Darkhan. This will be mitigated through consulting with relevant *aimag* officers on the timing of the road excavation, and signage to warn motorists of when the road closures may be needed.

328 **Consultations during Project Preparation:** Consultations with potentially affected people and key experts were undertaken during the project preparation. In general the public support the project as many of the residents, particularly in ger areas, recognize the need for improved sanitation including an effective WWTP.

329 Consultations with experts provided baseline data for the project as well as advice and opinions on specific aspects of the project including technology issues and the Grievance Redress Mechanism. As a result, the project proposes a robust Grievance Redress Mechanism which has been approved by the Darkhan Uul *aimag* authorities.

## 7.4 Conclusion

330 The findings of this IEE show that the project will not have any significant, long term or irreversible impacts on the physical, biological or socio-economic environment. The project will have short term impacts during construction which can be mitigated to an acceptable level through mitigation measures which seek to reduce the potential for harm to the environment and human health. These measures relate primarily to implementing good construction practice as well as meeting the particular needs of the project area through consultation with affected people. Good practice through comprehensive training and appropriate technological design will also contribute significantly to reducing the operational impacts of the project.

331 The project will have significant positive environmental benefits. It will lead to improved water quality in the Kharaa river as the effluent quality from the WWTP will be significantly improved over the long term. In addition the use of modern technology and replacement of the outdated and broken equipment will lead to better sludge management which will benefit the environment and the residents of the city.

# 8 SOCIAL SAFEGUARDS DUE DILIGENCE

332 An assessment of the socio-economic conditions of the beneficiary community, and of the likely impacts of the project was carried out as part of the project preparation work. The social assessment is based on analysis of secondary data, and on primary data obtained through: (i) a household socio-economic survey of beneficiaries; (ii) extensive focus-group discussions with project stakeholders; and (iii) interviews with key informants.

## 8.1 Poverty Reduction and Social Strategy (PRSS)

333 The Poverty Reduction and Social Strategy also includes: (i) a Social Action Development Plan (SADP): (ii) a Consultation and Participation Plan (CPP); and (iii) a Stakeholder Communication Plan (SCP). During the development of the PRSS, links were established to the national poverty reduction strategy and Country Partnership Strategy. A poverty assessment and social analysis were carried out to determine project benefits, gender and development issues, participation and empowerment concerns, and social risks and vulnerabilities, based on the results of the household socio-economic survey conducted. This work also identified: (i) mitigating measurements to avoid negative socio-economic impacts; and (ii) resource requirements.

334 The following surveys and data collection activities were conducted to inform the development of the social strategies and plans: (i) a household socio-economic survey of ger area and apartment area households of Darkhan city (The Survey Report is included as Appendix V); (ii) in-depth interviews with project-related stakeholders; (iii) focus group discussion among project beneficiaries; and (iv) data collection and analysis of secondary information such as: national and local-level statistical data and survey reports conducted previously. The Poverty Reduction and Social Strategy (PRSS) is provided as Appendix W.

### 8.1.1 Main Findings and Emphasis of the PRSS

335 Links to the National Poverty Reduction Strategy and Country Partnership Strategy: The project is aligned with national strategies, such as Long-term National Development Strategies (consistent with achieving the Millennium Development Goals (MDGs)), and “Regional Development Concept of Mongolia”, “Mid-Term Strategy of Regions”, and “Law on Management and Coordination of the Regional Development” of 2001 and 2003. According to the regional development concept of Mongolia, Darkhan city is a pillar center of the Central Region of Mongolia. The focus of the project on wastewater treatment and wastewater management improvement for Darkhan city is aligned with the Mongolian Government Action Plan for 2012-2016 approved by the Parliament of Mongolia on 2012. This identified Darkhan city as priority industrial center in the framework target of “Employed Mongolians for sufficient income”. It is also in line with the Action Plan for 2012-2016 of the Governor of Darkhan-Uul Aimag.

336 Poverty Incidence in Darkhan-Uul aimag and Darkhan city: The poverty measure of headcount ratio, which simply counts all the people below a poverty line, was 26.0 percent in 2011, which had decreased by 3.6 points compared to 2003.[75] This means that 26.0 percent of the total population or over one quarter of Darkhan city population lived below the poverty line in 2011. This is slightly lower when compared to average poverty headcount ratio of the whole of Darkhan-Uul aimag and of the Central region[76].

337 The minimum standard of living (poverty threshold) in Darkhan-Uul aimag was pegged at 117,500 tugrugs per capita per month as of 1st April 2012[77]. With the average size of the household at 4, the minimum standard of living (MSL) per household on a monthly basis is 470,000 tugrugs or 5,640,000 per year. The results of the household socio-economic survey suggest that the poverty

[75] “Millennium Development Goals and Poverty Map 2011: Region, Aimag, Soum and District Level Results” Harold Coulombe and Gereltuya Altankhuayag. National Statistical Office and UNDP, 2012.
[76] The other aimag centers with lower poverty incidence are: Dornogovi – Sainshand (15.9%), Umnugobi – Dalanzadgad (11.9%), Bulgan – Bulgan (22.3%), Bayan-Ugii – Ulgii (17.8%), and Uvs – Ulaangom (16.6%).
[77] http://www.infomongolia.com/ct/ci/3743/56/MinimumStandardofLivingwasrenewed.

incidence in the Darkhan city is currently 26.5%, where the poor earn an average monthly income of 3,642,642 tugrugs, way below the MSL for Darkhan-Uul aimag. For ger area households, poverty incidence is recoded at 44.0%, while it is 9.0% for apartment area households.

### 8.1.2 Project benefits:

338 Projects will impact household income and wellbeing of Darkhan city residents through the following mechanisms which provide the benefits of the project:

i. **Effectiveness of the Water Supply and Sanitation Company (Darkhan Us Suvag JSC):** The operating loss of the Darkhan Us Suvag JSC increases year by year. Sustainable service provision requires both improved management and tariff increase. Price increases for services provided by public utilities will increase household expenditure and thus impact negatively on household welfare.

ii. **Extension of business activities:** The current status of sanitation services influences business activities of both private and public enterprises. Due to deficiencies in the sewerage system, pipes fill up and blockage of wastewater flows is a regular occurrence. Consequently, almost every business unit needs to employ a plumber or pay for this service privately to solve frequent wastewater blockage issues. Improvement of the sanitation service will save these additional costs to businesses, and provide the opportunity to spend this cost for extension of their business.

iii. **Improvement of health condition:** Inefficient operation of sanitation services causes water and soil pollution, and increases the probability of water-based diarrhoeal diseases. The project will help save costs currently paid by households to treat water-borne and water-related diseases to doctors and public health centres.

iv. **Pleasant environment for residents:** Frequent wastewater flooding outside and in the basement of the apartment blocks and other buildings creates unpleasant and unhygienic conditions for neighbourhood residents. The project will help address this issue and thus create improved conditions for recreation, playing and walking, and of the immediate living environment.

v. **Improvement of the Kharaa river ecology:** The existing dilapidated and dated equipment cause frequent and significant overflows polluting the Kharaa river basin with negative environmental impacts in terms of water pollution and negative impact on aquatics life.

