

# **International Expert Panel on Drinking Water Safety**

## **Key Advice on Drinking Water Safety in Hong Kong**

### **Background**

The International Expert Panel on Drinking Water Safety (IEP) has affirmed that a holistic plan comprising the following components is required to safeguard the drinking water quality in Hong Kong:-

- (a) water safety regulatory regime;
- (b) drinking water quality standards;
- (c) water quality monitoring programme, associated sampling protocol and action plans in case of exceedance;
- (d) water safety plans (WSPs);
- (e) plumbing material control and commissioning requirements for new plumbing installations; and
- (f) public education and publicity on safe use of water.

2. The IEP has also provided advice on the methodology of testing the drinking water of PRH estates again as well as on the non-necessity for testing of drinking water in kindergartens, schools, welfare units and government quarters again.

3. This Note summarises the IEP's key advice provided on the above issues.

4. The IEP stressed that it is necessary for Hong Kong to handle the lead in drinking water issue in a holistic manner rather than restricting itself to the review of guideline value and sampling protocol for lead. A holistic plan including all components as described in the first paragraph above should be established.

5. The IEP has examined the current water safety regime in Hong Kong and expressed its full recognition and appreciation to the strong commitment of the Development Bureau (DEVB) and Water Supplies Department (WSD) in responding to the issues identified by the Commission of Inquiry into Excess Lead Found in Drinking Water (CoI). The IEP also recognizes the commitment of DEVB and WSD in safeguarding the drinking water quality and the great amount of work done and effort paid in setting up the Panel and organizing the meetings, as well as in preparing professional and well organized responses to the Panel about various ongoing water safety related issues.

## **Water Safety Regulatory Regime**

6. The IEP made the following comments on the key requirements and responsibilities of the Water Quality Regulator (the Regulator):

- (a) It was imperative that the Regulator be independent from the water suppliers (i.e. WSD in Hong Kong). This also tied well with the framework of the World Health Organization (WHO) and the public's expectation. Independence of the Regulator was through vesting it with the necessary power and not by its positioning outside or within the Government.
- (b) The merit of positioning the Regulator to be within the Government was to ensure good communication with the many different stakeholders ensuring everyone including the public has access to the same facts.
- (c) The Regulator must be vested with the power to protect public health by ensuring that the water supply is safe for use. The Regulator should make its decisions without undue influence and fettering and communicate equally and transparently to all stakeholders including the public. The Regulator should give its advice objectively and professionally; and its decisions made should be transparent.
- (d) There might be merits for the Regulator to report to the health authority, but other settings have been shown to work so long as independence can be maintained and the necessary health expertise is available through inputs/engagement of health agencies.
- (e) The appointment of an agency/authority as the Regulator should be to a defined position with a clear and distinct identity to show to the public that the Regulator has the independent status and authority. The Regulator should have experience in public health protection combined with direct experience and knowledge of the operation of water supply systems from source to tap.
- (f) A technical committee with participation of relevant stakeholders might be established to give advice to the Regulator. It would however be important that the technical committee gives advice only; otherwise the Regulator may, in performing its functions, be fettered or interfered with by the committee.
- (g) With regard to the waterworks (including their design, construction, operation and maintenance, especially the introduction of new water sources), the Regulator should exercise its regulatory control through review and audit of relevant information covered in the relevant Water Safety Plan and Water Quality Monitoring Programme.

- (h) The Regulator should be given the power to inspect all activities of WSD in relation to drinking water safety.
- (i) A good distinction should however be made between the Regulator and the plumbing regulator which regulates plumbing material standard and control. Considering that Hong Kong has only one major water supplier and therefore competition amongst water suppliers is not a concern, it is acceptable for WSD to continue to assume the role of the plumbing regulator.

7. On water safety legislation and drinking water quality standards, the IEP considered that:

- (a) The water safety legislation should include the setting of drinking water quality standards.
- (b) The drinking water quality standards could be established by adopting the WHO Guidelines for Drinking-water Quality (WHO Guidelines), taking into account local conditions. The Regulator could consult WSD and other stakeholders to assist in the review of drinking water quality standards. It would be sufficient for the water safety legislation to stipulate the requirement of wholesomeness of water. However, it was recommended that stipulation of the water quality standards in the primary legislation should be avoided.

8. The water safety legislation should identify the responsibilities of the water suppliers and the responsibilities of the Regulator. The legislation should also empower the Regulator to make regulations including setting and review standards, requirements of Water Safety Plans, etc. and to audit WSD.

### **Drinking Water Quality Standards**

9. WSD has engaged consultants (Water Research Centre (WRc) of the United Kingdom (UK)) to carry out a comprehensive review on drinking water quality standards and methodologies of setting the standards by two international organisations (the WHO and the European Union (EU)), and seven overseas nations (the UK, United States of America (USA), Canada, Australia, New Zealand, Singapore and Japan). The review study covered the drinking water quality standards for 12 WHO metal parameters<sup>1</sup> including lead.

#### *Water quality standard for lead*

10. According to the review study conducted by WRc, there is no overseas

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<sup>1</sup> The 12 WHO metal parameters include Antimony, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium and Uranium.

jurisdiction currently adopting a guideline/standard value lower than 10 microgram/litre ( $\mu\text{g/L}$ ) for compliance checking on lead in drinking water except USA which has adopted a non-enforceable value of 0  $\mu\text{g/L}$  as the Maximum Contaminant Level Goal (MCLG). Nevertheless, USA has adopted an action level of 15  $\mu\text{g/L}$  for lead in drinking water.

11. The WHO Guidelines published in 2011<sup>2</sup> stipulated a Provisional Guideline Value (PGV) of 10 $\mu\text{g/L}$  for lead on the basis of treatment performance and analytical achievability. The EU considers that the WHO Guidelines are based on scientific analyses and have taken account of the precautionary principle. EU has largely followed the recommendations of the WHO in setting the chemical parametric value of 10 $\mu\text{g/L}$  for lead in drinking water. Similarly, Singapore has adopted WHO's PGV of 10 $\mu\text{g/L}$  for lead after the review by its Technical Committee on National Drinking Water Quality Standards comprising local and overseas expert members. Canada, Australia and New Zealand have also derived a drinking water guideline for lead based on the assumption adopted by WHO and have arrived at a drinking water guideline of 10 $\mu\text{g/L}$  for lead. These countries are aware of the withdrawal of the Provisional Tolerable Weekly Intake (PTWI) by Joint Expert Committee on Food Additives (JECFA)<sup>3</sup> but have not reviewed/revised their guideline values since the withdrawal. They note that other than leaded solder and lead service lines, copper alloy components and fittings in the plumbing system which comply with the relevant material standards would also leach lead into drinking water.

