GENERAL MOTORS DE MEXICO (GMM)
RAMOS ARIZPE AUTOMOTIVE COMPLEX (RAAC)
WATER CONSERVATION AND REUSE PROGRAM

Supporting material

Ramos Arizpe, Coahuila, MEXICO
February 26, 2001

GENERAL MOTORS DE MEXICO (GMM)
RAMOS ARIZPE AUTOMOTIVE COMPLEX (RAAC)
WATER CONSERVATION AND REUSE PROGRAM

1. INTRODUCTION

General Motors de Mexico (GMM) Ramos Arizpe Automotive Complex (RAAC) is located in an arid region in the State of Coahuila, in northeast Mexico. Complex operations began in 1980. In 2000, RAAC manufactured 590,000 engines, 171,000 transmissions, and assembled 222,000 passenger vehicles.

The only source of water in the area where the Complex is located is a small, semi-confined aquifer, that has a limited water storage capacity, and a relatively high salt content (approximately 2000 mg/l total dissolved solids). This does not allow direct well-water use for industrial or domestic purposes. So it becomes necessary for GM to treat well water, and this is accomplished by utilizing several reverse osmosis (RO) desalination units.

When the Complex began operations, the following systems were installed: 1) several RO units for well water desalting, and an ion-exchange system to polish portions of the water supply, 2) separate physical-chemical wastewater treatment systems for the assembly and engine plant effluents, and 3) a biological wastewater treatment system for sanitary waste.

Since 1986, several things have occurred that changed RAAC's approach to water management. These include: 1) well-water levels have decreased, 2) fees that must be paid to the National Water Commission (CNA) for water rights have substantially increased, 3) CNA imposed limits on well water withdrawal, 4) limits on the concentrations of several parameters in the waste streams were issued, 5) The demand for high quality water has increased, due to the expansion of the Complex. The main consequences of these events are that all wastewater must be treated, and water reuse is practically the only source of supply for additional water requirements. The reduced well water withdrawal will eventually allow for an increased aquifer life.

To reduce water consumption, and to reduce the pollution load to the environment, the following main programs have been undertaken: 1) the development of a continuous intensive water conservation program, that includes leak detection and repair, and review of the different water-treatment and water-using processes to detect water-saving opportunities; 2) the implementation of an innovative system to recover most of the by-product brine from the RO systems; 3) the construction of solar evaporation ponds to convert the final brine stream to solid salts for potential reuse; 4) the implementation of a complete physical-chemical and biological wastewater treatment facility, to treat all industrial and sanitary wastewater; 5) the implementation of an innovative system to recover about 70% of the secondary effluent that results from the biological treatment of pre-treated industrial wastewater; and 6) the reuse of good quality treated sanitary wastewater to irrigate RAAC gardens and sport-fields, and to create a man-made lagoon, that is the center of a recreational area for the Complex workers and their families.

Fig. 1 presents the main components and flow diagram of RAAC Water Management System. The six main programs that have been implemented to reduce well water withdrawal and pollution impact to the environment are also indicated in the diagram.

