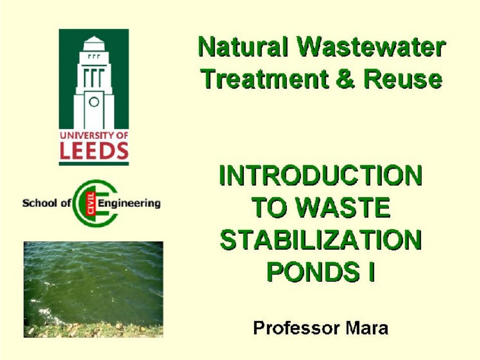
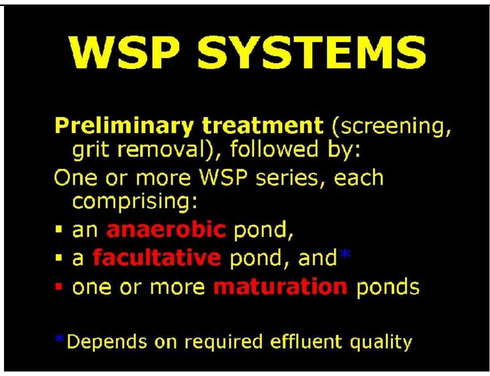
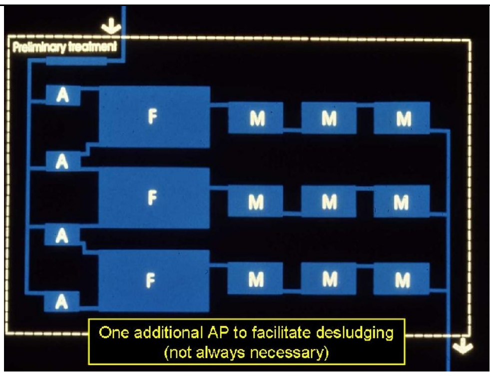
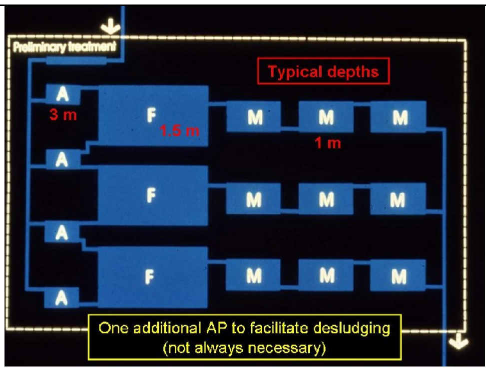
WASTE STABILIZATION PONDS 1
Introduction 1

1.		This is the first of seven presentations on waste stabilization ponds, and the first of two introductory presentations.
2.		With ponds systems we first have pre-liminary treatment, i.e. screening and grit removal, and then we have one or more series of ponds. Each series comprises an anaerobic pond, followed by a facultative pond and then, depending on the effluent quality required, one or more maturation ponds.
3.		Here we have an example (and it's only an example) of a pond system. There are three series, and each series has an anaerobic pond, a facultative pond and, in this case, three maturation ponds. There's an extra anaerobic pond: this can be useful when one of them is being desludged, but it's not always necessary.
4.		Typical pond depths are: ~3 m for anaerobic ponds; ~1.5 m for facultative ponds; and ~1 m for maturation ponds.