12. The WHO Guidelines are prepared and updated through the participation of numerous authoritative institutions and hundreds of experts from a wide range of developing and developed countries, and represent the consensus opinion based on worldwide scientific and medical studies. WRc concluded in its review study that the WHO Guidelines is the best reference source for the setting of guideline value for lead in drinking water.

13. The IEP agreed that, taking into consideration results of the international research studies and the possible contribution of compliant copper alloy fittings to lead in drinking water, it is appropriate and practical for Hong Kong to adopt the WHO's PGV for lead (i.e. 10 $\mu\text{g/L}$ ) as standard for compliance monitoring. The setting of the standard will be combined with other measures in the holistic plan to further reduce lead concentrations. As discussed in paragraph 17 the standard will be reviewed as implementation of the plan proceeds and results become available.

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<sup>2</sup> The WHO has published its WHO Guidelines, 4<sup>th</sup> Edition incorporating 1<sup>st</sup> Addendum in February 2017 and has maintained the PGV of 10 $\mu\text{g/L}$  for lead.

<sup>3</sup> In the WHO Guidelines 1993 and 2004, a Guideline Value (GV) of 10  $\mu\text{g/L}$  was derived for lead in drinking water based on health considerations that a PTWI of 25  $\mu\text{g/kg}$  body weight had been recommended by the JECFA of the Food and Agriculture Organization of the United Nations and that 50% of the PTWI should be allocated to drinking water for a 5 kg bottle-fed infant, who would be the most vulnerable among the population, consuming 0.75 litre of drinking water per day. JECFA withdrew the PTWI in 2010 as the dose-response analyses did not provide any indication of a threshold for the key effects of lead. The 10  $\mu\text{g/L}$  was maintained but was designated as PGV in the WHO Guidelines 2011 on the basis of treatment performance and analytical achievability.

### *Water quality standards for other parameters*

14. For the remaining 11 WHO metal parameters, WRc considered and IEP agreed that based on the precautionary approach adopted by the WHO in the derivation of their GVs/PGVs, it is appropriate to adopt the corresponding WHO's GVs and PGVs<sup>4</sup> as the standards of these metal parameters in Hong Kong.

15. For the other 80 WHO's non-metal parameters, WSD will carry out and complete the review in stages by 2018. The IEP agreed WSD adopting the WHO's GVs/PGVs, which are good reference sources of guidelines for drinking water quality, as the standards in Hong Kong before completion of the review study.

### *Way forward*

16. The IEP also recommended that it might not be necessary to include all the WHO parameters in the standards, WSD's review should adopt the risk-based approach advocated by WHO to identify those water quality parameters necessary to be included in the Hong Kong drinking water quality standards.

17. The IEP recommended that Hong Kong should carry out a review on the aforesaid standards including lead<sup>5</sup> when new information is available from WHO's revision of its Guidelines or when sufficient local data from the territory-wide water quality monitoring programme at consumers' taps, as well as test results on plumbing systems in new buildings are available say in 3 to 5 years' time.

18. The IEP also opined that upon the establishment of the regulatory mechanism on the drinking water quality in Hong Kong, the future Water Quality Regulator should be responsible for review of the standards.

## **Water Quality Monitoring Programme, associated Sampling Protocol and Action Plans**

### *Water Quality Monitoring Programme*

19. The IEP noted that WSD currently monitors the drinking water quality in accordance with the WHO Guidelines 2011 but no random samples have been taken at consumers' taps for testing of lead and other metals. The IEP considered that an effective water monitoring programme at consumers' taps is an essential tool to verify adequacy of the control measures for water safety and to identify any irregularity in the supply system. WSD should adopt a risk-based approach to develop its water quality monitoring programme as some parameters such as lead and *E.coli*, which carry more risk in terms of occurrence and health significance than others, warrant

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<sup>4</sup> In general, WHO's guidelines for drinking water and the opinion of the European Commission's Scientific Advisory Committee are used as the scientific basis for the quality standards in the drinking water for EU.

<sup>5</sup> The standards to be reviewed include lead as well as other five metals (viz. cadmium, chromium, nickel, copper, and antimony that could be present in the internal plumbing systems).

closer monitoring.

20. Based on the IEP's recommendation, WSD developed an enhanced territory-wide water quality monitoring programme (Enhanced Programme) for Hong Kong including taking Random Day Time (RDT) samples at consumers' taps (for six metals including lead that could be present in the internal plumbing systems) based on population of the respective supply zones.

21. The IEP reminded that RDT samples must be collected from potable drinking taps for parameters using a standard RDT sampling protocol. The IEP also agreed that RDT samples should be drawn from water accounts from 18 district council districts (DCDs) in Hong Kong according to the population distribution. An annual RDT sampling number of 664 for these 6 metal parameters at consumers' taps would be adopted (see **Annex**). The IEP did not recommend imposing weighting factors for certain water accounts of developments with large number of consumers such as schools, hospitals etc. in the random programme. The water safety of these developments could be further safeguarded by the implementation of WSP for buildings on a voluntary basis. The IEP noted that WSD is carrying out the review study of the non-metal parameters and more parameters may be incorporated into the Enhanced Programme upon completion of the review study by its consultants.

22. The IEP agreed that it was not uncommon in overseas jurisdictions like UK that the water suppliers did not have statutory right to enter premises to collect water samples. In order to ensure the integrity of the RDT programme as recommended by the IEP and sufficient RDT samples are collected to meet the monitoring requirements, an independent party would be engaged by WSD for drawing RDT units from a comprehensive list of water accounts of Hong Kong based on a pre-defined RDT sample selection methodology. The independent party would also be responsible for the preparation of detailed sampling schedule and backup sampling locations for handling unsuccessful sampling events as well as answering enquiry from consumers on sampling issues with a view to ensuring that the successful sampling rate and the methodology are statistically acceptable. As discussed in paragraph 49 a campaign will be undertaken to educate the public about implementation of the RDT programme.

### *Sampling protocols*

23. The IEP endorsed the recommendation on the adoption of two-tier sampling protocol for the water quality monitoring programme for metal including lead in Hong Kong as follows:

- (a) Tier 1 – RDT sampling: Unflushed 1-litre sample would be taken at random during normal working hours in daytime from a drinking water tap of consumer. During the sampling, the tap should be fully opened or as open as possible without losing sample. The 4th Edition incorporating the 1st Addendum of the WHO Guidelines advises that RDT samples reflect most truly the water that the consumer drinks. RDT samples

involve the taking of unflushed samples with various stagnation times.