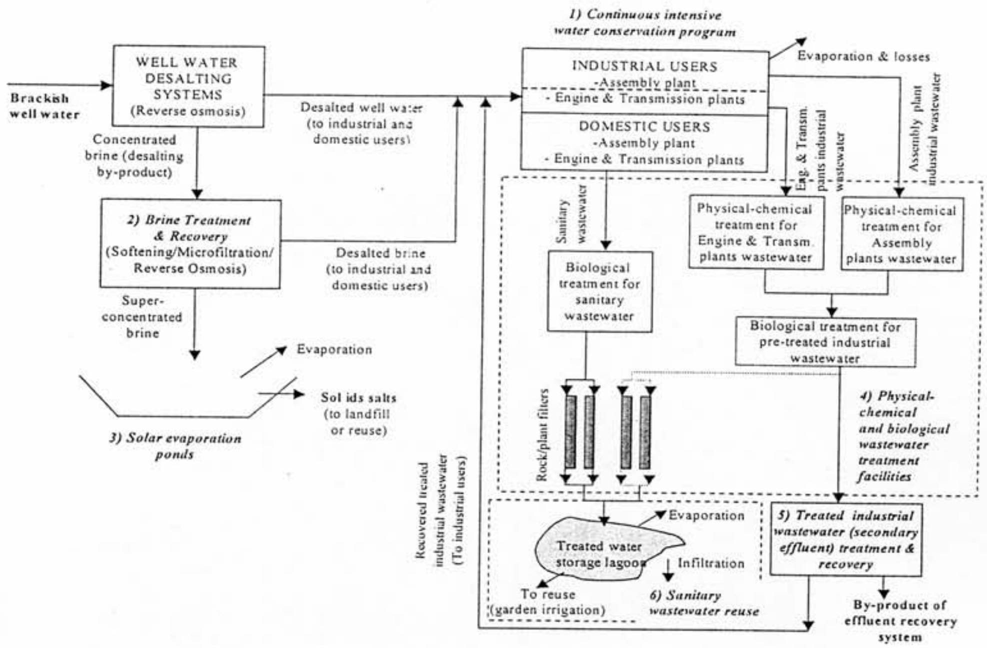


Fig.1- General Motors de Mexico Ramos Arizpe Automotive Complex Water Management System, indicating the six main programs that have been implemented to reduce well water withdrawal and pollution impact to the environment.

The following paragraphs present a brief description of these programs, and their main accomplishments from the point of view of water conservation and recovery, and pollution control.

1. WATER CONSERVATION PROGRAM

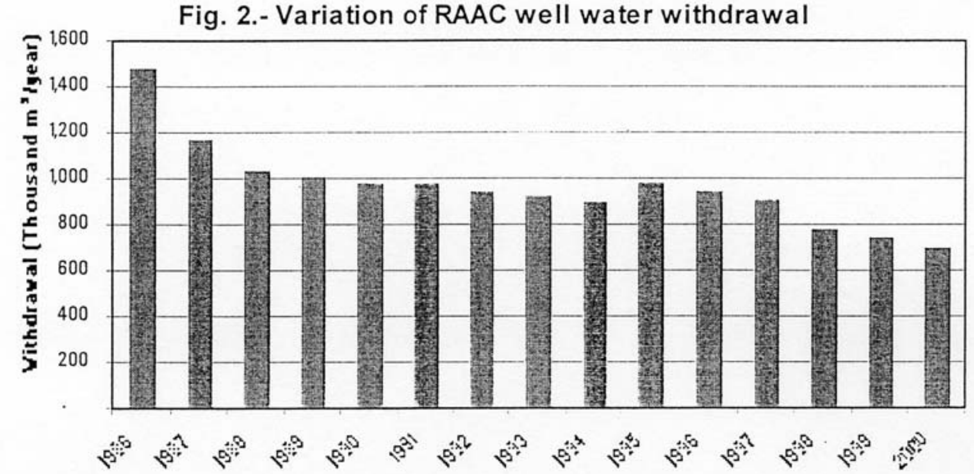
This includes leak detection and repair, and review of the different water-treatment and water-using processes to detect water-saving opportunities.

The main actions that have been implemented to satisfy water-use reduction objectives include:

- Water treatment: Increase of the well water reverse osmosis recovery from 67 to 73% (October, 1998).
- Industrial use: Reuse of non-treated effluent streams with low contaminant load in processes that do not require high quality water; control of air-supply houses and cooling tower blow-down; control of the phosphate line water discharges by monitoring conductivity or other relevant indicators;
- Domestic use: Installation of water-saving devices at showers and toilets, and of reduced-discharge "water-closets."

The effect of the water-conservation activities that were undertaken in the period 1986-1997 are reflected in the decrease in well-water withdrawal that is observed for this period in Fig. 2. For the period 1997-2000, the effect of water-conservation activities is relatively minor in comparison to the reuse projects that have been undertaken, due to the fact the actions with the largest effect were implemented during the first years of the program.