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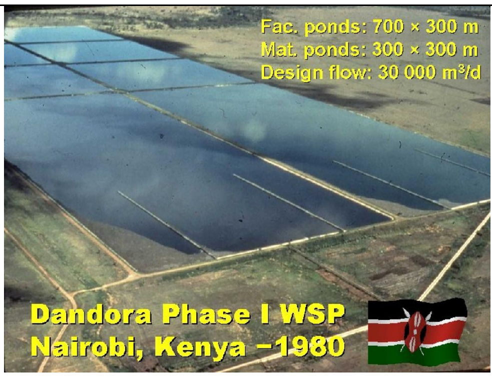
<td>5.</td>
<td>
</td>
<td>This is Phase I of the Dandora pond system serving the city of Nairobi in Kenya. There are two series, each with a facultative pond and three maturation ponds. They are quite large ponds: the facultative ponds are each 700 × 300 m, that's 21 ha; and the maturation ponds are each 300 m square or 9 ha. The design flow was 30,000 m^3/day, 15,000 into each series.</td>
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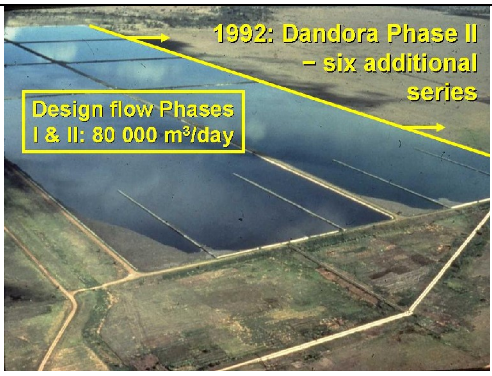
<td>
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<td>Phase II comprises six additional series, almost identical to those in Phase I, except that the maturation ponds are 300 × 150 m. The design flow is 80,000 m^3/day for Phases I and II combined − this reflects the fact that the capacity of the Phase I ponds was not in fact 30,000 m^3/day but closer to 20,000.</td>
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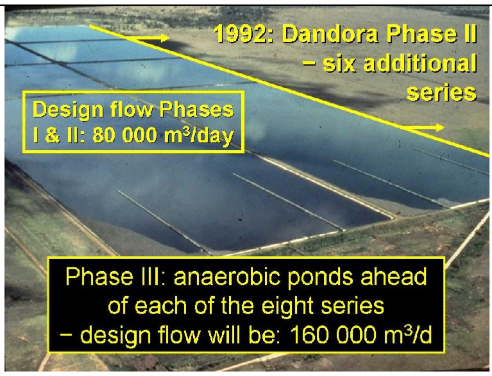
<td>
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<td>Phase III will comprise an anaerobic pond at the head of each of the eight series, and this will essentially double the design flow to 160,000 m^3/day. At 80 litres of wastewater per person per day, this is equivalent to a population of 2 million.</td>
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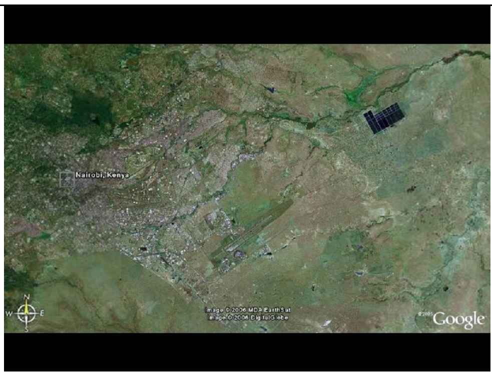
<td>
</td>
<td>This is a satellite photo of Nairobi, on the left, and the Dandora ponds, at the top on the right. The ponds are clearly visible, which is not surprising as their total area is of the order of 270 ha.</td>
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<td>9.</td>
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<td>This is Melbourne, Australia, in the southern temperate part of the country. The slide shows the ponds at the city's Western Wastewater Treatment Plant. It's a huge system: nearly 1700 ha of ponds, in three series, treating over 360,000 m^3/day of wastewater, over half of which is industrial wastewater.</td>
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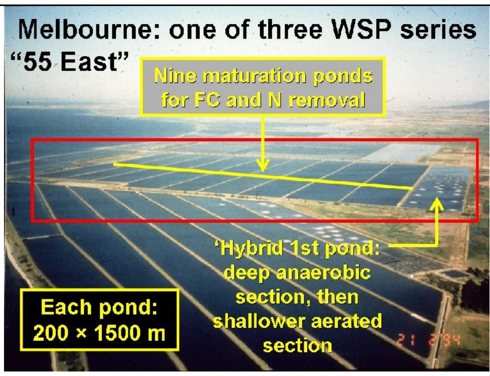
<td>10.</td>
<td>
</td>
<td>One of the three series is called "55 East" and this is shown inside the red box on the slide. There are ten ponds in series and each ponds measures 200 × 1500 m, that's an area of 30 ha.
The first pond is in fact a hybrid pond. The first 400 m are deep and this section acts like an anaerobic pond. The rest of the pond is shallower and is aerated, so this part is an aerated lagoon (rather than a facultative pond). The remaining nine ponds are maturation ponds for the removal of nitrogen and faecal coliform bacteria.</td>
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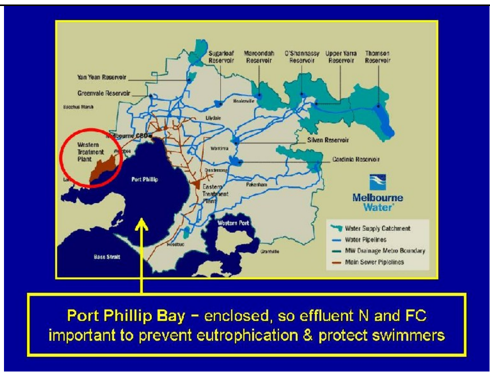
<td>11.</td>
<td>
</td>