### Justification

The IEP considered that RDT samples best represent the lead exposure of consumers within the drinking water supply zone as the random samples will cover a wide range of retention times and thus provide a good match with the consumption patterns of the consumers as a whole. This sampling protocol is proven, robust and pragmatic. A randomised pre-programmed RDT sampling regime has the advantages of taking into account the different stagnation times in a large number of water samples and hence the usage pattern and exposure in each of the supply zones over long term monitoring. Based on researches and studies over the past decades in many jurisdictions, this sampling protocol is proven, robust and pragmatic. It provides an unbiased assessment of zonal compliance. The RDT has been widely used in EU, including UK, Scotland, Germany, Italy, Czech Republic and Netherland. The sampling protocol has also been shown to be effective in picking up particulate lead contamination in drinking water, which is particularly applicable in Hong Kong's context where lead contamination is mostly caused by leaded solder.

- (b) Tier 2 – 30-minute stagnation (30MS) sampling: When a Tier 1 RDT sample exceeds the standard(s), 1-litre 30MS sample should be taken<sup>6</sup> for verification of metal exposure of the consumer in case of exceedance being found in the Tier 1 RDT sample<sup>7</sup>. If the Tier 2 sample is exceeded, further samples will be tested as detailed under paragraph 25. If no exceedance in the Tier 2 water sample is identified, the exceedance of the Tier 1 RDT sample should be due to unduly long stagnation time or sporadic presence of particulates before it is taken and the concerned premises would be classified as unaffected by metal contamination.

### Justification

The IEP considered that the 30MS sampling protocol is a robust, reproducible, less intrusive and well-established tool for investigation on the lead contamination of plumbing systems. It has been shown to be a valid alternative to 6-hour stagnation samples for systems without corrosion control. 30MS has been widely adopted in UK<sup>8</sup> and EU as a useful tool to follow up on exceedance of RDT samples. The Joint Research Centre of the European Commission in its “Guidance on sampling and monitoring for lead” published in 2009 recommended 30MS sampling protocol for investigating the section of the service pipe

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<sup>6</sup> For the 30MS sampling protocol, the tap should first be flushed for 5 minutes and then stagnated for 30 minutes before the 1-litre unflushed sample is taken.

<sup>7</sup> Tier 2 30MS sample will not be tested if there is no exceedance in the Tier 1 RDT sample.

<sup>8</sup> According to WRc who has confirmed with the Drinking Water Inspectorate (the water regulator in England and Wales) that 30MS is the approach typically used in UK for investigative sampling.

from which the lead problem arises. In addition, the study of European Commission entitled “Developing a new protocol for the monitoring of lead in drinking water” in 1999 recommended 30MS sampling protocol for identifying causes of observed lead exceedance.

IEP considered that in Hong Kong’s context where lead contamination in drinking water is mostly caused by leaded solder, the 30MS sampling protocol can provide adequate time for the lead to leach for detection. This is because the high lead content in the leaded solder, together with galvanic corrosion of the leaded solder joints would result in rapid production of lead corrosion products.

It is noted that 6-hour stagnation sample is taken in US and Canada for lead. However, the sampling protocol is for broader assessments of lead contamination including from lead service pipes. Besides, an action level of 15µg/L with a compliance rate of 90% is adopted in conjunction with the 6-hour stagnation sampling protocol. In fact, both 6-hour stagnation sampling against an action level of 15µg/L and 30MS sampling against the standard value of 10µg/L are adopted by the Health Canada as sampling alternatives for lead.

30MS sampling protocol is more practical in comparison with sampling protocols of longer stagnation as it causes less disturbance to the consumers. It eliminates the uncertainty/difficulty in ensuring that the water tap has not been used during the long stagnation period. In USA, 6-hour stagnation samples are required to be collected by the residents, which add further uncertainty on whether the samples are properly taken.

24. The IEP expressed that the standard of 10µg/L would be the compliance standard for lead for RDT and 30 MS samples. Water from the tap is safe for consumption when the lead in RDT or 30MS samples is below 10µg/L. Special consideration for borderline case was not necessary.

#### *30MS sequential and 2-minute flushed samples*

25. In order to enable prompt notification be made to the parties concerned of the testing results in case of exceedance and to advise whether the exceedance is confined to the premises or not so as to avoid alerting unnecessarily unaffected parties, the IEP supported WSD to collect 4 sets of samples in one single visit to the premises, i.e. (i) a RDT water sample, (ii) a 30MS water sample, (iii) a 2-minute flushed (2MF)<sup>9</sup> water sample (to support the applicability of the flushing advice – see next paragraph) and (iv) 30MS sequential water samples<sup>10</sup> (to assess if the problem is an isolated case, say,

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<sup>9</sup> For 2MF sampling, the tap is flushed for two minutes before the 1-litre sample is taken. The 2MF water sample is used to establish whether running/flushing the tap for 2 minutes before use reduces the concentration of the metal to below the standard.

<sup>10</sup> For 30MS sequential sampling, sequential samples (each of 1 litre) from tap to outside of the premises will be taken immediately after collection of Tier 2 30MS sample in the same visit. The sampling team will comprise a licensed plumber

confined to the premises itself or not).<sup>11</sup> The 30MS and 2MF sequential water samples will only be tested in case of exceedance found in both Tier 1 RDT and Tier 2 30MS water samples. WSD will analyse the test result of the 30MS sequential water samples and conduct material check on site with a view to assessing whether the exceedance problem is an isolated case or not.

26. Besides, the IEP endorsed the following mitigation advice be provided to the parties concerned, based on the test result of the 2MF water sample collected in the premises:-

- (a) If the 2MF sample is below the standard of the concerned metal(s): flushing advice i.e. tap to run for at least two minutes EACH AND EVERY TIME before drawing water for cooking and drinking will be given. However, if the exceedance is in respect of lead, alternative water sources (such as bottled water or water drawn from a certified filter) should be used for the more easily affected groups (i.e. children aged below 6, pregnant women and lactating women) for maximal protection; and
- (b) If the 2MF sample exceeds the standard of the concerned metal(s): only alternative water sources should be used for cooking, drinking, and baby formula preparation.