Fig. 2.- Variation of RAAC well water withdrawal

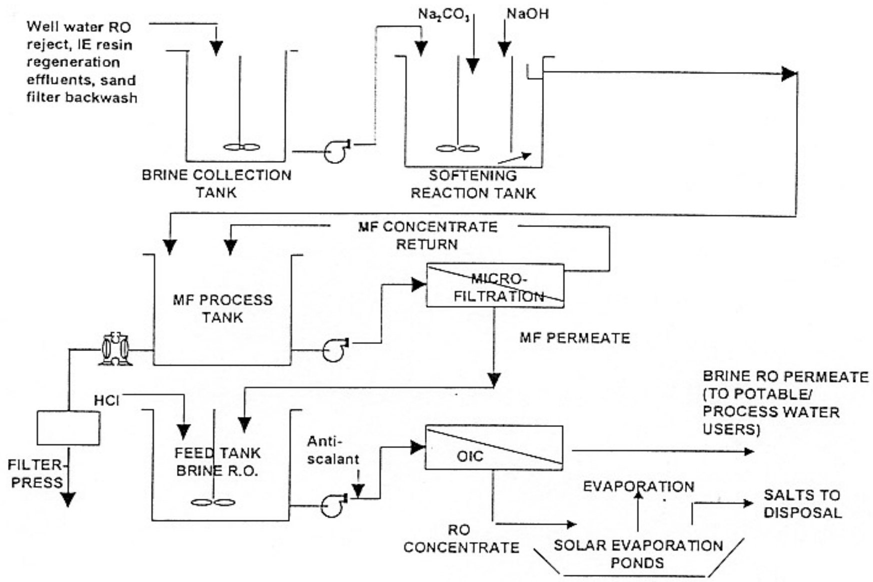


2. RECOVERY OF WELL WATER TREATMENT BY-PRODUCT STREAM

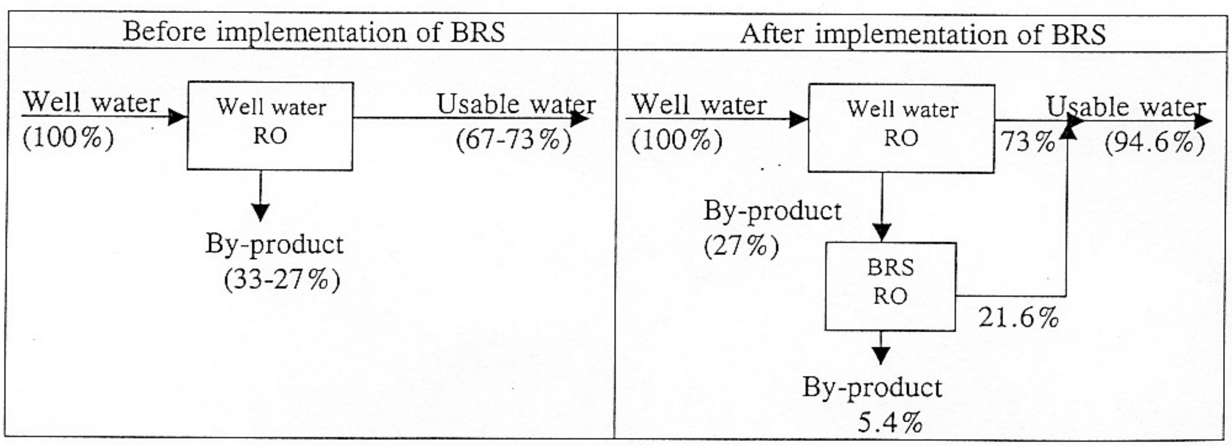
During the period 1980-1997, RAAC well water reverse osmosis systems operated at 67% recovery. This means that 33% of the well water flow was discharged to a nearby creek as a concentrated by-product stream. An innovative system was implemented in 1997 to recover about 80% of this brine stream. Other saline effluents, including the ion exchange resin regeneration waste and sand-filter backwash, are also treated in this system.

The brine treatment/recovery system comprises the following main processes: 1) softening, 2) microfiltration, and 3) reverse osmosis. A filter-press is used for dehydrating the softening by-product stream. Fig. 3 presents a flow diagram of RAAC brine-recovery system (BRS).

Fig. 3.- FLOW DIAGRAM OF THE BRINE RECOVERY SYSTEM INSTALLED AT GM DE MEXICO RAMOS ARIZPE COMPLEX



The BRS has been operating almost continuously for about 3 ½ years now. It has produced a permeate (product water) with low salt content, that has been used mainly for the engine and transmission plants' water supply. It has also allowed RAAC to substantially reduce well-water withdrawal. The successful operation of the BRS has allowed RAAC to increase significantly the percentage of utilization of waters with high salt content (from 67-73% to 94.6% overall recovery), as indicated below.

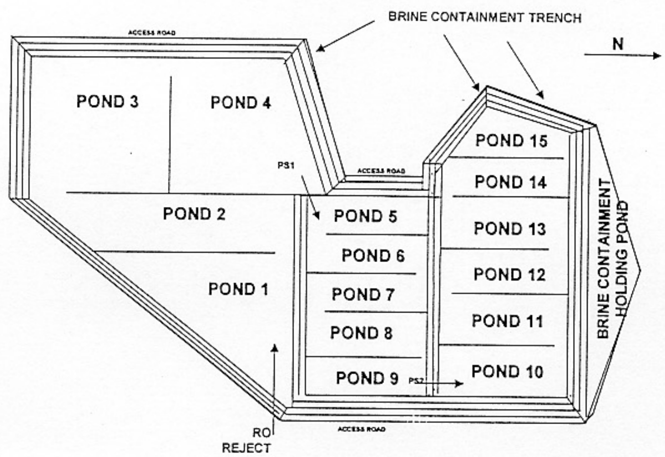


The main environmental benefits obtained from the BRS have been to reduce well water withdrawal, and to extend the aquifer life.