<td>This slide shows the city of Melbourne and the location of the Western Treatment Plant. The pond effluent is discharged into Port Phillip bay, which is an enclosed bay, so the regulator, the Environmental Protection Agency of the State of Victoria, has set quite stringent standards for total nitrogen and faecal coliforms – to prevent eutrophication of the bay, and to safeguard the health of people swimming and windsurfing in the bay.</td>
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<td>12.</td>
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<td>This is a satellite photo of the Western Treatment Plant, and the "55 East" series is in the centre.</td>
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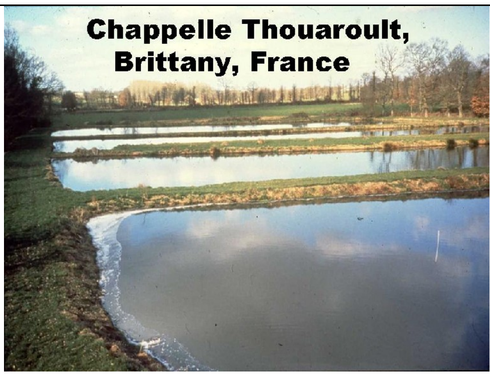
<tr><td>13.</td><td>
</td><td>Here you can see the first hybrid pond.</td></tr>
<tr><td>14.</td><td>
</td><td>The first half of the anaerobic section of this pond is covered to collect the biogas, which is used to generate electricity. This is a very good approach to use at large works. At the Western Treatment Plant biogas is collected from the anaerobic part of all three hybrid ponds. This generates a vast amount of electricity, much more than is needed on site. The large surplus is sold to the local power company and this yields a profit for Melbourne Water of around 1 million US dollars a year.</td></tr>
<tr><td>15.</td><td>
</td><td>A recent development has been the insertion in pond #5 of a nitrifying and de-nitrifying activated sludge plant. This was necessary because the regulator had specified an even higher standard for total nitrogen, which the ponds by themselves could not achieve.</td></tr>
<tr><td>16.</td><td>
</td><td>This is the pond system serving the village of Chappelle Thouaroult in Brittany in northern France. The village has a population of about 1500, and the pond system is a facultative pond followed by three maturation ponds.</td></tr>
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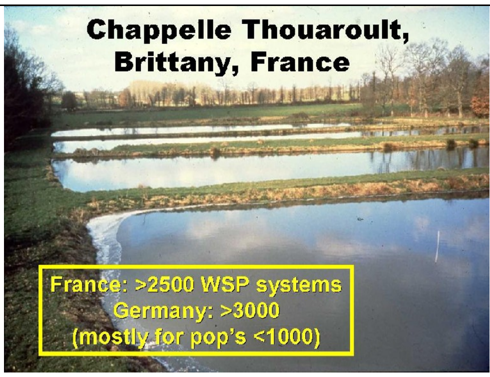
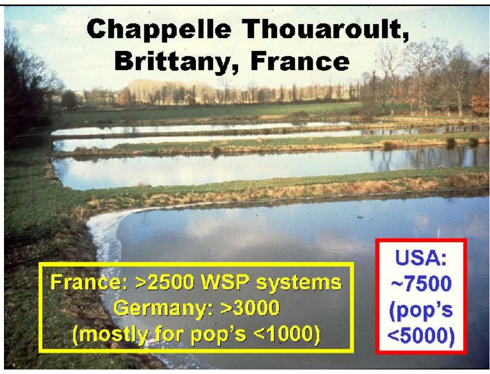
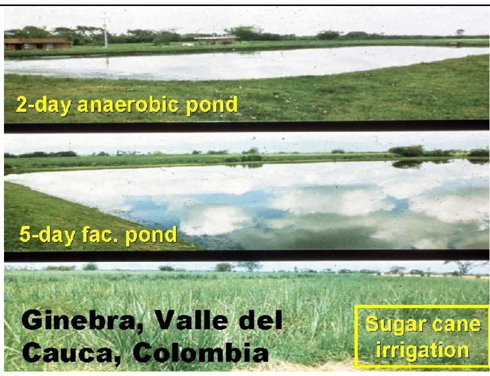
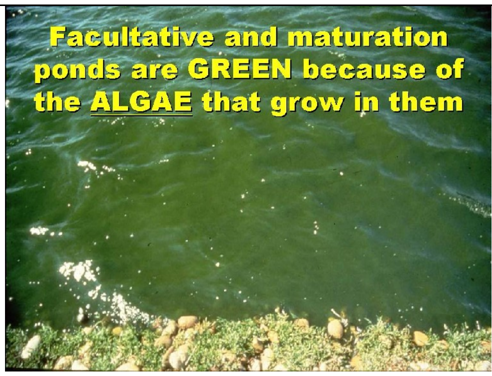
17.		In France as a whole there are around 2,500 pond systems, serving mainly small communities of a few hundred people. Germany has over 3,000 systems, with around 1,500 in Bavaria alone.
18.		And in the US there are some 7,500 pond systems, generally serving populations up to around 5000.
19.		This is Colombia in South America. Very little wastewater, only about 10 percent of the total, is treated in South America, although in some areas it is better than this. The slide shows a poster, an advert really, by AcuaValle, the water and sewerage company in the province of Valle, in the southwest of the country. The poster says "We treat our wastewater"!
20.		And this is one of AcuaValle's pond systems, serving the small town of Ginebra. The wastewater flow is about 25 litres/sec, and it's treated in a 2-day anaerobic pond and then in a 5-day facultative pond. The facultative pond effluent is used to irrigate sugar cane which is the main crop in this part of Colombia.