#### *Action plans in case of exceedance*

27. If the plumbing system of the concerned premises is confirmed to have lead or other metal contamination caused by the use of leaded solder or other non-compliant pipes and fittings, further investigation should be carried out to confirm if premises within the same building or estate also have the problem of metal contamination in their plumbing systems. The IEP however considered that as the custody of inside services rests upon respective parties under the current legislation, it would not be reasonable for WSD to take up the role and sole responsibility to further extend its investigation to identify other affected premises within the same building or estate. In terms of drinking water safety, WSD could communicate the risks and provide advice on further investigations to identify the extent of the lead contamination to parties concerned for their consideration. The further investigation should take into account all other relevant information such as the responsible subcontractors and licensed plumbers, cause of the excess lead (whether it is due to the use of leaded solder or other non-compliant pipes and fittings), etc.

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who will conduct an assessment on the plumbing system and determine the required number of sequential samples with a view to assessing whether the contamination problem (if existed) is confined to the premises or not. In general, for domestic premises, the number of sequential samples should cover all water pipeline within the premises (about 2-4 samples) plus additional of 2 litres of water covering the water pipelines outside the premises. Hence, about 4 to 6 samples will be taken in total.

<sup>11</sup> The IEP considered that this arrangement should be reviewed after the first three months based on the operational practicalities, including inconvenience brought to the consumers. The IEP also reminded it is important that the sampling staff are competent and experienced and provided with a written protocol and training.

28. Unlike the water sampling and testing exercise for PRH estates in the lead-in-drinking water incident in 2015 where one single failed water sample would lead to classification of the whole estate as affected, the IEP noted the remarks in the CoI's report: "The fact that once a single flat was affected, the whole estate would be classified as an affected estate was a cautious one". The IEP considered that it is not necessary to classify the whole estate as a non-compliant estate straight away in the event that the 30MS water sample has lead level exceeding 10µg/L during the implementation of the territory-wide water quality monitoring programme. Instead, further investigation as detailed in paragraph above should be conducted to identify the source of lead contamination in the plumbing system of the concerned flat and further investigation undertaken to determine the non-compliant zone within the housing block if the non-compliant water samples are not due to the tenant's own alteration of inside service within the flat.

#### *Publication of Water Quality Monitoring Data*

29. In order to enhance transparency and public confidence on the water safety in Hong Kong, the IEP recommended the minimum, maximum and average values as well as the compliance rate with the adopted standards of the following water quality parameters necessary for assessing the safety and characteristics of the drinking water supply of each DCD should be disseminated in the publication list at the website regularly, say quarterly or half-yearly:

- (a) E.coli – indication of microbiological quality of each DCD
- (b) Turbidity, colour and hardness – Aesthetic parameters affecting acceptability of drinking water
- (c) Lead – indication of possible lead leaching from the inside service
- (d) Fluoride – to ascertain its compliance with the target level recommended by DH

30. Furthermore, the IEP recommended that the publication of water quality statistics of all parameters of standards for each zone should be conducted annually. The IEP also reminded that when publishing the results of a RDT compliance monitoring program, these should be based on the 18 district zones and contain only the results of the RDT samples.

#### **Water Safety Plans (WSPs)**

##### *WSP for WSD*

31. The IEP considered that WSPs is an overarching document in safeguarding drinking water quality. WSPs should as far as possible cover the whole water supply chain from source to tap and should include water quality monitoring programmes, risk assessments and corresponding action plans (including incident management plans) and customer complaints handling procedure. WSPs should be prepared by the

parties responsible for the respective parts of the water supply chain. Thus, in simple and general terms, WSD should be responsible for the water supply chain from source (including Dongjiang (DJ) water at the reception point at Muk Wu in Hong Kong and local yield from the catchment) up to the connection point designated as WSPs for WSD, and building owners should be responsible for the inside services (i.e. beyond the connection point) designated as WSP for buildings.

32. The IEP acknowledged that WSD has generally followed the methodology advocated by the WHO in its development of WSPs for WSD. The IEP also noticed that WSPs for WSD have covered to certain extent risk assessment from source to distribution and have already included customer complaint handling procedures and a list of incident management plans. Besides, with respect to inside services, WSPs for WSD have set out its regulatory role including amongst others plumbing material control and approval of new plumbing installations. In this connection, the IEP agreed to WSD's proposal to enhance the WSPs in the aspect of hazard assessment by stipulating commissioning requirements for new plumbing installations in the WSPs. Plumbing material control and certification could be by means of a plumbing code<sup>12</sup>. Moreover, WSD has been promoting safe use of water through public education. These actions have provided a solid basis for further development of WSPs by WSD.

33. The IEP welcomed WSD's initiative to integrate and incorporate the updated WSPs for WSD into the newly established Drinking Water Quality Management System (DWQMS) of WSD, which would form an overarching and broader framework for management of drinking water quality in Hong Kong. In addition to the content of the existing WSPs, the DWQMS would incorporate new sections on quality policy for WSD and the department's regulatory role in controlling plumbing installations as well as improvement programmes. The IEP considered the composition and document structure of the DWQMS was satisfactory and agreed on WSD's approach of engaging staff at operator levels when conducting risk assessment and review of operational practices during preparation of the DWQMS. Apart from tackling the lead problem, the IEP advised that effectiveness of the disinfection process should be ensured in the DWQMS through setting targets and close monitoring of residual chlorine levels, contact time and turbidity of filtered water at water treatment works. The IEP also considered it beneficial to engage external auditors who have knowledge in WSP and water supply to offer independent opinions on the implementation of the DWQMS. In addition, the IEP advised that the DWQMS should be vetted by a third party before launching.

### *WSP for Buildings*

34. With respect to WSP for buildings, the IEP advised that these WSPs should be prepared and implemented by the building owners on a voluntary basis and WSD's role is advisory. In most cases, the implementation and monitoring of WSPs for buildings will focus on "user-friendly" checklists to be integrated into the wider routine maintenance schedule of the buildings. WSD could engage a team of

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<sup>12</sup> The IEP noted that WSD has already started compiling an up-to-date and integrated plumbing code.

stakeholders such as the Housing Authority, property management companies etc. to provide technical guidance in the development of a generic WSP template/checklist for general buildings.

35. The IEP considered WSD's approach of developing a guideline for WSPs for buildings including WSP templates and checklists for buildings with involvement of stakeholders appropriate. The WSP templates and checklists should be concise and written in plain language, and the templates contain components including brief description of the building/development, plumbing diagrams, risk assessment summary and water safety checklist. The IEP suggested that the templates should initially focus on key hazards only and might include more hazards later on with experience built up after implementation. Besides, appropriate auditing should be arranged by the building owners.