3. SOLAR PONDS FOR FINAL BRINE EVAPORATION

Beginning in March, 1999, the salty effluent that is obtained as a by-product of the above-mentioned brine-recovery system (BRS) is discharged to the first of three sections of solar evaporation ponds (SEP´s). These were designed to evaporate most of the water contained in the final concentrate of the BRS. Currently, average feed to SEP´s is 1.5 lps, with a salt content of about 3%. Fig. 4 presents a plant-view of the ponds that have been constructed at the Ramos Arizpe Complex for converting that effluent to solid salts, that will be reused if possible, or properly disposed otherwise. Solar ponds have several layers of insulation materials: a compacted bentonite base, and two films of high density polyethylene, with a layer of compacted clay and other of permeable soil, between the plastic films. The ponds also have a leachate collection system. The pond design indicates that the first salt removal should take place 3 ½ years after start-up (by the end of 2002), and annually in the subsequent years. The effective pond evaporation area is 4.2 hectares.

Fig. 4.- Diagram of the solar evaporation ponds installed at GM de Mexico Ramos Arizpe Complex



The main environmental benefit obtained for the SEP´s is to avoid the discharge of a salt-loaded stream to a creek whose water is used for crop irrigation purposes.

4. TREATMENT OF INDUSTRIAL AND SANITARY WASTEWATER

Industrial wastewater at RAAC is treated by the following processes (Fig. 5): 1) chemical precipitation of assembly plant wastewater; 2) oil flotation and bag filtration for free oil and suspended solid removal, and ultrafiltration for emulsified oil and high molecular weight compounds removal; and 3) biological treatment in a combined activated sludge/rock-plant filter system for reduction of organics, nutrients and coliforms.

RAAC sanitary wastewater is submitted to a biological treatment similar to that of the industrial wastewater.

A filter-press is used for dehydrating the Assembly plant chemical precipitation by-product stream; a chemical system that combines the addition of cationic and anionic polymers is employed to concentrate the oily by-product of the ultrafiltration system, and either sludge drying beds or a bag filtration system to reduce the water content of the industrial and sanitary biological systems by-product sludge.

The main environmental benefits obtained from the industrial and sanitary wastewater have been to reduce the pollution load of these streams, and to prepare them for recovery, as described in the following two sections.

5. RECOVERY OF TREATED INDUSTRIAL WASTEWATER

For several years, the effluent of the industrial biological system – combined with biologically treated sanitary wastewater- was discharged to an internal storage lagoon. A part of the stored water is used for irrigation purposes, another part is evaporated, and the remainder infiltrated to the subsoil.

An innovative system was implemented in 2000 to recover about 70% of the industrial secondary effluent. The effluent treatment -and recovery- system comprises the following main processes: 1) phosphate and total suspended solids removal, 2) microfiltration, and 3) reverse osmosis. Fig. 5 presents a flow diagram of the industrial effluent recovery system.

The Industrial Secondary Effluent Recovery System (ISERS) installed at RAAC has been operating for about 6 months now. It has produced a permeate (product water) with low salt content, that has been used mainly for supply to assembly plant air supply houses, that are currently the Complex's main water users. The reduction of well water withdrawal has been of the same order of magnitude (about 4 lps currently) as that of the Brine Recovery System.