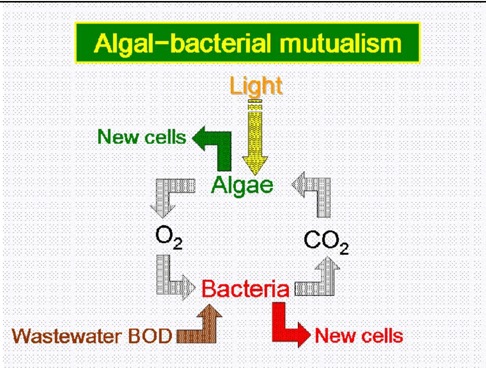
21.		This slide shows the two ponds more clearly. In front of the anaerobic pond are some experimental reactors operated by researchers from UniValle, the main university in the nearby city of Cali.
22.		We are now in Brazil – in, in fact, the Federal District which surrounds the capital, Brasília. This pond system serves Brazlândia and there are two series, each with an anaerobic pond and a facultative pond.
23.		This is another pond system in the Federal District, at Samambaia. There are in fact anaerobic sections in the facultative ponds on the right, but these aren't very clear in the slide. Each of the two facultative ponds is followed by two maturation ponds, and these were baffled to improve their hydraulics and thus their performance.
24.		We are now in Scotland, at Tigh Mor Trossachs in Central Perthshire. These ponds serve the holiday home complex situated immediately behind the baronial mansion shown in the top photo. The attractive "lake" in the foreground of this photo is in fact the facultative pond. In the lower photo you can see the facultative pond again, and it is followed by two maturation ponds, with the final effluent discharging into Loch Achray.