36. During the implementation, the building owners or building management or operators should be required in the WSP templates or checklists to record any observations or remedial actions taken when they carry out checking duties. In respect of cleansing of water storage tank which is one of the items in the checklist, the IEP suggested that cleansing of water storage tanks of general buildings should be undertaken at least on an annual basis. The IEP agreed on WSD's proposal to conduct WSP pilot trials at public and private housing developments, schools, hospitals and elderly homes. Except for specific developments like primary schools with the use of copper pipes connected with soldering, the WSP will not normally require specific water quality monitoring. All buildings will be covered by the routine RDT water quality monitoring programme undertaken by WSD. For primary schools with the use of copper pipes connected with soldering, the IEP suggested that the WSPs should include the requirement of water quality testing as students below 6 are considered belonging to the vulnerable group. It was also suggested that annual water quality testing be conducted for the first two years of implementation and the testing frequency be reduced to once per five years upon satisfactory testing results. Regarding WSPs for hospitals, the IEP advised that most hospitals should already have their own stringent standard practice to ensure water quality.

37. WSD is considering modifying the existing Quality Water Supply Scheme for Buildings – Fresh Water (Plus) (Q-Plus) by requiring the participants to adopt WSP either in the form of water safety checklist or full-fledged WSP with risk identification/assessment and control measures. The IEP considered it appropriate to combine WSD's Q-Plus scheme with WSP to safeguard water quality in buildings. Under the upgraded Q-Plus scheme with WSP, water quality testing for general buildings was considered to be unnecessary.

### **Plumbing Materials Control and Commissioning Requirements for New Plumbing Installations**

38. The IEP considered stringent material control and commissioning requirements for new plumbing installations is an important step to safeguard drinking water quality

from contamination by sub-standard plumbing materials. The licensed plumbers (LP) shall only use approved plumbing materials with documentary certificate/support for inside services.

### *Plumbing material control*

39. The IEP noted that WSD proposed prescribing the system design and materials requirements of the plumbing works in an integrated plumbing code to enable a more robust material control. The knowledge and integrity of the LP would be enhanced by launching continuing professional development scheme, tightening the requirements for renewal of licenses and strengthening the regulatory measures. In long term, WSD proposed that the plumbing works for large-scale building projects should be undertaken by registered specialist plumbing contractors and overseen by qualified personnel (e.g. building services engineer, mechanical engineer, etc.) independent from the plumbing contractors.

40. The IEP advised that the British Standard and European Norm (BS EN) is a robust system. The Four EU Member States France, Germany, the Netherlands and the United Kingdom Great Britain (4MS) Common Approach has no legal status, it is a working agreement between 4 member states of the EU to share knowledge with a view to the development of a common EU wide approach to Article 10 of the EU Drinking Water Directive which deals with systems for the testing, control and approval of materials. However, at the end of 2016 the EU Commission announced that it was carrying out a fundamental revision of the EU Drinking Water Directive, superseding the 4MS working arrangement. It was prudent and reasonable approach for Hong Kong to await the outcome of the EU Directive revision and meanwhile continue to use the BS EN standard for plumbing materials.

41. The IEP considered that the proposed enhancement measures on plumbing material control represented an all-rounded package which would offer adequate protection to drinking water safety of Hong Kong in the near future. Nevertheless, to strike the ultimate goal of reducing lead in drinking water as far as practicable, WSD should continue to explore the feasibility of introducing leaching test for plumbing materials in Hong Kong especially in the long run.

### *Commissioning requirements for new plumbing installations*

42. The IEP advised that 24-hour stagnation water sampling test has recently been introduced by the Public Utilities Board (PUB)<sup>13</sup> of Singapore in the commissioning of plumbing system in new buildings in December 2016. The IEP suggested on top of the existing requirements of material check for compliance with the legislative requirements and for lead in solder joints, a 24-hour stagnation water sampling test (24HS) should be conducted after thorough flushing of the plumbing system for new

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<sup>13</sup> PUB has issued a circular on 4 August 2016 that with effect from 1 December 2016, 1-litre first-draw sample should be taken from new plumbing installation after the water has been left stagnant in the plumbing installation for at least 24 hours, to test for metal parameters including lead.

plumbing installation i.e. to take water sample from the plumbing system of new buildings after 24-hour stagnation for testing of metals before commissioning of the system. Although it is a very stringent requirement and conservative, it could offer best protection to the consumers because surfaces of new copper alloy fittings are known to leach lead significantly, and adequate cleansing is required to clean up their surfaces before the plumbing system is put to use. The adoption of 24-hour stagnation water sampling in commissioning of the plumbing system in new buildings would ensure that sufficient cleansing has been carried out to lower the leaching of lead from the copper alloy fittings to an acceptable level to safeguard the quality of the water after the system is commissioned. The impact caused by different kinds of plumbing component installed in a building together with uncertainties like workmanship and product quality consistency can be assessed totally by the 24-hour stagnation test. Furthermore, the use of 24-hour stagnation water sampling is practicable in new buildings as they are unoccupied and would not cause inconvenience to the consumers. The 24-hour stagnation sampling is also consistent with testing undertaken for compliance with BS materials standards. However, for plumbing works carried out in occupied buildings such as replumbing and renovation works, the IEP agreed that the implementation of the 24HS water sampling test is impracticable, and a 30MS water sampling test coupled with more stringent control measures on the use of materials (e.g. installing fittings with low metal leaching and strengthening material check in the inspection process) would be appropriate.

43. WSD has conducted trials using 24-hour stagnation water sampling test at new plumbing installations for the six metal parameters (Lead, Cadmium, Chromium, Copper, Antimony and Nickel). The trial results indicated that with adequate flushing, the new commissioning requirement is achievable and practical. In tandem, WSD has engaged a professor in the University of Hong Kong (HKU) and developed flushing protocols for new plumbing installations to help the trade comply with the new commissioning requirements. The HKU professor has also developed a pretreatment protocol for reducing the metal leaching from fittings in replumbing and renovation works carried out in occupied buildings.

44. Building owner/licensed plumber should be responsible for conducting the investigation and material check upon failure of the 24-hour stagnation water sampling test. The IEP considered that in general further cleansing of the plumbing system is the appropriate response and this is likely to bring down the levels of lead and other metals to enable the plumbing system to pass the retest.