### 8.1.3 Gender and Development:

339 The Project is classified as having some gender elements[78] (SGE) which resulted in significant efforts being made on gender issues during project preparation. At the outset of project implementation, the following measures should be taken: (i) incorporate gender concerns into the planning, design, and implementation of improvements to sanitation and wastewater management services; (ii) organize awareness campaigns among women of the impacted households on the importance of the project and provide training on the correct maintenance of sanitation facilities; and (iii) strengthen participation of women in project implementation.

### 8.1.4 Participation and Empowerment:

340 The following conclusions can be drawn from the results of the household surveys in respect of participation and empowerment issues:

i. Participation of residents in community activities is low, but they want to participate more in them.

ii. Participation of entrepreneurs and business in the process of project planning and implementation is crucial.

[78] http://www.adb.org/sites/default/files/guidelines-gender-mainstreaming-categories-adb-projects.pdf

iii. Willingness to pay for improved service can be enhanced if public awareness of wastewater issues is increased.

iv. There should be active and leading participation of the Apartment Owners Associations in the project planning and implementation process.

v. There needs to be organizational or institutional reform and regulation among participants in the sanitation service.

vi. Residents worry about environmental issues, and especially pollution of the Kharaa River, and are prepared to help to solve this problem.

vii. Residents have very little knowledge and information about the water supply and sanitation services of Darkhan city, and have not realized that there are problems.

### 8.1.5 Social Risks and Vulnerabilities

341 **Affordability of Improved Service Tariff:** Improvements to the WWTP will demand a significant amount of investment. To recover this investment cost will require an increase in tariff for the service. This could have a detrimental impact on the quality of life and welfare of households, and on operational costs of businesses. According to the WTP analysis, or Probit analysis, conducted on the survey results, the mean WTP for waste water treatment service per cubic meter was estimated in 1,076 MNT (vas a vis the current charge of 700 MNT).

342 **Weak Public Awareness and Participation:** According to the household socio-economic survey result, 80.0 percent of apartment area residents interviewed are satisfied with their current sanitation situation, while none of the ger area residents surveyed is satisfied with their current sanitation situation. Apartment residents don't realized that there are problems with the wastewater system, although other implementing parties realize that there are many issues associated with the provision of sanitation services in Darkhan city. There needs to be a well-designed and well-publicized public awareness campaign, and public relationship activities are required to increase public awareness. These activities should cover not only understanding of the importance of the project, but also education to customers on how to properly use and work with sanitation facilities.

343 There will also be other social risks, such as from **Unfair Labor Practices and Health Risks.**

### 8.1.6 Mitigating Measures: Social Action Development Plan

344 A Social Development Action Plan (SADP) was prepared which specifies the key activities required to mitigate the identified social risks and issues raised by the Project. A summary matrix is attached as Appendix X of the attached PRSS Appendix V. The proposed mitigating measures for the identified social impacts and risks are:

i. **Establishing Community Engagement Work:** Community Engagement Work should be carried out at the following three levels:

- **Residents' community engagement works**: For the apartment area residents, the main stakeholders will be the Apartment Owners' Associations. For the ger area households, community engagement should be organised through bagh governors' office and kheseg leaders.

- **Business entrepreneurs' engagement works**: For business entrepreneurs, the main stakeholders will be branches of Commerce and Industry Chamber, and Mongolian Employers Federation of Darkhan-Uul aimag, as the main business representative organizations.

- **Other civil societies or non-government organizations' engagement works:** Civil societies will include non-government organizations for environment protection and for urban development, and other NGOs with an interest in the sector.

ii. **Development and implementation of an intensive Information, Education and Communication (IEC) Strategy:** The overall stakeholder communications strategy (SCS) for the project will involve the establishment of a system for information sharing and consultative activities in line with the Program's Consultation and Participation Plan and other social mitigation plans. The Stakeholder Communication Strategy is presented as Appendix 3 of the attached PRSS Appendix V. Aside from project details and mitigation plans, the IEC strategy will also include a design for creating awareness and/or to promote behavioural changes among the target sectors to include topics on: (i) health – the benefits of proper hygiene practices; (ii) behavioural changes – recommendation on how to work with sanitation facilities properly; (iii) environment – proper waste segregation at the households, and practice of the 3 Rs (reduce, reuse, and recycle) at the community level and among business entrepreneurs; and (iv) introduction and use of non-pollutive technologies on sanitation.

iii. **Integrating Community Needs in Project Design:** In the preparation and planning of the proposed infrastructure projects, integration of gender-specific and other community needs wil be mainstreamed into project design. The initial consultations will identify any design recommendations from residents' communities and business entrepreneurs. Any specific recommendations on the design should be revisited and reconsidered during the detailed engineering design stage.

iv. **Grievance Redress and Monitoring Mechanism:** The implementing agency, the Darkhan Us Suvag JSC, together with the resident and business community groups should track and process complaints and assess the extent to which progress is being made to resolve them. The monitoring and evaluation report database will include appropriate features for recording, monitoring, and resolving of feedback from target beneficiaries and affected persons. The Darkhan Us Suvag JSC should hire an independent or external reviewer of implementation of the investments to be conducted annually, including feedback from those who have used the facilities created.

v. **Mitigation of Risks on Labor:** Activities during the construction stage should be closely supervised by the implementing agency and community groups, and monitored by ADB to comply with national and international labour regulations, such as ensuring that at least minimum wages are paid, and ensuring safe working conditions for workers. The representatives of community groups should also provide support in the monitoring of construction activities and labour practices, based on core labour standards. This should in particular include: disallowing all forms of forced or compulsory labour, child labor, and discrimination in respect of employment and occupation.

vi. **Ethnic Minorities and Indigenous People**: Based on initial research results, all community members of Darkhan city are fully mainstreamed into the community and are highly unlikely to experience marginalization. The numbers in minority ethnic groups are small and it can be concluded are well-integrated into, and recognized as members of, the community. Thus, the proposed project is not expected to have impacts on indigenous peoples or ethnic minorities and as such is categorized as Category C under the Indigenous People's Policy Framework of the ADB. Thus no further action is required in this regard.

345 **Resource Requirements:** An indicative budget of US$ 50,000 is programmed for the implementation of activities detailed above under "social mitigation activities" and included in the Consultation and Participation Plan, Stakeholder Communication Strategy, and GAP, all of which will be integrated under the CAP for the Project. The breakdown of total indicative cost is presented in Appendix V.

## 8.2 Gender Action Plan (GAP):

346 As part of the GAP preparation, local gender and development policies, programs and institutions, and gender issues were evaluated. Project benefits to women were evaluated, and a gender action plan, and associated institutional arrangements, monitoring and evaluation system, and work plan were developed. The GAP is included as Appendix W.