25.		In the UK there are only about 40−50 pond systems and they are all privately owned, except this one at Scrayingham, a small village northeast of York, which is owned and operated by Yorkshire Water.
26.		If you think ponds only work well in hot climates, then think again! This slide shows a pond system in Quebec in winter.
27.		Facultative and maturation ponds are usually a deep green colour (and, if they're not, then something's likely to be wrong). The green colour is due to the profuse growth of micro-algae in the pond.
28.		OK, I'm not going to turn you into an algologist, but engineers need to know a little about these micro-algae as they are the "work horses" of facultative and maturation ponds. We can divide them into two broad groups: the motile and the non-motile algae.

29.

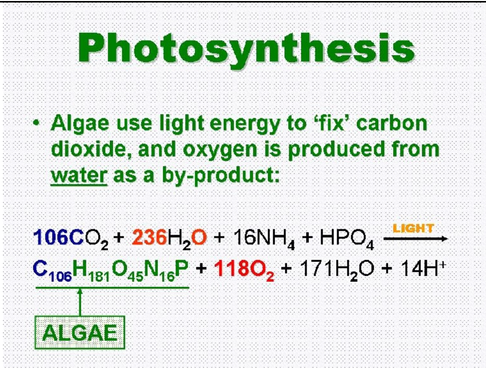
Motile algae have one or more "tails" called flagellae which enable them to move. So, in the fairly turbid waters of facultative ponds this gives them an advantage over non-motile forms and so they tend to predominate in these ponds. But as you move down a series of maturation ponds, the water becomes less and less turbid and you find more and more non-motile algae and fewer motile ones.

30.



Algae are extremely important in ponds. Their main role, but not by any means their only one, is to provide oxygen for the pond bacteria to oxidize the organic compounds in the wastewater (in other words to remove the BOD). Algae use light energy to 'fix' CO_2 into new cellular material – this is photosynthesis, and the main by-product of photosynthesis is oxygen. One of the main end-products of bacterial metabolism is carbon dioxide, and this is used by the algae. So there's a mutualistic relationship between the pond algae and the pond bacteria: the algae supply the bacteria with oxygen and the bacteria supply the algae with carbon dioxide.

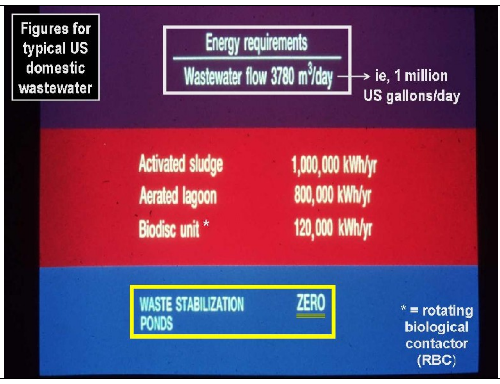
31.



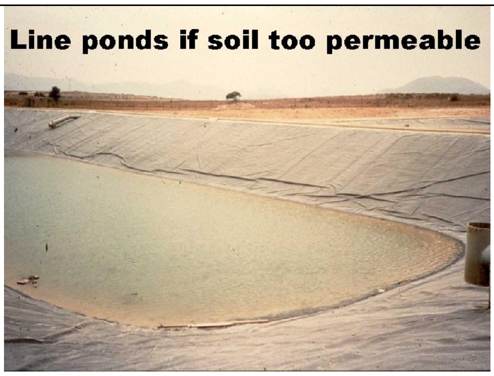
This slide shows the chemical equation for algal photosynthesis:

106 moles of CO_2 are fixed per mole of algae produced, and this requires 236 moles of water which become 118 moles of O_2. A little nitrogen and a little phosphorus are also required to 'make' the algae. It's important to note that the oxygen produced comes from H_2O, and *not* from the CO_2.

32.



The photosynthetic provision of oxygen gives ponds a big advantage over electromechanical forms of wastewater treatment. This slides shows the energy requirements of three types of electro-mechanical treatment: for a wastewater flow of 1 million US gallons per day (that's 3,780 m^3/day), activated sludge requires around 1 million kWh of electrical energy per year; aerated lagoons

		around 800,000 kWh per year; and biodisc units (now more commonly called rotating biological contactors) around 120,000 kWh per year; but ponds don't require any electrical energy: they get all the energy they need directly from the sun.
33.		Ponds are very simple to build, and the main civils work is earthmoving.
34.		But if the soil is too permeable (for example, sandy soils in coastal areas), then you have to line them with an im-permeable plastic membrane − as was done for this pond in southern Spain. The photo was taken before the pond was commissioned, so the liquid you see in the pond is stormwater.
35.		Ponds can receive a higher load in summer than in winter, so they're excellent in tourist resorts. Of course a pond designed to serve a winter population of p can only treat the wastewater from (2 or 3)p in summer (the precise value depends on the particular winter and summer design temperatures), but it's a simple enough matter in any one case to decide whether you design for winter or for summer.