45. The IEP endorsed WSD's proposal that the commissioning requirements for new plumbing installations be implemented in stages (a) starting with the mandatory requirement for applying the systematic flushing protocol to all newly installed inside services after approval for water supply and before occupation, (b) with the next stage of implementation involving the taking of a 6-hour stagnation (6HS) water sampling test after the flushing and (c) finally making the satisfactory 6HS water sampling test result a condition for approval of effecting the water supply in new buildings. In line with the Enhanced Programme, all six metals will be included in the water sampling test for new plumbing installations subject to review in due course when more test

results are available. When adequate water sampling test results are available, WSD will review the aforesaid measures and consider the adoption of water sampling test with longer stagnation time up to 24 hours as commissioning requirements to further enhance protection to the public.

46. The IEP noted that Professor Fawell has also suggested in the CoI hearing the monitoring of zinc in addition to copper and antimony. The IEP considered that as galvanised pipe is no longer used in Hong Kong, it is not necessary to include zinc in the 24-hour stagnation water sampling test. There is no health based guideline value for zinc. For copper and antimony, although the risk of exceedance of the corresponding GV in the WHO Guidelines 2011 is low, the IEP recommended that it would be prudent to include the two metals in the water sampling test for plumbing system in new buildings and their inclusion in the test may be reviewed when more test results are available say in 3 years' time.

47. It is noted that existing procedure for control of plumbing works does not only rely on the 2MF sampling protocol but also includes i) engagement of licenced plumber and submission of list of approved pipes and fittings to be installed for Water Authority's approval before commencement of works; ii) conduct of non-destructive tests on solder joints of newly installed fresh water inside service to check any illegal use of leaded solder; and iii) fully disinfection of plumbing works before effecting of water supply. In view of the above and that water quality of existing buildings will be monitored under the future territory-wide monitoring programme, the IEP considered that it is not necessary to conduct re-testing for those plumbing installations already approved based on the 2MF sampling protocol.

48. It may take some time for the buildings to be occupied after all water tests are passed. If the time gap is more than 7 days, the IEP considered that the building owners should be advised to fully flush the whole plumbing system again right before the actual occupation of the buildings.

### **Public Education and Publicity on Safe Use of Water**

49. The public should be advised on the safe use of water, such as flushing after long stagnation times (for instance, after several hours or overnight) and avoiding the use for drinking of water from hot water taps in order to reduce/avoid exposure to lead if any in the drinking water. The IEP noted that WSD had conducted public education activities in this aspect through various channels such as distribution of leaflets and posters, uploading of the advice onto WSD's website, etc. WSD has also arranged broadcasting of a tailor-made API (Announcement in the Public Interest) in television and radio in January 2017 to promote these tips on safe use of water through the mass media. Apart from the above, the IEP also welcomed WSD's initiatives to arrange seminars to promote more specific tips/guidance for the operators of specific premises, such as kindergartens and social welfare units.

50. Notwithstanding the above, a dedicated corner on WSD's website could be set

up to provide a one-stop information hub on water safety and quality. More guidance or other tips on safe use of water will be developed and provided to the consumers on safe use of water by undertaking studies and researches. The WSD could also offer incident-related advice to the general public as and when necessary to raise their awareness and at the same time avoid causing unnecessary panic.

51. The IEP also showed consent to WSD's proposal on educating the public more on the territory-wide water quality monitoring programme. WSD will provide more systematic and updated information based on monitoring zones i.e. the DCDs in regard to water quality monitoring results in the aforementioned dedicated corner on WSD's website in conjunction with the water quality monitoring results of the DJ water. Besides, it is important to educate the public more on the water quality monitoring programme as the programme might draw a lot of attention/enquiries. When the consumers are selected for water sampling, WSD could distribute a set of leaflet to the consumer concerned to explain the details of the programme, such as the possible outcomes of the test, the associated follow-up actions/advice. Together with publicity to promote the programme amongst the public, internal education/training should be provided to enhance WSD staff's understanding on the programme.

### **Testing of Unaffected PRH Estates Again**

52. The CoI has recommended the Government to test the drinking water of all PRH estates for lead again using an appropriate sampling protocol that would include the testing of stagnant water as well.

53. The IEP has reviewed the results of the water sampling tests conducted for the PRH estates in the lead-in-water incident. The IEP considered that the 2MF sampling protocol was on its own not an optimal one. However, with the systematic sampling programme based on detailed information on each of the individual plumbing system and the large number of water samples taken from each PRH estate, the IEP observed two distinct patterns of distribution of lead concentration in the flushed water sample test results between the Affected and Unaffected PRH Estates. Coupled with the use of the stringent criterion that one single failed water sample would lead to the classification of the PRH estate as affected, the IEP considered that the water sampling and testing exercise conducted for the PRH estates using the flushed sampling protocol was in general effective in distinguishing the Affected PRH Estates from the Unaffected PRH Estates. This was also confirmed by the independent investigation by the CoI expert witness.

54. The IEP further noted that WSD has been promoting the flushing of water taps after prolonged period of stagnation before taking the water for potable consumption to the public including tenants of the PRH estates. The IEP remarked that flushing is very effective in reducing the risk of lead exposure.

55. Indeed, the 2MF sampling protocol which was used for testing of the WHO parameters under the routine water quality monitoring programme was employed for

the water sampling tests for the PRH estates in 2015 against the backdrop of crisis over the drinking water quality therein. Taking into account the recommendation of the CoI and in order to put the minds of PRH residents at ease, the IEP endorsed that additional water samples from PRH estates for testing of lead could be taken as needed in conjunction with the implementation of the Enhanced Programme.

56. In this connection, the IEP considered that a risk based approach should be adopted. The Unaffected PRH Estates could be divided generally into two groups, namely (i) non-copper pipe group: those pre-2005 PRH estates<sup>14</sup> where no copper pipe was used; and (ii) copper pipe group: those post-2005 PRH estates where copper pipes were used<sup>15</sup>.

57. The IEP considered that specific testing for the non-copper pipe group (pre-2005 PRH estates) again is not necessary and in any event these estates would be included in the territory-wide water quality monitoring programme using the proposed 2-Tier sampling protocol.

58. As for the copper pipe group of estates, to respond to the recommendation of the CoI, the IEP agreed that the Government should take one additional water sample from each block of the post-2005 PRH estates if such blocks are not selected for testing under the Enhanced Programme. In other words, about 160 additional water samples<sup>16</sup> will be taken from the domestic building blocks of the unaffected PRH developments identified during the 2015 sampling exercise for testing of lead, in conjunction with the Enhanced Programme within the first year of its implementation. The arrangement (including the sampling protocol which would involve taking of stagnant water samples) adopted for these additional water samples will be largely the same as the Enhanced Programme, except that only lead content will be tested. Yet the IEP has stressed that the testing results should be separated from the statistics of the Enhanced Programme.