347 A household socio-economic survey was conducted under the project preparation work, with a total of two hundred (200) households in Darkhan city interviewed. The majority of the households were headed by males (79.0%), with an average household size of 4. However, one of every five households (21.0%) was headed by females. The survey found that among all households, 53 percent of family members who are mainly responsible for sanitation issues of households are women. An awareness campaign needs to be implemented among main project beneficiaries, (the female residents of apartments and ger areas) to implement the project successfully and to ensure project sustainability and effectiveness. The project should organize public awareness campaigns containing recommendations on how to work with sanitation facilities such as: what can or can't be thrown down the toilet, to use oil-solvent agents for washing dishes etc.

348 Women are mainly responsible for water-related tasks and other responsibilities associated with household sanitation, health and hygiene, and should be consulted on appropriate design features. The design of the sanitation infrastructure and services should respond to the specific and varying needs of women and men, including physical amenities. The participation of women in community affairs at the residents' meeting was observed to be high, as shown by the number of women attendees in the meeting of the Apartment Owners Associations. However, there are generally more men chairmen in the Apartment Owners Associations. Equal involvement of women and men in project activities will be assured through the community action planning and consultations carried out throughout the implementation period of the project.

349 Addressing these gender concerns will entail close consultation and collaboration with women, from project design, through implementation, and into project operation and monitoring and evaluation. The general strategy proposed under the project is to ensure that the design features of the infrastructure will be gender-responsive, appropriate, and affordable to the target users.

350 Focus group discussions with community representatives from apartment areas and ger areas have identified the perceived gender impacts of the proposed wastewater improvement projects. For improved sanitation, the anticipated impacts of the project include: (i) reduced time and energy spent to solve sanitation-related issues, especially among women household members, thus more time for other household tasks or time for productive income-generating work; and (ii) better hygiene practices. The risk of women and children to infectious diseases and water-borne diseases, and consequently the medical costs resulting from these diseases, will be reduced due to improved performance of the wastewater management system. The improvement of the sewerage system will also reduce the risk of spread of contagious or communicable diseases brought about by improper collection, disposal, and treatment of domestic wastewater.

351 At the commencement of project implementation, measures should be taken to: (i) incorporate gender concerns into the planning, design, and implementation of the proposed improvements to wastewater services; (ii) organize awareness campaigns among women of impacted households on the importance of the project; (iii) carry out training on proper maintenance of sanitation facilities; and (iv) strengthen participation of women in project implementation. The executing agency (EA) for the project will be MCUD and implementing agency (IA) will be Darkhan Us Suvag JSC. Darkhan Us Suvag JSC may cooperate with the Social Development Division of Darkhan Aimag Governor's Office, Children and Family Development Division and related non-government organizations and civil societies. The detailed work plan for the GAP is presented at Appendix W.

## 8.3 Community Action Plan (CAP)

352 Initial consultations and discussions were conducted with community representatives related to project activities. The outcomes from these discussions were used for the development of a community involvement action plan for the project. These discussions also informed the design and implementation for the plan and determined the implementing arrangements, budgetary estimates, and monitoring and evaluation methodology. The CAP is provided as Appendix X.

353 There is a need for active involvement of communities representing each group of stakeholders. The goal of the Community Action Plan is to promote an inclusive waste water management improvement of Darkhan city through active involvement of impacted community members. Community involvement was mobilised during the project preparation stage and the CAP needs to

sustain this level of activity during subsequent phases of the project to sustain the involvement of the communities in the detailed design and implementation phases.

354 Inputs to the design of Project were gathered through Household socio-economic survey (for apartment households and ger area households); focus group discussions with representatives of apartment and ger area residents; and key informant interviews (or In-Depth Interviews) with key stakeholders including representatives of implementing entities, government agencies, business units and Apartment Owners Association.

## 8.4 Design and Monitoring Framework (DMF)

355 The design and monitoring framework (DMF) for the project has been developed to incorporate the results and findings from the socio-economic surveys. The DMF is included as Appendix J. The DMF is developed based on ADB's guideline "Project Performance Management System: Guidelines for Preparing a Design and Monitoring Framework", July 2007 Second Edition, Asian Development Bank. At the project level, the DMF also draws on the MfDR framework which is based on a participatory approach to project design, and adapting this to the logical framework.[79]

356 The analytical and planning process used to develop the DMF used the following three data collection methods to obtain the socio-economic baseline data: (i) Quantitative survey: Household Socio-Economic Survey of Darkhan City; (ii) Qualitative surveys: Focus Group Discussions (FGDs) about water supply and sanitation and wastewater management services among Darkhan city residents and In-Depth Interviews (IDIs) with related stakeholders; and (iii) Desk Review: Data collection and analysis on water supply and sanitation services and other related data from officials and other statistical information and surveys carried out by other stakeholders.

357 **Household Socio-Economic Survey:** A total 200 households, of which 100 households each were from ger areas and apartment areas were covered in the household socio-economic survey. The purpose of the household socio-economic survey was to: (i) determine the socio-economic status of project target households and their members; (ii) assess the current situation and customers' satisfaction with water supply and wastewater collection and treatment services; and (iii) assess willingness and ability to pay for improved wastewater management services. The main beneficiaries of the project are households living in apartments of the Darkhan city. Data collection through the survey was conducted from 23rd January to 28th January of 2014.

358 **Focus Group Discussion (FGD):** One FGD was conducted on 24th January 2014 at the training room of Darkhan Us Suvag JSC. A total 8 respondents, of which 4 respondents each were from ger areas and apartment areas participated in the FGD.

359 **In-Depth Interview (IDI):** IDIs were conducted from 23th January to 27th January 2014. A total of 12 respondents were interviewed individually. Information on the respondents is provided in Annex 1 of Appendix XX. The content of the IDI was focused on analysis for development of the DMF.

## 8.5 Land Acquisition and Resettlement Requirements and Plan

360 Appendix U presents the Land Acquisition and Resettlement Plan (LARP) for the Project Preparation Technical Assistance (PPTA) for the Preparation of a Wastewater Management Project for Darkhan city under the Urban Sector Development Project for Mongolia (Loan 2301-MON: UDSP ). The LARP has been prepared in accordance with applicable laws of Mongolia, the Asian Development Bank's (ADB) 2009 Safeguard Policy Statement (SPS) and Land Acquisition and Resettlement Framework (LARF) for the Loan 2301-MON: UDSP.