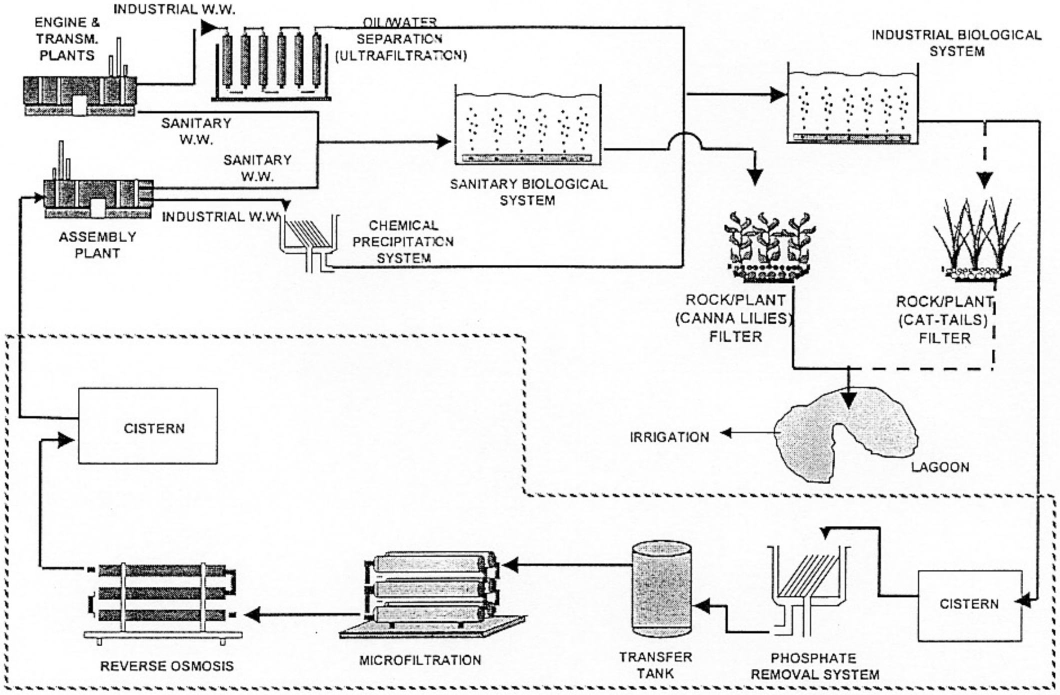
The main environmental benefits obtained from the ISERS have been to reduce well water withdrawal, and to extend the aquifer life.

6. REUSE OF TREATED SANITARY WASTEWATER

At RAAC, biologically treated sanitary wastewater is used for two main purposes: 1) to create a man-made lagoon, that is the center of a recreational area for the Complex workers and their families, and 2) to irrigate RAAC gardens and sport-fields.

The main environmental benefits obtained at RAAC have been to reduce well water withdrawal, to extend the aquifer life, and to improve Complex landscape.

Fig. 5.- RAAC Wastewater Treatment and Reuse - Flow Diagram



7. CONCLUSIONS

General Motors de Mexico Ramos Arizpe Automotive Complex (RAAC) has undertaken several programs to reduce water consumption, to suppress pollution due to industrial and sanitary wastewater discharge, and to reuse treated effluents. The combined effect of these programs has been: 1) to reduce well water withdrawal from 1,480,000 m^3/year in 1986 (there are no records of the previous years) to 700,000 m^3/year in the year 2000, while at the same time producing about 7 times more cars, 50% more engines and starting up a new transmission plant that manufactured 171,000 units in the year 2000 (Fig. 6). Well water withdrawal has been reduced from 31.8 m^3/car and 1.1 m^3/(engine or transmission) to 2.2 and 0.3 respectively (Fig. 7), and water consumption from 21.3 m^3/car and 0.7 m^3/(engine or transmission) to 2.2 and 0.3 respectively (Fig. 8), 2) to eliminate the discharge of the brackish well-water treatment by- product and sanitary wastewater, and 3) to reuse most of these waste streams to produce additional water for industrial applications, and to drastically reduce the flow and pollution of industrial wastewater discharges to the environment.

The programs described in this document are an integral component of RAAC's Environmental Management System. Numerous awards have been presented to RAAC by both the Mexican government and ISO 14000 certification officials in recognition of the