59. For the additional samples taken, the IEP considered that no further action would be needed if the lead level in the RDT or 30MS sample (in case the RDT samples fails) is 10µg/L or below. If the 30MS water sample has lead level exceeding 10µg/L, further investigation should be conducted to identify the source of lead contamination in the plumbing system of the concerned flat and further investigation undertaken to determine the non-compliant zone within the housing block if the non-compliant water samples are not due to the tenant's own alteration of inside service within the flat. The IEP considered that Housing Authority (being the owner of the PRH estates) should duly assume its role to carry out further investigation to confirm if premises within the same housing block or estate also have the problem of lead contamination in the plumbing systems taking into account all other relevant

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<sup>14</sup> Excluding three pre-2005 PRH estates: Kwai Shing (East) Estate (Shing Wo House); Tsz Lok Estate (Lok Foon House) and Lok Fu Estate (Lok Tsui House), where copper pipes with solder joints have been used for the re-plumbing works.

<sup>15</sup> Several estates which use stainless steel or copper pipes with compression joints are included in this group.

<sup>16</sup> The IEP considered that it is acceptable to take about 160 additional samples. By making reference to the UK regulatory water quality monitoring requirements that eight samples would be taken for population between 5 000 and 100 000 and the estimated population of the Unaffected PRH Estates is about 300,00, a total of 24 samples would be required only.

information such as the responsible subcontractors and licensed plumbers etc. If necessary, WSD should provide necessary technical advice to assist Housing Department (HD) in undertaking the further investigation. Besides, if a non-compliant flat is identified, the non-compliant water sampling test result together with the findings of the investigation on the source of lead contamination in the flat should be communicated by HD to the tenant of the flat as soon as the test results on the lead contamination of the flat are confirmed. As further investigation will take time, mitigation advice set out in paragraph 26 above should be given to the tenants in the concerned housing block in the interim.

60. Unlike the last water sampling and testing exercise for PRH estates in the lead-in-water incident in 2015 where one single failed water sample would lead to classification of the whole estate as affected, the IEP considered that it is not necessary to classify the whole estate as a non-compliant estate straight away in the event that the 30MS water sample has lead level exceeding 10µg/L during the retesting exercise. Instead, further investigation should be carried out to confirm the extent of non-compliant zone in the concerned housing block as set out in the preceding paragraph.

### **Testing of Kindergartens, Schools, Welfare Units and Government Quarters Again**

61. During the lead in drinking water incident in 2015, WSD assisted the Education Bureau (EDB) and the Social Welfare Department (SWD) to conduct water sampling tests for lead in most of the kindergartens<sup>17</sup> and welfare units<sup>18</sup> respectively. A total of 1,956 drinking water samples were taken at the inside service, wall-mounted dispensers (dispensers) and drinking fountains from these premises. While the 2MF sampling protocol was adopted for the water sampling at the inside service, a special sampling protocol<sup>19</sup> was designed for the water sampling at dispensers. About 98% of the 1,540 2MF water samples from inside service were found to have undetectable or very low lead level (i.e.  $\leq 1\mu\text{g/L}$ ) with the remaining samples less than 10µg/L. Except for 10 samples from dispensers from eight kindergartens, all the other 406 water samples from dispensers and fountains were found to comply with WHO's PGV for lead (i.e. 10µg/L). All the non-compliant dispensers were stopped from use immediately.

62. Water sampling and tests were conducted by EDB and the Architectural Services Department (ArchSD) for the inside service of the public sector and Direct

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<sup>17</sup> Children attending kindergartens are generally aged below 6 years old and are considered to be the most vulnerable group. 772 out of 996 invited kindergartens participated in the water sampling test jointly arranged by EDB and WSD in November 2015. For the remaining KGs chose not to participate, over 70% indicated that they would arrange their own tests.

<sup>18</sup> Welfare units in this paper are referring to the childcare services, children's homes, small group homes, pregnant girls' hostel, daycare and residential special childcare centres serving children aged below six who have to stay in the units for long hours.

<sup>19</sup> Prior to sample collection, the kindergarten/welfare unit/school was instructed to drain all the water in the wall-mounted dispensers, fill the dispenser with water again, boil the water and then allow the water to cool down before an unflushed water sample was taken. The time required for boiling and cooling was normally over 2 hours.

Subsidy Scheme (DSS) schools built with Government funding completed in or after 2005 (the post-2005 schools), including primary, secondary and special schools, and separate water sampling tests were arranged for wall-mounted dispensers of these schools<sup>20</sup>. A total of 667 drinking water samples were taken from these premises<sup>21</sup>. Except for the seven samples taken from a secondary school (including five from the inside service and two from the drinking fountains) and two samples from the wall-mounted dispensers of two other secondary schools, all other samples were found to be in compliance with WHO's provisional guideline value. The two secondary schools with non-compliant water dispensers have stopped using the devices and the non-compliant inside service and water fountains of the other secondary school concerned were arranged to be rectified.

63. In order to promulgate effectively information on reducing lead exposure of students in schools, EDB has issued letters to all schools and kindergartens attaching the health advice prepared by the Centre for Health Protection of the Department of Health (DH) for reducing lead exposure, organised talks on "Reducing Lead Exposure and Water Safety" in collaboration with DH and WSD for schools and kindergartens, and distributed to all schools and kindergartens a booklet on "Hong Kong's Water Supply – Reducing Lead in Drinking Water" and a leaflet on "Tips for Using Wall-mounted Dispensers" compiled by WSD. These advices and tips have also been uploaded to EDB's website<sup>22</sup>. Pamphlets were provided which highlight the proper use of wall-mounted dispensers, including the importance of and procedures for regular cleaning of dispensers, switching off the dispensers before long period of non-use and draining away of water in dispensers every morning, as well as simple steps for quick lead check of dispensers.

64. Similarly, in order to enhance the welfare sector's understanding of ways to reduce lead exposure, SWD has disseminated health advice about reducing lead exposure from the Centre for Health Protection of DH and the advice on the installation and use of wall-mounted dispensers provided by WSD in August and September 2015 respectively to different welfare units. SWD has also disseminated the "Tips for Using Wall-mounted Dispensers" published by WSD to the concerned welfare units in December 2015.