### 8.5.1 Project site and ROW

361 The project will improve the sewerage system of Darkhan city of Darkhan Uul aimag (Darkhan city) through: (i) renewing the central treatment facility; (ii) renovation of pump station of Shine Omnod industrial area and construction of 1.4km length sewerage pipeline which is planned to be

[79] "Project Performance Management System: Guidelines for Preparing a Design and Monitoring Framework" July 2007, Second Edition. Asian Development Bank.

constructed at the east side of the railway; (iii) renovation of 2nd pump station and 200m sewerage pipeline, and (iv) 600 m length sewerage pipeline in 5th bag area. The sewerage system will benefit around 80 000 residents Darkhan city. In order to minimize resettlement impact, the right of way (ROW) of the pipelines, which traverse the project areas in various directions, will be reduced to 5m in accordance with the Construction Standard and Rules of Mongolia for Water Supply, External Networks and Structures BNBD 40-02-06 once the detailed design prepared.

### 8.5.2 Scope of Resettlement Impact

362 Only some portions of the sewerage pipelines right-of-way will involve land acquisition and resettlement; other portions will be constructed on either public land or possessed land by Darkhan-Us Suvag agency. A total of 8 affected entities including two small enterprises, three commercial entities and three state budget institutions will be affected by land acquisition and resettlement. Of the 8 affected entities, 5 affected entities were enumerated in the socioeconomic survey. 5 affected entities will lose a total of 2711.1$m^2$ of land and all these losses are partial, all plots are possessed by the state institutions and private companies. No residential land or structures will be affected by the project. Fences and gates totaling 112m in length and belonging to 3 affected entities will need to be moved or replaced. Other affected structures include 2 entrance ways to the food shop and hair and beauty salon, speed bump and an advertisement board.

### 8.5.3 Indigenous People and Gender Impact

363 Indigenous people, i.e. tribal communities existing outside the cultural and legal mainstream of Mongolian society, are not present in the Darkhan city project site. Therefore, the ADB Policy on Indigenous People will not be triggered by this subproject. Adverse differential gender impact by the project on either men or women is not expected.

### 8.5.4 Legal and Policy Framework

364 Land acquisition and resettlement by the government for projects in urban areas is based on negotiation and contracts with affected persons according to the Civil Code of Mongolia. The ADB SPS recognizes negotiated LAR as long as there are willing and free buyers and sellers and eligibility and entitlements are clearly defined and agreed. All APs are eligible for entitlements, as stipulated in the LARF for the Project, including owners, possessors, users, legalizable occupants, non-titled occupants and lessees. The eviction of unlicensed APs is a violation of the ADB SPS. The eligibility and entitlements for specific types of losses in the project are summarized in the Entitlement Matrix in Table 5 of this RP.

### 8.5.5 Consultation and Grievance Redress

365 Information, consultation and participation of APs are ensured through individual and public meetings throughout the RP preparation and implementation process. To date one public meeting to prepare the APs for resettlement was held in October 2013. A four-step grievance mechanism with a clearly defined timeline of 5 weeks for each case has been established and a Grievance Action Form initiating and tracking the grievance process for each complaint prepared.

### 8.5.6 Institutional Arrangements and Monitoring

366 The Working Group for land acquisition and resettlement will be established prior to commencement of civil work which will be responsible for the implementation of the project RP. With the support of the PIU, the WG assists and ensures resettlement safeguard compliance prior to any resettlement, or the award of civil works contracts. Close coordination and commitment between all stakeholders are facilitated by the participation of the WG members.

### 8.5.7 Compensation Strategy and Budget

367 Losses of land and structures, as well as transaction and relocation costs for each AP are covered. The budget for resettlement in the Darkhan city project is expected to amount to **MNT 78,116,172** or **USD 45,313.9** for compensation, administration and contingency costs as well as for monitoring costs which will be funded from state government resources.

# 9 INVESTMENT COST AND FINANCING PLAN

## 9.1 Investment Cost

368 The project cost components are prepared based on technical design concepts that considered both existing and future demands in Darkhan Uul. Four technical options that combine new and existing technologies are being considered for the project. Cost estimates have been prepared for each based on available market price information, updated to suit local conditions. The cost estimation for the proposed project components follows the calculation of the dynamic prime cost as applied in ODA projects. The project cost components are discussed below.

- Civil works. Includes the costs of the construction of fixed and temporary works, auxiliary works, temporary buildings on site for living and construction management. Construction cost is based on bill of quantities for conceptual design, other estimated quantities and appropriate construction unit prices.

- Materials and equipment. Includes the costs of planned equipment and materials, including transportation cost from ports of production to the site, storage costs, and insurance fees. Equipment costs are based on quantities, types and market prices at the time of project cost preparation (Q3 2013).

- Institutional reform and capacity building. Formal and on-the-job training to improve general and financial management, including procurement capacity development at the levels of aimag and PUSO, and capacity upgrade in MCUD, and appurtenant costs. Training and seminar costs include costs for consultants, participants and all incidentals.

- Project management support. Includes organization and project management costs, calculated according to issued cost norms for project management and consulting services of construction projects in Mongolia.

- Start-up and adjustment works. Working capital required to initialize project operation. Funds are provided for the administration and maintenance of the start-up phase. A set of tools and materials have been included in the estimates.

- Taxes and duties. Includes VAT and custom duties. VAT is calculated on current rate at 10% based on Mongolian VAT Law. Duties on imported materials and equipment is calculated at 5% per Mongolian law for customs and duties. All project taxes will form part of and paid by GOM contribution to project financing (Refer to project financing and investment plan).

- Physical contingencies: Covers physical adjustments for unforeseeable works during project implementation. Physical contingencies are assumed at 5% for foreign cost components and 15% for local cost components.

- Price contingencies. Covers allowance for price inflation during project implementation. Local inflation rates applied in the evaluation are based on ADB published rates (Staff estimates): 2012, 15%, 2013, 9.5%, 2014, 10%, and 2015 onward, 8%. Foreign inflation conforms to the ADB and World Bank projected indexes (October 2013): 2012 at 2.7%, 2013, -1.6%, 2014, 2.3%, 2015, 1%, and 2016 onward, 1.4%. Foreign exchange rate is $1.00:MNT 1,690 (as of end October 2013). The base price used is at MNT 1,520 (as of August 2013), adjusted to current rate.

- Financial charge during implementation (FCDI). This refers to interest during construction (IDC) and commitment charge, when required by specific loan terms[80].

- Other costs. Includes reinvestments for electro-mechanical equipment to be replaced during the evaluation period 2014-30; and the residual value of the investment components still to be used beyond the period have been incorporated in the financial and economic projections. Replacements arising during operational period will be treated as capital expenditures to be financed by Us Suvag using own resources and thus do not form part of the project investment cost estimates.