Fig. 6.- Variation of RAAC well water withdrawal and production

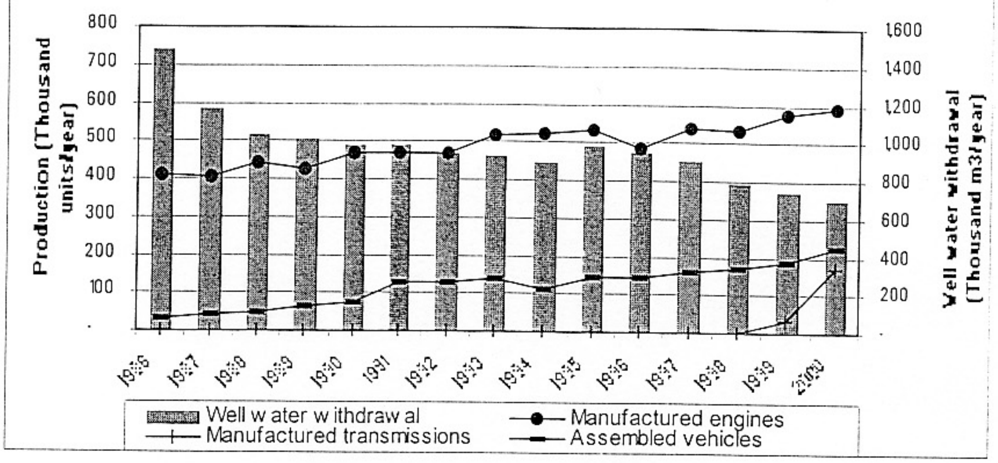


Fig. 7.-Variation of well water withdrawal per unit of production

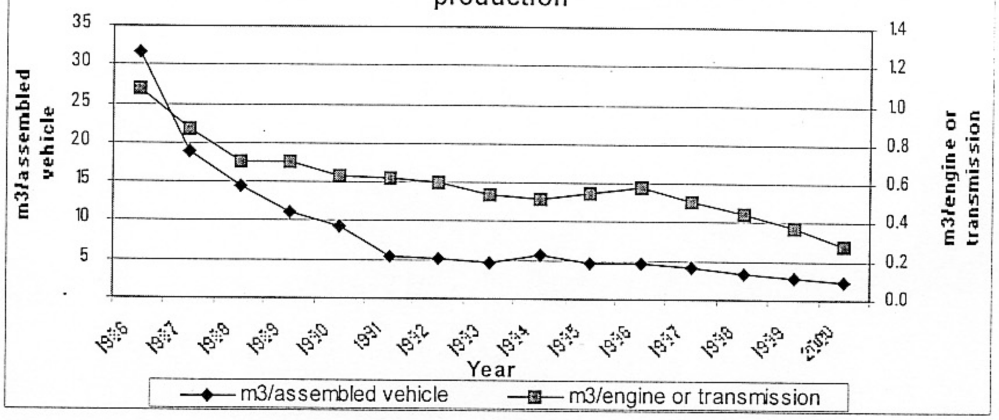
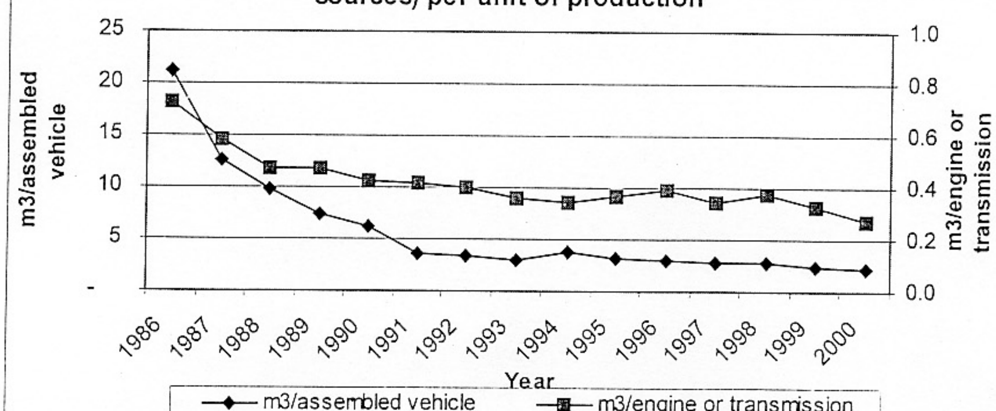


Fig.8.- Variation of water consumption (from different sources) per unit of production



Complex's environmental accomplishments: 1) "Clean Industry" award (State of Coahuila, 1995), 2) "Energy Conservation Award" - Third place (Mexican Electricity Commission (1995), 3) "Environmental Excellence" award (State of Coahuila, 1996), 4) "Clean Industry" Certificate (SEMARNAP -Mexican EPA-, 1998), 5) ISO-14001 Certification (Det Norske Veritas, 1999), and 6) "Clean Industry" Recertification (SEMARNAP, 2000).

Papers describing RAAC RO by-product brine and industrial secondary effluent treatment and recovery were presented at the 1998 and 1999 International Water Conferences (Pittsburgh, Pa., USA), and the Weftec-2000 Conference (Anaheim, Ca., USA).

A photographic display of RAAC's water and wastewater treatment and reuse facilities is presented in Appendix 1.