65. Furthermore, WSD has conducted seminars again in January 2017 for kindergartens and welfare units to provide tips/guidance on ways to ensure drinking water safety in their specific settings including the advice to flush the taps before filling dispensers or kettles.

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<sup>20</sup> Based on information from EDB and ArchSD, 73 out of the 79 post-2005 schools concerned participated in the water sampling test for the inside service of the schools and 39 schools participated in the separate water sampling test on dispensers. As regards the six post-2005 public sector and DSS schools that did not participate in the water sampling tests, all of them have arranged their own water tests. The age ranges for primary and secondary school students are generally from 6 to 11 years old and 12 to 17 years old respectively.

<sup>21</sup> Based on the information from EDB and ArchSD, the 667 water samples comprise 587 taken from the inside service of 73 schools, 75 taken from the wall-mounted dispensers of 39 schools and 5 from the drinking fountains of 3 schools.

<sup>22</sup> The website is <http://www.edb.gov.hk/en/sch-admin/admin/about-sch/reducing-lead-exposure/index.html>.

### *Kindergartens and Welfare Units*

66. The water consumed by the children in these premises generally only represents a portion of their total drinking water intake. In addition, the children will normally only consume boiled water centrally prepared by kindergartens and Welfare Units from dispensers (40 L) or kettles (>2L) and hence the direct first draw concern from taps does not apply.

67. In the lead-in-water incident, water samples from all dispensers in those participated premises were tested which was independent of the sampling protocol (due to homogeneous water quality inside the dispensers). Except for the 10 dispensers with non-compliant water samples, which are no longer used, the remaining dispensers all had water samples with lead content complying with the PGV in the WHO Guidelines. WSD has conducted seminars again in January 2017 for kindergartens and welfare units to provide tips/guidance on the ways to ensure drinking water safety in their specific settings including the advice to flush the taps before filling dispensers or kettles. Tips and guidance on use of dispensers and kettles are also provided on the EDB website.

68. Based on the above, the IEP considered that the risk of the children from lead exposure in drinking water in kindergartens and welfare units is low and testing in these premises again, apart from inclusion in the territory-wide water quality monitoring programme, is not necessary.

### *Primary and Secondary Schools*

69. IEP advised that flushing is a very effective way to reduce the risk from drinking water, not only for lead but for avoiding other water quality issues such as discolouration and turbidity due to corrosion or deposition of minerals in the water pipes. As drinking water taken by a student in schools generally amounts to only a portion of his or her total drinking water consumption and as the direct drinking water source in schools from the inside service is mainly from drinking fountains installed in schools, the IEP considered that flushing of water taps for potable consumption, in particular drinking fountains, after stagnation for a prolonged period, such as in the morning before school starts and at the midday before lunchtime, is generally effective in keeping the water suitable for drinking. The IEP considered that if the aforesaid flushing practice is implemented in schools as a routine, the risk of the students from drinking water would be low; and there is no urgency to test again the drinking taps in schools which in turn could be covered in the territory-wide water quality monitoring programme which the IEP understood would commence in December 2017/January 2018.

70. Separately, the IEP recommended the implementation of WSP in schools in due course in order to further safeguard the drinking water quality for students, in particular for schools with copper pipes and serving students aged at or below six. In the latter case, their WSP should also include an annual water sampling test using 30MS sampling protocol, and the frequency of which could be reduced from annually

to 5-yearly providing the water samples are compliant with WHO's PGV for 2 consecutive years. The schools' effort in implementation of WSP would sustain the water safety for the students. In this regard, the IEP noted that the Government would facilitate school managements' preparation and implementation of WSP on a voluntary basis (including regular cleaning of water tanks, inspection of the plumbing systems, etc.) by providing WSP guidelines and school-specific template. WSD has conducted pilot trials for development of specific WSP guidelines and templates for schools, which are completed in end August 2017. Training sessions and workshops have been provided to plumbing professionals by WSD to equip them with the necessary knowledge for implementation of WSP. The IEP further noted that, whilst school managements had previously been asked and reminded to flush the taps before use, WSD would continue to conduct briefings/seminars for schools to provide tips/guidance on the ways to ensure drinking water safety in school settings, including the flushing advice, and encouraging them to implement the WSP. A helpdesk has also been established by WSD to provide technical support on WSP as an ongoing measure.

### *Government Quarters*

71. During the lead-in-water incident, water samples were taken from four government quarters completed in or after 2005. A total of 34 2MF samples were taken from the inside service of the quarters and lead content of all samples were found to comply with WHO's PGV. In addition, the lead contents in 91% of the water samples (i.e. 31 tap samples) were undetectable (i.e.  $<1\mu\text{g/L}$ ) and the remaining 9% (i.e. 3 tap samples) had lead content of  $2\mu\text{g/L}$ . In addition, an unflushed water sample was taken from one of the government quarters in a separate exercise in March 2016 and found compliant with lead concentration less than  $10\mu\text{g/L}$ . Based on the above test results, the risk of lead contamination in the plumbing systems of the government quarters built by ArchSD is low.

72. The IEP considered that testing for the government quarters is not necessary and like other residential premises, they would be included into the territory-wide water quality monitoring programme.

### **Release of the Key Advice to the Public**

73. The above key advice has been agreed by the IEP for release to the public.

**Prepared by  
Development Bureau  
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## Annex

With reference to the regulatory requirements of the UK and all 28 countries in the EU, the sampling frequency of 6 metals including lead, corresponding to the population distribution of 18 DCD (reference from Table 34 of the “Hong Kong 2016 Population By-census - Summary Results” Report) using Tier 1 (RDT) sampling protocol is given below:

Territory	District	2016 mid-year population (to the nearest 10,000)	Number of samples per year for metal analysis *
Hong Kong Island	Central and Western	240,000	24
	Wan Chai	180,000	16
	Eastern	560,000	48
	Southern	270,000	24
Kowloon	Yau Tsim Mong	340,000	32
	Sham Shui Po	410,000	40
	Kowloon City	420,000	40
	Wong Tai Sin	430,000	40
	Kwun Tong	650,000	56
New Territories	Kwai Tsing	520,000	48
	Tsuen Wan	320,000	32
	Tuen Mun	490,000	40
	Yuen Long	610,000	56
	North	320,000	32
	Tai Po	300,000	24
	Sha Tin	660,000	56
	Sai Kung	460,000	40
	Islands	160,000	16
Total		7,340,000	664

\* 8 samples/5,000 - 100,000 population among 18 DCDs