369 Table 9.1 presents the total investment requirement amounting to MNT 34,920 million ($ 20.66 million).

**Table 9.1 Project Cost Estimates**

| Item | (MNT Million) | | | ($ Million) | | | % of Total Cost |
|---|---|---|---|---|---|---|---|
| | Foreign Currency | Local Currency | Total Cost | Foreign Currency | Local Currency | Total Cost | |
| **A. Investment Cost** | | | | | | | |
| 1. Wastewater Treatment Plant | 20,573 | 4,774 | 25,347 | 12.17 | 2.83 | 15.00 | 73 |
| 2. Pumping Stations and Sewers | | | | | | | |
| 2.1. Pump Stations | 1,480 | 164 | 1,645 | 0.88 | 0.10 | 0.97 | 5 |
| 2.2. Sewers | 711 | 474 | 1,184 | 0.42 | 0.28 | 0.70 | 3 |
| Subtotal (2) | 2,191 | 638 | 2,829 | 1.30 | 0.38 | 1.67 | 8 |
| 3. Project Management Support and Capacity Development | | | | | | | |
| 3.1. PMS, Design and Capacity Development | 2,002 | 222 | 2,224 | 1.18 | 0.13 | 1.32 | 6 |
| 3.2. PMU and PIU Support | 736 | 82 | 818 | 0.44 | 0.05 | 0.48 | 2 |
| Subtotal (3) | 2,738 | 304 | 3,042 | 1.62 | 0.18 | 1.80 | 9 |
| **Subtotal (A)** | **25,502** | **5,717** | **31,219** | **15.09** | **3.38** | **18.47** | **89** |
| **B. Contingencies** | | | | | | | - |
| 1. Physical | 765 | 171 | 937 | 0.45 | 0.10 | 0.55 | 3 |
| 2. Price | 1,492 | 118 | 1,609 | 0.88 | 0.07 | 0.95 | 5 |
| **Sub-total (B)** | **2,257** | **289** | **2,546** | **1.34** | **0.17** | **1.51** | **7** |
| **C. Financing Charges During Implementation** | | | | | | | |
| 1. Interest During Construction | 1,104 | - | 1,104 | 0.65 | - | 0.65 | 3 |
| 2. Commitment Fees | 88 | - | 88 | 0.05 | - | 0.05 | 0 |
| **Sub-total (C)** | **1,192** | **-** | **1,192** | **0.71** | **-** | **0.71** | **3** |
| **Total Project Cost (A+B+C)** | **28,951** | **6,006** | **34,957** | **17.13** | **3.55** | **20.68** | **100** |

Source: TA Consultant.

## 9.2 Financing Plan

370 The proposed improvement of the WWTP systems and the institutional development, start-up costs and consulting services will be financed by a loan from the ADB of MNT 31,265 ($18.5 million) or 89% of total financing, and contribution from the Government of Mongolia of MNT 3,684 million ($2.18 million) or 11% of total. Table 9.2 presents the details of the financing plan.

[80] These costs are calculated according ADB Technical Note on Preparation and Presentation of Cost estimates for Projects. Following the main LA 2301 terms, where Asian Development Fund (ADF) was applied, commitment charge is waived in the project cost estimation.

**Table 9.2 – Project Financing Plan, in $ million**

| Item | Total Cost | ADB Amount | ADB % Cost Category | Darkhan Aimag Amount | Darkhan Aimag % Cost Category |
|---|---|---|---|---|---|
| **A. Investment Cost** | | | | | |
| 1. Wastewater Treatment Plant | 15.00 | 13.33 | 89 | 1.67 | 11 |
| 2. Pumping Stations and Sewers | | | | | |
| 2.1. Pump Stations | 0.97 | 0.85 | 87 | 0.12 | 13 |
| 2.2. Sewers | 0.70 | 0.64 | 91 | 0.06 | 9 |
| Subtotal (2) | 1.67 | 1.49 | 89 | 0.19 | 11 |
| 3. Project Management Support and Capacity Development | | | | | - |
| 3.1. PMS, Design and Capacity Development | 1.32 | 1.20 | 91 | 0.12 | 9 |
| 3.2. PMU and PIU Support | 0.48 | 0.44 | 91 | 0.04 | 9 |
| Subtotal (3) | 1.80 | 1.64 | 91 | 0.16 | 9 |
| **Subtotal (A)** | **18.47** | **16.45** | **89** | **2.02** | 11 |
| **B. Contingencies** | | | | | |
| 1. Physical | 0.55 | 0.49 | 89 | 0.06 | 11 |
| 2. Price | 0.95 | 0.85 | 89 | 0.10 | 11 |
| **Sub-total (B)** | **1.51** | **1.34** | **89** | **0.16** | **11** |
| **C. Financing Charges During Implementation** | | | | | |
| 1. Interest During Construction | 0.65 | 0.65 | 100 | - | - |
| 2. Commitment Fees | 0.05 | 0.05 | 100 | - | - |
| **Sub-total (C)** | **0.71** | **0.71** | **100** | **-** | **-** |
| **Total Project Cost (A+B+C)** | **20.68** | **18.50** | **89** | **2.18** | **11** |

Source: TA Consultant.

**Table 9.3 Project Financing Plan in MNT million**

| Category/Item | ADB Loan Amount | ADB Loan Category % | Government Amount | Government Category % | Total Investment | % Total Investment |
|---|---|---|---|---|---|---|
| **A.1. Wastewater Treatment Plant** | | | | | | |
| Civil Works | 7,041 | 100% | - | 0% | 7,041 | 20% |
| Equipment | 11,182 | 100% | - | 0% | 11,182 | 32% |
| Resettlement | - | 0% | - | 0% | - | 0% |
| Environmental Monitoring | - | 0% | - | 0% | - | 0% |
| Taxes and Duties | - | 0% | 2,733 | 100% | 2,733 | 8% |
| **Subtotal (A.1)** | **18,223** | **87%** | **2,733** | **13%** | **20,956** | **60%** |
| **A.2. Infrastructure Rehabilitation/Replacement** | | | - | | | |
| Civil Works | 2,043 | 100% | - | 0% | 2,043 | 6% |
| Equipment | - | 0% | - | 0% | - | 0% |
| Resettlement | - | 0% | - | 0% | - | 0% |
| Environmental Monitoring | - | 0% | - | 0% | - | 0% |
| Taxes and Duties | - | 0% | 306 | 100% | 306 | 1% |
| **Subtotal (A.2)** | **2,043** | **87%** | **306** | **13%** | **2,349** | **7%** |
| **B. Institutional Reform & Capacity Development** | | | - | | | |
| Capacity Building (MCUD, Aimag/Us Suvag) | 2,452 | 100% | - | 0% | 2,452 | 7% |
| Taxes and Duties | - | 0% | 368 | 100% | 368 | 1% |
| **Subtotal (B)** | **2,452** | **87%** | **368** | **13%** | **2,820** | **8%** |
| **C. Project Management Support** | | | - | | | |
| Design and Supervision, PIU Establishment, Tendering | 1,457 | 100% | - | 0% | 1,457 | 4% |
| Taxes and Duties | - | 0% | 219 | 100% | 219 | 1% |
| **Subtotal (C)** | **1,457** | **87%** | **219** | **13%** | **1,676** | 5% |
| **Total Base Cost (A+B+C)** | **24,174** | **87%** | **3,626** | **13%** | **27,801** | **80%** |
| **D. Contingencies** | | | | | | |
| Physical | 2,224 | 100% | - | 0% | 2,224 | 6% |
| Price | 3,705 | 100% | - | 0% | 3,705 | 11% |
| **Subtotal (D)** | **5,929** | **100%** | **-** | **0%** | **5,929** | **17%** |
| **E. Financial Charges During Implementation** | | | | | | |
| Interest Charges and Fees | 1,190 | 100% | - | 0% | 1,190 | 3% |
| **Subtotal (E)** | **1,190** | **100%** | **-** | **0%** | **1,190** | **3%** |
| **Total Investment Cost (A+B+C+D+E)** | **31,293** | **90%** | **3,626** | **10%** | **34,920** | **100%** |

# 10 PROJECT IMPLEMENTATION ARRANGEMENTS

## 10.1 Approach to Project Execution and Implementation

371 The Ministry of Construction and Urban Development of the GOM will be the Executing Agency (EA) of the Project, supported by the existing Project Management Unit (PMU) of the Urban Sector Development Project for Mongolia (Loan 2301-MON) which will extend its existing responsibilities to include the proposed Investment Project. The PMU will continue to be headed by a Project Coordinator (PC). MCUD will be responsible for overall strategic guidance, technical supervision, and execution of the Project and ensuring compliance with loan covenants. The state-level Project Steering Committee (PSC) established for the Urban Sector Development Project for Mongolia (Loan 2301-MON) will provide overall policy guidance on the project and will have full powers to take decisions on matters relating to Project execution. The Project Coordinator is the Member Secretary and the committee is chaired by the State secretary of MCUD. Members of the committee include the Director MED, Director MOF, representatives of the Ministries of Environment and Green Development and Industry and the aimag government of Darkhan-Uul. Once the Project is made effective, the PSC will meet at regular intervals (at least once every 3 months) to review project performance and take decisions on major issues, such as, counterpart funding, implementation bottlenecks, land disputes, special procurement, policy reforms, etc.

372 Implementation of the Urban Environmental Improvement Components (Parts A1 and A2) of the project will be carried out by Us Suvag on behalf of the Darkhan-Uul aimag government with assistance from MCUD. At the aimag level, MCUD will establish a Project Implementation Unit (PIU) in Darkhan-Uul, headed by a senior engineer or technical specialist experienced in environmental engineering, wastewater management construction and equipment installation as the PIU Project Director. The Director will be responsible for the day-to-day implementation of the respective physical works and equipment packages. Implementation of the institutional reform and capacity development, and project management and implementation support parts of the project (Parts B and C) will be managed by MCUD through the PMU and with assistance from the PMU management support consultants.

373 During the project design period, the PMU, in discussion with MCUD, Darkhan-Uul aimag government and Darkhan Us Suvag will determine the detailed arrangements for operation and maintenance of assets created under the project. Through this process, agreement will be reached on which activities will be retained by Us Suvag as those for which they are directly responsible, and those for which they will retain an oversight, supervisory and management role, but which will be contracted out. In addition, discussions will be held with the local community surrounding the treatment plant to explore opportunities for members of the local community to be involved in simple maintenance tasks for the treatment plant area (landscape maintenance, dried sludge reuse or resale as fertilizer, and possibly fish farming in maturation ponds). This agreement will confirm the roles and responsibilities during plant operational phase for:

i. Darkhan-Uul aimag government

ii. Darkhan Us Suvag

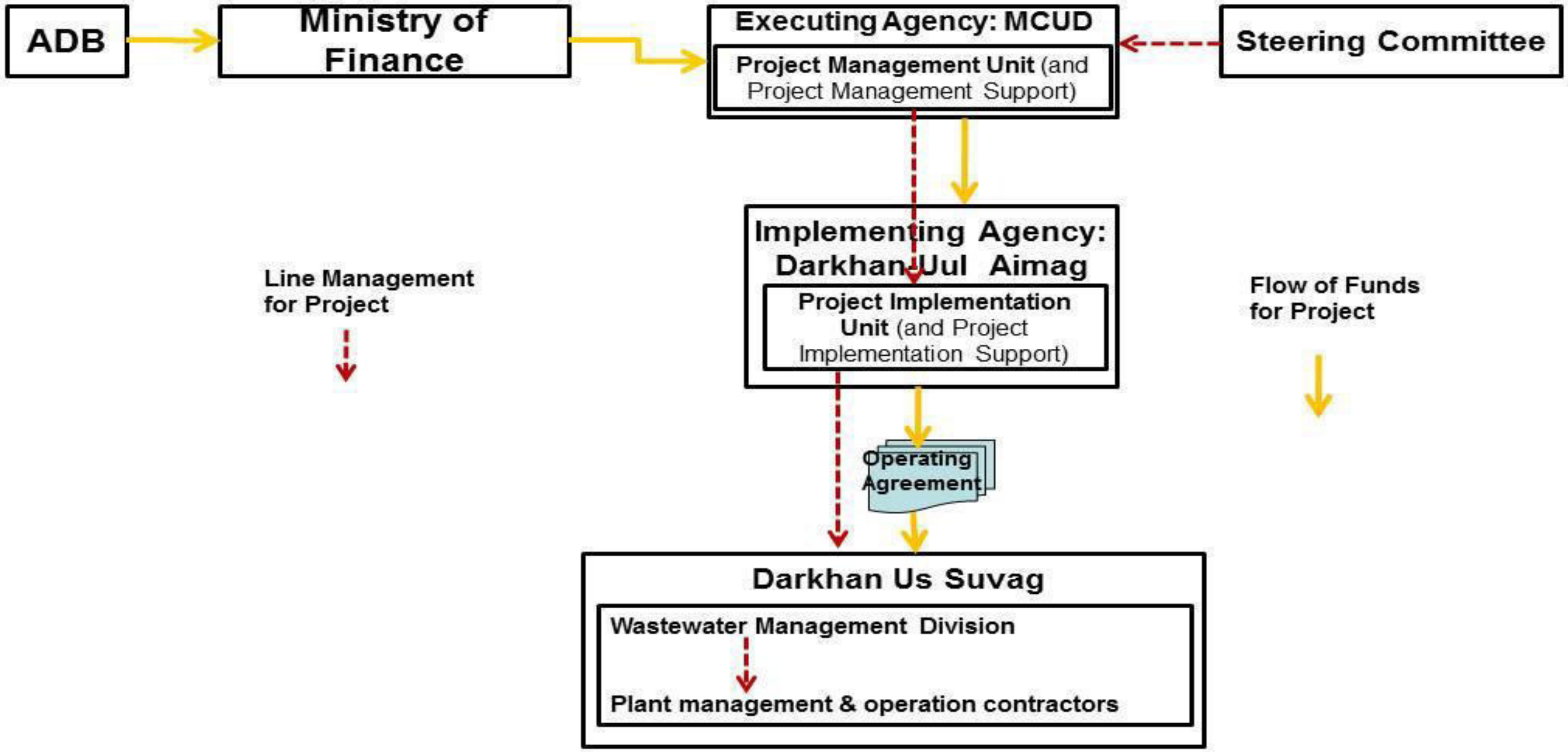
iii. Contractor for construction and installation of the WWTP

iv. A contracted private sector operator to manage overall plant operations

v. Local community group for maintain site landscape

374 Figure 10.1 below indicates the proposed project management and implementation arrangements and the flow of funding under the project. Further details of proposed execution and implementation arrangements are provided at Appendix O.

**Figure 10.1: Basic Project Implementation Arrangements**



## 10.2 ADB

375 The ADB will take the following roles in supporting execution and implementation of the project:

i. The Mongolian National Resident Mission (MNRM): Will take responsibility for overall supervision and administration of the loan project and review of contract documentation requiring prior review, with assistance from ADB head office on review of contract documentation relating to the wastewater treatment plant;

ii. Mount supervision missions to include: a review of project progress against milestones, a review of compliance with project assurances, and an assessment of compliance with due diligence requirements;

iii. Manages the proposed technical assistance for oversight and third party quality assurance of the design, tender and construction of the WWTP.

## 10.3 GoM: MoF, MoED and MCUD

376 MCUD is the executing agency for the project through a PMU which it is recommended should be the PMU currently responsible for the execution of the Urban Sector Loan 2301-MON. The PMU and State Government ministries would be responsible for the following activities:

i. PMU facilitates the process for MCUD to enter into a sub-project agreement with Darkhan-Uul aimag for the Project;

ii. PMU facilitates the process for MoF to enter into a sub-loan agreement with Darkan-Uul aimag for the Project loan (or a portion of the loan as agreed between the State Government (MoED and MoF) and Darkhan-Uul aimag;

iii. MoED approves the investment and, in co-ordination with MoF, carries out ministerial administration of the loan documentation;

iv. MCUD through the PMU is responsible for overall execution and high-level supervision of part A of the project (with a stronger role in implementation of Part A1 – the WWTP – of the Project), and implementation of parts B and C of the project.

## 10.4 Darkan-uul Aimag

377 Darkan-Uul aimag is the implementing agency for the project. Through the office of the aimag administrator carries out the following activities:

i. In collaboration with Us Suvag and the PMU, creates a Project Implementation Unit (PIU) with overall responsibility for project implementation;

ii. Enters into a sub-project agreement with MCUD;

iii. Enters into a sub-loan agreement with MoF:

iv. Enters into an on-lending agreement with Darkhan Us Suvag;

v. Monitors project implementation and ensures compliance with environmental, social and resettlement due diligence requirements.

## 10.5 PUSO - Us Suvag

378 Us Suvag is ultimate operator of assets created under the project and is responsible for the following:

i. In collaboration with Darkhn-Uul aimag and the PMU, creates a Project Implementation Unit (PIU) with overall responsibility for project implementation;

ii. Enters into an on-lending agreement with Darkan-Uul aimag for project elements as agreed between the two;

iii. Through the PIU, takes primary responsibility for implementation of parts A1 and A2 of the project;

iv. Is the primary recipient of parts B and C of the Project

# 11 PROCUREMENT PLAN OUTLINE

## 11.1 Project Procurement Approach

379 Wastewater treatment plants rely on sensitive bio-chemical processes and can present operation challenges, particularly in harsh climates such as Darkhan. Furthermore, the potential damage to the environment of process failure is high. To reduce this risk, it was initially proposed to investigate the possibility of the adoption of a design-build-operate-transfer (DBOT) modality for procurement. It is understood that a set of standard contract documents for such modalities are under formulation by the Government of Mongolia with the assistance of the ADB. Furthermore, such an approach has recently been adopted by Government in the tender for the construction of a new WWTP at Nisekh on the edge of Ulaanbaatar.

380 The “traditional” approach to wastewater treatment plant development involves a number of separate procurement actions and contracts: (i) an engineering company carrying out design, (ii) a separate construction company carrying out construction; (iii) probably a third company providing equipment (preferably, but not always, in consortium with the civil works contractor); a fourth company supervising construction, installation and commissioning (which may or may not be the design engineer); and (v) the owner accepting and then operating the system. At the interface between these actors there are frequently problems – and when things go wrong, money and time has to be spent to apportion blame and damages. The government takes the full risk in this eventuality.

381 This may: (i) increase costs; (ii) cause delay; and (iii) compromise plant operation, adversely affecting treatment efficiency. This risk may be significantly mitigated, or even removed by the adoption of a DBOT modality where one entity (a consortium leader) takes responsibility for designing, constructing and operating the plant according to the employer’s requirements. In this case, the employer (Darkan Us Suvag) is only looking to the designer, builder and operator to achieve an approved quality of effluent within a set of operating requirements and for a given unit cost – which could still be apportioned between capital and operating. Furthermore, since the treatment plant will be subject to international tender, this would be governed by FDIC tender procedures. Tendering according to FIDIC Yellow Book could allow tenderers to propose alternative technologies to that proposed in the tender documents for consideration during the design phase of the project.

382 Both the National Government (MCUD) and the Darkhan-Uul aimag government have expressed support for this approach. However, the benefits of such a procurement modality must be offset against possible disadvantages. These include: (i) the possibility that competition will be restricted by the specification of performance which only a few suppliers of a particular treatment technology are able to achieve; and (ii) the relatively strong regulatory environment and evaluation and management capabilities, and need for strong analysis and understanding of commercial risk and its attribution required to successfully complete such a transaction. It can be argued that the market within Mongolia is not yet mature enough to entertain DBOT implementation options. As things stand, obtaining the relevant approvals for designs and construction follows a rigid format with little opportunity for variation and change. This reflects the historical legacy of the centrally–planned approach to construction processes. If the usual trajectory for such changes is followed, it may be some years before the market matures within Mongolia to entertain works of this nature being completed under DBOT arrangements.

383 In view of the above, and the fact that the Government (MCUD) has elected to carry out the detailed design services using their own funding, tender for the wastewater treatment plant will be carried out under international competitive bidding rules to include construction, equipment supply and operational assistance. Under the proposed procurement arrangements, tenderes will be required to present detailed information on the specification of equipment to be supplied and installed as part of the bid.

384 Procurement financed from the ADB loan will be carried out in accordance with ADB's Procurement Guidelines (February 2007, as amended from time to time). International competitive bidding (ICB) will be applied to supply contracts estimated to cost $1 million or more. Supply contracts with a value less than $1 million will follow national competitive bidding (NCB), and those less than $100,000 will follow shopping procedures as reflected by particular circumstances of the contract packages. ICB will be used for civil works contracts valued at $1 million or more. Civil works contracts valued less than $1 million will be procured using NCB procedures. The selection and engagement of contractors will be subject to ADB approval. Before commencement of NCB procurement, ADB and the Borrower will review the Borrower's procurement procedures to ensure consistency with ADB requirements. Any necessary modifications or clarifications to the Borrower's procedures will be documented in the procurement plan. Any internationally tendered equipment packages will include the necessary technical support for ensuring proper installation, testing, commissioning, and training of operational staff as part of the related contracts. In accordance with ADB requirements, foreign contractors may participate in bidding for NCB contracts.

385 The procurement plan is provided below in Table 11.1. It is suggested that the contracts are bundled to the extent possible to reduce procurement risk and minimise the number of contracts – thus simplifying project management and reducing risk for the client. This means that: (i) the large contract for the wastewater treatment plant would include all civil works, equipment procurement and installation, commissioning and operational assistance. For the rehabilitation of the pumping stations, the supply of pumps and other equipment is rolled into the civil works contracts for the pump station rehabilitation since this will ensure that the contractor takes full responsibility for delivery and commissioning of a fully functional facility.

386 For packages tendered adopting NCB procedures, the first package will be previewed by the ADB. Subsequent packages will be subject only to post-tender review by ADB.

387 The MCUD through the PMU will establish a Tender Evaluation Committee for the project comprising a Chairman, secretary and members. Under the Procurement Law of Mongolia, in order to ensure transparency in the procurement process, at least two members representing related sectoral professional associations; the private sector; or non-governmental organization; a citizen appointed by the respective Citizen's Representative Khural; and an official from the respective Governor's Office shall be included on the tender evaluation panel. In addition a representative from Us Suvag should be included since it will be they who eventually have to accept the assets created and operate and maintain them.

**Table 11.1: Procurement Plan**

| Bid Package No. | Contract Description | Base Cost ($ million) | Method | Expected Date of Advertisement | Prior Review (Y/N) | Procurement Type |
|---|---|---|---|---|---|---|
| **Part A: Civil Works and Equipment Procurement and Installation** | | | | | | |
| **Part A1** | Rehabilitation of existing units and configuration of existing treatment plant to accept wastewater flow; rehabilitation of structures and reconfiguration to IFAS treatment system; provision, installation and commissioning of all equipment; and operational advice for 3 years | 12.4 | ICB | January 2015 | Y | Works and Equipment |
| **Part A2** | | | | | | |
| Pack. 1 | Pump station repair works, new duty and standby pumps, and 6kw power distribution networks at: (i) primary "new" pumping station at industrial estate and (ii) secondary pumping station in old Darkhan | 0.84 | NCB* | May 2015 | N | Works and Equipment |
| Pack.2 | Tertiary sewers at: (i) primary "new" south pumping station: 1,400m x 1 m dia.; and (ii) at old Darkhan hospital No. 2: 300m x 0.3 m dia.; and bypass main at secondary pumping station: 100m x 0.8 m dia.; | 0.55 | NCB* | May 2015 | N | Works and Equipment |
| **Part B: Organisational and Human Resource Development, and Institutional Reform** | | | | | | |
| B1 | Organizational and Human Resource Development (OHRD) and Capacity Building support for Darkhan-Uul government and Us Suvag; support to Us Suvag on institutional reform towards service delivery focus. | 1.3 | QCBS | March 2015 | Y | Consulting services |
| B2 | Creation, Development and Support to Us Suvag on creation of a ger area development support unit | 0.26 | QCBS | March 2015 | Y | Consulting services |
| **Part C: Project Management Support** | | | | | | |
| C1 | Project management support and quality assurance during design and tendering, and supervision support during construction and commissioning of the WWTP | 0.50 | ICS | July 2014 | Y | Consulting services |
| C2 | Project Management Support to PMU and PIU on project management, procurement and supervision, and pump station and sewer rehabilitation design. | 0.50 | QCBS | December 2014 | Y | Consulting services |
| C3 | Project Benefit Monitoring and Evaluation (PBME) | 0.10 | QCS | March 2015 | Y | Consulting services |

ICB = international competitive bidding, ICS = individual consultant selection; NCB = national competitive bidding, QCBS = quality- and cost-based selection; Y/N = yes/no.
First Package subject to prior review

# 12 RISK ASSESSMENT

## 12.1 Project Risks

388 The main risks to: (i) timely project execution; and (ii) realisation of anticipated project outcomes, objectives are benefits are considered to be as follows:

i. The technology adopted for the wastewater treatment plant: Darkhan provides a harsh construction and operational environment for new and more sophisticated treatment technologies. Poor choice of technology or poor quality construction and equipment installation will compromise treatment system performance;

ii. Limited procurement capacity compromises tendering: Darkhan-Uul aimag and Darkhan Us Suvag have limited procurement capacity and no experience in procuring works and equipment of this size and level of sophistication;

iii. Insufficient project management skills and experience compromises project quality: Darkhan-Uul aimag and Darkhan Us Suvag have limited project management and supervision capacity and no experience in managing and supervising procuring works and equipment of this size and level of sophistication;

iv. The operation of the wastewater treatment plant: Us Suvag is accustomed to operating a simple Activated Sludge Plant and the new treatment system in more sophisticated demanding greater operational skills. Poor operation will result in increased operational costs and reduced treatment efficiency;

v. Inefficient operation or overload of WWTP due to divergence in flow: Pace and nature of development diverges from that projected resulting in greater or reduced wastewater flows than projected and/or changes in quality of wastewater, leading to inefficient or overloaded operation of WWTP;

vi. Poor cost recovery compromises sustainability: Us Suvag is currently running at a loss and this threatens securing an adequate operational budget for the new WWTP. Failure to implement improved financial management will threaten WWTP operation.

## 12.2 Risk Mitigation

389 Mitigation for the above risks:

i. Optimisation of design, equipment specification and treatment operation under Darkhan conditions will be ensured by providing a wastewater management specialist through technical assistance during design of WWTP by Government to quality assure the detailed design consultants and provide top management supervision and third party quality assurance through construction, commissioning and early stages of operation.

ii. Project procurement and management risks will be addressed by: (i) project execution arrangements which involve the MCUD in procuring the WWTP (with involvement of Darkhan Uul aimag and Darkhan Us Suvag); and (ii) provision of technical assistance to the PMU and PIU in procurement, project management and supervision.

iii. To ensure that Us Suvag is capable of operating the new WWTP, the construction contract will include a period of operational assistance and training to operational staff, and/or operation could be contracted out under a management contract for the Plant.

iv. To mitigate risks from shock loadings or over- or under-loading, the plant is designed to balance shock pollution loads (through the balancing tank) and the biological reactor is divided into three streams, each with a design loading of about 8,000 cum/day. Under higher loading conditions three stream can be operated, or under lower operating conditions two or even one stream. In addition, Us Suvag will be strengthened in order to enforce national discharge standards for industries disposing of their effluent into the public sewer.

v. To ensure sufficient resources remain available for optimal operation of the sewage treatment plant, technical assistance will be provided to assist Us Suvag in the development and implementation of an institutional strengthening and reform road map and action plan for improved financial management and cost recovery.